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INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

6th National Conference on Multidisciplinary Design, Analysis and Optimization

ABSTRACT BOOK

Dates | 6th-8th December, 2023

Jointly Organized by

Department of Mechanical Engineering, IIT Guwahati &
Design Division, Aeronautical Society of India

6th National Conference on Multidisciplinary Design, Analysis and Optimization

(NCMDAO – 2023)

December 6 – 8, 2023, IIT Guwahati

Abstract Book

Jointly organized by

Department of Mechanical Engineering,
Indian Institute of Technology Guwahati
Guwahati – 781039, Assam India
And Design division of the Aeronautical Society of India (AeSI)

FOREWARD

With deeper understanding of physics of the system along with growing powerful computing technology, it is now viable to design more efficient and optimized engineering systems incorporating multiple physics. The field of Multidisciplinary Design, Analysis and Optimization (MDAO) enables the researchers and designers from academia and industry to build optimized systems that are efficient, accurate, reliable and robust.

The 6th edition of the National Conference on Multidisciplinary Design, Analysis and Optimization (NCMDAO 2023) is organized at Indian Institute of Technology (IIT) Guwahati during December 6 - 8, 2023. The conference is jointly organized by Department of Mechanical Engineering, IIT Guwahati and Design division of the Aeronautical Society of India (AeSI). The conference provides a unique platform to bring together the researchers and industry professionals working in the field of MDAO and share the expertize in the form of contributed paper presentations, keynotes and invited talks and a master class on contemporary topics.

IIT Guwahati was established as the six member of the IIT fraternity in 1994. The institute has 11 departments, nine academic centres, five extramural centres, and five schools. The campus of IIT Guwahati is on the northern banks of Brahmaputra and abuts the North Guwahati town of Amingaon. The campus is on a 700 acres (2.8 km sq.) plot of land which is around 20 km from the heart of the city. It has the Brahmaputra on one side and hills and vast open spaces on others.

The major themes covered by the conference are *Structural Optimization: Size, Shape, and Topology, Design and Optimization of Materials and Metamaterials, Multiscale and Multiphysics Problems, Metamodeling or Surrogate Modeling, Systems Design and Optimization, Machine Learning and Data Science in Optimization, Mixed Integer and Linear Programming, Evolutionary, Bayesian, Heuristic Optimization Techniques, and Quantum Algorithms for Optimization, Uncertainty Quantification, Reliability, and Robustness in Design, Optimization and Additive Manufacturing, Industry Applications and Case Studies in MDAO, Emerging Trends in Optimization, Online Optimization, Optimization in Industry 4.0/Digital Twin/IoT/Smart manufacturing, Generative engineering/ design synthesis, Underwater robots, and miscellaneous topics*. Approximately 132 extended abstracts/papers were submitted and 86 of them have been selected for oral presentation after review. The selected peer-reviewed full-length papers of the conference will be published by Springer in Scopus-indexed book series titled: Advances in Multidisciplinary Design, Analysis and Optimization. Three keynote lectures and four expert lectures from academia and industries are included in this conference.

We would like to acknowledge the financial support from the sponsors to make this conference a successful event. We thank all the authors, reviewers, sponsors, invited speakers, members of advisory committee, the local organizing team, student volunteers and all others who have directly or indirectly contributed to make the conference successful.

With regards

Deepak Sharma

Organizing Secretary, NCMDAO – 2023

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EXPERT TALKS

Structural Optimization using Topological Derivatives

Prof. G.K. Ananthasuresh

Professor, Department of Mechanical Engineering, Indian Institute of Science, Bengaluru

The topology derivative gives the sensitivity of a functional to topological perturbations in the design domain. Introducing an infinitesimal hole or inclusion amounts to a topological perturbation. The boundary conditions on the new hole (or inclusion) can be of Neumann (zero force) or Dirichlet (specified displacement) type. We discuss both cases in 1D, 2D, and 3D.

We first discuss the concept of introducing holes. The topological derivative defined over the domain can be used as a level set and thereby develop an efficient optimization algorithm to design a structure. The basic idea is that the topological derivative enables us to identify where in the domain an infinitesimal hole can be made to achieve the optimal solution. Doing this repeatedly will lead to a Pareto curve for the considered cost functional and volume of material. It will be illustrated for stiff structure optimization. We then present the concept of introducing inclusion. In particular, we calculate topology derivatives for adding and removing fiber in a matrix material. We use topology derivatives thus derived in the level-set approach to arrive at pareto optimal designs considering three phases, namely, the matrix, fiber, and void. Illustrative examples and a 3D printer that can print composite structures with multiple continuous fibers that are spatially steered will also be presented.

Finally, we consider how topological derivates with Dirichlet boundary conditions on the newly introduced hole could be used to identify new anchor points in the design of stiff trusses and compliant mechanisms.

Reimagining The World of Optimization with Visual Analytics: Principles, Progress and Prospects

Prof. Palaniappan Ramu

Associate Professor, Department of Engineering Design, Indian Institute of Technology Madras, Chennai

Optimization of complex systems are usually computationally expensive and typically the decision maker prefers to understand the design space over having just an optimal solution. In addition, when the objective or constraint functions are not available explicitly, which is usually the case, knowledge of the design space permits intelligent and accurate construction of approximations also called surrogates. Hence design space exploration is important but challenging in high dimensions.

The talk will introduce interpretable Self Organizing Maps (iSOM), an ANN as an approach to visualize design space enabling graphical optimization in higher dimensions, visualize Design of Experiments facilitating intelligent sampling, and make decisions on the pareto fronts with a visual cue permitting tradeoff decisions, among others. In addition, scope to use iSOM in transfer learning and explainable outcomes will also be presented.

Machine Learning Assisted Evolutionary Multi and Many-Objective Optimization

Prof. Dhish Kumar Saxena

Professor, Department of Mechanical and Industrial Engineering, Joint Faculty, Mehta Family School of Data Science & Artificial Intelligence, Indian Institute of Technology Roorkee

Evolutionary multi- and many-objective optimization algorithms (EMaOAs) iteratively evolve a set of solutions, towards a good Pareto Front approximation. The availability of multiple solution sets over successive generations, makes EMaOAs amenable to application of machine learning (ML), for different pursuits. This master class will begin by highlighting the existing studies on ML-based enhancements for EMaOAs, before focusing on the recently proposed innovized progress operators within the gamut of reference vector (RV) based EMaOAs. This will include a detailed discussion on how the convergence and diversity capabilities of RV-EMaOAs can be simultaneously enhanced, by learning efficient search directions through a judicious mapping of inter- and intra-generational solutions, respectively. Results on hard-to-solve test problems will demonstrate the utility of the above approach, in light of convergence-diversity balance, ML-based risk-reward tradeoff, and avoidance of extra solution evaluations.

Optimization and Uncertainty Quantification “a peek into the future”: Challenges “pronounced” as opportunities

Dr. Vinay Ramanath

Principal Key Expert Scientist, Siemens Technology

The talk will delve into the key challenges in todays’ optimization solvers and how these challenges presents as opportunities for further research. The talk will elaborate on how the emerging technologies such as Generative AI, Quantum Computing, Industrial Metaverse, and Sustainability are shaping the world of optimization to solve every demanding problems of the customers and the resulting innovations that we see, which are at the intersection of these technologies.

Modeling and Solving Optimization Problems with MATLAB and Simulink

Dr. Monalisa Pal

Senior Engineer, Education Team, MathWorks India Private Limited

Discover the power of mathematical optimization techniques in scientific and engineering applications with this masterclass on MATLAB. Learn to represent your problems using an intuitive syntax, starting from their mathematical descriptions. Master the following skills through practical examples: 1) Create arrays of optimization variables indexed by numbers, 2) Construct objectives and constraints using operators and functions involving optimization variables, 3) Incorporate black-box functions into optimization models, 4) Apply automatically selected solvers for efficient optimization solutions.

Two industry talks from COMSOL and BosonQ Psi are also organized.

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ABSTRACTS

Paper ID: 2

Basis Splines to Perform Isogeometric Topology Optimisation to Design the Outline of a Bridge Pier and Evaluate yhe Compliance Based Performance Index

KNV Chandrasekhar[1], V. Bhikshma[2], B.Ramana Kumar[3] , Gugilla Aruna[4], Bakka Ramya[5], Mamidi Sai Sagar[6], Ganta Pushpalatha[7], K. Jyothi[8]
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The rapid urban development of the major cities are going through a big transition in terms of rising traffic and increasing urban needs of the people. Millions of people are flowing into the city for various reasons every day in the morning and are leaving by the evening. The use of existing roads is becoming quite congested and hence there are traffic jams wasting several hours. The need of new flyovers is obvious to accommodate smooth flow of traffic and help the businesses and employees to perform their duties. The present study is focused on the design of a bridge pier and find the layout of the material at the ultimate elastic limit. The pier is modeled using first order basis splines and Isogeometric analysis is performed to determine the nodal displacements. The code is developed using MatLab®. Topology optimisation is performed using optimality criteria to determine the optimal distribution of material. The performance indices based on compliance are determined for the optimal layout of the material. The bridge pier is then designed using Indian standard codes to determine the steel required. Two examples of bridge pier are modeled using Idea Statica® software and analysed. The results show that the design of the bridge pier is optimal and gives similar results with those existing in the literature.

Paper ID: 3

Designing and Development of Can-Sized Satellite (CANSAT): Learnings, Challenges and Implementations

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This research involves the development, design, implementation, and navigation control of an advanced comeback CanSat that will be launched to an elevation of about 700 m utilising an amateur rocket from ground surface of a CanSat. The CanSat is a component of a project that was developed for the NASA's CANSAT Competition 2021-22. We have used Problem-Based Learning (PBL) initiative allowing students with different engineering backgrounds to work together on a real-world project. Through this program which was 11-months long which includes the phase from making of PDR, CDR to final launch where students were able to use their technical skills to design, construct, and develop a working CanSat system. This study also explores the transition from a traditional classroom environment to an online PBL environment using CanSat kits the feedback, benefits, and challenges of the project are presented, with students finding it interesting and rewarding due to its interdisciplinary nature. The study also highlights the challenges and difficulties encountered, and the solutions developed by students and facilitators to overcome them.

Paper ID: 4

Speaker Recognition System and Speech Features Characteristics

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Speaker recognition is the task of identifying a person based on their voice. The human voice carries a lot of acoustic information called voiceprints and individuals have their own voiceprint, which is a more robust medium to recognize a person. Speech, unlike traditional identification techniques such as keys and passwords, are drawn from people's own biological traits and are identifying methods that can be carried anytime, everywhere, and cannot be lost or leaked. This speech-based technology can be used for a variety of applications, such as voice biometrics for security or voice assistants that can personalize responses based on the user. This paper provides a comprehensive overview of the various forensic speaker recognition techniques, including one-to-one, one-to-many, text-dependent, and text-independent methods. In addition, authors also have discussed the strengths and limitations of some selected model-ling technique and examine recent developments in the field.

Paper ID: 6

Topology Optimisation of Reinforced Concrete Structures having Openings using Bsplines

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The inevitable use of reinforced concrete for large constructions and the need to provide openings require a proper layout of reinforcement steel to be provided within the design domain. An Engineer can apply topology optimisation to determine the optimal layout of the tensile areas where steel can be provided using a strut and tie model. The maximum stress at the optimal convergence and the energy of the structure can be determined by performing topology optimisation. The main focus of this study is to model the design domain using first-order basis splines and perform isogeometric analysis to determine the maximum stress and displacement in the material. The topology optimisation is performed by gradually removing the low-stress-carrying material, and the final layout of the material can be obtained at the optimal point of convergence. This layout can give an indication to the Engineer to provide the steel in the concrete domain. The results obtained when the design domain is modeled using basis splines are similar to the layout of material when the design domain is modeled using quadrilateral elements in the literature. These results have shown that basis splines can be very useful to model and analyze the concrete domains.

Paper ID: 8

Topology Optimization of Metamaterials using Functionally Graded Material

U Meenu Krishnan[1], Abhinav Gupta[2] and Rajib Chowdhury[1]
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Functionally graded materials (FGMs) hold significant relevance in diverse engineering applications. It is to be noted that Topology Optimization (TO) is a powerful technique for optimizing material distribution within a given design space to achieve optimal performance. However, its application to design auxetics, which have a negative Poisson ratio, has been limited due to various challenges emanating from the computational demand. To address this challenge, we describe the necessary technology and methodologies to perform TO with FGMs. Numerical examples demonstrate the effectiveness of the TO approach to design negative Poisson's ratio metamaterials with FGMs. The results shown in this study also demonstrate the potential for utilizing TO in practical applications with auxetics and different material gradations.

Paper ID: 9

Selection of a Propellant for Cold Gas Thrusters in Small Satellites using the Combined TOPSIS-AHP Approach

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Cold gas propulsion systems play an ideal role when considering small satellites for a wide range of earth orbit and interplanetary missions. The choice of fuel for such a system is a key factor and is the topic of discussion across various literature on small spacecraft propulsion. This paper's uniqueness lies in analyzing this question using the TOPSIS-AHP method-based approach to arrive at the optimal choice. Nine attributes, including specific impulse, impulse per unit volume, storage conditions, cost, etc., were compared between ten viable and proven propellants. The weightage for each attribute was derived using Saaty's method by considering various technical and managerial aspects. A comprehensive numerical analysis based on the proposed methodology for the given context has suggested Ammonia, Propane, Butane, and Xenon to be the most preferred propellants, while Helium, Hydrogen, and Argon were deemed unfavorable. The article also discusses some unquantifiable qualities like handling difficulties, self-pressurization, etc. There is good scope for expanding the analysis in the future by including additional attributes among more propellants, as well as complementing and expanding on alternate numerical methodologies.

Paper ID: 10

Air Intake Duct Optimisation for a Twin Engine Aircraft

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Air intake duct for a twin engine aircraft is designed using geometric optimisation. Development of Multi-Objective Optimisation framework to handle design of Three Dimensional complex intake duct is presented in this paper. Duct performance improvement is confirmed using CFD simulations.

Paper ID: 11

Adaptive Topology Optimization in Fourth-Order Plate Bending Problems Using Isogeometric PHT-Splines

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This paper introduces an adaptive mesh refinement (AMR) methodology for topology optimization (TO) of fourth-order plate structures using isogeometric PHT-Splines. We focus on the benefit of isogeometric analysis (IGA) to inherently discretize the C1 continuous weak form of plate structures. Our approach offers several advantages over traditional methods, including a discrete density field for the material distribution filtered through a first-neighborhood strategy and a hierarchical tree structure for the structural mesh that enables effortless implementation of an AMR strategy. Utilizing the Geometry Independent Field approximation (GIFT), we discretized the design and adaptive analysis stages independently through NURBS and PHT-Splines, respectively, enabling easy transfer of geometries from industry-standard packages. Numerical examples demonstrate the superiority of our proposed methodology over traditional methods in terms of solution accuracy and computational efficiency.

Paper ID: 13

A Coupled Fluid-Structural Solver

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Various applications in aerospace require a coupled solution of the surrounding air flow and structural response of the vehicle to external loads. Flutter prediction is an essential part of the design. Traditionally, fluid dynamics has been solved using either the simplified piston theory or steady solutions from Computational Fluid Dynamics (CFD) are used to predict flutter behavior. An integrated solver consisting of a structural and fluid flow solver is developed and presented. The fluid solver is based on the immersed boundary technique to model time-varying geometry more efficiently, thereby reducing simulation time for the CFD solver. The structural response is solved using the weak formulation through the Newmark time integration scheme.

Paper ID: 15

Machine Learning-Based Digital Hydrostatic Transmission for Optimal Power Generation in Wind Turbine

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The prevailing trend in the construction of large wind turbines (WT) involves the adoption of variable speed WT systems to enhance wind energy capture efficiency. Nonetheless, various studies have identified the conventional gearbox as the primary factor contributing to increased downtime and reduced reliability in WT operations. Thus, significant attention has been directed towards Hydrostatic Transmission (HST) as a viable alternative. However, in HST systems, the variable displacement motor operates at partial displacement levels when wind speeds are below the rated speed, resulting in a decrease in drivetrain efficiency. Consequently, this paper introduces the concept of Digital Hydrostatic Transmission (DHST). In conjunction, a control framework based on the control law and an Improved Extreme Learning Machine (IELM) is designed for optimal power generation. To assess the efficacy of the proposed system, real-time wind speed data, specifically covering region II wind conditions, is employed. A comparative analysis is conducted between the proposed system and the existing HST in the literature. The results demonstrate that the proposed system enhanced mean power generation by 11.65% when contrasted with HST systems. This substantiates the effectiveness of the proposed system in optimal power generation.

Paper ID: 16

A Brief Review on Intelligent Path Planning Techniques for Autonomous Underwater Vehicles

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In recent years, there has been a notable surge in interest within the research community regarding the advancement of Autonomous Underwater Vehicles (AUVs). This interest primarily revolves around two key objectives: extending the operational durations of AUVs and elevating their levels of autonomy. It is widely acknowledged that a pivotal component in enhancing AUV persistence is effective path planning. The core objective of this paper is to furnish a concise overview of the intelligent techniques employed in the domain of AUV path planning. These intelligent techniques and associated algorithms are systematically categorized, and subjected to thorough examination. Consequently, the article addresses the broader landscape of AUV research and underscores the formidable challenges that must be overcome in the pursuit of developing highly autonomous AUVs capable of extended mission durations. It is pertinent to note that approximately 85% of the references cited in this article were published subsequent to the year 2019, attesting to the relevance of the review.

Paper ID: 17

Optimization of an Airfoil with a Cavity Using Response Surface Methods

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In this study, response surface methodology (RSM) is used to optimize the shape and width of the cavity in the airfoil with a vortex by maximizing the L/D ratio and minimizing the mass suction with a constraint of fully attached flow at an angle of attack (AOA) of 12^o and 14^o using an initial design of experiment (DOE) of 320 designs. From the Pareto front obtained from the optimization using RSM, validity of the RSM surface was carried out with actual CFD simulations. An off design analysis was also done to ensure the feasibility of an optimized design at various angles of attack.

Paper ID: 18

Efficient Multiple Flaw Detection Using SBFEM and Bayesian Inference

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Structural health monitoring of engineered structures is necessary to detect the damages/flaws that could arise due to manufacturing constraints or during service life [1]. This work presents an efficient flaw detection framework for three-dimensional (3D) structures using the Scaled Boundary Finite Element Method (SBFEM) [2] and Bayesian inference [4]. By combining the SBFEM with octree decomposition [3], accurate identification of structural flaws is achieved while reducing the meshing burden for large-scale structures when the location and size of the flaw changes. Bayesian inference is employed to statistically quantify flaw parameters, incorporating prior knowledge and updating it with observed data to provide robust estimations of the posterior distribution. This enables the identification of multiple flaws and their corresponding geometrical parameters in 3D structures as well. To estimate the posterior distribution, the trans-dimensional Reversible Jump Markov Chain Monte Carlo (RJMCMC) method is utilized for efficient sampling, allowing for automatic model selection without apriori knowledge of the number of flaws. This adaptability makes the framework suitable for diverse scenarios. Additionally, the impact of additive Gaussian noise on observed data is investigated, addressing measurement uncertainties in flaw detection. Numerical examples, including the identification of multiple voids that will be discussed in the full-length paper, will demonstrate the effectiveness and efficiency of the proposed flaw detection framework in 3D structures. The results will highlight the approach's ability to accurately detect and characterize flaws by providing confidence intervals. This framework presents a valuable tool for practical applications in structural engineering and non-destructive testing, contributing to enhanced structural health monitoring, reduced maintenance costs, and prevention of catastrophic failures in engineered structures.

Paper ID: 20

Data-Driven Model of Thomson Coil Using Dimensionless Parameters

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Thomson coil can generate large forces in a short time and hence finds application in fast acting actuators. Behavior of Thomson coil actuator depends on multi-physics which involves various fields including electrical, electromagnetic, structural and their interactions. As a result, many design parameters related to the different physical domains are involved in the analysis of Thomson Coil. Thus, it becomes complicated to have a closed-form equation which can describe the behavior of this system. In this paper, we derive dimensionless parameters associated with the variables involved in the design of Thomson Coil using Buckingham Pi theorem. These dimensionless parameters are then used to develop data-driven models which help to predict the displacement of Thomson Coil disc at a specified time interval and gain insights about the actuator when it is subjected to changes in the design parameters.

Paper ID: 21

A Novel Niching Technique for Multimodal Optimization

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Several real-world optimization problems require finding multiple solutions instead of single best solution or the global optimum. These classes of problems are called as multimodal optimization problems. Evolutionary algorithms (EA), given their parallel search capability, are used to tackle such problems, so that the population achieves distributed convergence to multiple optima. For this purpose, niching techniques have been developed which helps an EA to detect multiple optima simultaneously. Classical niching methods rely on certain parameters which are difficult to set without having information about the function landscape, and are sensitive to these parameters. Hence, it is desirable to develop approaches which are less sensitive to parameters, for achieving niching using an EA. In the current work, we propose to use Directed Batch Growing Self-Organizing Map (DBGSOM) as a population partitioning approach to achieve niching since it is able to preserve topology of the design space, which is a property that can be utilised to achieve niching behaviour. We also demonstrate that the proposed algorithm is less sensitive to the parameters.

Paper ID: 22

Mixed Integer Linear Programming Approach for Optimal Transition of Fleet to Electric

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Due to sustainability push around the world, lot of depot operators are transitioning their vehicle fleet to electric vehicles. Before depot owners start the transition to sustainable transportation, there are many questions that need to be addressed. What kind of vehicle and charging infrastructure are needed. How to reduce the capital investment and daily operational cost. This paper proposes a methodology for optimal transition of fleet to electric vehicles. The problem statement is broken down into two subproblems: dispatching and charging. Two distinct algorithms are developed using mixed integer linear programming. The dispatch maximizes the EV utilization and charging minimizes the depot peak power and charging cost. For fleet size of 100 vehicles, the algorithm takes around two minutes to provide the optimized result.

Paper ID: 24

Multi-disciplinary Design Optimization of Conceptual Design of Hybrid Drone using Evolutionary Algorithm

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This study presents the conceptual design of a hybrid drone using Multi-disciplinary Design Optimization (MDO) through a Multi-disciplinary Design Analysis (MDA) using an evolutionary algorithm. It also discusses the parametric MDA studies and their effect on takeoff weight of hybrid drone W0 and flight and vehicle characteristics.

Paper ID: 25

Mesoscopic Deformation Behavior of Lithium-Based Superquadric Pebbles under Triaxial Compression

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Lithium-based ceramics in the form of pebble beds are used as tritium breeder materials in future fusion reactors. The Drucker–Prager (D-P) model is appropriate for predicting the macroscopic thermo-mechanical behaviour of granular pebbles. We developed a numerical framework to estimate these model parameters using the Discrete Element Method (DEM)]. These model parameters controlled the shape and size of the initial yield envelope. DEM was used to perform triaxial compression simulations to extract these model parameters, which can then describe the constitutive relationship of a homogenized finite element model of pebble beds. Our current study focuses on determining the DP parameters for lithium-based pebbles with varying morphologies. Specifically, we consider assemblies of superquadric particles, such as cubes, cylinders, and ellipsoids, with varying aspect ratios of 1, 1.25, 1.5, and 2. We used this granular assembly to extract the model parameters crucial for understanding pebble beds' behavior and strength. One of the DP parameters that defines the failure surface of the Drucker–Prager cap plasticity (DPCP) model is the friction angle (β). We predicted friction angles by performing triaxial compression experiments on a hydrostatic compressed granular assembly with various confinement pressures ranging from 0.1 to 0.8 MPa. An increase in the friction angle (from 29˚ to 47.5˚) was observed with an increasing aspect ratio for ellipsoidal pebbles with various aspect ratios. These values are large when compared to the friction angle observed for monodisperse pebbles (29˚ to 33˚) across various packing fractions and interparticle friction conditions. Another crucial parameter is the dilatancy angle (ψ), essential for the continuum modeling of pebble bed assemblies. The dilatancy angle can be obtained from the triaxial compression data and relates to the dilatancy behavior of the initial hydrostatic compressed sample. In addition, we discuss the mesoscopic deformation mechanics in detail to identify valuable insights into the behavior of various superquadric particles under triaxial compression.

Paper ID: 26

Quantum assisted Evolutionary Algorithm for Topology Optimization

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Topology optimization represents an innovative methodology aimed at determining the optimal material distribution within a given structure. Recent advancements in topology optimization have permeated various domains and have reached a level of maturity conducive to practical application in industrial settings. Nevertheless, the computational demands remain formidable due to the inherent complexity and scale of industrial applications, resulting in prolonged convergence times and extensive iterative processes. To address this challenge, we propose the integration of quantum computing techniques, renowned for their exceptional convergence rates, into the topology optimization framework. Quantum-assisted evolutionary algorithms offer the potential to deliver robust and precise solutions to intricate topology optimization problems. The primary objective of this abstract is to delve into the capabilities of a quantum-assisted evolutionary algorithm as a means of efficiently addressing complex topology optimization challenges.

Paper ID: 27

Structural Design and Optimization of Composite Serpentine Air Intake for UAV

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As the use of Unmanned Aerial Vehicles (UAVs) has a major role to play in defence, a critical requirement along with minimum weight is for the aircraft to have minimum Radar Cross Section (RCS) for stealth. The stealth characteristics of UAVs are enhanced by having a submerged air intake, engine and nozzle. Also, the air intake is serpentine to reduce RCS without compromising the aerodynamic performance. This paper aims to present a practical approach for the structural design and optimization of a serpentine air intake, given the shape. Initially, a baseline air intake (D-0) is designed such that it caters the aspects of manufacturing, assembly and stealth. The baseline design is then sized to meet the requirements of structural integrity using the conventional approach, leading to the conventional design (D-1). Structural optimization of the baseline design is then performed in two phases to minimize weight while maintaining sufficient structural rigidity. The optimized air intake (D-2) shows a weight saving of ~27% over the conventional design, thereby illustrating the advantage of utilizing structural optimization in airframe design.

Paper ID: 28

Analyzing Aeroelastic Wing Flutter: Trends in Eigenvalues and System Speeds for Improved Aircraft Design and Safety

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Aeroelastic wing flutter plays a crucial role in the field of aerospace engineering, as it addresses a significant concern in aircraft design and safety. Flutter refers to the self-excited oscillations that can occur in an aircraft's wings when subjected to certain aerodynamic forces and structural dynamics. These oscillations can lead to potentially catastrophic consequences if not properly understood and addressed. Understanding aeroelastic wing flutter is essential to ensure the structural integrity, stability, and performance of aircraft. It helps to identify critical conditions, design robust wings, and develop strategies to mitigate or suppress flutter, ultimately contributing to safer and more efficient air transportation. This technical paper presents an investigation on a system of equations, incorporating structural damping, and explores the solution to the corresponding eigenvalue problem across a range of speeds. The primary objective in this research is to analyze and visualize the trends of Vω (eigenvalue) and Vg (system speed), by writing a code in MATLAB. The code facilitates the numerical solution of the system equations, allowing for the study of damping effects on the system's behavior. By systematically varying the speed parameter, the resulting eigenvalues and system speeds are obtained and plotted to provide insights into the system's dynamic characteristics. The obtained trends shed light on the relationship between eigenvalues and system speeds, providing valuable information for the understanding and analysis of the system under consideration. By incorporating structural damping in the system equations, the code enables the examination of the dynamic behavior of the wing under different speeds. Flutter, an aerodynamic instability phenomenon, is a critical concern in aircraft design. By analyzing the Frequency and Damping ratio trends of wing, this study provides valuable insights into the flutter characteristics of the wing, helping researchers and engineers understand the conditions that lead to flutter and identify strategies to mitigate or prevent it. The findings of this study contribute to the development of more stable and efficient aircraft wings, enhancing the safety and performance of future aircraft designs.

Paper ID: 29

Development of a Hybrid BCGA Tuner for Artificial Neural Network in Assessing the Performance of Electromagnetic Forming and Perforation (EMFP) of Al6061-T6 tube

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Multi-point electromagnetic forming and perforation of tubes have been a cutting-edge manufacturing technique that has utilized the power of electromagnetic forces to shape and perforate tubes. This innovative process has offered several applications such as complex and customized exhaust systems in automotive industries, fuel lines and hydraulic systems in aircraft industries, screens, and filters in oil and gas industries. A hybrid approach that combines the Binary Coded Genetic Algorithm (BCGA) tuner and Artificial Neural Network (ANN) has been proposed. The BCGA tuner has been utilized to optimize the parameters of the ANN model, which has helped improve its accuracy and generalization capabilities. By leveraging the strengths of both BCGA and ANN, a robust and efficient predictive model has been developed. Accurate prediction of these indices has significantly enhanced the efficiency and reliability of the manufacturing process. The research methodology has involved several steps. Firstly, a comprehensive dataset has been collected, consisting of input parameters such as the discharge energy, tube thickness, number of punches, and spacer length (tool height), along with corresponding output data representing the thickness reduction. Secondly, the BCGA tuner has been applied to optimize the architecture and weights of the ANN model, ensuring its optimal performance. The model has then been trained using the collected dataset, and its predictive capabilities have been evaluated through various statistical metrics such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and coefficient of determination (R^2). The effectiveness of the trained ANN model has been assessed by comparing its results with simulation data. The comparison has been conducted using five different datasets, and it has been found that the maximum deviations between the model's predictions and the simulation results have been less than 5%. This demonstrates that the model has been highly accurate and capable of producing reliable outcomes. This will enable manufacturers to optimize process parameters and make informed decisions to achieve desired outcomes, reducing material waste and production costs. Moreover, the systematic nature of the developed model has ensured its applicability across various scenarios, making it a valuable tool for industrial implementation.

Paper ID: 30

Transient Analyses of Shape Memory Alloy Structures

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Shape Memory alloys (SMA) are one of the active materials that exhibit promising capabilities in mitigating unwanted vibration out of their inherent hysteretic stress-strain response, known as pseudoelasticity. To design SMA based damping elements, one needs a robust numerical model capable of simulating stress-temperature dependent phase transformation in SMA. In this article, a finite element (FE) based numerical model has been presented, simulating the transient response of SMA based structures under various thermo-mechanical conditions. The amplitude of vibration is found to be diminishing initially, till it manifests elastic response; following which constant amplitude oscillations are observed.

Paper ID: 32

Application of Multi Optimization Techniques on Transmission Components

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Due to recent technological advancements and a competitive market, most automobile OEMs seek lightweight, efficient, reliable, and cost-effective products. In this direction, the industry employs various weight optimization techniques such as topology optimization. This method enhances structural stiffness and reduces weight by optimizing material distribution. However, this technique lacks control over localized stresses. Typically, topology optimization is followed by couple of detailed stress analyses to achieve desired levels. This will increase analysis time and falls short of an optimal solution. In contrast, topography optimization redistributes mass while closely controlling localized stresses. The current study explores a combined simulation setup that integrates the benefits of both topology and topography optimization. This paper focuses on a transmission component, where the joint optimization approach reduced localized stress by 40% compared to topology optimization alone. GENESIS along with ANSYS® is utilized for model setup and defining loads, boundary conditions.

Paper ID: 33

Stress-Driven Topology Optimization-Based Design of Auxetic Microstructure

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This paper presents a stress-based topology optimization (TO) method for systematic designing of 2D auxetic microstructure. Auxetics exhibit unique mechanical properties characterized by lateral expansion (or contraction) when subjected to uniaxial tension (or compression). These materials have gained significant interest due to their potential applications in various fields, including aerospace, automotive, sports industry, defense sector, and so on. Density–based TO, relying on the Solid Isotropic Material with Penalization (SIMP) model, is used and the P-norm stress measure is adopted. The stress penalization is exploited to overcome the singularity phenomenon arising from the introduction of stress constraints within the framework of TO. The method of moving asymptotes (MMA) is employed as an optimization solver.

Paper ID: 34

Towards the Design of a Tensegrity Lattice Metamaterial with Tunable Wave Propagation Characteristics

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Tensegrity refers to a special class of structure made of continuous tension members, i.e., strings and isolated compression members, i.e., bars. In the stable equilibrium conguration, the individual members remain under pre-

stress. Because of high stiness-to-weight ratio, controllability, and deployability, these structures are nding growing applications in diverse elds like civil engineering, robotics, space technology, etc. Stiness and geometric properties of these structures can be tuned by changing the pre-stress in the strings. The pre-stress can be changed by changing the rest lengths. And through this, the nature of wave propagation and band gaps can also be tuned. This makes tensegrity a promising architecture for developing metamaterials for controlled wave propagation. With this motivation, the present study focuses on the numerical study of tunable one-dimensional wave propagation through a tensegrity structure.

Paper ID: 35

Linear and Non-linear Reduced Order Model of Scram-jet

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The model reduction technique exemplies the approach of representing solutions within higher-dimensional data through a lower-order spatial framework. This methodology serves to alleviate complexity by enabling the representation of solutions through a reduced set of modes. In this context, we shall endeavor to construct a lower-order representation of a scramjet system employing both linear and non-linear techniques. The linear reduced order model (ROM) utilized in our research encompasses dynamic mode decomposition (DMD) and Proper Orthogonal Decomposition (POD). The non-linear ROM, on the other hand, is predicated upon an articial neural network (ANN). This ROM is poised to facilitate the analysis of ow characteristics, optimization of geometrical congurations, and the design of a scramjet controller. Within the scope of this study, we will conduct a comparative assessment of the performance of ROMs obtained through the linear reduced order model and the ANN-based model, leveraging Computational Fluid Dynamics (CFD) data. Additionally, we will assess and compare the computational eciency of these distinct methodologies.

Paper ID: 36

Aerodynamic Shape Optimization at Low Reynolds Numbers using Artificial Neural Network (ANN) Model

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An aerodynamic shape optimization framework is proposed in the present paper using Artificial Neural Network (ANN) modeling. This methodology is applied to enhance the aerodynamic performance of an Eppler E387 airfoil in the sensitive low Reynolds number regime involving boundary layer transition. The aerodynamic performance of the airfoils is evaluated by solving the potential flow equations coupled with an integral boundary-layer formulation. ANN models are built using the aerodynamic datasets and the genetic algorithm is used as the optimizer. The optimization methodology is applied to four different objective functions, namely, (i) minimizing the drag coefficient C_d, (ii) maximizing the lift coefficient C_l, (iii) maximizing the lift-to-drag ratio (C_l/C_d) and, (iv) maximizing the endurance factor ($Cl^{3/2}/C_d$). Significant improvements in each of the objective functions is achieved. For all the optimal airfoil geometries designed by the present optimization procedure, the flow transition is delayed.

Paper ID: 39

Comparison Study of FEM and IGA Based Topology Optimization Methods for Elastic Structures

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Topology Optimization (TO) is an effective numerical technique by which one can obtain the optimal material layout of the design domain satisfying an objective function and a set of constraints. In general, the optimization tool is coupled with an analysis tool to determine the unknowns. Finite Element Method (FEM) is widely used as an analysis tool until the advent of Isogeometric Analysis (IGA). In literature, IGA has been reported to perform better in comparison to FEM, as the former one considers exact geometry for analysis, yielding more accurate results while using lesser degrees of freedom. In this paper, we try to compare the performance of both FEM and IGA based Topology optimization tools in terms of computational time, value of the objective function obtained and the number of degrees of freedom involved in the analyses.

Paper ID: 40

Adjoint based Airfoil and Freeform Shape Optimization using OpenMDAO and Metacomp Software Suites

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Open source optimization framework OpenMDAO is coupled with software suites provided by Metacomp Technologies. An airfoil and a freeform optimization exercises with an objective to minimize drag are performed in 2D and salient results presented.

Paper ID: 41

Topology Optimization of Metamaterials for Improved Shear Modulus

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This study aims to economically develop metamaterials for improved shear modulus properties using topology optimization (TO). We can significantly increase the microstructure's properties with topology optimization. The microscale properties of microstructures are related to the macroscale properties of the material through homogenization theory. The density variables in TO are updated using optimality criteria. Maximizing the shear modulus of metamaterials can improve the structure's performance and durability in various engineering applications.

Paper ID: 42

Optimization of the Bypass Duct Shape for the Effective Icing Air Flow to the Turboprop Engine Using Numerical Method

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A study has been carried out to optimize the size of the bypass duct, improve engine performance and prevent engine damage caused by icing particles in a commuter category aircraft turboprop engine air intake. Computational fluid dynamics (CFD) analysis using Ansys software is employed to visualize flow parameters and study the impact of design modifications. The study emphasizes the importance of bypass ratio optimization in achieving efficient and resilient engine operation to maintain ram recovery at engine inlet screen. CFD analysis under various aircraft conditions at different altitude provides insights into flow behavior and aids in optimizing the bypass duct size. The results indicate a decrease in the bypass ratio from 28 % to 18% at minimum climb and 38% to 27% at maximum cruise conditions leading to improved engine performance and minimizing the ingress of icing particles into critical engine components with higher ram pressure recovery.

Paper ID: 43

Unmanned Aerial Vehicle (UAV) with Heavy Payload Capacity and Enhanced Stability

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The paper presents a versatile drone platform designed for experimentation and testing. This modular test bed drone offers customizable payloads, advanced control systems, and a controlled environment for technology and algorithm assessment. It prioritizes flexibility, scalability, and integration ease, making it a reliable platform for UAV prototyping and concept evaluation. The project aims to advance drone technology by delivering a comprehensive and adaptable test bed, facilitating the development and validation of new UAV systems and applications, ultimately contributing to the evolution of unmanned aerial vehicles.

Paper ID: 44

Metamaterial Topology Optimization Using Enhanced Deep Super-Resolution Neural Network

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A super-resolution (SR) based technique is presented for predicting an optimised high-resolution topology of metamaterial for maximizing the bulk modulus. In this study, we construct and train a convolutional neural network

(CNN) along with an enhanced deep superresolution (EDSR) neural network. The primary aim is to establish a robust mapping between low-resolution (LR) and high-resolution (HR) topologies, encompassing different design objectives. Solid isotropic material with the penalization (SIMP) method generates training and testing data for different design objectives. Each sample comprises both LR and HR topologies. The neural network training utilizes a limited dataset consisting of 700 samples. Numerical experiments conducted in this study demonstrate the effectiveness of the proposed method in obtaining highly accurate high-resolution topologies within significantly reduced computational time.

Paper ID: 46

Conceptual Design and Optimization of Long Endurance Platform for Venus Exploration

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In the present study, the scientific goals of in-situ Venus exploration are reviewed and an exploration mission using LTA systems is conceptualized. A mission profile for a solar-powered airship is obtained through scientific requirements. The conceptual design of an airship for a critical mission on the planet is carried out using a design optimization approach. The objective of the design is to minimize the system mass by varying the airship dimensions and solar coverage area while satisfying the energy balance and neutral buoyancy constraints. Two design problems are formulated. In the first case, the conventional airship is designed to carry out circumnavigation at altitudes between 45 to 60 km in the daytime and imaging of 3200 km at 45 km altitude in the nighttime. Due to the high temperature (~ 100° C) at an imaging altitude of 45 km, the platform needs to carry out cruise and battery recharge in the cloud layer. In the second case, a tri-lobbed airship is designed that will execute the same mission and release an atmospheric descent probe of 2 kg.
For the case of a conventional airship carrying 18 kg of Payload, the system mass ranges from 110 kg to 740 kg for different cruise altitudes ranging from 46 km to 60 km. The lengths of the corresponding airships range from 11 m to 38 m. The trilobed airship for the same payload and 2 kg of dropsonde, the system mass and size vary monotonically in the range of 170 kg to 1645 kg and 10 m to 40 m respectively as the pressure/cruise altitude is increased from 46 km to 60 km. The minimum cruise altitude is therefore beneficial as it gives minimum airship size and system mass. However, the identification of the cruise altitude can only be done once the thermal characteristics of the battery and thermal protection system are identified.

Paper ID: 50

Economic Optimization of Silicon Carbide Insulation for Orbiter Re-entry

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Optimization of various sub-systems is crucial in space- craft's design. Thermal insulation system on outer surface of space craft requires great attention at design stage, as it has to bear very high temperatures (around 1650o C) during orbiter re-entry. Thermal insulation is one of those aspects which proves to be principal for mission success.

The focus of this study is to determine the optimized insulation system by considering the trending material, i.e., Silicon Carbide Foam (SiC). SiC is a porous material which can be sandwiched with the Silica (Si) Flexible Sheets, to form the Open Cell structure. In this study, thermal analysis of insulation is focused to form an economical alternative insulation system. This optimization includes multiple variables like cost, mass, volume as well as compactness. The mathematical model of heat transfer is solved considering Finite Element Analysis (FEA). In the results, optimum thickness of insulation was identified to be 0.079 m (at 0.8 open porosity) with greater emphasis on obtaining temperature gradient. The primary aim of this study is to design and optimize an effective insulation system from the economic aspect.

Paper ID: 51

Design and Optimisation of a Wheel Hub Incorporating Conic Curves to Mitigate Concentrated Stress Generated During Bumps, Cornering, and Braking

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In the contemporary world of engineering, design has evolved into a prominent discipline. Engineering design dictates the appearance, functionality, and performance of the engineered parts. Topology optimisation is a very nuanced concept in recent times in design engineering, which helps in reducing weight while maintaining structural integrity and improving the appearance of the object. Topology optimisation involves the removal of excess material from the design through multiple iterations. The research idea proposed here is an even more nuanced method wherein topology optimisation in the design is difficult. This research paper focuses on integrating conic curves to reduce the stresses induced in a design. With nature and high school math as the primary sources of inspiration, conic curves have been discovered to be the perfect shapes for conquering design issues in the current world.

Paper ID: 52

An Online Clustering Approach using Pareto Solutions for Industrial Data

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The proliferation of IoT sensors generates vast real-world streaming data, necessitating effective techniques for processing and gaining actionable insights from the observations. By grouping extensive, high-dimensional data into manageable units, clustering facilitates decision making and creates optimized representations for efficient analysis. Graph Partitioning (GP) is frequently employed in data clustering across domains. These are typically solved as multi-objective optimization (MOO) problems, and Genetic Algorithms (GA) are a preferred method of choice. One of the main obstacles to finding optimal solutions is to account for the continually generated data that leads to shifts in the clusters. In our work, we generate a collection of Pareto graph solutions from various trials using a fixed time window repeated across the entire data. We extract the unit pairs that have consistently co-occurred in the same clusters across all runs, to calculate the co-occurrence matrix. A new GP solution is then produced using this similarity matrix. With this framework of online clustering, any incoming data can be used to reevaluate the clusters periodically. We present the results for two use cases on industrial data.

Paper ID: 56

Design and Analysis of Micro-Gas Turbine Rotor Balancing System.

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The rotor balancing system is essential for identifying rotor imbalance in high-speed rotors such as micro-gas turbine rotor systems. Commercially available balancing equipment is built for heavy rotors, whose weights are typically above 1 kg. After installing the compressor, turbine and bearings, the micro-gas turbine rotor only weighs about 380 grams. In order to accurately balance the micro-gas turbine rotor, the balancing system needs to be custom-designed for the rotor's tiny mass and compact dimensions such that the rotor does not interfere with the supports during rotation. This project focuses on designing and fabricating a custom-made rotor balancing system for a micro-gas turbine rotor. This rotor balancing system is designed using SolidWorks®. The natural frequency analysis of the balancing system was performed through analytical formulations and finite element software (ANSYS®) and validated with impact hammer tests.

Paper ID: 57

Optimizing Mechanical Component Shape for Uniform Contact Stress: A Study using Iso-Geometric Analysis

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This research paper investigates the use of Iso-Geometric Analysis (IGA) for shape optimization of mechanical components to achieve uniform contact stress and enhance performance. Contact stress significantly impacts component wear and overall performance. Unlike Finite Element Analysis (FEA), which represents component shape discretely, IGA represents shapes exactly. To enable contact algorithms within the IGA framework, a Gauss point to segment (GPS) method is developed. By integrating CAD geometry with finite element simulations, IGA provides an efficient approach for shape optimization directly on control points. The study focuses on a cantilever beam in contact with a rigid surface and a curved beam in contact with a rigid barrier. The results demonstrate the effectiveness of the proposed methodology in accurate simulations and optimized component designs within the IGA framework. The primary objective is to minimize peak contact stress by optimizing the beam profile shape under constrained volume. This research contributes to the advancement of contact stress analysis and shape optimization techniques.

Paper ID: 62

High Fidelity Systems Modeling of Thermo-Fluid Cold Plate and Electro-Thermal Battery Pack

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Inhomogeneity across individual battery modules, varying thermal loads and cell-to-cell imbalances influence the battery pack performance characteristics. The cold plate that provides the cooling, delivers through multiple steps of thermal conduction and coolant fluid flow via multiple flow passages. Detailed thermal modeling of cold plates and battery packs with individual cells are reported in literature. However, they report within their own individual disciplines namely electro-thermal or thermo-fluid and often with restrictive configurations. High fidelity systems modeling of such multiple disciplines both together is not reported.

A detailed system model developed has a cold plate with thermal conduction, coolant fluid flow and electro-thermal battery pack. The battery pack has inherent cell-to-cell variations, and it exchanges heat dynamically with the cold plate. The discretized coolant flow passages vary in their configuration and geometry. The cold plate and individual cells battery pack are automatically generated into multi-disciplinary, discretized components, equation-based and acausal systems model using Modelica language. We perform the systems modeling simulations with various configurations that compare multiple cold plate designs, bringing out the pattern of cooling with variation of temperature between individual cells and the effects of inherent cell-to-cell inhomogeneity.

Paper ID: 64

Integration of the Finite Element Methods and Neural Network for Inverse Problem Solving with Partial Observation

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We present an approach that integrates neural networks (NNs)with partial differential equations (PDEs) as physical principle constraints for solving inverse problems with partial information. The algorithm is formed by combining the residual obtained from finite element methods with custom loss functions derived from neural networks. The models obtained are spatially discretized using the finite element method (FEM). We present an implementation of the approach by extending the existing FEM framework FEniCS and utilizing the algorithmic differentiation tool dolfin-adjoint.

Paper ID: 65

Machine Learning-Based ROM Prediction for A Lumbar Motion Unit

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A single lumbar motion unit was studied for its kinematic response and its sensitivity to anthropometric features like disc wedging angle, anteroposterior diameter, transverse diameter, vertebral height, and facet sagittal angle. Flexion-

extension, bending and axial rotation motions of the motion unit were predicted using a morphological finite element model. Kinematic output parameters were generated for moment loading from 0 to 10 Nm. A surrogate model was developed to predict the kinematic parameters using 140 different models. Design variables were generated corresponding to 140 people's geometry generated within an anthropometric corridor. A machine learning-based surrogate model approach was used to train the model between anthropometric data and kinematic output parameters. After training the model, it could predict with reasonable accuracy the range of motion (ROM), disc pressure and facet forces in flexion, extension, bending and axial rotation loadings for a particular anthropometric measurement at a specific moment loading. This model can help surgeons in predicting the ROM for specific patient anthropometry, without doing expensive and resource-intensive computation as well as when expertise of performing biomechanical simulations is not available.

Paper ID: 67

Effort and Cost Estimation in Agile Software Development

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Estimating is a very important and integral part of the software development lifecycle. No software can be developed without evaluating effort and cost. It is important to estimate as accurately as possible. Any software development estimation relies heavily on effort estimation. Effort estimation is a method for evaluating effort, and it is carried out based on the amount of resources required to finish the project activity in order to deliver a product that meets the functional and nonfunctional requirements of the product Owner. Agile is a popular development method. Agile methods include Extreme Programming, Scrum, Crystal, Feature Driven Development, and Learn Development. Work assigned to a team and collective effort are some of the challenges of estimating agile methods.

Today, estimating agile software development in the information technology industry is largely based on expert judgment and heuristic approaches such as planning poker but also many other approaches including ML, Deep learning etc. Without an Agile expert, evaluating The Agile software is considerably difficult. Agile software development requires algorithmic methods that can make accurate estimates. This article proposes an algorithmic estimation approach for agile software development and compares the results of the proposed methods to verify the real-time feasibility of proposed algorithmic methods.

Paper ID: 69

Investigation of Proton Irradiation Effects In n-in-p-MCz Thin Silicon Pixel Detector for FCC Experiments

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Physicists around the world are looking for the high performance of position sensitive and advanced design detectors which can be used in harsh radiation environment at Future Circular collider (FCC) for high proton fluence. According to RD50 collaboration, one of the leading candidates for the pixel detector material is p-MCz Silicon. In this work, we have proposed an advanced four deep trap level proton irradiation model for p-MCz Silicon detector. A very good agreement is observed in the experimental data of full depletion voltage and SRH data. The effective introduction rate (η_{eff}) of deep level donor trap E(30K) is played in the model using SRH statistics for effective doping concentration which helps to mitigate the increase of VFD at very high fluence. The extrapolated values of VFD and leakage current are shown up-to the fluence of 1 x 10^{17} n_{eq}/cm^2 in thin detector. CCE modelling confirms that there is significant degradation in CCE which has been observed up-to 1.04% with an uncertainty of 5%.

Paper ID: 70

Quantifying Player Performance and Optimizing Team Selection in Fantasy T20 Cricket

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The fantasy sports market in India was valued at approximately 25.44 billion in 2022 and is projected to reach 72.06 billion by 2030. A significant driver of this market's growth is the increasing popularity of fantasy cricket, with the Indian Premier League (IPL) being at the forefront. Fantasy cricket is an online game where participants create a virtual team by selecting players from both teams involved in a match, adhering to specific constraints. The participants earn rewards based on the points scored by their chosen players, which are determined by their performance on the field. However, many users fail to consider or are unaware of the various factors influencing a player's performance on any given day. In this study, we aim to address this gap by incorporating additional factors into the scoring system and team selection process to provide a more realistic reflection of player performance and enhance the overall fantasy cricket experience.

Paper ID: 71

Template Based Generation of Tree-like Support Structure for Additive Manufacturing

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In additive manufacturing, support structures anchor the overhanging regions of a part during the fabrication process. The problem of minimizing support has been of great interest to save material, reduce the printing time and minimize the post-processing requirements. One approach to reduce the support is to make use of bridge length (i.e. maximal self-supporting span of deposited material through FDM process), which would naturally generate the tree-like support structure. The problem of minimizing mass of such tree-like structure is equivalent to the problem of minimizing total length of the support structure, which is computationally as hard as NP-hard problem. Existing methods have used various heuristics, greedy approach and evolutionary methods to solve this problem, which provides an approximate and limited solution. We explore the idea of finding the minimal support of primitive overhang regions, store them as template, and then use the constructive approach to generate tree-like structure for any given overhang region. Thus, Template Based generation of support structure presents an alternate approach of solving np-hard problem within linearithmic time complexity. The generated structure is 3D printed and also compared with the tree supports generated by a current state of art commercial software.

Paper ID: 75

Nifty 50 Prediction Using Machine Learning Algorithms and Technical Indicators

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Investment in stock market, equity, mutual funds and many other investing option is reaching a new height in India. Investing is potential strategy to make the money work in a effective way of building wealth. Since the stock markets are uncertain in nature, investing in right stocks and at the right time is not easy task for the investor. In this paper machine learning algorithm is used along with the technical indicators to check the effectiveness of simple manageable predicting model using a single algorithm of Linear Regression along with 3 different indicators in the nifty 50 dataset. This paper helps in identifying the indicator which performs better with linear regression by evaluating each model accuracy and comparing the performance. This simple prediction model aids the investors in making the informed decisions of buying and selling.

Paper ID: 76

A Classical Multi-objective Approach for Coverage Path Plans for a Mobile Robot in an Uneven Terrain

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Coverage path planning (CPP) is a subtopic of path planning (PP) problems in which it is required to visit free cells of the given area at least once by avoiding the obstacle(s) with minimum cost. CPP is one of the most crucial research areas for a mobile robot. This research presents a multi-objective optimization (MOO) approach employing a genetic algorithm (GA) in conjunction with the Benson's method to solve simulation environments with variable terrains. In this paper, the working environment is discretised into cells of squares using grid-based method and it is assumed that a wheeled mobile robot covers a cell with one pass. The primary aim of the research is to minimize the energy consumption of the robot while covering the entire feasible region in the simulation environment. The objective functions are the energy consumed due to three parameters, (1) the distance traveled by the robot, (2) total elevation, and (3) the number of turns in the path. The results in various environments show that the proposed method outperformed the genetic algorithm with the traditional constraint method.

Paper ID: 77

Incorporating Qualitative Preferences in Evolutionary Multi-Criteria Decision-Making

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The task of multi-criteria decision-making (MCDM) involves incorporating the preferences of decision-makers (DMs) to arrive at one or more non-dominated near-Pareto-optimal solutions. The existing literature on evolutionary

MCDM techniques predominantly facilitates the DMs to incorporate their preference information in terms of objective function values. These preferences include but not limited to the reference point, reference direction, aspiration level, and scalarization approaches. Such techniques allow DM to have a better hold on the quantitative aspect of decision making, but lack the preference incorporation in a qualitative sense such as robustness, reliability, proximity to Pareto front (PF), and sensitivity, among others. However, along with arriving at a desired set of objective function values, often, DMs are also interested in finding the solution(s) that is more robust and/or reliable. In addition, the sensitivity among objectives, and proximity to the Pareto front can be other information of interest for DM's preferences. In the current paper, we propose introducing the metrics such as robustness, reliability, sensitivity, and proximity to PF for incorporating qualitative preference in MCDM tasks.

Paper ID: 78

Machine Learning-Based Predictions of Effective Elastic Properties of Auxetic Honeycomb Lattice

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Auxetic lattices are being explored for diverse industrial applications. Numerical homogenization offers a way to obtain effective material properties of a lattice structure without the necessity of intricate modeling for the entire lattice. In this study, a finite element approach is applied to a representative volume element of a re-entrant honeycomb auxetic lattice to determine equivalent solid properties via parametric tuning. To enhance computational efficiency, the machine learning technique is integrated with computational data for the prediction of effective elastic properties of auxetic honeycomb lattices of any configuration. Six machine learning-based algorithms were utilized to validate the outcomes derived from finite element homogenization. The machine learning model inputs the auxetic honeycomb design parameters and predicts the equivalent solid mechanical properties as output. The analysis revealed that the random forest algorithm emerged as the most effective machine learning model based on the finite element homogenization data. They exhibited remarkable consistency in replicating the test set trends and displayed a low validation mean absolute percentage error. The notion that changing the design parameters of an auxetic honeycomb has a perceptible impact on its effective elastic response is underlined by these predictions made by the trained algorithms, eliminating the need for costly computational methods.

Paper ID: 79

Advancing Heart Disease Prediction: A Comparative Study of Tree-Based Algorithms for Indian Patients

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Heart disease, responsible for 31% of global fatalities, remains a primary global cause of death. Recent advancements in medical support technology, employing data mining and machine learning, offer promising tool for prediction. This study focuses on machine learning algorithms to predict heart disease in Indian patients, utilizing tree-based techniques known for handling complex, nonlinear data. Pre-processing involves handling missing values and applying feature scaling techniques such as Min Max Scaler and Standard Scaler. Feature selection is performed using Chi-squared and ANOVA tests for categorical and numerical features, respectively. Tree based algorithms namely Decision Tree, Random Forest, Gradient Boosting, Adaptive Boosting (AdaBoost), and Extreme Gradient Boosting (XG Boost), are evaluated using 5-fold cross validation and grid search.

Each model's performance is assessed using metrics like accuracy, precision, recall, F1-score, and AUC-ROC (Area under the Receiver Operating Characteristic curve). Remarkably, the study identifies 'age' and 'gender' as non-correlating features and their removal improves model accuracy. The Random Forest model stands out as the top performer, achieving 99.5% accuracy, underlining its efficacy in heart disease prediction.

Paper ID: 80

Grasp Force Optimization as a Bilinear Matrix Inequality Problem: A Deep Learning Approach

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Grasp force synthesis/optimization is a non-convex optimization problem involving constraints that are bilinear. Traditional approaches to this problem involves general purpose gradient-based nonlinear optimization and semidefinite programming (SDP). With a view towards dealing with postural synergies and non-smooth but convex positive semidefinite constraints we look beyond gradient-based optimization. The focus of this paper is to undertake grasp analysis of biomimetic grasping in multi-fingered robotic hands as a bilinear matrix inequality (BMI) problem. Our analysis is to solve it using a deep learning approach to make the algorithm efficiently generate force closure grasps with optimal grasp quality on untrained/unseen objects.

Paper ID: 81

Structural Topology Optimization of Fractured Materials

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This work presents the structural topology optimization for maximizing the fracture resistance in brittle materials. Griffith's criteria underline the influence of crack propagation. A phase field for fracture (PF) approach derived from Griffith's criteria is incorporated for the fracture process in the material, which is proven to be a computationally efficient method to deal with fracture problems. The topology evolution of structure was carried out by non-gradient optimization methodology, proportional topology optimization (PTO). The design variable controls the change of the material properties in the structural design domain using the Solid Isotropic Material with Penalty (SIMP) method. The proposed PF-PTO approach is fully implemented in MATLAB R2023b. For validation of the PF-PTO method, three numerical benchmark examples from the literature are analyzed to examine the optimum topologies of the structure. Furthermore, the effectiveness of the proposed method is confirmed by examining the structures compared with and without cracks. The suggested methodology of the combined PF-PTO algorithm is accurate and efficient in solving structural topology optimization problems in the presence of cracks.

Paper ID: 83

Energy Storage Sizing and Management Using Optimization for an Anticipated Duck Curve in Mumbai

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The duck curve phenomenon is a grid challenge observed with high solar energy integration, against the daily electricity demand curve's shape. However, as solar installations grow, it could become a concern for grid operators for maintaining stability and economic dispatch. This paper utilizes dynamic optimization workflow offered by Model on Impact to size the Battery based energy storage (BESS) for mitigating the duck curve. Optimization is applied on a system level simulation model of Mumbai power system where the battery capacity is a degree of freedom with photovoltaic penetrations. The model then optimizes the operation of Indian grid, effectively mitigating the duck curve, and calculates the optimal size of the battery.

Paper ID: 84

Visualization-aided Design Space Exploration of MDO Problems

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Multi-disciplinary design optimization (MDO) problems require optimizing the design of a system or product by considering multiple disciplines or domains simultaneously. In such complex applications, visualization provides several benefits and addresses challenges that arise due to the high dimensionality and interdependencies of variables. Often, it is essential for a designer to visualize the design space, coupling variables, objective, and constraint function simultaneously for interactive decision-making and an intuitive explanation of the preferred design. The current state-of-the-art visualization methods are not sufficient for this task due to high-dimensional search space. The current work proposes an interpretable Self-Organizing Map (iSOM) visualization-aided design space exploration framework for high-dimensional MDO problems, which will be one of the first of its kind in enabling visualization across different levels along with coupling variables and permitting interactive decision-making.

Paper ID: 85

Multiobjective Modeling and Optimization of Proton Exchange Membrane Fuel Cell using Genetic Algorithm

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Proton Exchange Membrane (PEM) fuel cell is found to be one of the efficient cells that converts chemical energy of fuel cell into electricity. Often, it is designed either using operating parameters or modeling parameters for maximizing its power. In this paper, both operating and modeling parameters are considered as decision variables and a multiobjective modeling is proposed. The modeling includes maximization of power and minimizing the number of fuel cells and box constraints on all variables. The proposed modeling is solved using NSGA-II. The obtained non-dominated solutions and relationship among the sensitive variables of the modeling show useful insight of PEM fuel cell modeling.

Paper ID: 86

Automatic Headlight Luminance Adjustment System

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The internet of things offers solutions to many of our problems in day-to-day life. In today's living environment, advanced sensors are used to detect potential problems of a human being. Used to automate daily tasks allow humans to do other activities. These devices ultimately lighten people's
workload. In this paper, we have implemented an easy-to-use and cost-effective Headlight Luminance Adjustment System which can be used in both automatic and manual modes. In automatic mode whenever a opposite car approaches the intensity of the headlight be decreased and vice versa when the car goes away, here we use the LDR (Light Dependent Resistor) is a component that has a variable resistance that changes with the light intensity that falls upon it. The resistance of LDR decreases with the increasing intensity of light and vice versa. The LDR gives analog output values and connected to the analog pin on the Adruino. The output from LDR is used to control the intensity of led bulb. By this luminance of the headlight is adjusted automatically. Manual mode, in this mode the potentiometer connected with the Arduino will change the brightness of the Headlight by turning the potentiometer. Through programming, we can use the converted digital value to control the brightness of the LED on the control board.

Paper ID: 88

A Dual Branch Attention Enhanced CNN-LSTM Model for Diagnosis of Parkinson's Disease

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We propose a dual branch Convolutional Neural Network (CNN) and Long-Short Term Memory (LSTM) model to differentiate between Parkinson's disease (PD) patients and healthy subjects using gait data. Spatial and temporal features are extracted from the left and right feet gait data. The obtained feature map is combined using an LSTM layer, and the attention layer is used to concentrate features specific to a time zone. We use a publicly available PhysioNet data, which contains the vertical ground reaction force of the left and right feet of subjects. Results demonstrate that the proposed model performs better than existing techniques, giving a test set accuracy of 99.3%. Additional experiments are conducted to find out the best suitable time step, which again helps to increase the test set accuracy to 99.7%.

Paper ID: 90

Estimation of Optimal Weibull Parameters for Wind Power Potential Assessment of Indian Coastal Site using Reanalysis Data

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This study represents an effort in conducting wind resource assessment for a coastal location in India by optimizing the Weibull parameters. The analysis relies on a 22-year dataset from NASA MERRA-2 reanalysis. Wind characteristics are assessed using the Weibull probability distribution, with shape (k) and scale (A) parameters determined through three distinct numerical techniques at a 50 m height level. This is done to calculate wind power density using MERRA-2 reanalysis data. Performance evaluation is carried out using goodness of fit tests, RMSE, and R^2. The outcomes indicate that all employed methods for parameter estimation are suitable. However, for assessing wind potential, the Maximum Likelihood Method (MLM) emerges as the most accurate. These findings are expected to contribute to the existing literature on probabilistic modeling of wind resources and utility of MERRA-2 in wind resource assessment.

Paper ID: 92

Multi-Objective Artificial Bee Colony Algorithm Using θ−Dominance and Reference Lines

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In this paper, an environment selection for Artificial Bee Colony (ABC) algorithm is developed for solving multi-objective optimization problems. In this selection, $\theta-$dominance and reference-lines framework are used. The employee, onlooker, and scout bee phases are modified using the environment selection. An external archive is maintained that stores the best solutions from the three phases of bees. The proposed algorithm is tested on DTLZ 1 to 4 problems for 3, 5, 8, 10, and 15 objectives. Results demonstrate the equivalent performance of the proposed ABC algorithm with respect to NSGA-III.

Paper ID: 93

Prediction of Monthly Global Solar Radiation at Bhopal, India – Solar Resource Assessment

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A key hurdle to properly using solar energy in India has been found as a lack of accurate solar data and an erroneous calculation of the availability of solar radiation at a location. This paper presents the analysis and estimation of the monthly average global solar irradiation for the geographical location of Bhopal, India situated at 23.16° N and 77.36° E using different regression models. The models are based on ratio of monthly average daily global solar radiation (GSR) (H) to the extra-terrestrial radiation (H0).

Each categorised model is examined, verified, and compared separately. The objective is to apply regression models to estimate the monthly average daily GSR for Bhopal, India, and to validate these models by comparing them to measured GSR data from the Ministry of New and Renewable Energy (MNRE) using Python (SolarPy) and Microsoft Excel Advanced. It was evident from the study that Angstrom- Prescott model outperforms the other linear models in terms of accuracy. Akinoglu, Ogleman and Armstrong-Prescott models are suggested for assessing the GSR for the Bhopal region while taking into account all the considerations. The relevant model discussed in this paper may be used to estimate solar radiation relatively accurately for an area of Bhopal and the surrounding area, as well as possibly for any locations with a comparable climate. Further this study would help in selection and designing of adequate solar photovoltaic and thermal technologies for the climatic condition of Bhopal.

Paper ID: 94

Optimization of Weibull Parameters for Offshore Wind Potential Assessment with Reanalysis data using Metaheuristic algorithms

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Accurately assessing the potential wind resources is a critical phase in planning a wind energy project. The viability of wind power is determined using the Weibull distribution function, and its parameters are derived through numerical techniques. This study presents a methodology to estimate India's offshore wind potential by utilizing 22 years of MERRA-2 reanalysis data at a 50 m elevation to calculate wind power density. In this study three numerical methods (Graphical Method (GM), Modified Maximum Likelihood Method (MMLM) and Empirical Method of Justus (EMJ)) are applied to estimate Weibull distribution parameters along with three metaheuristic optimization algorithms the Social Spider Optimization algorithm, to evaluate the accuracy of these methods two statistical analysis methods have been used. When compared to the Genetic Algorithm (GA), the Social Spider Optimization (SSO) and Particle Swarm Optimization (PSO) were shown to be more efficient. The analyzed data offers useful early information on the wind potential, which is crucial for converting wind energy and figuring out whether or not wind energy generation is indeed feasible at a certain location.

Paper ID: 96

Bounded Constraint Normalization Scheme and Conditional Penalized Objective Function for Exterior Penalty Function Method

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Numerous methods for nonlinear optimization problems are being proposed continuously. But effective constraint handling has remained as a big challenge. Most methods still incorporate penalty function like schemes for handling constraints, modeling of which often requires incommensurable constraints to be normalized a priori. Although such fixed normalization of constraints and subsequent formation of a penalized objective function are theoretically correct, in practice, the generation of some particular variable values during the optimization process may make a constraint undefined or mislead to an infeasible solution as the optimum. For avoiding such cases, particularly in the exterior penalty function method, a bounded constraint normalization scheme and a conditional penalized objective function are proposed here, which are to be implemented iteration-wise according to the generated variable values.

Paper ID: 97

A Machine Learning Based Open-Source Tool for Predictive Maintenance

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With the adoption of the concept of Industry 4.0, the machinery used in large industries is getting more intelligent and complex. Therefore, designing an accurate and reliable fault detection and prediction system remains crucial. Poorly maintained machines can have consequences like replacement of components, severe accidents etc., leading to downtime and business losses. It suggests that a proper maintenance related decision-making system is crucial for monitoring the health of machines. The paper aims to develop an open-source predictive maintenance toolkit (called PdMTKT) for fault analysis and prediction. The tool follows a modular architecture with separate modules for data analysis, visualization, processing and training predictive models. All the modules in PdMTKT have user-friendly graphical user interfaces (GUI) and are currently under active development. The toolkit has been evaluated using the engine health data from the CMAPSS database as a test case, where PdMTKT can perform trend analysis, forecasting and prediction of the engines' remaining useful life (RUL). Upon full development, PdMTKT aims to be a general-purpose, open-source tool for the predictive maintenance activity of different machines.

Paper ID: 98

Trashbusters: Deep Learning Approach for Litter Detection and Tracking

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The illegal disposal of trash is a major public health and environmental concern. Disposing of trash in unplanned places poses serious health and environmental risks. We should try to restrict public trash cans as much as possible. This research focuses on automating the penalization of litterbugs, addressing the persistent problem of littering in public places. Traditional approaches relying on manual intervention and witness reporting suffer from delays, inaccuracies, and anonymity issues. To overcome these challenges, this paper proposes a fully automated system that utilizes surveillance cameras and advanced computer vision algorithms for litter detection, object tracking, and face recognition. The system accurately identifies and tracks individuals engaged in littering activities, attaches their identities through face recognition, and enables efficient enforcement of anti-littering policies. By reducing reliance on manual intervention, minimizing human error, and providing prompt identification, the proposed system offers significant advantages in addressing littering incidents. The primary contribution of this research lies in the implementation of the proposed system, leveraging advanced technologies to enhance surveillance operations and automate the penalization of litterbugs.

Paper ID: 101

Performance of Various Distance Minimization Algorithms for Isogeometric Contact Analysis

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One of the most challenging problems in computational contact mechanics is to find the point of contact between the bodies. This is usually carried out by posing it as a distance minimization problem. Several algorithms exist in the literature, for example full Newton-Raphson method, modified Newton-Raphson method, Least square method, Steepest descent method, etc. Each of these algorithms perform differently based on the initial guess of a parameter point on the master contact surface. The objective of the present work is to assess the performance of these algorithms when applied to isogeometric contact analysis.

Paper ID: 103

PyHexTop: A Compact Python Code for Topology Optimization Using Hexagonal Elements

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Python serves as an open-source and cost-effective alternative to the MATLAB programming language. This paper introduces a concise topology optimization Python code, named “PyHexTop,” primarily intended for educational purposes. Code employs hexagonal elements to parameterize design domains as such elements provide checkerboard-free optimized design naturally. PyHexTop is developed based on the “HoneyTop90” MATLAB code [1] and uses the NumPy and SciPy libraries. Code is straightforward and easily comprehensible, proving a helpful tool that can help people new in the topology optimization field to learn and explore. PyHexTop is specifically tailored to address compliance minimization with specified volume constraints. The paper provides a detailed explanation of the code for solving the MBB design and extensions to solve problems with varying boundary and force conditions. The code is publicly shared at: https://github.com/PrabhatIn/PyHexTop.

Paper ID: 106

Optimization of Skeletal Muscle Concurrent Usage Data to Create Customization Protocol

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Hamstring muscles in the back of the thigh plays a major role in activities of daily life to recreational activities. The Prevalence of Hamstring muscle tightness (reduced muscle length) is increasing. Reduced muscle length results in reduced functional capacity and increases proneness to injuries. With majority of population affected by this reduced functional capacity of Hamstring muscles, it becomes imperative to classify the population into groups to successfully address this issue. People with minimal or moderate level of involvement may benefit from education regarding this condition and group treatment regimens, whereas with severe involvement require customized treatment protocol. While testing the muscle for reduced muscle length, several other muscle groups works concurrently to account for the test result. Quantification of these concurrent muscle group work establishes a way to develop customized treatment regimen.

Paper ID: 107

Study of New Approach to Select Optimum Configuration for HAPS Using Discrete-Multi Criteria Decision Making (D-MCDM) Methods

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Aircraft configuration design involves multiple disciplines such as aerodynamics, structures, propulsion, control and avionics systems. There is plenty of information available in literature regarding the design procedure of aircraft with consideration for the abovementioned disciplines. But there is no literature available to objectively evaluate various configurations in conceptual stage towards selecting best configuration. As a result, even today the final aircraft configuration is finalized by experienced designers based on their heuristic knowledge acquired from their experience. A new approach of objectively selecting the best configuration is proposed using Discrete-Multi Criteria Decision Making method (D-MCDM) with a case study of aerodynamic configuration selection for solar powered HAPS (HighAltitude Pseudo Satellite). Based on mission requirement of HAPS, five configurations are designed using standard aircraft design procedure during conceptual design stage. Their aerodynamic performance parameters are estimated using Flight stream software, a surface vorticity based low fidelity software. The performance parameters are normalized and given appropriate weightage to formulate decision matrix. Then five configurations are evaluated using D-MCDM methods such as Weighted sum method (WSM), Weighted product method (WPM) and Technique for Order Performance by Similarity to Ideal Solution method (TOPSIS). Then based on the aerodynamic index obtained from the D-MCDM study with consideration for various performance parameters, the best configuration for HAPS is finalized.

Paper ID: 110

Optimization of Process Parameters During Additive Manufacturing of Oldham Coupling

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Nowadays, additive manufacturing procedures are taking the place of traditional production methods to realistically create the necessary component with a limited amount of material and a complex shape model. In this work, Oldham coupling was considered for manufacturing using the Fused Filament Fabrication (FFF) additive manufacturing technology at an optimal design. The disc of coupling was examined for the best design using ANSYS and optimized. The infill pattern, build orientation, and layer thickness were then taken into account using the design of experiments to determine an appropriate printing time. In order to efficiently create an Oldham coupling using FFF, the printing time was found to be 482.61 mins and material consumption is 250.01g under the combination of process parameters of 0.4 mm layer thickness, flat build orientation, and triangular infill pattern.

Paper ID: 111

UniPop: A Unidirectional Search Based Global Optimizer Assisted by Population of Solutions without Gradient Information

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Gradient-based deterministic optimization methods can ensure the convergence toward the optima of nonlinear problems. However, they need a descent search direction computed using the gradient of the objective function, which becomes expensive in many cases. This drawback motivated the development of various population-based metaheuristics without requiring gradient information, which could successfully approximate the global optima even of many challenging problems. However, they suffer from convergence proof toward the optima due to their inability to ensure a descent search direction, thus causing excessive function evaluation or even to get stuck at some local optima. Accordingly, this work proposes a new global optimizer, namely UniPop, by combining the unidirectional search used in gradient-based deterministic methods and population of solutions used in metaheuristics, in which descent search directions are first obtained by pair-wise connecting the solutions from the population without requiring any gradient information, and then unidirectional search is performed for determining the optimum points along those descent directions. The potentiality of UniPop is demonstrated here through its successful application to a large set of real-valued unconstrained benchmark functions of different nature.

Paper ID: 113

Investigation of Multiaxial Fatigue Behavior of 304LN Stainless Steel under Various Cyclic Loading Waveforms and Comparing the Damage

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This work investigated the effect of loading waveform on the material's response of 304LN stainless steel for the same equivalent strain amplitude. A triangular, sinusoidal, and trapezoidal proportional multiaxial loading waveform was used for the analysis. The hysteresis loop was compared for both axial and shear loading. The von Mises stress was evaluated and compared for the three waveforms. The sinusoidal Waveform was the most critical loading waveform and the triangular waveform was the most suitable waveform. The SWT, Liu-I, and II parameters were also estimated to compare the three loading waveforms. SWT parameter was highest for the sinusoidal waveform and least for the triangular waveform. Liu-I and II were also given the same kinds of results for the three waveforms.

Paper ID: 115

Reconfiguration of Power Distribution Networks for Energy Loss Minimization Using Mixed Integer Programming

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Distribution network reconfiguration has been used as a crucial technique to improve the efficiency of power distribution networks by reducing the line losses. However, the problem of reconfiguration is a complex combinatorial optimization problem due to the involvement of binary decision variable. In this paper, to address this complexity efficiently, the problem is approached through two modelling methods: firstly, as a mixed integer quadratic programming problem, and secondly, as a mixed integer conic programming model. The primary objective of the reconfiguration problem is to minimize the energy losses while simultaneously improving the voltage levels within the network, considering the fluctuations in power demand that occur on an hourly basis. The proposed models are verified on 33-node test system. A comparative analysis is given for the energy losses and voltage profiles before and after reconfiguration. This analysis offers insights into the potential benefits gained from the power distribution network reconfiguration.

Paper ID: 118

Deciphering Uncertainty in Excess Pore Water Pressure Profile in Single Drainage 1D Consolidation through Feynman-Kac Formulation

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This study presents a probabilistic methodology for solving the one-dimensional (1D) consolidation equation using the Feynman-Kac formula incorporating the randomness of coefficient of consolidation (cv). The Feynman-Kac formula establishes a connection between the expected value of a stochastic differential equation and the numerical solutions of the associated partial differential equation. A set of cv values following a normal distribution is selected and employing the Feynman-Kac framework, Monte Carlo simulations are executed till the exit time of the process. As a result, probabilistic solutions depicting excess pore water pressure (EPWP) profiles are generated which are then compared with the established analytical solutions of 1D consolidation under single drainage boundary conditions. The simulated pore-pressure profiles highlight that in contrast to the conventional analysis, the maximum EPWP need not occur at the farthest depth from the drainage boundary; rather, the location of maximum EPWP would be guided by the random variation of cv.

Paper ID: 119

An Improved Goswami Cycle Assisted by a Distillation Unit: A Comparison and Optimization Study

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This paper focuses on the conventional Goswami cycle, whose capacity to convert any waste heat source into useful outputs depends significantly on the quantity of vapor present at its turbine inlet. Clearly, any modification to increase the vapor generation will enhance the cycle performance. To achieve this, a distillation unit is added in the setup to generate additional vapor from the leftover working solution after the vapor extraction step in the conventional cycle. On comparing with the conventional setup, this modification has improved the total output/exergy efficiency from 38.50 kW/31.37% to 43.55 kW/32.68%, respectively. A single objective optimization is then performed on this modified setup, which reveals that it contains conflicting objectives. Based on this characteristic, a multi-objective dragonfly algorithm along with entropy-weighted TOPSIS decision method is used to obtain the best solution, which is 43.22 kW (turbine output), 10.54 kW (cooling output) and 31.48% (exergy efficiency).

Paper ID: 120

iSOM-derived Explainable Outcomes for Engineering Applications

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The use of Machine Learning (ML) and Artificial Intelligence (AI) has significantly transformed the decision-making process in datadriven engineering design. However, a decision-making task needs to be supported by explanations to arrive at an interpretable design to ensure transparency and trust in the decision-making process. The integration of interpretability and explainability holds the utmost importance in the domain of engineering design. Interpretability enables designers to understand the decision-making process, aiding in identifying critical design factors. Explainability provides insights into the reasoning behind specific outcomes. These aspects bring trust and facilitate collaboration between systems and human decision-makers (DMs), ensuring that the final design aligns with both technical requirements and human expertise. The current research proposes using an interpretable self-organizing map (iSOM) that plots the high-dimensional design data into a 2-D representation which can be easily interpreted by DMs. The topology preservation property of iSOM allows quantifying the interdependence of design variables and their correlation with the response function that permits a DM to interpret and explain the critical decisions in engineering design.

Paper ID: 121

TOaCNN: Adaptive Convolutional Neural Network for Multidisciplinary Topology Optimization

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This paper presents an adaptive convolutional neural network (CNN) architecture that can automate diverse topology optimization (TO) problems having different underlying physics. The architecture uses the encoder-decoder networks with dense layers in the middle which includes an additional adaptive layer to capture complex geometrical features. The network is trained using the dataset obtained from the three open-source TO codes involving different physics. The robustness and success of the presented adaptive CNN are demonstrated on compliance minimization problems with constant and design-dependent loads and material bulk modulus optimization. The architecture takes the user's input of the volume fraction. It instantly generates optimized designs resembling their counterparts obtained via open-source TO codes with negligible performance and volume fraction errors.

Paper ID: 122

A Mixed Integer Linear Optimization Model to Restore the Operation of Power Distribution Networks After High Impact Low Probability Failure Events

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Events characterized by their rarity but with a significant impact, like earthquakes, floods, and windstorms, are high-impact low probability (HILP) events. These events cause severe damage to power distribution networks (PDNs), leading to widespread and extended power outages. Hence, numerous operational measures are employed to restore the PDN after a HILP event. This paper uses dynamic network reconfiguration and distribution generation unit scheduling to restore the PDN after HILP events. An optimization problem is introduced to address the restoration of the PDN. The goal is to maximize the restoration of load demand based on the priority of the load. The optimization problem is formulated as a mixed-integer linear programming (MILP) model. Furthermore, the effectiveness of the provided framework is assessed by analysing it on the 33-bus test network for validation purposes.

Paper ID: 124

A Comparative Study of Pareto-front of Optimal Solutions Set for NAO Robot's Gait Optimization Using the Dominance Move Indicator based on Mixed Integer Programming

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Evolutionary multi-objective optimization (EMO) algorithms generate solution sets representing tradeoffs between conflicting objectives. The comparison between two EMO algorithm performances is challenging for real-world problems lacking reference Pareto fronts (PFs). Most performance indicators require a reference PF or point to compare the Pareto optimal solutions. This study uses Dominance Move (DoM), formulated as a Mixed Integer Programming (MIP), as it compares sets without any reference PF or points and avoids information loss. The GD+, IGD+, HV, ϵ, and MIP-DoM indicators have been used to compare solution sets from two popular EMO algorithms– NSGA-II and MOPSO. EMO algorithms are used to minimize power consumption and maximize stability for a 25-DOF humanoid robot gait optimization problem. The results show that NSGA-II outperforms MOPSO on this highly-constrained problem. The MIP-DoM exhibits the strongest correlation with the IGD+ indicator, whereas weaker correlations are seen for the Hypervolume and Epsilon indicators. The EMO performance has also been tracked over generations using IGD+, which provides additional insight into algorithm dynamics. The proposed techniques could be extended to other real-world optimization problems.

Paper ID: 126

Coverage Maximization for UAV Surveillance on Non-convex Domains using Genetic Algorithm

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Unmanned Aerial Vehicle (UAV) surveillance has emerged as a transformative tool in disaster management and response. In disaster scenarios, maximizing UAV network coverage is essential for extracting maximum environmental information. A majority of the planar coverage maximization solutions are primarily inapplicable to non-convex and disconnected regions. This paper presents a novel framework that processes input images, extracts boundaries, and reduces their dimensionality using the Ramer-Douglas-Peucker algorithm to generate a union of polygons, which may exhibit non-convexity, disconnectedness, or both. It then implements a genetic algorithm to produce a high-quality sensor configuration. Our approach innovatively integrates Monte Carlo sampling and directly encodes sensor positions into the chromosome, optimizing the use of problem geometry.

Paper ID: 127

Evaluating the Performance of Different Optimizers for Deep Learned Finite Elements

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The training process of deep neural network (DNN) involves adjusting numerous parameters to minimize the prediction error. Several optimization algorithms, such as stochastic gradient descent (SGD) [1], adaptive gradient algorithm (Adagrad) [2], root mean squared propagation (RMSProp) [3], adaptive moment estimation (Adam) [4], and adaptive moment estimation with infinity norm (Adamax) [5], among others, play a pivotal role in refining network weights and biases. Each algorithm exhibits unique characteristics, affecting convergence speed and final performance [1]. The choice of optimizer often depends on the nature of the problem, dataset size, and network architecture. The present study
compares the performance of these optimizers used for solving different numerical examples.

Paper ID: 128

Evaluation of Optimizers in DNN-based Classification Model for Quadrature Rule in Isogeometric Analysis

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In the training process of an artificial neural network (ANN) model, optimizers play a pivotal role by determining the manner in which the ANN model's parameters are adjusted during each iterative step. Within the machine learning (ML) literature, a range of gradient-based optimizers are commonly employed, including stochastic gradient descent (SGD), momentum-based methods, mini-batch gradient descent, as well as more advanced techniques such as AdaGrad, AdaDelta, RMSProp, and Adam. In this work, the performance of these optimizers is studied for a deep neural network (DNN) model. The DNN model is used to predict the number of Gauss quadrature points to compute element stiffness matrix in isogeometric analysis.

Paper ID: 132

A Comparative Analysis and Optimization of a Distillation Unit Assisted Goswami Cycle-Absorption Chiller Assembly

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The current study focuses on addressing the main weakness of the conventional Goswami cycle, namely that its cooling output is rather low in comparison to its ability to produce power. The suggested scheme incorporates a distillation unit assisted absorption chiller setup to the Goswami cycle, whose primary goal is to produce auxiliary cooling without any pressure losses and extra work input. The present modification has increased the conventional Goswami cycle's power and cooling output from 25.25 kW to 29.83 kW and 6.03 kW to 55.52 kW, respectively. Further, based on the assembly's thermal response and single objective optimization, it is found that its outputs from the Goswami cycle side, the absorption chiller side, and its exergy efficiency are in conflict with one other. After that, a multi-objective dragonfly algorithm and entropy-weighted TOPSIS methods are used to determine the optimal outputs for each side of the assembly at best possible exergy efficiency.

Paper ID: 133

Aerodynamic Analysis of Winglet through Optimization using CFD

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This paper focuses on Design Optimization of winglets for a hybrid drone with a staggered biplane configuration. The study involves varying the Cant angle of the winglets and optimization is carried out to maximize the lift-to-drag ratio and obtain the optimum winglet design.

Paper ID: 134

Topology and Structural Optimization of the Fuselage for Hybrid Drone

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This paper focuses on the shape optimization of the fuselage using CFD analysis and topology and structural optimization of the bulkhead of the fuselage of a Hybrid Drone for the DroneNet application to capture spent stages of the launch vehicle. The Hybrid Drone is a staggered biplane.

Paper ID: 135

Conceptual Sizing and Optimization of the Propulsion System Sizing for a Hybrid Drone

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This paper focuses on the design Optimization of a Hybrid Propulsion system for a hybrid drone using Genetic algorithm. A brief study of the various Hybrid propulsion systems has been conducted to select suitable powertrain configurations for the hybrid drone including the formulation of the components of the Hybrid Propulsion system. The study also aims to identify the optimal design point by analysing energy losses and net power for each configuration. The Optimal propulsion system, hence obtained, would be used for capturing the decelerating stages of the rocket.

Paper ID: 136

Assessing the Status of Mental Well-Being for Students of HEI: A Data-Driven Approach

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Most educational institutes are now emphasizing the students' mental well-being as it is an important component for the overall growth and academic success of the students and society at large. In the case of higher educational institutions (HEIs), like that of IITs, the students have several issues many of which are related to mental wellbeing. The objective of the present study is to identify the patterns and trends of mental health issues faced by students on the basis of various factors which include gender, age group, course enrolled, department, and year of study. Data for this study is collected from the wellness center at IIT Roorkee for 10,000 students over a period of two years. The four different phases of this study are (1) data curation (2) data analysis (3) efficiency calculation of the departments through Data Envelopment Analysis (DEA) (4) Concluding remarks.

Paper ID: 138

Classification of Virgin and Recycled Polyolefins by FTIR Spectra: A Machine Learning Approach

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In the recent era, polyolefins are increasing enormously. Approximately 380 million tons of waste is generated every year. Recycling is a mitigation option to reduce the wastage of post-consumer recycled waste. Many challenges have been observed during recycling, such as off odor, generating volatile organic compounds (VOCs), and reducing mechanical properties [1]. This study aims to employ machine learning (ML) algorithms that will help us segregate the VOCs and odorous compounds. Broadly, this study is divided into three different phases [2]. In the first phase, the data is collected experimentally through Fourier Transform Infrared (FTIR) spectra; in the second phase, the data is curated and brought into a format that the machine can understand, and finally, the ML algorithms are applied to classify VOCs and odorous compounds in polypropylene (PP) [3]. It was observed that the application of ML algorithms helped us classify the compounds with more than 98% accuracy, indicating that ML algorithms can be a good option for classifying experimental data obtained through FTIR [4]– [6]. We aim to use four Machine learning (ML) algorithms, viz. Random Forest (RF), XGBOOST, Support Vector Machine (SVM), and Gradient Boosted Decision Tree (GBDT) for the classification of VOCs and odorous compounds in the Virgin PP (Vpp) and Recycled PP (Rpp) classes.

Paper ID: 140

Chainless Drive Train Mechanism with Bearing Gear and Customized Sprocket Gear for Bicycle

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The conventional chain-driven mechanism has played a vital role in delivering power to vehicles, machinery, and numerous mechanical applications. The study investigates the chainless drive train mechanism in bicycles. Aim to follow the evolution of the power transmission system. The chainless drivetrain mechanism featuring specialized bearing gears and customized sprocket gears offers a groundbreaking solution for efficient power transfer in mechanical systems. Evaluate this newly developed mechanism with a conventional chain-drive mechanism. This paper aims to present a detailed design and analysis of the chainless drive train technology. This technology ensures smoother and more reliable operation, optimizing power transmission for various applications. This innovation replaces traditional chain drive with customized bearing gears and precisely designed sprocket gears, reducing maintenance and improving performance. It ensures smoother and more reliable operation, optimizing power transmission for various applications.

Paper ID: 143

Optimization Strategies on Evolving a Blade Profile of Savonius Wind Turbine

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The focus of this study lies on evolving a new blade profile of the Savonius wind turbine rotor through the integration of two distinct optimization strategies. The two different optimization strategies i.e., simplex search method (SSM) and non-dominated sorting genetic algorithm (NSGA-II) have been chosen to develop the blade profile. The developed profile is simulated using ANSYS Fluent software to get the numerical results and the performance is calculated in terms of power coefficient (Cp). The SSM takes a single variable point to define the blade geometry while, the NSGA-II takes three variable points. The Cp obtained through NSGA-II surpasses the maximum Cp achieved through the SSM. This observation underscores that the methodology employed in this study is effective in developing the blade profile by the optimization algorithms.

Paper ID: 144

Deciphering Relationship Among Design Variables of A Battery Pack System Through Multi-Objective Optimization

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In this study, we investigate the outcome of optimizing a battery-pack system using a multi-objective approach. First, a multi-objective optimization problem for the battery-pack system is solved to generate the Pareto-optimal solutions. Subsequently, a comprehensive analysis on the obtained Pareto-optimal solutions is conducted to decipher relationships among the design variables and objective function that are responsible for trade-off between objectives. The analysis also involves identifying critical design variables influencing the objectives. The results of the analysis offer valuable insights that can help designers to optimize and design the battery-pack system.

Paper ID: 145

Fish Classification Analysis Model Using Convolutional Neural Network and Different Optimization Techniques

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One important image processing function in computer vision is image classification. The classification of fish is currently a hot topic in the fields of machine learning and segmentation of images. Additionally, it has been expanded to a number of fields, including marketing tactics. The convolutional
neural network (CNN)-based fish classification algorithm presented in this paper is efficient. On a fresh dataset of native fish species to West Bengal, various splitting techniques were used in the studies. We give a thorough analysis of many well-liked CNN optimizers. We compare five cutting-edge gradient descent-based optimizers for CNN, including adaptive delta (AdaDelta), stochastic gradient descent (SGD), adaptive momentum (Adam), adaptive max pooling (Adamax), and root mean square propagation (Rmsprop). Rmsprop, Adam, and Adamax scored well in comparison to the remaining optimisation techniques utilised, but AdaDelta and SGD did the poorest, according to the whole outcomes of the experiment. Additionally, the findings of the research showed that the Rmsprop optimizer achieved the highest scores for performance measures of 75-25% splitting trials, while the Adam optimizer achieved the best outcomes for performance metrics of 70-30% and 80-20% splitting experiments. The suggested approach is then contrasted with cutting-edge deep CNNs models. As a result, the suggested model improved CNN's skill in categorization, amongst other things, with an overall accuracy of 98.83%.

Paper ID: 146

Topology Optimization of Metamaterials for Improved Bulk Modulus

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This study aims to economically develop metamaterials for improved bulk modulus properties using topology optimization (TO). We can significantly increase the microstructure's properties with topology optimization. The microscale properties of microstructures are related to the macroscale properties of the material through homogenization theory. The density variables in TO are updated using optimality criteria. Maximizing the bulk modulus of metamaterials can improve the structure's performance and durability in various engineering applications.

Paper ID: 148

Failure Rate Prediction Method of Evolutionary Parts

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For industries dealing with design and development of mechanical parts, the capability to predict the reliability is one of the important tasks to proceed ahead with further robust product development and meeting the customer requirements. This type of reliability prediction is performed using well established reliability standards, handbooks. Such methods are well established and proven for the parts that are manufactured by conventional manufacturing processes (CMP) due to past field failure data but as the design and development methods of product is evolving, evolution is being seen in case of various manufacturing processes across industries. Due to speed of production and cost benefits, industries are now preferring additive manufacturing (AM) process over CMPs. Additionally, AM process has other advantages such as better part strength, light weight, less material waste etc.

The manufacturing processes play a significant role in achieving desired quality (reliability) target of a product. Hence, the failure rate prediction methods of product need to be evaluated as per the manufacturing processes, especially when limited or no field failure data available for AM manufactured parts. Thus, considering above limitation this paper proposes a methodology to predict the failure rate of the AM manufactured evolutionary parts. The proposed methodology develops a multiplying factor to base failure rate (BFR) that consider probability of manufacturing a healthy component (PMHC) as its primary function. The laser powdered bed fusion (LPBF) is the AM process used for the proposed methodology but the method could be applied for other AM manufacturing processes also.

Paper ID: 149

Design of Vertical Axis Wind Turbine

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Horizontal Axis Wind Turbines (HAWT) attract a high cost of operation and maintenance and are too expensive for the diminutive power requirements. The Vertical Axis Wind Turbines (VAWT) are compatible with urban environments and can be installed on buildings. Being compact and comparatively smaller; a series of such turbines can be installed in urban areas or coastal regions. The work presented here aims to design a vertical axis wind turbine for specified power output and a given meteorological condition. The approach used here is creating a step/procedure in finding out the physical dimensions of a VAWT based on the type of turbine to be installed in a specific region, and as required by the user for a specified meteorological condition. Various parameters in the design of VAWT are compiled to lead to the turbine design. The analysis of designed VAWT in commercial CAD software, AUTODESK FUSION 360 and AUTODESK CFD is presented. The comments on the structural analysis and safety are presented.

Paper ID: 150

Generative Adversarial Network for Heart Disease Prognosis Using Deep Learning Machines

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Early prognosis of heart diseases or related issues can save lives in an enormous way. Heart Disease (HD) is one of the leading reasons to high death rate all over the globe. Learning machines are playing a vital role in the noninvasive, less expensive, and reliable prognosis of HD. Some essential biomarkers for HD prognosis using learning machines are blood sugar, heart rate, and blood pressure etc. Deep Learning (DL) models are found to be more accurate for HD detection in comparison to Machine Learning (ML) models. Further, Deep Learning Models work well with sufficiently huge amount of dataset. This study contributes a novel two-phased deep network comprising a Generative Adversarial Network (GAN) for data generation and a LSTM based deep network for HD prognosis. The proposed model is benchmarked against few selected HD prognosis models from the literature. The dataset from University of California (Irvine) naming Cleveland is used for experimentation. The statistical investigation reveals that the proposed two-phased HD prognosis model is effective with accuracy and f-measure of 99.6% and 99.63% respectively.

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