



11<sup>th</sup> & 12<sup>th</sup>  
January  
2024

3<sup>rd</sup> International Conference on  
**Industry 4.0** and  
**Advanced Manufacturing**

**Book of Abstracts**



**11-12 January 2024**

Book of Abstracts

Programme & Conference Chair

**Prof. Amaresh Chakrabarti**

Department of Design and Manufacturing  
Indian Institute of Science, Bangalore

Programme & Conference Chair

**Prof. Satyam Suwas**

Department of Materials Engineering  
Indian Institute of Science, Bangalore

Programme & Conference Vice-Chair

**Prof. Manish Arora**

Department of Design and Manufacturing  
Indian Institute of Science, Bangalore



## **ABOUT THE CONFERENCE**

Industry 4.0 is about using connected intelligence to usher in greater productivity, quality, flexibility, safety and resource utilisation across manufacturing enterprises, in which advanced manufacturing technologies such as Robotics or Additive Manufacturing play a critical role.

International Conference on Industry 4.0 and Advanced Manufacturing, abbreviated as I-4AM (pronounced i-forum), is a biennial conference series, which intends to provide a platform to bring together all stakeholders in manufacturing and Industry 4.0, in particular those in academia and industry, in both India and abroad for them to deliberate on the nature, needs, challenges, opportunities, problems and solutions in this transformational area of endeavour. A specific focus of I-4AM is to provide a platform for exploring avenues for creating a vision of, and enablers for sustainable, affordable, and human-centric Industry 4.0, and to showcase cutting-edge practice, research and educational innovation in this crucial and rapidly evolving area.

I-4AM 2024 is the third in a series of conferences held in India by the Department of Design & Manufacturing (erstwhile Centre for Product Design & Manufacturing), Indian Institute of Science (IISc), Bengaluru (<https://cpdm.iisc.ac.in/cpdm/index.php>) during 11-12 January 2024. IISc is one of India's leading science and technology institutions and is one of the Institutes of Eminence decreed by the Ministry of Education (MoE), Government of India (<https://iisc.ac.in/>). I-4AM 2024 is sponsored by the Smart Factory at IISc (<https://cpdm.iisc.ac.in/smartmanufacturing/>), a Common Engineering Facility Centre (CEFC) under the Samarath Udyog Bharat 4.0 Programme (<https://www.samarthudyog-i40.in/>), Ministry of Heavy Industries, Government of India (<https://heavyindustries.gov.in/>).

The proceedings of I-4AM 2024 will be published as a book by Springer Nature that is indexed in Scopus and other databases.

The I-4AM series was initiated in 2019 by the Department of Design and Manufacturing (erstwhile Centre for Product Design and Manufacturing), Indian Institute of Science, Bengaluru, under its Common Engineering Facility Centre (CEFC) on I4.0India@IISc (Smart Factory) within the SAMARTH Udyog Bharat 4.0 programme of the Ministry of Heavy Industries, Government of India.

## **PROGRAMME & CONFERENCE CHAIR**

Prof. Amaresh Chakrabarti

*Department of Design and Manufacturing, Indian Institute of Science, Bengaluru*

Prof. Amaresh Chakrabarti is a Senior Professor and current Chairman for the Department of Design and Manufacturing, Indian Institute of Science (IISc), Bengaluru. He has BE (Mech Engg, IEST Shibpur), ME (Mech Design, IISc) and PhD (Engg. Design, Univ. of Cambridge UK). He led for 10 years the Design Synthesis group at EPSRC CoE Engg Design Centre at Univ of Cambridge. His interests are in synthesis, creativity, sustainability, and informatics. He published 14 books, over 290 peer-reviewed articles, and has 10 patents granted/pending. He co-authored DRM, a methodology used widely as framework for design research. He has been Associate Editor, AI EDAM & Design Science Journal (Cambridge University Press), Area Editor, Research in Engg Design, Regional Editor, J Re-manufacturing (Springer), and Advisory Editor for 7 Journals incl. Clean Tech & Env. Policy (Springer), and J of Engg D and Int J Design Creativity & Innovation (T&F). He was on Advisory Board and Board of Management, Design Society; member, CII Design Council India; Jury, India Design Mark; invitee, CII Smart Manufacturing Council India. He founded IDeaSLab - India's first Design Observatory. He is Programme chair for International Conference Series on Research into Design (ICoRD), 22nd CIRP Design Conference 2012, 3rd Intl Conference on Design Creativity 2015 (3rd ICDC) and vice-Chair for AI in Design and Design Computing & Cognition Conferences. He is an Honorary Fellow of Institution of Engineering Designers, the peer society under the UK Royal Charter in engg design, and TUM Ambassador Awardee from TU Munich Germany. 16 of his papers won top paper awards in international conferences. He co-initiated India's first Smart Factory Lab. He also heads IISc-TCS Innovation Lab, IISc Press, and Springer International Book Series on Design Science & Innovation. He received Careers360 Faculty Research Award 2018 for being the 'Most Outstanding Researcher' in Decision Sciences. He is the current Editor-in-Chief of AI EDAM Journal (CUP).

## **PROGRAMME & CONFERENCE CHAIR**

Prof. Satyam Suwas

*Department of Materials Engineering, Indian Institute of Science, Bengaluru*

Prof. Satyam Suwas is a Professor and currently the Chair of Materials Engineering at Indian Institute of Science, Bangalore, India. He obtained his Ph.D. in Materials and Metallurgical Engineering from IIT Kanpur, and worked at Defence Metallurgical Research Laboratory, Hyderabad; University of Lorraine, France and RWTH Aachen, Germany before joining Indian Institute of Science. His specialization includes materials processing, crystallographic texture and mechanical behaviour of materials. He is a fellow of Indian National Academy of Engineering (INAE) as well as National Academy of Sciences, India (NASI).

## **PROGRAMME & CONFERENCE VICE-CHAIR**

Prof. Manish Arora

*Department of Design and Manufacturing, Indian Institute of Science, Bengaluru*

Prof. Manish Arora is an Associate Professor in the Department of Design and Manufacturing, Indian Institute of Science (IISc), Bengaluru. He obtained Ph.D. in applied Physics from the University of Twente, The Netherlands (2006) and B. Tech in Chemical Engineering from Indian Institute of Technology, Delhi (2002). He has got 100+ patent and research publications both in national and international level to his credit. He has employed with University of Oxford, UK between 2006-10, GE global Research 2010-12 and Nanyang Technological University, Singapore 2012-14. His areas of interest include biomedical devices, co-design, collaboration, open source in design and quality manufacturing of medical devices. He is the Principal Investigator in UTSAAH Lab, which aims at developing affordable and accessible medical technology solutions for promoting universal healthcare. He also teaches courses at IISc on Mechatronics and Design of Biomedical Devices and Systems.

## Venues:

Plenary Sessions	JN Tata Main Auditorium
PS 1	JN Tata Main Auditorium
PS 2	JN Tata Hall A
PS 3	JN Tata Hall B
PS 4	JN Tata Hall C
Lunch & Tea	JN Tata Auditorium Lower Foyer
Conference Dinner	Jawahar Lawn, Gymkhana, IISc

<b>Title of Tracks</b>	<b>Descriptions</b>
Digital Manufacturing	CAD/CAM/CAE, DFX, Simulation/visualisation, AR/VR/MR/XR/Haptics for manufacturing, Digital twins, Model-based manufacturing, informatics & quality control, Computational metrology, Digital human modelling
Materials Processing & Joining	Additive manufacturing, Hybrid manufacturing, Feed stock generation, Friction stir welding, Deformation processing/modelling, Composites
Industry X.0	Industry 4.0 & 5.0, Wireless sensor networks, Cyber-security protocols, Fog/edge computing, Artificial Intelligence, Certification, and standards
Training and Education	Training & education in Industry 4.0, Training & education in advanced manufacturing, Alternative modes of learning (including online & blended learning)
Sustainable Manufacturing	Assessment/ traceability, Lifecycle costing, Developing new sustainable materials & manufacturing processes, Environmental,

	social, & governance (ESG), Inclusive manufacturing
Controls, Autonomous Systems, Robotics	AGVs/ walking robots/drones for factory traffic management, Micro/nano manufacturing, Cobotics
Policy & Entrepreneurship	Start-ups, eco-systems & incubators, Distributed manufacturing, Fuzzy front/back end of manufacturing innovation and entrepreneurship
Supply Chains	Blockchain, Market platforms, Smart contracts, Network games, Dynamic routing/control, large scale logistics, Supply chain simulation, Optimisation.

## Day 1 11 Jan 2024 Thursday

### ▶ Inaugural Session

*Time: 0900-0930 IST*

*Venue: JN Tata Main Auditorium*

**Chief Guest:** Shri Vijay Mittal, Joint Secretary, MHI (TBC)  
Chair of Steering Committee, I4AM24: Prof. B Gurumoorthy  
Co-Chair, I4AM24: Prof. Amaresh Chakrabarti  
Co-Chair, I4AM24: Prof. Satyam Suwas  
Vice-Chair, I4AM24: Prof. Manish Arora

### ▶ Keynote Sessions 1 & 2

*Time: 0930-1100 IST*

*Venue: JN Tata Main Auditorium*

Chair: Prof. Satyam Suwas

#### ▷ Keynote 1

1

*Time: 0930-1015 IST*

Prof. Sundar Krishnamurty

#### ▷ Keynote 2

2

*Time: 1015-1100 IST*

Mr. Parasuraman TR

### ▶ Tea Break

*Time: 1100-1130 IST*

*Venue: JN Tata Auditorium Lower Foyer*

### ▶ Keynote Sessions 3 & 4

*Time: 1130-1300 IST*

*Venue: JN Tata Main Auditorium*

Chair: Prof. Manish Arora

#### ▷ Keynote 3

3

*Time: 1130-1215 IST*

Prof. Suhas S. Joshi

#### ▷ Keynote 4

5

*Time: 1215-1300 IST*

Prof. Sathyan Subbiah

▶ **Lunch Break and Photo Session**

*Time: 1300-1400 IST*

*Venue: JN Tata Auditorium Lower Foyer*

▶ **Panel Sessions**

*Time: 1400-1600 IST*

*Venue: JN Tata Main Auditorium*

- ▷ **Panel Discussion 1:** Challenges, Opportunities, and Initiatives by/for Strategic Sectors in Industry 4.0 and Advanced Manufacturing

6

*Time: 1400-1500 IST*

Chair: Dr. S Dwarakanath

**Panel Members:**

Shri Vikas Dogra, Director, MHI (TBC)

Shri RK Ramanathan

Shri FR Singvi

Dr Kallappa Pattada

Mr Jagannathan

Dr Adishesha Sivaramasastry

- ▷ **Panel Discussion 2:** Challenges, Opportunities, and Initiatives by the Government and Industry

7

*Time: 1500 - 1600 IST*

Chair: Dr. Purnendu Sinha

**Panel Members:**

Shri S Manohar

Shri Anup Wadhwa

Dr. Nagahanumaiah

Prof. Ramesh Babu

Shri Venu Allam

▶ **Tea Break**

*Time: 1600-1630 IST*

*Venue: JN Tata Auditorium Lower Foyer*

► **Parallel Sessions**

*Time: 1630-1830 IST*

▷ **PS 1: Digital Manufacturing**

Chair: Senthil Kumaran

*Venue: JN Tata Main Auditorium*

**Paper ID Title of the paper**

2	Evolution of AI-Driven Services: Comprehensive Literature Learning	8
15	Integration of Machine Learning in Virtual Workstations for Improved Efficiency and Productivity in Industry 4.0	9
22	Development of Low-Cost IIoT based Machine & Factory Monitoring using Current Measurements for Smart Factory application to MSME industries	10
24	Augmented Reality for Enhanced Fault Diagnosis of Robotic Welding Cells	12
29	An XML schema to represent material and hierarchical information for additive manufacturing	13
30	Data-driven Aircraft Engine Prognostics using Probabilistic Machine Learning on NASA C-MAPSS Dataset: An Industry 4.0 standpoint	14
31	Milled Surface Defect Detection and classification on Inconel 617 using Machine Vision based on YOLO algorithm	16

▷ **PS 2: Materials Processing and Joining**

Chair: A M Kuthe

*Venue: JN Tata Hall A*

**Paper ID Title of the paper**

17	AI Assisted Model for Predicting a Compressive Strength of 3D Printed Scaffold Used In Bone Tissue Regeneration	17
34	Multiobjective optimization of hole characteristics during LTD of ZTA	19
35	Revealing the Reinforcement Influence on Flexural Behaviour of Poly Lactic Acid Composites for Affordable and High-Performance Transtibial Prosthetic Socket	20

46	A Comprehensive Analysis and experimental investigation of Tribological characteristics of Friction Stir Welded Aluminum Based Metal Matrix Composite Plates	21
51	Effect of PWHT on TIG and MIG Welded Joint of Stainless Steel and Chrome Moly Alloy	22
61	Enhancing Impact Performance of Fused Filament Fabricated Polymer Composites: An Experimental and Statistical Investigation	23
66	Fabrication of Customized Orthopedic Metallic Implants by Sand Casting Root.	24
69	Adaptive Slicing for 3D Printing based on Load Concentration	25

▷ **PS 3: Industry X.0**

Chair: Koushik Vishwanathan

Venue: JN Tata Hall B

**Paper ID Title of the paper**

6	System and Method for Enhancing Airlines Turnaround Operations	26
9	A Web-Deployable Deep Convolutional Model for Rice Disease Classification with Crop Segmentation Approach	27
14	Enhancing Network Anomaly Detection: A Machine Learning Approach	28
38	The Art of Collaboration: A Comprehensive Review of Human-AI Cooperation in Visual Imagery Generation	29
42	Advancing Predictive Maintenance: A Data-Driven Approach for Accurate Equipment Failure Prediction	30
54	Analysis of factors influencing the integration of IoT in Additive manufacturing: a case study	31
58	Remaining Useful Life Prediction using Gradient Boosting Regression over turbofan Simulation Dataset	32

▷ **PS 4: Training and Education**

Chair: Srinivasan Venkataraman

Venue: JN Tata Hall C

**Paper ID Title of the paper**

12	Unravelling Entrepreneurial Mindset: Exploring the Relationship between Entrepreneurship Education, Intention and Behaviour.	33
55	Confidence Building Among ODL Students for Industry 4.0 Readiness	34
57	Impact of Robotics Artificial Intelligence and Automation (RAIA) in upskilling and employment	35
83	A Virtual Reality-based Game to Train Mining Workers	36
84	Design of Smart Interactive Toys for Future Kids	37
89	A Qualitative Study on the Different Design Processes Used by Students in a Bio-design Classroom	38

▶ **Visit to the IISc Smart Factory**

Time: 1830-1900 IST

▶ **Conference Dinner**

Time: 1900-2130 IST

Venue: Jawahar Lawn, Gymkhana, IISc

**Day 2 12 Jan 2024 Friday**

▶ **Parallel Sessions**

Time: 0900-1100 IST

▷ **PS 1: Digital Manufacturing**

Chair: Kusum Meena

Venue: JN Tata Main Auditorium

**Paper ID Title of the Paper**

37	Optimizing Quadcopter Chassis through Generative Design: A Novel Approach	39
41	Digital Twin of Axisymmetric part storage QC & Inspection workstation	40
44	Development of Digital Twin for Real Time Monitoring and Virtual Commissioning Applications in an Assembly Line	41

50	A digital twin for extruded layer qualification of 3D printed concrete	42
56	Demonstration of Robotic Welding Operation using Immersive Augmented Reality experience	43
70	Creating Digital Immersive Heritage Experience of Historically significant Architectural Structure	44
77	Enhancing Maintenance Learning in the Industrial Metaverse: Integrating Virtual Reality and Machine Learning	45

▷ **PS 2: Materials Processing & Joining**

Chair: Abhik Choudhury

Venue: JN Tata Hall A

**Paper ID Title of the Paper**

73	Fabrication of Thin walled structures via laser powder bed fusion technique	46
75	3D printed UV-Thermal Dual curable bio-composite for carbon-neutral building construction applications	47
82	Towards selective micro laser melting for the formation of conductive traces: influence of energy deposition rates and laser fluence	48
85	Mechanisms for Upward and Downward Warp Deformation of FDM 3D Printed Parts	49
86	Characterization of Discharge in Microwave Machining	50
92	Design for manufacturing (DFM) criteria- Incorporation of pattern allowances for casting of a Bush model	51

▷ **PS 3: Sustainable Manufacturing + Controls, Autonomous Systems, Robotics**

Chair: S Vinodh

Venue: JN Tata Hall B

**Paper ID Title of the Paper**

25	Creating a digital dashboard in a garment manufacturing unit - A case study.	52
36	Carbon Rewards (A sustainable solution to PUC)	53
62	Inculcating a Behaviour Change among Impulsive Online Shoppers: Adapting to Mindful Spending Habits	54

71	Speed Control of Brushless DC Motor Using PI Controller With Fuzzy Logic	55
74	Mobile robot path planning in global environment using MATLAB simulation	56
88	Congestion-aware path planning for multiple shelf carrying mobile robots in Robotic Mobile Fulfillment System	57
94	Predicting product issues in the use-phase from online customer reviews – a demonstration using UV-C sterilizer products	58
95	Automation of Public Transportation System in Dehradun, Uttarakhand	59
▷	<b>PS 4: Springer Publishing Workshop</b> Chair: Swati Meherishi Venue: JN Tata Hall C	60
▶	<b>Tea Break</b> Time: 1100-1130 IST Venue: JN Tata Auditorium Lower Foyer	
▶	<b>Keynote Sessions 5 &amp; 6</b> Time: 1130-1300 IST Venue: JN Tata Main Auditorium Chair: Prof. Satish Vasu Kailas	
▷	<b>Keynote 5</b> Time: 1130-1215 IST Prof. Ashitava Ghosal	61
▷	<b>Keynote 6</b> Time: 1215-1300 IST Dr. S. Devarajan	63
▶	<b>Lunch Break</b> Time: 1300-1400 IST Venue: JN Tata Auditorium Lower Foyer	

▶ **Panel Session**

*Time: 1400-1500 IST*

*Venue: JN Tata Main Auditorium*

- ▷ **Panel Discussion 3:** Challenges, Opportunities, and Initiatives in Training and Education of Advanced Manufacturing and Industry 4.0 65  
*Chair: Prof. B Gurumoorthy*

**Panel Members:**

Prof Rishiksha Krishnan

Prof Satish Vasu Kailas

Dr U Chandrasekhar

Dr S RaviShankar

Shri AN Chandramouli

▶ **Parallel Sessions**

*Time: 1500-1600 IST*

▷ **PS 1: Digital Manufacturing**

*Chair: Riby Abraham Bobby*

*Venue: JN Tata Main Auditorium*

**Paper ID Title of the Paper**

79	Enhancing Production Efficiency through Genetic Algorithm Assisted Visualization in Industrial Metaverse: Factory Layout Planning Scenario	66
93	Digital Twin-Driven Simulation for Wire Electrode Temperature Control in WEDM	67
97	Automated Visual Inspection for Defects Using Data Augmentation for Deep Learning Based Image Classification	68

▷ **PS 2: Industry X.0**

*Chair: Rajnish Mallick*

*Venue: JN Tata Hall A*

**Paper ID Title of the Paper**

78	Revolutionizing Small-Scale Industries in India: A Cost-Effective Industry 4.0 Framework for Enhanced Motion Control Using PLC-Servo Motor Integration	69
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80	Assignment of Resources to Aircraft Maintenance Using Pentagon and Generalized Fuzzy Models	70
99	Exploring the Synergy between Ergonomics and Productivity in the Workplace: An empirical analysis using inertial motion capture	71

▷ **PS 3: Policy & Entrepreneurship**

Chair: Biranchi Panda

Venue: JN Tata Hall B

**Paper ID Title of the Paper**

10	What do Entrepreneurs with Disability Want? Understanding the Needs for Entrepreneurship Capacity Building Training Programmes	72
20	Unleashing the Prospect: Cracking the Nexus between Women's Entrepreneurial Intention, Behavior, and the Entrepreneurial Ecosystem	73
65	Start-up Ecosystem through the Lens of Action Research	74
67	A Systematic Cost Viability for Entrepreneurial Start-up with Reference to Bodo Eri Dokhona	75

▷ **PS 4: Supply Chains**

Chair: Bisheshwar Haorangbam

Venue: JN Tata Hall C

**Paper ID Title of the Paper**

13	Multi-Objective Vehicle Routing Problem with Semi Soft Time Windows	76
16	Powering the Electric Vehicle Transformation: Modelling and Analysis of the conversion of Fuel Outlets to Hybrid Outlets	77
52	Integrated Dynamic Inventory Classification and Replenishment in Multi-echelon Supply Chain Networks	78

▶ **Tea Break**

Time: 1600-1630 IST

Venue: JN Tata Auditorium Lower Foyer

▶ **Visit to the IISc Smart Factory**

Time: 1630-1700 IST

▶ **Robotics Competition Presentations and Prizes**

*Time: 1700-1800 IST*

*Venue: JN Tata Main Auditorium*

Chairs: Abhra Roy Chowdhury, Sanjeev Shrivastava

Jury Members: Dibakar Sen, Ashitava Ghosal, Abhijit Biswas,  
Pradipta Biswas

▶ **Best Paper Awards and Valedictory**

*Time: 1800-1830 IST*

*Venue: JN Tata Main Auditorium*

Chairs: Amaresh Chakrabarti, Swati Meherishi

▶ **Vote of Thanks and High Tea**

*Time: 1830-1900 IST*

## **INFUSING ADVANCED MANUFACTURING INTO UNDERGRADUATE ENGINEERING EDUCATION**

Prof. Sundar Krishnamurty

*University of Massachusetts, Amherst*

**Bio.** Dr. Sundar Krishnamurty is the Ronnie & Eugene Isenberg Distinguished Professorship in Engineering and Department Head of Mechanical and Industrial Engineering at UMass Amherst. He is the PI for the NSF I-Corps program at UMass Amherst and Site Director for the NSF I/UCRC Center for e-Design. Krishnamurty is a fellow of ASME and an elected member of the Department Head/Chair of the ASME Executive Committee. For his pioneering work in modeling & simulation and engineering knowledge management in design and manufacturing, Krishnamurty received the 2022 Excellence in Research Award from the Computers and Information in Engineering (CIE) Division of ASME.

**Abstract.** In 2023, the National Academy of Engineering's Study Committee on Infusing Advanced Manufacturing into Undergraduate Engineering Education released its report on how engineering programs can better develop advanced manufacturing capabilities. The committee examined advanced manufacturing techniques in academia and industry, with a particular focus on the role that industries and governments can play by including undergraduate engineering students in their manufacturing initiatives. My talk will present highlights from this study, including a robust roadmap with specific guidance on ways to incorporate experiential learning emphasizing advanced manufacturing and strengthen ties between academia, industry, and government through mentoring and internship programs.

*Notes:*

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## **FUTURE OF MANUFACTURING IN PROPELLING INDIA TOWARDS A TEN TRILLION ECONOMY**

Mr. T. R. Parasuraman

*Chairman ASSOCHAM State Development Council, Chairman Karnataka State Development Council & Past President BCIC*

**Bio.** Mr. Parasuraman is the Chairman of the ASSOCHAM State Development Council, Chairman of the Karnataka State Development Council and the former President of the Bangalore Chamber of Industry and Commerce (BCIC). He has over 36 years of experience in TVS & Toyota affiliate companies in various domains. He is the past Chairman of Quality circle forum of India, Karnataka chapter. He is regularly invited for various national/state level seminars/conference to talk on global manufacturing/best practices. He is the member of the governing council of many academic institutions. Mr Parasuraman is the founding member of the governing council of BCIC, Brigade skill and has led the Bangalore Chamber of Industries and Commerce from the front to support many MSME, SME & other companies during the COVID pandemic and to start business at the earliest.

**Abstract.** With the growing geo political crisis and China plus one coupled with a young population, Indian manufacturing is likely to grow very steep in the coming decade from the current level of 17% of GDP to close to 30% of Indian GDP. This growth would translate to huge opportunities for MSMEs to contribute more significantly and contribute to the manufacturing growth story. Simultaneously, there is a huge transformation happening in the manufacturing with the rapid adoption of industry 4.0 across several sectors. To balance and achieve this growth, there is a greater necessity to improve the efficiency by rapidly skilling up on the appropriate technologies. Embracing the industry 4.0 Indian manufacturing will grow significantly and contribute to make India a manufacturing hub of the world in the next decade.

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## DESIGNING RE-ENTRANT CAVITIES FOR ROBUST LIQUID-INFUSED SURFACES

Prof. Suhas S. Joshi

*Indian Institute of Technology Indore, India*

**Bio.** Dr. Joshi has been the Director, IIT Indore since 2022. After his Ph.D. from IIT Bombay, he joined Tata Motors, and became faculty member at IIT Bombay in 1999. He was BOYSCAST Fellow (post-doc) at Georgia Tech and a Visiting Faculty at University of Illinois-UC. At IIT Bombay, he was - founder principal investigator of The Boeing Company supported National Centre for Aerospace Innovation and Research, 2009-14, Rahul Bajaj Chair Professor, 2014-22; Head - Mechanical Engineering, 2014-17 and Dean - Alumni and Corporate Relations, 2018-22. He supervised 20 doctoral and 117 masters students. He published 350+ articles including 200+ in international journals. He is a Fellow of the Indian National Academy of Engineering (INAE) and the National Academy of Sciences of India (NASI).

**Abstract.** Omniphobic surfaces, capable of repelling all types of liquids in addition to water are a great value addition in various applications ranging from self-cleaning, anti-icing, anti-biofouling, and hydrodynamic drag reduction to oil repellent coatings and oil/water separation. The texture design consists of a re-entrant topography that is vital to achieve oleophobicity as it enhances the stability of the composite liquid-solid-air interface. These surfaces are however prone to failure due to external pressure resulting in the loss of functionality. Liquid Infused Surfaces (LIS), another class of super wettable surfaces, consist of a micro/nanotextured surface infused with a lubricating liquid to achieve liquid-repellent properties. The lubricant used is incompressible and immiscible with the external liquid, thereby creating a stable pressure phase. Thus, the presence of the infused lubricant within the cavities is integral to the success of LIS. In bulk flow, LIS, however, are susceptible to drainage failure caused by external shear imposed at the liquid-lubricant interface. In this work, we combine the re-entrant topography (dovetail-shaped cavity) with a lubricating liquid and numerically evaluate the shear-flow-induced liquid-lubricant interface dynamics in a microchannel. The results show that when the lubricant is kept fixed, a less viscous external liquid aids in better lubricant retention. Due to the shear imparted, three stable and two failure meniscus shapes have been distinguished. Additionally, it was evident that, as the viscosity ratio was reduced, the effect of the cavity opening was no longer dependent on the flow rate. Further, to understand the durability of LIS, we focus on the

interface dynamics of LIS during transport for food packaging applications. We analyse the lubricant retention within the cavities when subjected to pure oscillations (zero net flow). The microchannel is excited longitudinally at  $f = 0.1 - 10$  Hz for viscosity ratios ( $\mu_r = 0.4 - 1.0$  and  $\mu_r = 1.8$ ) for a dovetail cavity with a lubricant of two different densities. The results show a strong dependence on the viscosity of the external liquid and the density of the lubricant. A more viscous external liquid and a denser lubricant dampen the vibration effects and thereby exhibit a stable state with an intact meniscus. Next, to demonstrate the performance of LIS with Newtonian and non-Newtonian liquids, 1D textures (ribs) are fabricated using a femtosecond laser and the drop movement is evaluated by varying the lubricant viscosity and tilt angle. The results show that increasing the tilt angle, the drop velocity increases whereas, the increase in lubricant viscosity enhances the drag and reduces the drop velocity. In addition, the surface is subjected external vibrations and shows a strong dependence on lubricant viscosity. A more viscous lubricant dampens the vibrations effects and does not deplete from the cavities, thus retaining the functionality of LIS.

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## **MANUFACTURING IN SPACE FOR SPACE AND FOR EARTH - SOME RECENT DEVELOPMENTS IN INDIA**

Prof. Sathyan Subbiah

*Indian Institute of Technology Madras, India*

**Bio.** Sathyan Subbiah obtained his B.Tech. in Mechanical Engineering in 1997. He then joined University of Illinois Urbana-Champaign, USA to pursue his M.S. degree, which he completed in 1999. Subsequently he joined Hayes-Lemmerz International, an automotive company in Michigan, as a manufacturing engineer. In 2002 he joined Georgia Institute of Technology, USA for pursuing his Ph.D. While at Georgia Tech he topped the Ph.D. qualifying exam and was the recipient of two fellowships. Sathyan moved to Singapore Institute of Manufacturing Technology, SIMTech (an A\*STAR Research Institute) for about 6 months before moving to NTU in 2007. He was with NTU until May 2014 after which he joined IIT Madras as Associate Professor. He is now a Professor at the Department of Mechanical Engineering at IITM.

**Abstract.** In the era of Space 2.0, exploring outer space involves traveling long durations, creating settlements in faraway locations, and exploiting partial gravity; these require extra-terrestrial manufacturing capability. Efforts are on-going in India to develop the ability to safely manufacture components, assemblies, and biologicals in outer space for use in space and back on Earth. The manufacturing technologies needed in space differ from the earth-based ones due to limited resources (space, energy, water, materials), micro/partial gravity, recycling, and limitations to track process inputs and outputs and to effectively recycle by-products. Access to various forms of micro-gravity platforms are important to simulate space environments and study several physical phenomena, and the know-how will influence the process technologies being developed. This talk will explore these exciting developments in the area of extra-terrestrial manufacturing (ExTeM).

*Notes:*

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11 January 2024 | 1400 - 1500  
*Panel Discussion: Panel 1*

## **CHALLENGES, OPPORTUNITIES, AND INITIATIVES BY/FOR STRATEGIC SECTORS IN INDUSTRY 4.0 AND ADVANCED MANUFACTURING**

**Panellists:**

*Dr S Dwarakanath (Chair)*

*Shri Vikas Dogra, Director, MHI (TBC)*

*Shri RK Ramanathan*

*Shri FR Singvi*

*Dr Kallappa Pattada*

*Mr Jagannathan*

*Dr Adishesha Sivaramasastry*

*Notes:*

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11 January 2024 | 1500 - 1600  
*Panel Discussion: Panel 2*

## **CHALLENGES, OPPORTUNITIES, AND INITIATIVES BY THE GOVERNMENT AND INDUSTRY**

**Panellists:**

*Dr. Purnendu Sinha (Chair)*

*Shri S Manohar*

*Shri Anup Wadhwa*

*Dr Nagahanumaiah*

*Prof. Ramesh Babu*

*Shri Venu Allam*

*Notes:*

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## **ID 2: EVOLUTION OF AI-DRIVEN SERVICES: COMPREHENSIVE LITERATURE LEARNING**

\*Sandipan Bhattacharjee (1), Jui Jagtap (1), Sabyasachi Biswas (1) and Bhaskar Saha (2)

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**Abstract.** The development of design is being significantly influenced by technology. We are entering a digital era that is developing quickly, and designers are starting to use terms like artificial intelligence, machine learning, big data, deep learning the internet of things, blockchain, spatial computing, and other related terms. The touchpoints that designers must take into account are becoming more complicated, and their jobs are changing accordingly. It is getting more difficult to integrate AI breakthroughs into user-centered designs with user experience design. This inspired us to do a literature study to see how AI is changing how designers approach their work and how they create artefacts for AI. This study was critical in demonstrating how designers are changing their perspectives, competencies, and expertise to handle these cutting-edge technology possibilities. ACM Digital Library, Google Scholar, and Springer were searched extensively for articles on design and AI. The work finds interesting research clusters at the nexus of Design, Human-Computer Interaction, and Intelligent Systems, but there are few studies that provide specific instructions on how to design with AI-driven services. We contribute to a greater comprehension of how current design methodologies must change when interactions turn into living ecosystems and reflect complicated exchange to the designers by synthesizing the existing literature on AI and Design. So, it is increasingly vital to research new concepts for communication between humans and AI.

*Keywords: Human-centred Design, Interaction Design, Artificial Intelligence, Decision making, Service Design*

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## **ID 15: INTEGRATION OF MACHINE LEARNING IN VIRTUAL WORKSTATIONS FOR IMPROVED EFFICIENCY AND PRODUCTIVITY IN INDUSTRY 4.0**

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**Abstract.** The integration of machine learning (ML) in virtual workstations has emerged as a promising solution for improving efficiency and productivity in Industry 4.0. This work addresses the need for an ML-based ecosystem in digital manufacturing by proposing a connected system that incorporates all elements of predictive maintenance functionality in a virtual workstation. The system allows real-time monitoring and analysis of critical manufacturing processes, enabling early detection of potential issues and facilitating proactive maintenance interventions.

By establishing virtual visibility of the workstation from the headquarters, decision-makers can remotely access and evaluate the manufacturing processes, leveraging ML algorithms to identify patterns and anomalies. This enables timely decision-making and reduces downtime, leading to increased operational efficiency and productivity.

To validate the effectiveness of the generalized proposed approach, a practical example of its implementation in a relevant manufacturing facility has been considered. The results demonstrate that the ML-integrated virtual workstation significantly improves maintenance procedures, reduces costs, and enhances overall performance. The generalized nature of this ecosystem justifies its applicability to various manufacturing industries, emphasizing its potential as a scalable solution for optimizing Industry 4.0 operations.

*Keywords: Machine learning, Virtual workstations, Predictive maintenance, Real-time monitoring, Decision-making, Operational efficiency*

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## **ID 22: DEVELOPMENT OF LOW-COST IIOT BASED MACHINE & FACTORY MONITORING USING CURRENT MEASUREMENTS FOR SMART FACTORY APPLICATION TO MSME INDUSTRIES**

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**Abstract.** The adoption of implementing industry 4.0 solutions to their factory floors is becoming top priority to the organizations. The industrial assets and system monitoring involves collecting data from various sources within an industrial production system to monitor the performance of the machine, metrology-based equipment's and its processes. The data collected in the industry are analyzed for productivity enhancement, ease of maintenance using trends and anomalies, quality improvements and cost reduction. The IIoT based energy monitoring solutions which are available in the market are providing information related to energy utilization and also, they are expensive. The energy related parameters are limited to energy utilization for the industrial assets and buildings. There is a lot of requirements for MSME's sector to monitor the machine monitoring and factory productivity using low cost IIoT based solutions. This paper is mainly aimed at developing low cost IIoT solution for productivity monitoring to MSME Industries.

The developed solution uses inexpensive hardware for sensing, controller for data collection & analysis and edge gateway for cloud storage. The collected data is represented and analyzed using web based front end and back-end software technologies for machine and factory monitoring. The developed solution gives information about the factory status, machine status, productivity tracking of machines and part count measurements possibility. The developed software allows users for automatic reports through Email, SMS and also allows user to create reports for daily and monthly reports. The solution has been implemented in factory floors of MSME for validation and testing.

*Keywords: Smart, Energy Meter Current based energy monitoring, IIoT, Machines and Factory Monitoring*

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## **ID 24: AUGMENTED REALITY FOR ENHANCED FAULT DIAGNOSIS OF ROBOTIC WELDING CELLS**

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**Abstract.** With the emergence of Industry 4.0, often known as the fourth industrial revolution, the notion of "Smart Factories" has gained momentum. One of the prominent applications of Industry 4.0 is the robotic welding cell, which revolutionizes the welding process by automating it with the help of robots and advanced data-driven systems. A robotic welding cell is a specialized production setup that employs industrial robots outfitted with welding instruments to execute precise and efficient welding operations, this saves manual labor, increases production, and assuring constant quality. With the ever-increasing advancement in artificial intelligence and machine learning algorithms, there would be a significant increase in the adaptive and self-learning capabilities thus making the production process "Smart." When combined with IoT, AR-IoT, opens avenues for remote monitoring and control of robotic welding cells. Sensor data from the welding cell, such as temperature, voltage, and current, can be collected in real-time and transmitted to a central monitoring system. Through AR interfaces, operators can access this data remotely, analyze it, and make informed decisions or adjustments to the welding process. Additionally, AR-IoT can facilitate predictive maintenance, as data-driven analytics and machine learning algorithms can identify potential equipment failures or maintenance requirements in advance, reducing downtime and improving overall equipment effectiveness. Data gathered in facilitation with AR are the next steps in the pipeline, resulting in Future Proactiveness, identification of emerging issues, and resolution.

*Keywords: Industry 4.0, Smart manufacturing, Augmented reality (AR), Quality control, Robotic welding cell (RWC), IoT*

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## **ID 29: AN XML SCHEMA TO REPRESENT MATERIAL AND HIERARCHICAL INFORMATION FOR ADDITIVE MANUFACTURING**

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**Abstract.** Additive Manufacturing (AM) has numerous benefits over conventional manufacturing processes, such as producing complex geometries, printing multi-material parts, and parts with variable scales of lattice structures. The design intent should transfer through each step in the AM process planning. The de-facto standard file format used in AM is STL (Standard Tessellation Language). However, these STL files contain only geometrical information about the design; other information, such as colour, material variations, and structure variations in the design domain, cannot be represented in the existing STL file. Extensible Mark-up Language (XML) is a human and machine-readable standard representation of information widely used to share information and other descriptions over multiple mediums. We propose an XML schema-based approach in this work to represent the material and hierarchical structure information along with geometry in CAD. The proposed approach will eliminate the limitations of the existing file formats used in AM. Current process planning tools can read these files for printing the part effectively. The effectiveness of the proposed approach is tested with a case study of a wireless mobile charging case with multi-material and different lattice structures and is presented in this work.

*Keywords: AM File formats, XML schema, Additive Manufacturing, Multi-material, Hierarchical structures*

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## **ID 30: DATA-DRIVEN AIRCRAFT ENGINE PROGNOSTICS USING PROBABILISTIC MACHINE LEARNING ON NASA C-MAPSS DATASET: AN INDUSTRY 4.0 STANDPOINT**

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**Abstract.** Industry 4.0 has become more integrated in the mechanical and aerospace industries due to the development of the Internet of Things (IoT), sensors, and big data. Aircraft engines are intricate mechanical systems which require constant monitoring to ascertain airworthiness and constitute approximately 35 to 40 per cent of the total maintenance expenditure. The remaining useful life (RUL) of a jet engine is crucial for its operational efficiency, as it determines how long the engine can operate before maintenance is needed. The process of determining the RUL is known as prognostics. Traditionally, data-driven prognostic methods rely on run-to-failure data, called training data. The National Aeronautics and Space Administration (NASA) has provided the Commercial Modular Aero-Propulsion System Simulation (C-MAPSS) dataset, which is used to train machine learning (ML) models. This study suggests that a probabilistic approach is more effective than a deterministic approach for training ML algorithms in data-driven prognostics. The probabilistic supervised ML method used in this study is Gaussian Process Regression (GPR), a Bayesian approach that does not require specific parameter values for regression problems. Three deterministic algorithms, namely Multi-Layer Perceptron (MLP), Support Vector Regression (SVR), and Relevance Vector Regression (RVR), are compared with the GPR. A scoring metric provided by NASA is used to compare the deterministic and probabilistic approaches. The MLP, SVR, RVR, and GPR scores are 18000, 1380, 1500, and 1045, respectively. The root mean square error (RMSE) for the different methods are 37.56, 20.96, 23.80, and 19.49, respectively. Among all the methods, the probabilistic GPR model achieves the highest NASA score and the lowest RMSE, elucidating its superior performance over the deterministic methods.

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*Parallel Session: Digital Manufacturing*

*Keywords: Industry 4.0, Data-driven Prognostics, Remaining Useful Life (RUL), Probabilistic Machine Learning, Gaussian Process Regression (GPR), Jet Engine, NASA C-MAPSS*

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## **ID 31: MILLED SURFACE DEFECT DETECTION AND CLASSIFICATION ON INCONEL 617 USING MACHINE VISION BASED ON YOLO ALGORITHM**

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**Abstract.** Surface defects are a significant concern in the manufacturing industries, as they affect the functionality and performance of machined components. Traditional methods for multiple defects detection on milled surfaces rely on human inspection, which is subjective, time-consuming, and prone to errors. This research aims to address this challenge by developing multiple surface defects detection system based on machine vision techniques that utilize-focus variation based optical profilometer to capture the images, and computer vision algorithms, to automatically detect and classify defects on milled surfaces as per ISO 8785 that includes scratches, pitting, deposits, erosion, and blowholes. This work involved machining straight slots using end milling on Inconel 617 alloy under varied machining conditions. You Only Look Once (YOLOv7), an object detection algorithm, was used for defect localization and detection. A total of 18,024 images, with 13,215 images for training (75%) and 4809 images for validation (25%), were used for developing the machine vision-based surface defect detection system. 7,020 images are used for validation. The precision and recall values of the model were observed to be around 43% and 45%, respectively, along with mean average precision coming around 40%.

*Keywords: Surface defect, Image processing, Machine vision, YOLOv7*

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## **ID 17: AI ASSISTED MODEL FOR PREDICTING A COMPRESSIVE STRENGTH OF 3D PRINTED SCAFFOLD USED IN BONE TISSUE REGENERATION**

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**Abstract.** The study on artificially designed bone implants for dental reconstructions, trauma surgery, and cancer therapy has to be refined further, as implant acceptance by the medical community is always a key issue. The present workstudy of the fabrication of bone scaffolds and the important parameters required to manufacture bone scaffolds which are properties of composite biomaterials, porosity, pore size, strand diameter, scaffold printing architecture, and compressive strength of bone scaffolds is studied. From research articles, data collection for these parameters and the working of 3D-biplotter has been studied. From observations, 3D bioprinting processes have many problems such as the high cost of bioprinting and bioprinters, lack of full automation, lack of compatible materials, speed of bioprinters and complex workflow. Therefore, there is a need to bridge the gap between current bioprinting processes and Artificial Intelligence. In this, we considered four different Machine Learning models which are Hist-Gradient Boosting Regressor, Gradient Boosting Regressor, K-neighbors Algorithm, and Random Forest Regressor to analyze the collected data in which we considered, the properties of composite biomaterials, porosity, pore size, strand diameter, scaffold printing architecture as input parameters and compressive strength as an output parameter. From the data, the model gets trained, and by testing the dataset the accuracy of the models is found. From the results, we concluded that the Hist-Gradient Boosting Regressor model gave the best-predicted output and we found out 95.33% accuracy and mean absolute percentage error (MAPE) is 7.6927 for model. It means that the model gets trained from the training dataset and can predict future output for required inputs with up to 95.33% accuracy. The current procedure, more human interaction in the fabrication process. We were able to decrease human intervention and estimate the compressive strength of bone scaffold before fabricating it with the patient specific inputs using our approach

11 January 2024 | 1630 - 1830  
*Parallel Session: Materials Processing and Joining*

*Keywords: Rapid prototyping (RP), 3D bioprinting, Tissue engineering (TE), Bioceramic materials, Artificial Intelligence, Machine Learning*

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## **ID 34: MULTIOBJECTIVE OPTIMIZATION OF HOLE CHARACTERISTICS DURING LTD OF ZTA**

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**Abstract.** Zirconia Toughened Alumina (ZTA) ceramic composite offers excellent mechanical properties. Therefore medical implant, cutting tools, and structural parts are fabricated by the ZTA. Many applications of ZTA requires circular hole in it. Conventional circular hole making methods are not preferred due to hostile machining characteristics of ZTA. However laser circular cutting or laser trepan drilling (LTD) is a better option among available nonconventional hole making methods. But optimum selection of laser trepanning parameters value for ZTA to get quality hole circularity with minimum taper is challenging. In the present research paper optimum set of input parameters to optimize the multiobjective responses of the drilled hole is investigated. A multiobjective response of the drilled hole is considered as top and bottom circularity and taper during laser trepan drilling in ZTA plate. The mathematical equation of the multiobjective functions are developed using artificial neural network. The research findings show an overall improvement of approximately 12% in multiple quality characteristics. Further, optimum results have been verified with confirmation experiment that shows small variation of 3.9%

*Keywords: Laser trepan drilling, Zirconia toughened alumina, hole characteristics, Multiobjective optimization*

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## **ID 35: REVEALING THE REINFORCEMENT INFLUENCE ON FLEXURAL BEHAVIOUR OF POLY LACTIC ACID COMPOSITES FOR AFFORDABLE AND HIGH-PERFORMANCE TRANSTIBIAL PROSTHETIC SOCKET**

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**Abstract.** The loss of a lower limb can have a profound impact on an individual's mobility and independence. To address this issue, transtibial prosthetic sockets (T\_P\_S) have been developed as medical devices to assist amputees in regaining their mobility. However, the production of these T\_P\_S has encountered challenges due to the diverse range of process variables (P\_V) involved. This study aimed to examine the flexural behaviour of poly lactic acid reinforced with carbon fibre (PLA-CF) using the fused filament fabrication (F\_F\_F) technique. The specific objectives were to investigate the influence of two P\_V: the nozzle hole diameter (N\_H\_D) with options of 0.15mm, 0.25mm, and 0.40mm, and the internal filling pattern (I\_F\_P) with options of grid, honeycomb (HC), and tri-hexagon (TRH). To comprehend the impact of these P\_V on the flexural behaviour, comprehensive flexural tests were conducted on the fabricated samples. Furthermore, the failure morphology of the samples was analysed to gain insights into their structural integrity. The obtained data from the flexural tests were subjected to statistical analysis using the analysis of variance (ANOVA) by Taguchi methodology (T\_M). This statistical approach facilitated the determination of the relationship between the flexural behaviour and the selected P\_V. The research findings have significant implications in the field of T\_P\_S development. By gaining an understanding of how different P\_V affect flexural behaviour, it becomes possible to optimize the manufacturing process and enhance the performance of T\_P\_S.

*Keywords: Fused Filament Fabrication, Taguchi, PLA-CF, Flexural Strength, Transtibial Prosthetic Socket*

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## **ID 46: A COMPREHENSIVE ANALYSIS AND EXPERIMENTAL INVESTIGATION OF TRIBOLOGICAL CHARACTERISTICS OF FRICTION STIR WELDED ALUMINUM BASED METAL MATRIX COMPOSITE PLATES**

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**Abstract.** Aluminium is commonly accessible light weight, low melting temperature non ferrous metal. Many industries, including aerospace, medical, automotive, and home and personal care, use aluminium and its alloys. A wide range of applications and material substitutes are influenced by aluminum's unique high strength-to-weight ratio. The aluminium alloy blend with silicon carbide ceramic particles and high modulus e-glass fibre form hybrid composites an advantage over alloys. Using a traditional stir casting process, the current work primarily focuses on fabricating composite materials (AA2024, AA6061, and AA7075). These materials are then joined using friction stir welding, where various welding parameters are used, including spindle speed (600, 900, and 1200 rpm) and feed rates (40, 80, and 120 mm/min) utilising an ETA manufacturing FSW machine. Weld nugget zone machined as an ASTM fretting specimen and subjected to a fretting wear test to evaluate tribological properties with varying stoke length. The addition of reinforcements significantly reduced fretting wear compared to the base AA2024, AA6061, and AA7075 and the fretting wear increased with increased welding feed rate and the wear was found to be maximum at feed rate of 120mm/min and minimum at feed rate of 40mm/min and tabulated the fretting results among three base and composite plates.

*Keywords: Fretting wear, aluminium alloy, friction stir welding, composites*

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## **ID 51: EFFECT OF PWHT ON TIG AND MIG WELDED JOINT OF STAINLESS STEEL AND CHROME MOLY ALLOY**

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**Abstract.** Dissimilar weld joints are critical to various industrial applications. An important performance measure of the joint is its mechanical properties. In this work, investigations were carried out to understand the effect of post weld annealing heat treatment on the welded joint of SA312 TP304 stainless steel and SA335 P11 chrome moly alloys formed by tungsten inert gas welding (TIG) and metal inert gas welding (MIG). The microstructures were studied using optical microscope and the correlation between microstructures and microhardness is assessed at the different regions of the joints before and after the heat treatment. The effect of post weld heat treatment has been observed on the microstructure in all regions of the welds indicated by the alteration in the grain size and formation of precipitates. Subsequently, increase in the hardness is observed in the base metals, heat affected zones (HAZ) and weld zone of these joints. The maximum hardness was measured at HAZ of SA335 P11 alloy side of the heat-treated specimens. Base metal and HAZ of SA312 TP304 of both TIG and MIG, as-welded joints are characterized by twinned equiaxed grains of austenite free from grain boundary precipitation whereas substantial carbide precipitation was observed in these regions after heat treatment. The weld zone revealed dendritic structure comprised finer metal carbides formed during solidification of weld pool.

*Keywords: Annealing, Dendritic, Dissimilar, PWHT, Weld*

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## **ID 61: ENHANCING IMPACT PERFORMANCE OF FUSED FILAMENT FABRICATED POLYMER COMPOSITES: AN EXPERIMENTAL AND STATISTICAL INVESTIGATION**

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**Abstract.** With the advent of fused filament fabrication (FFF), scientists are now able to mass-produce intricate geometrical shapes for the purpose of designing high impact energy absorbing structures for use in a variety of applications. This study performed an Impact test to quantify the energy absorption of FFF-fabricated polymer composites namely poly-lactic-acid reinforced with multi-walled carbon nano tubes (PLA-MWCNTs), poly-ethylene-terephthalate-glycol reinforced with carbon fibre (PETG-CF), and poly-lactic-acid reinforced with carbon fibre (PLA-CF) with varying internal filling patterns (IFP) and nozzle hole diameter (NHD). Energy absorption is greatest at grid IFP and NHD of 0.40mm for PLA-CF. Taguchi's method (TM) and response surface method (RSM) are applied to the results of the impact tests to recognize how the energy absorbing behaviour depends on the specified process constraints (PC). Using the FFF method, the results of the tests may be utilized to create functional components in prototype, unit, and small-lot production.

*Keywords: Impact energy, fused filament fabrication, polymer composites*

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## **ID 66: FABRICATION OF CUSTOMIZED ORTHOPEDIC METALIC IMPLANTS BY SAND CASTING ROUTE.**

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**Abstract.** The manufacture of the metallic Implant is most critical as the Implant is fitted in the patient body. The casting route for manufacturing said product is constantly criticized as obtaining zero defects cast part requires more resources and technical expertise. RP in metal casting is now well-established technology but needs to be refined when the product is an orthopedic Implant. The feasibility of casting, more specifically sand casting of Implant, is discussed in this paper, taking into consideration various issues like the feasibility of sand casting made from the FDM technique of RP Pattern and customization of Implant. The accuracy of sand casting was improved by casting simulation. The confirmatory experimentation proves that medical-grade implants can be fabricated with minimum defects by casting route.

*Keywords: Metallic Implant, Sand Casting, AutoCast, Rapid Prototype*

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## **ID 69: ADAPTIVE SLICING FOR 3D PRINTING BASED ON LOAD CONCENTRATION**

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**Abstract.** Additive manufacturing, commonly known as 3D Printing, is a process that produces its output as a tangible item. Slicing is the procedure necessary to prepare a digital 3D model for additive manufacturing. The slicing of the model is done using conventional slicing programs that convert the model as G-code for printers. There are degrees of freedom in this process, start point of slicing sequence and thickness of each layer, which changes the quality of the model—these parameters of slicing influence the print process, varying time, and quality of the manufacturing. Slicing of CAD model with a minimal slice thickness leads to long build time and high strength. In the case of large slice thickness, the surface of a part has bad quality. It is necessary to find optimal thickness for layers of the 3D model. This paper presents an adaptive slicing method for varying layer thickness. It uses adaptive computing for layer heights to print parts. It has the potential to generate high fidelity printed parts with a minimal volume of Printing. The study can help in printing the parts faster rather than the conventional uniform slicing method; this proposal was validated with computer simulation and visual comparison of the 3D model. The study concludes on methods to evaluate the layer thickness based on the topographical load on the 3D model. This approach is in conception and intends to locate the boundaries using mathematical algorithms accurately and, in turn, adjusting slicing thickness.

*Keywords: Topological optimization, FEM modeling, 3D slicer, Additive Manufacturing, Grasshopper3d, Generative Design*

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## **ID 6: SYSTEM AND METHOD FOR ENHANCING AIRLINES TURNAROUND OPERATIONS**

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**Abstract.** Aircraft turnaround management is a highly complex and cross-functional process with multiple interdependencies. The key to an airlines' consistent on-time performance depends on the smooth execution of its aircraft turnaround time (TAT) management. Following a manual process to accomplish this will only add to further complexities. Hence it is imperative to on-board a digital companion solution. TCS brings to the table a proprietary suite of airline solutions called TCS Aviana™, which consists of "TCS Aviana™ SmartTurn" – a digital aircraft turnaround management solution. TCS Aviana™ SmartTurn can be used as a technology ecosystem platform to drive the efficiencies end to end, on-time performance (OTP) and deliver the outcomes promised.

This solution helps in bringing:

1. Deep real time visibility of turnaround management process
2. Remote operations and turnaround information and OTP on-the-go.
3. Helps to identify delay causalities and its impact on OTP
4. Brings in statistical capability to come up with a systematic continuous process improvement plan.

In this paper, we are bringing out industry proven solutions that can accelerate its digitalization journey for Aircraft Turnaround management and a platform that supports continuous improvement of airline processes. Subsequently, we have proposed an innovative approach on multi-hop turnaround time predictions.

*Keywords: Airlines, Turnaround time, Critical Path Activities, Six Sigma methods, Contingency Matrix*

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## **ID 9: A WEB-DEPLOYABLE DEEP CONVOLUTIONAL MODEL FOR RICE DISEASE CLASSIFICATION WITH CROP SEGMENTATION APPROACH**

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**Abstract.** Rice plays a crucial role in the economy of South-East Asia, but the region is grappling with the decline in rice crop production and quality due to diseases and pests. The manual monitoring and identification of these issues pose considerable difficulties for farmers. To tackle this problem, a real-time automated system is proposed, which identifies common rice crop diseases based on leaf symptoms. The system incorporates a user-friendly web interface that enables farmers to upload leaf images for analysis. To improve accuracy, the system employs a segmentation approach during the preprocessing stage, effectively isolating diseased portions in the leaves. Disease classification is then performed using a lightweight Convolutional Neural Network (CNN) model, resulting in an impressive overall accuracy of 97.01% with k-fold cross-validation. The proposed model surpasses the performance of pre-trained CNN models in disease classification. Furthermore, to showcase its effectiveness, the model is validated on a maize dataset, achieving an accuracy of 94.00%. By offering prompt and accurate disease identification, this automated system provides invaluable support to farmers, empowering them to make informed decisions and mitigate the adverse effects of diseases on rice crops.

*Keywords: Rice disease recognition, Convolution neural networks, Crop segmentation*

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## **ID 14: ENHANCING NETWORK ANOMALY DETECTION: A MACHINE LEARNING APPROACH**

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**Abstract.** Effective anomaly detection techniques are now essential to ensure the security and integrity of computer networks due to the complexity and volume of network traffic data. Traditional techniques often struggle to cope with evolving new attacks and fail to detect novel anomalies. This has led to the adoption of machine learning algorithms, which can automatically learn patterns and identify deviations from normal network behaviours. In this paper we represent a novel approach to detect anomalies in the network using machine learning models like Decision tree and Random Forest Classifier. Our approach consists of a system for detecting anomalies in real-time data and generating an email notification whenever anomalies are detected. The email includes the details of the network traffic data that have been identified as anomalies. The proposed methodology is implemented using KDD CUP dataset. Furthermore, the machine learning models are deployed and evaluated using machine learning techniques.

*Keywords: Decision Tree, Random Forest Classifier, KDD CUP*

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## **ID 38: THE ART OF COLLABORATION: A COMPREHENSIVE REVIEW OF HUMAN-AI COOPERATION IN VISUAL IMAGERY GENERATION**

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**Abstract.** The field of artificial intelligence (AI) has revolutionized the generation of visual imagery, resulting in the production of remarkably realistic and aesthetically pleasing content. This study delves into the current landscape of human-AI collaboration in visual imagery creation, offering insights into its development, challenges, and future prospects. Through an extensive literature review encompassing research initiatives and industry applications, the research aims to accumulate knowledge that can advance best practices and enhance original design output through the integration of human input and control systems.

The study seeks to scrutinize the diverse ways in which humans and AI can collaborate in the creation of visual imagery. It examines the impact of this collaboration on the creative process while also addressing the ethical questions it raises. Additionally, the review process elucidates the principal obstacles and constraints impeding effective human-AI collaboration in visual imagery production, emphasizing the need for clarity in AI-generated graphics, explainability, and mitigation of bias. By explicitly recognizing the implications and limitations of the research methodology, this abstract offers a clearer perspective on the study's scope and objectives.

*Keywords: Human-AI collaboration, Co-creation, Image Generation, Visual Imagery, Image Originality*

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## **ID 42: ADVANCING PREDICTIVE MAINTENANCE: A DATA-DRIVEN APPROACH FOR ACCURATE EQUIPMENT FAILURE PREDICTION**

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**Abstract.** Maintenance of industrial equipment is crucial for ensuring uninterrupted operations and minimizing costly downtime. Traditional reactive maintenance approaches are often inefficient and can lead to unexpected failures. In recent years, predictive maintenance techniques powered by machine learning and data analysis have emerged as a promising solution. This research article presents a comprehensive study on the development of an equipment failure prediction model for predictive maintenance. The objective is to leverage advanced data analysis techniques and machine learning algorithms to accurately forecast equipment failures and enable proactive maintenance actions. The research methodology involves data preprocessing, feature engineering, algorithm selection, and model evaluation using metrics such as accuracy, precision, recall, and F1 score. Additionally, techniques for model interpretability and explanation are explored to gain insights into the factors contributing to equipment failures. The findings of this research contribute to the field of predictive maintenance by providing a robust and accurate model for equipment failure prediction. The developed model has the potential to assist industrial organizations in implementing proactive maintenance strategies, optimizing resource utilization, and minimizing production disruptions. This article serves as a valuable resource for researchers, practitioners, and decision-makers interested in enhancing operational efficiency and reducing maintenance costs through predictive maintenance techniques.

*Keywords: Predictive maintenance, equipment failure prediction, machine learning, data analysis, feature engineering, model optimization, interpretability, proactive maintenance, operational efficiency*

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## **ID 54: ANALYSIS OF FACTORS INFLUENCING THE INTEGRATION OF IOT IN ADDITIVE MANUFACTURING: A CASE STUDY**

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**Abstract.** Customised products can be manufactured using additive manufacturing (AM) process, but the drawback in this process is that they cannot be used for mass production of customised products. Another drawback of AM is requirement of human supervision in event of error. On the other hand, Internet of things (IoT) facilitates to operate and control machines remotely. Integration of these two technologies enhances production experience. Both direct and indirect tooling method through AM is used for mass production of products. Integrating IoT and AM processes aid in better decision making through analysis of real time data, allocation of material resources to machines, scheduling machines and employ which would eventually result in reduction in operation cost and increase in production efficiency. The primary aim of this study is to analyse factors influencing the integration of IoT with AM process. 16 factors and seven criteria are considered for this analysis. Criteria considered for evaluation of factors are in the context of management and process oriented. Multicriteria decision making method grey Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is employed to analyse factors and criteria and the factors are ranked based on its relative closeness index score. The result indicates effective utilization of internet-based technologies in AM is important for the development of smart and sustain-able manufacturing.

*Keywords: Internet of things, Additive manufacturing, challenges, MCDM, Grey TOPSIS*

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## **ID 58: REMAINING USEFUL LIFE PREDICTION USING GRADIENT BOOSTING REGRESSION OVER TURBOFAN SIMULATION DATASET**

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**Abstract.** Ensuring the turbofan engine's optimal performance and safe operation necessitates regular maintenance. The Remaining Useful Life (RUL) refers to the remaining time before a machine or its component requires repair or replacement. It serves as a critical measure in the field of Predictive Maintenance. Predictive maintenance involves scheduling maintenance based on predictions of equipment failure. By analyzing data measurements from the equipment, machine learning can be used to develop models that predict failure before it occurs. This paper presents a comparative study of machine learning algorithms for predicting the Remaining Useful Lifetime (RUL) of turbofan engines in aircraft. The study utilizes NASA Turbofan Simulation Dataset to construct the machine learning models. To enhance the accuracy of predicting maintenance requirements, this paper endeavors to employ several models and choose best among all. By thoroughly examining the performance metrics of various models and meticulously fine-tuning their parameters through random search, we aim to ascertain the remaining useful life of the turbofan engine with unprecedented precision.

*Keywords: Industry 4.0, Machine Learning, Remaining Useful Life, Predictive Maintenance, Prognosis*

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## **ID 12: UNRAVELING ENTREPRENEURIAL MINDSET: EXPLORING THE RELATIONSHIP BETWEEN ENTREPRENEURSHIP EDUCATION, INTENTION AND BEHAVIOUR.**

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**Abstract.** Entrepreneurship has been considered a catalyst for economic development by prominent scholars and practitioners. The intention and behavior to pursue entrepreneurship serve as an antecedent to the creation of an enterprise. Our study aims to identify the effect of entrepreneurship education in the form of an entrepreneurship capacity-building program on the entrepreneurial intentions and behaviors of the international participants from 27 countries partaking in the program, with the mediating impact of the behavioral entrepreneurial mindset. Our paper hypothesized the relationship between entrepreneurship education (EE), behavioral entrepreneurial mindset (BEM), entrepreneurial intentions (EI), and entrepreneurial behavior (EB). SPSS software Regression analysis and Mediation Analysis were used to analyze and explain the relationship between variables of the study using survey data collected from 149 participants of the Indian Technical and Economic Cooperation (ITEC) program. According to the findings of the study, BEM considerably mediates the relationship between EE and EI. Furthermore, the study discovered a relationship between EI and EB. The statistics, however, show no significant direct relationship between BEM and EB. The findings add to the philosophical perspective of the entrepreneurial literature and practice of entrepreneurship capacity-building programs by highlighting the significance of BEM in the development of EI.

*Keywords: Development Program, Entrepreneurial Intention, Entrepreneurial Mindset, Entrepreneurial Behavior, Theory of Planned Behavior*

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## **ID 55: CONFIDENCE BUILDING AMONG ODL STUDENTS FOR INDUSTRY 4.0 READINESS**

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**Abstract.** Industry 4.0 has highlighted the nurturance of affective skills in higher education institutions including ODL for meaningful functioning effectively in both society and professional workplaces. The present study explores the nature of pedagogical interactions in ODL that could lead to confidence building among students, from the sociological and psychosocial theoretical perspectives. The data collected from 390 IGNOU students enrolled between 2017-2022 pursuing under-graduation and post-graduation, was statistically analysed using CFA and ANOVA. The findings revealed that constructive interactions with teachers and peers foster self-awareness, active listening skills, critical thinking skills, reflective skills, and emotional intelligence, leading to confidence and holistic personality development to be able to function meaningfully in a workplace. This also enables an individual to contribute towards strengthening of a positive, safe and mutually beneficial environment, a much sought after ability in the fast emerging industry 5.0. The study reveals the nature of social interactions to be facilitated using varied pedagogical practices in ODL, which could further be explored using the ever evolving synchronous and asynchronous interactive platforms in the 21st century.

*Keywords: Industry 4.0, Industry 5.0, Confidence, Social Interaction, Distance Education*

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## **ID 57: IMPACT OF ROBOTICS ARTIFICIAL INTELLIGENCE AND AUTOMATION (RAIA) IN UPSKILLING AND EMPLOYMENT**

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**Abstract.** In the swiftly evolving digital era, characterized by rapid technological advancements, the surge in automation underscores the critical need for diversified knowledge, particularly in realms such as robotics and artificial intelligence (RAIA). A notable 73% of organizations globally are poised to embrace RAIA deployment, recognizing its potential to enhance productivity. Acknowledging the imperative for perpetual learning in the face of technological progress, this conceptual paper aims to elucidate the pivotal impact of RAIA on the upskilling of individuals for employment. The research sets out to investigate the multifaceted repercussions of RAIA advancements on net employment, scrutinizing organizational, global, national, and individual perspectives. The primary objective is to construct a systematic conceptual framework that comprehensively addresses the intricacies of individual upskilling and employability within the dynamic landscape of RAIA. This study anticipates contributing valuable insights that can inform strategies at organizational, governmental, and individual levels, fostering a nuanced understanding of the evolving employment paradigm in the era of RAIA

*Keywords: Robotics, Artificial Intelligence, Automation, Upskilling, Training, Employment, Industry 4.0*

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## **ID 83: A VIRTUAL REALITY-BASED GAME TO TRAIN MINING WORKERS**

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**Abstract.** To reduce accidents, increase safety and productivity in mines, training is necessary. There are multiple benefits of using gamification and virtual reality to impart training. The objective of this work is to develop and validate a prototype of a virtual reality-based game for training mining personnel to increase their safety and productivity in mines. Various features such as varying levels of difficulty, operations like drilling, blasting and loading, hazards like fire and waterlogging, an instant feedback system on user's action, information with regional language support, problem solving practice on various scenarios, and performance evaluation and reward factors are incorporated in this prototype. The prototype is tested for its usability with few users; it is found that the game is playable, and areas for further improvement are identified.

*Keywords: Coal Mine, Virtual Reality, Gamification, Safety, Prototyping*

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## **ID 84: DESIGN OF SMART INTERACTIVE TOYS FOR FUTURE KIDS**

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**Abstract.** The general properties of smart toys are examined in this chapter, along with new studies on the subject. Smart toys are modern toys with both physical and technological elements that enable two-way interactions between children and smart toys to do useful activities. The characteristics of smart toys as cognitive tools to facilitate learning are analyzed in this chapter, along with projects based on them. In order to comprehend the potential consequences of smart toys on children, this chapter also discusses the relationship between smart toys and children's developmental phases, with a focus on motivation.

*Keywords: Cognitive development, Child Interaction, Communication, Emotion, Sensor*

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## **ID 89: A QUALITATIVE STUDY ON THE DIFFERENT DESIGN PROCESSES USED BY STUDENTS IN A BIO-DESIGN CLASSROOM**

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**Abstract.** This research examines the different design processes used by students in a bio-design course over a period of 3 years respectively. The bio-design studio is part of the third year as part of the interior design studio which is focused more towards multidisciplinary exploration in design. The purpose of the de-sign studio is to let students not only explore the idea of bio-design but go deeper into understanding the possibilities and extremities of connecting de-sign with science. The studio gives an opportunity to the design students of exploring a multi-disciplinary venture, allowing information and influences from other disciplines such as visual communication, product design, engineering, new media, and digital, even interaction design. Bio-design as a course is focused largely on looking at the biological phenomena at all levels in the ecological system. The study focuses on analysing, exploring, and comparing the course methodologies and different design processes adopted by students of 3 batches over a period of 3 years respectively. It also focuses on whether a particular design process helps students to derive design solutions conveniently. The study shall further analyse the student design process works in bio-design and explore how every design process eventually has helped the students develop multiple concepts, at the same time explore different parts of the biological system and its natural beings.

*Keywords: Bio-design, design education, design process, bio-cards, design sprints*

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## **ID 37: OPTIMIZING QUADCOPTER CHASSIS THROUGH GENERATIVE DESIGN: A NOVEL APPROACH**

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**Abstract.** Generative design (GD) has shown promise as an advanced automated computer-aided design (CAD) method that incorporates artificial intelligence (AI) to create new product designs. GD generates potential designs that streamline the design process. This research examines GD and the various algorithms associated with it for generating a quadcopter chassis similar to the DJI F450. The cloud-based platform Autodesk Fusion 360 is utilized to generate myriad possible quadcopter chassis designs that replicate the loads and boundary conditions of a commercial DJI F450 chassis. All the generated designs are compared against the desired properties of the final design. This study compares the top two designs, and the best design is selected for analyzing the computational results. Compared to the DJI F450 drone frame, the computed results reveal a weight reduction of 42 grams, enabling a larger capacity battery that extends the flight time. This translates to an increase in the drone's mission time by approximately 60 seconds, which is particularly valuable for agricultural operations, farmers, flying operators, and other engineering and defence applications.

*Keywords: Generative design, Quadcopter, Unmanned Aerial Vehicle (UAV), AI in Design, Additive manufacturing*

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## **ID 41: DIGITAL TWIN OF AXISYMMETRIC PART STORAGE QC & INSPECTION WORKSTATION**

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**Abstract.** As the advancing industries and technologies, the term industry 4.0 has its own advancements. CPS refers to the integration of physical items and digital systems, resulting in a symbiotic link between the physical and virtual worlds. This paper presents the implementation of a dynamic digital twin for a workstation dedicated to quality control and inspection of axisymmetric parts within a storage facility with the help of Simulink. The digital twin serves as a virtual representation of the physical workstation, enabling real-time monitoring and analysis of the inspection processes. By integrating advanced sensor technologies and data analytics, the digital twin enhances efficiency and accuracy in quality control procedures. The virtual environment allows for the simulation and optimization of workflows, facilitating proactive decision-making and reducing non-value-added times. The results demonstrate the effectiveness of the digital twin in improving overall inspection performance, reducing downtime, and enhancing reliability.

*Keywords: Digital Twin, MATLAB/ Simulink, Workstation, Real-time monitoring, Industry 4.0*

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## **ID 44: DEVELOPMENT OF DIGITAL TWIN FOR REAL TIME MONITORING AND VIRTUAL COMMISSIONING APPLICATIONS IN AN ASSEMBLY LINE**

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**Abstract.** This paper aims in developing the real time emulation of a workstation by connecting it through PLC which serves as copula among the real physical asset and the digital replica (twin) of the machine. Since the digital twin model is data driven, the actual movements in the work station are compared with the movements of the digital twin and arrived with an adjustable time dilation of about 20 milli seconds, which apparently conveys the readiness in monitoring the digital twin in real time. This paper also conveys about implementing a new set of operations for a new product through virtual commissioning of the workstation for the pallet from the DCV assembly to Cotter joint assembly. This paper gives the readers the preliminary idea of how to make a digital twin for the assembly operations using Emulate3D software and how to analyze the data for real time monitoring applications.

*Keywords: Digital Twin, Industry 4.0, Smart Manufacturing, Emulate3D, Virtual Commissioning, Real Time Monitoring*

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## **ID 50: A DIGITAL TWIN FOR EXTRUDED LAYER QUALIFICATION OF 3D PRINTED CONCRETE**

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**Abstract.** Monitoring concrete layer during the 3D printing process is a challenging task due to non-contact measurement and the risks associated with physical contact. This study explores the use of image processing techniques to measure filament width and texture after deposition while monitoring each layer's texture and irregularities. Real-time data streams, line scans, images, and dimensional parameters, are utilized to enable monitoring and facilitate necessary adjustments to critical parameters such as the extrusion rate and nozzle speed by the user. In addition, this paper presents the development of a robust and reliable digital twin that simulates the behavior of 3D printing using sensors. By combining in-situ sensor data, the digital twin identifies layer anomalies in concrete printing during production, leading to a deeper understanding of defects in additive manufacturing parts with higher accuracy. This innovative approach contributes to improved quality control and reliability in the production of 3D concrete structures, addressing the challenges posed by the monitoring and control of the printing process.

*Keywords: 3D Concrete printing, Digital Twin, Computer Vision, Monitoring*

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## **ID 56: DEMONSTRATION OF ROBOTIC WELDING OPERATION USING IMMERSIVE AUGMENTED REALITY EXPERIENCE**

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**Abstract.** Augmented reality is one of the new technologies that is assisting in the enhancement of human-computer interactions. Augmented reality improves Industry 4.0 by allowing real-time data visualization, remote help, and interactive training, while also enhancing operational efficiency and simplifying data-driven decision-making in smart factories. An industrial robot equipped with a welding instrument is used in a robotic welding cell, a specialized production setting, to perform accurate and efficient welding operations. This reduces the need for manual labour, boosts output, and guarantees consistent quality. The intricacies of the welding process are difficult for users to understand while learning robotic welding using traditional approaches, which frequently rely on static visual aids or in-person observation. We have created an immersive augmented reality application that uses state-of-the-art technology to produce a realistic, engaging, and instructive experience in order to overcome this constraint. This project allows users to view the full robotic welding procedure by integrating augmented reality (AR) into the field of welding instruction. Users are able to engage with the virtual environment, comprehend welding parameters, and see the actions of the welding robot using the mobile application. The main goal of the project is to provide a smooth, interactive environment that will improve the welding process, simplify training, and lower human error while simultaneously increasing precision and efficiency. Our Augmented Reality training benefits rookie welders by providing immersive learning without the hazards of the real world. It also highlights the applicability of AR for interactive, cross-industry training solutions, with broader implications in maintenance, construction, healthcare, and education.

*Keywords: Augmented Reality, Robotic Welding Cell, Demonstration, Animation, Training, Troubleshooting*

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## **ID 70: CREATING DIGITAL IMMERSIVE HERITAGE EXPERIENCE OF HISTORICALLY SIGNIFICANT ARCHITECTURAL STRUCTURE**

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**Abstract.** In the past decade, there has been steady development with technologies that blend digital and physical realm, namely virtual and augmented reality. The uses of immersive virtual reality in reconstructing digital heritage are evolving, which helps in preserving cultural and architectural monuments. In this paper, the study area is developed as a virtual reality platform with interactive information overlay. The workflow described in the paper will be demonstrated with the study of 200 years old Panduranga Vitthal temple, Kandi village, near Hyderabad. It is unusual for a Maratha origin temple to be found in the Telugu region, but this temple is an example of movement and influence of culture to the neighbouring state. The uniqueness of this temple complex built in stone and brick using intricate wooden details, stepwell and connecting pond gave an opportunity to capture it using photogrammetry. Photogrammetry makes it possible to create a VR experience that allows the user to explore the place. We propose a workflow of creating immersive virtual reality models using digital and 3D data generated using photogrammetry. Emphasis is given on simplification of the high detail photogrammetry model to a smaller optimized mesh model with texture and normal maps which is small enough from realtime rendering. Creating virtual experience design helps the user to engage with space without endangering the heritage structure, record and document it in its present form and make it accessible for people to view from anywhere with relevant, interactive information overlay

*Keywords: Photogrammetry, Immersive technologies, UV mapping, Digital heritage, Virtual experience, Virtual reality*

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## **ID 77: ENHANCING MAINTENANCE LEARNING IN THE INDUSTRIAL METAVERSE: INTEGRATING VIRTUAL REALITY AND MACHINE LEARNING**

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**Abstract.** This research focuses on developing an efficient learning platform for maintenance workers. Recognizing the challenges maintenance workers face, such as difficulties in identifying faulty components and disassembling unnecessary parts, this project aims to address these issues by integrating the Metaverse and Machine Learning. By leveraging machine learning models that accurately detect faults, maintenance workers can access a robust, immersive learning environment that empowers them to make informed decisions and avoid unnecessary tasks. This approach enhances learning efficiency, reduces downtime, and cultivates practical problem-solving skills among maintenance workers. The outcomes of this research contribute significantly to the advancement of integrating virtual reality technologies and machine learning within Industrial Metaverse settings, paving the way for improved maintenance processes and more efficient learning experiences.

*Keywords: Maintenance Training, Industrial Metaverse, Virtual Reality(VR), Visualization, Machine Learning(ML)*

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## **ID 73: FABRICATION OF THIN WALLED STRUCTURES VIA LASER POWDER BED FUSION TECHNIQUE**

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**Abstract.** The rapid evolution of laser powder bed fusion (LPBF) has revolutionized manufacturing processes across various industries. One area of particular interest and significance is the production of thin-walled structures, which have widespread applications in fields including healthcare medical devices, automotive, and aerospace. However, very limited research has been performed on the fabrication of structures with thickness less than 500  $\mu\text{m}$ . The primary objective of this research article is to investigate the viability of the LPBF process for manufacturing thin-walled structures. Particularly, the thin-walled structure having wall thicknesses of 350  $\mu\text{m}$  and 300  $\mu\text{m}$  at layer thickness of 20  $\mu\text{m}$  has been fabricated. Further, a thorough analyses on evaluating the surface features, dimensional accuracy and viability of LPBF in achieving these intricate designs was done. The surface features of the fabricated specimens are found to be irregular in shape. The irregularities in the fabricated specimens arise from the presence of spatter particles and its clusters adhering to the edges of the specimen. The fabricated specimens exhibit increased width compared to the designed wall width, mainly attributed to the preheating effect. Hence, the current study demonstrates the feasibility of fabricating thin-walled structures using LPBF, yet further optimization of process parameters, structure orientation, material composition, and post-processing is essential to achieve more accurate intricate designs successfully. The present work on analyzing and fabricating thin-walled structures contributes valuable insights to advance additive manufacturing, enabling innovative thin structural design possibilities and enhanced engineering solutions.

*Keywords: Additive Manufacturing, Thin-Walled Structures, LPBF*

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## **ID 75: 3D PRINTED UV-THERMAL DUAL CURABLE BIO-COMPOSITE FOR CARBON-NEUTRAL BUILDING CONSTRUCTION APPLICATIONS**

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**Abstract.** Globally, 39% of carbon emission is due to the building & construction industry, of which 11% is due to building materials like concrete & steel-related emissions. To prevent disastrous climate changes, decarbonizing this sector is critical. Novel environment friendly bio-composite materials and 3D printing techniques and technologies have been developed as an alternative to subtractive manufacturing processes and hazardous materials. The construction sector is one such sector witnessing a paradigm shift in both materials and manufacturing technology. The authors have made one such attempt in the growing research domain to present and address the following gaps: 1) Absence of a promising bio-composite formulation with enhanced properties as an alternative to the conventional concrete material 2) A suitable 3D printing technology for building construction parts from the novel material proposed. This paper formulates a novel carbon-neutral bio-based UV-thermal curable composite with high-performance behavior as an alternative to concrete for 3D printing building and construction components and discusses an autonomous, energy-efficient UV 3D printing system for using the UV-thermal curable composite. Multiple formulations have been discussed and the structural integrity and performance of the new formulation showcasing the best properties versus the existing steel rebar-concrete (RCC) are compared using a 3-point-bend test simulation in ANSYS Structural Analysis. Subsequently, a UV-assisted gantry 3D printing technology has been discussed for dual curing of the UV thermal composite.

*Keywords: Biocomposites, UV 3D printing, Sustainability, Construction*

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## **ID 82: TOWARDS SELECTIVE MICRO LASER MELTING FOR THE FORMATION OF CONDUCTIVE TRACES: INFLUENCE OF ENERGY DEPOSITION RATES AND LASER FLUENCE**

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**Abstract.** We present an experimental investigation into the selective micro laser melting (SMLM) technique applied to commercially available lead-free solder paste on a polylactic acid (PLA) polymer structural member. Unlike traditional heating methods such as furnaces or ovens, SMLM allows for precise localized heating, enabling the formation of intricate 3D printed interconnects or traces on low heat deflection temperature (HDT) polymers. Our approach aims to achieve superior conductivity that closely mimics the electrical properties of bulk metals. Our study focuses on analysing the melted traces of Sn-3 mass%Ag-0.5 mass%Cu (SAC) without causing any deformation to the low temperature PLA polymer structural member. We explore the impact of energy density and energy deposition rates on the characteristics of the conductive traces. Intriguingly, our findings reveal that the rate of energy deposition significantly influences the dimensions of the melted interconnects or traces, even when maintaining a consistent energy density. These compelling results highlight the need for further comprehensive analysis and precise quantification of the optimized process parameters to obtain melted interconnects or traces that exhibit robust electrical conductivity.

*Keywords: Selective micro laser melting, Laser fluence, Electrical conductivity*

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## **ID 85: MECHANISMS FOR UPWARD AND DOWNWARD WARP DEFORMATION OF FDM 3D PRINTED PARTS**

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**Abstract.** Constrained volumetric shrinkage of the solidifying material layers in Additive Manufacturing (AM) causes warpage of the 3D printed part. The geometry of the part affects the magnitude and profile of the warp deformation. This paper aims to characterize warpage as a function of part height in the Fused Deposition Modelling (FDM) process. A thin vertical wall geometry is modelled for this study with part height considered as the geometric variable. Optimal process conditions are maintained on an open 3D printer to prevent detachment of the parts from the build plate during fabrication. Temperature distribution across all layers was recorded throughout the fabrication of each sample. A comparison of the measured warp deformation profiles of each sample indicates that warpage occurs in the part even in case of strong build plate adhesion. A previously unreported downward curling is observed in parts of lesser height. The warpage magnitude in upward curled samples increases with increasing part height contradicting previously reported trends. An optimum build plate temperature ensures part substrate adhesion throughout the fabrication. Yet, shrinkage in the material is still constrained resulting in a stress distribution that causes downward warping. The uniformity of temperature distribution across the part layers affects the warp deformation profile. The present work attempts to provide a unified explanation for upward and downward warpage in 3D printed parts. These findings necessitate an improvement in the numerical models to predict downward warping.

*Keywords: Warp Deformation, Part Height, Residual Stress, Downward Warp*

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## **ID 86: CHARACTERIZATION OF DISCHARGE IN MICROWAVE MACHINING**

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**Abstract.** Microwave machining utilizes microwave-induced discharge to cause material removal. The current work investigates the discharge characteristics during the machining of duplex stainless steel (thickness: 1.0 mm) inside a customized microwave applicator operating at 3.0 kW power and 2.45 GHz frequency. Thoriated tungsten (diameter: 1.6 mm) was employed as a pointed tool to trigger microwave-induced discharge in atmospheric conditions under preset tool-work gaps. Microwave-induced discharge was observed in the form of spark and arc but with a delay. It was observed that the spark and arc initiation instant varied even for the same processing conditions. The spark initiated, grew in area and collapsed within a short duration of the order of 40 ms. Long-lived arc initiated similarly but attained greater area and intensity and proceeded with pulsation in the arc area. Arc ceased at the end of the microwave exposure or an instant when the tool lost sharpness due to tool wear. Stochasticity in microwave-induced discharge was evident in microwave-induced discharge machining. Arc is primarily responsible for machining since the total spark duration was much less than the arc duration. Measures to reduce the stochasticity of microwave-induced discharge machining have been discussed.

*Keywords: Microwave machining, Microwave-induced discharge, Delay, Spark, Arc*

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## **ID 92: DESIGN FOR MANUFACTURING (DFM) CRITERIA- INCORPORATION OF PATTERN ALLOWANCES FOR CASTING OF A BUSH MODEL**

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**Abstract.** Patternmaking plays a crucial role in sand-casting process. This paper discusses the DFM criteria of pattern allowances for a Bush model casting. Here an algorithm is developed for incorporating all the allowances just by giving input the part model to be casted and the final output from the algorithm is the modified pattern dimension. The calculation of dimensions for the pattern after various allowances like shrinkage, machining and draft are done in a sequential manner. The initial design is done in the modelling software SolidWorks 2016 and then the allowances are incorporated one by one. Finally, the modified dimension for the pattern is calculated. In this paper, an overall process by which the final dimension of a pattern can be calculated is discussed in detail.

*Keywords: Bush model, Pattern, Allowance, SolidWorks*

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## **ID 25: CREATING A DIGITAL DASHBOARD IN A GARMENT MANUFACTURING UNIT - A CASE STUDY.**

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**Abstract.** Sustainable management refers to the production of goods or the provision of services through the use of strategies, technologies, and workplace practices that aim to reduce industrial waste, minimize pollution, recycle waste, conduct paperless operations, and produce environmentally friendly products and services. One of the primary criteria for getting the business (bulk order) is the sampling department, which converts the design into garments to confirm the fit, aesthetics, comfort, texture, and drape according to the buyer's requirements. Transparency in the execution of procedures will also provide a distinct viewpoint on the process and aid in its improvement. The sampling department, which places a vital role in the development of any kind of sample and in procuring the bulk order from the customer, is studied completely, and various important activities like daily production meetings, risk analysis meeting, MIS, and Efficiency reports are initiated to get the track of the sample being developed, to increase the efficiency and to reduce the sample lead time. Dashboards for Daily production and Efficiency analysis have been introduced as a part of process simplification, which also reduced the processing time. MIS in the sampling department provides traceability and the status of the sample being produced and ensures all the samples are held accountable.

*Keywords: Sampling, Management Information System (MIS), Analysis  
Dashboard*

*Notes:*

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## **ID 36: CARBON REWARDS (A SUSTAINABLE SOLUTION TO PUC)**

\*Shweta Kukade (1), Soumyashri Singha (1), Akriti Ringe (1), Nikhil Gupta (2) and Kishanprasad Gunale (1)

*(1) Dr. Vishwanath Karad MIT World Peace University, Pune, (2) Volkswagen IT Services (VWITS) India Pvt. Ltd., Pune*

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**Abstract.** The transportation industry is a significant contributor to air pollution and one of the biggest producers of CO<sub>2</sub> emissions. The automobile industry's effects on the environment have recently attracted attention. Burning fuel is responsible for 75 percent of the carbon impact. For developing nations, the fast-increasing quantity of vehicles is a cause for concern. To operate a car on the road in India, one must obtain a pollution under control (PUC) certificate, however this requires ongoing monitoring and individuals have no awareness about their contribution to this air deterioration menace. Hence, this paper goes into great depth about an IoT-based system for tracking a vehicle's carbon dioxide emissions in real time. This device enables users to monitor vehicle health and measure CO<sub>2</sub> emissions wirelessly which promote sustainability and consciousness among people.

*Keywords: CO<sub>2</sub>, SGP30, HTML/CSS, Python-Flask*

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## **ID 62: INCULCATING A BEHAVIOUR CHANGE AMONG IMPULSIVE ONLINE SHOPPERS: ADAPTING TO MINDFUL SPENDING HABITS**

Manaar Jafri (1), Samriddhi Nagdev (1), \*Arundhati Guha Thakurta (1) and  
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**Abstract.** Over the years, the categories of online purchases have exponentially evolved. This, when combined with heavily discounted prices, sales and marketing tactics, celebrity endorsements, and more, result in a drastic increase in impulsive online purchases. The aim of this study was to understand what are the nudges, cues, and triggers that lead to one's impulsive purchases and the motivation behind the same. The initial stages of the study included desk research and review on existing literature around the topic, followed by conducting interviews and surveys. The insights received and the gathered data helped us in creating a design solution that would help inculcate a behaviour change among people who have recently gained access to their bank accounts and are on the brink of becoming partially or fully financially independent. After various stages of prototyping, iterations, and testing, the designed solution 'DigiSave' was made, a mobile application that would enable users to set pre-allocated budgets for different categories and give them prompts and notifications when they exceed the limit, thus increasing the time frame between adding items to a shopping cart and making the purchase. Other prominent features like price comparison of the same product on different sites and connecting a user's UPI and bank account to track spending habits, have been included to always keep a check on personal spending and reduce the urge to buy online impulsively.

*Keywords: Impulsive Buying, Online Shopping, Online Buying Behaviour, Budgeting App, Price Comparison*

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## **ID 71: SPEED CONTROL OF BRUSHLESS DC MOTOR USING PI CONTROLLER WITH FUZZY LOGIC**

\*Arka Bandyopadhyay (1)

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**Abstract.** The Brushless Direct Current (BLDC) Motor is an DC voltage fed, electrically commutated motor. As implied by its name it doesn't contain brushes for commutation. An BLDC motor comprises of a permanent magnet rotor and stator in form of multi-phase armature windings. Better efficiency compared to brushed motor, high power-to-weight ratio, better speed-torque characteristics, noiseless operation and long durability due to a lack of frictional loss and electrical losses makes it a pioneer in the EV (Electric Vehicle) industry and other small to large scale industries. The construction is similar to a Permanent Magnet Synchronous Motor (PMSM) but with a trapezoidal back-emf waveform. In this proposed model, a DC voltage source, upon applying through an inverter circuit and with feedback signals provided by Hall Sensors, with a unique commutation logic, is used to energize the pole pairs so as to achieve a unidirectional torque in the rotor. A combination of PI controller and Fuzzy Logic Controller is used to stabilize various dynamic characteristics. Different dynamic characteristics such as - torque, speed back emf are analyzed using MATLAB Simulink Model of the BLDC Motor and the ESC (Electronic Speed Controller).

*Keywords: BLDC Motor, PI Controller, Fuzzy Logic, Electronic Speed Controller, Permanent Magnet Synchronous Motor*

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## **ID 74: MOBILE ROBOT PATH PLANNING IN GLOBAL ENVIRONMENT USING MATLAB SIMULATION**

Dewan Zahid Ahmed (1), Ashish Verma (1), Manoj Sangtani (1) and \*BBVL Deepak (1)

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**Abstract.** In this paper, a path planning algorithm is developed for an unmanned vehicle in a known environment using the general search for minimum distance or shortest path. The code for the algorithm is developed using MATLAB software. The study focused on developing an algorithm to create a virtual simulation of an unmanned vehicle in a known or static environment like that of shop floor of a manufacturing cell layout with ten, five or three cells having a network of paths connected with each cell. The main purpose of this study is to find a shortest path between the cells when an input command is given to the unmanned vehicle to move from one cell to another. The algorithm also takes care of the command where the unmanned vehicle is asked to visit multiple cells one after another sequentially. Thus, the algorithm is robust enough to execute the command for making the unmanned vehicle move from source position to either one cell or multiple cells in a chronological manner.

*Keywords: Path planning, Mobile robot, Fitness function, Unmanned vehicle*

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## **ID 88: CONGESTION-AWARE PATH PLANNING FOR MULTIPLE SHELF CARRYING MOBILE ROBOTS IN ROBOTIC MOBILE FULFILLMENT SYSTEM**

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**Abstract.** Path planning plays a crucial role in optimizing robotic warehouse operations, ensuring efficient and timely robot movement while avoiding collision and congestion. This research focuses on congestion-aware path planning for multiple shelf-carrying mobile robots in robotic mobile fulfillment system. Congestion-aware path planning facilitates the navigation of mobile robots in a proficient manner, circumventing areas with high congestion levels while simultaneously minimizing energy consumption and turns executed. To meet the aforementioned objectives, a reinforcement learning-based path planning algorithm with a dynamic action space is proposed. Simulation results for different cases demonstrate the algorithm's effectiveness in generating feasible paths, offering potential to improved order fulfillment.

*Keywords: Reinforcement learning, Robotic mobile fulfillment systems,  
Congestion aware, Path planning, Warehouse automation*

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## **ID 94: PREDICTING PRODUCT ISSUES IN THE USE-PHASE FROM ONLINE CUSTOMER REVIEWS - A DEMONSTRATION USING UV-C STERILIZER PRODUCTS**

\*Kumari Moothedath Chandran (1), Sara Ayachit (1) and Rohan Mallesh (1)

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**Abstract.** Producer responsibility (PR) in the use-phase of a product lifecycle is challenging due to information obscurity once the product reaches the customers. To aid traceability of products in their use phases, the potential of customer reviews from e-commerce platforms are explored in this work. In this work, UV-C sterilizers is taken as a product class to illustrate the proposed method to track product issues during use-phase through customer reviews from Amazon platform. The study uses sentiment analysis and tagging of reviews to understand use-phase issues. A method to predict product issues of importance during the use-phase is presented to aid faster product recalls by early spotting of product design flaws after-market release. The research aims to aid agencies to promote responsible product practices and user safety through a data mining approach.

*Keywords: Predictive Analysis, Product Safety Prediction, Mining Customer Reviews, UV-C Sterilizer*

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## **ID 95: AUTOMATION OF PUBLIC TRANSPORTATION SYSTEM IN DEHRADUN, UTTARAKHAND**

\*Debashis Majumder (1), Jeevesh Makker (1) and Ipsita Das Gupta (2)

(1) UPES, (2) 66 Libra Design Pvt Ltd

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**Abstract.** The Autonomation of the public transportation system in Dehradun, Uttarakhand is a significant step towards modernizing and improving the efficiency of transportation in the city. With rapid urbanization and increasing population, it has become imperative to find innovative solutions to tackle traffic congestion and reduce pollution levels. Autonomation refers to the integration of autonomous technology into existing systems, allowing for self-driving vehicles that can operate without human intervention. This technology has the potential to revolutionize public transportation by enhancing safety, reducing travel time, and optimizing resource utilization. By implementing autonomation in Dehradun's public transport system, commuters can expect a seamless travel experience with reduced waiting times and improved reliability. Autonomous Trackless Trams (ATT) equipped with advanced sensors and artificial intelligence algorithms will navigate through traffic more efficiently, minimizing delays caused by human error or congestion. Moreover, autonomation will also have a positive impact on environmental sustainability. Electric-powered autonomous vehicles produce zero emissions, improving air quality and reducing carbon footprint. This aligns with Uttarakhand's commitment to promoting sustainable development and combating climate change. In conclusion, the autonomation of Dehradun's public transport system holds great promise for transforming urban mobility. By embracing this innovative technology, the city can enhance its transportation infrastructure while simultaneously addressing pressing environmental concerns.

*Keywords: Automation, Public Transportation System, Self-Driving Vehicle, Trackless Tram, Carbon Footprint*

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12 January 2024 | 0900 - 1100  
*Parallel Session: Workshop*

## **PUBLISHING WORKSHOP**

Swati Meherishi

*Springer India*

*Notes:*

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## RESEARCH ON SOFT AND CONTINUUM ROBOTS AT THE ROBOTICS LAB @ IISC BANGALORE

Prof. Ashitava Ghosal

*Indian Institute of Science, Bengaluru*

**Bio.** Ashitava Ghosal is a Professor in the Department of Mechanical Engineering, IISc Bangalore with joint appointments at the Centre for Product Design and Manufacturing and at the Robert Bosch Centre for Cyber Physical Systems. He obtained a PhD from Stanford University, California, a master's and bachelor's degree from University of Florida, Gainesville and Indian Institute of Technology, Kanpur, India, respectively. His broad research areas are kinematics, dynamics, control and design of robots and other computer controlled mechanical systems. His current interests are in design of parallel manipulators and robots, cable actuated robots, numerical and experimental investigations in quadruped walking and reaching tasks by human arm and product design. He has authored a textbook entitled "Robotics: Fundamental Concepts and Analysis" by Oxford University Press and recently two NPTEL Courses on Robotics (2021) and Dynamics and Control of Mechanical Systems (2022). He was elected fellow of the Indian National Academy of Engineering in 2010 and as member of the IFToMM Executive Council (2016-2019) & (2019-2023). He has 5 patents, more than 180 publications in archival journals, national and international conferences. He has guided 16 PhDs and more than 60 Master students. He is currently serving as an Associate Editor in Mechanism and Machine Theory and ASME Journal of Mechanisms and Robotics.

**Abstract.** In soft and continuum robots, the body is made compliant unlike in industrial robots where the body is typically rigid. This makes them amenable for use in narrow constricted spaces for exploration, search and rescue, be in contact with humans, to grasp delicate and irregular objects and to manipulate them effectively. In this talk, we will present research done at the robotics lab in the areas of kinematic modelling, analysis and simulation of soft and continuum robots and experimental validation of the theories developed. The talk will focus on two kinds of actuators, namely pneumatic and cables, and present new results and approaches for continuum robots actuated by pneumatic artificial muscles and cables. The motion of an actuated endoscopic catheter and a three fingered cable driven robot which can grip and manipulate various objects are shown. The theory developed is also used to simulate and display the motion of a continuum robot in a pipe, in the GI tract and in a cluttered environment.

12 January 2024 | 1130 - 1215  
*Keynote Session: Keynote 5*

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## **PRACTICAL METHODOLOGY AND APPLICATION OF IIOT TO ENSURE MANUFACTURING TAKES KEY FOR FUTURE GROWTH OF INDIAN GDP**

Dr. S. Devarajan

*Bangalore Chamber of Industry and Commerce (BCIC) 2023-2024,  
Bengaluru*

**Bio.** Dr. Devarajan has been associated with TVS Motor Company for 38 years. In his current role, he is facilitating the implementation of new process technology, lean manufacturing systems, digital manufacturing, TPM and JIT across the company. He has been awarded the prestigious Rolls Royce Award for "Excellence in Manufacturing concepts and implementation in UK" and the "Thought Leadership Award" by Automotive Manufacturing Solutions UK. He is an active member of NITIE, IMTMA, CII and in Board of studies in Engineering & Management Institutes. Devarajan pursued his Bachelor of Engineering (Mechanical) from Bangalore University followed by an MBA from University of Missouri and Manufacturing Systems MS and Engineering Doctorate in Manufacturing Systems Engineering from University of Warwick, UK. He has represented State of Karnataka and Bangalore University in Table Tennis.

**Abstract.** Indian GDP is growing and is currently among the top 5 in the world. Targeted to reach the top 3 by 2030, the potential for growth is around 8 to 10 %. Manufacturing is the key to growth. With Atma Nirbar Bharat and production-linked incentive PLI (for localisation of newer areas like EV), let us look at the overall scenario. There is push-pull, "push" - from the younger population with a lot of keenness for new needs and requirements and sustainability goals "pull" - from the companies, Indian market conditions, competitiveness, and quality (zero defect). The drive towards competitiveness is skill up and reskilling of the workforce. The three groups of operators/supervisors, middle managers, and top management have different shares of roles of responsibility and authority. The top management focus is on breakthrough/innovation, operators on retainment, and middle management is on 30% of breakthrough and 70% on retainment. The drivers of skill enhancement is about going deeper (changes in EV, product, battery, cost; lightweighting - aluminium, titanium), integration of hydrogen, methanol etc. for cost competitiveness. Adaptation towards digital, operation research techniques - (linear and stochastic tools) for the right strategy is required. As the population is younger - each product is different  $N = 1$ . So, the speed of delivery should be combined with flexibility of facilities and

agility for quicker response time. Though we talk about AI/ML, Digital, OR techniques - the basics should be made stronger and not forgotten. Traceability is the key for capturing data from factory environment and actions for improvement. The availability of sensors, data capturing, analysis & actions in various areas and improvement of productivity, quality, cost and sustainability are shared in this talk.

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## **CHALLENGES, OPPORTUNITIES, AND INITIATIVES IN TRAINING AND EDUCATION OF ADVANCED MANUFACTURING AND INDUSTRY 4.0**

**Panellists:**

*Prof. B Gurumoorthy (Chair)*

*Prof Rishiksha Krishnan*

*Prof Satish Vasu Kailas*

*Dr U Chandrasekhar*

*Dr S RaviShankar*

*Shri AN Chandramouli*

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## **ID 79: ENHANCING PRODUCTION EFFICIENCY THROUGH GENETIC ALGORITHM ASSISTED VISUALIZATION IN INDUSTRIAL METAVERSE: FACTORY LAYOUT PLANNING SCENARIO**

\*Nirbhay Beri (1) and Ramesh Manickam (2)

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**Abstract.** Effective factory production floor layout planning is essential for production management and requires careful consideration of multiple factors. This study proposes an industrial metaverse visualization approach for optimizing machine and workstation arrangement to improve production outcomes. This approach employs an algorithm to explore the feasible layout space, considering factors such as machine proximity, ergonomics, and production requirements. The resulting layouts are visualized in an industrial metaverse environment, allowing stakeholders to evaluate the impact before implementation. By leveraging industrial metaverse visualization, this approach eliminates the need for physical prototyping, reducing costs and risks associated with physical changes. A case study in a factory setting demonstrates the potential of industrial metaverse visualization, showing that it can improve floor space utilization, reduce cycle time, and enhance production efficiency compared to traditional manual methods. The study highlights the importance of visualization tools in facilitating decision-making and improving production outcomes, contributing to the growing body of literature on the use of metaverse visualization for industrial applications.

*Keywords: Industrial Metaverse, Layout Planning, Genetic Algorithm, Visualisation, Virtual Reality(VR)*

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## **ID 93: DIGITAL TWIN-DRIVEN SIMULATION FOR WIRE ELECTRODE TEMPERATURE CONTROL IN WEDM**

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**Abstract.** Wire Electrical Discharge Machining (WEDM) is a complex process that requires precise control of various parameters to ensure optimal performance and product quality. This paper presents a data-driven approach using digital twin modeling to predict the wire electrode temperature in WEDM. By leveraging real-time data from temperature sensors integrated into the WEDM machine with a specialized design fixture. The DT model accurately replicates the physical process and provides insights into the wire electrode temperature distribution. The present DT model builds up in python with experimental data and validate with 12 set of experimental data. The validation results shows the noise reduction in the develop DT model. Real-time monitoring with the digital twin model allows for predictive analysis of temperature fluctuations that may lead to wire rupture. The digital twin can identify potential rupture risks and suggest adjustments to prevent overheating and wire breakage.

*Keywords: Digital Twin, WEDM, Wire Electrode Temperature, Simulation*

*Notes:*

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## **ID 97: AUTOMATED VISUAL INSPECTION FOR DEFECTS USING DATA AUGMENTATION FOR DEEP LEARNING BASED IMAGE CLASSIFICATION**

Ikechi K Ndukwe (1) and \*Riby A Boby (2)

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**Abstract.** This article explores automated visual inspection for classifying defects in industrial products. Visual inspection to detect defective samples poses a significant challenge in industries due to the inherent variations present. Gathering an adequate amount of data for defect detection and classification using deep learning is particularly challenging in industrial automation due to the scarcity of defective samples. To address this issue, various data augmentation methods have been proposed, including geometric transformations, image fusion, variational autoencoders (VAE), and Generative Adversarial Networks (GANs). Convolutional Neural Network (CNN) model for defect classification was developed and evaluated using a dataset of electrical pin connectors augmented by image processing techniques and variants of conventional GANs, namely Deep Convolutional Generative Adversarial Network (DCGAN) and Wasserstein Generative Adversarial Network (WGAN). The developed model achieved an accuracy of over 90% on all three uniquely augmented datasets, representing an improvement in performance compared to the model's performance on the original dataset. However, it is worth noting that GAN-based methods were more time-consuming and computationally expensive. Hence, when considering data augmentation methods for implementation, it is advisable to first explore image processing techniques. If these do not yield satisfactory results, a combination of image processing and GAN-based methods may be considered.

*Keywords: Computer Vision, informatics & quality control, Artificial Intelligence, Visual Inspection, Data Augmentation*

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## **ID 78: REVOLUTIONIZING SMALL-SCALE INDUSTRIES IN INDIA: A COST-EFFECTIVE INDUSTRY 4.0 FRAMEWORK FOR ENHANCED MOTION CONTROL USING PLC-SERVO MOTOR INTEGRATION**

Saubhagya Ranjan Behera (1), \*Achirangshu Patra (1) and Nitai Sunder Das (1)

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**Abstract.** Smart factories, incorporating Programmable Logic Controllers (PLCs), are a crucial foundation for streamlining industrial automation. But, transitioning to Industry 4.0 can be expensive. Existing PLCs often lack necessary protocols like OPC UA. Some companies offer IoT modules to bridge this gap. However, in developing countries like India, replacing existing PLCs or investing in IOT modules might not be economically viable for small-scale industries. In the ever-evolving landscape of industrial automation, precise and efficient motion control is essential for many applications across various industries. Among these, linear motion control plays a critical role in manufacturing, robotics, and automation processes. In this paper, we have proposed a solution to streamline this transition for a linear motion control process with some open-source tools as efficient replacements for expensive HMI, SCADA, and cloud subscriptions and offer alternatives to expensive IoT modules. Moreover, we demonstrate how these advancements can be seamlessly integrated even with legacy PLC systems lacking OPC UA communication protocols.

*Keywords: Industry 4.0, Motion Control, Axis Control, Smart Manufacturing, IoT, PLC, OPC UA, MySQL, Node-Red*

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## **ID 80: ASSIGNMENT OF RESOURCES TO AIRCRAFT MAINTENANCE USING PENTAGON AND GENERALIZED FUZZY MODELS**

\*Vijayarangan Natarajan (1) and Sai Mahesh Chukka (1)

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**Abstract.** The aircraft turnaround stage is one of the most critical processes that airlines and airports must face in their daily operations. The turnaround of an aircraft comprises all tasks that need to be completed since it arrives to the assigned gate until it is ready for departure. These activities include such as boarding and disembarking of passengers, cabin-cleaning, catering, aircraft maintenance and re-fueling, loading and unloading of baggage, cargo check, security inspection, etc., thereby, the flight delays are strongly correlated with the turnaround process. This problem can be sorted out using the assignment problem by matching resources along with tasks. In this paper we have applied Haar Hungarian algorithm approach by means of pentagon and generalized models to solve a fuzzy aircraft maintenance during turnaround process.

*Keywords: Aircraft, Hungarian Algorithm, Haar Tuple, Fuzzy Number, Fuzzy Assignment, Turnaround Process, Membership Function*

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## **ID 99: EXPLORING THE SYNERGY BETWEEN ERGONOMICS AND PRODUCTIVITY IN THE WORKPLACE: AN EMPIRICAL ANALYSIS USING INERTIAL MOTION CAPTURE**

\*Charu Tripathi (1), Manish Arora (1) and Amaresh Chakrabarti (1)

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**Abstract.** Productivity and ergonomics are two very important facets of the manufacturing industry. However, empirically confirming the existence and magnitude of interrelationship between ergonomic workplace design and productivity can be challenging due to factors such as job rotations, unreliable ergonomic assessments, and the dynamic nature of real-world workshop environments used for research purposes. In this study, we focused on a laboratory simulated assembly-disassembly task involving manual material handling and analyzed productivity outcomes by altering the workplace design based on the results of ergonomic evaluations conducted using the Rapid Upper Limb Assessment (RULA) method. To ensure reliability, we employed direct measurement through inertial motion capture for RULA score calculations. Our findings provide statistical evidence of enhanced productivity in relation to improvements in ergonomic exposure scores.

*Keywords: Ergonomics, productivity, RULA, inertial motion capture*

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## **ID 10: WHAT DO ENTREPRENEURS WITH DISABILITY WANT? UNDERSTANDING THE NEEDS FOR ENTREPRENEURSHIP CAPACITY BUILDING TRAINING PROGRAMMES**

\*Simran Sodhi (1) and Amit Kumar Dwivedi (1)

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**Abstract.** In the last few decades, people with disabilities have shown keen interest in being an entrepreneur. Their journey from being socially to economically inclusive has been challenging. A new set of challenges follows them as they direct their path towards entrepreneurship. Whether creating a new enterprise or sustaining the existing one, entrepreneurship training has helped and supported entrepreneurs in their journey. Observing the trend of entrepreneurship among people with disabilities, many training programmes are being organised. The problem lies with the fact that we have not tried to understand their needs as an entrepreneur. People with disabilities have their own bunch of problems, and without understanding their side of the issues, we can never provide them with what they want. This research tries to understand what problems people with disabilities face in the process of enterprise creation or in sustaining their enterprise and parallelly analyse whether the existing training programmes for entrepreneurs with disabilities are able to provide the required training to them.

*Keywords: Entrepreneurship, Capacity Building, Training, People with Disabilities, Assistive Technology*

*Notes:*

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## **ID 20: UNLEASHING THE PROSPECT: CRACKING THE NEXUS BETWEEN WOMEN'S ENTREPRENEURIAL INTENTION, BEHAVIOR, AND THE ENTREPRENEURIAL ECOSYSTEM**

Raunak Gupta (1), \*Ashutosh Mishra (1) and Amit Kumar Dwivedi (1)

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**Abstract.** Women's entrepreneurship has recently sparked significant scholarly interest, and action has gone a long way toward restoring the prior undervaluation of female entrepreneurs and their endeavors. Recently, a few studies have started paying attention to this less-explored aspect of studying entrepreneurship and reported their findings about how women's entrepreneurial intentions (EI) get shaped into their behaviors. Existing research conveys that the supportive or non-supportive entrepreneurial ecosystem's actors and factors in-dependently can help or hinder their behaviors. The current empirical study examines how women's entrepreneurial intentions influence entrepreneurial behavior (EB), considering the consequences of the entrepreneurial ecosystem (EE). To assess the relationship and the analysis of the data, we have used PLS-SEM. We applied the methodology for the data collected from the sample of 707 young females studying in Higher Education Institutes (HEI) from India's top business-reforming regions. The respondents were either studying or about to complete their degree soon, as students in HEI are believed to be the most impacted by the uncertain and dynamic business environments regarding their career decisions. The findings indicate that the entrepreneurial ecosystem strengthens the actions of women entrepreneurs and positively intensifies the relationship between entrepreneurial intentions and the behavior of women entrepreneurs.

*Keywords: Entrepreneurial Behavior, Entrepreneurial Ecosystem, Entrepreneurial Intention, PLS-SEM, Women Entrepreneurship*

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## **ID 65: START-UP ECOSYSTEM THROUGH THE LENS OF ACTION RESEARCH**

Krishna Dixit (1), \*Nandini Varshney (2) and Reshmi Manna (1)

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**Abstract.** Start-ups are founded to develop some unique offerings to the market, which are crucial for any entrepreneurial economy. They are adept at bringing economic and social change through economic recovery and responsible growth. However, to successfully influence the rate of these new enterprises, an attempt should be made to understand how these start-ups' ecosystem factors impact a particular economy. Start-ups' competitive edge gain from many external factors relating to academia or university tie ups, industry associations, government bodies, and civil society, which constitute the core pillars of the quadruple helix approach. Hence this study fulfills the gap by bringing the conceptual framework of the quadruple helix model: in context to India and then by understanding the impact of these enabling factors on the pillars of the ecosystem through participatory action research performed in the ecosystem of Gujarat. The implications drawn are similar to what was proposed by the participant in the Action Seminar and the five-year report on state start-up ranking framework.

*Keywords: Start-up, Start-up Ecosystem, Entrepreneurship, Quadruple helix model, India*

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## **ID 67: A SYSTEMATIC COST VIABILITY FOR ENTREPRENEURIAL START-UP WITH REFERENCE TO BODO ERI DOKHONA**

Chaitali Brahma (1), Anirban Chowdhury (2), Abhirup Chatterjee (3) and  
\*Bhaskar Saha (1)

*(1) Central Institute of Technology, Kokrajhar, Assam, India, (2) School of  
Design, Graphic Era Hill University, Dehradun, India, (3) Center of  
Excellence in Neurodesign and Neuromarketing, West Bengal, India*

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**Abstract.** The rich heritage of weaving amongst the traditional Bodo artisans is a source of inspiration to the entire civilization at large. Bodo women rear silkworms. They extract 'Eri or Endi' silk yarn, by which they weave their own attire in a home environment. The Bodos being flawless weavers marks weaving as their traditional culture. The impact of this study is to conserve and create sustainability of the weaving traditions, thus encouraging the weavers to realize their economic competence in their home and family environmental conditions. The service design pipeline approach so framed acts on the economic viability of the production of Dokhona, the Bodo traditional attire, taking into consideration the cost-aspect. This paper focuses on the feasibility of the lifestyle of the rural people concerned. Thus, the novelty of this work lies in the cost aspect and its critical analysis of weaving an Eri Dokhona through the concept of an innovative start-up design process. The Bodos are the indigenous ethnic tribe of Assam in north-eastern India and known for their indigenous weaving expertise. This traditional ethnic identity needs to be sustained to uphold the Bodo heritage and culture, which in turn, would augment the Bodo weavers' socio-economic empowerment.

*Keywords: Bodo weaving, Empowerment, Family environment, Innovative start-up, Entrepreneur*

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## **ID 13: MULTI-OBJECTIVE VEHICLE ROUTING PROBLEM WITH SEMI SOFT TIME WINDOWS**

\*Haripriya K (1), Viswanath Kumar Ganesan (1) and Usha Mohan (2)

(1) Tata Consultancy Services (2) Indian Institute of Technology Madras

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**Abstract.** This paper defines a Multi-Objective Large Scale Single Depot Capacitated Vehicle Routing Problem with semi-soft time windows using a lexicographic or goal programming approach. The primary objective of the problem is to minimize the number of customer orders that are tardy and use series of other objectives viz., the total distance travelled, the total tardiness and number of vehicles with their waiting times to bring in business context to solve very large problems. A mathematical formulation of the problem is presented, and an efficient Lexicographic Variable Neighborhood Search Algorithm (LVNSA) has been developed that iteratively uses the objectives in a lexicographic manner to generate good and better solutions on smaller benchmark problems and very large instances with 10000s of customers from real-life case data. A comparative evaluation from a practical sense is demonstrated with business implications.

*Keywords: Vehicle Routing, Soft Time Windows, Variable Neighborhood Search*

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## **ID 16: POWERING THE ELECTRIC VEHICLE TRANSFORMATION: MODELLING AND ANALYSIS OF THE CONVERSION OF FUEL OUTLETS TO HYBRID OUTLETS**

\*Shazeb L (1), Viswanath Kumar Ganesan (2), Arshinder Kaur (1) and Haripriya K (2)

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**Abstract.** Zero tailpipe emission, cost savings, government incentives, technological advancements are paving the way towards increased sale of Electric Vehicle (EV). In spite of spike in the sales of EV there exist a concern among most of the EV users due to insufficient charging infrastructure causing the range anxiety. Efficient implementation of charging infrastructure will remove the barriers and enable manufacturers target multiple automobile segments thereby reducing the dependence on fossil fuels. In this study, a novel hybrid capacity planning model for provisioning EV recharging ports and fuel refilling points is proposed on the existing fuel outlets. The problem is formulated as a Mixed Integer Linear Programming (MILP) model with the aim of minimizing the surplus and deficit capacities of recharging ports and refilling points with demand projections. The simulation of proposed MILP model is carried out for 5-year period into future for three different scenarios using the traffic flow data collected from five fuel outlets. The results demonstrate the scope of strategic decisions on the progressive transformations of the existing fuel outlets to innovative hybrid outlets that would help the existing outlets to adapt themselves to the rapidly changing market needs. Finally, the formulation is extended as a revenue maximization model with differential pricing to get insights on the expected returns from the hybrid outlets.

*Keywords: Electric vehicle, Charging station, Location and sizing, MILP*

*Notes:*

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## **ID 52: INTEGRATED DYNAMIC INVENTORY CLASSIFICATION AND REPLENISHMENT IN MULTI-ECHELON SUPPLY CHAIN NETWORKS**

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**Abstract.** The most common challenge faced in managing the inventory replenishment is to prevent running out of inventory, eliminating higher safety stocks, and ensuring right margins for the products. Effective inventory replenishment decisions are critical for businesses to maintain profitability while meeting customer needs. In this study we present Mixed Integer Linear Programming (MILP) models that formulates a coordinated inventory replenishment that simultaneously optimizes inventory classification and replenishment decisions while considering transportation requirements between multiple Distribution Centers (DCs) and many stores. The main objective of the model is to maximize the profits. In this study we explore and analyze replenishment needs by selecting Cycle Service Level (CSLs) using the store level forecasted demand across multiple SKUs considering different attributes like cost of the products, store level budgets, holding cost and transportation cost. The proposed approach has also been experimented with stationary and non-stationary demand patterns generated using statistical distributions to bring out the business implications and scalability.

*Keywords: Inventory Classification, Replenishment, Network Optimization*

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## **A “Tweet” of Significant Research Findings**

- ID 02 The study underscores the evolving challenges for designers in integrating AI into user-centered design, necessitating a shift towards anticipatory design and the creation of autonomous, adaptable, and unpredictable digital ecosystems.
- ID 06 TCS Aviana™ SmartTurn aids the airlines to improve the efficiency of turnaround time operations and reduce the operational cost by means of AI/ML methods.
- ID 09 Lightweight custom CNN model, fine-tuned on limited data, proves helpful for farmers in early disease diagnosis through a user-friendly web-based application, advancing precision agriculture
- ID 10 There is a considerable gap in demand and supply of the on-going entrepreneurship capacity building training programmes designed for PwD, majority of which can be cemented through the intervention of Artificial Intelligence and advanced manufacturing.
- ID 12 The research contributes by defining the significant role of an entrepreneurial mindset in developing entrepreneurial intentions, which ultimately enhances the plausibility of entrepreneurial behavior by individuals pursuing entrepreneurship education programs
- ID 13 An efficient VLSN algorithm to solve larger multi-objective routing problems with 20000 customers that demonstrates using of broader time-windows significantly minimizes the operational cost as against narrow time-windows for deliveries.
- ID 14 Machine learning-based approach for detecting attacks, especially in industrial networks. Decision Tree, Random Forest models used for anomaly detection. Email alerts with detailed data provided. Evaluated on KDD Cup dataset.
- ID 15 Integrated system of ThingSpeak, MATLAB, and NodeMCU can effectively predict humidity using a SVR model, with an R-squared value of 0.9970 and low MAE and RMSE values.
- ID 16 A capacity planning model formulated as Mixed Integer Programming Problem, strategically encourages investment in

- EV charging infrastructure, and promotes retail fuel outlets' transition to hybrid outlets for future EV penetration.
- ID 17 The give study able to decrease human intervention and estimate the compressive strength of bone scaffold before fabricating it with the patient specific inputs using AI approach
- ID 20 In Indian states, known for their strong business support, women entrepreneurs are empowered to convert their intentions into concrete behavior irrespective of their academic backgrounds or familial connections to entrepreneurship.
- ID 22 This paper presents a low-cost IIoT solution for real-time energy monitoring in MSME industries. It integrates cost-effective hardware, controller, edge gateway, and web-based software for efficient electrical system management and machine monitoring.
- ID 24 Augmented reality and IoT technology were combined in the Robotic Welding cells to enable proactive maintenance, defect discovery, and efficient data analysis, resulting in Improved operator efficiency and field quality.
- ID 25 Data capturing and presentation in an appropriate form will help in the analysis and decision-making in critical situations and increase efficiency and productivity.
- ID 29 To facilitate the widespread adoption of additive manufacturing, authors propose an XML schema-based file format that integrates diverse material properties with geometric information to enhance the representation of multi-material data.
- ID 30 Gaussian Process Regression is used for determine the condition of jet engines remaining useful life.
- ID 31 YOLOv7 model takes a few milliseconds for image processing with reliable precision and is suitable for real-time defect analysis and identification of fine differences in 2D images.
- ID 34 Laser trepan drilling on ceramic composite zirconia toughened alumina performed successfully.

- ID 35 An ultimate FS of 57.307 MPa was achieved at 0.40 mm NHD and HC IFP which is 27.09% compared to the specimen fabricated at 0.15 mm NHD and Grid IFP.
- ID 36 This paper proposes an IoT-based device which enables users to monitor vehicle health and measure CO2 emissions in real-time wirelessly, promoting sustainability and consciousness among people.
- ID 37 Generative Design has been employed for reduction of 42 grams of weight of a quadcopter, resulting in an extended flight time, by approximately 60 seconds or more.
- ID 38 Human-AI collaboration in visual imagery creation holds promise for creativity and task automation, but challenges remain such as communication, bias, and ethical considerations.
- ID 41 Creating a dynamic digital twin model to improve process and performance of the assembly workstation by receiving signals from PLC.
- ID 42 Pioneering predictive maintenance through machine learning, this research optimizes resource usage and minimizes disruptions, emphasizing real-world implementation and model interpretability for diverse industry applications.
- ID 44 The digital twin model helped in real time monitoring and virtual commissioning of pallet in an assembly line by changing process sequence and improving ladder logic without manual intervention on running line.
- ID 46 Investigating fretting wear properties of friction-stir-welded aluminum alloys, we found that AA7075 demonstrated superior fretting wear resistance, while AA2024 exhibited the highest frictional force.
- ID 50 Leveraging on in-line image processing technique, a digital twin is built to perform quality assessment in 3D concrete printing.
- ID 51 Investigations carried out to study effect of post weld heat treatment on the welded joint of SA312 TP304 stainless steel and SA335 P11 chrome moly alloys TIG and MIG welding.
- ID 52 A decomposition-based time space model that integrates three decisions in two-echelon retail supply chains viz., store level

inventory classification and replenishment with distribution center replenishment is demonstrated using MILP Models.

- ID 54 Based on the analysis of 16 factors influencing IoT integration in Additive Manufacturing, effective utilization of internet-based technologies in AM is important for the development of smart and sustainable manufacturing.
- ID 55 The study explores from the sociological and psychosocial theoretical perspectives, the nature of pedagogical interactions with teachers and peers in ODL that could lead to confidence building among students.
- ID 56 Improvising the hands-on training experience of the operators to use Robotic Welding Cell through an interactive Augmented Reality experience which can be implemented remotely also enabling their quality and efficiency.
- ID 57 The research work is to examine the profound impact of Robotics Artificial Intelligence and Automation on the upskilling of individuals and to investigate the consequences of net employment levels
- ID 58 Machine Learning based accurate Remaining Useful Life (RUL) prediction for turbofan engines, using tuned Gradient Boosting Regressor achieving 99% accuracy, facilitating proactive maintenance and operational efficiency.
- ID 61 Energy absorption is greatest at grid Internal Filling Pattern and Nozzle Hole Diameter of 0.40mm for Poly lactic acid reinforced with carbon fibre.
- ID 62 Findings reveal impulsive buying has emerged as a prominent trend among online buyers, driven by factors such as discounts, sales, marketing tactics, and most importantly, the convenience of online payments.
- ID 65 This study addresses gap by applying the quadruple helix model to India and using participatory action research to assess its impact of enabling factors on the pillars of Gujarat's ecosystem.
- ID 66 Sand casting with rapid prototyping and simulation software can produce customized orthopaedic implants with fewer defects, lowering costs and improving accessibility to medical devices.

- ID 67 Examining the systematic cost-viability of entrepreneurial start-ups with special attention to Bodo Eri Dokhona guarantees a comprehensive comprehension of financial sustainability in the ever-changing business environment.
- ID 69 Additive manufacturing, or 3D printing, creates tangible items through slicing, a process that converts digital models into G-code. This paper introduces an adaptive slicing method using varying layer thickness, aiming for faster, high-fidelity prints validated through simulation and visual comparison.
- ID 70 Over the past decade, the integration of virtual and augmented reality technologies has progressed. This paper explores the application of immersive virtual reality in preserving cultural heritage, focusing on the Panduranga Vitthal temple. The study proposes a workflow using photogrammetry to create optimized VR models for interactive exploration and documentation.
- ID 71 The paper presents a hybrid PI-Fuzzy Logic controller that significantly improves the speed control of electric motors, enhancing their efficiency and reducing settling time in various industrial applications.
- ID 73 Laser Powder Bed Fusion shows the potential for fabricating thin-walled structures with thickness nearly 300 microns and highlighting challenges such as surface irregularities and dimensional variations that require further optimization.
- ID 74 A path planning algorithm named as Waypoint Algorithm (WA) is developed for an unmanned vehicle in a known global environment for finding the shortest path between any two input cells.
- ID 75 The paper presents a UV-thermal dual curable bio-nano composite with low carbon footprint for 3D printed construction application, as a sustainable alternative to concrete, reducing emissions, and enhancing structural performance.
- ID 77 Machine learning-powered VR learning platform leverages data visualization to enhance maintenance workers' skills through immersive, risk-free simulations for practicing machinery maintenance on identified faulty components.

- ID 78 We have proposed a cost-effective Industry 4.0 architecture for linear motion control, utilizing open-source tools as alternatives to expensive devices such as IoT modules and cloud subscriptions, and providing options for small-scale industries in India.
- ID 79 Industrial metaverse visualization technique leverages VR technology to improve machine and assembly layouts, while enhancing user understanding of efficiency, safety considerations, and informed decision-making for efficient industrial deployment.
- ID 80 The GenAI assignment problem is to find the optimum assignment so that the total cost of performing all the jobs in minima or the total profit of all in maxima.
- ID 82 Selective micro laser melting enables the fabrication of conductive traces on polymer substrates.
- ID 83 A VR game prototype for training mining personnel to increase safety and productivity is developed and tested, with features like varying difficulty, operations, hazards, feedback, language support, and performance evaluation.
- ID 84 Design of Smart Interactive Electronic Toy for Future Kids to introduce money concept and buying selling in an easy method
- ID 85 Previously unreported downward warping of samples and transition from downward to upward warpage profile with increasing height of parts which remain adhered to the build plate during FDM 3D printing.
- ID 86 Microwave-induced discharge was location-dependent and generated with some delay in the form of short-lived sparks followed by long-lived arc, which mainly contributed to microwave machining.
- ID 88 A Reinforcement Learning algorithm is proposed for path planning in robotic mobile fulfilment system, addressing congestion awareness and energy consumption among mobile robots, with a focus on path length reduction.
- ID 89 The study seeks to investigate and comprehend the many techniques, processes, and approaches employed by design students in the development of bio-design project concepts.

- ID 92 A novel DFM algorithm is developed which provides a framework for optimal approach to establish a sequence or order of allowances to be applied in a pattern of bush casting.
- ID 93 The data-driven approach using digital twin (DT) modelling has been used by leveraging real-time data from temperature sensors integrated with a specialized design fixture for wire breakage prognosis of WEDM.
- ID 94 A method to predict product issues during product use-phases from customer reviews to aid early spotting of product design flaws and to aid agencies to promote responsible producer practices.
- ID 95 Visualization of Interior and Exterior Design of An Autonomous Public Transportation System in Dehradun, Uttarakhand
- ID 97 Data augmentation techniques enhance classification accuracy in automated visual inspection of manufactured components by compensating for limited training data, especially when creating extensive datasets is impractical.
- ID 99 The study provides a robust empirical evidence of the interplay between productivity and ergonomics in the manufacturing domain using reliable measures for both the aspects utilizing direct measurement technique.



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