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on Engineering and Technology

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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.

The sixth edition of My First Conference was held at the University of Rijeka, Faculty of Civil Engineering on September 22, 2022. . During the conference, 29 papers were presented as well as one plenary and one keynote lecture.

This year, the conference takes place at the University of Rijeka, Faculty of Engineering on September 14, 2023. The seventh edition of My First Conference includes 19 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 seventh 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 eight edition of My First Conference in 2024!

Organizing Committee of MFC 2023

KEYNOTE LECTURE:

dr.sc. Franko Hržić

Road to PhD: Case Study of Applied AI to Medicine

PLENARY LECTURE:

dr.sc.Matej Gljušćić

Sustainability-Driven Design of Fiber-Reinforced Composites

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Marijana Balas, Jasna Prpić-Oršić, Marko Valčić

Implementation and comparison of selected natural based algorithms commonly used in route optimization

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Homomorphic Encryption and its Application in Privacy-Preserving Machine Learning

Marko Šuljić, Antonio Blažina, Đani Mohović, Robert Mohović

Contribution to the reduction of ship collision risk by simulating the collision avoiding action

Karlo Jakac, Luka Lanča, Stefan Ivić

An effective drifter deployment strategy in rugged coastline region

Characteristics of underwater vehicles

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Abstract

The underwater environment is an under-researched area, and in recent years there has been a great interest in its research. Robotization or the use of underwater vehicles, has had significant impact on the exploration of the underwater environment without exposing people to risk. The needs for the use of underwater vehicles are becoming more diverse and complex, and the correct choice of technological solutions is of crucial importance for future efficient and economically viable use. When working with underwater vehicles, we encounter challenges and problems, their positive and negative features. Therefore, it is necessary to plan the mission to use the capabilities of underwater vehicles depending on their characteristics and the desired activities that we plan to do. Thanks to underwater vehicles, opportunities are opening up to protect national interests in the exploration and exploitation of the underwater world, and many previously completely unrealistic plans are thus coming within reach. In general, robotics and underwater vehicles are recognized as a key strategic area for the development of military systems in the near future.

Keywords

Underwater vehicle, classification of underwater vehicles, military, threat

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Implementation and comparison of selected natural based algorithms commonly used in route optimization

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Abstract

This study investigates the implementation and comparison of three popular natural-based algorithms: Ant Colony Optimization (ACO), Artificial Bee Colony Optimization (ABCO), and Particle Swarm Optimization (PSO). A comprehensive overview of the relevant literature and previous research is presented as well. An improved version of the ACO algorithm, which mimics the behaviour of ants in finding the shortest path between their nest and a food source, is a good example of an effective method for solving a multi-objective optimization problem for ship weather routing [1]. The implementation of the ABCO algorithm in ship routing optimization involves encoding the potential routes as solutions which the employed bees, onlooker bees, and the scout bees iteratively explore and improve, ultimately discovering near-optimal routes. The PSO algorithm mimics the social behaviour of a swarm of particles moving toward an optimal solution. PSO uses a population of particles, where each particle represents a potential solution [2]. The algorithm considers multiple objectives, such as minimizing travel time, maximizing safety, and reducing emissions, enabling efficient and sustainable ship routing decisions. To compare the performance of ACO, ABCO, and PSO algorithms, several problems are presented and solved with each algorithm, providing detailed insights into the performance of each algorithm [3]. Various metrics such as solution quality, convergence speed, computational efficiency, and robustness are considered. The results of the comparative analysis provide insight into the strengths and weaknesses of each algorithm and help in selecting the most appropriate approach for specific ship route optimization scenarios.

Keywords

Natural based algorithms, Particle Swarm Optimization, Ant Colony Optimization, Artificial Bee Colony Optimization

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Homomorphic Encryption and its Application in Privacy-Preserving Machine Learning

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Abstract

The large amounts of data that are being generated, stored, analyzed, and transmitted electronically on a daily basis incentivize researchers to investigate and devise new methods that will ensure data security, incapacitate attackers, and allow users' data to withstand sophisticated cyber attacks. To achieve this, modern cryptographic algorithms are designed around computational hardness assumptions that arise from lattice-based cryptography [1]. This paper will explore the issue of performing computations on encrypted data and present one possible solution while highlighting its mathematical foundations. Even with the most advanced encryption schemes, if a system has to decrypt data in order to process it, that step presents a vulnerability subject to attacks or breaches. However, if the system allowed to perform computations on ciphertexts and produced an encrypted result equivalent to the same computation on plaintexts, its security would be greatly improved. The presented solution, called homomorphic encryption, maintains the structure of the encrypted data even after certain computations are performed on it. Furthermore, this paper will examine how homomorphic encryption could provide a framework for addressing privacy concerns in the context of machine learning [2]. Machine learning models typically require substantial amounts of data for training, which may contain sensitive personally identifiable information. Even if individual data points are anonymized, combining multiple sources or utilizing auxiliary information can lead to the disclosure of specific details or reidentification. Therefore, it is crucial to explore how homomorphic encryption can be applied for ensuring responsible and privacy-preserving machine learning practices. Keywords
Fault detection and diagnosis, HVAC systems, Fan coil unit, TRNSYS, Random Forests

Keywords

Homomorphic encryption, privacy-preserving machine learning, data security, lattice-based cryptography

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Contribution to the reduction of ship collision risk by simulating the collision avoiding action

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Abstract

Close-quarters situation is a term used in the International Regulations for Preventing Collisions at Sea. As the term is not precisely defined, the authors analyse the interpretations and definitions of a term close-quarters situation by various authors or courts, based on judicial processes and judgments. In the end, the authors suggest their own definition of the term close-quarters situation. Knowing the minimum distance from another ship and time to the closest point of approach, at which collision may still be avoided by one's own manoeuvre is an information that each officer would like to know. In accordance with the proposed definition of the term close-quarters situation, minimum distances between ships and time to the closest point of approach in which the ship can still take action to avoid a collision by its own manoeuvring were determined by means of simulations on navigational simulator. A total of 168 simulations were performed with three "fine-form" vessel sizes and three "full-form" vessel sizes. Due to the extensive amount of data, the paper presents the results for one vessel only.

Keywords

Close-quarters situation, Last opportunity to avoid collision, Action to avoid a collision

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An effective drifter deployment strategy in rugged coastline region

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Abstract

A surface drifting buoy, mostly referred to as a drifter, is an instrument that approximately follows water at the ocean surface, thus providing information on ocean currents by estimating velocities along their trajectories[1]. This estimation is conducted with the analysis of the observed position differences and time increments of available drifters. As a result, the application of drifter GPS positioning has become a favored method for studying surface currents due to its cost-effectiveness in providing velocity data comparable to more expensive and complex technologies[2]. In this research, we investigate a rapid approach to drifter deployment with the primary objective of achieving maximum coverage of the observed sea area. We not only consider drifter coverage but also the deployment time of drifters, particularly due to the usage of a vessel in the further going experimental setup. Our deployment strategy focuses on the placement approach of drifters in real-case scenarios near Rijeka Bay, where the experiment will be conducted. Through this assessment, we aim to evaluate the effectiveness of the drifter placement strategy in capturing the dynamic nature of surface currents. Ultimately, the goal of this investigation is to contribute to fast decision-making processes and deployment strategies in various oceanic applications regarding our forthcoming research.

Keywords

GPS Drifters, Coverage, Deployment time, Oceanographic research

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Experimental and numerical analysis of pure bending in heterogeneous and orthotropic material

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Abstract

Micropolar or Cosserat continuum theory promises a better description of mechanical problems occurring in materials with pronounced microstructure. Such materials, like foams or bones, are oversimplified when modelled with the classical elasticity theory, which, in its general form, assumes that the material is both homogeneous and isotropic [1]. In order to ensure that the numeric simulations made with the newly developed micropolar finite elements describe its physical system accurately it is necessary to validate its results. Since physical experiments require higher material costs than virtual ones, the goal of this work is a verification of the classical elasticity-based numerical simulation of the physical system that is of our interest. The resulting classical elasticity simulation will be used for the validation of micropolar simulation in future works. With that in mind, the pure bending experiments were conducted in the Constructions Laboratory at the Faculty of Civil Engineering and the Laboratory for Precision Engineering and Micro- and Nanosystems Technologies at the Faculty of Engineering. Heterogeneous and orthotropic samples in the form of aluminium beams with artificially created microstructure based on [2] were obtained for this task. Resulting displacements and strains were measured both via direct methods (with strain gauges and LVDTs) and digital image correlation (DIC) technique. The physical system was simulated in the FEAP solver as a plane stress problem. Deviations from numerical values were tracked throughout the changes in boundary conditions (change in support span) and are varying in size for different observed variables.

Keywords

Pure bending, heterogeneous and orthotropic material, experimental analysis, numerical analysis, DIC

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Evaluating the parameters of potential field UAV coverage control

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Abstract

This work deals with the utilization of Heat Equation Driven Area Coverage (HEDAC) [1] algorithm for Unmanned Aerial Vehicles (UAVs) motion control in autonomous search and rescue operations. The HEDAC algorithm guides the search team of UAVs towards the greater probability of target (missing person) occurrence by using the gradient of the potential field. The method contains parameters α and β which can be tuned to alter the potential field generation and therefore achieve different search behaviour [2]. Their values affect the smoothness of the potential field which will effect whether the search is more local or global in nature. They need to be chosen in accordance with the domain size, search time and the number of agents. This study aims to identify the optimal values of α and β that maximize the coverage of a search domain, which can be surveyed by a single UAV within a 30-minute time period. Additionally, we examine whether the same parameters yield comparable coverage outcomes when employing multiple UAVs.

Keywords

HEDAC algorithm, Search and rescue, UAV motion control

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Numerical Modelling and Analysis of Statically Loaded Functionally Graded Low-Alloy Steel Specimens

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Abstract

Various engineering components frequently encounter substantial performance challenges as a result of localized, high static and dynamic loads and stresses. To enhance the load-carrying capacity and durability of these components, various heat treatments are employed. Surface hardening techniques are commonly used due to their ability to induce martensitic transformation in the surface layer of components, improving surface hardness and strength while preserving the core's lower hardness and consequently, higher ductility. This approach minimizes the risk of components' brittleness and related performance issues, particularly for components exposed to high impact loads [1]. These materials, known as functionally graded materials (FGMs), possess a gradual variation in material properties and are employed to optimize and enhance the structural integrity of components in a targeted manner [2]. This study specifically focuses on the stress-strain response of notched and unnotched specimens made from functionally graded low-alloy steel (42CrMo4) under static loading conditions. Accurate results of material response from numerical analyses require high-quality experimental data on the distribution of material properties, with careful attention to the numerical fit of the experimental data. The study employs a combination of simplified models for defining a material gradation profile, and a data-driven approach to define the material model. To accurately capture the stress-strain behavior, especially near notches, a multilinear material model is employed. Residual stresses which are relevant for behavior of surface hardened components are also considered and possibilities of their simulation is discussed in the context of investigated functionally graded components. Future studies aim to experimentally validate the proposed model, potentially expanding its scope to include cyclic loading conditions.

Keywords

Functionally graded materials, Finite element analysis, Data-driven approach

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Acknowledgments

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Random Forests Model for HVAC System Fault Detection in Hotel Buildings

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Abstract

Heating, ventilation, and air conditioning (HVAC) systems play a crucial role in maintaining a comfortable indoor environment within contemporary structures. Nevertheless, these HVAC systems are notorious for their substantial energy consumption, often accounting for as much as 50% of a building's overall energy usage [1]. Consequently, it becomes imperative to promptly identify and address issues within HVAC systems. Employing fault detection and diagnosis (FDD) techniques can be extremely useful in monitoring HVAC systems and optimizing their performance to ensure energy efficiency [2]. In this work, we illustrate the process of creating effective fault detection systems by combining physics-based modeling with machine learning. We demonstrate the development of a simulation model for a hotel building, which is subsequently utilized to generate augmented data that simulates common faults frequently encountered in HVAC systems. We employ random forests (RFs) to train predictive models. Our findings indicate that RFs can serve as autonomous detectors for FDD, although their performance is notably influenced by the quality of the data.
Acknowledgement: This work was funded by the European Regional Development Fund (ERDF) under grant agreement number KK.01.2.1.02.0303, project Adria Smart Room.

Keywords

Fault detection and diagnosis, HVAC systems, Fan coil unit, TRNSYS, Random Forests

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TC Notched and Doweled Composite Beams: Structural Analyses and Evaluation of the Results

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Abstract

In this paper, brief overview of the typological groups of timber-concrete composites (TCC) is given, their structural features and composite actions (CA) are described, and available calculation methods (analytical and numerical) are discussed [1, 2]. The focus is set on the structural analysis of two typological groups of TCC beams - in the first, the CA is achieved using dowels, and in the second, using notches (grooves), with or without an additional doweled-type fastener. These two groups were selected due to their differences, considering the possibility of applying the analytical procedure based on the γ-method. Planar numerical models (strut and tie), suitable for practical application have been prepared for both groups [1, 3]. The effectiveness of numerical models was evaluated for two characteristic cases: the stiffness of the joint is considered or completely neglected. Design analyses (analytical and numerical) were performed only for the shortterm CA (the effects of long-term loads and rheological behaviour of the constituent materials were left out) [1]. The results of experimental and numerical research, available from the literature [4], were used as a basis for the analysis. The results of the analyses carried out in this thesis were compared with bibliographic data, conclusions were derived and guidelines for practical application were given [1].

Keywords

TCC beams, notched and doweled composites, short-term structural analysis, numerical and analytical models, comparison of the results and guidance for practical application

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A Data-Driven Model for Predicting Indoor Temperatures in Buildings with HVAC Systems

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Abstract

Increasing energy demand is an important issue due to limited resources and environmental concerns. Buildings are responsible for a large portion of total energy consumption, with heating, ventilation, and air conditioning (HVAC) systems being the largest consumers [1]. With the advent of internet of things (IoT) technology, a large amount of data can be collected from buildings, providing insights into the operation of their HVAC systems. This data can be used in conjunction with data-driven methods to improve energy efficiency, analyze performance, and develop models of system behavior [2]. This study presents a data-driven artificial neural network model for predicting indoor temperatures in commercial buildings, specifically hotels. The data preprocessing procedure is described, and the main features used to build the model are identified. The results show that the data-driven model can predict indoor temperatures with an intraday root mean squared error (RMSE) of 0.85 °C. The developed model has the potential to be integrated into a predictive control system as a possible solution to reduce energy consumption and associated CO2 emissions in buildings.

Keywords

Temperature prediction, data preprocessing, ANN, HVAC

References

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Comparison of properties and behaviour of different technical ceramics with aim of ballistic protection

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Abstract

When considering ballistic protection of people and vehicles, several solutions of materials, combinations of materials and their geometry have found their application over time. As each solution had its own advantages over the previous one, new possibilities in design of armours emerged. As metal armours were very heavy, different types and qualities of technical ceramics began to take part in the development of ballistic protection, and over time definitely made strong position in this field. Regarding the advantages that ceramic material can provide, such as low density combined with very high hardness and compressive strength [1], there are also weaknesses such as high production and testing costs and complex brittle behaviour in the moment of projectile impact, which has been studied by Rahbek, D. B. et al. [2] both on bare ceramic plates and those covered with composite materials. As Silva, M.V. et al- [3] summed up, most common ceramic materials used for ballistic protection are Al_2O_3, SiC and B_4C compositions, and in this paper some of them are considered. The behaviour under different environmental conditions, in which the armour must operate in, will be analysed on four quality grades of "Saint-Gobain Ceramics" ballistic ceramics respectively bonded SiC, sintered SiC, sintered SiC-B_4C and hot pressed B_4C. Results will be validated, and predictions for future work made through software simulations.

Keywords

Ballistic protection, technical ceramics, mechanical properties, testing

References

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Impact of restrictions caused by the emergence of the COVID-19 virus on intermodal transport routes within the EU

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Abstract

The history of COVID-19, began in 2019 when the first case was reported in Wuhan, China. It quickly spread across the globe, ultimately becoming the fifth pandemic since the 1918 flu pandemic. As of February 2023, there have been over 600 million confirmed cases and more than 6.7 million lives lost to the disease. [1]
On the 1st of March, 2020, global health authorities, government agencies, and the public were unsure of how COVID-19 would spread and impact everyday life. In the first months of the pandemic, the disease was considered a severe problem confined to China. However, COVID-19 rapidly transformed into a global health emergency almost overnight. China went from reporting thousands of new cases per day to dozens by March. [2] Meanwhile, cases in Europe were rising rapidly. On March 13th, the WHO declared Europe as the epicentre of the pandemic, and on the same day, the US declared a state of emergency.
Amid the pandemic, many governments around the world closed their borders to all non-citizens and non-residents (e.g., through visa bans or mandatory health certificates) or imposed "self-isolation" as a condition of entry in order to limit the spread of the virus during quarantine, strict social distancing, and general contact tracing measures. [3]
The purpose of this research is to examine the impact of COVID-19 restrictions on internal transportation routes within the European Union (EU). Specifically, this study aims to evaluate the effects of the pandemic on transportation infrastructure, including road, air, and sea routes, as well as the implications of COVID-19 restrictions on transportation and supply chains. Understanding the impact of COVID-19 on transportation and supply chains is crucial for policymakers and industry leaders in managing future pandemics.

Keywords

Intermodal transport networks, Transportation routes, COVID-19, Pandemic

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Leveraging Data in Manufacturing: Achieving Operational Efficiency and Data

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Abstract

This paper emphasizes the critical role of data integration in optimizing manufacturing operations. The speakers, professionals from a CNC machining organization with more than 100 of CNC machines and employees, share their experiences in streamlining data management and establishing a "Single source of truth." The presentation focuses on the improvements made to their enterprise resource planning (ERP) and manufacturing execution system (MES) to address data silos and enhance data input efficiency. These initiatives have resulted in reduced queries and phone calls, while providing increased visibility of information within the system. The speakers highlight the challenges faced by CNC machining organizations in managing data effectively and present strategies employed to overcome these challenges. Attendees will gain valuable insights into the transformative power of data integration, enabling streamlined operations and a unified view of manufacturing processes. The presentation concludes with practical recommendations for implementing data integration initiatives in manufacturing environments, enabling attendees to leverage data as a driving force for operational efficiency.

Keywords

Single source of truth, Data, MES, CNC

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Numerical Simulations of a Ship Navigating in Rough Seas

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Abstract

Validation of numerical methods in marine hydrodynamics is usually done by experimental tests under strictly controlled conditions with the possibility of test repetition and assessment of errors in measurements. This is however, not the case for measurements conducted in ship scale since numerous uncertainties are to be addressed and characterized. There are some existing guidelines on conducting full-scale simulations which are however, only valid for calm water conditions [1]. In this paper, the results from the numerical simulations are compared with onboard measurements that are performed on an ocean-going ship, navigating in the near coastal area of South Africa [2]. Variables of interest include ship motions, i.e., seakeeping responses and integral values of thrust and torque delivered by the propeller. For the seakeeping part, potential flow solution is firstly investigated using a weakly non-linear solver based on Rankine panel discretization method [3]. Also, a more precise solution is investigated using fully viscous CFD solver based on a second-order finite volume method [3]. Since the computational cost of the CFD part is much higher, ship navigation is reconstructed with a wave train using restricted number of wave components.

Keywords

Onboard measurements, marine hydrodynamics, CFD, self-propulsion

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Preliminary condition assessment of timber lamella vaults in Šibenik

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Abstract

Timber lamella vaults were constructed during the mid-20th century near Šibenik as hangars for military purposes. These structures possess historical and architectural value due to their rareness, intricate geometry and distinctive structural characteristics. A group of three adjacent hangars has been investigated and a detailed preliminary condition assessment has been carried out with the aim to explore the possibilities for the adaptive reuse of the complex. Based on visual examination and extensive geometric measurements that led to the creation of the geometric model, it has been established that structure typology belongs to the original Zollinger structure system [1]. Furthermore, a visual inspection revealed that the lamellas are constructed from larch wood, displaying various irregularities in growth patterns. In order to define the mechanical properties of the material and inspect the presence of decay, non-destructive tests have been performed. Four sets of elements have been selected for measurements in each object, encompassing moisture content and dynamic ultrasound tests. Additionally, air temperature and humidity levels have been determined. The correlation between the velocity of acoustic wave propagation through the material and the dynamic modulus of elasticity enabled the determination of the static modulus of elasticity and strength classification. After statistical data processing of obtained values, strength classes standardized to a moisture content of 12% have been determined: C35 for hangar 1, C30 for hangar 2 and C35 for hangar 3 [2]. It is important to emphasize that preliminary condition assessment represents only the initial phase of a comprehensive structure reliability evaluation. All the aforementioned activities have been undertaken with the intention of providing input data for subsequent research which will include the development of a numerical model, analysis of the joint stiffness and overall assessment of the structural suitability to meet modern safety requirements.

Keywords

Timber lamella vault, Zollinger structure, preliminary assessment, ultrasound test

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Numerical Analysis of Beam Dynamics

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Abstract

This paper deals with the numerical analysis of the beam dynamic behaviour. The displacement field at each particular time instant is obtained using the finite element method. The beam is a continuous segment discretized into smaller segments, where each segment represents a finite element [1]. Each finite element has two nodes and each node has three degrees of freedom, two of which describe the displacement and one describes the rotation, so that the displacement field of the beam can be fully described. The behaviour of each beam element depends on the shape functions used to evaluate stiffness and mass matrices. In this case, we will use third degree polynomial interpolation functions. The simulations are performed using the consistent and lumped mass matrices. In this work, an analysis of undamped free vibrations and dynamic response of a beam under the influence of a concentrated force is presented. In order to be able to describe the time variation of the displacement field, the discrete degrees of freedom are considered as functions of time. The time integration of the degrees of freedom is performed using different numerical integration methods, namely finite difference [2] and Runge-Kutta methods [2]. We focus on the evaluation of the convergence properties of each method by varying the time step size. This includes the evaluation of solution accuracy, stability and convergence rates. The numerically obtained solutions are compared with the existing analytical solution for free undamped vibrations. This serves as a validation process to evaluate the accuracy and reliability of the numerical methods used to analyze the dynamic behaviour of the beam.

Keywords

Beam, *Dynamics*, *Finite element method*, *Finite difference method*, Runge-Kutta *method*

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The Study on the Efficiency of Differential GPS Corrections in the Function of Range

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Abstract

Differential Global Positioning System (DGPS) correction service is influenced by distance-dependent inaccuracies caused by uncorrelated errors between the base and rover stations [1]. DGPS uses a stationary base station to compute corrections that GPS receivers can apply, to reduce effects from prevalent error sources on GPS rover station [2]. This research aims to assess the accuracy of L1 positioning, as the most established and commonly used satellite positioning method. Single-frequency positioning operates at a frequency of 1575.42 MHz and consists of the Coarse/Acquisition Code (C/A) and the Precision Code (P-code) [3], as well as DGPS correction effectiveness in the function of range. The study utilized the EUREF network [4], incorporating a total of nine stations, with Roma (M0SE00ITA) selected as the base station, and the remaining eight stations used as rover stations. Using RTKLIB 2.4.3 [5], [6], an extensive dataset referring to 3 January 2022 was analysed for both L1 and DGPS positioning. Positioning solutions were generated by combining observation files, which contain recorded signal measurements received by the GPS receiver at that specific location, and navigation files, that comprise critical system information and navigational data. The collected data allowed for a thorough analysis of DGPS effectiveness at increasing distances between the base and rover stations. Post-processing and analyses were conducted within the RStudio Integrated Development Environment (IDE) [7]. The results generally align with the notion that there is a decrease in performance and practicality of DGPS as the distance between the base station and the rover station increases. The positional accuracy provided by DGPS exhibits a noticeable downward trend with distance, albeit with some irregularities. Ultimately, there comes a point where the limitations of DGPS surpass its advantages, emphasizing the need for alternative approaches. As an illustration, when employing DGPS for all three coordinates - latitude, longitude, and altitude - the farthest

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station from the base station exhibits significantly larger deviations in range compared to a regular L1 signal. Notably, the most substantial deviations are observed in latitude, with a deviation magnitude of 3.58 m when employing an L1 signal, as opposed to 12.75 m when utilizing DGPS. Following latitude, deviations in longitude also display a noticeable difference, measuring 2.35 m with an L1 signal and 4.04 m with DGPS. Finally, in terms of altitude, the disparities amount to 10.57 m for the L1 signal and 11.80 m for DGPS. Considering one day of observation and the relatively small distance and density between stations, it has to be noted that the observed data may not offer a comprehensive or fully representative image. While there are strong indications supporting presented presumptions, it is too early to confirm the existence of a noticeable trend. It is essential to recognize that these findings are based on preliminary research, and further investigation is necessary to draw more conclusive and comprehensive results.

Keywords

Satellite navigation, DGPS, single-frequency positioning, positioning accuracy, distance-dependent inaccuracies, statistical analysis

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Comparative Analysis of 3D-Printed Polymer Picks for Piezoelectric Harvesters: Material Characterization and Performance Evaluation

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Abstract

This paper presents a study of the material properties and a performance evaluation of 3D-printed polymer plectra for a piezoelectric harvester activated by mechanical impacts [1]. The aim of the work is to explore different 3D printing techniques and plectra shapes to identify an optimal design configuration that maximizes the energy conversion efficiency. To achieve this objective, various 3D printing techniques and polymer materials are used to fabricate the plectra, each with unique structural properties. Finite Element Method (FEM) analysis is employed to simulate the mechanical response and energy harvesting performances of the piezoelectric harvester system under diverse impact scenarios. The material properties of the printed picks are methodically examined through standardized testing samples using a dedicated testing machine. The outcomes of the performed study offer valuable insights into the performances and material characteristics of 3D-printed polymer plectra for piezoelectric energy harvesters. The experimental results obtained from mechanical testing provide a comprehensive understanding of the mechanical strength and limitations of the chosen materials, aiding the selection of suitable polymers that exhibit enhanced durability and reliability. What is more, the numerical analysis of the plectra configurations allows pinpointing the optimal plectrum design, facilitating improved energy conversion efficiency for future piezoelectric harvester applications. This work has been supported by University of Rijeka under projects numbers uniri-pr-tehnic-19-21, uniri-tehnic-18-34 and by Croatian Science Foundation under the project number IP-2019-04-3607.

Keywords

Piezoelectric harvesting, plectra, polymers, 3D printing

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