transformations. These transformations produce new liquid or gas phases, which are subsequently injected into the environment. The interfacial, thermal and ablation properties of carbon fiber/phenolic resin composites are evaluated in this study. Different materials, such as plain carbon fabrics, as reinforcement, resole type phenolic (IL800, Resitan Co.) as matrix, p-toluene sulfonic acid (PTSA) and polyvinyl Butyral resin (PVB) as additive, have been used in the synthesis of the composites. Four groups of samples were fabricated to be investigated by a plasma torch. In order to explore the interlaminar shear strength of the composites, short-beam shear tests were conducted.
Short-beam shear tests indicate that the interlaminar shear strength of the C/P/PVB composite is 17% greater than that of the other samples. Observations show that 20% PVB has an important effect on proper adhesion between carbon fibers and the resole matrix of C/P composites, and on achieving improved interlaminar characteristics.
The ablation test results reveal that composites with 20resin (C/P/PVB) have the highest ablation resistance, and the erosion rate (mm/s) of these specimens are 20% lower than other specimens. Additionally, the high insulation index of the C/P/PVB samples indicates that these composites are the best ablative materials in the present study. But, results show that the mass reduction percentage of C/P/PTSA/PVB samples is around 28% lower than C/P/PVB samples. According to Table 3, addition of PVB to C/P composites caused 70% improvement in the thermal conductivity of C/P/PVB composites.
Regarding samples with 4-7 wt% PTSA, against our expectations, these samples, because of their porous structure, did not have appropriate ablative performance.

Key Words: Carbon phenolic composites, ablation, interlaminar shear strength, plasma torch.

DETERMINATION OF THE MAXIMAL SINGULARITY-FREE CIRCLE IN THE WORKSPACE OF PLANAR PARALLEL MECHANISMS USING INTERVAL ANALYSIS AND CONSTRUCTIVE GEOMETRIC APPROACH

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Abstract
This paper proposes a systematic algorithm, based on the interval analysis concept, in order to optimize the maximal singularity-free circle within the workspace of 3-DOF planar parallel mechanisms. A 3-RPR parallel mechanism is considered as the case study. Two approaches are presented, namely, interval analysis with four algorithms and a geometric constructive approach. A new concept in applying interval analysis is introduced, which could be of great help in other optimization contexts.
The proposed algorithm in the interval analysis section is divided into four sub-algorithms, which eases the understanding of the main concept and leads to a more effective and robust algorithm to solve the problem. First, the workspace of the mechanism is obtained, using the branch and prune method. Then, by the same token, the singularity locus of the mechanism under study will be obtained. Afterwards, the maximal singularity-free circle for a constant orientation and a prescribed guess box is found. Finally, the maximal singularity-free circle for all orientations of the end-effector is achieved.
Moreover, a geometric approach, referred to as the offset curve approach, is presented, which can be implemented either in CAD software or in a computer algebra system. This method is quite fast and can be applied to more complicated mechanisms. As it is a geometric approach, it can be easily extended to higher degrees of freedom parallel robots.
The main contribution of this work can be regarded as a combination of the maximal singularity-free circle with the workspace analysis, upon considering the stroke of the actuators, as additional constraints to the latter problem.
The results of this paper reveal that the singularity-free circle of any parallel mechanism can be readily obtained upon following the proposed algorithm, and, as a case study, a 3-DOF planar parallel mechanism is presented.

Key Words: Planar parallel robots, workspace, singularity, interval analysis, offset curve approach.

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Abstract
Different methods have been employed to improve the accuracy of 3D scanning, including hardware and software solutions. The most straightforward solution to improve the accuracy of scanners is to increase the number of sensor elements of the sensing array. However, such a system will not only be expensive, but will also generate a large amount of data, resulting in the need for higher computation power and memory. In addition, other affecting factors, such as lens resolution, lens distortion and aberrations, sampling rate, noise, and environmental related errors limit the final accuracy of the system. The current paper addresses the accuracy of scanning and, consequently, presents a new technique to improve the accuracy of a 3D model reconstruction of mechanical parts. The idea, called the Mechanical Dithering Technique (MDT), takes advantage of small movements of either the sensing array or the object and rescanning. Movements provide the sensing array with images of the object cast in different positions on the sensing array. The sensing array, being a digital device, will sample the image every time with different quantization errors, the average of which should normally approach zero. The idea is similar to the dithering technique, but random movements are used instead of random noise. The current work deals first with the problem theoretically. The idea is then verified by experimentation. A test rig was established and controlled tests were carried out. The rig consists of a stationary CCD camera as the sensing array, a laser beam projector as the structured light source, a conveyor belt with controllable speed, a robot arm as a programmable stand for the fine adjustment of light source position and orientation, and, finally, a geometrically known object as the control object. A triangulation technique, along with structured laser light with Gaussian distribution, is used to generate depth information. Prior to actual experiment, the calibration process is performed to obtain the intrinsic and extrinsic parameters of the camera. Calibration allowed the elimination of major sources of lens and camera error. In order to compute the depth information of the object, the angle of sheet of light must also be known, the value of which should be measured mechanically or by means of optics. Here, a novel simple method was used to obtain this value. The experiment procedure includes illumination of the object with laser structured light and capturing an image, then moving the object to a new position and repeating the capturing several times. The 2D image data for each capture is transferred to the computer and pre-processed. During extracting the 2D data point, some curve approximation methods are also used to construct a smooth curve and remove the effect of noise during the measurement process. Using MDT, different 2D images are converted to a single image, from which a more accurate geometric model can be reconstructed. The 3D geometric model is then generated and converted into a CAD data format. Consequently, the CAD model is generated in a CAD environment. To test the functionality of the system and to evaluate the accuracy of the developed system, several control points measured by a CMM machine were compared to those obtained by the developed system. It is observed that the system works well and MDT improve the 3D model reconstruction accuracy. However; the extra accuracy is obtained at the cost of extra scanning time. The larger number of movements, the higher the improved accuracy. But, most improvements are obtained for the first few movements.

Key Words: 3D scanning, triangulation method, model reconstruction, dithering technique, improved accuracy.

THE EFFECT OF VARIOUS ADDITIVES ON THE MECHANICAL, THERMAL AND ABRASIVE CHARACTERISTICS OF ABLATIVE COMPOSITES

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Abstract
During atmospheric re-entry, a ballistic or space vehicle is subjected to severe aerodynamic heating and its successful return through the Earth's atmosphere depends largely on the provision that is made for reducing aerodynamic heat transfer to its structure. For this purpose, an ablative heat shield is normally used, which undergoes physical, chemical, and mostly endothermal

The nonlocal theory of Eringen is a well-known continuum mechanics theory to account for small scale effects by specifying stress at a reference point as a function of the strain field at every point in the body. Many papers dealing with the analysis of nano-structures have been published on this topic, but, in many of the papers, the solutions of the governing equation are based on numerical methods and approximate analytical methods, like the Navier type solution method. Hence, no exact closed-form solution is available in the literature for the free vibration analysis of nano-plates under various boundary conditions.
In this paper, the exact analytical solution proposed by Hosseini-Hashemi et al. is employed to solve the governing equations of motion of a rectangular nano-plate for nonlocal Mindlin theory. To this end, equations of motion are derived via equations of momentum balance. Introducing a set of auxiliary and potential functions, the governing equations are decoupled for transverse vibration analysis. By transforming the displacement variables into known functions, the problem leads to a soluble form without any approximations. The solution of natural frequencies is obtained for Levy-type boundary conditions, and, in order to confirm the reliability of the method considered, the results are compared with those reported in the literature. Also, the effects of nonlocal parameters, aspect ratio, thickness to length ratios of the plate and different boundary conditions on vibration frequencies are investigated.

Key Words: Exact analytical solution, free vibration, nonlocal elasticity, Mindlin nano-plate.

MOBILE ROBOT SEMANTIC MAPPING USING HISTOGRAM BASED FRONTIER EXPLORATION

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Abstract
Home and service robotics is an area of intelligent robot applications. In this regard, robots need to collect sufficient perceptional information from their environment in order to decide how to perform their tasks. The environment semantic map is a helpful base for robot decisions. In this paper, a system is proposed to generate a semantic map of the environment. In this system, a place classification method is used, in order to classify the images into a set of predefined classes. When the region of the current place of the robot is recognized, the new information of the region is correlated to other components in the semantic map. The generated semantic map consists of the room shape model, the metric and topological map and the appearance model of each region. Also, the proposed system benefits from a low computational histogram based exploration method, which suggests navigating the robot towards the boundaries between free and unknown areas in the map in order to facilitate autonomous semantic map generation. A global occupancy grid map of the environment is constantly updated, based on which, a global frontier map is calculated. Then, a histogram based approach is adopted to cluster frontier cells and score these clusters, based on their distance from the robot, as well as the number of frontier cells they contain. In each stage of the algorithm, a sub—goal is set for the robot to navigate. A combination of distance transform and A* search algorithms is utilized to generate a plausible path towards the sub-goal through the free space. In this way, a reliable distance from the obstacles is guaranteed, while searching for the shortest path towards the sub-goal. The whole process is iterated until no unexplored area remains in the map and, consequently, a semantic map of all parts of the environment is generated. Experimental results of the proposed method in the simulated and real environments show that the semantic map of the environment is generated with high accuracy in a short time.

Key Words: Service robot, semantic map, exploration, feature extraction, visual place classification.

IMPROVING THE ACCURACY OF LASER SCANNING FOR 3D MODEL RECONSTRUCTION USING MECHANICAL DITHERING TECHNIQUE

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EXACT SOLUTION FOR NONAXISYMMETRIC ACOUSTIC RADIATION FROM A SUBMERGED HOLLOW SPHERE

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Abstract
In this paper, an analytical vibro-acoustic model, based on 3D elasticity theory, is formulated for acoustic radiation from a fluid-loaded arbitrary thick hollow sphere driven by internal/external distributed/concentrated harmonic loads. The classical Navier equations of linear elasticity and the Helmholtz equation for the internal/external acoustic domains are employed to present an exact solution for three dimensional non-axisymmetric steady-state sound radiation from an arbitrarily thick hollow elastic sphere submerged in an unbounded compressible ideal acoustic medium, filled with another compressible ideal acoustic fluid, and subjected to arbitrary time-harmonic distributed/concentrated mechanical drives at its internal and/or external surfaces. The Legendre Fourier Transform in the azimuthal and circumferential direction is utilized to obtain an expression for the radiated pressure field in the frequency domain. The analytical results are illustrated with numerical examples, in which air-filled, water-submerged, thick-walled steel spheres are driven by harmonic concentrated or distributed radial internal/external loads. The numerical results reveal the important effects of loading configuration and excitation frequency on the sound radiation characteristics of the submerged structure. Limited cases are considered and the validity of results is established with the aid of comparison with the data in the existing literature. The proposed model is of basic academic interest due to its inherent value as a canonical problem in structural acoustics. It can be of practical value for understanding the fundamental physics of the interaction of acoustic waves with real structures. The presented exact solution can provide an invaluable guide for structural acoustic engineers involved in the dynamic analysis and design of submerged thick-walled spherical vessels, storage tanks, underwater lab rooms, and sonar transducers. It can also serve as a benchmark for comparison to solutions obtained by costly numerical methods or approximate asymptotic approaches. Furthermore, it can aid in solving the corresponding transient radiation problem with different configurations of internal cavity.

Key Words: Fluid-structure interaction, spherical shell, variable thickness, acoustic radiation.

AN EXACT SOLUTION FOR FREE VIBRATION OF NONLOCAL MINDLIN RECTANGULAR NANO-PLATES

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Abstract
Due to the rapid development of nanotechnology, nanoplates are used in MEMS or NEMS for their superior mechanical, thermal and electrical properties. The dynamic behavior of nano-plates used as thin film elements requires a two-dimensional nano-structure analysis. Hence, one must consider small scale effects in order to refine classical theories and derive the governing equations for these structures. The scale effects are accounted for by considering internal size as a material parameter. The local (classic) continuum theory neglects the effects of long-range load on the motion of the body, and long range inter atomic interactions. Therefore, the internal scale is neglected. Nonlocal linear theory, which has both features of lattice parameter and classical elasticity, could be considered a superior theory for modeling nano-materials.

bodies were simulated using the Volume of Fluid (VOF) method and Youngs' free surface reconstruction algorithm. To predict the shape of the cavity, Navier-Stokes equations, in addition to an advection equation for the liquid volume fraction, are solved. The main application of the Volume of Fluid method is on the simulation of free surface flows. In this work, another capability has been added to the original Volume of Fluid model to solve, simultaneously, the gas and liquid phases. After this step, by applying an analytical-numerical mass transfer algorithm, the cavitation phenomenon has been simulated. The mass transfer between the liquid and vapor is modeled using Kunz's method. Simulation of the cavitation is based on a homogenous equilibrium flow model. The main features of the developed model compared to available work in the literature are in the use of Youngs' algorithm to construct the cavity region and in the consideration of surface tension, which becomes important in the prediction of the cavity closure region. The developed model was used for different geometries in a wide range of cavitation numbers from cloud cavitation to a super cavitation regime. The developed numerical model can accurately predict the geometrical parameters of a super cavity, such as its length, diameter, and the closure region. In addition, the flow parameters of a supercavity, such as its drag coefficient, pressure coefficient, and re-entrant jet, were simulated with very high accuracy. The model can also simulate the characteristics of cloud cavitation, such as the separation of large vapor structures from the main cavity region. Totally, the developed model accurately captured the cavity closure region with its transient features of re-entrant jet movement and bubble detachment. In comparison with other available models for cavitation (such as the commercial software, Fluent) the developed algorithm is more efficient and needs far less CPU time and memory.

Key Words: Supercavitation, partial cavitation, free-surface flows, volume-of-fluid (VOF) method, homegenous equilibrium flow, mass transfer model, drag coefficent.

RELIABILITY EVALUATION OF HRSG CONSIDERING OPERATIONAL AND ENVIRONMENTAL CONDITIONS, MAINTENANCE AND AGING EFFECTS

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Abstract
Combined cycle power plants consist of three main sections, namely; gas turbine, Heat Recovery Steam Generator (HRSG) and steam turbine. Occurring failure in each part of them causes a reduction in power plant output power. As the main part, if HRSG fails, the steam turbine will be unusable and have no output power, so, the reliability assessment of HRSG has a great importance for forecasting the probability of occurring failure and also reducing failure causes. In this paper, the reliability of HRSG, considering the effects of the aging phenomenon, maintenance and working and operational conditions on reliability, are modeled. Weibull distribution is used in order to model the aging phenomenon. Proportional Age Setback (PAS) and Proportional Age Reduction (PAR) models are introduced to model the maintenance effects. Accelerated Life Model (ALM) and Proportional Hazard Model (PHM) are presented and the ALM model is used to model working conditions (operational and environmental conditions). Afterwards, a method to estimate the model parameters is introduced, which is based on the Maximum Likelihood Estimator (MLE) approach. Using the presented method, failure data of six HRSGs of a plant, each with a capacity of 50 MW, are analyzed and the model parameters are calculated. By the proposed method, the unique parameters are calculated for the whole six HRSGs. To ensure that the fitted distribution is true, the estimated parameters are assayed using the Chi-Square test. Then, the behavior of HRSG reliability related functions, hazard rate and reliability function are studied under different conditions. Finally, the HRSG failure causes are discussed. Using the presented method, one can evaluate the reliability of a power system under different conditions and decide how to choose the best maintenance policy. Results show that maintenance operations can reduce failures and consequently increase the reliability of HRSGs. The estimated Weibull parameters of the HRSG case study show that it is in the aging period and has an increasing hazard rate function.

Key Words: Reliability, aging, operational and environmental conditions, maintenance, HRSG.

that, by employing a plasma actuator, the airfoil characteristics improved obviously and caused more lift and less drag coefficient in the airfoil compared with cases with no plasma actuator.
The results also show that the presence of a plasma actuator on the top surface of the airfoil and exactly at the tip of the airfoil transferred the separation point from x=16 mm to x=90 mm in 18 degrees of the angle of attack, which means that using the plasma actuator before the separation point on the top surface of the airfoil can delay the separation point about 74 mm. The growth of the aerodynamic efficiency of the airfoil by using a plasma actuator is so considerable, as it caused a 100% increase in the ratio of lift to drag coefficient and the efficiency of the airfoil at the same angle of attack.

Key Words: Plasma actuator, active flow control method, separation point, boundary layer, stall angle.

EXPERIMENTAL INVESTIGATION OF TURBULENT FLOW AROUND A 3D SQUARE CYLINDER WITH WALL EFFECT

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Abstract
A turbulent flow over a finite height square cylinder placed vertically on a wind tunnel floor is experimentally investigated. All experiments were conducted with a single-component hot-wire anemometry in an open subsonic wind tunnel. The test section of the wind tunnel has a cross section of 457mm*457mm and a length of 1200 mm. The square cylinder has a side of 15mm and its aspect ratio is selected as 3 and 7. The model was mounted on the wind tunnel floor and its blockage ratio is 3.3 %. The model was placed 550 mm downstream from the entrance of the test section. The Reynolds number based on the cylinder side and inlet velocity is selected between 11000 to 22000 (free stream velocity is chosen between 11-22 m/s). The maximum turbulence intensity of flow in the wind tunnel is less than 0.2 %. Significant flow parameters, such as mean and rms velocity, dissipation rate, Kolmogorov length scale, frequency analysis and Strouhal number, are measured and calculated for different Reynolds numbers. The formation of the different types of vortices around the cylinder is observed by measurements of the present study. For example, it is observed that a vortex forms in the upstream of the cylinder close to the junction of the model and wall. Researchers also reported occurrence of this type of vortex for different geometries. The results indicate that the variation of Strouhal number is independent of the Reynolds numbers considered and is, approximately, equal to 0.11. The results also show that the energy dissipation rate varies directly with the turbulence intensity, while it varies indirectly with the Kolmogorov length scale. The experimental results are compared with the available data of the researchers and a reasonable agreement is observed. Furthermore, an accurate uncertainty analysis is applied to determine the errors in the obtained experimental results. The maximum errors for instantaneous velocity and turbulence intensity are found equal to 7 % and 12%, respectively.

Key Words: Wake, square cylinder, hot-wire anemometry, frequency analysis, experimental study, wind tunnel.

NUMERICAL SIMULATION OF CAVITATION OVER AXISYMMETRIC BODIES USING THE VOLUME-OF-FLUID (VOF) METHOD

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Abstract
In this study, transient cavitating flows over 2D-axisymmetric geometries of cavitators and projectile

DESIGN AND OPTIMIZATION OF A LAB SCALE THERMOACOUSTIC HEAT PUMP

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Abstract
In recent years, due to international energy and environmental aspects, thermoacoustics have gained interest by being considered as an alternative technology for renewable energy utilization. Typical thermoacoustic systems deal with the conversion of heat energy to sound energy and vice versa. This phenomenon dates back more than a century. Recent advances in the field of thermoacoustics have altered the working mechanism of many conventional heating and cooling devices. Thermoacoustic systems have three distinctive advantages: first, they are simple in structure, have no moving parts, and have low manufacture costs with high reliability; second, by using inert gases as a working fluid, they are environmentally friendly, and; finally, heat driven thermoacoustic devices can be driven by low quality energy sources such as waste heat, solar energy, and etc. Although thermoacoustic refrigerators were developed in the early 1980s and despite recent remarkable achievements in thermoacoustic refrigerator systems, to the knowledge of the authors, less attention has been paid to the application of thermoacoustic prime movers and heat pumps. The main purpose of a thermoacoustic heat pump is to transfer heat from a cold reservoir to a hot reservoir via consuming acoustic power. The basic mechanism of a standing wave thermoacoustic heat pump is very simple and is based on the wave interaction processes of gas particles with their surrounding environment. The essential components of a stand-alone thermoacoustic heat pump include an acoustic driver (i.e., a loudspeaker), a resonance tube, a stack of plates, and heat exchangers.
The present work deals with the design and optimization of a lab scale thermoacoustic heat pump using the linear theory. Different design parameters, as well as constraints, are investigated, and ultimately, an algorithm for optimization of thermoacoustic heat pumps and refrigerators is developed. The proposed algorithm is validated using DeltaE software. Further, a parametric study is carried out, where the effect of various design and operational parameters on the performance of the system is studied.

Key Words: Thermoacoustic, heat pump, design.

THE NUMERICAL STUDY OF THE EFFECT OF PLASMA ACTUATOR PLACEMENT ON INCREASING AIRFOIL EFFICIENCY

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Abstract
The plasma actuator is one of the newest devices in flow control techniques which can delay separation by inducing external momentum to the boundary layer of the flow. The purpose of this paper is to simulate a NLF0414 airfoil, both experimentally and numerically, in the presence of the body force vector induced by a specific plasma actuator. For this reason, the simulation is done, both numerically and experimentally, for a NLF0414 airfoil with compressible 25m/s velocity airflow in two different cases: with no plasma actuator located on the airfoil and with body force produced by a plasma actuator located on the top of the airfoil, in order to investigate the effect of plasma on the flow passing over it and its effect on postponing separation flow on the airfoil.
Simulation of the flow over an airfoil with the presence of a plasma actuator shows that the numerical distribution of induced body force by the actuator, which is calculated by the Suzen et al. model, is in good correlation with experimental results. The results also indicate

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Abstract

The principle goal of this paper is to present a methodology for a reliability based launch vehicle conceptual design (RLVCD). In this design methodology, launch vehicle reliability is determined based on customer needs. Then, a multiple weighted criterion method, called the Analytic Hierarchy Process (AHP), is enabled to assess the reliability allocation of a launch vehicle subsystem, based on utilized technology, cost, complexity and operation time. These criteria are selected to decide about the optimum reliability of each individual subsystem, such that the reliability goal of the launch vehicle can be achieved. This is a logical approach, because system reliability is the product of subsystem reliabilities, and, therefore, if they are optimized and compatible, with respect to the mentioned criteria, system reliability will also be optimized and compatible. The aforementioned method utilizes the link between the MATLAB code (evaluation of the inconsistency index of a matrix based on Eigen vector) and the EXCEL sheet (creation of the compared matrix of objective function, compared matrix of criterion and compared matrix of alternative). In the RLVCD methodology, the Monte Carlo method is applied to launch vehicle reliability analysis and will also validate the launch vehicle subsystem reliability allocation. So, in the developed algorithm, mass-energy coefficients and technology selection are affected by subsystem allocated reliability using a statistical process. In this paper, only the effect of engine modification in the design process on launch vehicle ballistic parameters will be considered, due to several problems, such as lack of data about other subsystems. There are some sub-cycles in the reliability based conceptual design of the launch vehicle, in which the algorithm iterates to meet the design requirements. Consequently, the RLVCD methodology is applied to an existing launch vehicle with different reliability. The obtained results show that the suggested methodology is an efficient method for reliability based design in the conceptual design phase.

Key Words: Reliability, launch vehicle, conceptual design, modular design.

FREQUENCY DOMAIN IDENTIFICATION OF FRICTION AND BACKLASH FOR SERVOMECHANISMS

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Abstract

A servomechanism with undesirable nonlinearities, such as friction and backlash, is difficult to identify. These nonlinearities are the most significant drawbacks in high precision servo systems. Common identification methods based on sinusoidal or binary excitation signals may be ineffective in the presence of backlash to determine the nonlinear friction.

The focus of the current study is to model the behavior of friction and backlash and to identify the exact kinetic coefficient of friction as well as backlash. To do this, system identification in the frequency domain is proposed, utilizing frequency sweep as an excitation signal, to capture and construct the servo-system dynamics. As shown, the frequency sweep is better than the pseudo binary excitation signal, with respect to the power spectral density. Moreover, it has no problem in the identification of nonlinear plants. The transfer function of the plant is identified based on the already proposed technique that uses the differences of inputs and outputs. To remove the effect of nonlinearity from the linear part, the plant is excited with two inputs. Then, the differences of these inputs and the differences of the corresponding outputs are used to identify the model. It can be shown that if the amplitudes of the inputs are increased, the effect of the nonlinear part is further reduced. This technique was already proposed for identification of the plant in the presence of friction, and is used in this paper for identification of a plant in the simultaneous presence of friction and backlash. The width of backlash is determined, based on the phase delay of the identified model, and the equivalent friction coefficient is determined based on the optimization.

For the first time, the CIFER user interface is employed for comprehensive analysis and transfer function modeling, regarding its unique capability of windowing. The results show that the current technique is remarkably superior and could easily identify the system parameters. In addition, the robustness of the proposed method, with respect to the noisy output signals, is proven and it can outperform existing identification methods.

Key Words: Servomechanism, frequency domain identification, friction, backlash, CIFER.

Inversion method is determined by the order of inputs. First, the controller is designed based on the dynamic inversion method with a single feedback loop and a double one. Then, the neural network with a single hidden layer is added to the dynamic inversion controller with a single feedback loop. Finally, it is applied to STT missile air defense via two stages. The six degree of freedom (6DOF) simulation shows that neural networks adaptively can cancel the linearization errors of the approximate dynamic inversion controller by a simple weight update rule derived from the Lyapunov theory. Using the Lyapunov theory guarantees the stability of the closed-loop system.
In addition, results compare the above controllers and indicate that the performance and tracking error of the neural-adaptive nonlinear autopilot is better than other designed dynamic inversion controllers; and dynamic inversion with a double feedback loop is better than a single one.

Key Words: Lyapunov stability analysis techniques, adaptive controller, nonlinear control system, neural network, dynamic inversion.

AXIAL BUCKLING ANALYSIS OF FGM CYLINDRICAL FLUGGE SHELLS USING THE MLPG METHOD

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Abstract
In this paper, the meshless local Petrov-Galerkin (MLPG) method is implemented to study the buckling of FGM (Functionally Graded Material) cylindrical shells under axial load. Displacement field equations, based on the Flugge shell theory, are taken into consideration. Material properties are assumed to be temperature-dependent and graded in the thickness direction according to different volume fraction functions. A FGM cylindrical shell made up of a mixture of ceramic and metal is considered. The FGMs are multifunctional composite materials, the mechanical properties of which vary smoothly and continuously from one side to the other. This is achieved by a continuous change in composition of the constituent materials. The set of governing equations of motion are numerically solved by the Meshless method, in which a new variational trial-functional is constructed to derive the stiffness matrices, so that the critical buckling loads are obtained under various boundary conditions, using a discretization procedure and solving the general eigenvalue problem.
The MLPG method, based on a local formulation, can include all other meshless methods based on a global formulation, as special cases, if the trial and test functions and the integration methods are selected appropriately. In the MLPG, the nodal trial and test functions can be different. Herein, the moving least squares (MLS) interpolation is employed to construct both trial and test functions. The present method is a truly meshless method based on a number of randomly located nodes, upon which no global background integration mesh is needed and no element matrix assembly is required. In the present MLPG formulation, a local variational form is constructed over a local sub-domain instead of using the conventional weighted-residual procedure. The influences of some commonly used boundary conditions, variations of volume fractions and effects of shell geometrical parameters are studied. The results show the convergence characteristics and accuracy of the mentioned method.

Key Words: MLPG method, axial buckling, cylindrical shells, Flugge theory, FGM.

RELIABILITY BASED LAUNCH VEHICLE CONCEPTUAL DESIGN (RLVCD)

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DESIGN OF A MISSILE CONTROL SYSTEM USING DYNAMIC INVERSION AND NEURAL NETWORK

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Abstract

Advances in fighter aircraft technology have created new challenges for designers of anti air weapons systems and the need for agile missiles. The dynamics of agile missile flying are intrinsically nonlinear and may vary rapidly with time. Furthermore, these dynamics are highly uncertain, since aerodynamic data for vehicles operating under such conditions are difficult to obtain or simulate, and may in fact be a poor approximation of the actual dynamics. These and other worries have prompted researchers to look beyond classical methods, which have historically dominated the field of missile autopilot design, to robust, nonlinear, and "intelligent" control techinques. Most nonlinear control techniques are based on linearizing the equations of motion by the application of nonlinear feedback in trim points. Known variously as feedback linearization, dynamic inversion or gain scheduling methods, they depend heavily on knowledge of plan dynamics. More recently, neural networks have appeared as means of clearly accounting for uncertainties in plant dynamics.

This paper describes a hybrid approach to the problem of STT missile control in front of unknown nonlinearities and unmodeled dynamics. The mentioned controller has been designed with the help of neural networks and dynamic inversion methods. The dynamic inversion is a derivate of the feedback linearization technique, which has been one of the most popular methods during recent decades. The number of feedbacks in the Dynamic