6th Annual PhD Conference
on Engineering and Technology

MY FIRST CONFERENCE 2022

Book of Abstracts

MFC 2022

September 22, 2022

Hosted by: University of Rijeka, Faculty of Civil Engineering
Radmile Matejčić 3, Rijeka, Croatia

ORGANIZED BY

BOOK OF ABSTRACTS – MY FIRST CONFERENCE 2022

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ORGANIZED BY:

Faculty of Civil Engineering, University of Rijeka

Faculty of Maritime Studies, University of Rijeka

Faculty of Engineering, University of Rijeka

Under the sponsorship of GP Krk d.d.

ISBN: 978-953-6953-59-2

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PREFACE

My First Conference is an annual conference for doctoral students in engineering and technology studying at the University of Rijeka. It is a joint initiative of Faculty of Engineering, Faculty of Maritime Studies and Faculty of Civil Engineering of the University of Rijeka. Doctoral students from other institutions and graduate students with ambitions in scientific research are also welcome to participate in this annual event.

The goals for the participants of this conference are:

- To provide feedback for student's ongoing research; the work presented should include not only the completed research, but also research that is not yet complete
- Improvement of the presentation skills in English at a scientific conference without cost
- Developing the opportunity for interdisciplinary research projects between doctoral students from different institutions
- Public presentation of research results required as part of the doctoral study obligations (this presentation may be used for this purpose if the person in charge of the institution's doctoral study approves it).

The first edition of My First Conference took place at the University of Rijeka, Faculty of Engineering in September 2017. At the first conference, two keynote lectures and 29 contributed lectures were presented.

The second edition of My First Conference was held at the University of Rijeka, Faculty of Maritime Studies in September 2018. During the conference, 34 papers were presented along with two plenary lectures.

The third edition of My First Conference took place at the University of Rijeka, Faculty of Civil Engineering in September 2019. During the conference, 27 papers were presented along with one plenary lecture.

The fourth edition of My First Conference was held at the University of Rijeka, Faculty of Engineering in September 2020. For the fourth edition, 33 abstracts were presented together with one keynote speaker lecture.

The fifth edition of My First Conference was held at the University of Rijeka, Faculty of Maritime Studies on September 23, 2021. For last year’s edition, 30 abstracts were submitted along with three plenary presentations and one keynote lecture.

This year, the conference takes place at the University of Rijeka, Faculty of Civil Engineering on September 22, 2022. The sixth edition of My First Conference includes 29 abstracts, as well as one keynote lecture and one plenary lecture.

Finally, the organizers would like to thank all authors for their participation in the sixth edition of My First Conference, as well as the organizing institutions and the members of

the Scientific and Organizing Committee for their contribution to the realization of this year's event.

We hope to see you again at the seventh edition of My First Conference in 2023!

Organizing Committee of MFC 2022

KEYNOTE LECTURE:

dr.sc. Marko Lavrenčić

Numerical Procedures for Nonlinear Static and Dynamic Analyses of Shell Systems

PLENARY LECTURE:

dr.sc.Anton Bogdanić

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Reducing the Dimensionality of DICOM Metadata using Autoencoders

Numerical Procedures for Nonlinear Static and Dynamic Analyses of Shell Systems

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Abstract

We study mixed(-hybrid) finite element formulations for shell-like structures, and implicit time-stepping schemes that preserve basic constants of the motion. The considered finite elements are based on large rotation inextensible-director shell model and rotation-less extensible-director shell model. The performance of the current state-of-the-art mixed(-hybrid) shell finite element formulations is assessed and some "near optimal" mixed-hybrid shell finite element formulations are presented. They allow for large solution steps, show near optimal convergence characteristics and display little sensitivity to mesh distortion [1].
We critically compare implicit dynamic schemes that belong to the groups of generalized-α methods and energy-conserving/decaying and momentum-conserving methods [2]. We further assess how these features extend to nonlinear elasto-dynamics. Novel energy-conserving/decaying and momentum-conserving schemes are derived for the previously introduced mixed-hybrid shell formulations [3]. The numerical examples demonstrate that the robustness and efficiency of the novel static formulations can be prolonged to dynamics.
Finally, the ability of these schemes to handle complex buckling and post-buckling processes is assessed. It is demonstrated that controlled numerical dissipation of higher structural frequencies is necessary for an efficient simulation of a post-buckling response.

Keywords

shells, mixed finite elements, implicit dynamics, buckling

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Numerical and experimental investigation on anchor channels

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Abstract

Anchor channels are a type of cast-in-place fastener that are well suited for supporting curtain walls and other applications in commercial construction. In modern high-rise buildings, composite slabs consisting of profiled steel decking with an in-situ cast concrete topping are commonly used. In some countries, it is also common to install the attachment point of the curtain wall in a recess of the concrete member often called a "pocket". Therefore, the specific geometry of the composite slab and pockets is a major factor to consider when designing anchor channel connections. However, the influence of complex geometry on the concrete capacity has not been investigated and design is based on engineering judgement. The main aim of this project is to investigate the behavior of anchor channels in composite slabs and pockets, for both tension and shear loads. Extensive numerical parametric studies and several experimental campaigns have been carried out to evaluate the difference in the capacity between slabs with complex geometry and equivalent plain concrete slabs under un-cracked conditions [1, 2, 3, 4]. The numerical models were validated against the corresponding experimental tests and showed excellent agreement. Based on the results, the existing design models valid for plain concrete slabs have been modified and enhanced to improve their predictability, especially in the case of thin members. Moreover, additional modification factors have been proposed to account for the influence of complex geometry on the concrete capacity.

Keywords

Anchor channels, composite slabs, steel decking, pockets, thin members, concrete failure

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A brief introduction of machine learning techniques for discharge estimation in the areas of estuaries and tidal rivers

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Abstract

Tidal rivers and estuaries are affected by many natural disasters that cause problems in the areas such as agriculture and transport [1]. Over recent years, research aimed at discharge prediction in those areas has achieved great success with the help of Machine Learning (ML) methods. Directly measuring discharge cannot be done by any instrument; however, it is possible to obtain it from collectible and measurable river parameters (flow velocity and water depth) [2]. The often-applied method of Rating Curves (RC) is relatively inexpensive and reliable, especially in the upstream area of the tidal limit. Problems with the RC approach in tidal rivers arise due to the nonlinear relationship between discharge and water stage [3]. Hydrologic and hydraulic models can explain river flow dynamics but with many downsides. The two most crucial downsides include the necessity for a large dataset with a high cost of measurements and model calibration [4]. As none of those approaches is considered optimal, ML has been introduced as the solution for discharge prediction. The advantages and limitations of ML approaches (single and hybrid models) are emphasized, with suggestions for future research. It was observed how hybrid ML models provided better results when compared with the single models' implementations, especially by using the signal processing technique, Wavelet Transformation (WT).

Keywords

Tidal rivers, Machine learning, Discharge

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* Corresponding author
This work was fully supported by the Croatian Science Foundation under the project IP-2018-01-3739, IRI2 project ”ABsistemDCiCloud” (KK.01.2.1.02.0179), and the University of Rijeka projects uniri-tehnic-18-17 and uniri-tehnic-18-15.

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Application of machine learning on negatively inclined buoyant jets

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Abstract

The process of discharging effluent with higher density in marine areas with lower density can be extremely harmful to the environment due to the deposition of hypersaline and chemical wastes on the seabed. Such processes are common during releasing brine from desalination plants or cooling water from liquefied natural gas (LNG) plants [1]. Negatively inclined buoyant jets are formed in such cases and it is crucial to know their behaviour for various flow conditions and outfall geometries. Numerical simulations are a useful tool for detailed investigation of mixing and jet behaviour prediction but are computationally expensive and require preparation efforts. Therefore, we propose a methodology based on machine learning (ML) to predict the behaviour of jets for different fluid flow conditions. The framework includes generating synthetic data using OpenFOAM to create a database for machine learning model training and validation. The input data for the proposed framework would include the inclination angle, water and pipe height, nozzle diameter, effluent velocity, effluent and brine density. The output features are geometrical characteristics of the jet, more specifically, the horizontal and vertical locations of the centreline peak, terminal rise height and return point location. Algorithms such as Support Vector Regression, Artificial Neural Networks, and Gradient Boosting could be used within the proposed framework. Furthermore, with this methodology, it is possible to investigate the most influential ML model features in order to increase the understanding of the physical process.

Keywords

OpenFOAM, machine learning, buoyant jet, mixing

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Sustainable ballast water management in the Adriatic sea

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Abstract

Ballast water is the key element for the safe and efficient operation of the ship, providing proper trim, stability, strength, maneuverability and cargo operations. Maritime transport, carrying approximately 90% of all cargo in international trade, represents a significant factor in pollution of the marine environment caused by transfer of unwanted organisms with ballast water releases. International Maritime Organization (IMO) adopted International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention), which is obligatory since 2017., with the goal of reducing the spread of Harmful Aquatic Organisms and Pathogens (HAOP) in ballast water. BWM Convention introduced two ballast water management standards, D-1 and D-2. Under D-1 standard, ships are required to exchange their ballast water in open seas, i.e. at least 200 nautical miles from nearest land with minimum 200 meters depth. With D-2 standard IMO specified the maximum concentration of viable organisms allowed for discharge through ballast water into port's aquatorium, reducing the risk of spreading of invasive species in comparison with water exchange methods. The goal of this paper is to determine the amount of ballast water discharged in most significant Croatian ports, where CIMIS (Croatian Integrated Maritime Information System) is used for analysis of the data for respective ports. Furthermore, possible alternative solutions for ballast water treatment in ports are considered, with the aim of reducing the harmful consequences on the environment, human health and global economy, supporting sustainable development of the specified area.

Keywords

Ballast Water, *Harmful Aquatic Organisms and Pathogens, BWM Convention, Ballast Water Treatment*

Acknowledgements

This research was supported by the European Regional Development Fund**,** Operational programme competitiveness and cohesion 2014 - 2020, within the project ProtectAS - Protect Adriatic Sea

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Initial Design project and Naval Architecture calculations of a RoRo ship with AVEVA Marine

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Abstract

As one of marine tools for ship design and calculations, AVEVA Marine software offers wide range of options. Starting phase of every ship project contains stability check according to the rules and regulations. Through the Surface, Compartments, Hydrostatics and Hydrodynamics modules within AVEVA Marine, all relevant information for initial design can be obtained. This article presents requirements needed to have as a starting point of a RoRo ship project and challenges with naval architecture calculations. Having a ship form, additional inputs are general ship data and compartments definition. Within the Hydrostatics phase, lightweight should be checked and weight distribution shown, then the form calculations and loading conditions for different cases. Calculations applied are according to IMO rules. Special regulations should be checked as well in way of calculating difference between net and gross tonnage, vessel freeboard, floodable lengths and equipment number. Necessary probabilistic stability assessment can be performed according to new SOLAS resolution. Within the hydrodynamics in AVEVA Marine, ship powering and manoeuvring will be checked and presented as the final part of initial design. All the results will be shown through the tables and charts. Outputs will show end phase of initial design and eligibility of the ship form for further project development.

Keywords

Marine, *Naval Architecture*, *Ship design*, *Calculations*, *Hydrostatics*

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On the Overset Grids in Computational Marine Hydrodynamics

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Abstract

An overview of using overset grids in computational marine hydrodynamics is presented. The main advantage of this method is the ability to capture large rigid body displacements that a ship withstands during voyage. Two different cases are presented in which overset grids are appropriate, using open source CFD toolkit OpenFOAM® [1]. First example includes wave response of a container ship scale model in regular steep waves. Results agree well with the experiment [2] which confirms the superiority of fully viscous CFD solvers for seakeeping problems. Second case is intrinsically different: open water propeller characteristics are calculated where rotating motion and advance speed are apriori known. Thrust and moment values are derived from the numerical simulation, showing good agreement with K_T and K_Q coefficients obtained by experiment [2]. Without any constraints in terms of motions, overset technique offers a powerful tool in numerical marine hydrodynamics despite having higher computational costs. Given the presented possibilities of overset, further work is revealed. With the possibility to validate the numerics with data from onboard measurements of a real going ship [4], expected investigations in terms of speed loss, propulsion efficiency etc. using high fidelity CFD tools are discussed.

Keywords

CFD, *marine hydrodynamics*, *seakeeping*, *onboard measurements*

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Modelling and Utilization of the PV Inverters to Mitigate Voltage Deviations in Distribution Grid

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Abstract

PV systems convert solar energy into electricity. Solar irradiance is not a constant so the energy source is interrupt. As a result, it is hard to predict generation of a PV system. Shadows directly affect reduction of the realized generation. Main causes of the shadows are weather conditions and changes such as clouds, storms and rains. Therefore, there is a need to describe solar power generation in PV system depending on weather conditions. Stochastic models are used for this problem modelling. In this paper, several stochastic models for solar irradiance on earth surface will be described, respectively models for generated power of PV system.
These models are not used just for estimation of generated power, but also for various simulations such as active and reactive power regulation in purpose to mitigate voltage deviations in the distribution grid. Several methods for this type of regulation will be described in this paper.

Keywords

PV system, smart *PV inverter*, *stohastic model*, *reactive power control*, *smart grid*

References

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Reducing the Dimensionality of DICOM Metadata using Autoencoders

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Abstract

Medical data are typically stored in Digital Imaging and Communication in Medicine (DICOM) format [1]. The format consists of medical images coupled with descriptive metadata containing information such as imaging modality, performed procedure and diagnosis description, anatomic region examined, and so on. These tags can be used for different machine learning tasks; ranging from classification and categorization [2] to other types of DICOM image manipulation [3]. However, DICOM tags can prove to be numerous which can undoubtedly impact computational performance during clustering tasks. To tackle this problem, we delve into the possibility of using autoencoders as a means of compressing DICOM metadata. We speculated that, when clustered, compressed data would have similar results to raw - uncompressed data [4]. We have worked with a dataset containing 25,000 randomly selected DICOM files, subsampled from the Clinical Hospital Center Rijeka PACS. Our results show no significant difference when clustering compressed and raw (uncompressed) data ($p > 0,05$). We conclude that good clustering results are achievable even when working with a smaller representation.

Keywords

DICOM, Autoencoders, Medical Imaging, Clustering

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Experiences in Tuning Performance of Hybrid MPI / OpenMP Applications on HPC Bura

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Abstract

High Performance Computing (HPC) is becoming more important each day as a researcher's tool in many areas of science. But efficient usage of HPC is not only important for scientific reasons but also has environmental and economic aspects. Performance improvement through optimization is a continuous process that lasts throughout the whole service life of computing hardware.
Application performance tuning covers a wide range of possible options [1, 2]. In most cases, it is not possible to intervene in program code, but there are many other approaches to improving cluster operating efficiency. Approach to performance tuning is made through the proper sizing of available resources. In this research, the focus was on the optimization of MPI, OPENMP, network, CPU and memory usage on HPC Bura. In this research, we plan to use it mainly on GROMACS software, but also on other software that we will find interesting during this research (like LS-DYNA). GROMACS is a free and open-source software suite for high-performance molecular dynamics and output analysis. LS-DYNA is a general-purpose finite element program capable of simulating complex real-world problems and it is widely used for solving problems in automobile, aerospace, construction and civil engineering, military, manufacturing, and bioengineering industries.
Performance tuning also has a significant impact on the stability of calculations, the quality of results and total runtime.

Keywords

High Performance Computing, HPC, performance tuning, optimization, GROMACS, LS-DYNA, MPI, OPENMP, CPU and memory usage

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A preliminary assessment of buildings of the historic city centre of Senj

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Abstract

Senj is a medieval town that developed very spontaneously and experienced rapid development in the 15th century [1]. It is one of the cities with a rich but also turbulent past. According to various authors, 80% of the buildings in the historic city center were destroyed [1, 2]. The city center is protected as a cultural heritage unity. According to the seismic area classification of the Republic of Croatia for a return period of 475 years, Senj is located in an area where the horizontal peak ground acceleration is 0.24 g [3]. Furthermore, it is important to emphasize that Senj has been hit by strong earthquakes throughout history [4]. The historic city center of Senj is interesting for research for two reasons: 1) old stone buildings predominate within the historic city center, which is the focus of research; 2) Senj is located in an area where significant earthquakes are most likely to happen. Visual inspection of buildings is the first step in gathering information on the condition assessment of buildings. In order to make a contribution regarding the behavior and seismic resistance of existing buildings, it is first necessary to visually establish the typology of buildings and the masonry typology. The visual inspection of the buildings within the historic city center indicated that most of the buildings were built of stone and brick parts. This type of masonry with mixed materials – stone blocks with fragments of brick in mortar – may be attributed to fast reconstruction after the great destruction in World War II.

Keywords

Preliminary assessment, *heritage buildings, stone masonry*, *seismic resistance*

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Data Visualization Tool for Smart Buildings HVAC Systems

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Abstract

Heating, ventilation, and conditioning (HVAC) system problems have been reported to be directly tied to a 30% contribution to CO_2 emissions and a 40% contribution to overall energy consumption in the EU [1]. Furthermore, there is an expected rise in the human population, which contributes to the growth of real estate business and the constant high demand for electrical energy [2]. As a result, buildings must become smarter in order to reduce energy waste and enhance energy management. One of the most important segments of smart buildings are HVAC systems which usually require a considerable amount of energy and, as such, need regulations for potential anomalies in the system. If buildings do not develop a method to control and monitor HVAC activities, it can lead to low-quality user comfort, high bills because of excess energy consumption, and negative effects towards the environment. This issue is of major importance, especially in the context of hotel buildings. With that in mind, we have developed a web-based data visualization tool that offers an exploratory approach to data analysis and can be easily scaled and integrated within the existing smart building system. The tool offers a simple and intuitive user interface and includes visualization dashboards for a better understanding of HVAC system data. Users can monitor HVAC system activities, discover irregularities, analyse thermal comfort and make informed decisions on how to manage the hotel's energy consumption based on the application feedback. Furthermore, the tool does not exclude non-experts as it is designed to be used by a wide range of users, from professional data analysts to hotel operators.
This work has been supported in part by European Regional Development Fund (ERDF) under grant agreement number KK.01.2.1.02.0303, project Adria Smart Room.

Keywords

HVAC systems, smart buildings, data analytics, monitoring tool

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Shear Strength of Sand-Kaolin Mixture

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Abstract

Implementation of the principles of unsaturated soil mechanics is essential for a variety of geotechnical problems involving partially saturated soils, such as compacted soils or soils above the groundwater table [e.g., 1,2]. Physical landslide models are a typical example where the build-up of downscaled or real-size slope models usually requires the compaction of several soil layers to achieve the desired moisture and density conditions [3]. Unsaturated soil property functions play a critical role in studying the hydromechanical response of such slopes under various rainfall infiltration conditions [4]. Soil water retention curve and hydraulic conductivity function are hydraulic properties that determine the transient rainfall infiltration process. To determine how rainfall infiltration affects the stability of a slope, the unsaturated shear strength properties of soils must be known. In this study, the unsaturated shear strength properties of a sand-kaolin mixture used as one of the soil materials for the construction of small-scale slope models in the research project "Physical modelling of landslide remediation constructions' behaviour under static and seismic actions" are investigated. The soil samples investigated were obtained by adding 15% kaolin to a uniformly graded fine sand. The samples were thoroughly mixed with a predetermined amount of water and installed into testing devices to achieve the desired density and moisture content conditions. Constant moisture content and suction-controlled tests were conducted using the conventional and modified (axis-translation based) direct shear apparatuses to investigate the effect of soil moisture content and soil suction on soil shear strength properties under normal stress conditions relevant to downscaled slope models.

Keywords

Unsaturated soils, Landslides, Physical models, *Direct shear tests*

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Behaviour of sandy soil in a small-scale landslide physical model and application of similarity

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Abstract

Small-scale landslide physical models are increasingly being used to investigate the landslide hazard. This is mostly due to the high cost of conducting in-situ landslide investigations, the difficulty of obtaining all the necessary data, and the ability to fully control initial and boundary conditions in laboratory environments where small-scale landslide physical models are conducted. Although numerous studies have investigated landslide behaviour using small-scale models, most of the studies conducted present experimental results without at least partial consideration of the theory and the law of similarity. Theory of similarity is a concept applied to test a variety of engineering models. Basically, a model is similar to a real slope (i.e., prototype in this case) if it shares geometric, kinematic, and dynamic similarities with it [1]. Most studies implicitly assume a scale ratio of 1:1 in all behavioural aspects when comparing a small-scale model to a real slope, which is far from realistic conditions. Only in some studies on soil mechanics the law of similarity is mentioned and taken into account, even if only partially [2–5].
An overview is given of the laws of similarity, their mutual influence, and the features that comprise their application to landslides [6]. Since the main problem of small-scale models in 1g are low overburden stresses present in a model [3,5], determining the shear strength and constitutive behaviour of the material in a small-scale model with respect to a real slope is one of the most important tasks. In this study, preliminary results from laboratory tests in the triaxial shear apparatus are presented. Samples of sandy material from the small-scale model are tested under small effective stresses similar to those in the small-scale model and under standard effective stresses encountered in a real slope. Further research steps for contribution to the application of similarity are formulated: determination of the most appropriate soil constitutive model for the behaviour of soil in a small-scale model and numerical simulations to validate the experimental tests of the small-scale model. The focus of the numerical simulations is on the process of rainfall infiltration in the experimental tests and comparison to rainfall patterns and rainfall events that usually occur on real slopes.

Keywords

landslide, physical models, similarity laws, sand, shear strength

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Acknowledgement: This work has been fully supported by the Croatian Science Foundation under the Project IP-2018-01-1503 ModLandRemSS.

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Examination of trajectory precision in different approaches of unmanned aerial vehicle motion control

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Abstract

This work deals with Unmanned Aerial Vehicles (UAVs) motion control implementation for search and rescue applications [1,2] using a pre-planned method for yaw angular velocity regulation. The goal of this research is to determine how accurately the UAV executes received commands and consequently, how does the achieved trajectory compare to the ideal trajectory. The ideal trajectory will be defined with a forward velocity magnitude and an angular velocity as time functions. To execute the mission the UAV will be moving at a constant forward velocity while changing its angular velocity (and therefore changing its heading angle) to generate a curved flight trajectory. The ideal trajectory will be compared with the trajectory generated in the simulator and the trajectory obtained by Global Positioning System (GPS) in a field experiment. Comparison is based on DJI Simulator application results and real experimental recordings using DJI multirotor UAVs. Gathered results and conclusions are used to endorse the gradient-based approach [3] for yaw-based motion control which does not accumulate position error as a pre-planned yaw regulator. The gradient-based approach utilizes a vector field that autocorrects UAV direction based on the obtained current GPS position of the UAV.

Keywords

UAV motion control, *Trajectory precision*, *Field experiment*

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Investigation of unmanned aerial vehicle vision system parameters for search and rescue application

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Abstract

Search and rescue (SAR) operations are challenging tasks, as they involve searching large areas with complex terrain and environmental features in a limited time span. Therefore, the probability of finding and successfully aiding the victim mostly depends on the unmanned aerial vehicle's (UAV) vision system[1]. In this research, the use of multi-rotor UAVs equipped with powerful sensing systems will be examined for search and surveillance missions. They typically operate at lower altitudes than manned aircraft which allows them to provide detailed data depending on the camera's setup, such as altitude, pitch angle, spatial resolution, and field of view[2]. These parameters can differ based on the equipment and flight parameters used in SAR missions[3]. In this work, we experimentally investigate the feasibility of adjustable parameters for successful detection in SAR applications. The experiment is conducted in Mediterranean terrain and vegetation environment using visible and thermal imaging sensors mounted on UAV. A goal of this experimental investigation is to provide a realistic and applicable UAV sensing setup for forthcoming research.

Keywords

UAV, *Flight parameters*, *Vision system*, *Search and Rescue*

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Preliminary analyses of the optimal distance between a roundabout and signalized intersection

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Abstract

With increasing urban traffic flows and increased congestions, the question of design modifications and intersection reconstruction is a common problem for urban traffic designers. Roundabouts are often chosen when planning new intersections and reconstructing old ones, given numerous advantages in terms of traffic safety and lower maintenance costs. When planning roundabouts, in addition to micro-location, it is important to consider functional criteria and the influence of adjacent intersections [1]. Usually, roundabouts experience less queuing than signalized intersections. The queues for the signals will govern and, in the case of a more significant amount of traffic, have a negative impact on roundabout capacity. In the literature, it is emphasized that the positioning of a roundabout between two adjacent signalized intersections should be avoided [2], [3]. Still, in practice, it is not always possible to prevent this situation. There are no specific guidelines for the acceptable distance between signalized intersection and roundabout.

Traffic queues that extend into adjacent intersections need to be analyzed further. The design of the system generally follows the principles of isolated roundabout design, but modeling requires two steps. The first step is providing a model as an isolated intersection – deterministic models. The second, often overlooked, step is analyzing the model as a system – stochastic model [4].

The research utilized the well-known software package VISSIM to evaluate the performance of signalized intersections and roundabouts, respectively. Four-leg intersections at different distances were taken into account. A microsimulation analysis was performed to determine the minimum distance at which a nearby signalized intersection does not affect the traffic flow of the roundabout.

Keywords

delay, minimum distance, roundabout, signalized intersection, VISSIM

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Pure bending in orthotropic micropolar continuum

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Abstract

Unlike the classical (Cauchy's) material, micropolar (Cosserat's) material has two independent kinematic fields; the translatory displacement field (also present in the classical continuum theory) and a so-called microrotation field, representing the orientation of a point. The existence of the additional kinematic field results in the occurrence of an additional stress tensor, the so-called couple-stress tensor [1]. By presuming the material to be elastic and isotropic, six material parameters are needed to describe such a material. Additionally, by assuming the material to be orthotropic, the number of micropolar material parameters further increases. In this work, the pure-bending problem of an orthotropic micropolar continuum is analysed and the isotropic micropolar analytical pure bending solution given in [1] is extended to orthotropic behaviour. By assuming orthotropy only in the classical part the number of necessary material constants is reduced to ten. Three different Young's moduli and six different Poisson's ratios [2] are obtained through virtual experiments using the finite element method in the classical isotropic elasticity conducted on aluminium specimens with artificially created heterogeneity. The derived analytical solution is then compared to the elastic four-point bending virtual experiment in order to detect the value of the characteristic bending length as a key micropolar material parameter in a substitute micropolar continuum capable of describing the average behaviour of the specimen.

Keywords

Orthotropic micropolar continuum, pure bending, orthotropic analytical solution, virtual experiments

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Micropolar and couple-stress analytical solutions for stress-concentration factor in a uniaxially loaded plate with a circular inclusion

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Abstract

In order to determine distribution of stresses in a plate with a circular hole under uniaxial loading it is useful to express the equations of 2D elasticity in a polar co-ordinate system. The analytical solutions for some of the representative problems in classical, micropolar, and couple-stress theories are given by Timoshenko and Goodier [1], Eringen [2] and Mindlin [3], respectively, but not always with a sufficient level of detail, especially in the compatibility equations. Depending on the theory used, the stress-concentration factor as the ratio between the maximum longitudinal stress (actually taking place at the edge of the hole) and the applied longitudinal traction is predicted differently.

For an infinitely wide plate, the stress concentration factor in the classical theory is always equal to three. In the micropolar theory and the couple-stress theory, however, the stress-concentration factor is smaller. It is reported in the literature that the experimentally measured stress-concentration factor for a large ratio between the plate width and the hole diameter is also smaller than three, which we will attempt to confirm in our future work and explain by means of some of those alternative continuum theories.

Keywords

Micropolar theory, Couple-stress theory, Analytical solution, Circular inclusion, Compatibility equations.

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DIC-based experimental analysis of plate specimens with central holes loaded in tension

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Abstract

Digital Image Correlation (DIC) experimental method is receiving a significant attention recently both in research and industry since it enables full-field, non-contact optical measurements of deformations and strains on almost any material and any geometry [1, 2]. In this study, DIC measurement system was used for determination and analysis of the values of strains and stresses in plate specimens with central hole loaded elastically in tension using a tensile testing machine. In order to determine the applicability of the method and the sizes of geometrical discontinuities i.e., stress concentrators that can be successfully characterized with available equipment, plate specimens made of various materials and with central holes of different sizes were studied. An important step in preparation of the specimens, which can have significant influence on results, is creation of the appropriate random speckle pattern on the specimen's surface which is usually done by spraying paint [3]. In this work, speckle pattern was applied using airbrush system and influence of speckle pattern on measurement results was considered. Values of strains and stresses on individual specimens were determined using basic empirical equations, numerically with the FEA software and compared with those determined experimentally using the DIC system. Results of the study are reported.

Keywords

Digital Image Correlation (DIC), plate with central hole, stress concentrator, experiment

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Acknowledgments: This work has been supported by Croatian Science Foundation under the project IP-2020-02-5764 and by the University of Rijeka under the project uniri-tehnic-18-116.

Estimation of glass plate boundary conditions using laser Doppler vibrometer

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Abstract

Some material properties can be measured directly but most can only be estimated indirectly. Structural parameters can almost always be estimated indirectly. Estimating parameters and properties from measurements is becoming increasingly important.
Due to the mounting technique with an elastic resin, the boundary conditions of a glass plate are between simply supported and clamped. However, comparing the results of computer models and experiments requires fairly accurate knowledge of the extent to which the supports are clamped. We want to present a method for estimating the boundary conditions of a glass plate based on measurements of vibration velocity at some points on the plate.
Unknown boundary conditions are parameterized with the parameter ‘k’ which describes the extent of the constraint on the supports and has a value in the interval from 0 to 1. The parameter ‘k’ is visible only after the boundary conditions are introduced using Lagrange multipliers. The procedure is similar to [1], [2] and [3], but at this stage of development only experimental and calculated vibration results are compared.
We propose to estimate the constraint on thin plates using experimental measurements and numerical simulations. The unknown extent of the constraint on the supports is determined from different types of data sets, such as displacements, velocities, and accelerations at different sampling frequencies. The extraction of the unknown parameter 'k' is done using inverse analysis techniques.

Keywords

Parameter estimation, boundary conditions, laser Doppler vibrometer, glass plate

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Simple model for inverse estimation of material parameters from three-point bending tests

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Abstract

Laboratory experiments provide large amount of data, and using measurements for estimation of material parameters is becoming increasingly important. The experimentally obtained data can usually be linked to a mathematical model that appropriately links effects various parameters with the global response of the tested medium. Model developed for this research is based on simple beam theory, a fractured cross section divided into layers [1], and steel and concrete behaviour equations that differ in tension and compression. Both equation contain the unknown material parameters, for which optimal values are determined by testing from a set of solutions.
Three-point bending tests were conducted on a total of nine beams; dimensions 70 x 70 x 280 mm with 210 mm span between supports; with and without steel fibers placed in a row in a notch. The results of bending were force-displacement curves recorded until beam failure from which the post-peak behavior is determined. Three parameters were recorded during the experiments: deflection, crack opening deflection (CMOD) and the loading force. All data were recorded together with the magnitude of the time step.
Verification of the model is done using a parametric analysis. At this stage of the research, it is important to obtain numerical results that are mathematically similar to the experimental data. Further work will include appropriate inverse methods to estimate the relevant parameters, similar to [2].

Keywords

Three-point bending, fiber reinforced concrete, mathematical model, parameter estimation

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Comparative analysis of structured light scanners' performance and influence of lighting conditions on scanning results

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Abstract

Based on the increased interest and applications of the 3D scanning in various industrial fields [1] as well as in research, a comparative analysis of outputs and performance of two different scanners has been conducted in this study [2]. Scanning was carried out using a high-budget metrology-grade Faro Cobalt Duo scanner and low-budget EinScan-SP scanner, both of which are of structured light type and scanning object was an actual industrial component - a sheet metal vehicle hinge. Main aim of comparing mentioned scanners was to determine differences in their precision and to get better insight on their individual capabilities. For this purpose, results obtained with calibrated and certified Faro Cobalt Duo scanner were used as a reference. Processing and analysis of scanned data was conducted in software Geomagic Control X software which allows detailed and elaborate quality control and dimensional and geometrical analyses of 3D scans. Furthermore, preliminary analysis of influence of scanning environment i.e. different lighting conditions on the EinScan-SP scanner performance and precision/quality of resulting 3D scans was performed. Scanning was carried out in two different environments, first under normal, ambient laboratory lighting and the second one with conditions close to ideal i.e. in full darkness. Results were analyzed and compared in order to determine possibility of improving scanning results.

Keywords

3D scanning, 3D scanners performance, Measurement precision, Comparison, Lighting

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Acknowledgements: This work has been supported in part by the University of Rijeka under the project uniri-tehnic-18-116 and by the company CadProduct

Microcrack Phase-Field Modelling of Sintered Steel

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Abstract

In recent years, the use of new advanced materials plays an ever-more significant role in modern structures and machine components. However, the porosity of the sintered materials causes stress concentration, strain localization and damage accumulation in a material microstructure, which can lead to the material failure [1]. Therefore, fracture modelling on the material microscale level is necessary for the reliable behaviour and life-time assessment on the macroscale. During recent years, the Phase-field method has gained huge popularity within the computational fracture mechanics field. It is a diffusive method that regularizes the sharp crack discontinuity within a volume. Such a complex fracture or fatigue crack patterns could not be obtained with almost no method available. A simple heterogeneous numerical examples are presented by Nguyen et al. [2] and Emdadi et al. [3] to show capabilities of phase-field method. Herein, a 2D P-F formulation will be used for modelling microcrack propagation in sintered materials. Different porous models will be extracted from metallographic images. Heterogeneous elasto-plastic material properties are obtained by the instrumented indentation. The numerical results will be compared with uniaxial tests and scanning electron microscopy.

Keywords

Phase-field met, heterogeneous fracture, microcrack propagation, porous sintered steel

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Robust Nonlinear Speed Control of a Magnetic-Geared Drive

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Abstract

Like conventional mechanical gears, magnetic gears (MGs) are used to match the speed of the prime mover with that of the load. However, unlike mechanical gears in which the torque transmission from the high-speed to the low-speed side (or vice versa) is based on physical interaction between mechanical teeth, MGs transmit torque in a contactless way by modulating the magnetic field. Such a contactless operation provides numerous benefits such as reduced need for maintenance, reduced acoustic noise and inherent overload protection. Although these advantages make them an attractive alternative to mechanical gears, the low stiffness and nonlinear torque transfer characteristic make an MG a less "friendly" system from a control engineer's perspective. This partly explains the lack of published research papers dealing with the control of magnetic-geared drives and, at the same time, represents a major obstacle to the wider use of MGs in high-performance drives.

Existing control systems for magnetic-geared drives are, to the best of our knowledge, based on linear controllers (e.g., state feedback controller). Therefore, to overcome the drawbacks of classic linear controllers, above all the dependence of their performance on the operating point, we propose a nonlinear controller for a magnetic-geared drive. In essence, we show that linear dynamics can be imposed to an MG by applying a nonlinear change of coordinates and a nonlinear control law, thereby ensuring exponential tracking of smooth reference trajectories with the exact same performance throughout the entire operating region. The nonlinear controller is enhanced by a disturbance observer which is used to estimate not only the load torque, but also the mechanical uncertainties related to the attached load which is usually unknown. Furthermore, based on Lyapunov's stability theory and some well-known results from matrix calculus, we derive sufficient conditions under which the closed-loop system is exponentially stable, whereby the region of attraction corresponds to the stable operating region of the MG. Finally, our work is

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completed by simulation results of magnetic-geared drive under the proposed nonlinear controller and an analysis of the system's robustness against parameter uncertainties.

Keywords

nonlinear systems, nonlinear control, magnetic gear, speed tracking

Application of feature selection techniques in assessing variables relevant for estimation of materials parameters and behavior

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Abstract

To adequately design a structure or a part, the behavior of a material, more precisely, relation between its stresses and strains, must be known. Considering that the experimental determination of fatigue and cyclic material parameters is costly and long-lasting, as opposed to monotonic tensile tests, it is of great interest to use more easily obtainable monotonic properties to estimate cyclic and fatigue material behavior [1].
Building a predictive model from acquired data can be done using classical approaches, such as regression, or more recently, various available machine learning methods. The dataset which is used as an input for such models needs to be of appropriate size and have an adequate number of input variables, also called predictors, to avoid underfitting or overfitting a model. Higher ratio of number of samples to number of predictors makes the model less likely to be affected by possible errors in data and to generalize new cases well [2]. To increase the data volume, additional datasets can be acquired by performing experiments which take a great amount of time. Therefore, it is more economical to implement a feature selection (i.e. feature engineering) techniques instead, which enable the detection of redundant input variables followed by their removal which then consequently reduces model complexity [2]. In this study, using several chosen feature selection techniques, importance of each predictor in relation with the response is determined and a subset of the most relevant variables for predicting the cyclic and fatigue parameters is selected. Building models with newly acquired subset should reduce overfitting, improve interpretability and decrease the complexity of the model.

Keywords

Material behavior, Cyclic/fatigue parameters, Feature engineering/selection

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Acknowledgments: This work has been supported by Croatian Science Foundation under the project IP-2020-02-5764 and by the University of Rijeka under the project uniri-tehnic-18-116.

Neural network based model for thermoelastic rubber behaviour

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Abstract

Neural networks have been researched for their application in the field of computational mechanics for quite some time [1] but have been considered a fringe area. With the advent of greater computational power in recent years as well as well established machine learning libraries such as TensorFlow, neural networks have become quite popular. They have been adapted for use in modelling material behaviour [2], fracture modelling directly from experimental data, neural networks have been used to accelerate optimization processes or to serve as a surrogate for finite element modelling. Of interest to this paper is modelling adiabatic thermoelastic behaviour of rubber. The model has been trained on stress-strain pairs representing experimental data. A classical Feed-forward Neural Network has been used as suggested in similar work. The results show excellent accordance and that neural networks can be employed for modelling adiabatic rubber thermoelasticity.

Keywords

Deep learning, *neural networks*, *rubber*, *material model*, *thermoelastic*

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Comparison of macroscopic and mesoscopic approaches for fluid flow modelling around an airfoil

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Abstract

Nowadays, conventional computational fluid dynamics (CFD) numerical methods, that are based on solving the Navier Stokes equation, e.g. finite element method (FEM), have been used the most for fluid flow modeling. However, with an increase in computational resources, which is especially noticeable for General Purpose Graphic Processing Units (GPGPUs), other methods, such as the Lattice Boltzmann method (LBM) have seen an increase in popularity [1, 2]. Therefore, in this work, we compare the conventional macroscopic approach with the LBM mesoscopic method. The Altair AcuSolve software is used to assess the FEM approach, while the LBM approach is investigated with Altair's UltraFluidX GPGPU-based solver. The pressure coefficient around the NACA0012 airfoil for a medium Reynolds number of 190000 is used to compare these approaches. LBM, in comparison to FEM that uses elements, is based on lattices, where the statistical Boltzmann equation is analyzed through collision and propagation of particles between lattices. The FEM approach was run in parallel on CPUs, while LBM on GPGPUs on the BURA supercomputer.

Keywords

Lattice Boltzmann method (LBM), *Finite element method (FEM)*, *airfoil*, *GPGPU*

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Novel Numerical Model of Subsurface Pitting Mechanism

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Abstract

Subsurface rolling-sliding contact fatigue mechanisms occur in well-lubricated power transmission machine elements such as bearings, gears, wheel-rail, etc [1]. In general, the pitting phenomenon occurs as a consequence of rolling-sliding contact fatigue during an elastohydrodynamic lubrication condition (EHL). The pitting phenomenon is initiated below the surface at the point of the highest shear stress which is related to material impurities, inclusions, and other microstructural defects causing stress concentrations [2]. In this research, a novel numerical model for describing the subsurface fatigue mechanism pitting is developed and computed by the software *ABAQUS*. The rolling-sliding contact pressure distribution is described in the numerical model by means of coupling of six nonlinear differential equations [3]. Fatigue damage initiation and propagation caused by the subsurface-initiated pitting is described by the phase-field method [4] and implemented into *ABAQUS* via user subroutines.

Keywords

pitting, rolling-sliding, EHL, damage, lubrication, phase-field

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Additive Manufacturing – A Disruptive Technology for the Maritime Spare Parts Supply Chain

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Abstract

Traditional spare parts supply chain in the maritime and offshore industry implies that the needed spare part is shipped from a central distribution centre to the ship's next port of destination or offshore facility. This process can become inefficient in terms of time and costs in cases when it is hard to harmonize the delivery of spare parts with ship's route. Additive manufacturing (AM) technology already proved useful in various industry sectors for spare parts logistics, but yet waits to make an impact in the maritime and offshore industry. This paper seeks to identify the research gaps that need to be closed in order to facilitate the adoption of AM in the maritime and offshore sector. Findings are based on the extensive review of related publications indexed in Web of Science, Scopus and Google Scholar platforms. Results show that the challenges can be categorized as technical and financial. Latter consist of concerns over the cost of introducing the new technology, acquiring new materials and training the personnel, while the former consist of solving the problem of AM on the sea, behaviour of AM materials in maritime environment and quality assurance of the process and product. Based on the results of the review, possible directions for future research are given.

Keywords

Additive manufacturing, 3D printing, spare parts, maritime industry, offshore industry

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Realization of a modular integrated software for the management of multimodal passenger transport services in port areas

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Abstract

The development of a modular integrated software for the management of intermodal transport services in port areas for passenger transport will improve data connectivity and harmonization for the Adriatic intermodal network, increasing the efficiency, quality, safety and environmental sustainability of maritime and coastal transport services. It will be shown how services, interfaces and core functionalities can be designed and developed in a modular software platform. The modular integrated information software E- CHAIN was developed as a web platform and is divided into three main functions: before, during and after the trip, which are described in detail in this article. In the future, new modules will be developed, more providers will be integrated with Google Transit Routing and events with date, time and location will be uploaded to the web platform. This study was funded by the European Regional Development Fund under the Interreg V Italy-Croatia CBC program, project ID: 10048282. (E- CHAIN - Enhanced Connectivity and Data Harmonization for the Adriatic Intermodal Network).

Keywords

modular integrated software, multimodality, transport services, data connectivity and harmonization

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