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Program of the Conference

Title: **Various failure constraints of stress-based topology optimization for fluid-structure interaction**
Topic: **Acoustic**
Type: **ORAL**
Abstract:
The present research considered the failure theories for brittle and ductile materials in the stress-based topology optimization method (STOM) for steady state fluid-structure interaction (FSI). From some relevant researches in topology optimization (TO), the subject of stress-based topology optimization minimizing volume with local von-Mises stress constraint has been researched. However, various failure theories for ductile and brittle materials such as the maximum shear stress theory, the brittle and the ductile Mohr-Coulomb theory, and the Drucker-Prager theory, has not been considered in STOM for FSI. For a successful STOM for FSI, in addition to the physics interpolation issues between structure and fluid and the issues related to STOM, the mathematical characteristics of the various failure theories should be properly formulated and constrained for the STOM for FSI system. To resolve all the involved computational issues, the present study applied a monolithic analysis, the qp-relaxation method and the p-norm approach of these failure constraints. The present TO method was able to create optimal layouts minimizing the volume constraining local failure constraints for ductile and brittle materials for a steady state fluid and structural interaction system.

Authors:
Yoon, Gil Ho - **(*presenter)**[Hanyang University] - KOR

Title: **Parameter Estimation in a Thermodynamic Model Using Differential Evolution in Parallel Phyton**
Topic: **Chemical Processing Equipments**
Type: **ORAL**

Abstract:
The parameter estimation is an important practice in Chemical Engineering, since the prediction capability of thermodynamic models (such as equations of state or excess Gibbs free energy models) is extremely dependent on these parameters. In this work, we presented results regarding the parameter estimation of Wilson model (an activity coefficient model/excess Gibbs free energy model, for the description of liquid phase nonidealities) in the binary system composed by n-hexane + cyclohexane at low pressures. The compositions and equilibrium temperatures for both phases were obtained using a low-pressure ebulliometer. The vapor phase was considered as an ideal gas. The parameter estimation procedure was conducted using the Differential Evolution algorithm (a stochastic optimization method) under Parallel Phyton. Differential Evolution is a stochastic method with widespread use, based in three operations: mutation, crossover and selection. Parallel Phython is a Python module that permits the use of multicore computers or clusters. In this sense, each run of Differential Evolution is assigned to an specific core of the computer, promoting a gain in terms of computation time. In our computational experiments, we compared 80 runs of Differential Evolution considering serial runs and the use of Parallel Phyton. The average values and standard deviations are very close for the two scenarios. The results shown that the speedup between serial and parallel runs is close to 8.6, indicating that Parallel Phyton is an useful tool for hard engineering problems.

Authors:
Vasconcelos, Lucas - **(*presenter)**[Rio de Janeiro State University] - BRA
Luz, Jorge - [Rio de Janeiro State University] - BRA
Platt, Gustavo - [Rio de Janeiro State University] - BRA

Title: **Thermodynamic Approach: A Review With Regard to Optimization**
Topic: **Chemical Processing Equipments**
Type: **POSTER**

Abstract:
The need to save energy based on fossil fuels supplied to the industrial process is mainly due to two reasons: economic and ecological. Furthermore, alternative sources have not adequately met the consumption. To minimize them, it should be developed a strategy for optimizing the processes, improving the energy efficiency. Among the several methods, those using the thermodynamic optimization have been widely used. Although the balances of mass and energy (First Law of Thermodynamics) are valuable tools for analyzing energy and mass transfer allowing determining unknown data, they fail to take into account constraints of nature, which the processes are submitted. Thus, it is the Second Law of Thermodynamics that allows dealing such constraints.
Having as aim at the process optimization, a new rethink on the entropy, exergy and Gibbs free energy concepts have been considered due to flaws in the conceptual exploration and consequently misunderstanding. In addition, complementary approaches on the reversible state and steady state should be taken into account because the understanding of differences between both concepts can reduce possible misunderstandings in optimization of processes. It should be clear that reversibility is a thermodynamic concept while the steady state is related with time, being consequently a physical concept. Moreover, it is in the reversible state where occurs the maximum work, the maximum heat transfer and conversion rate, furthermore, the consistent move towards reversible state may indicate if the process runs well organized or not. Consequently, such considerations have a pivotal role for the process optimization and thus it gives rise to the following question: how to find the conditions that can lead the process towards reversibility? What is the steady state associated to reversibility? It should be also emphasized that the use solely of the steady state can lead to sub-optimal results. Several methods and strategies can be chosen to find the operating conditions depending on the specific problem, namely: the minimization of Gibbs free energy, the minimization of the entropy production rate and exergy analysis. It can be also seen in the literature a wide range on the successful application of minimum entropy production for thermal processes and reactive systems for which the main interest is to reduce irreversibilities present in the system. Exergy analysis has gained an expressive acceptance in the industrial community due to its analytical capacity to give value to the different kinds of energy source. However, since exergy can be sensitive to the variations of the dead state, then its use still presents some restrictions due to the practical difficulties. For closed systems, the use of Gibbs free energy or more specifically the global minimum of the Gibbs free energy can be more appropriate and it is related with the conditions imposed to achieve equilibrium, for example, in a multiphase multicomponent system. Applied to reactive system, the objective of this paper is to clarify the intersection points and differences between the concepts aforementioned to optimize such systems.

Authors:
Manzi, João - **(*presenter)**[Federal University of Campina Grande] - BRA
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Title: **MINLP superstructure optimization for protein extraction in the surimi manufacturing process**
Topic: **Chemical Processing Equipments**
Type: **POSTER**
Abstract:
The surimi process starts from holding fish, sorting by size and cleaning. After that, process stages for meat separating are achieved, which are heading and gutting by mechanical fish meat separators, a preliminary washing to remove the blood and adherent particles and then, deboning and mincing.
The cyclic washing and rinsing processes of the minced fish, which is also called leaching process, are the central stage. The objective of this stage is to remove soluble compounds resulting in concentrated myofibrillar proteins, which mainly contribute to gel formation.
The leaching stage in the manufacturing process of surimi gel requires a large amount of wash water, where more than 65% of the total amount of fresh water required by the entire process is used in the leaching process resulting in high operating cost. Traditionally, the leaching process is achieved in three continuous cycles of washing, where fresh water is added at each one of the three leaching tanks, and the wastewater is subsequently removed from the meat by a rotary sieve before the next washing stage, this is called the conventional arrangement. Other possible configuration is a countercurrent one, in which the fresh water is only supplied to the last tank; then, the wash water is recycled to the previous one. In a previous work, it was proved that the countercurrent configuration entails minimum water consumption in this stage, 56% less than the conventional arrangement for three stages.
In this work, a mathematical optimization model for the optimal design of the leaching process is presented, in order to define the optimal number of stages. Precisely, a detailed Mixed Integer Nonlinear Programming (MINLP) model, including operational and geometric constraints, is developed and implemented in GAMS, based on our previous optimization model (NLP model) for water consumption minimization. Discrete decisions associated with the number of stages (leaching tanks and auxiliary equipment units, such as sanitary pumps and rotary sieves) are modelled by using integer variables. Continuous variables are used for process conditions (temperatures, flow-rates, tank volumes, velocities, rate of extraction among others). A maximum of four stages are defined in the model.
The optimal results adopt the maximum number of stages (four) and higher volume tanks. The fresh water consumption decreases when the number of stages increases, due to the fact that more recycle streams are available in the countercurrent arrangement, reducing both the fresh water requirement and the liquid waste stream. Despite the fact that the model includes cost aspects, the optimal solution adopts the highest number of stages, because only the operating costs are implicitly contemplated in the objective function. From a computational cost point of view, the model resulted to be enough flexible to perform optimizations and sensitivity analyses.

Authors:
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Title: **Vapor-Liquid Equilibrium of a Binary System Composed by Heptane + Dodecane: Experimental Procedures and Parameters Estimation**
Topic: **Chemical Processing Equipments**
Type: **ORAL**
Abstract:
The present work goals the study of vapor-liquid equilibrium (VLE) of binary system composed by heptane and dodecane. The importance of VLE study lies on its applications on industrial processes, such as separation and also for the description of vapor-liquid coexistence loci. The experimental stage of this work consists on the obtainment of a calibration curve, which correlates the mixture density with the molar fraction of the components. Afterwards many experiments are performed using an ebulliometer, model VLE-602 FISCHER® with pressure control. Each experiment provides two samples, which contains liquid and condensed vapor phases. The molar fraction of components in each phase is determined by a calibration curve. The ebulliometer also provides the vapor and liquid temperatures and the pressure in which the experiment was taken.
It is of great importance to know whether the experimental data obtained at isobaric conditions are able to be used on the next steps of this work. So, it is used the thermodynamic consistency test proposed by Herington to make sure if all the points obtained will generate reliable results.
The data obtained on the experimental stage of this work are used for the estimation of binary interaction parameters of the Wilson model. The determination of these parameters appears as an optimization task through the minimization of an objective-function (or fitness function). For such, a stochastic method known as Differential Evolution was applied. This method consists in a simple and very efficient algorithm. Then, an statistic analysis is realized as well, looking forward to the confidence regions for the parameters of the Wilson model. Finally, it is possible to plot the phases diagram with the experimental points and the Wilson model prediction for the mixture.
Keywords: vapor-liquid equilibrium; Differential evolution; Wilson model; Parameter estimation and ebulliometer.

Authors:
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Lacerda Custódio, Dayana - [IPRJ-UERJ] - BRA
Vasconcelos, Lucas - [Rio de Janeiro State University] - BRA

Title: **TOPOLOGY OPTIMIZATION OF PLANE FRAMES**
Topic: **Civil Engineering**
Type: **ORAL**

Abstract:
Columns are structural elements responsible for the transmission of loads vertically to the foundations, including the self-weight. The definition of the number of columns, as well as their positions in the structure, is one of the tasks of the designer, and has a significant impact on both cost and structural behavior. In usual building structures, a small spacing among columns can interfere on the architectural design or parking space. On the other hand, a small number of columns leads to greater spans and, as a consequence, larger beam heights. This work presents a study developed in order to obtain the spacing of reinforced concrete columns of building structures corresponding to the smallest global cost (concrete, steel, and formworks). To achieve this objective, the plane frame is modeled as beam elements supported by springs with rotational rigidity. The optimization design variables are the height of beams and the cross sectional dimensions of columns. At the beginning of the process, columns are closely positioned, with small spacing among them, being the cost of the whole structure minimized. The less stressed column is removed from the structure, generating a redistribution of efforts. The optimization process is repeated, the columns being successively removed from the structure. The optimal spacing corresponds to the configuration of minimum cost. The present work presents some examples of structures analyzed by the proposed procedure. It was observed that the optimum column spacing is similar to those suggested by practice. The methodology proposed in this work is being adapted to spatial structures, aiming to generalize the results obtained. Although it has been applied to reinforced concrete structures, the proposed procedure can be easily adapted to structures composed by other materials. In the present stage of the study, global stability of the structure was not taken into account.

Authors:
Kripka, Moacir - **(*presenter)**[University of Passo Fundo] - BRA
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Title: **OPTIMAL PLACEMENT AND DISTRIBUTION OF HYSTERETIC DAMPER BASED ON THE INCREMENTAL INVERSE PROBLEM**
Topic: **Civil Engineering**
Type: **ORAL**
Abstract:
ABSTRACT
Building and civil structures are often subjected to destructive environmental forces including those due to earthquakes, wind and waves. The forces on structure produce excessive vibration, not only undesirable from the standpoint of security, but also convenience. The structural control reduce the demand for energy dissipation in structural elements under the action of dynamic forces by changing the mechanical properties of the structure such as stiffness and damping. The hysteretic device system is a passive control concept, the aim is to dissipate the largest part of the input energy through a mechanism that is independent of rate frequency load, number of cycles of the load or variation in temperature. The objective of this work is to find the optimal placement and distribution of hysteretic damper based on the incremental inverse problem.
A structure is subjected to design loads and subsequently validated by the respective design code. The design stage is finished if in the first analysis all parameters are satisfied, in otherwise, should make other attempts. The incremental inverse problem is an optimization process considering the structural parameters as unknowns. At the moment that these parameters are determined, is selected the configuration and the size of the elements.
The behavior of mass-spring model with hysteretic damper will be study in terms of the transfer function and incremental inverse problem formulation. The model consist of masses, spring stiffnesses and damping coefficients of dashpots.
The mathematical formulation regards the amplitude of the transfer function as a general dynamic property and ignores the influence of motions or external forces.
According to Izuro Takewaki (2009): “The object is to find the optimal damper placement to minimize the sum of amplitudes of the transfer functions evaluated at the undamped fundamental natural frequency of a structural system subject to a constraint on the sum of the damping coefficients of added dampers. For a given shear building model with a hysteretic damping system, an optimal distribution of passive dampers is obtained automatically with the optimality criteria-based sensitivity ratios of amplitudes of transfer functions at the fundamental natural frequency as the target performance indices”.

REFERENCE
Takewaki, I., 2009. Building Control with Passive Dampers: Optimal Performance-based Design for Earthquakes. John Wiley and Sons (Asia), Singapore.

Authors:
David Sánchez, Wilson Emilio - **(*presenter)**[Universidade de Brasília] - BRA
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Vital de Brito, Jose Luis - [Universidade de Brasília] - BRA

Title: **Topology Optimization of I-Section Beams with Web Openings using ESO and BESO Methods**
Topic: **Civil Engineering**
Type: **ORAL**

Abstract:
Evolutionary Structural Optimization (ESO) and Bidirectional Evolutionary Structural Optimization (BESO) are known as “hard-kill” optimization methods, since they are based on the concept of gradually removing unnecessary or inefficient material from a structure to achieve an optimal design (minimization of mass-to-stiffness ratio). The ESO and BESO methods have become popular especially due to their simplicity, straightforwardness to implement and possibility to link with black-box commercial structural mechanics software. A known shortcoming of ESO and BESO methods is the possibility of discontinuity in boundary conditions leading to a statically indeterminate structure. This problem can be avoided by checking boundary conditions at each iteration during the optimization process.
The placement of openings within the web of I-section beams has been employed in structural design for over 100 years to improve their mass-to-stiffness ratio, enabling the use of longer spans and eliminating the probability of cutting holes in inappropriate locations for electric, hydraulic and air conditioning installations. Castellated and cellular beams, with or without reinforcement, are the most used types of perforated beams. Elliptical and sinusoidal openings have been recently studied. The fabrication of I-sections using the plate assembly technique increases the number of options for positions and shapes of the openings.
This “removal” of material that creates web openings can be looked at from a topology optimization point of view. One of the goals of this work is to obtain different web opening configurations using structural optimization methods such as ESO and BESO. The bending stiffness reduction due to the openings is not very significant, since the contribution of the web to the moment capacity is very small. Since transversal forces are usually resisted by the web, the reduction in shear capacity at the opening can be significant. It is also necessary to check the possibility of the beam’s lateral torsional buckling.
In order to study the structural performance of the obtained configuration in comparison to a beam with circular web openings (cellular), a nonlinear Finite Element Analysis (FEA) was performed. The buckling loads and post-buckling behavior of both structures were compared.

Authors:
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Title: **How to get rid of the discontinuities when constructing surrogates from discontinuous functions**
Topic: **Design of Experiments**
Type: **ORAL**
Abstract:
Structural shape optimisation has developed significantly over the last four decades. Significant strides had been made in alleviating the issues associated with remeshing by advances in mesh morphing and isogeometric analyses. Albeit remeshing remains a convenient approach to resolve large shape changes between designs at the cost of introducing discontinuities in the objective and constraint functions. These discontinuities are due to the discretisation error that changes non-smoothly between designs and often manifest as local minima for classical interior point methods.

Gradient-only optimisation has been shown to robustly optimise these functions. Recently the benefits of allowing large changes in mesh grading between designs has been demonstrated. This was achieved by only reducing the discretisation error as the optimizer converges. This allowed for computationally efficient analyses initially that only increased as the optimiser progressed towards convergence. As usual a gradient-only interior point strategy was used.

However, this work is not limited to only structural optimisation problems but any differential equation or partial differential equation optimisation problem that is solved using variable time strategies or spatial remeshing. The benefits in material characterisation using variable time steps has been demonstrated, again using interior point gradient-only approaches. In fact all gradient-only work to date was focussed on interior point methods.

This study investigates the possibilities of gradient-only optimisation to construct surrogate functions from discontinuous functions. Here, we construct surrogates using only gradient information. The result is a smooth surrogate that completely ignores the presence of the discontinuities. This is in stark contrast to surrogates that are constructed from function values only. Although these surrogates are also smooth, additional local minima are introduced into the smooth surrogate as a direct result of the discontinuities.

To draw concrete conclusions in this study we compare gradient-only constructed surrogates against conventional function value based surrogates as well the lesser used mixed surrogates that uses both function values and gradients to construct the surrogates. This also allows us to decompose the contributions of function values and gradients to the resulting surrogate. We consider two test problems. First, a one dimensional problem with the benefit that the density between function values and derivatives are the same. Secondly, a multidimensional surrogate for which the data density of gradients are much higher than for functions values only.

Authors:
Wilke, Daniel - (*presenter)[University of Pretoria] - ZAF

Title: **Alternatives of Linear Search in the context of Interior Points applied to Power Flow Problem on Large Electrical Systems**
Topic: **Electrical Systems**
Type: **ORAL**

Abstract:
The solving the Optimal Power Flow (OPF) is a major problem in Electrical Systems. Its importance is, among other reasons, to provide in a few iterations a solution respecting the preset limits: voltage, circuit flows, etc. The solutions obtained by the traditional methods of Power Flow (FP) require subsequent adjustments to meet these limits. Normally this procedure requires a long time, lowering productivity. The OPF is presented as an important alternative to provide solutions in a much shorter time. The Power Flow Problem is a Large Nonlinear Programming Problem with hundreds to thousands of variables and nonlinear constraints. Since it was presented by Carpentier in 1962, several methods have been applied in resolving the OPF. Currently, the program FLUPOT owned by CEPEL has been used to good effect in solving large electrical system like the Brazilian Electric System. The implementation of FLUPOT program is based on Primal Dual Interior Point Method. This is due to the good performance of this method in Large Linear Programming and in Convex Quadratic Programming. Historically, FLUPOT shows good results in Large Electrical Systems. In this context, it seeks to improve the performance of FLUPOT program using the Linear Search Criterion with appropriate merit functions. The Linear Search in Optimization using methods in which the original function or derived function is available. For a suitable choice of Linear Search takes into account the descent direction, the step size and the choice of merit function. On the other hand, it is a linear search optimization subproblem should not be computationally expensive, especially for large problems such as electrical systems with hundreds to thousands of variables and nonlinear constraints. With these considerations Armijo Search is the most appropriate for their good performance and low computational cost. Five alternatives merit functions were tested in order to find what best would fit the OPF problem. Computational tests with electric medium to large systems are presented and discussed.

Authors:
ALVES DE OLIVEIRA, LUIZ ANTONIO - **(*presenter)**[CEPEL] - BRA
OJEDA SOTO, JAVIER RUBEN - [CEPEL] - BRA

Title: **Lagrangian Relaxation in Optimal Power Flow Problem applied to Large Electrical Systems**
Topic: **Electrical Systems**
Type: **ORAL**

Abstract:
The Optimal Power Flow (OPF) is a large nonlinear programming problem with hundreds to thousands of variables and nonlinear constraints. It was defined in the 1960s by Carpentier. Since then various solution methods have been proposed to address them: The method of Dommel-Tinney based on Reduced Gradient, the method of Abadie-Carpentier based on Gradient Reduced Generalized (GRG), the injections Differential method proposed by Carpentier and the method of Augmented Lagrangian designed proposed by Burchett, based on Quadratic Programming. Successive Linear Programming techniques were also applied to the OPF problem. Finally, due to the good performance of the interior point method in large linear programming and in Quadratic and Convex Programming motivated its application to the OPF. The program FLUPOT owned by CEPEL. The implementation of FLUPOT is based on Primal Dual Interior Point Method. Currently, FLUPOT program has been used with good results for the solution of large electrical systems as is the case of the Brazilian Electric System. The algorithm implemented to solve the OPF problem has performed very robust numerically. In most cases, the solution provides FLUPOT few iterations. However in cases in which the electrical system has stress conditions, and the program can't provide a satisfactory solution, this is the case as hasn't converged. If not converged, the FLUPOT program exceeded the maximum number of iterations. Generally, when the case is being studied by FLUPOT is not convergent dual variables of the OPF, also called Lagrange Multipliers, signal the critical variables of the problem. These multipliers have high values and a strategy for finding a solution can be made affecting a relaxation of these critical variables. This technique is known as Lagrangian Relaxation and has been implemented in FLUPOT program. This methodology ends with a report with the new limits of the variables that were relaxed. Computational tests with large electrical systems are presented and discussed.

Authors:
ALVES DE OLIVEIRA, LUIZ ANTONIO - **(*presenter)**[CEPEL] - BRA
OJEDA SOTO, JAVIER RUBEN - [CEPEL] - BRA

Title: **A MULTI-OBJECTIVE IMMUNE ALGORITHM FOR PLACEMENT OF CAPACITORS IN A SYSTEM WITH NONLINEAR LOADS**
Topic: **Electrical Systems**
Type: **ORAL**
Abstract:
The rising increase usage of industrial nonlinear loads has brought a few major drawbacks to electrical distribution systems such as harmonics and rapid change of reactive power requirements. Harmonics may disrupt normal operation of other devices and increase operating costs. Besides that, reactive compensation in distribution networks is another typical problem of great technical and economic importance which has been faced over five decades. The allocation of capacitors in electrical distribution network with nonlinear loads must be carefully evaluated because series or parallel resonances caused by the distribution line inductances and the capacitors can amplify the current harmonics. The resonance amplification may destroy the capacitor and neighboring power equipment. Hence, the consideration in designing the capacitor banks is not only the power factor compensation but also the overrating caused by harmonic pollution. Another important question in distribution systems is to provide electric power with specified voltage in all time for all customers. The voltage profile constraint is defined by regulatory agency and the electric utility is obliged to comply with it. The selection of the number, type, size and location of the capacitors depends on factors such as harmonic distortion, voltage regulation, power factor, power and energy losses and investment costs. The solution of this problem is considered a very difficult task because it is a combinatorial constrained problem described by a nonlinear and nondifferential objective function. In this paper, a multi-objective algorithm is proposed for the placement of capacitor banks in order to support the decision maker during the planning of the distribution system. A constrained Multi-objective Immune Algorithm is used. Investments costs, power and energy losses costs and harmonic mitigation are considered in the solution. The main contributions of this work are as follows:
• Developing a general algorithm for placement of capacitor banks applied for any feeder of an electrical distribution network, where all buses in the feeder are potential candidates for allocation and the number of capacitor banks used in the solution is defined by the decision maker;
• Pareto-optimal solutions are obtained based on three criteria: investments costs, power and energy losses costs and harmonic mitigation;
• Pareto-optimal solutions are obtained based on voltage profile constraints;
• A constrained multi-objective immune algorithm is used to solving the placement problem.

Authors:
Alves, Helton - (*presenter)[Instituto Federal do Maranhão] - BRA

Title: **Parameter Optimization of a Lead-Acid Battery Model**
Topic: **Electrical Systems**
Type: **POSTER**

Abstract:
There are critical systems where it is not tolerated failures in the power supply, such as hospitals and banks. The disturbances in the available energy has serious economic impact, and in some cases, can affect human safety. Thus, to meet the requirement for reliability for those power supply systems, battery banks are used. These devices are used when there is a need to meet consumption during failures of the main power grid.
The normal operation of battery based on energy supply systems involves multiple charge and discharge cycles. The problem of use of battery banks is the need to periodically evaluate its SOC (state of charge) in order to check that it will meet the energy requirements in case of a failure. Since the measurement of SOC is generally not directly available, there is a need to use estimation techniques, generally based on the electrical characteristics of the batteries. These battery models can be employed to predict its behavior under various charging and discharging conditions, and it enables the analysis of its behavior under various design specifications.
It is analyzed a lead-acid battery model for SOC and voltage estimation that can represent up to four types of batteries: lead-acid, NiMH, NiCD and Li-Ion. The chosen model can be used both for charging and discharging. Another important feature of the chosen model is the simplicity with which the dynamic model parameters are extracted. Only three points on discharge curve are required to obtain the parameters. Only the first point is fixed, the initial voltage of a fully charged battery. The other two points are arbitrary chosen by the designer, being the accuracy of the model subject to these choices.

This work aims to define two remaining points in the discharge curve. Both the model and the estimation algorithm are evaluated. The second point is based on the derivative of voltage. The definition of the third point, which causes most difference in the final result, is chosen to minimize an objective function based on the least squares error. The study is based on seven scenarios with different charge and discharge currents within the range 1.85A to 13.1A. With these current levels, SOC varies from 30% to 100% in validation data.
The computer efficiency of the estimation technique is compared to that obtained using an iterative method of nonlinear optimization IMNO. For a specified hardware, the computation of the IMNO method requires 20.41 seconds, while the proposed method, 0.021 seconds. This comparison takes into account that the error obtained with both methods are in the same range.

Authors:
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Lima, Antonio - [Universidade Federal de Campina Grande] - BRA

Title: **Battery Test System with Regenerating Capability**
Topic: **Electrical Systems**
Type: **POSTER**

Abstract:
One of the reasons why the study of the development of batteries is increasingly important is because the electronics scalability, as well as the automation levels, which requires electronic circuits to be operated in remote conditions that does not provide a connection to power grids. However, the battery technologies have difficulties in following the electronics development, becoming a critical element in the system integration.
Between the most critical metrics for choosing the appropriate battery for a specific project, it is the lifetime and capability, where a strong relation exist between the two. However, the estimation of these coefficients is not trivial, once the existing mathematical models are developed for specific technologies and charging/discharging profiles. The international standard IEC 61427 from 2005 specify a series of tests that can be performed on lead-acid batteries. However, the laboratory experiments can take months, conducting charge and discharge procedures.
Looking for an automated solution, this paper propose a battery test system that can perform the presented tests without human intervention. This allows a high number of cycles to be performed, with detailed specifications and specifics current/voltage profiles. Such platform enables the reduction of human resources, as well as the reduction of human errors.
For energy conversion, it is used an active front-end converter in series with a DC-DC converter with a LCL coupling, which operates with bidirectional capability. The LCL coupling provides an efficient way of reducing the ripple effect for a step-down conversion with high ratio, allowing the active-front end to operate with a DC bus voltage higher than the grid voltage, and consequently, allowing a high power factor operation. The control algorithm of the active front-end employs a synchronous reference frame, where the signals are transformed employing the angles estimation from a phase-looked loop. The DC-DC converter employs a mixed voltage/current control based on the operating point of the battery. The digital control of the static converter is implemented on a digital signal processor with real time communication for command and data logging.
A controlled hydrothermal tank, in association with controlled voltage source inverts are used for temperature control. The control employs a hysteresis rule, using a FieldLogger device for tracking of defined references. All the references and data logging are carried out using an x86-64 computer, with the main procedures of the test programmed. The supervisor computer is used for remote verification and control of the test. Experimental results are presented for the current platform, using commercial lead-acid batteries.

Authors:
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Title: **Remote Switches Placement in Electrical Power Systems using SPEA-2**
Topic: **Electrical Systems**
Type: **ORAL**

Abstract:
The allocation of distribution switches can improve the reliability of the electricity distribution system, by reducing the outage time, which reduces the energy not supplied to costumers unaffected by a system fault. In the allocation process is necessary to indicate sections of the feeder, type of each switch used as manual or remote controlled switch. Furthermore switch allocation has a cost and investment cost varies with the allocated group devices quantity and automation. So in a budget constraints scenario, it is necessary to find a balance between the investment cost and reliability, better suited to the system reality. Thus, in order to develop a tool to assist in planning and decision making on the switch allocation was developed, in this paper, an algorithm to assist in quantity and site and determine the use of section and tie switches and remote and manual controlled switches in the Distribution System. This is a Multi-Objective Algorithm based on Strength Pareto Evolutionary Algorithm 2, it considers as decision factors the system average interruption duration index and cost involved. It is discussed the increasing automation of the network, the need for optimization and described the whole formulation needed to solve the problem, including energy not supplied. The tool's application results were simulated in a real radial distribution system with 103 sections from northeast of Brazil. The results of the 60 simulations were evaluated by algorithm metrics and summarized in a table. Algorithm reached between 6 and 18 non-dominated solutions. This table also shows the average space between the solutions, what demonstrates a good distribution between solutions. Moreover, it is presented the Pareto Front graphic that shows the decreasing of the interruption duration to less than 3hours and 53 min and the cost to less than 1,73 million $. Therefore the tool has demonstrated effectiveness in obtaining a set of solutions to placement of switch devices in electrical power distribution systems.

Authors:
Alves, Helton - **(*presenter)**[Instituto Federal do Maranhão] - BRA
Sousa, Railson - [IFMA] - BRA

Title: **Applying Robust Optimization to Unit Commitment**
Topic: **Electrical Systems**
Type: **POSTER**

Abstract:
The optimal generation scheduling is an important daily activity for electric power generation companies. The unit commitment problem determines the combination of generating units and scheduling their respective outputs to satisfy the forecasted demand with the minimum total production cost under the operating constraints enforced by the system for a specified period that usually varies from 24 hours to one week. The short-term unit commitment problem is a large-scale, mixed-integer nonlinear program, which is difficult so solve efficiently, especially for large-scale instances. Recently, the ever increasing capacity for renewable generation has strongly increased the level of uncertainty in the system, making the ideal unit commitment model a large-scale, non-convex, uncertain program. Robust Optimization deals with uncertainties to the area of energy systems. This paper presents an application of robust optimization to solve the unit commitment problem under wind power forecasting uncertainty.

Authors:
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Title: **Energy consumption optimization for rotation control of a parametric pendulum with variable length**
Topic: **Energy Generation and Transmission**
Type: **ORAL**

Abstract:
In recent years, there has been a growing interest in energy harvesting from the parametrically excited pendulum, based on the high energy of its rotational motion. Two sources are mainly considered: vibrating machines and the motion of the sea waves. In both cases, rotations can be achieved only for some forcing conditions and initial conditions. Since stable rotations are required to extract energy, the pendulum needs to be controlled. One of the possible control actions corresponds to a telescopic adjustment of the pendulum length, which can be performed by a hydraulic or pneumatic actuator. The control consists in giving the pendulum and aid to reach (and maintain) rotations, accelerating the motion by modifying conveniently the position of the bob. Since the pendulum harvester is supposed to be autonomous, the control system must take power from the generation. Consequently, the energy required for the control action must be the least possible in order to make the technology viable.
We address in this article the minimization of the energy spent by the rotation control system. This implies that the work done by the actuator during the control action must be minimal, being of course mandatory the reaching of a rotational motion. Three parameters are considered in the optimization analysis. One is the threshold angular velocity of the pendulum, above which the pendulum is supposed to be rotating and thus no control action is needed. Hence, a low threshold velocity is desired in order to reduce the control action. But an excessively low threshold velocity may not be enough to reach rotations. The other two parameters are steepness factors involved in the transition of the telescopic adjustment. This transition must be steep in order to adequately reach rotations. But high steepness requires high velocities and accelerations of the actuator, which lead to an increased energy consumption.
The control parameters which minimize the energy consumption are obtained for different forcing scenarios. Then a technique for the selection of these parameters is proposed and discussed with a view of energy harvesting from pendulum systems.

Authors:
Dotti, Franco - **(*presenter)**[UTN-FRBB / CONICET] - ARG
Reguera, Florencia - [UNS / CONICET] - ARG

Title: **Designing hybrid energy systems for buildings**
Topic: **Energy Generation and Transmission**
Type: **ORAL**

Abstract:
Climate change, the finiteness of fossil fuel, the unreliability of renewable energies, technological progress and political requirements lead to the constant need to rethink the energy supply. In this talk we focus on the design of the energy supply when planning new buildings like storehouses or office buildings.
For the components of a building's energy supply we have to select the types of energy production (solar power, heat pumps, fuel-based generators, wind turbines, geothermal energy, power grids, and so on), the energy buffers (batteries, heat stores), the capacity or rated power of the components and the actual devices. The choice should satisfy the conflicting objectives low investments, low operating cost, low CO2 emissions and minimal risk of shortcomings in covering the demand.
To obtain a sufficiently precise estimation of the operating cost and CO2 emissions, we simulate the load of the components during one or several years. We assume that the energy demand is known or authoritatively estimated for each hour or quarter of an hour of a year. For each such time step we have to solve the problem of controlling the components to satisfy the current demand based on the controls' state and a prediction of the future demand.
We present a mathematical model and solution approach for the component control problem as well as the superordinate component selection problem.

Authors:
Maag, Volker - (*presenter)[Fraunhofer ITWM] - DEU

Title: **A suitable programming paradigm for optimizing short-term hydrothermal generation scheduling**
Topic: **Energy Generation and Transmission**
Type: **ORAL**
Abstract:
Short-term generation scheduling is the optimization process through which the levels of generation are set for each of the units of an electric power system for the next or the next few days in order to obtain a safe and low-cost operation. This work describes the development of software for short-term generation scheduling in hydrothermal systems and shows its implementation on the Chilean Central Interconnected System. The software was implemented considering an object-oriented programming paradigm in the Python language.
The mathematical optimization problem is formulated using Mixed-Integer Linear Programming (MILP) and solved with the optimization solver GUROBI through a combination of the Branch-and-bound algorithm and heuristics. The formulation considers a wide range of constraints, among them system constraints, transmission constraints, cascading hydro constraints, security constraints, and a number of technical constraints of both thermal and hydro generation units (e.g. startup exponential curves, convex and non-convex cost curves, ramp-rate limits, and up and down-times, among others).
The short-term generation scheduling tool implementation is illustrated for Chile's largest interconnected system, serving nearly 92.2% of the country's population and from North to South covering a span of 2200 kilometers. As of 2015, it has 158 generating plants (72 of them hydro), 890 buses above 12 kV, and 7 storages, several of them in cascading hydro schemes. The mathematical program for a week with hourly steps considers approximately 770000 variables (20000 of them binary) and 250000 constraints, so formulating and solving it can be quite challenging and take considerable time. Therefore, the adoption of an object oriented programming paradigm can help simplify significantly the mathematical program formulation and the processing of results.
Object-oriented programming offers a number of advantages for the formulation of optimization problems, as its methods or functions make code more maintainable and identifying the source of errors becomes easier because objects are self-contained. This research shows how to efficiently use an Object-Oriented Paradigm to build a short-term generation scheduling problem defining classes (i.e. Central Class, Bus Class, Transmission Lines Class), subclasses using the concept of inheritance (i.e. Thermal SubClass, Hydro SubClass), and how to interact with these classes to generate the objective function and the set of constraints. Since objects contain both data and functions that act on data, objects can be thought of as self-contained modules. This makes it easy to reuse code for other power systems and also allows us to store objects created in one class from another class (i.e. a set of hydro units connected to an object that belongs to the Bus Class). This kind of paradigm also provides with all the information needed to replace the object without affecting others, making easy to replace old and inefficient code with faster algorithms.

Authors:
Gil, Esteban - **(*presenter)**[Universidad Técnica Federico Santa María] - CHL
Soto-Ruiz, Christian - [Universidad Técnica Federico Santa María] - CHL

Title: **Optimal management policies for the economic optimal dispatch of a hydrothermal power grid**
Topic: **Energy Generation and Transmission**
Type: **POSTER**
Abstract:
This work focuses on the economic optimization of the short-term (three day time horizon) hydrothermal dispatch problem, while analyzing different scenarios regarding the rivers inflow (increasing/decreasing) and the water usage policy at the reservoirs (using versus storing). Here, five different circumstances are considered for the variation of the river flow rate during the second day: constant steady flow, 1% and 2% per hour increases, and 1% and 2% per hour decreases. Meanwhile, every possible alternative is analyzed when it is decided to store or use the water available at every location.
The proposed model for the power grid includes the demand profile at each node and transport capacity between them, the design and operating characteristics of the hydric and thermal power plants, as well as the economic evaluation of each mayor part of the system. The resultant set of equations constitutes a mixed integer non-linear programming (MINLP) model, and is implemented in the optimization software GAMS.
The solutions here obtained represent economic optimal profiles with minimum operating costs for the hydrothermal dispatch of the power grid, and details the advised values for every practical interest variable, including the generation, transport and demand stages (effectively delivered power/energy at each plant, water volume stored/used in every dam, energy transported between nodes, among others).
It is then concluded that the operating costs, and therefore the electricity one, increases as the river flow rate decreases, as result of a lower generation capacity for the hydric generation, which needs to be fulfilled by thermal one. Moreover, a policy that allows water usage at the reservoirs derives in a larger availability of this resource, which in turn implies lower operating expenditures.
On the other hand, some scenarios originate infeasible conditions for the operation of the system, for example if storing water is required as the river inflow experiences a steep decrease over time. These cases represent real world situations where a well-planned water management policy needs to be defined and promptly implemented.
In every case study, the minimum operating cost for the whole system is achieved as more hydric energy is delivered and a lower number of thermal plants are dispatched. Therefore, the comprehensive analysis of the behavior of the system here presented could become a key tool for decision makers, since policies implemented in the day-to-day operation will also impact the future sustainability of the system.

Authors:
Godoy, Ezequiel - **(*presenter)**[Universidad Tecnológica Nacional] - ARG
Scenna, Nicolás - [Universidad Tecnológica Nacional] - ARG
D'Emanuele Ares, Carolina - [Universidad Tecnológica Nacional] - ARG

Title: **An efficient design optimization of anisotropic cylinders using evolutionary algorithims**
Topic: **Evolutionary Techniques**
Type: **ORAL**
Abstract:
The present study demonstrates major achievements in recent years in an application of evolutionary algorithms to the design optimization of fibre-reinforced laminated composite structures. Using an anisotropic laminated cylindrical shell and an exact elasticity solution as an example, we show how the optimum or near-optimum solution can be found in a more efficient way. As an example we consider the critical pressure, both internal and external, in a laminated anisotropic thick cylinder. The objective function is non-linear and very complex,and in particular, occupies about 700 lines of the computer code. Our aim is to show that the above problem can be analysed efficiently even in the case of 40 design parameters, which gives a very large number of different combinations.

First we employ the genetic algorithm (GA) which has excellent, fast and efficient performance for a few design parameters. However, its performance changes with the increase in the number of design parameters to 10 and 20. The length of the chromosome becomes too long to efficiently exchange the genetic material and, as the number of parameters increases beyond 20, the genetic algorithm becomes inefficient and can hardly produce an acceptable accuracy.

Next, the particle swarm optimization (PSO) technique is used. The main advantages of PSO over the GA is its much better ability of handling multidimensional spaces and, of course, simplicity. Despite the sensitivity of the algorithm to the control parameters, the result proves to be outstanding. In our case, instead of a couple hours, the same problem can be solved within a couple of minutes. Moreover, the results obtained are even better than those obtained with GA.

The Big Bang - Big Crunch optimization method relies on one of the evolution theories of the universe, namely the Big Bang - Big Crunch theory. In the Big Bang phase the population of feature vectors randomly fills the space, while in the Big Crunch phase these points are drawn into a dense cluster with the centre of gravity being the optimum solution of the optimization problem.
The performance of the algorithm is amazing, even in the most complex case of a 40-D problem, the near-optimum solution is already achieved after a couple of minutes. The amazing property of this algorithm is that its convergence rate is practically independent of the number of design parameters, obviously, the function time calculation will slow down with the high number of parameters.

Hence, we use the three techniques to demonstrate how progress in modern evolutionary algorithms has revolutionized the design optimization of composite structures. Even more recently such problems presented a formidable task.

Authors:
Tabakov, Pavel - **(*presenter)**[Durban University of Technology] - ZAF
MOYO, SIBUSISO - [Durban University of Technology] - ZAF

Title: **COMPUTER VISION AND FEATURE SELECTION WITH BBIL FOR RECOGNITION OF AGRICULTURAL MANAGEMENT ZONES**
Topic: **Evolutionary Techniques**
Type: **POSTER**
Abstract:
The Precision Agriculture (PA) proposes the practice of agriculture in a precision way in response to statistical analysis of georeferenced data over time. The PA can be applied to any production systems which present variability in space and time and one of its main goals is to increase productivity. Besides soil georeferenced analysis, several other applications have emerged, highlighting the techniques of Computer Vision (CV). The CV is a branch of computer science that deals with systems for acquisition, processing, analysis and interpretation of multi-dimensional image data through computers. Examples of applications include recognition, reconstruction and classification of images. Feature Selection (FS) is the process of identifying and separating the most relevant features of a dataset to obtain the best solutions for an image classification problem. The main benefits of FS include more accurate classification models, simplified interpretation of models and a reduction in the processing time required for classification. One of the main approaches used in FS is the wrapper. In this approach features are selected based on an evaluation performed by a classification algorithm. This paper proposes a new wrapper that combines two evolutionary techniques: the Population-Based Incremental Learning (PBIL) and the Cultural Algorithms. The wrapper, which is referred to here as Belief-Based Incremental Learning (BBIL), is applied to a dataset of images in order to be used to CV. The aim of this paper is to evaluate the performance of the proposed wrapper in recognition of productivity images of a smallholding. The images were generated by interpolation of data from georeferenced samples obtained over 24 years (1985-2008). The wrapper classifies images by five-year periods, while identifying management zones (which feature corresponds to a pixel in black and white images with a 10x10 resolution) with better or worse potential to influence this classification. The paper analyzes and discusses the advantages and disadvantages of the proposed technique in terms of accuracy, number of features selected and computational cost. The classifiers were the well-known Logistic Regression, Naïve Bayes e Linear Discriminant Analysis, both applied with 10-fold cross validation and bootstrap. The results were satisfactory for all of the classifiers with both validation methods and showed that, despite a relatively high computational cost, the BBIL algorithm achieved the best results in terms of accuracy and also selects subsets with a small number of features. It is expected that the proposed solution assists the farmers in their decision making based in the soil behavior over time and space.

Authors:
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THOM DE SOUZA, RODRIGO CLEMENTE - [UNIVERSIDADE FEDERAL DO PARANÁ - UFPR] - BRA
Guedes Filho, Osvaldo - [Universidade Federal do Paraná] - BRA

Title: **Evolutionary and local search based hybrid optimization model to solve facility layout problem of unequal compartments**
Topic: **Evolutionary Techniques**
Type: **ORAL**
Abstract:
A facility layout design is one of the most commonly faced problems in the manufacturing sectors. The problem is mixed-integer in nature and usually an NP-hard problem. Due to mixed-integer nature of the problem, it is difficult to solve the problem using classical optimization techniques. However, classical optimization techniques are better for local search. To overcome these limitations, this paper proposed a new evolutionary and classical algorithm based hybrid optimization method for solving static facility layout problems with the unequal size of compartments.
In this paper for solving a facility layout problem in the defined population based optimization model, the solutions of the facility are represented in the form of coordinates, i.e. taking all the reference points as the lower left corner for each compartment in a vector. Here, the objective function of the problem is non-linear in which the sum of the material handling cost has been minimized. Apart from the conventional evolutionary operators, i.e. selection, crossover, mutation and elitism, this paper has also used exchange, rotation and interchange operators. Initially a random set of layout solutions are generated in the population and these solutions may have compartments intersecting with each other. To overcome this intersection between compartments a gradient based local optimization technique is fused with the defined algorithm taking the intersection area as the constraints. This local search technique also helps to finds the local optimal solution of the individuals. After, the population has to pass through the evolutionary operators. In the exchange operator, any two random layout solutions from the population will exchange the location of the compartments from an exchange site with each other. This operation is similar to the binary crossover in genetic algorithm. The rotation operator is used to orient some random compartments with in a solution of the facility in the population. Here the dimensions of the compartment are interchanged keeping the center point of the compartment as same. The rotation operator is also used to avoid mixed-integer formulation of the problem. Use of rotation operator has also reduced the number of variables significantly. After the above two operations there may be intersection between the compartments in the solution. So, again the local search technique is introduced at this stage to reduce the intersection and find the local optimal. These operators will help in creating new individuals which are superior and inferior to the previous population. Here, the elitism operator helps in preserving the best individuals to take part in the next interaction. Now this iteration are continued till the termination criteria is reached.
The performance of the model is tested over a previously solved problems selected from the literature. The evaluation of the results shows that the performance of the proposed model is better than many existing algorithms and has the potential for field applications.

Authors:
Hasda, Ranjan Kumar - **(*presenter)**[Ecole Centrale de Nantes] - FRA
Bhattacharjya, Rajib Kumar - [Indian Institute of Technology, Guwahati] - IND
Bennis, Fouad - [Ecole Centrale de Nantes] - FRA

Title: **1- Evolutionary algorithm and sensitivity analysis comparison applied to axial flow turbine**
Topic: **Evolutionary Techniques**
Type: **ORAL**
Abstract:
Essentially, evolutionary algorithms are powerful to handle multiobjective design optimization problems. In turn, especially for turbomachinery designs, there are many conflicts parameters that should be managed in order to achieve high performance engine. The present work demonstrates a comparison between two evolutionary algorithms applied to axial flow, as well as the sensitivity analysis and shows the feasibility of the present method and also provides a multiobjective optimization of an axial turbine design. The simulation was carried out to maximize the overall isentropic efficiency and the total pressure ratio drop. The design variables, constraints and objective functions are analyzed and discussed in the present work, as well as the optimization process coupled to design phase. The results present the relevant parameters used during the turbomachinery optimization process.

Authors:
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Title: **Optimized representation of overlapped welded joints using shell FE and the structural stress method**
Topic: **Finite Elements Method**
Type: **ORAL**
Abstract:
The structural stress method is widely applied to fatigue analysis of welded components. The literature contains several modeling techniques capable of representing such structures. However, these techniques can only approximate the stiffness of the structure. The scope of the present work is to propose an optimization-based modeling technique to represent overlapped welded components (lap joints).
This technique employs optimum parameters in order to reproduce the stiffness of the real structure without any significant errors. The design variable is defined as the thickness of the shell finite element representing the weld fillet. Linear programming is employed to solve the optimization problem. The objective function is defined as the residual error of the first natural frequencies obtained by a shell finite element model compared with the ones obtained by a solid model.
This kind of modeling technique could be directly applied to large/complex problems, where global/local analysis are performed for structural integrity verification and fatigue life simulation. Once, this optimized modeling technique is used, global/local analysis are no longer needed and a single shell FE model can be applied for all the structural analysis.
After proposing an optimization-based modeling technique, its result with respect to the structural stress are compared with the ones obtained with other methodologies presented in the literature and the standards. Results concerning errors when representing the structure total mass and first natural frequencies are presented.

Authors:
Echer, Leonel - **(*presenter)**[UFRGS] - BRA
José Marczak, Rogério - [Universidade Federal do Rio Grande do Sul] - BRA

Title: **Variable volume heart blood flow simulations made easy with automatic grid generation**
Topic: **Fluid Mechanics**
Type: **ORAL**
Abstract:
The fluid flow analysis of the CFD simulated blood flow in the leaving heart is made possible by using the advance visualization techniques, which enables the doctor to diagnose more precisely the heart diseases of the patient under treatment.
This is especially appropriate for the heart diseases, which require surgical operation, thus enabling the surgeon to develop the operation plan for the very specific patient. This is expected to remove the errors coming from the doctor subjective experience, by taking into account the very exact and specific patient data. Before operation, the surgeon requires, not only to see the behavior of the heart blood flow, but also to understand how the heart will behave after the operation is completed. And in such way, the risks of the patient in undertaking such operation are reduced. The analysis of the real heart blood flow before operation enables the surgeon to select the most appropriate operation steps between the alternatives he has, and thus make the correct decision about the specific operation steps he will perform.
In this paper 2 numerical simulations for the real heart geometry have been performed (1) CFD was performed with the FlowVision code and (2) FEM with Abaqus code, and their results have been discussed and compared. The first approach is based on getting the real heart geometry from the MRI/MRT scans and the second one is simulating the whole heart behavior in the frame of the Leaving Heart Project. Both approaches allow getting a more realistic blood flow conditions, as taking into account the heart geometry of the real patient under treatment.

Authors:
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Aksenov, Andrey - [TESIS] - RUS
Luniewski, Tomasz - [Capvidia] - BEL
Zietak, Wojtek - [Capvidia] - BEL

Title: **An efficient approach for optimization of physical modeling of wave-induced phenomena**
Topic: **Fluid Mechanics**
Type: **ORAL**
Abstract:
A natural consequence of the progress achieving in coastal and offshore engineering is an increasing number of hydraulic laboratories which are indispensible to conduct physical modeling of wave-induced phenomena or current-affected processes. The development of new facilities and modern laboratory equipments is necessary for the prediction of physical processes vital for a sustainable development of coastal and offshore areas or for conducting fundamental research. The problem is that physical modeling is an expensive and time consuming process. Especially expensive and time consuming are novel type of laboratory experiments of significant importance for studies on clime changes recently conducted by the team of researchers from the Institute of Hydroengineering, Polish Academy of Sciences, Gdansk. Multidisciplinary investigations on the hydrodynamic effects on permafrost degradation and changes of shoreline in the arctic areas require time consuming and very expensive serious of preparatory works and experiments in a wave flume or a wave basin. An attractive alternative for time consuming and very expensive investigations related with tedious preparatory and conceptual works and preliminary experiments is a very accurate semi-analytical model developed to describe wave-induced phenomena or current-induced processes with high accuracy. The model enables us to optimize laboratory experiments and to speed up investigation processes many times. This efficient approach enables us to examine a variety of cases and scenarios at a very low cost.

KEYWORDS: efficient technique, optimization, nonlinear waves, wave-induced phenomena

ACKNOWLEDGEMENTS
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Authors:
Sulisz, Wojciech - **(*presenter)**[Polish Academy of Sciences] - POL

Title: **Thrust Optimization in Cephalopod Locomotion**
Topic: **Fluid Mechanics**
Type: **ORAL**

Abstract:
Cephalopods including jellyfish and squid are know for jet and vortex propulsion. There is a significant body of evidence pointing to thrust optimization in their locomotion. In this study we present a detailed study of jellyfish locomotion and directly simulate the flow hydrodynamic around two different type of jellyfish and calculate the thrust and locomotion efficiency in each case. A model for this jet propulsion is offered where a formation number dictate the optimal stroke ratio for maximal thrust generation. The model identifies two parameters that control the formation number. These are the acceleration/deceleration of the generating shear layer and the shear diameter during the vortex formation. Based on this knowledge we also present a design of vortex ring thrusters (VRTs) for underwater locomotion. VRTs are fabricated and installed on several generation of autonomous underwater vehicles empowering them with unique maneuvering cababilities. Result of operation of such an autonomous underwater vehicle in an automated docking procedure will be presented.

Authors:
Mohseni, Kamran - **(*presenter)**[University of Florida] - USA

Title: **Cluster validity analysis in evolving fuzzy clustering algorithms**
Topic: **Fuzzy Optimization**
Type: **POSTER**
Abstract:
Fuzzy clusters are structures that represents the data's degree of pertinence in function of its distance from the data groups that have some similarity. This structures are widely used to infer fuzzy rules from the data, which is necessary when the system's complexity exceeds the capability of the human expert to infer a sufficient number of rules that describes the cluster's influence in the output of the system. From this premise, in the context of training a clustering algorithm, each sample's pertinence to a cluster, and the associated output are a pair of characteristic, so the functions that can be estimated from these pairs are rules that describes the influence of that particular cluster on the system's output.
Among the algorithms used to obtain fuzzy cluster, the evolving algorithms has gained notoriety due to its learning capacity and performance in on-line applications. This paper intends to do a further analysis on the performance of evolving algorithms in comparison to other classical approaches using modern metrics to validate clusters, other than those that were applied to validate the results at the time they were published. These modern metrics have shown better precision in estimate how well the clustering algorithm can make consistent clusters, without being affected by variations solely due to change in the parameters, as occurs with indices like partition coefficient, classification entropy and proportion exponent.

Authors:
Carvalho Vieira, Libanio - **(*presenter)**[IFMA] - BRA
Donato Rocha Filho, Orlando - [IFMA] - BRA

Title: **A possibilistic model for tactical planning of a manufacturing company with demand uncertainty**
Topic: **Fuzzy Optimization**
Type: **ORAL**

Abstract:
This work presents a robust possibilistic model for the optimal planning of a manufacturing company where demand uncertainties are modeled using fuzzy set theory. For this case, fuzzy sets used to describe human behavior are adapted to formulate the constraints quantitatively and adapt the problem to the needs of the modeler. The motivations for this work are focused in the requirements of the industries to consider situations when the data are not precise or there are some facts that give vagueness in their operation; some of them can be internal such as failures in the equipments or labor absenteeism, or external, like price fluctuations of the raw materials, delays in materials provision, uncertainties in the markets demands. To overcome those circumstances it is a frequent practice generate a mathematical program to optimize the operations of the manufacturing plant in order to minimize the economical impact of changes in the functional parameters.
The study case corresponds to a manufacturing company having two productive sites. In the first plant are made all final products in order to be sold in the markets and also in this one is manufactured an intermediate product for the second plant. In this second facility only final products are made. The model generated is a multiproduct multiperiod one having a horizon time of one year to make operational tactical decisions. The decision variables of the model are the number of units per period to be produced according to the demand, the unsatisfied demand (if there is one) the units transferred from one site to the other. The objective function minimizes fixed and variable costs of: production, inventory and transport, and also penalizes the risk of having product scarcity below a safety stock and the loss of sales. As was mentioned previously the demand vagueness is modeled using fuzzy sets whose characteristics are deduced from market studies and experts in the area. The proposed model is an alternative formulation for imprecise data which penalizes the constraint violations of the uncertain parameter and gives, as a result, a unique tactical plan of the manufacturing company activities feasible for whole range of demand, having robust optimality in the sense that the minimum cost is optimal or close to optimal for all possible demand values.

Authors:
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Title: **A Multiobjective Evolutionary Algorithm for Heat Exchanger Optimization**
Topic: **Genetic Algorithms**
Type: **ORAL**
Abstract:
Heat exchangers are very important devices being applied in various areas of engineering. They are widely used in nuclear power plants and even in household appliances such as refrigerators, computers and air conditioners.

A good performance in a heat exchanger is highly desirable since maintaining security in cases such as plants and preserves the lifetime of the device. This prevents them to overheat and lose their efficiency or even stop working. Thus, the search for optimal configuration of a heat exchanger becomes an important practice in the process of its manufacture.

Thus, it is intended in this paper to present the results of computer simulations aimed at optimizing a heat exchanger. To this end, Abaqus computing platforms are integrated in the Python programming language, to the solution of heat conduction problem using the Navier Stokes equations and a genetic algorithm to deal with the optimization problem.

Sometimes, it may be interesting to improve several intuitive configurations involving the heat sources in a channel in order increasing the temperature and diminishing the pressure. Also, it is possible to search for the optimum number of sources to find this objectives independently considering monoobjective optimization problems. On the other hand, the both objectives can be considered into a multiobjective problem.

This paper presents numerical experiments considering mono-objective as weel as multi-objective optimization problems in a heat transfer exchanger where the design variables are the positions and number of source so as to maximize the temperature and minimize the lost of pressure between the inlet and outlet of the heat exchanger.

Authors:
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Hallak, Patricia - [Universidade Federal de Juiz de Fora] - BRA
Bernardino, Heder - [Universidade Federal de Juiz de Fora] - BRA

Title: **Bioremediation of oil-polluted marine zones: Weak and strong control of the discharge of substances**
Topic: **Geophysics**
Type: **ORAL**
Abstract:
Oil is comprised of many different toxic compounds which endanger the marine environment involved in a spill. Therefore, the design of new strategies which can help to restore already oil-polluted zones is of vital importance. One strategy is based on the use of microorganisms to clean up oil-polluted shorelines (bioremediation). For example, by the addition of nutrients which accelerate the consumption of oil by indigenous hydrocarbon degrading microorganisms (biostimulation).
In this work, we formulate an optimal bioremediation strategy considering that oil is stranded on a rocky or inaccessible shoreline. Thus, the sea currents can be used to deliver nutrients to the contaminated zones instead of releasing them directly on the site. In this case, the key for achieving a fruitful biostimulation is obtaining a critical concentration of nutrients needed for maximum growth of microorganisms, and keeping this concentration as long as possible. The strategy is considered as optimal if it minimizes the mass of nutrient introduced into the aquatic system, i.e., if it minimizes the cost of biostimulation and its impact on the environment.
An initial boundary-value problem for the advection-diffusion equation and its adjoint problem are considered to model, estimate and control the dispersion of nutrient in a limited region. It is shown that the advection-diffusion problem is well posed, and its solution satisfies the mass balance equation. In the oil-polluted zone, the mean concentration of nutrient is determined by means of an integral formula in which the adjoint model solution serves as a weight function. We consider two strategies (weak and strong control) to determine the optimal discharge parameters: the release point and discharge rate of nutrient.
In the weak control, a variational problem is considered. The objective is minimizing the mass function for a nutrient provided that the mean concentration of this substance is equal to a critical concentration during a finite interval of time. The analytical expression for the optimal rate of discharge of nutrient is given as a multiple of the solution of adjoint problem calculated for the oil-polluted zone. Through this expression, a nonlinear mass function is obtained whose minimum value determines the optimal discharge point.
In the strong control, the discharge rate is designed to maintain the critical mean concentration of nutrient in the zone since a suitable moment which depends on the sea currents, location of the polluted zone and discharge point. This formulation is an ill-posed problem. To find a regularized solution, we assume that the conditions of dispersion are stationary and use the steady solution of dispersion model as well as the generator of adjoint functions. The discharge rate is determined as a linear combination of Dirac functions, and the corresponding coefficients are calculated as the solution of a system of linear equations which is solved through a Tikhonov regularization. The optimal discharge point is obtained as in the weak control.
Numerical experiments demonstrate the effectiveness of the two strategies of bioremediation in a two-dimensional oil-polluted area.

Authors:
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Skiba, Yuri - [Centro de Ciencias de la Atmósfera, UNAM] - MEX

Title: **MULTIGLODS (global and local multiobjective optimization using direct search)**
Topic: **Global Optimization**
Type: **ORAL**
Abstract:
MULTIGLODS (global and local multiobjective optimization using direct search) is a well-established derivative-free optimization algorithm, based in directional direct search, which extends the concept of GLODS to multiobjective optimization. In GLODS, for single-objective directional direct search, a strategy was proposed aiming at identifying several local minimizers. In MULTIGLODS we attempt to identify global and local Pareto fronts.

A multi-objective optimization problem always involves two spaces: the feasible region (the variable space) and the objective function space. In the objective function space, the concept of Pareto dominance is used to compute approximations to Pareto fronts. But this concept is only applied locally, i.e., a point is only compared with its neighbors in the feasible region. At the end of the optimization process we can get multiple local Pareto fronts, from which the global Pareto front is easily computed.

MULTIGLODS alternates between a search step, where potentially good regions of the feasible region are located, and a poll step where the previously located regions are explored. This exploitation is made through the launching of several pattern search methods, one in each of the regions of interest. Differently from a multistart strategy, the several pattern search methods will merge when sufficiently close to each other.

We will describe the algorithmic structure considered, present the main associated theoretical results, and report related numerical experience.

Keywords
Derivative-free optimization, multiobjective optimization, global optimization, pattern search methods

Authors:
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Title: **A SELF-REGULATED FRETWIDTH HARMONY SEARCH ALGORITHM FOR PREDICTING FUGACITY AND ACTIVITY COEFFICIENTS IN BINARY MIXTURES**
Topic: **Global Optimization**
Type: **ORAL**
Abstract:
Knowing thermodynamic properties of mixtures and pure components is of paramount importance. Technical literature is prolific in reporting experimental data of properties such as activity and fugacity coefficients, as well as, of other physicochemical parameters. Binary mixtures are particularly interesting, not only for their wide industrial use, but also because they have been historically useful as models, with a relative facility for evaluating thermodynamic properties of a given component composition and nature. For over one and a half century correlations have been deduced and continuously improved, based on experimental data, and striving to extend their validity to multi-component mixtures. Likewise, as years have gone by and technology has improved, dependence on experimentation has diminished (though it has not been abandoned completely), motivated to improve the prediction capability of theoretical models, or, even, of realistic and flexible semi-empiric ones. Different components have been extensively studied at low and high pressures (including the critical region), mainly on binary mixtures. This list includes carbon dioxide, ethane, acetone, benzene, methanol, hexane, ethyl ether, and methyl acetate, amongst others. Throughout this work, we assume that binary mixtures are subject to near atmospheric pressure. Hence, it can be safely assumed that the properties of liquid phase are unaffected by pressure. However, this assumption does not apply to the gas phase, but its effect can be estimated with relative easiness. This article proposes the use of a novel variant of the HS algorithm (Harmony Search), that is, the SFHS (Self-regulated Fretwidth Harmony Search Algorithm) for calculating and predicting fugacity and activity coefficients in binary mixtures. Different previously reported systems were selected, at 25°C and 40°C, and at low and moderate pressure levels. Moreover, two solutes were selected: carbon dioxide and ethane. Different solvents, both polar and nonpolar, were selected with comparative purposes. Activity and fugacity coefficients were calculated using the Redlich-Kwong state equation and Lewis rule, along with the SFHS algorithm, assuming both solutes in vapor phase. Consistency of the activity coefficients was analyzed by the Redlich-Kister strategy. Results were very close to those found experimentally by other authors, and most of them did not differ in more than one percentage unit. It was demonstrated that fugacity and activity coefficients can be obtained via the SFHS algorithm. By comparing our data against previously reported experimental results for different binary systems, we observed that our results are accurate within the error margin. Hence, the proposed computational strategy is valid and it can be easily implemented. Similarly, the values of activity coefficients were consistent, as was confirmed using the Redlich-Kister approach, for the two randomly selected examples.

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Title: **CONTROL OF HEAT FLUX USING COMPUTATIONALLY DESIGNED METAMATERIALS**
Topic: **Heat and Mass Transfer**
Type: **ORAL**
Abstract:
Using newly designed thermal metamaterials, heat flow can be manipulated in ways inconceivable with naturally occurring materials, as shown by Maldovan (2013). These met-amaterials are often designed based on conformal mapping and/or in the researchers' intuition (Narayana and Sato, 2012; Schittny et al., 2013). Here, Computational Material Design (CMD) is proposed as an alternative method to rationally design a metamaterial by modifying its microstructure. By this way, a special distribution of effective anisotropic conductivity is sought, variable throughout the body, in order to guide the heat conduction in a desired way. Mathematically speaking, this is an optimization problem where the goal function measures the accomplishment of the heat flux guidance task, and the design variables are the parameters defining the microstructure distribution in the whole body. Three examples of heat manipulation, proposed by Narayana and Sato (2012), are now studied using CMD: shielding, concentration and inversion of heat flux.
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Title: **Effects of temperature during ultrasound-assisted extraction of anthocyanins from grape pomace: mathematical modeling.**
Topic: **Heat and Mass Transfer**
Type: **POSTER**
Abstract:

The solvent extraction is widely used to extract bioactive components from food matrix. The application of ultrasonic-assisted extraction (UAE) in food processing technology is of interest for enhancing the extraction efficiency of desired compounds from the vegetal materials.
It is important to use mathematical tools in order to model the extraction process and determine the kinetic parameters. Food processes are usually dynamic in nature. First-principles models, which are derived from physical and chemical relationships, reflecting the underlying principles that govern the process behavior. These mathematical models usually include algebraic, partial and ordinary differential equations.
A mathematical model to analyze the ultrasound-assisted extraction process of anthocyanins from grape pomace is presented in this research work. Spherical particles of grape pomace were considered. Therefore, temporal variations of the anthocyanin concentration in the radial direction were contemplated. This mathematical model consists of sets of algebraic and partial differential equations. Implicit finite difference method was used to discretize partial differential equations. The resulting model was implemented into the optimization environment General Algebraic Modeling System (GAMS). The objective function consists of minimization of the mean square error between the predicted and the experimental value of anthocyanin concentration from the extract over time.
For model validation, experimental runs at different temperatures (25, 45 and 65 ºC) were carried out, using a hydro alcoholic solution (50:50) as solvent. An ultrasound bath system with the frequency of 40 kHz was used and the acoustic energy density during extraction was identified to 36 W/L. Anthocyanin concentrations were determined every 5 minutes during 30 minutes of extraction.
A good agreement between experimental and optimal extraction yields was obtained. In addition, it was observed that an increase in temperature from 25 to 45 °C increased the yield and reduced the extraction time of anthocyanins from grape pomace. However, further temperature increase to 65 °C resulted in a lower increase in anthocyanins yield due to the susceptibility of anthocyanins to high temperature. Thus, the optimal temperature for extraction of anthocyanins without resulting in degradation was 45 °C. Regarding the extraction time, it was observed that slight differences in anthocyanin concentration were found for more than 20 minutes of extraction. Therefore, an evident trade-off between extraction yields and operating costs exists.
The results obtained using the mathematical modeling of the present work, can provide useful information for designing, optimizing and scaling up the ultrasound-assisted extraction in food processes. As further work, the model here presented will be adequately expanded considering operating costs.

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Title: **OPTIMIZATION DESIGN OF KEEL BEAM FOR CJ828 STRUCTURE**
Topic: **Aeronautical Industry**
Type: **ORAL**

Abstract:
This paper discusses the structural optimization of the keel beam in the wide body airplane CJ828 to be built by the students of Large Aircraft Advanced Training Center of National Lab supported by the Chinese Government. The objectives of the optimization were to minimize the structural weight and to lower the stress level.
In this paper an analysis is conducted firstly for a typical keel beam structure in a Boeing and Airbus aircraft. The keel beam structure of Boeing aircraft is a double beam box in which the two lower edge of the beam run through the forward and the rear of the fuselage. The box structure of aluminum alloy is Airbus aircraft's typical structure. The advantages and disadvantages of the two company's keel beam are analyzed from the aspects of force-transfer characteristics, maintenance, manufacturing and assembly process.
The position of the keel beam in the fuselage and load carrying capability are also discussed. CATIA is used for 3D modeling of the keel beam structure and ABAQUS is used for the strength and stiffness analyses. The results show that there is a big optimization space to work on for the structure.
The topology optimization of the main parts of the keel beam by using ABAQUS optimization module is made so that some materials of the keel beam were saved by the optimization. The topology optimization results show that the keel beam can have some holes to reduce its weight. The preliminary structural design of the keel beam is extracted from the results of the topology optimization. The results of the finite element analysis show that the preliminary design of the keel beam structure is consistent with the force characteristics, but local stress concentrations exist which can be improved in the shape optimization stage.
The shape optimization is used to modify the surface shape of the structure. It is usually used to minimize the local stress concentrations and a stress analysis is used to modify the structure surface element node position until the stress level is lower than the specified ones. After the shape optimization stage, the structure edge of the keel beam becomes smooth and the stress level is lowered.
The size optimization changes the thickness of the shell elements, the cross sectional area of beam and so on to improve the structural characteristics of weight reduction, stress lowering and stiffness increase. In the size optimization stage of the keel beam, the key geometric parameters of the shape optimization results and the thickness are the design variables. The objective is to optimize the quality and the strength of the structure is the constraint condition. The software called iSIGHT is used to optimize the size and an optimum design is obtained.
The weight of the final keel beam is expected to fall thirty percent compared to the original baseline structure and thus the overall performance of the fuselage structure will have a significant improvement. This optimization method is also applied to other type of structures such as ship structures which need to reduce the weight, lower the stress, and increase the stiffness.

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Title: **On Probabilistic Optimization of Aircraft Composite Structures in Uncertain Conditions**
Topic: **Aeronautical Industry**
Type: **ORAL**
Abstract:
Polymer-matrix composite materials (PMC) are broadly used as primary structural elements in numerous rotary-wing and fixed-wing aircraft applications. Their main advantage is significant weight reduction in comparison with similar metallic designs. In addition, heterogeneous micro-structures of composites allow a wide range of variations through fiber orientation, 3D reinforcement, complex laminate lay-up, etc. This opportunity is consistently used by designers to achieve additional structural efficiency. However, such optimization process is usually considered as a deterministic problem, i.e., inevitable uncertainty of load/environmental conditions is either tremendously simplified or accounted for through over-conservative safety margins. It is primarily explained by complexity and computational cost of full probabilistic analysis. It is also often driven by assumptions that deterministic and probabilistic optimized designs will be relatively close. The objective of this work, therefore, is evaluation of differences between corresponding deterministic and probabilistic optimization solutions for PMC aircraft structures, explanation of considered tends, and eventually, summarization of lessons learned. Considered examples include typical aircraft and spacecraft PMC applications and address the random natures of load conditions, environment (temperature), as well as material properties. These representative examples are primarily based on works by the author but also include generalizations for other aircraft structural problems in uncertain conditions. Finally, major existing challenges are discussed and directions for future more systematic exploration are highlighted.

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Title: **Damage detection algorithm optimization based on selection signal parameters for the smart composite**
Topic: **Aeronautical Industry**
Type: **POSTER**
Abstract:
Application of guided waves excited by a network of PZT transducers integrated with a given structure is one of the promising approaches to Structural Health Monitoring (SHM). The performance of a SHM system based on PZT network is rooted in two distinct areas of the technology development, that is: the hardware and the signal analysis. The first includes is the type of transducers used to built a network and the way of their integration with a monitored structure. For composites, beside the possibility of the transducers attachment to a surface of an element, also immersing of PZTs into their internal structure is available. In the article Barely Visible Impact Damage (BVID) detection capabilities as well as selected physical properties of the embedded and surface attached PZT transducers are compared in broad frequency range of the excitation. Among the compared parameters are the impedance and capacitance spectra up to 600 kHz. The damage detection capabilities are compared in the range 100 – 350 kHz. In addition to purely qualitative detection of damages a new algorithm of their localization is proposed and compared between the embedded and surface attached transducers for the frequency optimal to detect BVIDs. This algorithm is a modified version of the RAPID imaging method, but optimized to be used also in the case of non-homogeneous sensor networks. Finally the performance of a system is verified with use of a composite panel having PZT transducers embedded into its internal structure. The structure is designed to have some features of aircraft vertical stabilizer. The network geometry was tailored to fulfill specific demands regarding the structural performance.

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Title: **SYNTHESIS AND DESIGN OPTIMIZATION OF STRUCTURAL LAYOUTS FOR AIRCRAFT COMPONENTS**
Topic: **Aeronautical Industry**
Type: **ORAL**

Abstract:
Nowadays, leading aviation companies often use topology optimization methods as an efficient tool for obtaining new and lighter structural component designs. Most of such researches are related with design of small structural parts such as ribs, spars, door intercostals, etc. [1]. The application of topology optimization for determination of reasonable structural layout was proven to result in advanced designs. Significant weight reducing is achieved after the sizing optimization of the obtained structural layout. The purpose of this research is to develop novel approach which combines modern topology optimization methods with two-level sizing optimization technique for design of larger aircraft components such as wing, tail and fuselage. One of approaches of the authors to design of wing structures with using topology optimization was presented in [2]. The proposed method is based on the integration of the global-local method for sizing optimization [3] together with topology optimization in the unified cycle of multidisciplinary design which includes aerodynamic and aeroelasticity analyses.
The general flow-chart of the developed approach includes the following steps:
1. Create a solid topology optimization model and an aerodynamic model which are specified by geometric outlines from CAD system.
2. Perform a set of topology optimizations with different control parameters to reveal where load-bearing material should be located in global sense.
3. Interpret the obtained topology results and choose several alternative structural layouts.
4. Generate finite element models of the alternative structures.
5. Perform design optimization to determine sizes of structural elements with satisfying stress/buckling/aeroelasticity constraints.
6. Rank the obtained structural layouts on the basis of comparison of optimal weights.
In the paper main aspects of integration of the energy-based topology optimization methods together with two-level design method for determination of structural sizes are discussed. Stages of such evolutionary approach to synthesis structural layouts of aircraft components are described in details. The approach is demonstrated on the example of structural optimization of helicopter wing and tail boom. It is shown that sizing optimization with including strength/buckling/aeroelasticity constraints results in to the design with significantly less weight compared with the one obtained by conventional approach.

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Title: **MULTIDISCIPLINARY ASPECTS OF STRUCTURAL OPTIMIZATION IN AIRCRAFT DESIGN**
Topic: **Aeronautical Industry**
Type: **ORAL**
Abstract:
The purpose of this research is the mutual use of previously developed methods of multidisciplinary optimization [1] and topology optimization methods [2] to create an efficient design procedure of aircraft load-bearing structures. The complexity of aircraft structural design consists in the fact that many operating constraints from various technical disciplines should be under consideration. Hence, the problem is formulated as a multidisciplinary aero-structural optimization where aerodynamics, aeroelasticity and strength requirements are mutually taken into account. In this case the optimization results are strongly related on the choice of the initial structural layout. To predict the reasonable initial location of the load-bearing structural elements the topology optimization methods are used. Then shape/sizing optimization procedure is performed in multidisciplinary optimization environment.
Thus, the proposed integrated method includes the use of topology/shape/sizing optimization in the computational environment with analysis of the aerodynamic/inertial loads. The general process includes the topology optimization directed on the search of reasonable structural layouts subjected to several load cases. Then the results are interpreted to find out the location of the primary structural elements in a thin-walled structure. The second stage is design of the structural elements in the interpreted layouts. It includes shape and sizing optimization with the aim to minimize structural weight under stress/buckling/flutter constraints. Structural design procedure, optimization methods and main features concerning the topology/shape/sizing optimization problems are discussed.
The developed multidisciplinary design procedure was applied for determination of the wing tip part geometry together with the parameters of the wing primary elements. The results are presented for two different configurations of the aircraft with high aspect ratio wing. The obtained optimal wing plan-forms are qualitatively different, and it is largely due to aeroelasticity requirements. For the T-tail airplane configuration it was obtained that the slightly forward sweep wing tip with respect to the baseline wing is optimal. On contrary, for the airplane configuration with engine under the wing the optimal sweep angle of wing tip part is in backward direction with respect to the baseline wing.
The developed approach of multidisciplinary analysis and optimization as well as the obtained results show high efficiency and they serve the basis for further investigations on determination of optimal structural layouts of aircraft.

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Title: **Domain reduction strategy for stability analysis on NACA0012 airfoil**
Topic: **Aeronautical Industry**
Type: **ORAL**

Abstract:
Flow unsteadiness is associated to undesirable load variations that could represent a serious problem for engineering applications. The flow instability analysis represents a powerful method for predicting the onset of flow bifurcations leading to these instabilities.
Linear stability analysis, in the modal framework, is based on the decomposition of the flow variables as a sum of a steady base state and a small amplitude perturbation. When this decomposition is fed into the Navier-Stokes equations it results in a generalized eigenvalue problem (EVP). The imaginary part of the complex eigenvalue from the EVP represents the frequency while the real part is responsible for the growth rate of the, initially small, disturbance.
This technique could be successfully employed for problem with low degrees of freedom, which arise from simple flow configurations at relative low Reynolds numbers. However, the high memory demanded for solving EVP with high degrees of freedoms, makes these methods inefficient and even intractable for realistic industrial 3D problems.
Over the last decades, many efforts have been focus on detection of lower-memory demanding approaches, but the problem still remains open.

The main goal of this work is to study the applicability of instability analysis to local regions in a full configuration where the phenomenon of interest is located. Starting from a reference known fluid configuration, a smaller region of the domain will be studied in order to understand if the stability analysis on the reduced domain is able to recover the stability proprieties of the complete flow in the region of interest.

The transonic buffet on the NACA0012 represents the perfect test case for this analysis. The Buffet phenomenon is a strong interaction between the boundary layer and the shock wave that appears on the airfoil during the transonic condition. The consequence are strong vibrations, called buffeting, that could damage the structure of the wing and that are usually also perceived by the pilot. This phenomenon is strictly localized on the top of the airfoil, such as the area of interest for domain reduction can be easily detected.

The new methodology proposed involves four steps:
-The computational domain is discretized using a two-dimensional non-structured mesh.
-The solution of the flow problem for the whole domain is recovered using TAU-DLR code and its stability analysis is performed.
-A second smaller mesh is generated. This mesh should include the leading disturbances from the previous stability analysis.
-The solution of the full computational domain is interpolated into the second mesh and new boundary conditions defined. The stability analysis of the flow in the reduced domain is performed and compared.

As told before, TAU-DLR code, and internals UPM codes for generating and cutting mesh will be used. Stability analysis will be performed with in-house tools.
Successfully results on recovering the stability properties in a reduced domain for this test case represent an important starting point for performing stability analysis over more complex geometries, currently not affordable.

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Title: **Search for the Optimal Structuring Element for Contrast Enhancement Morphological Algorithms using Genetic Algorithms**
Topic: **Imaging**
Type: **ORAL**
Abstract:
The low contrast in digital images hinders the visualization, detection and extraction of artifacts present in them. The contrast enhancement techniques for digital images have received much attention and span a wide range of applications, including the visual quality enhancement of portraits made in low lighting, their application in the area of materials and in medical images. Algorithms based on mathematical morphology are used for contrast enhancement, the choice of size and form of the structuring element being fundamental in order to obtain satisfying results. This paper proposes a search mechanism for the optimal structuring element for contrast enhancement morphological algorithms by applying genetic algorithms that seek to maximize contrast enhancement while minimizing image distortion. The experiments carried out across different types of images verify that the methodology succeeds at enhancing the image in every case.

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Title: **Monitoring Methods in Electrical Impedance Tomography**
Topic: **Imaging**
Type: **POSTER**
Abstract:
This paper summarizes some relevant aspects in the survey information to develop a framework which contributes to the improvement in imaging of electrical impedance tomography (EIT). EIT is a technology used to image regional impedance distributions in a cross-sectional area of the body. Pulmonary perfusion imaging remains a challenge. Some lines of research have found promising results characterizing the physiological behavior observed in EIT experiments. Topics such as suction during breathing and pneumothorax monitoring are examples that confirm this procedure. With advances in digital imaging, signal-processing algorithms and the rapidly growing processing power of computers, a breakthrough in pulmonary chest monitoring is expected.
Keywords: Electrical Impedance Tomography (EIT), Tomography, Diagnostic Image, Respiratory Therapy, Pulmonary Perfusion.
Biological tissues conduct electricity because they contain ions which act as charge carriers. Some tissues conduct electricity better than others and it is possible to use this property to produce images showing the distribution of the impeditive tissue in a region.
In EIT, the internal conductivity distribution of the subject is reconstructed based on electrical measurements from electrodes attached around the torso. Electrodes are attached on the surface of a subject and a set current pattern is injected into the subject through stimulation electrodes. Alternating currents with amplitude around several mA with a frequency of 1-100 kHz are used as stimulation. With the measured voltage in the electrodes, the reconstruction method can be used to calculate the internal conductivity distribution.
EIT has been used in much research in medical applications. Possible medical applications for EIT are monitoring for lung problems, such as accumulating fluid or a collapsed lung, noninvasive monitoring of heart function and blood flow. The EIT method relies on the visualization and quantification of tissue impedance determined by injecting small electrical currents and measuring the resulting voltages at the surface of the torso. Due to its capability to show changes in tissue impedance very quickly, it may be a valuable tool to adjust ventilator settings for the individual patient at the bedside. Mapping of the regional functional behavior of the lung is of specific interest for clinicians treating patients with severe acute lung injury or exacerbation of a chronic lung disease. Quasi-online bedside assessment of regional lung behavior has the potential to tailor respiratory therapy: adjustment of tidal volumes and airway pressures, indication for recruitment maneuvers, initiation of high-frequency oscillatory ventilation, or intermittent continuous positive airway pressure mask ventilation after extubation. EIT is a method to assist the medical diagnosis.
In EIT, the distribution of local tissue resistance (or, more generally, impedance) within a cross section of the body is displayed as a tomographic image. As impedance Z is defined as voltage V over current I, regional impedance may be computed from measurements of currents and corresponding voltages on the surface.

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Title: **Optimization of horizontal generator components by numerical and immuno-inspired methods.**
Topic: **Machinery Optimization**
Type: **ORAL**
Abstract:
Since the middle of the last century, many solutions to problems related to engineering, economy, planning, and other knowledge areas were proposed based on artificial intelligence techniques. Generally, the artificial intelligence algorithms are inspired on mechanisms that are observed in the nature, such as the behavior of ant's colonies, the animal's nervous systems, the mammal's immune systems, and so on.

The artificial intelligence algorithms can be applied to solve optimization problems and a kind of artificial intelligence tool that can be used to solve this kind of problem is known as evolutionary algorithms. In these algorithms, each possible combination of decision variables is defined as an individual. Each individual is subject to random mutations and the mutated individuals that imply on better solutions have more chances to survive and generate descendants. In other words, the solutions are subject to a process similar to the one proposed in the species evolution theory, until a determined set of variables that imply on a solution with the desired quality is found.
The immuno-inspired algorithms are a subclass of the evolutionary algorithms. In those algorithms the mutation and the selection rules are based on mechanisms observed in mammal's immune systems. This class presents a series of advantages if compared to regular evolutionary algorithms, such as the maintenance of the individual's diversity and the capacity to find many local optima, even the ones that are in low peaks of the search space.

In this article, the solution to an optimization problem related to the reduction of costs of a fly-well, that is a horizontal generator component, is presented. This problem is non-linear, presents discrete and continuous decision variables, and presents constraints related to the manufacturing process. The problem was solved both by non-linear optimization numerical methods and by an immune-inspired algorithm developed specially to that application. The comparison and the details of the implementation are presented, and the advantages and disadvantages of each methods are discussed.

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Title: **2- Axial turbine preliminary design optimization**
Topic: **Machinery Optimization**
Type: **ORAL**
Abstract:
In this work are presented the optimization process of axial turbine preliminary design for a turbojet in development. The multiobjective optimization was applied to improve the turbomachinery overall efficiency. The designs variable, constraints and objective functions are analyzed and discuss in this paper, as well as the evolutionary algorithm in the turbomachinery designs. Finally the authors show the couple process between different commercial software. The AXIAL® NREC for turbomachinery designs and ModeFrontier® for the optimization, the results present the important parameters during the turbomachinery optimization process.

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Title: **Multi-Objective Control Optimization for Curing the Shell-like Composite Structures**
Topic: **Materials processing**
Type: **ORAL**

Abstract:
The growth in use of polymeric composites is the most intensive in the aircraft industry due to increased strength or stiffness and better weight saving of these materials that sufficiently exceed the same properties of metal lightweight alloys. Most typical polymeric composites reinforced with glass/carbon fibers with the thermoset resin matrix are used in manufacturing of such parts as fairings, radomes and cowlings with open-shell geometry. The open-mold forming is the most suitable for components with such geometry. According to this technology which involves the use of only one mold surface, over which the layers of fiber or fabric are tightly placed, most often a quasi-isotropic laminate on the part surface is formed. Then a mold packed with a raw material is placed into a vacuum bag, which is disposed in an autoclave where prepreg is exposed to controlled thermal action and external pressure from the pressurized gas. In a typical two-stage cure cycle for a glass / carbon fiber–epoxy prepreg, the first stage consists of increasing the temperature at a controlled rate up to the start of resin fluidization and dwelling at this temperature until the minimum resin viscosity is reached. Such an isothermal hold is also applied at the process completion to allow the temperature distribution to become more uniform, especially in large components with thickness variations. At the end of cure cycle after resin vitrification, the temperature is slowly reduced while the laminate in the autoclave is still under external pressure.
In order to synthesize the process control that provides the best quality of the cured part for the acceptable processing time, we formulate the optimization problem for the two-stage cure process control. We consider this process using an example of composite cowling with varying wall thickness. This problem has been formulated and solved numerically as a multi-objective optimization problem to provide the best fulfillment of processing objectives, including minimum deviations of temperature and degree of cure within a cured part considering constraints imposed by manufacturing requirements. The forward problem uses the system geometry exported from its CAD model; it describes the thermokinetic phenomena in a prepreg during the full cure cycle, and it is implemented as the FE model. The outputs of model's transient analysis are the set of process objectives calculated by integration on each time step in the volume of the cured composite part. The Pareto-based optimization algorithm performs mapping of the area in the design space to the area in the objective space. For the clarity and better understanding of the optimization results, we use the multiple views of 2-variate plots, which are projections of the objective subset to 2-D design subspaces. The present modeling and optimization approach for the cure process control and means of optimization results visualization allow providing insight into complex curing phenomena, estimating the best achievable quality indicators of manufactured composite parts, finding satisfactory parameters of the control law, and making the best decision taking into account all manufacturing constraints.

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Title: **MAPPING THE CASH PROBLEM FOR DATA CLUSTERING ALGORITMS**
Topic: **Mathematical Programming Algorithms**
Type: **ORAL**

Abstract:
Companies' evergrowing data storage has propelled the field of data mining, and this field is useful in spotting hidden knowledge in amounts of data that would make manual analysis impracticable. The mentioned field possesses several machine learning algorithms, each with different input parameters. Manually setting these algorithms is a great challenge, for it is also a laborious, empirical and uncertain task. This paper approaches the difficulty in mapping the CASH problem (Combined Algorithm Selection and Hyperparameter Optimization Problem) in data clustering. The CASH problem can be divided into Algorithm Selection and Parameters Selection. Algorithm Selection considers a set of learning algorithms A and a set of data, aiming at indicating the highest-performing algorithm for the data selected. Parameters Selection considers an algorithm A, a set of instances I and a criteria C, aiming at finding the parametric configuration of A with an optimum value of c and i, and c can be a computational time or, in case of an optimum solution, the mistake found after a pre-set time, or yet any other well-defined criteria. We considered the K-Means, Self-Organizing and Ant Colony algorithms. The objective of this study was to determine the need and practicability of search methods in automatizing the parameters selection process in data clustering algorithms. Tests were carried in six databases with two selection methods: random search and genetic algorithms. To assess the generated groups, we employed an internal and relative kind of criteria, the Calinski-Harabasz criteria, which evaluates differences in the patterns of a group for its centroid, determining the intra-group similarity, as well as assessing the differences of group centroids as opposed to a global centroid, therefore determining the inter-group dissimilarity. Algorithms were run multiple times, in an attempt to analyze test results from either the random search method or the Genetic Algorithm based method, considering that higher values for the Calinski-Harabasz criteria determine relatively better groups (if the same database was used). One observation was that search methods surpassed the standard choice in all the cases. Another was the difference in algorithm performance. Following the criteria, K-Means proved to be better than the other two algorithms in five cases, regardless of the search method. When it came to the amount of time the processing of each algorithm took, there was no significant difference between the search methods, as opposed to what happened among the clustering algorithms. In all cases, K-Means required less processing time than the other two algorithms. Hence, one could reason that the K-Means clustering algorithm is the best choice the user could have, for being both faster and bringing better results. Its disadvantage is it does not automatically determine the number of groups, which can be solved through an automatic search of parameters.

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Title: **Aplication of Conjugate Gradients Method in Linear Systems**
Topic: **Mathematical Programming Algorithms**
Type: **POSTER**

Abstract:
Nowadays, the presence of problems that require a numerical solution to increase higher dimensions of differential equations, so it is necessary the use of numerical methods ever faster for its resolution. Most of these methods results in linear systems of large dimensions, which prevents the use of directs methods such as Gaussian Elimination. Therefore, the solution that are able to attend this need is the use of iterative methods that are capable of generating good approximations of the solution quickly.
The study and search for solution of linear systems of large dimension, it is necessary the use of alternative methods to reverse matrices or Gaussian Elimination. It is in this context that we use optimization for such a solution. It is proposed a function to be optimized by an algorithm so that the minimum of this function is the solution for the linear system found. Dealing with computer numerical methods is necessary to find those with less expenditure of resource, for that sparse matrix entries are considered, and to work with those systems type was chosen the iterative methods.Among the iterative methods, will be used the Conjugate Gradients Methods (CG), which was developed by Hestenes and Stiefel in 1952. This is a numerical technique for optimization, which can be applied for solving linear systems. The CG then performs a number of calculations or iterations to be able to generate approximations to x. Searching to find a final value more precisely as possible to solve the problem, for this uses the concepts of orthogonalization and conjugation, generating a process in which each iteration of CG result in a new direction created by linear combination of the residue of the previous steering. Given by orthogonal vectors to the matrix, can be called A-conjugate, because they are a conjugated version of the successive gradients found during the search for the solution.

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Title: **A Quantum Adiabatic Algorithm for Multiobjective Combinatorial Optimization**
Topic: **MDO - Multidisciplinary Design Optimization**
Type: **ORAL**
Abstract:
A quantum computer may be understood as a hypothetical computer that promises increased computational power. Several examples of problems exist where quantum computers outperform classical computers; for example, Shor's algorithm for factoring large composite numbers, Grover's algorithm for search problems and the efficient simulation of quantum physics. In this regard, quantum adiabatic computation is a quantum computation paradigm that has been very popular in recent years due to its applications in optimization and artificial intelligence. Several authors showed how to encode optimization problems into time-dependent Hamiltonians (which are operations describing the energies of quantum systems) and used them to rapidly find optimal solutions. Optimization problems are important for its many practical and theoretical applications. Moreover, most of the problems that appear in situations of interest are in fact multiobjective in nature, that is, there are several objectives that must be optimized at the same time.

In this work we propose what we consider the first quantum algorithm for combinatorial multiobjective optimization, at least for the best of our knowledge. The proposed algorithm is constructed by mapping a combinatorial multiobjective optimization problem into a Hamiltonian using a convex combination among objectives. The Adiabatic Theorem guarantees convergence of our algorithm provided certain convex combinations of objectives are used. Thus, we present mathematical properties of the eigenspectrum of the associated Hamiltonian identifying properties on the convex combinations.

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Title: **Optimal design of a hydrocyclone using a phenomenological-based semiphysical model**
Topic: **MDO - Multidisciplinary Design Optimization**
Type: **ORAL**

Abstract:
Nowadays, the effort to understand and quantify the separation mechanism in hydrocyclones can be classified from a point of view extremely theoretic or empiric. Although these separation equipment are widely used in the mineral processing industry to classify solids due to high separation efficiency and the relative easy operation, the design and modeling have been majority heuristic. Probably, the reason is due to the complexity of the involved phenomena. However, the optimal design of this kind of processes requires a feasible representation of the real object. To this end, Muñoz et al. (2015) developed a Phenomenological-Based Semiphysical Model (PBSM) (Álvarez et al., 2009) for hydrocyclones considering as modeling hypothesis that the feed flow splits in two flows, underflow and overflow. Both flows create hypothetical spiral paths in hypothetical pipe form with constant cross-area, which travel together until a point where the overflow changes its direction. The last hypothesis is that the particles moving through the underflow pipe describe a unique trajectory and that the pulp movement uses the available energy by each branch. The model was validated using experimental data measured in a real plant, giving errors less than 7%, which indicates that the model was right in the prediction. The model, given the hypothesis, is semiphysical because its structure is developed through process matter, energy and momentum balances, and uses empirical formulations for various parameters as a part of the model. This kind of model is not only useful to predict the main variables of the process but also to represent the physical characteristics of this kind of systems. In order to improve the efficiency of this process, a nonlinear program (NLP) is formulate to improve the efficiency of the separation process for hydrocyclones, where the PBSM is taken as nonlinear constraints and the decision variables correspond to geometric and operations ones. The inherent restriction caused over process inputs span when nonlinear behavior are included into the NLP as inequalities constraints. This operation region showed that the input variables will produce a given set of operating acceptable values for model outputs. Out of this region, no meaning can be given to output values.

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Title: **Selecting optimal flight parameter for prediction of loads of vertical stabilizer of an aircraft**
Topic: **Mechanical Engineering**
Type: **POSTER**
Abstract:
The knowledge about loads of the structure occurring during aircraft operation, is one of the fundamental element of the so called damage tolerance approach to aircraft design. In the optimal case, such information could be available from a network of sensors, e.g. strain gauges, deployed in the aircraft structure and measuring its local stress. However systems of operational loads monitoring (OLM) are still not widely applied. Instead, what is available, is a set of flight parameters, which by the laws of inertia and aerodynamics should determine dominant part of loads, acting on a given element. In the paper canonical correlation analysis (CCA) will be discussed, as a proper method for selection of optimal flight parameters proper for prediction of aircraft loads. CCA allows both for identification of different modes of stress distribution as well as identification of flight parameters which are the best suited for their prediction. In the paper application of this method for identification of loads acting on vertical stabilizer of an aircraft is presented

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Title: **Surrogate-based optimization of model parameters for the improved modelling of industrial-scale gas explosions**
Topic: **Metamodels and Surrogates in Optimization**
Type: **ORAL**
Abstract:
This paper discusses a method for optimizing the predictive capabilities of a computational fluid dynamics (CFD) tool used for consequence analysis in the process industries.

Accidental gas explosions represent a severe hazard in industry – a recent example is the Deepwater Horizon disaster that occurred on 20 April 2010, causing 11 fatalities. The process industries undertake considerable efforts to manage the risk of accidental explosions, and consequence analysis of accident scenarios is part of the overall risk analysis. In order to predict the consequences of an explosion, a CFD simulation tool is often employed, which solves the time-dependent Navier-Stokes equations for compressible fluid flow. Due to limitations in practical simulation time and memory storage, the grid resolution needs to be significantly larger than the scales where chemical reactions interact with the flow. The success of CFD tools for estimating explosion loads in large-scale geometries consequently relies on the implementation of sub-grid models to account for a wide range of scales and ensure representative solutions. Coupling sub-grid models with the fundamental equations requires the adjustment of empirically determined sub-grid model parameters within their uncertainty ranges or physically allowable bounds.

The objective of this paper is to implement a procedure for surrogate-based optimization of sub-grid model parameters. The present study investigates whether the optimization approach is applicable to the gas explosion application of a CFD tool for selected gas explosion experiments. In addition, optimization may detect model limitations, supporting ongoing research in qualification and further development of complex CFD models. The optimization problem is formulated as a least-squares problem to yield best fit between certain output of the CFD model and corresponding experimental values. Sensitivity analysis is applied to determine which model parameters have the greatest influence on relevant model output, i.e. the maximum overpressure and the maximum pressure impulse obtained in specific monitor points. This allows for reducing the number of parameters to optimize. As large-scale gas explosion simulations in general require a (single-core) CPU time ranging from five minutes up to several hours, the model responses are approximated by surrogate models based on neural networks. The use of surrogate models accelerates the evaluation of the objective function and hence the optimization process. The optimization problem is solved with a quasi-Newton method combined with a multi-start method for global optimization. In the present work, model parameters are optimized for a selected group of experiments representing similar physical phenomena. The optimization process is found to improve significantly the model predictions of overpressure-time curves for specific monitor points.

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Title: **Kriging-based Multiobjective Optimization of a Fuselage-Like Composite Section with Curvilinear Fibers**
Topic: **Metamodels and Surrogates in Optimization**
Type: **POSTER**
Abstract:
This paper presents the multiobjective optimization of an aircraft fuselage-like composite section with curvilinear fiber paths. The structure is a reinforced composite panel with an oblong cutout. The skin of the fuselage section, which is the part to be optimized, is a 24-ply symmetric and balanced laminate. The fiber paths are parameterized using two parameters per ply, totalizing 12 continuous design variables in the [0, 90] degree space. The objectives examined are the first natural frequency (to be maximized), the maximum displacement (to be minimized) and the reserve factor of the Tsai-Wu failure criterion (to be maximized). Also, the buckling load under shearing is imposed as a constraint.
To overcome the problem of long run times, Kriging-based approaches are used here.
When using Kriging, usually the efficient global optimization (EGO) algorithm is the standard technique for single objective optimization.
Three different approaches for dealing with many-objective problems using Kriging surrogate models are compared: (i) the efficient global optimization (EGO) algorithm applied to a single objective function of the combined objectives responses, (ii) the expected hypervolume improvement (EHVI), and (iii) the variance minimization of the Kriging-predicted Pareto front (VMKF).
In approach (i), a weighting function is used to combine all goals into a single quantity which then is modeled into a Gaussian process (Kriging) so EGO can be employed. As this technique suffers from scaling and non-linearity of the cost functions, EHVI (ii) attempts to address these limitations by expanding the idea of the maximization of the expected improvement (EI) to a multiobjective framework. This approach also merges all goals into a single objective function which have to be optimized, so, roughly, it is similar to EGO algorithm in a higher framework.
Although there are some efficient algorithms to calculate and/or estimate the expected hypervolume improvement, it is usually a costly operation which significantly scales with the size of the Pareto set. To overcome this issue, a simpler algorithm is proposed by the present work (iii). In this approach, each goal is modeled using Kriging and a state-of-the-art multiobjective algorithm (NSGA-II) is used to generate a Pareto set of the predicted mean of the surrogate models. Then, the algorithm interactively minimizes the variance of the predicted Pareto front.
To evaluate the efficiency of these three methods, a baseline solution is created by multiobjective direct optimization (no surrogates are used) applying the NSGA-II algorithm. Finally, the results are compared and discussed, showing the computational burden reduction and the efficiency of VMKF technique.

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Title: **Improving the optimisation performance of an ensemble of radial basis functions**
Topic: **Metamodels and Surrogates in Optimization**
Type: **ORAL**

Abstract:
Surrogate model based optimization has become a popular method to reduce the computational cost associated with engineering design. However, these approaches still require choices to be made regarding the surrogate kernel and updating criteria, which may be a difficult task. Moreover, these issues can be exacerbated when considering problems with large numbers of design variables and a restricted computational budget.
There are a wide range of techniques for constructing models from observational data, such as generalized linear models, and Gaussian stochastic process models. A major drawback with these techniques is that a large number of training points may be needed to construct an accurate surrogate, and the computational burden increases, as a set of undetermined parameters need to be estimated after each prediction. In the case of radial basis functions (RBF) a cross-validation approach is used to calculate a loss function (e.g. RMSE) which is than minimized in order to find the optimal shape parameter. This approach strongly depends on the size of the data-set, which is governed by the allotted computational budget. The lack of sufficient information describing the relationship between the response and the input variables may also make it difficult to determine which RBF is the best for a specific problem. One solution is to construct multiple RBFs based on a common training data-set, and employ these within an ensemble.
In this paper we investigate ensemble optimization performance using two different ensemble approaches, and a novel update strategy based on the local Pearson correlation coefficient. The first ensemble, is based on a selective approach, where ns RBFs are constructed and the most accurate RBF is selected for prediction at each iteration, while the others are ignored. The second ensemble uses a combined approach, which takes advantage of ns different RBF, in the hope of reducing errors in the prediction through a weighted combination of the RBFs used.
The update strategy uses the local Pearson correlation coefficient as a constraint to ignore domain areas where there is disagreement between the surrogates. In this study three cases are investigated, unconstrained, low constrained, and high constrained.
These ensembles are compared using 5 analytical test problems with 2 to 50 dimensions, and one engineering problem related to the frequency response of a satellite boom with 2 to 40 dimensions. Three different computational budgets are analysed, based on a Latin-hypercube sampling plan. All of the functions are assumed to be a black-box, and a bootstrap methodology is applied for assessing statistical accuracy in terms of bootstrapped mean and 95% confidence intervals.
Results indicate that with a small computational budget the local Pearson correlation coefficient is beneficial in most of the cases analysed. However, the level of performance improvement is somewhat reduced increasing the computational budget.

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Title: **Climate Prediction based on Mamdani Fuzzy Model**
Topic: **Meteorology**
Type: **POSTER**

Abstract:
Predictions about behavior and phenomena atmospheric became certainly a big step for humanity. Such forecasts are extremely important, whether in the economic activities of a region or even in daily lives of people. Climate prediction helps in making decisions according to ambient weather conditions. However, this process have a failure risk, because the process depends to analyze the behavior of several variables, such as relative humidity, temperature, atmospheric pressure, speed and direction wind, sunlight intensity. Technological development in recent years has resulted in greater efficiency in the results, ensuring greater reliability of weather predictions. However, the method for climate prediction can be improved for the treatment of uncertainty and inaccuracy of the measured data as well as the development of low-cost technologies for this purpose. Since 1980, fuzzy systems have been applied in modeling and control of nonlinear and dynamic systems, it is due to structure based on rules that allows approximation of functions, nonlinearities and uncertainties as well. A climate prediction based on Mamdani fuzzy model is presented in this abstract: A MISO (Multiple Input and Single Output) model to obtain rain prediction, is formulated. From a monthly rainfall database, related to the input variables of the MISO model (humidity relative in the air, temperature, atmospheric pressure, speed wind) fuzzy sets were formulated in the consequent of Mamdani fuzzy model. The development of the proposed fuzzy model was based on a survey and analysis of meteorological data of the input variables. First, only two variables were selected for input system (humidity relative in the air and temperature). Considering that the climate behavior varies throughout the year, data were collected for different times of the year , it were also analyzed the degree of influence that the choice of months have on the rain prediction provided by the system. A study of how the two variables (humidity relative in the air and temperature) are related to rain was performed in order to define the fuzzy sets and rules in the Mamdani fuzzy model consequent. Finally, to improve the Mamdani fuzzy model to prediction rain, the atmospheric pressure and speed wind variables was added. Computational results show the efficiency of the proposed methodology, once the system presents satisfactory results to rain prediction.

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Title: **Multicriteria allocation of resources under conditions of uncertainty**
Topic: **Multi-objective Optimization**
Type: **ORAL**
Abstract:
In any type of planning (strategic, expansion, etc.) there are always two fundamental questions: "what to do?" and "how to do?". The second question is usually related to rational allocating various types of resources (financial, logistic, etc.) between strategic actions, expansion schemes, etc., defined by answering the first question. This allocation is generally aimed at achieving diverse objectives on the basis of using information with high levels of uncertainty. Considering this, the present work is dedicated to multicriteria allocation of recourses under conditions of uncertainty.
The lack of clarity in the concept of "optimal solution" is the main methodological complexity in solving multicriteria problems. When using the Bellman-Zadeh approach to decision making in a fuzzy environment to analyze multiobjective models (models), this concept is defined with reasonable validity: the maximum degree of implementing all goals serves as a criterion of optimality. It conforms to the principle of guaranteed result, providing constructive lines in obtaining harmonious solutions on the basis of analyzing associated maxmin problems.
The results related to considering the uncertainty factor with the use of the possibilistic conception are based on combining two branches of mathematics of uncertainty (game theory and fuzzy set theory) and are to be considered as a generalization of the classic approach to handle information uncertainty for multicriteria problems. The general scheme for multicriteria allocation of resources providing robust solutions is associated with the following stages:
▪ The first stage consists in building payoff matrices for considered objective functions for all combinations of solution alternatives Xk, k=1,…,K and representative states of nature (scenarios) Ys, s=1,…,S. To build payoff matrices it is necessary to analyze S models. It permits one to obtain K (K≤S) solution alternatives. Thereafter Xk, k=1,…,K are to be substituted into objective functions for Ys, s=1, …,S to obtain payoff matrices.
▪ The second stage is associated with analyzing the payoff matrices and is based on considering the choice criteria of the classic approach to handle information uncertainty as objective functions with applying the corresponding aggregation procedures. It permits one to use available quantitative information to the highest degree to reduce decision uncertainty regions. However, if the resolving capacity does not permit one to obtain unique solutions, it is possible to apply the third stage.
▪ The third stage is based on constructing models for the subsequent contraction of the decision uncertainty regions. Their analysis is associated with fuzzy preference modeling and permits one to consider indices of quantitative character as well as qualitative character, whose definition is based on knowledge, experience, and intuition of involved experts.
One of the important moments of the work is a unique approach to building objective functions of models to reflect planning objectives.
Examples are to be considered to illustrate steps of multicriteria allocation of resources under conditions of uncertainty.

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Title: **Multiobjective Dijkstra Algorithm applied to path planning**
Topic: **Multi-objective Optimization**
Type: **ORAL**
Abstract:
Dijkstra algorithm is well known and vastly used to find the cheapest path between two vertices in a graph given edge costs, with applications ranging from path planning in GPS trackers to design of transmission lines for power systems. It is fundamentally an efficient exhaustive search, which guarantees its optimality for any edge cost distribution and graph. This work investigates its application to multiobjective problems, i.e. to multiple edge costs assigned to each edge. For instance, this is useful in a routing problem, where the shortest path solution and the fastest track solution are often required. A multiobjective approach can provide tradeoff solutions in between these two objectives. With these solutions at hand, the user may decide which one is better for the needs.

Since a path cost is linear relatively to edge costs, a weighted sum in edge costs implies the same weighted sum in objective functions (i.e. path costs). Furthermore, a path cost is also linear relatively to optimization variables (i.e. binary variables indicating presence of respective edges in the path), so that a weighted sum of objective functions may be used to sample every Pareto optimal point using the classical Dijkstra algorithm, which is a well-known guarantee for convex (hence, linear) problems. This is the fundamental idea of the multiobjective Dijkstra algorithm proposed in this work, which is known as the weighted sum scalarization procedure.

As a study case, the proposed multiobjective Dijkstra algorithm is used to design transmission lines given cost maps, which fundamentally define the cost per unit of length inside polygons so that costs may be properly assigned to edges of an underlying grid graph. The costs may be grouped together into a single objective function or may be separated into two or more objectives according to user needs (e.g. installation cost and environmental cost). The grid graph encloses the convex hull of all considered thematic maps in order to guarantee optimality, and also the starting and ending points. The resulting algorithm is able to cope with thematic maps of 300 x 300km with a 1km accuracy within seconds. Moreover, the results interpretation is very intuitive when analyzed from the input maps standpoint. Indeed, showing them together is a nice graphical output.

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Title: **Design of a commercial aircraft environment control system using Bayesian optimization techniques**
Topic: **Multi-objective Optimization**
Type: **ORAL**
Abstract:
In this paper, we present the application of a recently developed algorithm for Bayesian multi-objective optimization to the design of a commercial aircraft environment control system (ECS). The ECS is composed of two cross-flow heat exchangers, a centrifugal compressor and a radial turbine, the geometries of which are simultaneously optimized to achieve minimal weight and entropy generation of the system as a whole. While both objectives impact the overall performance of the aircraft, they are shown to be antagonistic and a set of trade-off design solutions is identified. The algorithm that we use for optimizing the system implements a Bayesian approach to the multi-objective optimization problem in the presence of non-linear constraints. The emphasis is on conducting the optimization using a limited number of system simulations and, as a particularity, the algorithm is run on a non-hypercubic design domain and implements hidden constraints handling capabilities.

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Title: **Multi-Objective Optimization of monitoring well location for CO2 leakage detection in GCS**
Topic: **Multi-objective Optimization**
Type: **POSTER**

Abstract:
Capture and sequestration of CO2 in deep geological formations is an attractive option to reduce the amount of CO2 emissions into the atmosphere. The capture of CO2 is mostly done at large stationary point sources, such as power plants and refineries, and then it is injected in deep saline aquifers. One of the environmental concerns with this strategy is the potential leakage of CO2 back to the atmosphere through abandoned oil and gas wells. In this context, an alternative in order to detect leakage, is to place pressure-monitoring wells in overlying geological formations in order to detect changes in pressure. The monitoring strategy becomes a question of optimization that tries to answer the question of how many wells to place and where to place them. In order to address this specific problem, this study proposes a methodology that incorporates a numerical model of pressure propagation, based on Monte Carlo simulations, the use of a Kalman filter and an evolutionary algorithm to answer the specific question. The physical model used simulates the propagation of pressure perturbations through overlying formations in an analytical form. The model assumed 10 leakage wells, 400 possible monitoring well locations, and 2 geological formations - an injection formation and an overlying monitoring formation. Given that the main uncertainty of the physical system lies in the unknown permeability of the leakage wells, the model was ran under a Monte Carlo scheme in order to explore all the potential combinations of pressure propagation. Once the potential pressure perturbation was modeled and the corresponding variance and covariance calculated (for the 400 possible monitoring wells), the values were used to reduce the coefficient of variation (CV) by choosing different number of monitoring well locations. The change in CV was calculated using a static Kalman Filter and the combination of number of monitoring well and their locations were evaluated using an evolutionary multi-objective algorithm (the already established NSGA-II algorithm). For this study two cases were run: In the first case, the potential leakage well locations were known but with unknown permeability; the results show that the uncertainty can be almost completely reduced when using 10 monitoring wells (or more) but a substantial reduction is attainable with only 3 wells – uncertainty reduction of 64.41%. The results also show that the location of 10 monitoring wells does not really matter and any location would reduce the uncertainty. For the second case, the potential well leakage locations and as well as the permeability were considered to be unknown. This case showed that the uncertainty is reduced only by 67% with 10 wells and the placement of the wells follows a symmetric pattern. With 4 wells the uncertainty reduces by 51.37%. Overall, this methodology justifies the potential benefits of using monitoring wells to detect leakage pathways associated with carbon capture and sequestration.

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Title: **Differential Evolution with the Adaptive Penalty Method for Structural Multi-Objective Optimization**
Topic: **Multi-objective Optimization**
Type: **ORAL**

Abstract:
Real-world engineering design problems, like structural optimization, can be characterized as a multi-objective optimization when two or more conflicting objectives are in the problem formulation. The differential evolution (DE) algorithm is nowadays one of the most popular metaheuristics to solve optimization problems in continuous search spaces and has attracted much attention in multi-objective optimization due to its simple implementation and efficiency when solving real-word problems. Recently, the well-known GDE3 algorithm with an adaptive penalty technique for constraint handling showed efficiency in the solution of structural multi-objective optimization problems. This paper compares the performance of the GDE3 algorithm, equipped with the adaptive penalty scheme, with that of its original version in order to investigate the advantages and limitations of this constraint handling technique. We also compare those algorithms with the most commonly used multi-objective metaheuristics from the literature: NSGA-II. The results indicate that the GDE3 algorithm with an adaptive penalty technique is more efficient than both the original GDE3 and NSGA-II in most of the performance metrics adopted for the structural multi-objective optimization problems considered here.

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Title: **MultiObjective Optimization of Piezoelectric Patch Distribution for Vibration Attenuation in Sandwich Plates**
Topic: **Multi-objective Optimization**
Type: **ORAL**
Abstract:
In the last decades, sandwich structures have been widely used in aeronautic and aerospace applications. These structures usually have a soft core and stiff faces, resulting in a high bending stiffness, associated to a low specific weight. Normally, applications with sandwich structures in the aerospace field consist of large but lightweight panels and, thus, they usually present vibration problems that must be corrected, without jeopardizing the gain in weight reduction achieved.

The use of hybrid passive-active treatments for structural energy dissipation is a solution to circumvent these vibration problems. A disadvantage of hybrid passive-active treatments is precisely the increase in weight due to the use of viscoelastic materials (passive treatment suitable for high frequency damping) and piezoelectric materials (active treatment suitable for low frequency damping). It is thus necessary to determine which is the best distribution of these materials in a given structure to ensure a good performance, reducing to the minimum the added mass by these treatments. Optimization techniques are an indispensable tool to solve this type of problems, finding the best distribution of the hybrid material treatments in order to minimize the mass of the structure and maximize the damping.

In this work, recent developments in vibration attenuation with active damping are introduced, showing the importance of an appropriate finite element model associated to a multiobjective optimization method. A new finite element model based on the Carrera's Unified Formulation (CUF) was used, with a layerwise approach, for modeling and dynamic analysis of orthotropic plates with viscoelastic layers and piezoelectric patches or layers. The design variables are the number and position of the piezoelectric patches, and the objectives are the minimization of the number of patches, maximization of the fundamental modal loss factor and maximization of fundamental natural frequency.

A recent methodology of optimization, based on direct search techniques was used: Direct MultiSearch (DMS) optimization [1]. This methodology does not use derivatives and does not aggregate any of the problem objective functions. To the authors knowledge, it is the first time that DMS is applied to this class of problem, being applied previously to active damping design of sandwich structures [2] but with a fixed number of patches. Trade-off Pareto fronts and the respective optimal configurations are obtained and the results are analyzed and discussed.

[1] A.L. Custodio, J.F.A. Madeira, A.I.F. Vaz, L.N. Vicente, Direct multisearch for multiobjective optimization, SIAM Journal on Optimization, 21 (3):1109-1140, 2011.
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Title: **Routing and Spectrum Allocation in EON. An approach based on Multi-objective Genetic Algorithms**
Topic: **Multi-objective Optimization**
Type: **ORAL**

Abstract:
The increasing network traffic and the need to expand the capacity and performance of transmissions are achieved through the use of optical fiber. The current working of the transmission networks are based on Wavelength Division Multiplexing (WDM). This technology has the ability to transport, route and assign multiple channels on a single optical fiber that supports the transmission of different wavelengths. Here, each channel is assigned a single type of traffic, which results in resource underutilization when channel does not operate at maximum capacity. Consequently, elastic optical networks emerge as an alternative to WDM networks to maximize the use of the bandwidth of the optical fiber based on flexible spectral grid. This enables the allocation of variable bandwidth to optical channels with low-speed traffic, resulting in an increased efficiency of the spectrum.
In WDM networks, the routing and wavelength assignment (RWA) algorithm seeks a physical path through the network and assign a wavelength for information transport between source and destination nodes. The selected wavelength is set to be constant throughout the physical path (known as the wavelength continuity constraint). In elastic optical networks, the routing and spectrum allocation (RSA) algorithms are also subject to the contiguity constraint. This constraint requires that the frequency slots occupying each channel be contiguous in the medium. The scope of the paper is RSA problem, which is a NP-hard problem and branches into the RWA problem as a particular case.
In this work, RSA is addressed as a multi-objective optimization problem. In this context, we propose a multi-objective genetic algorithm (MOGA) that calculates the optimal routing and spectrum allocations for a set of unicast requests with static traffic requirements. The MOGA seeks to optimize the total number of frequency slots used and quality of service defined by the distance between source and destination node, simultaneously.
Performed testing shows promising results with respect to the solution produced by an Integer Linear Programming, which provides a set of suitable solutions that can be selected based on the network administrator’s preferences.

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Title: **Using design optimization for a dynamically equivalent truncated mooring system**
Topic: **Oil and Gas Industries**
Type: **ORAL**
Abstract:
The installation scenario of the floating production facilities is often severe, becoming a challenge for oil and gas offshore industry. This may require new materials and innovative systems to resist the environmental loads. For designing mooring systems with these characteristics, it is need to know the dynamic behavior of the platforms and their mooring lines. Testing on ocean basin laboratories is performed to develop and verify the new floating production systems. Several procedures have been proposed and developed to overcome this challenge in ultra-deepwaters testing. The most realistic alternatives are the hybrid model testing methods, especially the hybrid passive systems. The first step is fundamental and refers to the design of the equivalent water depth truncated mooring system. The success of the testing may be compromised if this step is not performed adequately. Thus, in this work, we investigate efficient design optimization procedures to obtain the ideal truncated design considering the dynamic effects. We use a dynamic simulator for analysis of the mooring system and an optimizer based on gradient. The adjust of the design variables to optimally fit truncated mooring system to full-depth mooring system was performed by a calibration method. For the purpose to verify the concordance with the full-depth mooring system, we check the truncated optimal design for many wave conditions. We use computer cluster to quicken this process due to the large computational cost needed to performed checking in all wave conditions. Furthermore, we will present and discuss two cases: a catenary moored semi-submersible and a semi-taut moored FPSO. In two cases, the preliminary results obtained show similarity between the responses of truncated and full-depth systems.

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Title: **Using design optimization for a dynamically equivalent truncated mooring system**
Topic: **Oil and Gas Industries**
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Abstract:
The installation scenario of the floating production facilities is often severe, becoming a challenge for oil and gas offshore industry. This may require new materials and innovative systems to resist the environmental loads. For designing mooring systems with these characteristics, it is need to know the dynamic behavior of the platforms and their mooring lines. Testing on ocean basin laboratories is performed to develop and verify the new floating production systems. Several procedures have been proposed and developed to overcome this challenge in ultra-deepwaters testing. The most realistic alternatives are the hybrid model testing methods, especially the hybrid passive systems. The first step is fundamental and refers to the design of the equivalent water depth truncated mooring system. The success of the testing may be compromised if this step is not performed adequately. Thus, in this work, we investigate efficient design optimization procedures to obtain the ideal truncated design considering the dynamic effects. We use a dynamic simulator for analysis of the mooring system and an optimizer based on gradient. The adjust of the design variables to optimally fit truncated mooring system to full-depth mooring system was performed by a calibration method. For the purpose to verify the concordance with the full-depth mooring system, we check the truncated optimal design for many wave conditions. We use computer cluster to quicken this process due to the large computational cost needed to performed checking in all wave conditions. Furthermore, we will present and discuss two cases: a catenary moored semi-submersible and a semi-taut moored FPSO. In two cases, the preliminary results obtained show similarity between the responses of truncated and full-depth systems.

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Title: **CONSTRAINED WATERFLOODING OPTIMIZATION USING AN ENSEMBLE-BASED METHOD WITH SENSITIVITY REFINEMENT**
Topic: **Oil and Gas Industries**
Type: **ORAL**
Abstract:
In this paper, an implementation of an ensemble-based method for constrained waterflooding optimization is presented. Net present value (NVP) is maximized subject to constraints on total production and injection rates. The refinement of the sensitivity matrix for computation of the gradient vector is discussed. The objective function is maximized using the sequential quadratic programming (SQP) algorithm. Control variables are the flow rates of both injector and producer wells. An approximation of the gradient vector is calculated as the product of the sensitivity matrix of the local NPV ´s of each well and a column vector of ones whose length is the total number of wells. The sensitivity matrix is computed based on the product of the pseudo-inverse of the covariance matrix of the ensemble control variables and the ensemble estimate of the covariance of well NPV´s with the control variables. The refinement of the sensitivity matrix is obtained from the study of the dependency of well NPV´s with control variables at all wells. The simulations are performed in parallel using a commercial black-oil simulator. The ensemble realizations are perturbations of previous controls during the optimization process.
The proposed methodology was applied to a reservoir model with 12 wells and 6 control cycles. We analyze the sensitivity of the NPV of a well with the different controls of the other wells. Ensemble size is one of the major parameters studied since it is essential to use small number of realizations in the ensembles. In this paper was used an ensemble of size 4.2% of the total number of control variables. The best result obtained with the refinement of the sensitivity matrix was 3% higher than that obtained without refinement of the sensitivity matrix.

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Title: **Optimizing vessel fleet logistics for oil transport from off-shore platforms to the refineries**
Topic: **Oil and Gas Industries**
Type: **POSTER**

Abstract:
Currently, a major challenge for oil companies is to ensure a competitive level of oil production compatible with the resources available to the costs of extraction. Considering that the most significant part of oil extraction over the world occurs in off-shore platforms, the aim of this work is to propose a logistics organization model of the transport liquid bulk of offshore platforms, via cabotage, to refineries on the coast that minimizes costs for transport and allocation of ships. In large industries, the transportation activity of raw materials, semi-finished or finished product is on average most of the logistics costs. At first, it performed a literature review to understand the modeling techniques and mathematical programming in transportation logistics. It was observed that the proposed problem is characterized as VRP (Vehicle Routing Problem), a generalization of the "Traveling Salesman Problem". The VRP is classified as NP-hard, in which the computational effort required to solve the mathematical model that is growing exponentially with the number of points to be covered. We selected four oil platforms draining its production to three refineries. It was decided to model the problem with predefined routes having already been optimized by the Matlab software, taking into account the order with minimum distance to each. The decision variables were: time spent for each vessel covering certain route; time each ship was docked; distance traveled for each vessel; number of times each ship traveled the same route; oil volume taken by each ship at a platform; volume of oil discharged in each port refinery; and the possibility of certain oil loading at one compartment of a ship. The objective function was defined as the cost to be minimized associated with time spent and distance traveled. Restriction inequalities have been prepared and the model was implemented and solved in GAMS software using the CPLEX solver. The model was validated from the results obtained.

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Title: **Simultaneous Optimization of Rock Facies and Porosities leveraging Spatial Dependencies**
Topic: **Oil and Gas Industries**
Type: **POSTER**
Abstract:
Analyzing data with spatio-temporal structure is a challenging effort in machine learning and signal processing that has many applications in, e.g., mobile communication, earthquake prediction, geosciences data analysis, traffic flow modeling and the neurosciences.

In our work, we consider the case where imprecise input instances with high measurement noise depend on latent variables with inherent known dependency structure. Further, for a small fraction of input instances, a high-quality, low noise regression label is available. The task is to infer regression labels for each of the unlabeled input instances. We cast this problem as a semi-supervised regression task.

Our main idea is to consider the structure of the latent variables and appropriately propagate the accurate label information to the unlabeled samples. If we successfully capture a latent structure that has strongly correlated dense connections within each cluster and scarce (or weakly correlated) connections between clusters, we can accurately infer the latent variables and thus predict the regression label easily.

To achieve this goal, we developed a transductive conditional random field regression method (TCRFR). TCRFR assumes that the latent structure is partially known: the edges of a spatio/temporal neighborhood graph define the potentially interacting samples, but the interaction strength is learned from the data.

We apply our novel method to the rock porosity prediction problem in petroleum reservoirs, a crucial step in the oil industry to recover hydrocarbons such as crude oil or natural gas. Porosity, defined as the fraction of void space over the total rock volume, is a major indicator for the existence of hydrocarbons. It can be directly measured at wells once they are drilled, however drilling is extremely costly and typically conducted only at the locations where a petroleum reservoir is highly likely to exist. Accordingly, it is preferable to predict porosity from less expensive information sources. Seismic impedance, which is estimated by analyzing reflections of sonic waves, is the main information source available for the whole volume of the target area. Importantly, the relation between porosity and impedance depends on a latent property known as facies. Each facies represents a distinct group of rocks with similar features like mineralogy, grain size, and sedimentary structures. It is reasonable to assume strong spatial structure of facies. Oil companies try to predict porosity of the whole volume in the target area from sparsely observed porosity and densely observed impedance, taking the latent spatial structure of facies into account.

Considering the impedance as an input, porosity as an output, and the facies as a latent variable, this application exactly matches the setting for which TCRFR is developed. Porosity labels are only observed at a few locations. TCRFR enables accurate clustering by capturing the spatial structure of facies and propagating that scarce label information to the unlabeled data. Experimental results show the effectiveness of our method, with 0.15 MAD accuracy for 5% of labeled data against 1.58 from the closest competitor.

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Title: **Numerical simulation of in-situ combustion model using a mixed complementarity algorithm with the finite element method**
Topic: **Oil and Gas Industries**
Type: **ORAL**
Abstract:
Due to the increasing shortage of light oils and increasing global energy demand, the recovery of heavy oil becomes more and more necessary. One of the main characteristics of this type of oil is its high viscosity, which hinders the recovery. One way to reduce the viscosity consists of applying thermal methods as, for example, steam injection and in-situ combustion. The steam injection process is difficult when the oil is offshore. In-situ combustion is a thermal recovery technique which consists in injection air, burning small amount of oil, producing heat and consequently reducing oil viscosity [2].

In this paper we present a model of in situ-combustion, which consist of a system of parabolic and hyperbolic partial differential equations which need to be studied numerically. We rewrite the system as mixed complementarity problem [1], where the combustion front corresponds to a moving boundary. We obtain the numerical solution using a finite element method combined with a feasible directions algorithm for nonlinear complementarity problems [3]. We validate our simulation by comparing it to analytical solution for a simple one-dimensional case obtained through method of characteristics.

[1]. Chapiro, G., Mazorche, S.R., Herskovits, J., Roche, J.R., Solution of the non linear parabolic problems using nonlinear complementarity algorithm (fda-ncp), Mecánica Computacional, Vol. XXIX, n.21, pp. 2141-2153(2010).

[2]. Chapiro, G., Gutierrez, A.E., Herskovits, J., Mazorche S.R., Pereira W.S., Numerical Solution of a Class of Moving Boundary Problems with a Nonlinear Complementarity Approach. Journal of Optimization Theory and Applications. 2016 Feb 1;168(2):534-50.

[3]. Mazorche, S.R., Herskovits, J., A feasible directions algorithm for nonlinear complementarity problems and applications in mechanics. Structural and Multidisciplinary Optimization, Vol. 37, pp. 435-446(2007).

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Title: **Crude oil scheduling optimization including specific operational aspects of a Brazilian refinery**
Topic: **Oil and Gas Industries**
Type: **POSTER**
Abstract:
Oil is the most important energy source in the world. However, one oil company, such as a commodity producer, is individually unable to control the price of its products in the international market, which depends on supply and demand, as well as global macroeconomic and geopolitical factors. In this context, optimize the use of resources in a refinery is strategic for maintaining viability and competitiveness of the company. The objective of this work is to develop an optimization model of the crude oil scheduling problem, which is able to represent a large size refinery restricted to specific operating rules of the Brazilian oil industry. It aims at maximizing the contributing margin, by defining the most suitable allocation of resources, sequencing and timing of tasks and operating parameters. The real-world refinery under study encompasses nine charging tanks, three crude distillation units (CDU) and thirty-six types of crude oil. A set of different crude parcels composed of a crude mix is scheduled to arrive at the refinery at different points in time along the time horizon, which is pre-defined by planning. Crude oil parcels are unloaded directly to charging tanks. The crude mix is not specified at the charging tank level but at the CDU level, which means that each distillation unit can be fed by more than one charging tank. The set of charging tanks are subdivided in two disjoint subsets, namely; the subset of base tanks which are used to compose the major portion of CDU load , and the subject injecting tanks which are used to only complement the CDU load. Different scenarios were tested varying aspects such as initial inventory, number of crude parcels and time horizon length. The state-of-the-art continuous-time formulation MOS, proposed by Mouret et al. (Comput Chem Eng, 2011, 35, 1038) was used as a basis whereof, the following aspects were added: tank heel, settling time, split of crude oil parcels, alignment of multiple tanks to the same distillation unit with unsynchronized transfer durations. Moreover, a smoothening transition strategy called TIMT (temporary injection of multiple base tanks) is imposed when switching from one base tank to another. The TIMT consists of an overlap of the time windows of the base tank leaving and the one taking over the CDU load. A set of rules are imposed for the transition operation. The purpose of the TIMT strategy is to soften the composition variation during tank switches and thus minimizing the CDU perturbation. The resulting model was implemented in the GAMS system and two solution strategies were employed to solve the nonconvex MINLP problem; an mMILP-NLP decomposition proposed by Mouret et al. (Ind Eng Chem Res, 2009, 48, 8515) and a linear-based approach based on the proposition by Reddy et al. (Chem Eng Sci, 59, 2004, 1325). A performance analysis is carried out for comparing the two solution strategies. In general, the CPU time seems to be the most challenging factor tackling real-world sized problems, whereas robustness can be achieved by adding slack variables to selected complicating constraints.

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Title: **Optimization of energy supply projects of industrial plants**
Topic: **Oil and Gas Industries**
Type: **POSTER**
Abstract:
This work presents an optimization methodology developed to provide the optimal design for both generation and cogeneration systems on industries. Mathematical programming using a set of non-linear equations and associated constraints was applied to define the optimal configuration of such systems. The resulting model considers several aspects of the designing problem such as technical limitations, capital cost, operational costs and equipment reliability.

Objective function minimizes the present value of total cost subject to equipment minimal load and desired minimum plant availability. In addition, this analysis can be applied for choosing both to choice among different electrical power sources in an industrial plant as to define a cogeneration plant.

Two case studies were used to evaluate the methodology. The first case, considers the electricity supply for a Gas Treatment Unit, where three alternatives were compared and evaluated for that matter. The first two alternatives consider that electricity is generated using gas turbine and reciprocating engine. In the third alternative, the plant operates importing energy from the National Grid.

The second case, a cogeneration plant that supplies steam and electricity to a refinery was evaluated using the developed methodology as well. Several alternatives configuration were compared. For both case studies, a configuration with minimal total cost was found.

With that respect, the expectation of the authors is to provide an alternative technique that can be applied for the definition of energy supply projects.

In conclusion, the article presents an alternative technique that can be applied for the definition of power supply projects, in order to improve or confirm choices taken by designers.

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Title: **Modeling, simulation and optimization of ethanol extractive distillation using glycerol**
Topic: **Optimization with Approximate Models**
Type: **ORAL**

Abstract:
The extractive distillation process of ethanol, using glycerol as extractor was modeled, simulated, analyzed and finally optimized. The process modeling was developed in steady state. The models involve equipment such as two distillation columns (with their respective condensers and boilers), splitter, mixers, pressure modifiers elements (valve and pump) and a heat exchanger. The models were implemented in EMSO (Environment for Modeling, Simulation and Optimization). The optimization problem focused in finding the optimal values for three operational variables (extraction column reflux ratio, makeup glycerol flow and regenerated glycerol purity) in order to maximize a profit objective function. For solving the optimization problem, a surrogate model strategy was adopted, getting elude the typical convergence problems on simulation of nonlinear complex system. In order to build the surrogate model, a data set of objective function values for different combinations of decision variables was obtained using the EMSO Case Study tool, which carries out a global sensitivity analysis. The surrogate model parameters were estimated in EMSO using this data set. Only two cycles of optimization task were needed: a first surrogate model to reduce the feasible region and a second surrogate model (with updated model parameters) for increasing the accuracy. The optimal values for the decision variables were found by applying the interior point optimization algorithm built in EMSO. These optimal values for the decision variables were fed into the rigorous model for verifying that they really correspond to a maximum of the objective function in the rigorous model. A sensitivity analysis was performed with the rigorous model for testing the sensitivity of the objective function to variations on the decision variables apart from the optimum point, demonstrating that the iterative optimization procedure using the adaptive surrogate model was successful.

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Title: **Integrated system to perform surrogate based aerodynamic optimisation for high-lift airfoil**
Topic: **Optimization with Approximate Models**
Type: **ORAL**

Abstract:
The design of a high-lift system is vital for the success of a commercial airplane. Although the high-lift system is applied only during take-off and landing in the low speed phase of the flight the cost efficiency of the airplane is strongly influenced by it. The ultimate goal of an aircraft high lift system design team is to define the simplest configuration which, for prescribed constraints, will meet the take-off, climb, and landing requirements usually expressed in terms of maximum L/D and/or maximum CL. The aircraft high lift system designer is usually given a wing designed for cruise conditions. The maximum chord of the slat and/or flap(s) is usually dictated by the size of the wing box determined for structural and fuel capacity considerations. Therefore, very little leverage exists on the shape of these elements but more on the spacing with respect to each other (gap and overlap). The ability of the calculation method to accurately predict changes in objective function value when gaps, overlaps and element deflections are varied is therefore critical. The combination of complexity in flow physics, geometry, and system support and actuation has historically led to a lengthy and experiment intensive development process. However, during the recent past engineering design has changed significantly as a result of rapid developments in computational hardware and software. In aerodynamic design, computational methods are slowly superseding empirical methods and design engineers are spending more and more time applying computational tools instead of conducting physical experiments to design and analyse aircraft including their high-lift systems.
Despite advances in computer capacity, the enormous computational cost of running complex engineering simulations makes it impractical to rely exclusively on simulation for the purpose of design optimisation. To cut down the cost, surrogate models, also known as metamodels, are constructed from and then used in place of the actual simulation models. This work outlines the development of integrated systems to perform multi-objective optimisation for a three-element airfoil test case in high lift configuration, making use of surrogate models.
Five metamodeling techniques available in MACROS Generic Tools, which has been integrated in our design tool, have been compared based on multiple performance criteria. With MACROS is possible perform either optimisation of the model built with predefined training sample (GSO) or Iterative Surrogate-Based Optimization (SBO). In this first case the model is build independent from the optimisation and then use it as a black box in the optimisation process. In the second case is needed to provide the possibility to call CFD code from the optimisation process, and there is no need to build any model, it is being built internally during the optimisation process. Both approaches have been applied.
A detailed analysis of the integrated design system, the methods as well as the optimisation results of the comparison between the techniques is provided. The question of how design acceleration affects the design quality is also addressed.

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Title: **Minimum Energy Control for Fractional Discrete-Time Systems**
Topic: **Optimization with Approximate Models**
Type: **POSTER**
Abstract:
During last few years mathematical fundamentals of fractional calculus and general theory of fractional dynamical systems both continuous-time and discrete-time have been studied in many publications. On the other hand minimum energy control problem for various kinds of standard dynamical systems has been recently discussed in several papers and monographs. However, in the literature there are only few results on optimal control and minimum energy control problem for fractional discreten or continuous dynamical systems. Therefore, in the present paper minimum energy control problem for infinite-dimensional fractional discrete-time linear systems with multiple delays in control is considered.

Since generally the solution of minimum energy control problem is strongly connected with controllability concept, hence first of all necessary and sufficient conditions for controllablity of the linear fractional discrete-time system in a given finite-time interval are formulated and discussed. Controllability plays an essential role in the development of the modern mathematical control theory. There are important relationships between controllability, stability and stabilizability of linear control systems. Roughly speaking, controllability generally means, that it is possible to steer dynamical system from an arbitrary initial state to an arbitrary final state using the set of admissible controls.

Next, assuming controllability in a given time interval sufficient conditions for the solvability of the minimum energy control problem for the fractional discrete-time systems with multiple delays in control are formulated and proved. Using controllability operator for infinite-dimensional case or controllability matrix for finite-dimensional case theorems, which give analytic solutions for minimum energy control are formulated and proved. The form for minimum value of optimal control is also presented and discussed. Solution of minimum energy control problem depends on the inverse of controllability operator or in finite dimensional case on the inverse of controllabilibity matrix and on the initial state and given final state.

Numerical procedure for computation the optimal sequence of discrete-time inputs minimizing global energy of control in a given finite time interval is proposed. Possible practical applications, which illustrate theoretical considerations are also discussed. Finally, it should be pointed out that in the literature there are results concerning different kinds of controllability and minimum energy contro problems, which depend on the type of dynamical control system. However, to the best knowledge of the author the minimum energy control problem for the infinite-dimensional fractional discrete-time linear systems with delays has not been considered yet. It should be mentioned that presented method is quite general and my be exteneded to cover wide clas of fractional dynamical systems with delays in state variables.

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Title: **Two-dimensional Knapsack Problem using industrial robots**
Topic: **Optimization with Approximate Models**
Type: **ORAL**
Abstract:
This work is related with a famous problem of material cutting at a robotic environment. The problem is called two-dimensional non guillotine single knapsack problem (2D-SKP) and the environment is composed by a 6-DOF robot and a plasma cutting machine. Given a set of rectangular pieces and a single rectangular container, the 2D-SKP consists of orthogonally cutting a subset of the pieces within the container such that the sum of the values of the cut pieces is maximized. The solution of the problem must be communicated to the robot through a special code. This code must indicate the cutting points, trajectories, velocities and positions at a joint variables framework. To generate this code it was necessary to design the forward and inverse kinematic model for the robot.
In this paper we concentrate on development of the forward kinematic model for the HP20D manipulator of Yaskawa-Motoman. This model allows computing the position and orientation of the end-effector expressed in terms of joint variables. The solution procedure is presented with application of two Denavit Hartenberg conventions: classical and modified. The obtained model is validated through comparison of results in two scenes: (1) simulation of the robot based on the obtained model, (2) experimentation with the robot controller in Laboratory. The results compared are: position in Cartesian coordinates, orientation in rotation angles. The comparison allows confirming that the kinematic is correct. The model would be used as a component of an optimal automatic cutting system in the context of logistic operations.

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Title: **Extremum Seeking Optimization for Wastewater Quality Parameters**
Topic: **Optimization with Approximate Models**
Type: **POSTER**

Abstract:
Recent research efforts have been devoted to the improvement of carbon and nitrogen removal from wastewaters anaerobic-anoxic approach. The optimal operation of this kind of process is complicated to reach, mainly due to their highly nonlinear and unstable nature, inhibition by substrates or products and by the substantial unmodeled dynamics. In the case of fish processing industry, wastewater composition may vary widely depending on the mode of operation of the processing plants. It contains large amounts of biodegradable organic matter, mainly in the form of proteins and lipids and high levels of salts, especially when seawater is used in the processing. In addition, a high ammonia concentration is sometimes observed due to the high blood content of the wastewater. In this way, mathematical modeling, optimization and control are fundamental tools to optimally design and operate production facilities of such processes. This research proposes an extremum-seeking control based on periodic perturbation signals to maximize wastewater quality parameters in an anaerobic-anoxic reactor treating synthetic wastewater from a fish industry process. As a model-free real time optimization approach, extremum seeking is well suited for systems with unknown dynamics or those that are affected by high levels of uncertainty and or external dynamics. Thus, the method does not rely on the knowledge of system modeling parameters being robust to parametric uncertainties and unmodeled dynamics. In particular, extremum seeking does not merely monitor the direction of the output response but explores the measured response to estimate the gradient of the map and update the control input in proportion to the gradient of the map. Extremum seeking has the dual benefit of rigorously provable convergence and the simplicity of implementation, by employing only an integrator as well as optional high-pass and low-pass filters. For dynamic systems, it is enough to select the extremum seeking probing frequency reasonably smaller than the highest frequency that can pass the system without significant attenuation. This choice allows for the time-scale separation between plant and controller dynamics facilitating the convergence proof via singular perturbation and averaging theory. Anaerobic Digestion Model n. 1 (ADM1) has been traditionally used to represent carbon removal. This model takes into account seven bacterial groups. The biological degradation processes are described using Monod kinetics, while the extracellular processes and the biomass decay are described by using first order kinetics. Here, a modified version of ADM n.1 was used to represent simultaneous carbon and nitrogen removal in an anaerobic-anoxic reactor. This model was previously calibrated using experimental data from batch experiments of fish processing industry. Matlab/SimulinkR was used for all modeling and simulation. Highly nonlinear dynamics were observed for the models and practical local stability around to unknown optimal set-point was analyzed. Numerical experiments illustrate the effectiveness of the proposed approach.

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Title: **Cost Reduction for Nonlinear Systems Under Restrictions on the Manipulated Variables**
Topic: **Optimization with Approximate Models**
Type: **ORAL**

Abstract:
This paper describes a numerical scheme to approximate the solution of the optimal control problem for nonlinear systems with restrictions on the manipulated variable. The method proposed here systematically reduces the cost associated with successively updated control strategies after proposing an initial seed trajectory. It follows two main lines of reasoning, the first one relying on linearizations around a seed state/control trajectory and on exploiting a theoretical expression for the differential of the original cost functional. This setup is wholly valid in regular situations, but some of its features are also useful in many cases when saturations occur. One of its advantages is that the decreasing of the cost can be assessed without integrating the nonlinear dynamics numerically. An alternative approach is activated when saturations make the first scheme invalid and the cost ceases to decrease. Then a number of different perturbations of the current control strategy are generated and tested. Some perturbations are solutions of the differential Riccati equation for the linearized system and appropriate quadratic performances. Other variations, similar to those Pontryagin used in generating the final cone of states, are created by modifying the locations of switching-times, by introducing oscillations in the interior of regular periods, or by adding admissible changes on the control values during small subintervals of the time horizon. The results are illustrated by optimizing a pair of two-dimensional nonlinear systems with a scalar bounded control.

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Title: **FUZZY LOGIC MODELING AND OPTIMIZATION OF ENZYMATIC HYDROLYSIS OF LIGNOCELLULOSIC MATERIALS**
Topic: **Optimization with Approximate Models**
Type: **ORAL**
Abstract:
In recent decades there have been great advances in the production of bio-ethanol from lignocellulosic materials. In present are being installed industrial capacity plants, such as is the case of plant in Piracicaba (Brazil) of Raizen company. In this plant the bagasse of sugarcane is utilized for obtain bio-ethanol. Obtain a high conversion of carbohydrates in fermentable sugars, is critical to the success of this type of projects.
The combination of a dilute acid pretreatment followed by enzymatic hydrolysis has been the technology that more progress had in last years for decomposing the feedstock into fermentable sugars.
It is important to properly modeling these steps for performing an optimization process, since the conversion efficiency is determined mainly in the pretreatment and enzymatic hydrolysis stages.
The thermochemical pretreatments, such as dilute acid, have received many studies. Has been reported to the decomposition of the constituents of lignocellulosic materials follow first order kinetics in this type of process. In the literature there are several studies on the determination of decomposition rates for different materials of interest (Aguilar, Ramírez, Garrote, & Vázquez, 2002).
Moreover, the step of enzymatic hydrolysis has also received a large amount of research. In which is identified a large number of variables related to the performance of enzymatic conversion. Obtain a model that accurately represents the process of enzymatic hydrolysis of cellulose is a highly complex problem, because it includes a variety of phenomena (Bansal, Hall, Realff, Lee, & Bommarius, 2009).
There are two major groups of works on the enzymatic hydrolysis process. On the one hand, experimental work to determine conversion yields for certain raw materials and specific pretreatments. And on the other, they are works oriented to establish the relevance of the various phenomena in determining the enzymatic conversion under certain circumstances. But obtaining a general model is still distant.
Against this background is considered the alternative of modeling the enzymatic hydrolysis step using Fuzzy Logic. This tool has proven useful in the field of control of complex systems that do not have a suitable model (Gupta, Dey, & Sinha, 2012; Takagi & Sugeno, 1985). Fuzzy logic can utilize the knowledge of experts to determine what the system behavior and how to control it. An important aspect is that fuzzy logic allows working with certain levels of inaccuracies or ambiguities in the values of the variables of interest.
In this work is developed an optimization model of the stages of pretreatment and enzymatic hydrolysis of lignocellulosic materials. Using Fuzzy Logic for modeling the enzymatic process. Particularly are studied the case of treatment of sugar cane bagasse, using bibliographic information. The model was implemented in Matlab and the results have been compared with data reported in experimental researches.

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Title: **Walsh single shooting and multiple shooting to solve dynamic optimization problems**
Topic: **Optimization with Approximate Models**
Type: **POSTER**

Abstract:
Recent works have been focusing on adaptive parameterization algorithms applied to dynamic optimization problems. In particular, shooting methods have been deserved special attention. This paper addresses numerical improvements on discretization strategies for dynamic optimization. The proposed algorithm uses a parallel multiple shooting together with a Walsh adaptive refinement procedure which allow a sequential refinement of control variables. We compared our approach with a simultaneous dynamic optimization method. The results have evidenced that Walsh multiple shooting presents some advantages over single shooting and simultaneous approaches, e.g. lower computational cost, higher numerical stability and lower dimensionality.

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Title: **OPTIMAL DESIGN OF FUNCTIONALLY GRADED MATERIAL PLATE STRUCTURES**
Topic: **Optimization with Approximate Models**
Type: **ORAL**
Abstract:

This paper deals with the optimal design of plate structures made of functionally graded materials (FGM), which are characterized by a continuous variation of the material properties over the thickness direction achieved by mixing two different materials, metal and ceramic. The design of such structures is considered for static, buckling and free vibration objectives and constraints by using equivalent single layer discrete finite element models based on higher order shear deformation theories, which were previously developed for anisotropic composite laminated structures [1]. In the present work these models are extended to the analysis of thick to thin plate structures with functionally graded materials subjected to mechanical and thermal loads. The FGM developed finite element models are benchmarked to compare its predictions, accuracy and applicability and then gradient based [2, 3] and derivative-free optimization techniques [4, 5] are used to obtain the optimal solution of FGM plate type problems.

ACKNOWLEDGEMENTS
This work was supported by FCT, Fundação para a Ciência e Tecnologia, through IDMEC, under LAETA, project UID/EMS/50022/2013, and also CNPq, CAPES and FAPERJ, from Brazil.

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Title: **SOLVING POSITIVE DEFINITE TOTAL LEAST SQUARES PROBLEMS BY ORTHOGON DECOMPOSITIONSAL**
Topic: **Optimization with Approximate Models**
Type: **ORAL**
Abstract:
We consider solving an overdetermined linear system of equations with multiple right hand sides, where the unknown matrix is to be symmetric and positive defnite. Several algorithms exist for solving such problems when the data matrix and the right hand sides are assumed to be free of error. Here, we consider the more realistic case with the presence of error in data and present a new approach using a proposed error function to solve the resulting positive defnite constrained total least squares problem. The proposed approach makes use of orthogonal decomposition of the data matrix. We implement our method and present a comparison of our approach with the interior point method and a method based on quadratic programming. Using the Dolan-More performance profles, the experimental results show that the new approach is not only more effcient but also leads to smaller standard deviation of the error entries and smaller effective rank, as desirable features for control problems.

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Title: **Heuristics to solve the based fruit beverage lot-sizing problem**
Topic: **Planning**
Type: **ORAL**

Abstract:
This study deals with the planning and programming production problem of a based fruit beverage company. This is a two-stage lot sizing and scheduling problem (tank and machine stages) with some specific features, such as a production buffer between the stages and a periodic clean-in-place (CIP) in each stage. These features make this problem different of other beverage problems and includes additional difficulties to solve it.
In the literature we have not found any paper that integrates lot-sizing decisions with periodic maintenance (CIP) in the context of beverage industry.
Lot sizing and scheduling problems are classified as NP-hard and because of the sizes of the real problem instances, two heuristics are proposed here, called H1 and H2. The goal is to find good solutions in reasonable times, because in the company practice the time spent to find a feasible production plan exceeds two hours.
These heuristics have two main steps. In the first, a mathematical model representing one of the stages is solved and its result is used in other step. In which a constructive phase synchronizes production with the other stage. Capacity constraints are verified , if the whole plan is feasible then the procedure stops. Otherwise, the reduction in the capacities are imposed and the heuristic runs again.
The first step mathematical model aims to optimize the bottleneck stage, while the second step construction phase intends performs the synchronization between the stages. In the H1 heuristic the mathematical model optimizes the tank stages and in H2, the model optimizes the machine stage.
Computational tests were performed with generated instances based on real data. The results show that the heuristics are effective and fast, compared to the company solution. When comparing to the two heuristics, H2 shows better performance in terms of solution quality and run time.

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Title: **Design of a linear-goal programming model for the dairy production planning of medium-sized farmer**
Topic: **Planning**
Type: **ORAL**
Abstract:
The dairy industry in Paraguay is an important sector of national production for their implications for employment generation, food security and rural producer rooting through income generation. This industry is dominated by cooperatives in Paraguay, and private equity firms engaged in the production of milk and dairy products, mainly in the Central Chaco region and in Central and South Eastern Region of the country. This study proposes the development of an optimum production plan for a medium-sized dairy farmer that produces and sells raw milk, based on the design of a linear programming model considering goals proposed in making management decisions. In the proposed mathematical model, operations are represented by a set of constraints that connect the decision and deviation variables, and parameters. The deviation variables are evaluated in the objective function in stages and according to the priorities set by the owner of the dairy to each goal, i.e. lexicographical way: an optimization after another and incorporating the above solution to optimize each model. Insemination operations and purchase of productive cows are considered in the design, as well as the needs of food and milk, taking into account the reproductive cycle of a number of dairy cows, in a 2-years time horizon. The goals we want to accomplish are linked to the planning of establishment production, as the total satisfaction of demand, not exceeding the annual budgets to purchase productive cows for replacement herd cows, not to be exceeded annual purchase budget of food needed for the nutrition of animals according to their status in the production cycle, not exceeding the capacity of milking establishment and not exceeding the capacity of productive cattle pens.

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Title: **Design of an annual plan of harvest and storage of fruit and vegetable through an optimization model**
Topic: **Planning**
Type: **ORAL**
Abstract:
In Paraguay the agriculture is considered important for the economic development of families. Fruit and vegetable production represents 32% of the value of national production in monetary terms, and is developed by family farmers, to which 83% of national production farms belong. This research is focused on generating a plan for harvesting and storage for a group of producers in Aveiro Company of the city of Ita, by designing a mathematical model based on linear programming (LP). On the studied farms are not performed proper planning of harvesting crops, making it difficult for producers to determine accurately the financial resources and materials to be used in agricultural activities. To satisfy demands, decisions regarding the allocation of greenhouses for continuous production and in seasons with unfavorable climate for the development of crop production are necessary. The interest of the study on the optimization of the harvest and management of resources for fruit and vegetable production, mainly because the country is still using traditional production systems, which do not account for planning short and medium preserved term agricultural operations and product availability for timely commercialization. The main variables to generate an annual optimal plan are related to the amounts and periods of harvest of various items produced - tomato, pepper, melon and cucumber - as well as a plan of purchasing and inventory of resources used for conditioning. Alternative installation of greenhouses for the associated production and temporary storage of products was taken into account to achieve the levels of satisfaction of demand. The restrictions deemed essential for operational activities were the product levels in plot for each period, the harvest capacity in each farm crop and greenhouse, proportionality in the associated sale according to each individual production capacity, and purchase and storage capacity of products and resources.

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Title: **A multi-period programming model for the production optimization of a polyurethane foaming plant**
Topic: **Planning**
Type: **POSTER**
Abstract:
This work presents a multi-period production planning model for the simultaneous optimization of the manufacturing process and the stock management of a polyurethane foaming plant.
The basic stages of the plant consist of the blooming process that produces polyurethane foam pieces with certain characteristics such as density and dimensional features, and the curing stage that involves the location of these pieces in a limited area during certain time such that the produced blocks attain the required properties: temperature, rigidity and stability. After this time, the blocks get the necessary conditions to be stored and further processed.
A single foaming machine is used for producing the polyurethane blocks of different densities and dimensions and a long setup machine is required between width changes. The objective function considers the cost of the set up involved, mainly labor cost, when a change of width is required from one day to the other. Also a loss of material occurs when a transition of densities is presented. This cost is included in the objective function. In summary, the model performance measure takes into account the cost of width and density changes in the production plan and penalizes unsatisfied demand and unfulfilled safety stock.
Due to the volume of the foam pieces and the limited area of the curing step and the final storage, an efficient stock management is crucial in order to minimize costs and satisfy demand; and that is the reason to include those decisions in the production planning model. As it was mentioned, a multi-period approach is considered where the production requirements based on the estimated demand are known. The proposed model provides a detailed production program for a set of days selected by the manager, while a more general plan is obtained for the rest of the days of the planning horizon, in an overall multi-period formulation.
The detailed program includes information about how to place the foamed blocks in the curing area taking into account precedence constraints. The purpose of the first part of the plan is to facilitate the production decisions on the plant floor considering all relevant constraints involved in the process. On the other hand, the approximated production plan, determined for the rest of the days in the planning horizon, gives information to estimate raw material purchases, labor requirements and operational costs, among others. In addition, for each day in the planning horizon, the model determines the blocks to be foamed and the inventory management.
Several relations among the problem stages and the involved decisions are assessed; therefore a Generalized Disjunctive Programming (GDP) approach allows a clear outline of the simultaneous optimization problem. GDP provides a quantitative and qualitative framework to formulate the problem and their relationships in a natural way. Different study cases are solved which represent typical plant floor scenarios and their solutions are compared, in order to assess the model capabilities and facilitate the decision-making of the company.

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Title: **Optimal Allocation of Gathering Centers for Glass Containers**
Topic: **Planning**
Type: **ORAL**
Abstract:
In Paraguay, recycled materials that are treated and sent to transform them into new products reached in the last years 12% of all the waste. This value is achieved by precarious separation processes of marketable recycled materials, made by informal workers, in landfills. Regarding waste management from the cities of Asunción and Gran Asunción (composed of 19 municipalities), have not implemented programs to reduce and/or source separation of waste generated, only there are a few separation and recycling programs of certain materials with little impact in comparison to the volume currently generated. In this regard, any municipality performs selective waste collection, so transportation and management is made completely mixed and contaminated, significantly limiting the possibility of a subsequent effective removal process. If source separation and selective collection is achieved in a consistent way, significant savings would be obtained in the medium and long term for municipalities and will generate greater social and economic impact on the beneficiary population, since this is related to saving water, energy and raw materials for the recycling industry and thus involves matters, the return of recovered raw materials to the manufacturing process. Currently, just one company uses recycled glass for the production of glass bottles in the country: Paraguayan Glass Factory (FPV S.A.). The main objective of this work is the strategically placed of gathering centers for one of the highly recyclable materials, glass, in Asunción and Gran Asunción, using a combinatorial optimization model so, to allocate discarded glass containers in these cities to the collection centers in order to reach a volume that allows operation meet the demand for recycled glass of FPV S.A. at the lowest operating cost. Given this scenario, the model to be addressed, is an allocation problem with characteristics of materials transport and transshipment, and production planning.

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Title: **RELIABILITY BASED STRUCTURAL TOPOLOGY OPTIMIZATION SUBJECT TO STRESS CONSTRAINTS**
Topic: **Reliability-Based Design Optimization**
Type: **ORAL**
Abstract:
In this paper we propose a new approach for reliability based structural topology optimization problems under stress constraints. Thanks to the Sequential Optimization and Reliability Assessment approach, the problem can be decoupled into a deterministic topology optimization step and a reliability analysis step. This procedure allows us to use topology optimization algorithms already developed with only small modifications. Here, the deterministic structural topology optimization problem subject to stress constraints is addressed with an efficient algorithm based on the topological derivative concept and a level-set domain representation method. The reliability analysis step is handled as in the Performance Measure Approach. The resulting alternative algorithm is applied for solving some benchmark problems, showing the efficiency and robustness of the proposed approach.

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Title: **An approach for the robust design of friction damper passive control systems**
Topic: **Reliability-Based Design Optimization**
Type: **ORAL**
Abstract:
It is known that the use of passive energy dissipation devices, as friction dampers, reduces considerably the dynamic response of a structure subjected to earthquake ground motions. However, the parameters of each damper as well as the best placement of these devices remain difficult to determine. Thus, in this paper, robust design optimization of friction dampers to control the structural response against earthquakes is proposed. In order to take into account uncertainties present in the system, some of its parameters are modeled as random variables, and consequently, the structural response becomes stochastic. To perform the robust optimization of such system, two objective functions are simultaneously considered: the mean and variance of the maximum displacement. This approach allows finding a set of Pareto-optimal solutions. A genetic algorithm, the NSGA-II (Nondominated Sorting Genetic Algorithm), is applied to solve the resulting multi-objective optimization problem. For illustration purposes, a six-story shear building is analyzed. The results showed that the proposed method was able to reduce the mean maximum displacement in approximately 70% and the variance of the maximum displacement in almost 99% with only three dampers.

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Title: **Portable electronic nose applied to determination of contaminants in milk**
Topic: **Artificial Intelligence and Neural Networks**
Type: **POSTER**

Abstract:
Milk is one of the most consumed foods in the world and one of the most likely to suffer adulteration by adding water or even chemical substances which represents a serious risk to consumer health, due to this the development of more effective tools for the analysis of milk has been the subject of constant studies. Among the characteristics of milk, the aroma is one of the most important and can say much about the quality of the product. The electronic nose has demonstrated to be a promising tool for the analysis of flavorings and similar to human olfaction, it uses an array of chemical sensors with partial selectivity associated with pattern recognition powerful techniques, among them the artificial neural networks have shown satisfactory performance and efficiency, being the most used for discrimination of aromatic profiles. This paper presents the performance of a portable electronic nose designed for the quality evaluation of milk when it is subjected to adulteration by chemicals such as formaldehyde, sodium hydroxide and urea, the differential of this device compared to hallowed techniques of physicochemical analysis is the possibility of obtaining real-time response and adds portability, low cost and simple interface. For two months we analyze five commercial brands of milk and from these, samples were separated containing different proportions of the contaminants cited, altogether 40 samples were analyzed. For the recognition and classification of each contaminant we use a neural network Multilayer Perceptron, in addition, other techniques facilitated the development of neural network such as the bootstrap resample used to create a network training data set from the original samples, network parameters were adjusted using sequential simplex optimization and the reliability of the results was analyzed through statistic tools. The neural network showed satisfactory performance recognizing all contaminants from the set of test samples constituted only by the original samples, samples used for training obtained from the bootstrap, 95% were correctly classified as 97% of validation samples, this demonstrates that the network is able to learn to identify the aromatic profile of each contaminant. The advantage observed by the incorporation of artificial neural networks to the electronic nose is the possibility to circumvent the effects of noisy signals and interferences which the electrical measurements are subject. This is the first time that the electronic nose is applied to discrimination milk when subjected to adulteration by various types of contaminants which makes it an innovative tool for the dairy industry.

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Title: **A Practical Methodology for Path Planning from CAD and CAE Data**
Topic: **Robotics**
Type: **ORAL**
Abstract:
Industrial robots are widely used for automation of processes in every industry. Its implementation has helped to increase speed in serial production. However, emerging manufacturing paradigms like Flexible Manufacturing Systems (FMS) and batch production, demand faster programming of industrial robots. The constant change of workpieces in these manufacturing systems become a challenge for the programming of industrial robots into these kind of processes. A tool to overcome this, is the off-line programming. There, in order to program faster with this method is necessary to define a path for each workpiece, so that the robot end effector can follow it through trajectory planning. In this paper an approach for path planning based on Computer Assisted Design (CAD) and Computer Aided Engineering (CAE) will be described. Some experiments over different kind of surfaces like flat and regular volume profiles are performed to test this approach.

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Title: **Robust management in reservoir engineering problems**
Topic: **Robust Design**
Type: **ORAL**
Abstract:
Reservoir simulation is used extensively to identify opportunities to increase oil production in heavy oil reservoirs. In this scenario water flooding (WF) is one the most common used method to improve oil recovery after primary depletion. The management of the field can be formulated as an optimization problem in which the rates in the producers and injectors wells as well as the duration of control cycles are to be obtained fulfilling specific constraints.
Traditionally, reservoir management is based on a production forecast from a single (deterministic) reservoir model. However, in the real world, uncertainty and randomness are prevalent in the context of reservoir management due to the lack of accurate petrophisics data such as permeability and porosity fields among other uncertainty sources.
Moreover, it is well known that optimization under a deterministic approach generally leads to a final design whose performance may degrade significantly and or a design that can violate constraints because of perturbations arising from uncertainties. In this scenario a better target, one that provides an optimal design and gives a high degree of robustness, is indicated. That is a feasible design which is relatively invariant with respect to changes in uncertain parameters. The process of finding such optimum is referred to as Robust Design Optimization (RDO), in which feasibility improvement and variability reduction in the performance are the targets.
Several robustness measures have been proposed in the literature, in particular, the expected value and standard deviation are considered here. When these two robustness measures are combined it follows that the mathematical formulation of the RDO problem emerges as a multiobjective optimization problem, in which, both the expected value and the standard deviation of the output of interest have to be optimized In addition to that, the robustness in terms of feasibility conditions could also be taken into account, considering the variability for some of the constraints.
In Reservoir Egineering, most of the reported robust works are formulated based on a single-objective optimization, commonly in terms of net present value (NPV). Also, the optimization strategies of water-flooding often lack robustness to geological uncertainties. The present work focuses on the development of a computational tool to obtain robust reservoir management in the context of RDO problem.
However, the consideration of the rock properties along every cell of the numerical model that represents the reservoir as uncertain variables would lead to an unfeasible large number of variables and consequently, a difficult problem for uncertainties quantification. To overcome that, some form of petrophisics parametrization has to be employed. In this paper we will investigate two techiniques. They are: kernel Karhunen– Loève expansion (KKLE) and Isomap technique.
In this work the stochastic responses of interest are calculated by Monte Carlo method and also by the point collocation method.
The black oil model is used in this paper, and simulations are made by the IMEX commercial simulator from CMG. If necessary, surrogate models based on kriging data fitti

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Title: **Robust Network Routing and p-Cycle Protection under Hose Traffic. An Optimization based on Genetic Algorithm**
Topic: **Robust Design**
Type: **ORAL**

Abstract:
The complex problem of designing communication networks requires the study of sub-problems as the physical and/or virtual topologies design, location resource links and nodes, the unicast and multicast routing, and protection against link failures. This problem is more complex in the presence of dynamic and uncertain traffic leaving evidence of the importance of network design in a context of robustness.

This paper approaches the next problems simultaneously: (i) design: optimal resource allocation in links, (ii) management: optimal flow assigning under splittable traffic, (iii) and survivability: protection against single link failure. Given the importance and complexity of the problem of robust network design, this paper proposes an approach based on Genetic Algorithms (GA) that seeks to minimize the cost of design subject to protection against single link failure. In this sense the designed network is ready to support single link failures and traffic pattern changes subject to the traffic hose model.

Given a set of k routes for each pair of network nodes, the problem of optimal allocation of resources is solved initially allocating a percentage of traffic flow for each path and then the worst traffic case scenario for each link is calculated subject by traffic hose model. The problem of link-fault tolerance is based on preconfigured protection cycles (p-Cycle) that offers share resources redundancy. The proposed GA allows to optimize the distribution of flows traffic between pair node in order to minimize the network cost as well as the cycles of protection against single link failure.

The results allow to conclude that the traffic distribution with k = 2 routes between pair node gives excellent results, and to use values greater than 2 takes longer time to find the results because the set of solutions is growing rapidly. With regard to the cycles protection, the results indicates that the cost of its implementation is quite high compared to a design without protection.

Keywords: Robust Networks, Uncertainty, Hose Traffic, Single Link Failures, Protection, Network Design, Genetic Algorithm

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Title: **Optimal lot-sizing and scheduling of multistage batch plants considering multiple orders per product**
Topic: **Scheduling**
Type: **ORAL**
Abstract:
In the process industry, batch production systems provide greater flexibility since a large number of products can be elaborated using the same equipment. In these facilities, products compete for the use of the resources required for manufacturing, such as processing equipment, storage tanks, utilities, raw materials, etc. and consequently the production scheduling plays a crucial role in this type of industries. Several modeling approaches and solution strategies for the scheduling problem of batch facilities have been addressed in the last decades, however the mathematical programming has become one of the most widely explored methods for solving this problem.
Batch scheduling is a highly combinatorial problem involving two issues: the lot-sizing or batching problem, which defines the set of batches to be scheduled and their sizes, and the short-term scheduling problem, which determines the assignment, sequencing and timing of the selected batches.
In sequential production environments, for complexity reasons, the whole problem has been traditionally solved in a hierarchical manner, where the batching is solved first to define the number and sizes of batches, and the short-term scheduling problem is later solved for determining when and where the pre-defined batches are to be produced. That is, orders are first divided into batches according to unit capacities, and then these batches are used as inputs in the scheduling problem. Although this typical sequential procedure is generally used in practice and academia, the quality of the production schedule is indeed highly dependent on the lot-sizing decisions already taken. Furthermore, in these optimization methods, a common assumption is to consider fixed processing times, irrespective of the corresponding batch sizes, which is not always valid depending on process specifications. Thus, batching and scheduling must be simultaneously considered in order to achieve appropriate and efficient solutions.
In recent years, attention has been paid to the development of integrated optimization models for simultaneously solving both problems. In the literature, a few works with this approach have been presented.
In this work, a mixed-integer linear programming (MILP) formulation for the simultaneous batching and scheduling in multistage multiproduct batch plants with nonidentical parallel units is proposed. The slot-based model considers multiple orders per product with different due dates, variable processing times, zero-wait (ZW) transfer policy, and sequence-dependent changeover times. An order may be fulfilled by one or more batches, therefore, an appropriate number of batches must be proposed for each order with the purpose of ensuring optimality of the solution. The goal problem is to determine (a) the number and size of batches for each customer order, (b) the assignment of batches and their sequence on each unit, and (c) the timing of selected batches. The model is flexible to accommodate different objective functions, such as earliness, makespan, and processing costs. Different examples are presented in order to highlight the application and performance of the proposed algorithm.

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Title: **Optimization Of AirTransport System In Offshore Platforms**
Topic: **Scheduling**
Type: **POSTER**
Abstract:
The transport of people for offshore platforms is accomplished through sea and air modal, the latter is predominant, given its speed, flexibility, comfort and cost benefit. This work aims to optimize the helicopters routing with specificity of human transport to offshore platforms, implementing a mathematical model in order to minimize transportation costs and to accomplish the demand of people boarding and landing offshore platforms, at the predetermined time. It was developed a mathematical model of Mixed Integer Linear Programming (MILP), implemented in the GAMS software (General Algebric Model System) and solved by CPLEX solver, which uses the branch-and-bound method. The results obtained show that the mathematical model developed proved to be effcient, reaching the proposed objective.

Authors:
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Title: **Crude oil scheduling including the pipeline schedule connecting terminals and in-land refineries**
Topic: **Scheduling**
Type: **ORAL**
Abstract:
Scheduling involving the crude oil supply is one of the most challenging problems in a refinery plant. The crude oil scheduling is of great importance to ensure that distillation columns operate continuously and the quality of the crude mix always lies within desired range to meet operating constraints and at the same time guarantee high profitability of the process. Across the years, a great number of studies concerning the crude oil scheduling problem have been proposed in the literature. However, time and logistics involving the crude transfer between terminals where the crude oil is unloaded and the in-land refineries is generally neglected in these works. In the present work, the pipeline connecting a terminal and an in-land refinery is included in the crude oil scheduling model. Three cases studies were considered in order to study the behavior of the system with different infrastructure, namely: a single shared pipeline between storage tanks and charging tanks, two shared pipelines between storage tanks and charging tanks. Finally, a special case was also studied in which a short pipeline connecting vessels and storage tanks is also considered to capture the cases where the crude volume retained in that pipeline cannot be neglected. The models resulted in MINLP problems due to the tracking of mixture qualities throughout the resources, which were implemented in the GAMS system and solved with DICOPT. For the three studied cases, the objective function was to maximize the gross profit margin. A comparison analysis of the results generated considering instantaneous transfer and the shared pipeline is carried over to show the impact on the optimized solutions.

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Title: **Sensitivity analysis of water stage and pollutant concentration profiles for an open-channel course**
Topic: **Sensitivity Analysis**
Type: **POSTER**
Abstract:
For many years researchers have been interested in modeling the transport of pollutants, which could endanger the ecosystem and peoples' health if released to a water course. In most cases, interest is focused on forecasting the peak concentration that would occur at particular locations, the arrival time of the peak and the occurrence and duration of dangerous pollutant levels.
In this work, estimations of flow profiles are obtained as a first instance, in order to understand wave routing. The equation of advection-diffusion is considered to represent mass transport in flowing water and a 1D model of the channel and is presented for a given geometry and flow characteristics. By solving the model, the pollutant peak and level concentration over the whole cross-section of the channel are estimated. As expected, different temporal concentration profiles of the transported pollutant in the water course are obtained, which depend upon the duration and form of the substance release, its flow rate and the diffusion coefficient. Afterwards, a sensitivity analysis is pursued, thus observing the behavior of the system when the values of the channel roughness, slope, width and pollutant inflow rate are modified. The proposed model is solved by means of the optimization software GAMS, using the finite differences method. This strategy proves to be resource and time-efficient, and allows obtaining flow and concentration profiles for multiple feasible scenarios, and will be used as starting point for determining critical distances in the case of a natural or accidental pollutant release, where the substance concentration may result detrimental for the wellbeing of the ecosystem and surrounding human population.

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Scenna, Nicolás - [Universidad Tecnológica Nacional] - ARG
Santa Cruz, Alejandro - [CAIMI] - ARG

Title: **Is it possible to tune a drum?**
Topic: **Shape Optimization**
Type: **ORAL**

Abstract:
It is well known that the sound produced by string instruments has a well defined pitch. Essentially, this is due to the fact that all the resonance frequencies of the string have integer ratio with the smallest eigenfrequency. However, it is enough to use the Ashbaugh-Benguria bound for the ratio of the smallest two eigenfrequencies to conclude that it is impossible to build a drum with a uniform density membrane satisfying harmonic relations on the eigenfrequencies. On the other hand, it is known since the antiquity, that a drum can produce an almost harmonic sound by using different densities, for example adding a plaster to the membrane. This idea is applied in the construction of some Indian drums like the tabla or the mridangam. In this work we propose a density and shape optimization problem of finding a two-density membrane that satisfy approximate harmonic relations of some eigenfrequencies. The problem is solved by a domain decomposition technique applied to the Method of Fundamental Solutions and Hadamard shape derivatives for the optimization of inner and outer boundaries. This method allows to present a new configuration of a membrane for which the first 21 eigenfrequencies have approximate six harmonic relations, involving some multiple eigenfrequencies.

Authors:
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Title: **Sizing optimization of frame structures subjected to dynamic stress constraints**
Topic: **Size Optimization**
Type: **ORAL**
Abstract:
Gradient-based optimization of real-world structures subjected to dynamic loading (e.g. offshore jackets) is a challenge due to the computationally expensive transient analysis and corresponding design sensitivity analysis [1, 2]. Transient sensitivity analysis is necessary for constraints on structural criteria, such as stress and displacement constraints. For example, in contrast to static problems, stress constraints need to be enforced over the entire time span of the applied loads. Even for small time spans, this can rapidly result in an intractable number of constraints and large memory requirements. The aim of our research is to develop special purpose numerical optimization techniques that can effectively handle a prohibitive number of time-dependent stress constraints.

We consider sizing optimization of 3D frame structures subjected to many dynamic loadings O(1e3), and each loading is obtained from a 10-minute time series simulation.The structures consist of tubular members, modeled by Timoshenko beam elements, and the transient response of the structure is obtained by performing a dynamic analysis. The optimization problem is to minimize the mass subject to local dynamic stress constraints with the thickness and diameters of the members as design variables. The considered optimization problems are characterized by the fact that the number of nonlinear constraints of order O(1e10) greatly exceeds the number of design variables O(1e1).

In order to deal with the large number of constraints, we propose solving a sequence of reduced optimization problems solved to optimality using an interior-point solver (e.g. Ipopt [3]). Every reduced optimization problem considers only a subset of critical stress constraints at specific locations and time intervals. This subset is selected by performing a full analysis before solving every reduced optimization problem. Every stress constraint at a spatial and temporary location that enters the subset remains part in all subsequent optimization problems; i.e., the initial subset increases gradually until it includes all critical stress constraints. The dynamic analysis in every reduced optimization problem only considers dynamic load cases associated with the subset of critical stress constraints. It is expected that the reduced analysis in combination with the active set strategy greatly reduces the computational costs and required memory storage, and consequently, makes the problem tractable. The capabilities of the method are demonstrated by performing optimal design of 3D frame structures.

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Authors:
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Title: **Adhesion: Model Calibration and Validation**
Topic: **Solid Mechanics**
Type: **ORAL**

Abstract:
This paper presents a strategy to be used for validation of adhesion models. The classical cohesion adhesion model is considered here. The first part of the work constructs the search for information of model parameters as a Statistical Inverse Problem. The posterior densities of model parameters are explored using Population Based Markov Chains along with an Adaptive Metropolis sampler.
Some experimental results from ten test specimens are presented to assess the effectiveness of the present approach. Six of the test specimens are used for model calibration and the other four are used for model validation. The model validation results are quite compelling inasmuch one can predict the maximum adhesion force with a significant level of accuracy.

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Title: **A FEMU METHODOLOGY TO OBTAIN MATERIAL PARAMETERS FOR THERMOPLASTIC MATERIALS**
Topic: **Solid Mechanics**
Type: **ORAL**

Abstract:
Necking formation on thermoplastic materials presents a particular heterogeneous strain field that, as pointed out by many authors, may mask the real mechanical response of the material. The necking may propagate to the entire specimen when submitted to finite strain. Moreover, the mechanical response of thermoplastics is highly dependent of the strain rate. These issues incorporate difficulties on the identification parameter procedure. Usually, only the force information from a monotonic experimental testing may be not sufficient to characterize the mechanical response of the material and the kinematic behavior of the necking region. Then, in order to determine the material parameters for a constitutive model capable to represent the realistic behavior of these materials, suitable characterization techniques should be employed. In this work, a numerical-experimental characterization is presented to obtain material parameters from a nonlinear thermoplastic submitted to large strains. The proposed characterization is based on a FEMU methodology that take into account the experimental mechanical response of force, obtained from a uniaxial tensile test, and the localized displacements of the necking region, obtained from optical measurements. Experimental tests are performed on polyvinyl chloride (PVC) specimens in order to obtain the typical force and displacement curves. Furthermore, Digital Image Correlation technique is used to provide the displacement field from the necking region. Constitutive models for nonlinear elastoplasticity materials are implemented on a finite element code that provide the numerical mechanical response of force and the displacement field on the necking region. The numerical and experimental data of force and localized displacement are used to define a particular objective function. Finally, the parameters of the material model are determined by an optimization procedure using a hybrid methodology that combines genetic and gradient based algorithms. The results shown that this methodology is capable to take into account force and kinematic responses into an identification parameters procedure. Also, for the material models studied, only the force data is not capable to capture the kinematic behavior observed experimentally, pointing out that experimental information of the necking region is necessary.

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Title: **STRUCTURAL OPTIMIZATION AND MATERIAL FITTING OF A MATERIAL WITH INHERENT BISTABLE ELEMENTS**
Topic: **Solid Mechanics**
Type: **ORAL**
Abstract:
It is known from the literature that extreme damping can be achieved in materials incorporating negative stiffness inclusions. In this paper polyethylene foam sheets are utilized as a base material and a negative stiffness component is supplied by an inherent bistable element introduced by additional cuts. In order to optimize the arrangement, position and shape of these cuts for vibration damping, a suitable material model must be chosen. Then the optimization can be carried out by finite element software accompanied by a suitable optimization algorithm.
Several experimental tests were performed on the base homogeneous material specimens (BM) and on the plates with cuts - Structure with inherent, periodically distributed, bistable elements (SIBE) - under unilateral tension, compression and cyclic loads using a universal testing machine. It was concluded that the material model must account for orthotropy, highly compressible hyperelasticity and non-linear viscoelasticity. There is moreover different behaviour in tension and in compression, acting in an opposite way than in a typical hyperelastic material, i.e. BM is stiffer in tension and softer in compression. Tests on SIBE also revealed that the number of tests affects the length of the additional cuts which is reflected in the effective behaviour.
Fung orthotropic foam was selected as a main material model. Viscoelasticity was added by Prony series and behaviour in tension and compression was controlled by internal state variables specified in user defined subroutines implemented in software ABAQUS. First of all material fitting was carried out on BM. Reference time dependent displacement and lateral strain curves were obtained from averaged values given by 2D digital image correlation VIC 2D from Correlated Solutions and material parameters were obtained by Matlab curve fitting procedure.
Regarding the SIBE specimens, 2D and 3D results from digital correlation were used to track numerical representation of the displacement controlled test in ABAQUS, with back-loop of adjusting the material parameters. 3D digital image correlation results were obtained by the four-camera system Dantec Dynamics Q-400, GenTL/GenICam at NTIS. 2D digital image correlation results were obtained by VIC 2D from Correlated Solutions at IDMEC. The authors acknowledge these institutions to make available these equipments. J. Heczko and L. Lobovský were supported by the project LO1506 of the Czech Ministry of Education, Youth and Sports. Project UID/EMS/50022/2013 is appreciated by Z. Dimitrovová and H. Rodrigues. Moreover, the work developed by the first author was sponsored by SFRH/BSAB/113776 attributed by Fundação para a Ciência e a Technologia in Portugal.

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Title: **Adomian Decomposition Method applied with Newton's Method for fiber orientation optimization in thin plates submitted to linear bending**
Topic: **Solid Mechanics**
Type: **ORAL**
Abstract:
The aim of this paper is the development of a mathematical tool for improving the fiber orientation optimization process in symmetric laminated thin plates submitted to a linear bending. Together with the Newton's Method, the Adomian Decomposition Method is considered so as to determine the ABD matrix in a way which gives flexibility to derive the project variables' first and second derivatives. With it, not only can the stacking be modified but also can the fiber orientation be alter, in a very straightforward form. As a result, the computational costs can be reduced, even in problems with a high number of project variables. Due to the recursive nature of Adomian's Method, the modified system uses information of the iteration to accelerate the optimization process. The obtained results are discussed and compared to those found in the literature. Given the non-linear nature of Adomian's Decomposition, achieved results in this paper might be applied to non-linear laminated plate's bending.

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Title: **Free material optimization using FDIPA-GSDP, a feasible directions method for general SDP**
Topic: **Solid Mechanics**
Type: **ORAL**
Abstract:
Free material optimization or FMO involves a class of structural optimization problems that looks for the best material proprieties distribution for a given objective function and mechanical constraints. In particular, we are interested in the lightest structure that satisfies stress, displacement and fundamental frequencies constraints. In consequence, our design variables are the elasticity tensor for a linear elastic material. For physical reasons, this tensor must be symmetric and positive definite.

We propose an optimization model for this problem that involves nonlinear constraints and also semidefinite conditions on the elasticity matrices. Based on the finite element method, the objective function and the constraints are computed and the sensitivity analysis is performed.

FDIPA-GSDP, that is based in the well-known FDIPA, and is used to solve our optimization model. One of the advantages of FDIPA-GSDP is that all iterations are feasible. We need positive definite material matrices to have a regular equilibrium equation. FDIPA_GSDP solves two large linear systems at each iteration. We propose a formulation that makes their solution computational tractable for large real size problems.

Test problems are solved with this new formulation and compare the results with open source software obtaining faster computing results. Large size FMO problem is also solved very efficiently.

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Title: **Multi-objective optimization of intensified separation sequences using a hybrid DE method:**
Topic: **Space Industry and other Industrial Applications**
Type: **POSTER**
Abstract:
Multi-objective optimization of intensified separation sequences using a hybrid DE method: Performance of separation efficacy and costs

C.L. Salas-Aguilar & A. Bonilla-Petriciolet
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ABSTRACT: The distillation process is a separation technology widely used in the chemical industry. This process is characterized by low energy efficiency. Some alternative for solving this problem is the use of in-tensified separation schemes that include less energy requirements. However, the main problem in the design of these processes is that the available methods for process design are incapable of determining reliably the optimum design parameters for the operation of these processes. In addition, the thermodynamic performance of these systems, in terms of separation efficacy, cannot be established a priori and this performance metric is highly depended on the process operating conditions. In this study, we have performed the process design of multicomponent intensified separation schemes using a multi-objective optimization approach. A hybrid Dif-ferential Evolution (DE) method has been used for the simultaneous optimization of two objective functions of the intensified separation process: the thermal load of the process and the purity of one key component in the mixture. Intensified separation schemes have been obtained from nonsharp distillation sequences for ternary mixtures. Pareto fronts for different separation schemes have been obtained and a per-formance analysis has been conducted for identifying the design parameters of these separation schemes. Re-sults from the simulation of intensified processes have been compared with those obtained for conventional distillation systems. Finally, the optimization approach used in the present study is useful to enhance the performance of intensified separation process by offering different design parameters that help to minimize ener-gy consumption and to maximize the purity of desired product. Pareto fronts can be also used in the character-ization of design behavior for the intensified distillation systems.

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Title: **Decentralized strategies for ill posed inverse problems**
Topic: **Tomography**
Type: **ORAL**
Abstract:
Most if not all the mathematical formulations of inverse problems (a.k.a. reconstruction, identification, data recovery, non destructive engineering,...) are known to be ill posed in the Hadamard sense. The main reason for this is that in general inverse problems try to fulfill (minimize) two or more very antagonistic criteria. One classical example is the Tikhonov regularization, trying to find artificially smoothed solutions close to naturally nonsmooth data. We consider here the theoretical general framework of parameter identification coupled to -missing- data recovery. Our aim is to design, study and implement algorithms derived within a game theoretic framework, which are able to find, with computational efficiency, equilibria between the "identification related players" and the "data recovery players". These two parts are known to pose many challenges, from a theoretical point of view, like the identifiability issue, and from a numerical one, like convergence, stability and robustness problems. These questions are tricky and still completely open for systems like e.g. coupled heat and thermoelastic joint data and material detection.
We shall present first theoretical and numerical resuts, which illustrate the efficiency of our approach, applied to second order linear elliptic Cauchy problem and to the linear elasticity model.

Authors:
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Title: **TOPOLOGICAL SENSITIVITY ANALYSIS FOR CONTACT PROBLEMS IN ELASTICITY WITH GIVEN FRICTION**
Topic: **Topological Derivatives and other techniques**
Type: **ORAL**
Abstract:
The topological derivative is defined through a limit passage when the small parameter governing the size of the topological perturbation goes to zero. Then, it can be used as a steepest-descent direction in an optimization process like in any method based on the gradient of the cost functional. In this paper, we deal with the topological asymptotic analysis in the context of contact problems with given friction. Since the problem is non-linear, the domain decomposition technique together with the Steklov-Poincaré pseudodifferential boundary operator are used for asymptotic analysis purposes with respect to the small parameter associated with the size of the topological perturbation. As a fundamental result, the expansion of the strain energy coincides with the expansion of the Steklov-Poincaré operator on the boundary of the truncated domain, leading to the associated topological derivative. Finally, the obtained result is applied in the context of topology optimization of structures under contact condition with given friction.

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Title: **Topology Optimization of Structures Subject to Pressure Loading**
Topic: **Topological Derivatives and other techniques**
Type: **ORAL**

Abstract:
In this paper the topological derivative is applied in the context of topology design of structures submitted to hydrostatic pressure. The standard problem based on compliance minimization under volume constraint is considered. In particular, the topological asymptotic expansion of the total potential energy associated with plane stress or plane strain linear elasticity, taking into account the nucleation of a circular inclusion with non-homogeneous transmission condition is rigorously developed, which represents the main contribution of this work. Physically, there is a hydrostatic pressure acting on the interface of the topological perturbation, allowing to deal with loading-dependent structural topology optimization. The obtained result is used to devise a topology optimization algorithm based on the associated topological derivative together with level-set domain representation method. Finally, some numerical examples are presented, showing the influence of the hydrostatic pressure on the topology of the structure.

Authors:
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Title: **Topology optimization of 2D and 3D heat conduction structures**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
Three topology optimization softwares have been developed at two different institutions for topology optimization of 2D and 3D heat conduction problems. The well known Method of Moving Asymptotes (MMA algorithm) [1] is adopted as the optimization algorithm, and the SIMP method (Solid Isotropic Material with Penalization) is used as the penalization technique for the material distribution.

In a first part, we show that, for topology optimization of heat conduction problems, the non-uniqueness of a solution depends as a whole on both the optimization problem structure (i.e. the degree of convexity/non-convexity) and on the algorithm itself, but also strongly on the initial design variables values especially when using the MMA algorithm [1]. We quantify the influence of the initial design variable values, discretization method and the interpolation schemes on producing different 2D heat conducting structures. The results illustrate that different thermal performances, as defined by [2], are produced by the MMA depending on the initial settings leading to final structures that are found as local or global solutions.

In a second part, several 3D simulations are performed for the topology optimization of volume-to-point heat evacuation problem in a cube using two isotropic materials. Several 3D conductive structures are obtained at a volume fraction of 25% illustrating the effect of conductivity ratio on modifying the final 3D structures.

As a conclusion, the results of this detailed parametric study highlights the necessity to pay more attention in the future to the lack of robustness of the MMA algorithm, especially if applied to heat conduction problems.

Keywords: Topology Optimization; heat conduction structures; volume-to-point problem; method of moving asymptotes; thermal performance;

References

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Title: **Multi-material topology optimization of truss structures**
Topic: **Topology Optimization**
Type: **ORAL**

Abstract:
Multi-material structural optimization has recently become the focus of much research due to advancements in manufacturing techniques. These include multi-material topology optimization for continuum structures and Discrete Material Optimization for laminated composite structures. These approaches have produced optimal designs that can be feasible for future automated or additive manufacturing techniques.
This study focuses on multi-material topology optimization of truss structures. The parametrization often determines only the cross sectional areas of the member bars such that the optimal structure fulfills basic design constraints on stiffness and strength. The models in most topology optimization problems for truss structures consider a single-material obtaining optimal designs that become lighter when stronger materials are used, but usually at extra costs. This suggests that strong materials are preferred to standard materials when the goal is to minimize the weight and not the cost of the structures.
The objective of this study is to include the choice materials with different stiffness, strength, cost, and density properties in the models and obtain optimal multi-material truss structures. These structures are not only lighter but also less expensive compared to the single-material structures that can be made from any of the materials.
The problem is formulated using disjunctive programming based on a ground structure approach in which nodes are distributed in the design domain and all adjacent pairs of nodes are connected by potential bars. The discrete design variables thus describe both the cross section areas of the bars as well as the selection of material candidates. The basic design requirements on the limits on nodal displacements and maximum allowable stresses are the constraints.
The resulting problems are re-formulated as Mixed Integer Linear Programming (MILP). These problems are known to demand extensive computational effort specific to certain truss topology optimization problems. In our numerical experiments, we consider a special case where we have a material available in three yield strength grades and discrete cross-section areas, and solve the problems using the heuristics and global optimization methods in the branch-and-bound software IBM ILOG CPLEX. The results show that the partial use of the materials with higher yield strengths in structures, despite associated with extra costs compared to the standard materials, benefits in the reduction of the overall cost of structures.

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Title: **An improved ground structure method for large-scale truss topology optimization problems**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
The ground structure methods became popular and important tools in truss topology optimization due to their robustness and reliability. Contrary to other methods the positions of nodes of the ground structure is frozen which requires a relatively dense cloud of nodes with a huge number of possible connections, i.e. potential bars. This inevitably leads to a large-scale optimization problem which is hard to solve in a direct way, however, to overcome this drawback the adaptive ground structure methods can be applied. The main advantage of the ground structure methods results from the fact that the topology optimization problem can be written in the form of linear programming, which from definition is convex and free of local minima, thus enabling to find the globally optimal topology.
It is well known that topologically optimal discretized trusses tend to Michell structures with infinite number of infinitesimal bars. In spite of some inherent limitations the theory of Michell structures plays an important role in structural topology optimization, by enabling the derivation of exact analytical solutions for the least-weight trusses capable of transmitting the applied loads to the given supports within limits on stresses in tension and compression. Thus the exact solutions derived by means of this theory may serve as valuable benchmarks for any structural topology optimization method. In general, the exact analytical solutions are very hard to obtain since they require in advance a good prediction of the optimal layouts. Fortunately, the Michell structures can effectively be approximated numerically using trusses of large but finite number of bars.
In this paper a new method of solving large-scale linear programming problems related to Michell trusses is proposed. The method is an extension of the adaptive ground structure methods developed recently by the author. In the present version both bars and nodes can be switched between active and inactive states in subsequent iterations allowing significant reduction of the problem size. Thus, the numerical results can be attained for denser ground structures giving better approximation of exact solutions to be found. The proposed method makes use of both primal and dual formulation of truss topology optimization problem and can be regarded as a specific combination of the interior point and active set methods. Both methods combined together provide an unprecedented opportunity for solving huge optimization problems with the number of design variables of billions or more. The proposed method enabled to obtain new important solutions which extend the class of known Michell trusses to 3D space and multiple load conditions. The new results clearly indicates that the optimal 3D trusses form shell-like structures composed of lattice surfaces.

Authors:
Sokol, Tomasz - (*presenter)[Warsaw University of technology] - POL

Title: **Unstructured Cellular Automata for topology optimization in engineering applications**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
Optimization of structural topology is a permanently developing area and one of the most important issues stimulating this progress nowadays is appearance of efficient and versatile optimization algorithms. Utilizing this progress in recent years increasing range of implementation of structural topology optimization especially to practical engineering problems has been observed. Moreover one of the most important problems to cope with is to adjust optimization algorithms abilities to high requirements imposed on effectiveness and reliability of structural analysis tools. It is well known that for real structural elements implementation of regular structured finite element meshes is in many cases inadequate. For example complicated shapes, holes and sharp edges indicate stress concentration, and in order to obtain reliable stress distribution the regions of such intensity should be covered with a more fine mesh. On the other hand to avoid an increase of computational cost one wish to use rough mesh for regions where element concentration is not necessary. As the result, a non-uniform density of elements represented by unstructured meshes should be used in order to achieve an accurate solution without excessive increase of number of elements. Since structural analysis is often a part of optimization problem therefore irregular mesh problem arises also for performing design process. Although irregular meshes have been frequently used in structural finite element analysis, implementation of unstructured meshing in topology optimization tasks is not in common use. Recent development of Cellular Automata implementation into optimal design problems has shown that the automaton can be an effective tool for generation of optimal topologies. Nevertheless, the vast majority of results have been obtained to date for regular lattices of cells. The aim of the present paper is to extend the concept of Cellular Automata towards irregular grid of cells related to non-regular mesh of finite elements. Some results of recent research show, that the strategy which consists of resizing of traditional uniform grid of cells allows to obtain more reliable solutions. Introducing irregular lattice of cells allows to reduce number of design variables without loosing accuracy of results and without excessive increase of number of elements caused by using fine mesh for a whole structure. It is worth noting that the non-uniform density of finite elements can be, but not necessary is, directly related to design variables which are related to cells of Cellular Automaton. The implementation of non-uniform cells of Cellular Automaton requires a reformulation of standard local rules, for which the influence of neighborhood on current cell is independent of sizes of neighboring cells and neglects for example the size of cells or length of mutual boundaries. This paper proposes therefore new local update rules dedicated to implemented irregular lattices of cells. The novel concept is illustrated by the results of topology optimization of selected plane and spatial engineering structures.

Authors:
Tajs-Zielinska, Katarzyna - **(*presenter)**[Cracow University of Technology] - POL
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Title: **Practical Aspects to Simultaneous Structural and Material Optimization**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
In recent years one of the ultimate goals has been set on the pursuit of extremely lightweight structures as well as the efficient use of raw materials for reduction of energy consumption to preserve the environment. In terms of efficient use of materials, composite structures are a key player, offering the possibility of tailoring the material to the application. The introduction of composite materials as part of the design formulation for structural optimization is both to determine the optimal spatial distribution as well as the optimal use of the material, i.e. the orientation and anisotropy of the local material tensor which is controlled by the composite microstructure. In practice, the local control over the microstructure is rather limited. The only eligible design factors are: the volume ratio of the matrix and the reinforcement, the orientation of a given microstructure and the topology of the microstructure, all within a fixed set of design variables.

As an engineering approach, which so far has been focused on optimization of laminated composites, the design problem can therefore be reduced to finding the optimal distribution of orientation angles of a material reinforcement in order to satisfy a global structural design objective. A lot of effort has been put on developing a general continuum-based structural optimization method, especially for the simultaneous structural and material optimization, in such a way that the non-convex nature of the problem, resulting in the difficulty of avoiding local optima, is overcome [1].
Various approaches focus on directly finding a physically meaningful solution based on a limited number of predefined candidate angles, e.g. DMO (Discrete Material Optimization). On the other hand approaches like FMO (Free Material Optimization) which avoid the local optimum problem by relaxation of design space, face the difficulty that the optimization may yield a theoretically optimal structure but not always a physically feasible structure, especially for more complex structures or loading scenarios.

In the current work a modified FMO approach is proposed aimed at developing a method that yields physically realistic material configurations and is based on a reasonable amount of design variables but without adding unnecessary restrictions to the design space.
The material symmetry is limited to orthotropic materials where the orthotropic axis is predefined based on a preliminary stress analysis. In a second step the material tensor is optimized, imposing physically based interdependencies on the tensor components in order to obtain a feasible structure in terms of physics and fabrication. The concept is illustrated by some example problems for laminated composites. It should be noted, however, that the concept can be generalized to 3-dimensional composite topologies.

[1] Nomura, Tsuyoshi, et al. "Nomura, Tsuyoshi, et al. "Simultaneous Optimization of Topology and Orientation of Anisotropic Material using Isoparametric Projection Method." 11th World Congress on Structural and Multidisciplinary Optimization (2015, Sydney, Australia)

Authors:
Lang, Margit Christa - **(*presenter)**[Montanuniversität Leoben] - AUT

Title: **Solving large-scale structural topology optimization problems using second-order methods**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
Structural topology optimization based on material interpolation schemes generally result in non-convex nonlinearly constrained optimization problems. They are commonly solved using first-order methods such as the Method of Moving Asymptotes (MMA). However, some state-of-the-art second-order methods for nonlinear optimization, such as Sequential Quadratic Programming (SQP) and interior point methods can also be used for this type of problems. The benchmarking study in [1] suggests that second-order methods can significantly reduce the number of iterations at the expense of increasing the computational time in the sub-problems.

This work presents a primal-dual interior point algorithm [2] to solve the classical minimum compliance problem with a constraint on the total volume of the structure, called TopIP. Interior point algorithms are one of the most powerful algorithms, but for large-scale problems, the computational bottleneck is the solution of the saddle-point system required to compute primal and dual search directions at each iteration. Thus, the cost of this second-order method is reduced to the cost of solving large linear systems.

In particular, an efficient iterative method to solve these indefinite and large systems is implemented and developed for the minimum compliance problem in the nested formulation. Since the Hessian of the compliance is computationally very expensive, the saddle-point system is reformulated to reduce the computational time even more. More specifically, the proposed iterative method combines some state-of-the-art techniques such as Krylov sub-space methods, block preconditioners, and geometric multigrid techniques [3].

Large-scale 3D topology optimization problems are presented in the numerical experiments. The results show good convergence and robustness properties of the proposed TopIP solver.

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Authors:
Rojas Labanda, Susana - **(*presenter)**[DTU] - DNK
Stolpe, Mathias - [Technical University of denmark] - DNK

Title: **Stress constraint topology optimization for compliant mechanisms design under large displacements**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
This work presents a topology optimization of compliant mechanisms using a constraint on the maximum stress. In order to allow large displacements to the mechanism, geometrical nonlinearities are applied to the equilibrium equations, along with a compressible Neo Hookean material model to avoid numerical instabilities.
The maximum stress is calculated based on a normalized version of the P-norm effective von Mises stress. The method of moving asymptotes is used for design variables updating.
To ensure nearly discrete designs, a density filter and a projection scheme are applied together with the so-called SIMP approach for the physical densities.
The classical compliant inverter benchmark problem is applied to test the methodology. Preliminary results are presented, advantages and possible drawbacks are discussed as well as limitations of the proposed methodology.

Authors:
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De Leon, Daniel - [FURG] - BRA
Gonçalves, Juliano - [UFRGS] - BRA

Title: **Topology Optimization Method Applied to Gas Adsorption Systems with Phase Change Materials**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
Natural Gas is an attractive alternative fuel to be employed in the industrial and transport sectors and the quality and efficiency of the methods applied on the gas transport and storage directly affects how much desirable it is. An efficient manner to store natural gas is in a porous media by the adsorption phenomenon mean, the Adsorbed Natural Gas. Adsorption's efficiency is known to be temperature dependent. Studies applying Phase Change Materials (PCM) as heat exchanger in ANG systems suggests the combination improves the vessel capacity and adsorption and desorption rates behavior. In addition, these improvements are directly related to PCM body shape and position inside the vessel. This fact makes the topology optimization method (TOM) very attractive for this problem. The topology optimization method is a versatile tool for material distribution inside a domain and in the last decades several advances have been made as much in its implementation as in its capacities of exploring the fabrication processes characteristics. This study aims to improve the capacity and performance of Adsorbed Natural Gas (ANG) Vessels using TOM to distribute PCM material in the vessel interior. The physical model consider a coupled heat and mass transfer trough an ANG vessel with PCM in its interior caused by the applied pressure at the inlet. The analysis is conducted from the beginning of the adsorption cycle until the end of the desorption cycle. The governing equations were implemented in python language using the FEniCS Project libraries to work the solution for the differential equations. The dolfin-adjoint libraries are used for the sensitivities calculus. The PCM distribution inside the vessel is defined as the project variable. The numerical method employed is a thermal properties correction for the element based on the analytical solution for the phase change problem. The specific heat correction is a linear interpolation between the properties values of the first phase to the second phase preserving the amount of energy stored in the PCM mass. The PCM amount in each phase is determined by the energy stored in the phase change process. The governing equations were implemented in python language using the FEniCS Project libraries to work the solution for the differential equations. The dolfin-adjoint libraries are used for the sensitivities calculus. The implementation of a low cost and coupled heat and mass equation model presented in this model makes it an attractive approach for the topology optimization method as its assumptions remove the numerical phase change model necessity and maintain the duality between the adsorbent volume to adsorb gas and the PCM volume to store thermal energy for the TOM to solve. As results, a 2D ANG vessel optimization is performed, the final topologies are presented and their total adsorption volume and charging/discharging time are compared.

Authors:
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Title: **Solving Low Volume Fraction Problems of Topology Optimization Based on Bacterial Chemotaxis**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
The BCBTOA (Bacterial Chemotaxis Topology Optimization Based Algorithm) was firstly Showed by (Guzmán et al., 2008) and this solves topology optimization problems of beams subjected to point loads. The algorithm simulates the optimal material distribution systematically from the combination of the finite element analysis and a model of collective behavior of self-organization shown by chemotaxis marine bacteria to minimize compliance.

In (Leon and Guzmán, 2014) is performed a tuning of the BCBTOA parameters R and Fact for different load states via multi-objective optimization. However by changing the amount of the volume fraction f parameter, it intervened changing the layouts obtained.

According to qualitative model-based chemotaxis towards oxygen of communication between marine bacteria Thiovulum majus and a Vibrioid bacterium described in (Thar and Kühl, 2005), complex patterns were generated from the accumulation of bacteria in a veil, as Honeycomb, interwoven bands and inverse honeycomb to volume percentages in the domain higher than 0.5, equal to 0.5 and less than 0.5 respectively. According to this, the f parameter related to the volume fraction controls the connection between isolated groups of bacteria. This research shows a model that at low volume fractions retains the honeycomb pattern.

The BCBTOA algorithm functions from the use of the communication between bacteria model shown in (Thar and Kühl, 2005). But this was not considering adapting the model for use in topology optimization, it worked well for a high percentage of the volume fraction, but not at low percentages. In conducting this research, we observed that the BCBTOA algorithm works correctly at low volume fractions, if we modify the mathematical model of communication between bacteria, making the pattern in the form of honey comb remains. This is how we modify the sombrero-shape describing the environmental parameter Q, which infers attractive high areas of oxygen for bacteria.

As a result, we obtained several layouts for different topology optimization problems of continuous bi-dimensional structures at low volume fractions and with this we show the correct behavior of the modification made to the algorithm BCBTOA.

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Thar, R. ; Kühl, M.: Complex pattern formation of marine gradient bacteria explained by a simple computer model. FEMS microbiology letters 246, no. 1 (2005): 75-79.

Authors:
Leon Medina, Jersson Xavier - **(*presenter)**[Universidad Santo Tomas-Tunja] - COL
Giraldo Avila, Juan Felipe - [National University of Colombia] - COL
Guzmán, María Alejandra - [National University of Colombia] - COL

Title: **A Topology Optimization Method for the Design of Plate Structures**
Topic: **Topology Optimization**
Type: **ORAL**

Abstract:
Topology optimization techniques render insight into the optimal distribution of material inside a space envelope in the design of a structure or material. Design engineers use this insight to translate the optimal topology into one or more computer aided design (CAD) concepts, which are then analyzed to determine their structural performance. As anyone who has had the experience of using topology optimization for design in industry may corroborate, this translation almost always departs in a substantial way from the optimal topology. This departure is due to the fact that the prevalent free-form topology optimization methods render organically-looking structures that can rarely be manufactured with the processes at hand. This shortcoming is particularly notorious when we desire to design structures using fixed-thickness plates. Moreover, the differences resulting from this translation often derive in the violation of structural performance requirements, which must then be addressed downstream the design process, requiring not only a significant time investment in 'fixing' the design, but often causing an increase in weight. Since plate structures are common in mechanical, civil, and aerospace engineering, methods to explore their design are highly needed.

In this presentation, we introduce a topology optimization method for the stiffness-based design of structures made of plates. Our method renders topologies made distinctly of plates, thereby producing designs that better conform to manufacturing processes tailored to plate structures, such as those that employ stock plates that are cut and joined by various means. To enforce the structural members to be fixed-thickness plates, we employ the geometry projection method to project an analytical description of a set of fixed-thickness plates onto a continuous density field defined over a 3-dimensional, uniform finite element grid for analysis. The proposed method accommodates the case where the plates in the topology are rectangular and solid, and the case where the boundaries of the plates can change and holes can be introduced. We present examples that demonstrate the effectiveness of our method and discuss future work.

Authors:
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Zhang, Shanglong - [University of Connecticut] - USA
Gain, Arun - [Caterpillar Inc.] - USA

Title: **Stress Constraint Aggregation without Constraint Relaxation in Topology Optimization**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
Topology optimization with stress constraints has been a major challenge. Two of the main difficulties are (i) the presence of singular optima, and (ii) the typically large number of local constraints that leads to a computationally expensive problem. Singular optima are true optima that lie in lower dimensional subdomains of the feasible domain, and are therefore inaccessible to standard gradient-based optimization. The large number of local constraints is caused by the fact that stress is a local state quantity. Consequently, the number of constraints is of the order of the number of design variables, and there is no benefit in using adjoint sensitivities.

The conventional strategy to tackle both difficulties is to subsequently apply constraint relaxation and aggregation. First, constraint relaxation replaces the original constraints by smooth approximations, which makes singular optima accessible. Then, constraint aggregation transforms the local constraints into a single global constraint, thereby reducing the computational costs. Well-performing stress-based designs have been obtained following this strategy. However, one of the difficulties is that this strategy introduces new parameters; i.e., a relaxation- and aggregation parameter. The optimal choice of these parameter turns out to be problem-dependent, which makes choosing proper parameter values very difficult.

In this work, we demonstrate on an elementary two-bar truss example that aggregating local stress constraints by a lower bound aggregation function makes singular optima accessible. The main advantage is that no separate constraint relaxation techniques are necessary, which reduces the parameter-dependency of the problem. Furthermore, there exists a clear relationship between the original feasible domain and the perturbed feasible domain in terms of a single aggregation parameter. We validated the proposed approach in density-based topology optimization on the classical L-bracket example.

Authors:
Verbart, Alexander - **(*presenter)**[Technical University of Denmark (DTU)] - DNK
Langelaar, Matthijs - [Delft Univeristy of Technology] - NLD
van Keulen, Fred - [Delft University of Technology] - NLD

Title: **Multiscale thermomechanical topology optimization and additive manufacturing of porous injection mold**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
This work introduces a design methodology of lightweight, thermally efficient injection molds with conformal cooling and functionally graded cellular (porous) structure using multiscale thermomechanical topology optimization. The proposed design approach makes use of thermal and mechanical finite element analysis to evaluate the component's stiffness (deformation under thermo-mechanical loads) and heat conduction (temperature gradient distribution) in two length scales: macroscopic and mesoscopic. The macroscopic scale contains the components boundary conditions including the external mechanical loads as well as the heat sources and sinks in the form of a mold cavity and conformal cooling channels. The mesoscopic scale contains the structural features of the porous material. Homogenized thermomechanical properties are derived and analytically expressed in terms of the volume fraction of the mesoscale porous material. The design problem addressed in this work is to find the optimal distribution of given number volume fractions within the component so its mass is minimized while satisfying stiffness and heat conduction constraints. Transient state thermal analysis is used to evaluate the cooling time during the injection process. The design of the mesoscopic structure is carefully evaluated to avoid the use of supports during the additive manufacturing process. The multiscale design includes provisions of open pathways for removal of excess (powder) material so the design is appealing to direct metal laser sintering (DMLS) additive manufacturing. The results demonstrate that a small reduction in mechanical and thermal performance allows for significant mass savings: examples show that 1% heat conduction reduction results in 10% mass reduction while satisfying the stiffness constraint. Numerical results are physically verified with a 3D printed mold in stainless steel 15- 5 PH1.

Authors:
Wu, Tong - **(*presenter)**[Purdue University] - USA
Tovar, Andres - [Indiana University-Purdue University Indianapolis] - USA

Title: **TOPOLOGY OPTIMIZATION VEHICLE CHASSIS: SOFTWARE APPLIED TO OPTIMIZATION TRUCKS AND BUSES CHASSIS**
Topic: **Topology Optimization**
Type: **POSTER**
Abstract:
The necessity to reduce production costs in the automotive industry is strongly investigated by product engineers. For this reason, engineers and designers search in other areas modern techniques that can be improved or used in their projects, using computational methods for optimization applied to the part design. The application of this technique is a further step to the use of CAE software currently used on a large scale in the automotive industry. This actual technique is well-known with "Topology optimization".
As the vehicle chassis is the link between the cabin, engine, transmission and axles, it has a great importance in the construction of vehicle. For the development of production, engineering companies have high costs due to the time it takes to get a better product, and it is very difficult to develop and design a product with the lightweight of the material that suits to the application. The stringer chassis is one of the most important items of the vehicle because that is where it supports all parts of the structure in the propellant vehicle.
Actually, the United States, Denmark, China, Japan, etc., use the optimization technology in the construction of their products, reducing the weight, size and final cost of production. This paper search to identify such optimization technology, and applies it in the analysis of a chassis (trucks or buses), comparing some comercial software for this analysis. It will be used for comparison some softwares that have some optimization type incorporated such as Optistruct (Altair), SolidWorks (Dassault Systemes) with ParetoWorks (Sciart) and ANSYS and Spaceclaim (ESSS) with Virtual PYXIS(Virtual CAE).
After this comparison, will be creat in a next article a new software through of the simplex algorithm theory, which has the linprog (a routine MATLAB),software specific for weight reduction chassis.
By experimental knowledge, this technology has never been used in Brazil specific in the automotive industry.
Nowadays, there are at least, five [1] broad classes of distinct optimization technology. They are: Structural Optimization [2], Parameter Optimization, Multidisciplinary Optimization, Multi-objective or Pareto Optimization and Robustness and Reliability Optimization. These are broad classes commonly used for many applications in industry and academy. Depending of the nature of the design problem is used one or other optimization broad classes.
So, the proposal this article find to identify the problems of the product engineers , searching to reduce material for better distribution of weight x power ratio, with the use of the optimization topology. The results will contribute to a new application in academic and industrial use.

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Authors:
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A. Santos, Givanildo - [IFSP - Instituto Federal de SP] - BRA

Title: **Stress Constrained Topology Optimization of Structures with Ductile Materials under Thermal Stresses**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
In the present study, a level set approach known as Pareto method is utilized to find the optimal topology of the structures with ductile materials under thermal effects. To achieve this, sensitivity of the objective function with respect to a perturbation in the design domain is calculated. Maximum von Mises stress in the domain is chosen as the objective function and thermal stress is added to elasticity equations governing structure. Thermal causes changes in relation between stress and strain and moreover changes in strain energy density. By considering these effects and solving governing equations, desired sensitivity is obtained.
The sensitivity analysis results achieved by the developed formula are compared with numerical results. Numerical sensitivity for each element is calculated by removing an element, finding the changes in objective function and finally divided it to element's volume. For several structural domain and various temperature distribution, sensitivity formula is checked. The results show the precision and efficiency of the obtained formula.
In the next step, topology optimization utilizing calculated sensitivity are performed for several common problem in structural optimization. In addition to mechanical load, different temperature distributions are applied to the domain. The obtained optimum topologies are compared with each other to show the effect of thermal stresses on the optimization process.

Keywords: Topology optimization, Thermal stress, Stress constrained, Sensitivity analysis, Pareto method

Authors:
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Yoon, Gil Ho - [Hanyang University] - KOR

Title: **Structural optimization considering smallest magnitude eigenvalues: a smooth approximation**

Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
An issue that frequently arises in structural optimization problems considering eigenvalues is the non differentiability of repeated eigenvalues. In order to overcome this difficulty, several schemes were already presented in literature. However, these approaches generally have other disadvantages such as inclusion of additional constraints, inaccuracy of representation of smallest/largest eigenvalues, significant increase in the computational effort required and incompatibility with finite differences schemes. In this paper a smooth p-norm approximation for the smallest magnitude eigenvalue is employed. The resulting approximation is differentiable, converges to the exact value as p is increased and is very simple to use (it is also compatible with finite difference schemes). Although the use of smooth approximations for maximum/minimum operators is a classical approach, for some reason it was not extensively studied in the context of structural optimization considering eigenvalues. Three examples concerning topology optimization for the maximization of the first natural vibration frequency of plane stress structures are presented in order to show the effectiveness of the proposed approach.

Authors:
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FARIA, JAIRO - [UFPB] - BRA

Title: **Using topology optimization technique to determine the optimized layout of steel reinforcing bars in concrete structures**
Topic: **Topology Optimization**
Type: **POSTER**

Abstract:
In structural concrete design, disturbed regions, so called as D-region, has been a challenge for decades. Currently, topology optimization technique is widely used to define the layout design of such reinforced concrete structures that are presented as truss-like topologies. Bi-directional evolutionary structural optimization (BESO) [1,2] has been well established and applied widely to topology optimization problems. This study presented an optimization procedure based on the modified BESO approach to optimize both location and orientation of discrete reinforcing bars within concrete structures, while satisfying the prescribed realistic volumetric ratio of steel amount into the continuum concrete. Opposed to the strut-and-tie model (STM) mechanism, both tension and compression are taken into account in reinforcing bars. The optimization variables are only applicable to steel reinforcements that are modeled as discrete truss bars embedded into the concrete domain. The flexible orientation of each reinforcing bar is achieved by employing a heuristic orientation finding scheme according to the principal strain direction into a two-dimensional (2D) BESO algorithm. Also, a subsequent update scheme is developed to be involved in the final decision making process of truss elements' remain and remove due to the asymmetric property of concrete. The capability of the proposed optimization method is shown through several cases. It can be concluded that the proposed method obtains a reasonable steel reinforcement layout under the volume constraint of steel used in reinforced concrete structures. Reinforcing bars playing high contribution to the structural behavior are remained within the presence of a constant concrete domain, which provides a valuable suggestion for the distribution of steel reinforcements.

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Authors:
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Wong, Simon Ho Fai - [Technological and Higher Education Institute of Hong Kong] - HKG

Title: **Development of an overhang constraint for topology optimization and additive manufacturing**
Topic: **Topology Optimization**
Type: **ORAL**
Abstract:
This work falls within the scope of computer-aided optimal design and aims to integrate the topology optimization procedures and recent additive manufacturing technologies. In recent years the topology optimization has become a perfect tool to maximize the potential and freedom that these revolutionary manufacturing technologies offer, allowing to conceive designs that utilize available resources optimally. However, there are still many theoretical and practical issues regarding automatic integration of both technologies. The proposed work focuses on implementing a strategie that provides the ability to control the overhangs present in the optimized solution. The need for scaffold structures to support large overhangs is dependent on the specific additive manufacturing process used, as some do not require support structures at all. Up to a point, the processes that require supports, can self-support so long as the overhang is above a particular angle to the horizontal. In general, these auxiliary structures increase the final cost of the product, since they consume a larger volume of material and require additional work for removing the support. Its complexity may vary depending on the manufacturing process and the type of material, involving manual removal or chemical products if soluble materials are used. Some authors have investigated the effect of varying the optimization parameters of topology optimization algorithms, like the checkerboard filter radius, minimum feature sizes, perimeter measures, etc. This was done with the intention of finding the parameters most suitable for additive manufacturing to increase the complexity of the design and reduce the need for support structures. It was found that most of the checked parameters did not appear to have enough of an effect to make a significant difference to the requirement for support structures. The aim of the work presented in this paper is the development of a specific overhang constraint to be added within the minimum compliance formulation, in order to include the requirement for the geometry to be mostly self supported when it is manufactured using additive technologies. The algorithm identifies potential boundaries in discrete and variable density methods, selecting only downward facing edges and quantifying a mean value of the overhang measure, which will be used later as additional constraint for the topology optimization problem. Different numerical examples are presented to show the validity of the developed algorithm.

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Title: **Optimization under Uncertainties of Friction Dampers in Civil Structures for the Passive Control of Vibrations**
Topic: **Vibrations and Structural Dynamics**
Type: **POSTER**

Abstract:
The dampers optimization is a new area that has been studied in the last years, having a big impact in the optimal design of devices for the vibration control in structures subjected to dynamic loads due to natural hazards such as earthquakes. In this proposal a new approach is presented taking into account the optimization under uncertainties of friction dampers, this is, considering uncertainties in both structural and load properties. The main objective of the research is to develop a methodology to carry out robust simultaneous optimization of friction dampers. In order to minimize the mean of the maximum story acceleration, their locations in structure and their parameters are simultaneously optimized. It is noteworthy that such methodology applied to friction dampers is innovative because there are not robust optimization works associated with this type of damper in literature. This device stands out among passive devices due to the low cost of construction, installation and maintenance, as well as the high performance for vibration control. The results showed that the proposed methodology was able to achieve a significant reduction in mean maximum acceleration.

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Title: **Optimal seal parameter values for rotating machines considering uncertainties**
Topic: **Vibrations and Structural Dynamics**
Type: **ORAL**

Abstract:
Internal seals play an important role in the dynamics of rotating machines. Depending on the seal parameter values, the system might get unstable. In this paper the shaft is modeled using the beam theory and discretized by means of the finite element method. A linear model is considered for the seal, where stiffness and damping parameters are the control parameters. Futhermore, it is assumed that the direct stiffness values are the same for the two lateral directions, and that the cross coupled stiffness coefficients values are the same. The same is valid for the direct and cross coupled damping coefficients, yielding a total of four control parameters. This paper aims to compute the optimal seal parameters values in two senses: (1) to avoid instability and (2) to be robust in the present of uncertainties. The objective function is composed by the mean value and the variance of a penalization function. The penalization function penalizes parameter values that lead to points in the instability region. The uncertainties are related to the values of the seal parameters themselves. The investigation is carried out approximating the optimization problem with the Levenberg-Marquardt algorithm.

Authors:
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Title: **Inverse stochastic identification of vehicle suspension damping coefficients**
Topic: **Vibrations and Structural Dynamics**
Type: **ORAL**

Abstract:
This work is devoted to identify the damping coefficients of the suspension systems of a vehicle by using stochastic optimization methods in an inverse problem approach. The studied road vehicle has two axles and the rear suspension differs from the front suspension and both suspension systems are passive. Consequently, two damping coefficients are identified, one for the front suspension and the other for the rear suspension. The direct problem is represented by a half car model, describing a vehicle traveling at 60 km/h on a road with a step with height equal to 0.1 m. The bump excitation applied on the wheels, promotes oscillations in the mechanical system, which are damped by the suspensions. The solution of the direct problem furnishes the kinematics of the wheels and of the chassis. Two stochastic optimization methods are used to solve the inverse problem: the particle swarm optimization (PSO) and the random restricted window (R2W). Particle swarm optimization is an evolutionary algorithm based on the social behavior of birds looking for food. As well as the birds are attracted by the food, the values of the design variables are updated by the attraction of the minimum value of the cost function. So, in the particle swarm, a population of possible solutions for the optimization problem is created and this population evolves. On the other hand, in the random restricted window method, a population is randomly created in a restricted region of the domain and the best individual of the population is selected to be the center of the new window. The population is discarded and a new population is created around those best individual. This procedure is repeated until optimum solution is found. In the proposed inverse problem, PSO and R2W minimizes the sum of the quadratic errors between the estimated and pseudo-experimental data of the chassis bounce and pitch accelerations and the vertical displacements of the wheels. To avoid the inverse crime, random error are introduced in the pseudo-experimental data. Thus, the proposed inverse problem is a multi-objective optimization problem with box constraints, since the damping coefficient has a typical range. To satisfy the box constraints, the adopted PSO requires a repair procedure. Otherwise, R2W does not require such procedure since the box constraints establishes the window to create the first population. The performance of the studied stochastic optimization methods are compared, considering populations with different sizes and noise levels in the pseudo-experimental data. The results show that PSO and R2W provide satisfactory results, identifying correctly the damping coefficients.

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Title: **Rotation-based sampling MPCA-HJ for Vibration-based Damage Identification**
Topic: **Vibrations and Structural Dynamics**
Type: **ORAL**

Abstract:
The structural vibration-based damage identification is formulated as an optimization problem. The objective functional is expressed by a least square difference between measured and computed forward model displacements. The latter functional is minimized by using the hybrid metaheuristic Rotation-based sampling Multi-Particle Collision Algorithm with Hooke-Jeeves (RMPCA-HJ).

Multi-Particle Collision Algorithm (MPCA) is a stochatic optimization method inspired on the physics in the nuclear reactor, where absorption and scattering phenomena are represented. In the MPCA algorithm, a set of particles (solutions) travels in the search space. After a certain number of function evaluations, they share the best particle solution found. MPCA -- working together to the Rotation-Based Learning (RBL)-- is used as a first stage of the hybrid method performing a global exploratory search. RBL is a novel extension of Opposition-based Learning (OBL). In RBL, a rotated solution is calculated by applying a specific rotation angle to the original solution. Here, the new Rotation-Based Sampling (RBS) solution projects a point between the original solution and its rotated solution. RBS could be more flexible than RBL -- and also OBL -- to find the promising candidate solutions. The intensification search stage of the hybrid metaheuristic is addressed by the direct search Hooke-Jeeves (HJ) method. HJ consists of the repeatedly application of exploratory searches for all dimensions around a base point. If the exploration has success finding a better solution, a pattern move is performed.

The hybrid algorithm is tested to identify damages over a truss structure. Experimental data was generated in silico, using time-invariant damages. Experiments with noiseless and noisy data, under several noise level, were carried out. Good estimations of damage location and severity are achieved.

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Title: **A Feasible Point Algorithm for General Semidefinite Programming**
Topic: **Nonlinear Programming**
Type: **ORAL**
Abstract:
This talk deals with nonlinear smooth optimization problems with equality and inequality constraints, as well as semidefinite constraints on symmetric matrix-valued functions. Semidefinite Programing (SDP) constraints are involved in several structural optimization problems. This is the case of free material optimization, that needs positive definite elasticity matrices. Constraints on the fundamental structural frequencies can be stated as SDP constraints. We describe some basic concepts involved in nonlinear optimization, beginning by unconstrained function minimization and following with constrained problems. Finally we present a new semidefinite programming algorithm, FDIPA_GSDP, obtained as a generalization of the well known Feasible Direction Interior Point Algorithm for nonlinear smooth optimization, FDIPA. FDIPA_GSDP makes iterations in the primal and dual variables to solve the first order Karush-Khun-Tucker optimality conditions. Given an initial interior point, FDIPA_GSDP generates a descent interior sequence, converging to a local solution of the problem. At each iteration a feasible descent direction is defined. A line search along this direction looks for a new interior point with lower objective. To compute the search direction, the present algorithms simply require the solution of two linear systems with the same matrix. Feasible iterates are essential in applications where the calculus of some of the constraints requires the satisfaction of a set of so called “hard constraints”. This is a requirement in some applications of advanced materials optimization, to ensure that the stiffness matrix has a unique solution. Global convergence to stationary points is proved. Some structural optimization test problems were solved very efficiently, without need of parameters tuning.

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Aroztegui M., Herskovits J., Roche J.R., Bazan E. (2014) A feasible direction interior point algorithm for nonlinear semidefinite programming. Structural and Multidisciplinary Optimization pp 1-17.

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Bazan Cordova, Elmer - [COPPE - Federal University of Rio de Janeiro] - BRA

Title: **Optimal Speed of Multiple UAVs based on Nonlinear Programing to Avoid Collision in Periodic Paths.**
Topic: **Nonlinear Programming**
Type: **POSTER**
Abstract:
Due to technological and scientific development, particularly in electronics, computing, control and automation areas, the number of autonomous vehicles (UAVs) has increasingly risen to perform certain tasks. Such devices represent a revolution for specific tasks by leading to cost reduction and improving the efficiency.
Multiple autonomous vehicles may be necessary in specific applications such as monitoring large regions, where the cyclic trajectory of multiple robots must be evaluated to prevent their collision. Therefore, the challenge is to determine the speed of each robot along the way to meet the programmed route in minimum time consumption and still maximize the distance between robots in the common points of the trajectories or the collision points. In this case, constraints related to maximum and minimum speeds must be considered.
The literature has presented several works to handle the aforementioned problem that use methods as Mixed Integer Linear Programming (MILP), where the dynamic constraints of the robot, such as speed bounds, as well as the constraints of time and candidate cycles are considered, which leads to a complex optimization problem. Such features make it difficult to represent the nonlinearities due to, for instance, obstacles in the robot path.
Against this background, the present work proposes a technique to determine the optimal speed of multiple UAVs aiming at maximizing the difference between the times required by the robots to achieve the collision points. Then, the objective function is given by the squared difference between the functions that give such times. The constraint related to the time required by each robot is weighted by using the summation of the times spent by the robot in the whole route. Speed limits are included in the problem as constraints. The formulation is suitable to be solved by nonlinear programming comprising only continuous variables. The proposed problem can be easily solved by using any nonlinear optimization package due to the reduced number of continuous variables. Additionally, the method allows including obstacles in the robots' trajectories, enabling variations in their speeds to correct their positions along the way.
Results using two robots and four collision points will be presented to show the effectiveness of the proposed approach. Comparisons with other methods used in the literature indicate that the proposed methodology is promising for application in real systems with multiple robots.

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Souza, Marina - [Federal University of Juiz de Fora] - BRA

Title: **An improvement on the IED method for solving constrained nonsmooth and nonconvex optimization problems**
Topic: **Nonlinear Programming**
Type: **ORAL**
Abstract:
In optimization, problems involving constrained nonsmooth and nonconvex functions are difficult to solve. Lagrangian Duality is a technique that can be used for solving such problems where the constraint functions are appended to the objective function to form the lagrangian function. This approach requires the minimization of the lagrangian function which is an unconstrained problem. The Interior Epigraph Direction (IED) method is an algorithm based on Lagrangian Duality that considers the dual problem induced by a generalized augmented lagrangian duality scheme and obtains the primal solution by generating a sequence of iterates in the interior of the dual epigraph. The original version of the IED method uses the MatLab routine fminsearch for minimizing the lagrangian function. We present a new version of the IED method where we replace the fminsearch routine by the version of the Nonsmooth Feasible Directions Nonconvex Algorithm (NFDNA) for solving nonsmooth nonconvex unconstrained optimization problems. We solve several tests problems and compare the results with those obtained by the original version of the IED method.

Authors:
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Title: **Analysis on the parallel computing applied to a nonlinear problem using the deflation technique**
Topic: **Nonlinear Programming**
Type: **ORAL**
Abstract:
The evolution and popularization of robotic industries together with the need of solutions in optimized time produce challenging and increasingly complex problems, which demands the constant progress for even more efficient computational frameworks. A relevant problem in this context is the analysis of robotic manipulator kinematics. Considering a robotic arm, as example, constructed by a considerable quantity of articulations, the problem is based on the optimization of the relative positions of the articulations, knowing the data that describes the orientation and position required for the robotic arm. Solving this problem is considered a complex task, mainly because of the huge amount of possible solutions and the dimensionality of the nonlinear algebraic equations system that describes the (inverse) kinematics of the manipulators. In some situations, this nonlinear system is converted into an optimization problem, using an scalar fitness function. In this scenario, it is possible that some solutions may not be computed, depending on the optimization technique used. Considering this fact, an efficient approach is the use of deflation techniques, namely, once found a solution, the objective solution is modified by a method that creates repulsion areas in the vicinities of the results found in order to, when executed again, the algorithm avoids previously calculated solutions and consequently raises the chances of finding a distinct solution. In order to compute each of the solutions, the metaheuristic chosen was the Cuckoo Search. Based on the natural behavior of some bird species, the algorithm presents a good performance in relatively complex problems, as well as the low sensibility on the adjustment of control parameters. Besides the deflation technique, which aims to compute all the problems solution with the possibly minimal quantities of algorithm executions, the technical features of the present problem validates the optimization of the results through the concept of parallelization. On these circumstances, a tool that can help on the lowering of computational cost is the Parallel Python. This Python module, of easy integration and use, is an efficient alternative on providing mechanisms for the execution of parallel computational routines implemented in Python (for multicore computers and clusters). Therefore, a statistical analysis of the use of these tools is highly important to raise the productivity of new alternatives.

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Platt, Gustavo - [Rio de Janeiro State University] - BRA
Parajara, Caroline - [Rio de Janeiro State University] - BRA

Title: **Numerical analysis on the vapor-liquid critical point of binary mixtures: a study about the critical curve of the nonlinear system**
Topic: **Nonlinear Programming**
Type: **ORAL**

Abstract:
In a mixture, a vapor-liquid critical point can be understood as the condition where the properties of the liquid and vapor phases converge, which means that these phases have similar thermodynamic properties such as density, viscosity, molar entropy, refraction index, composition, among others. The occurrence of the vapor-liquid critical point is given under specific conditions of temperature and pressure, specifying the global composition of the mixture. The determination of vapor-liquid critical points is a challenging task, however, its robust calculation is essential in many industrial processes related to fluid processing. In the oil sector, specifically, there are many cases in which the knowledge of critical points is extremely important in the design of equipments and extraction of compounds with economic interest. In binary mixtures, the calculation of critical points can be described as a system of nonlinear algebraic equations from the plane to the plane. This paper proposes the application of the initial steps of a robust technique for solving nonlinear algebraic systems in critical point problem (the numerical inversion of the functions from the plane to the plane). The present method is able to obtain all solutions of the problem and provide global information about the behavior of the function studied by analyzing the critical curves (in the mathematical sense, where the Jacobian matrix is singular). The formulation of the problem through a function from the plane to the plane will be performed using the Peng-Robinson equation of state together with the classical van der Waals mixing rules.

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Title: **OPTIMIZATION OF RECOMBINANTE L-ASPARAGINASE PRODUCTION USING METABOLIC FLUXES DYNAMIC MODEL**
Topic: **Nonlinear Programming**
Type: **POSTER**
Abstract:
L-asparaginase enzyme is used as a chemotherapeutic agent in the treatment of acute lymphoblastic leukemia and other lymphoid malignancies. New enzyme sources are needed for patients who have developed hypersensitivity reactions to existing enzymes. The bacterium Zymomonas mobilis, which has therapeutic properties and has been used in the development of probiotics, has been studied as an alternative. However, due to the low productivity of the enzyme by Z. mobilis, recombinant enzyme can be produced using E. coli as an expression system. The proposed mathematical model for recombinant protein production takes into consideration the plasmid and enzyme production in the cellular metabolism, the enzyme expression induction when lactose is present, flux balance analysis (FBA) to characterize the metabolism, and mass balance of the extracellular components. The proposed model consists of three parts, dynamics, kinetics and metabolic, and have been solved in an integrated manner using static optimization approach (SOA), which instantaneous optimization problems are solved for each time interval. Within the metabolic block, which used the E. coli metabolic network with the plasmid and enzyme production reactions, is considered the resolution of two optimization problems, a linear programming (LP) to maximize cell growth rate, and a quadratic programming (QP) to minimize the fluxes square sum (principle of maximum enzymatic efficiency). However, since the plasmid and enzyme production requires a significant amount of energy (ATP), the calculated fluxes, of these components, were null. Once the formation of these compounds is experimentally observed, a multi-objective optimization, using the ε-constraint method, has been proposed. Through Pareto-optimal solutions, it was possible to obtain a consistent model with the experimental maximum flux of plasmid. Furthermore, since the presence of an inducer for the formation of recombinant proteins is necessary, as observed experimentally, it was considered the induction of enzyme expression only in the presence of lactose. The dynamic block, consisting of ordinary differential equations, represents the mass balance for the components, including the fluxes calculated in the metabolic block. The kinetic block takes into consideration the reaction rates using the Michaelis-Menten kinetics. Some model parameters, related to kinetics, enzymatic synthesis of secondary metabolites, such as lactate and acetate, and formation of biomass, were estimated using least squares. With the proposed process model, a dynamic optimization problem to maximize the L-asparaginase production was successfully solved using the sequential method, considering the lactose feed flow rate as decision variable.

Authors:
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Alves, Tito Lívio - [COPPE-UFRJ - Programa de Engenharia Química] - BRA
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Title: **An scaled SQP algorithm for solving the minimum distance problem in mechanisms**
Topic: **Nonlinear Programming**
Type: **ORAL**
Abstract:
The minimum distance problem can be used to approach the kinematical synthesis of mechanisms with success, specially when no good initial guess is given. I order to do so, this problem is used as error function which is afterwards optimized. Due to the nonlinear nature of the minimum distance problem, an optimization algorithm is to be applied. In previous developments, the minimum distance function was obtained in a simple penalty function method and the synthesis problem was approached by means of a genetic algorithm. The problem of the use of penalty functions is that the obtained solution lacks of precision and this translates on a benefit for low stiffness mechanisms. In this work we have solved the problem by means of Lagrange Multipliers, which alleviates the low stiffness problems. In order to perform initial tests of the function we have tested it by calculating the relevant matrices in a finite differences approach, which allows to take conclusions on the performace that will be obtained when exact derivatives are introduced. This will also allow to perform the check for possible bugs in the exact derivatives. The tests have shown that, in most cases, due to the ill conditioning of the problem, oscillatory divergence may happen. To solve this problem, an stabilization algorithm has been developed in the Karush-Kuhn-Tucker solver. This algorithm is based on the separation of the increment vector in the part needed to verify the constraints and that related to the improvement of the error function. To do so, we have resorted to a custom LDU method to obtain the minimal less squares solution. This improves stability of the algorithm along with a high computational efficiency. The method is used both for linear and for non linear restrictions. The final set of reduced equations is solved by means of a symmetrical factorization method which deals with indefinite systems by means of combination of pivoting and rotation which was developed in the same working group and has shown to be competitive when compared to Bunch-Parlett and similar methods. The derivatives of the error function and the constraints are obtained by central differences. This choice has been made because, althoug not yet implemented, the exact derivatives will be introduced in the near future. The use of central differences allows one to extract conclusions on the future performance of the algorithm with exact derivatives. This developments have been tested with simple problems, showing good behavior. This leads to the conclusion that the use of this kind of function will be of good use when applied to the synthesis of mechanisms.

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Title: **Optimization Methods for Commodity Model Calibration**
Topic: **Nonlinear Programming**
Type: **POSTER**
Abstract:
The objective of this work is to develop and implement several stochastic models, univariates and multivariates, representing the dynamics of commodity prices, such as oil derivatives, along a given interval of time. Those models depend of certain parameters (mean, variance, correlations), which are unknown and must be estimated such that the models can adhere to the reality and be used when simulating future prices in the oil industry. The calibration involves the estimation of model parameters that more accurately reflect the reality. For this we write the models in a state space formulation, using univariate treatment for a multivariate model, so that calibration can use Kalman filter. This one is applied to generate estimates of the state variables and calculate the likelihood function. The maximum likelihood method provides an approach to parameter estimation problem, and begins with a likelihood function of the time series, which it contains the unknown parameters. Those values of the parameters that maximize the time series likelihood are known as the maximum likelihood estimates. The parameter estimation problems generated by the calibration involves constraints on semidefinite matrices. Then we have a semidefinite problem since the constraints matrices have to be strictly definite positive at each iteration. We solve semidefinite problem employing a modificated version of FDIPA for general nonlinear semidefinite programming, based on the iterative solution in the primal and dual variables of Karush-Kuhn Tucker optimality conditions, which generates a feasible decreasing sequence.
Keywords: Time series, Maximum Likelihood, Semidefinite Programming.
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Aroztegui M., Herskovits J., Roche J.R., Bazan E., A feasible direction interior point algorithm for nonlinear semidefinite programming, Journal of Optimization Theory and Applications 99(1), pp 121-146, 1998.

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Luna, Juan Pablo - [COPPE-UFRJ] - BRA

Title: **Optimizing Universities Allocation with Integer Programming Using a New Distance Measure**

Topic: **Integer Programming**
Type: **ORAL**
Abstract:
The report Education at a Glance Indicators – OECD, emphasizes that in Brazil there is a great opportunity for the growth of higher education, because only 14% of the population has an undergraduate degree. In recent years, the Brazilian government has attempted to increase the population with higher education, through the Restructuring and Expansion of Federal Universities Program-REUNI. This program's goal is to offer places in higher education to 30% of the population aged between 18 and 24 years, creating new public universities. The expansion in the number of universities has the following criteria: at the end of 2018 there must be a university in every city with a population higher than 200,000 inhabitants or with a distance of more than 200 km from a city that has one university. Based on REUNI criteria, the following question must be answered: How will we select a set of cities where a university must be founded? In case of the Amazonas State, which is the largest Brazilian State by area, the use of the REUNI criteria will result in higher number of cities where a university must be established. The capital, Manaus, is the only city with more than 200,000 dwellers. The other 61 cities are clustered along navigable waterways, which are accessible only by boat, and the distance between cities, by inland waterway, are in most cases greater than 200km. Alternatively, this paper proposes a multi parametric integer optimization to select the best group of cities where a university must be established. The optimized solution must consider the following arguments: It must minimize the distances between the cities without a university to a city that has one university; it must prioritize cities with a higher population; it must prioritize cities with a lower Human Development Index (HDI). The use of a multi parametric approach was only possible by introducing the concept of a generalized distance that considers the three parameters: distance, population and HDI. This proposed generalized distance meets the criteria required by a proximity measure, but does not meet the one required by a proximity metric. This problem is addressed in two ways. First, as a set-covering problem, trying to find a solution that meets the criteria raised by REUNI. Second, as a p-median problem, trying to answer the question of how to select the best set of p cities in which to locate universities. The second approach is necessary since the first approach results in a large number of universities to be established. The parameters used in the generalized distance expression are normalized in three different ways: using maximum and minimum values, mean values, and standard deviation values. Two types of distances are proposed: one that resembles the Euclidian distance and the other, the Manhattan distance. Different solutions are obtained for the set covering and for the p-median problem, using the two distances and the three normalization criteria. The solutions are evaluated from a perspective of finding the one that presents best values for the three aforementioned parameters. The results obtained were evaluated using a chi-square statistical significance test.

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Title: **Second Proof That P=NP**
Topic: **Integer Programming**
Type: **POSTER**
Abstract:
The paper presents a second proof that P=NP. The first proof was proposed by Munapo in early 2016. This proof is just like the first proof where the general binary linear programming problem is transformed into a convex quadratic programming problem. The convex quadratic programming problem is then solved by interior point algorithms. Since the general binary linear problem is NP hard and the worst case complexity of interior point algorithms for the convex quadratic problem is polynomial (P) then P=NP.

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Title: **A Probabilistic Approach to Inverse Problems**
Topic: **Stochastic Optimization**
Type: **ORAL**
Abstract:
In many application areas (mechanics, geophysics, image processing,...), a large number of real-life problems can be cast as an inverse problem. In the field of energy, key problems related to engineering, maintenance and management of power systems are inverse problems like for example the nondestructive testing of some components of nuclear power plants or the forecasting of electricity prices. The inverse approach is hence of great interest in industry and a lot of work has been devoted to the development of a wide set of approaches and techniques, ranging from the deterministic classical least squares to stochastic Bayesian methods.

We introduce here a new approach based on a probabilistic formulation for dealing with linear inverse problems. With this approach, solving a linear inverse problem is formulated as maximizing the probability to satisfy a set of two-sided (bilateral) random inequalities. A key property needed for solving such problems concerns the concavity of the probability function. Even restricting to the case (considered here) of coefficient vectors with nondegenerate multivariate Gaussian distributions, only sufficient conditions for characterizing concavity of the joint probability function have been reported so far in the literature.

New results stating necessary and sufficient conditions for concavity will be presented, both for the case of a single-sided (unilateral) and two-sided (bilateral) probabilistic inequalities [1]. These results open the way to efficient resolution of linear inverse problems using the proposed probabilistic approach.

As a typical illustration, we discuss a series of computational results on random Gaussian linear systems featuring some typical characteristics of inverse problems like ill-conditioning.

[1] : M. Minoux, R. Zorgati, "Convexity of Gaussian Chance Constraints and of Related Probability Maximization Problems", DOI 10.1007/s00180-015-0580-z, published online in Computational Statistics, 19 April 2015.

Authors:
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Minoux, Michel - [University P. and M. Curie (PVI), Paris] - FRA

Title: **A probabilistic approach for optimal design of structures under seismic loads**
Topic: **Stochastic Optimization**
Type: **ORAL**
Abstract:
During their lifetime, the greater part of structures are subjected to several different load conditions, usually defined as suitable combinations of quasi-static loads and seismic actions. Both actions are unknown and time-dependent, but the quasi-static load history can be described as a suitable combination of some deterministic values representing the basic loads of an assigned admissibility load domain, while the seismic load history is typically random and can be characterized by means of suitable probabilistic approaches.
Furthermore, for the structure in such a load conditions it is possible to define some serviceability conditions related to the simultaneous presence of quasi-static loads and seismic actions of low intensity as well as some limit conditions related to the simultaneous presence of quasi-static loads and high intensity seismic actions. In serviceability conditions the structure must ensure its full integrity and usability, therefore it is advisable that it is designed at the elastic limit state, while in limit conditions its ductility features can be taken into account and it can be designed at the impending collapse limit state.
Taking into account just the serviceability conditions, the present paper is devoted to the determination of the minimum volume design of structures subjected to a load history defined by the combination of any unknown time-dependent history of quasi-statical loads acting for the entire lifetime structure and of a time-dependent seismic load history defined in a limited time interval and constrained to behave elastically. In particular, for the sake of simplicity, reference is made to elastic flexural plane frames, but the proposed procedure can be easily generalized to any other more complex structure. The structural response, due to the presence of the seismic actions, is probabilistically discussed. In particular, in the present paper the simulation of artificial accelerograms is based upon a filtered uniformly modulated stochastic zero-mean Gaussian process assumption. Furthermore, a suitable method to evaluate in closed form the probabilistic response functions of the classically damped linear structural system is utilized. Finally, a suitable heuristic algorithm is adopted to determine the minimum volume structure related to a fixed probability of failure characterized by the relevant value of the elastic safety factor.
The performed applications, even if related to simple plane frames, confirm the effectiveness of the proposed approach and the obtained results are verified by the related effected dynamic analysis.

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Title: **STOCHASTIC OPTIMIZATION FOR OPTIMAL CONTROL OF A FERMENTATION PROCESS FOR XYLITOL PRODUCTION**
Topic: **Stochastic Optimization**
Type: **POSTER**
Abstract:
STOCHASTIC OPTIMIZATION FOR OPTIMAL CONTROL OF A FERMENTATION PROCESS FOR XYLITOL PRODUCTION

Laís Koop, Marcos Lúcio Corazza, Fernando Augusto Pedersen Voll, Adrián Bonilla-Petriciolet

Bioprocess control is characterized by providing a near optimal condition for the biomass to grow up, multiply, and produce a desired product. In the special case of fed-batch bioreactors, the optimization has been traditionally done by manipulating the substrate feed rate. However, this task is a challenging optimization problem because of its dynamic behavior. Despite of that, the behavior of bioprocesses is also highly nonlinear and time varying. It means that the optimization strategy required to find the best feed rate in this case must outweigh those obstacles. Therefore, the goal of this work is to show the performance of different stochastic methods in the optimal control of a fermentation process subject to different operation conditions. The described bioreactor simulates the production of xylitol, a five-carbon sugar alcohol, which is an important commercial sweetener. For this specific fermentation, a better strategy is to feed the bioreactor with two substrates, xylose and glucose. The biomass uses the glucose for cell grow and most of the xylose provided in the feed is use to be transformed in xylitol, which improves the process yield. The best feeding profiles were determined using Differential Evolution (DE), Particle Swarm Optimization (PSO) and Artificial Bee Colony (ABC). Performance of these stochastic methods was compared at different operating conditions of this fermentation process. Capabilities and limitations of these methods have been analyzed. Results showed that DE and PSO are the more robust methods for solving this case of study.

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Title: **Adjoint based multi-objective shape optimization of a transonic airfoil under uncertainties**
Topic: **Stochastic Optimization**
Type: **ORAL**
Abstract:
In the present paper, the results of ongoing work within the FP7 project UMRIDA will be presented and discussed. The main idea of this work is to combine the non-intrusive polynomial chaos based uncertainty quantification methods with the gradient based methods for stochastic optimization.
When introducing uncertainties in a design process, the objective is no longer deterministic and can be characterized by its mean and its variance, i.e. in a robust design the optimization becomes multi-objective. Gradient based optimization of the mean objective and of the variance of the objective therefore requires the gradient of both quantities. It can be shown that these can be obtained from the polynomial chaos decomposition of the gradient of the objective. Having obtained the polynomial expansions, the gradient of the mean objective is combined with the gradient of its variance using weights. By changing the weights the Pareto front (if any, i.e. if the 2 objectives are conflicting) can be recovered.
The proposed method is applied to the optimal shape design of a transonic airfoil under uncertainties. Currently, the flight conditions (the Mach number and the angle of attack) are considered as uniformly distributed uncertain parameters. The objectives considered are the mean drag coefficient and its variance. In this work, the continuous adjoint solver and the CFD solver of SU2 (an open source CFD solver) are coupled with the polynomial chaos methods for the optimal shape design of a transonic airfoil. Hicks-Henne function is employed to parameterize the airfoil and to represent a new geometry in the design process. The optimization procedure is performed using the sequential least square programming (SLSQP) algorithm.

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Title: **A Comparison Between Scilab Versions in a Thermodynamic Problem**
Topic: **Stochastic Optimization**
Type: **ORAL**
Abstract:
Nowadays, metaheuristic algorithms are very commonly employed in order to solve engineering problems. On the other hand, the computational cost of a metaheuristic in a continuous optimization problem is, usually, large when compared with classical deterministic methods (such as Newton's method). Thus, computational routines have been continuously improved in order to overcome the problem of computational cost. In this work, we presented a rigorous comparison between a metaheuristic algorithm in two platforms: Scilab 5.5.2 (64 bits, under Windows) and Scilab 6.0.0 Beta 1 (64 bits, under Windows). Scilab 6 was recently released (february, 2016), with a new computation core. The problem chosen to test the environments was the calculation of an azeotrope in the system formed by ammonia + R-125 (usually employed in refrigeration). The calculation of the azeotrope (under specification of temperature, and obtaining the azeotropic pressures and compositions) is characterized by a nonlinear system of algebraic equations. This system was then converted to an scalar function (fitness), permitting the test of the metaheuristic. Particularly, this thermodynamic problem exhibits two azeotropes in temperatures close to 49 celsius degrees. Furthermore, we chose the Differential Evolution technique as the metaheuristic used to minimize the fitness function. This algorithm has become very popular in recent years in many areas and is considered an effective metaheuristic. The comparisons were performed considering several processors (with different number of cores). The results indicate that Scilab 6 performed better than Scilab 5 in this kind of problem.

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Title: **SUPPLY CHAIN INVENTORY CONTROL POLICY WITH STOCHASTIC DEMAND EVENTS**
Topic: **Supply Chain Management**
Type: **ORAL**

Abstract:
Supply chains can be described as a set of entities that convert materials from the suppliers till the final costumers involving both physical and information flows. One important problem within such systems is the establishment of adequate inventory control policies that may deal with demand variability. Many approaches found in the literature deal with an optimization problem where inventory, for instance, is to be minimized in a particular period of time. However, our proposal follows a different approach where decisions are taken according to the occurrence of asynchronous events triggered by demand or inventory levels. The dynamic behavior of a single product supply chain composed by two echelons: retailing and production, is modeled, through a simulation model based on discrete event systems. A continuous review system for finished goods replacement in the retailer inventory associated with a inventory control policy is considered, which establishes the reorder point based on the events occurrence and consequent demand values exploring a order-up-to-level (r,S) policy. Such policy differs from the published inventory policies as it is considers simultaneously lead time replenishment, demand forecasts, safety inventory level, replenishment level, inventory position, and order quantity (lot size) decisions. The lot size is calculated based on an order-up-to-level policy while the reorder point is considered variable and is adjusted as a function of the lead time and the ordered quantity (lot size) so as to face demand variability at each productive period. The results obtained show that the developed approach contributes to reduce the bullwhip effect between supply chain levels as well is able to deal with demand uncertainty while ensuring higher service levels when compared to traditional inventory policies. Real case data on a Brazilian company were used to test the model developed.

Keywords: supply chain; discrete event simulation; demand uncertainty; order-up-to-level policy.

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Title: **Optimization Strategy of Supply Chain Design Using Hybrid Meta-Heuristics Approach in Context of Multi-suppliers**
Topic: **Supply Chain Management**
Type: **ORAL**

Abstract:
The study aims at presenting the optimization the strategy of Supply Chain Design (SCD) by utilizing Hybrid Meta-Heuristics (HMH), which is demonstrated in one numeral example of multi-supplier supply chain (SC). Generally, this strategy is fulfilled from two main separated pillars: SCD and optimization through HMH by using the latter as solution method for the former. Thus, first of all, we will theoretically study and address the two to emphasize their characteristics as well as applied frameworks. Afterwards, the strategic compromise of two domains will be presented and discussed through the state-of-the-art review, which we conduct on 46 articles collected from 2006 to 2015. In this review, we especially concentrate on the technical aspects of how to generate the procedure of new hybridization as well as its application in given problems of SCD.
In our illustrated case, we follow the roadmap of Corominas et al. (2015) with some modifications to design our SC. The 5-stage framework namely SCOP (SC Outline Process) model includes: 1. Identify Object, environment and objectives: Concentrate on investigating challenges of the business environment and factors have led to the requirements of (re)design SC before setting out the objectives of the new SC; 2. Define SC macrostructure: Outline preliminary sketch of the SC macrostructure. In this step, the future SC characteristics are strictly delineated; 3. Identify SC mesostructure: Define product structure and production process as well as evaluate options of each SC design activity; 4: Define SC microstructure: Formulate all SC specifications into mathematical model; 5: Choose of SC configuration: Find the optimal results by optimizer. These solutions are key references for managers to decide their new SC structure. To solve the mathematical model obtained from step 4, in step 5 we propose one HMH (programmed by MATLAB 2013b), that integrated from popular Meta-Heuristics (MH). By profoundly investigating the procedure of individual MH “parents”, we build up one novel search procedure to hybridize them in a seamless manner. Finally, the performance of proposed HMH as well as this optimal strategy is strictly qualified by being compared with different optimal algorithms on the same problem.

Keywords: Optimization, Meta-Heuristics, Hybrid Meta-Heuristics, Supply chain design.

Reference

A. Corominas, M. Mateo, I. Ribas, and S. Rubio, Methodological elements of supply chain design, International Journal of Production Research, 2015, 53, 5017-5030.

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Title: **Parametric Optimization of a Ladder Vehicle Chassis**
Topic: **Automotive Industry**
Type: **POSTER**

Abstract:
This paper presents an analysis and improvement of a vehicle's ladder chassis.The main purpose is the reduction of the amount of material needed in its manufaturing process. The automotive chassis is responsible for the proper operation of almost all the other systems in a vehicle (relative to sustention, fixation and protection). In this work, a Cargo C-816 chassis model is studied, it is conceptually compound by two stringers and five traverse beams that connect them, usually with a C section. The geometry and the dimensions of these structural components are used as parameters to be modified in order to get the objective function minimization, which is the structure's total volume. To perform this procedure there are several numerical analysis methods and optimization algorithms applicable to structures, through which is possible the formulation of automotive component models and improvement studies in many areas. Then, this paper proposes the application of a structural analysis softwares combination to accomplish the study object's modelling and optimizing it. The proposed methodology is developed initially by the chassis modelling through ANSYS 13.0, when it is applied the possible loads that the chassis may be subjected and then the structural analysis results are extracted so that, posteriorly, the optimization process is performed by modeFRONTIER software, where iteratively modifications are made until the optimal configuration is obtained. Based on Computer Aided Engineering (CAE), this paper uses analysis with the Finite Element Analysis (FEA) and concepts of manufacturing processes and mechanic of materials (as Saint-Venant Principle) to certify the structure's integrity after the initial volume reduction.

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Title: **METAMODELING-BASED OPTIMIZATION OF DRIVER RESTRAINT SYSTEMS**
Topic: **Automotive Industry**
Type: **POSTER**

Abstract:
An optimization procedure for a vehicle driver restraint system is here presented, focusing on minimizing trauma during vehicle frontal impact. Approximate models are used aiming to replace FE models in order to produce fast and reliable results. These approximate models are referred to as metamodels or surrogate models, and were created according to Kriging methodology and applied in the optimization process based on the GA (Genetic Algorithm) technique.

The driver restraint system was optimized considering the complex interaction between the anthropomorphic test devices and the different components that assemble the restraint system, like airbag, safety belts with/without pre-tensioners, seatbelt load limiting devices and steering column stroke. The methodology applied helped to develop a robust restraint system, target to meet Brazilian regulations (CONTRAN Resolution No. 221/07 – ABNT NBR15300 option 3) which is similar to United Nations regulations (ECE R94).

The numerical computational model was initially correlated with a physical test, followed by 36 numerical simulations. The numerical computational simulations were performed based on Design of Experiments. Five control factors were evaluated during the optimization phase. They are: seatbelt load limiter, airbag vent holes diameter, airbag tethers length, seat belt height adjuster and steering column stroke. Three noise factors were considered, sources of uncontrollable variation that affect a systems function, H-point variations (X/Z directions), seatbelt load limiter variation and steering column stroke tolerance.

The simulations were developed considering the vehicle frontal impact at 56 km/h against a deformable barrier at 40% overlap (ODB) in accordance with the United Nations Regulations ECE R94. The test were carried out with two 50th percentile male Hybrid III dummies belted at the front seats.

The metamodel was created combining the test sample points with respective simulation results. Finally, the single objective optimization of the chest compression was conducted based on the GA (Genetic Algorithm) technique. Both control factors and noise factors were considered as discrete variables in the optimization process.

The optimized parameters provided by GA approach based on metamodel lead to a significant reduction in the probability of injuries in a vehicle frontal impact. The computational numerical optimization tool helped to reduce the cost and time development of a safer vehicle that meets the current regulations. The results presented excellent correlation between numerical simulation and physical test and the goals of the optimization were achieved showing that this tool is reliable and helpful for current and future developments.

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Title: **PRODUCTION OPTIMIZATION OF MIXED MODEL ASSEMBLY LINE IN AUTOMOTIVE INDUSTRY USING MATHEMATICAL PROGRAMMING**
Topic: **Automotive Industry**
Type: **ORAL**

Abstract:
This work uses Mixed Integer Linear Programming (MILP) to investigate productivity differences found in a Mixed-Model Assembly Line. The solution approach is based on construction and resolution of mathematical models for the Mixed-Model Assembly Line Balancing Problem (MALBP), followed by the Car Sequencing Problem (CSP). A discrete simulation was used to check the results obtained by the mathematical models. The planning horizon for the mathematical model encompasses about one hour of production and a week for discrete simulation. The study reports the real case of an automotive body in white line that performs the final steps of the body production of three different vehicles, sharing the same line. The production is characterized as low cadence (e.g., up to 15 vehicles/hour) and fully manual. The line is formed by unpaced roller tables in series. The main objective is to investigate how to improve productivity, while maintaining the flexibility characteristic to meet a variable demand in volume and product diversity. Results of this study are presented and indicate which flexible balancing mixes are feasible. Production time differences of no more than 6% were observed in such flexible choices. However, when checking some possible combinations for the six mixes of products, a production (cycle) time difference of up to 19%, depending on the sequence of products for a certain mix of products, was observed. Another factor that also influenced production time differences – of 20% on average – was the allocation of buffers. The obtained results indicate that it is possible to operate a flexible assembly line with a level of productivity similar to a single product line, in case of careful choices in balancing/sequencing. On the other hand, if the operating conditions of balancing and sequencing were not properly taken into account the cumulative loss in throughput may be significant (e.g., for some studied cases, production time exceed the theoretical value by 30%). Although production line balancing and sequencing in many practical applications may be a challenging task, due to market flotation, this work concludes that it is possible to find a practical solution to minimize the cumulative loss in throughput by a correct allocation of “one slot” buffers between workstations. It was found that the use of “one slot” buffers combined with “resilient” production balancing, together, enable the ability of decrease the variability of cycle times and refrain throughput loss – to range lower than 10% – while maintaining production capacity (despite having three very different products) in the same line. At the new configuration – with “one slot” buffers – no new workstation was created, but new task allocations were obtained by the MILP model. As a practical result, with the new configuration it was possible decrease from nine to six workstations at the production line without harming production throughput and/or flexibility.

Keywords: Mixed-Model Assembly Line Balancing Problem (MALBP), Car Sequencing Problem (CSP), Flexible Production, Automotive Indus

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Title: **Assessment of Energy Management Strategies for a Hybrid Electric Bus**
Topic: **Automotive Industry**
Type: **ORAL**

Abstract:
Hybrid electric vehicles (HEV) present several advantages over conventional mobility platforms. In order to maximize the benefits of incorporating a hybrid transmission an adequate energy management strategy (EMS) is required. The later sets the operating condition of both the propulsion system and the internal combustion engine (ICE) given the operational state of each component and the driving requirements set by the driver. The EMS main objective is to maximize the overall efficiency of the vehicle; however, other indicators like tailpipe emissions and component deterioration have to be taken into account when establishing the optimum EMS. This paper assesses two online EMS applied to a hybrid electric bus (HEB). Specifically, the Load Following Strategy (LFS) and the Equivalent Consumption Minimization Strategy (ECMS) are evaluated performing a parametric sweep. In order to establish the driving conditions to which the bus will be subjected to, a Buenos Aires urban bus driving cycle (BADC) based on GPS data is presented. A model of the HEB is developed using maps and low order models to establish efficiency and dynamics of the different subsystems involved. Furthermore, a dedicated model to quantify the battery deterioration is implemented. Results show that using either strategy a considerable reduction on battery stress can be achieved at expense of a relatively low fuel consumption increase. The best fuel performance is obtained with the LFS while the lower battery deterioration is performed by the ECMS. Results are validated using Autonomie™ and compared with the optimal solution obtained from the deterministic dynamic programming.

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Title: **Tackling sequencing uncertainties at a vehicle painting line through simulation and mathematical mod**
Topic: **Automotive Industry**
Type: **ORAL**

Abstract:
This working paper aims to improve production throughput and to tackle uncertainties at a vehicles painting line located at the metropolitan region of Curitiba, Brazil. The studied painting line has 117 stations – or positions – that can be occupied by a vehicle at the painting line, where 30 of them are buffer positions. The 87 stations associated to the painting cab line can have different processing times. Also, metallic colors require additional operations due to varnish application after painting. In this case, the same robots perform both painting and varnish application, imposing some idleness to the line. This painting line can process several colors and different vehicles at any order. Its operation is not affected by setup times – due to process automation. Difference in processing times have an impact on station idleness along the painting line, forcing the line to be unpaced. But there are other reasons for idleness such as the production mix (amount and sequencing of metallic color vehicles), correction and rework of defects along the process, line servicing (warm-up) times, production time windows, and feed uncertainties – since there are two bodies in white lines feeding the painting line. Due to all the mentioned uncertainty causes that impact on production throughput, the approach to solve this problem is twofold: i) process simulation is performed using SIMIO® software; and ii) a mixed integer linear programing (MILP) model is proposed for the scheduling of this flowshop problem with time windows, using GAMS/CPLEX® software. The company has provided the data for six months of operation of the studied painting line. While the scheduling model – maximizing production throughput – aims to provide optimal daily production sequences, process simulation aims to validate and check how process reliability is impacted by variations on painting line feed sequencing, as well as painted vehicles output. One important restriction to the scheduling solution is that final assembly sequencing of products – which is previously set – impose painting time windows to all vehicles. As mentioned before, according to the produced vehicle, the painting line is supplied with vehicles from two distinct bodies in white lines and processing disruptions can happen at these two feeding lines. Therefore, inversions on vehicle sequencing along the painting line are being simulated seeking an insight over how to tackle production uncertainties that could be expressed as processing restrictions at the scheduling model. That is, through simulation, new processing restrictions are sought in order to have optimal scheduling solutions that are more reliable, since they would refrain process uncertainties. This working paper intends to provide an extensive report on how the painting line is affected by different sources of uncertainty as well as how to tackle them.

Key words: Sequencing, Flexible manufacturing, Simulation, Flowshop scheduling, Productivity

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Title: **STUDY OF AN ANISOTROPIC VARIATIONAL MODEL FOR SOFT BIOLOGICAL TISSUES**
Topic: **Bio - Mechanics Applications**
Type: **ORAL**
Abstract:
Soft biological tissues are mainly composed by collagen, elastin and ground substance and have important structural functions in the human body. Due to their constituents the mechanical behavior of the material is nonlinear, viscoelastic and anisotropic.
Several assumptions and different models can be employed to describe its mechanical behavior. Variational constitutive models are based in the fundamental laws of thermodynamics for solid materials with internal variables, where a local minimization provides the internal variables update for each load increment. The variational mathematical framework allows to choice or to construct suitable nonlinear functions for elastic and inelastic potentials with the expected individual dependence, in order to obtain the mechanical behavior experimentally observed.
Aiming to test different function combinations to the elastic and viscous potentials for biological tissues, the present work studies an anisotropic viscoelastic model presented in the literature, finding the most suitable potential functions for the model, as well as their possible restrictions into the minimization operation.
The results shown that the variational framework is capable to solve the minimization problem at each step increment even for highly nonlinear functions, but it still needs additional restrictions to take into account physiological restrictions.

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