I-4AM 2026

DeScIn

4th International Conference on Industry 4.0 and Advanced Manufacturing

08-09 January 2026
Indian Institute of Science, Bengaluru

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Book of Abstracts

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Ministry of Heavy Industries
Government of India

भारतीय विज्ञान संस्थान

I4.0 India@IISc

DM IISc

4th International Conference on Industry 4.0 and Advanced Manufacturing

08-09 January 2026
Indian Institute of Science, Bengaluru

BOOK OF ABSTRACTS

Programme & Conference Chair
Prof. Amaresh Chakrabarti
Department of Design and Manufacturing
Indian Institute of Science, Bengaluru

Programme & Conference Chair
Prof. Satyam Suwas
Department of Materials Engineering
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Programme & Conference Vice-Chair
Prof. Manish Arora
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Indian Institute of Science, Bengaluru

ABOUT THE CONFERENCE

Industry X.0 is about using connected intelligence to enable human empowerment through greater productivity, quality, flexibility, safety, and sustainability across manufacturing enterprises, in which advanced manufacturing technologies such as robotics and additive manufacturing play a critical role.

The International Conference on Industry 4.0 and Advanced Manufacturing (I-4AM) (pronounced i-forum) is a biennial conference series that provides a platform to bring together stakeholders in manufacturing and Industry X.0, particularly from academia and industry in India and abroad, to deliberate on the nature, needs, challenges, opportunities, problems, and solutions in this transformational area of endeavour.

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

I-4AM 2026 is the fourth in a series of conferences held between 08-09 January 2026. I-4AM 2026 is sponsored by the Smart Factory at IISc and the Centre of Excellence in Design at IISc. The proceedings of I-4AM 2026 will be published in book volumes by Springer Nature that is indexed in Scopus and other databases.

I-4AM 2026 is organised under the auspices of DeScIn: India's Academy of Design Sciences. The objectives of DeScIn Academy are to establish and operate as an academic and peer society in India, focusing on research into design sciences, fostering the development of a vibrant academic community of the highest international standards, and promoting collaboration, inclusivity, and innovation in all areas of design research; to promote and disseminate high-quality research outputs through conferences, workshops, seminars, summer/winter schools, webinars, academic journals, and other publications, with a focus on topics of relevance to India and the world; to recognize and support individuals and organizations for outstanding achievements in design sciences; and to collaborate with stakeholders to advance policy, consultancy, and academic awareness in the field.

Prof. Amaresh Chakrabarti

Department of Design and Manufacturing,
Indian Institute of Science (IISc), Bengaluru

Prof. Amaresh Chakrabarti, Senior Professor & Chair, Department of Design & Manufacturing, IISc, Bengaluru, has BE (Topper, Mech Engg, IIEST Shibpur), ME (Topper, Mech Design, IISc), PhD (Engg Design, University of Cambridge UK). For 10 years, he led Design Synthesis at EPSRC CoE Engg Design Centre (EDC), University of Cambridge. His interests: synthesis, creativity, sustainability, informatics, Industry 4.0. He published 36 books, 370+ peer-reviewed articles, 13 patents. He co-authored DRM, used widely as framework for des research. He has been Area Editor, Research in Engg Design, Regional Editor, Journal of Remanufacturing (Springer), and Advisory Editor for nine Journals. He was on Advisory Board & Board of Management, Design Society UK; member, CII National Committee on Des & CII Smart Manufacturing Council India; Jury, India Design Mark. He founded IDeASLab - India's first Design Observatory. He is founding chair, International (Intl) Conference (Conf) Series ICoRD and I-4AM, Chair, 22nd CIRP Design Conf 2012, 3rd Intl Conf on Design Creativity 2015.

He is an Honorary Fellow (HonFIED), Institution of Engg Designers, peer society under UK Royal Charter in Engg Design; Fellow, Design Society (FDS), UK; TUM Ambassador, TUM Germany; Fellow, Design Research Society, UK (FDRS). 27 of his papers won top paper awards in Intl Conf. He co-initiated India's first indigenous Smart Factory, heads IISc-TCS Innovation Lab, IISc Press, Springer Intl book series Design Science & Innovation, chaired Smart Manufacturing Sub-committee, Bureau of Indian Stds. He received Careers360 2018 Faculty Award 'Most Outstanding Researcher' in Decision Science, and is among global top 2% researchers in 'Design Practice & Management'. He is Editor-in-Chief AI EDAM, CUP. He was/won a J Nehru Doctoral Fellow, University of Cambridge UK 1987, ORS Award, Committee of Vice-Chancellors UK 1987, Lundgren Award, University of Cambridge 1991, UK MG MIAA Commendation Award 1994, Heiwa-Nakajima Visiting Fellow Japan 2007, UK Royal Society Visiting Fellow 2010, Cambridge Commonwealth Reciprocal Visiting Fellow 2014, ASEM-DUO Visiting Fellow Italy 2020, Jubilee Professor, Chalmers University Sweden 2025. He received IISc Alumni Award for Excellence in Research in Engg 2022, and 2025 ASME Ruth &Joel Spira Outstanding Des Educator Award. He is founding president of DeScIn - India's Academy of Design Sciences. In 2025, he was elected Honorary Fellow, Condition Monitoring Society, and Fellow, Indian National Academy of Engg (FNAE), India.

Prof. Satyam Suwas

Department of Materials Engineering,
Indian Institute of Science (IISc), Bengaluru

Dr. Satyam Suwas is a Professor of Materials Engineering, and currently the Dean of Mechanical Sciences 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 has co-authored/co-edited 5 books, and published 400+ papers in reputed international and national journals. He is the recipient of many awards, the most notable ones being the Friedrich Wilhelm Bessel Research Award from Humboldt foundation, Germany, and GD Birla Gold Medal from Indian Institute of Metals. He serves on the editorial board of many reputed international journals in the field of Materials Science and Engineering. He is a fellow of Electron Microscope Society of India (EMSI), Indian National Science Academy (INSA), 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 (IISc), Bengaluru

Prof. Manish Arora is an Associate Professor in the Department of Design & 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 70+ 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

Title of Tracks	Descriptions
 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

Title of Tracks	Descriptions
 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 **08 Jan 2026, Thursday**

▶ **Inaugural Session**

Time: 0830-0900 IST

Venue: JN Tata Main Auditorium

Chief Guest: Prof. Jayant Modak, Dean, Faculty of Engineering, IISc

Chair of Advisory Committee, I-4AM'26: Prof. B. Gurumoorthy

Co-Chair, I-4AM'26: Prof. Amaresh Chakrabarti

Co-Chair, I-4AM'26: Prof. Satyam Suwas

Vice-Chair, I-4AM'26: Prof. Manish Arora

▶ **Keynote Sessions 1 & 2**

Time: 0900-1030 IST

Venue: JN Tata Main Auditorium

Chair: Prof. B. Gurumoorthy

▷ **Keynote 1**

Time: 0900-0945 IST

Prof. Sunil Jha 49-50

▷ Keynote 2

Time: 0945-1030 IST

Mr. A. N. Chandramouli 51-52

▶ Coffee Break & Group Photo

Time: 1030-1115 IST

Venue: JN Tata Auditorium Lower Foyer

▶ Parallel Sessions

Time: 1115-1315 IST

▷ PS 1: Digital Manufacturing

Chair: Dr Koushik Vishwanathan

Venue: JN Tata Main Auditorium

Paper ID	Title of the paper	
15	ARTEMIS: A VR based application to train Clinicians and Lab Technicians with techniques to deal with Antimicrobial Resistance	67
121	Sustainable EV Battery Recycling: Robotic Disassembly via Bayesian-Optimized Multi-Resolution CNN	68
37	Casting Quality Improvement using AutoCAST Simulation	69

▷ PS 2: Materials Processing & Joining

Chair: Dr Subhas C. Mandal

Venue: JN Tata Hall A

▷ PS 3: Industry X.0

Chair: Dr. Arlindo Silva

Venue: JN Tata Hall B

▷ PS 4: Sustainable Manufacturing

Chair: Dr. Monto Mani

Venue: JN Tata Hall C

▶ **Lunch**

Time: 1315-1415 IST

Venue: JN Tata Auditorium Lower Foyer

▶ **Keynote 3**

Time: 1415-1500 IST

Venue: JN Tata Auditorium

Chair: Prof. Vishal Singh

▶ Panel Session

Time: 1500-1600 IST

Venue: JN Tata Main Auditorium

▷ Panel Discussion 1: Supporting Manufacturing Innovation

Chair: Prof. B. Gurumoorthy (Chair)

Panel Members: Prof. Eckhard Kirchner
Prof. Suryakumar S
Dr. T. Parasuraman
Dr. S. Devarajan
Mr. A.N. Chandramouli
Dr. Col. K. Joshil Raj

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▶ Tea Break

Time: 1600-1630 IST

Venue: JN Tata Auditorium Lower Foyer

▶ Parallel Sessions

Time: 1630-1830 IST

▷ PS 1: DeScIn Academy & DRM Gurukooll

Chairs: Dr Shakuntala Acharya & Dr Srinivasan Venkataraman

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Venue: JN Tata Main Auditorium

▷ PS 2: Materials Processing & Joining

Chair: Dr Apurbba K. Sharma

Venue: JN Tata Hall A

▶ Parallel Sessions

Time: 1630-1830 IST

▷ PS 3: Industry X.0

Chair: Dr Amar K Behera

Venue: JN Tata Hall B

▶ Parallel Sessions

Time: 1630-1830 IST

▷ PS 4: Digital Manufacturing

Chair: Dr. Senthilkumaran Kumaraguru

Venue: JN Tata Hall B

215	A benchmark process for designing user centric smart respiratory inhaler system	123
231	Key design parameters for helmet impact and the influence of rotational acceleration on head kinematics	124

▶ Cultural Programme

Time: 1830-1900 IST

Venue: JN Tata Main Auditorium

▶ Conference Dinner

Time: 1915-2130 IST

Venue: Jawahar Lawn, Gymkhana, IISc, Bengaluru

Day 2 09 Jan 2026, Friday

▶ Parallel Sessions

Time: 0830-1030 IST

▷ PS 1: Digital Manufacturing

Chair: Dr. Devika Kataria

Venue: JN Tata Main Auditorium

▷ PS 2: Control, Autonomous Systems, Robotics

Chair: Dr B.B.V.L. Deepak

Venue: JN Tata Hall A

▷ PS 3: Industry X.0 and Policy & Entrepreneurship

Chair: Dr Pradipta Biswas

Venue: JN Tata Hall B

▷ PS 4: Training and Education

Chair: Dr. Abhay K Kuthe

Venue: JN Tata Hall C

▶ Break

Time: 1030-1100 IST

Venue: JN Tata Auditorium Lower Foyer

▶ Parallel Sessions

Time: 1100-1300 IST

▷ PS 1: Policy & Entrepreneurship

Chair: Dr N. D. Shivakumar

Venue: JN Tata Main Auditorium

▷ PS 2: Supply Chains

Chair: Dr. Debashis Majumder

Venue: JN Tata Hall A

▷ PS 3: Sustainable Manufacturing

Chair: Dr Vinodh Sekhar

Venue: JN Tata Hall B

▷ **PS 4: Springer Author Workshop**

Chair: Swati Meherishi 64

Time: 1100-1300 IST

Venue: JN Tata Hall C

▶ **Lunch Break**

Time: 1300-1400 IST

Venue: JN Tata Auditorium Lower Foyer

▶ **Keynote Sessions 4 & 5**

Time: 1400-1530 IST

Venue: JN Tata Main Auditorium

Chair: Prof. Dibakar Sen

▷ **Keynote 4**

Time: 1400-1445 IST

Prof. David Inkermann 55-56

▷ **Keynote 5**

Time: 1445-1530 IST

Prof. Eckhard Kirchner 57-58

▶ Tea Break

Time: 1530-1600 IST

Venue: JN Tata Auditorium Lower Foyer

▷ **Keynote 6**

Time: 1600-1645 IST

Venue: JN Tata Auditorium

Chair: Prof. Manish Arora

Prof. Kannan Govindan 59-60

▶ **Panel Session**

Time: 1700-1800 IST

Venue: JN Tata Main Auditorium

▷ **Panel Discussion 2: Supporting Manufacturing Education**

Chair: Prof. Satish Vasu Kailas (Chair)

Panel Members	Prof. Arlindo Silva Prof. David Inkermann Prof. Vinodh Sekar Prof. Kannan Govindan Dr. Nagahanumaiah Prof. Apurbba K Sharma	62

▶ Distinguished Paper Awards and Valedictory

Time: 1800-1900 IST

Venue: JN Tata Auditorium

Chairs: Amaresh Chakrabarti, Swati Meherishi

▶ High Tea

Time: 1900-1930 IST

Venue: JN Tata Auditorium Lower Foyer

A 'TWEET' OF SIGNIFICANT RESEARCH FINDINGS

TWEETS

ID 4	The paper proposes a unified framework integrating life cycle analysis, cause–effect mapping, and MCDA to quantitatively identify and evaluate sustainability conflicts specific to medical device design.
ID 5	Effective supply chain integration of suppliers, internal processes, and customers significantly enhances organizational performance, efficiency, product quality, and competitive advantage, with industry-specific variations influencing outcomes.
ID 7	An invention, which leverages a combination of AI/ML integrated with data from the airport and the customer touchpoint for RTS and RTA during the airport alerts at every moment.
ID 9	Adopting and implementing CSS enriches a large pool of viable ideas, improving the overall effectiveness of the idea-generation process, enabling hardware-based tech-startups to penetrate new markets with a competitive edge.
ID 11	The paper proses an LLM-based pipeline that automates lifecycle segmentation, conflict extraction, and MCDA scoring for scalable sustainability conflict detection in medical device design.
ID 15	A virtual reality application made using Unity 3d to teach clinicians and lab technicians means to tackle with Anti Microbial Resistance via Immersive Learning
ID 16	The proposed software-supported method uses a newly introduced SiME function structure to systematically combine and select components, thereby fostering holistic design and improving quality, efficiency, and accessibility.
ID 17	Flux-bounded TIG welding with CaO flux significantly enhanced penetration depth in Al 6061, achieving over 200% improvement compared to conventional TIG welding while maintaining controllable bead geometry.

ID 22	This study systematically highlights primary challenges associated with implementation of Industry 4.0 technologies in the context of typical Indian aerospace product development using Fuzzy TOPSIS multi-criteria decision-making (MCDM) technique.
ID 24	The significance of the study is identification and prioritization of factors of I4.0 to I5.0 transition for automotive component manufacturing organization using N-VIKOR for better handling uncertainty in decision making
ID 25	It is observed that smaller organizations, employing a workforce of 50 or fewer, struggle to attract or retain the requisite skills and experience necessary to pursue innovative concepts or technologies.
ID 30	Digital fashion is recognized for reducing waste and enabling virtual experimentation, yet Gen Z perceives it as an adjunct, not replacement, reflecting sustainability scepticism and cultural attachment to physical garments.
ID 31	The paper proposes and experiments with Least-Pattern Making (LPM), a scalable, reproducible, sustainable technique integrating digital-physical methods to reduce fabric waste, improve design accuracy, and advance eco-conscious fashion industry practices.
ID 32	Burud artisans preserve multi-generational bamboo craftsmanship, face market & input constraints, but exhibit strong adaptive capacity, projecting viable growth if supported with design, standardization, and sustainable supply chains.
ID 33	The study finds that integrating CAD/CAM with Kolhapuri copper jewellery contemporizes traditional designs, expands global market access via digital platforms, and sustains artisanal livelihoods, though technological adoption and identity preservation remain challenges.

TWEETS

ID 36	The study shows that Baramati Textile Park's 78% Industry 4.0 adoption leads the region's textile industry, with 87.5% zero-waste awareness and growing support for sustainable practices despite existing infrastructure challenges.
ID 37	Modifications resulted in improvement in quality reducing the rejection by 4.50%. Casting parameters selection and sleeve introduction reported 81.33% yield enhancement and shrinkage porosity elimination.
ID 38	Study shows that positive learning from adverse experiences and entrepreneurial mindfulness can help entrepreneurs adapt strategies, explore opportunities, and turn challenges into valuable experiences.
ID 39	Students from select institutions excel in entrepreneurial actions due to flexible curriculum, pedagogy, and evaluation, active student communities, regular mentoring, and institutional mechanisms to reward, recognize, and support their efforts.
ID 41	The developed IoT-enabled data analytics and quality prognosis system for vertical centrifugal casting achieved early defect prediction with up to 93.5% accuracy, reducing waste and optimizing production efficiency.
ID 43	A waste-derived bamboo–paper composite material was developed and demonstrated through a coffee table application, exhibiting functional durability, spill resistance, and adaptability for use across diverse product typologies.
ID 46	The findings demonstrate that students who have willingness, and ability towards entrepreneurship are more likely to start their ventures with family support because it provides emotional and financial support.

ID 48	Sustainable construction demands nature as stakeholder, policy support, circular ecosystem, traditional and biomimicry revival, scalable low-carbon solutions, reduced cement use, collaboration, cost-effectiveness, longevity assurance, and user confidence to accelerate eco-friendly housing transformation.
ID 51	Student involvement in externally partnered initiatives and precise alignment of goals considerably improve institutional perceptions and trust in GAI collaborations in India.
ID 52	Greater emphasis on student evaluation over rote learning is the key parameter for success in I4.0, thereby requiring faculty in higher technical education to think beyond the call of duty.
ID 53	Redesigning HVAC with ergonomic, tactile controls enhances driver safety by reducing cognitive load and distraction, supporting eyes-on-the-road operation compared to touchscreen systems.
ID 54	Chaaya is a biomimetic, voice- and interface-controlled smart blind system that enhances comfort and energy efficiency in Indian homes, achieving up to 25% energy savings through adaptive light management and expressive design.
ID 55	This research demonstrates a non-invasive, retrofittable actuator enhances smart home adoption by addressing cost and installation barriers while creating an engaging, emotionally resonant user experience.
ID 61	Whale Optimization Algorithm outperforms other metaheuristic methods for anomaly detection in aircraft weight and balance data, achieving reduced anomaly scores and reconstruction errors across categories.

TWEETS

ID 62	Demonstrated that the application of dimensional analysis to the input parameters of density-predicting neural networks can improve their performance.
ID 63	The study introduces original evaluation matrices using the Pugh framework, demonstrating SMART Foundry as a cost-efficient, adaptable alternative for orthopedic implant manufacturing in South Asia.
ID 66	The study proposes a smart supply chain framework integrating RFID, IoT, and blockchain to enhance transparency and traceability, in the Indian handloom sector's decentralized value chain
ID 72	UCB outperformed A2C in perishable inventory control, yielding lower costs, fewer shortages, and more stable performance, indicating simple methods can surpass complex RL methods in cost-sensitive settings.
ID 73	The first study of D. stocksii bamboo fibers in various forms reveals yarn form as the most suitable sustainable reinforcement for polymer composites, owing to improved inter-fiber friction.
ID 79	IOT-based Digital Product Passport portal, designed for organised fashion manufacturers in India, holds good potential for Industry 5.0 alignment, tracking, and tracing, and making the Indian fashion scenario more sustainable.
ID 80	This study presents a scalable two-phase MILP framework evaluating economic–environmental trade-offs in agri-food supply chains, guiding crop planning, inventory design, and policy decisions.
ID 81	A machine learning-based DSS optimizes agri-food logistics by tailoring transport and packaging for suppliers and retailers, balancing cost, emissions, and product loss using commodity attributes and key parameters.

ID 83	The hybrid integration of SLA 3D printing with investment casting enables highly accurate, customized jewellery production with complex designs, reduced lead times, and improved cost-effectiveness over traditional methods.
ID 86	The study evaluated an air purifier across contaminated, closed, and open rooms using AQI and PM2.5 metrics. Results showed significant improvement: up to 55% AQI and 48% PM2.5 reduction in contaminated rooms, and nearly 69% AQI and 67% PM2.5 reduction in closed rooms.
ID 88	A torsion-enhanced PETG lattice structure achieved stable energy absorption, improved plateau behaviour and SEA compared to conventional designs, validating its potential for lightweight, replaceable shock-absorbing applications via FDM.
ID 94	The study highlights consumer perception and willingness to buy upcycled glassware products. It encourages similar initiatives and provides opportunities to address the pressing waste management issue towards a greener economy.
ID 95	The study reveals a significant gap in DFM education in Indian design institutes and proposes a 4C pedagogical framework to systematically integrate manufacturability into undergraduate design curricula
ID 98	The key contribution is the development and validation of a mixed reality based interactive digital twins using IoT-based data systems to enhance the manufacturing workforce training.
ID 99	Participatory action research explored conscious contemporization of Jharkhand's traditional Khovar wall art through distributed and inclusive production using silk screen printing of its motifs on textiles and terracotta with artisans.

TWEETS

ID 102	The study finds that integrating ADM with Industry 4.0 technologies in interior design education bridges traditional pedagogy and smart practices, enhancing creativity, technical fluency, and experiential learning among students.
ID 103	The study examines employee intrapreneurial behavior and opportunity exploration, moderated by management support. Findings show employee risk-taking is significant in public sector enterprises, and management support strongly moderates opportunity exploration.
ID 105	Our study presents a seahorse tail-inspired hybrid soft robot arm that combines stiffness gradients, durability, and safety, achieving industrially viable flexibility and resilience beyond existing soft-rigid designs.
ID 109	Banarasi wooden toys, sustainable and culturally rich with cutting-edge technology, face near extinction. Only five families remain, incomes are unsustainable, and plastic toys market threatens survival.
ID 113	The platform effectively saved 50–60% of weekly marketing time and reduced tool switching by 75%, which resulted in a 50% rise in social media interaction.
ID 114	AI-driven tools significantly enhance fashion design by improving creative prototyping, promoting sustainability, and enabling data-informed decision-making, as evidenced by industry insights and survey-based analysis.
ID 115	Key statistical insights show variability in fabric types (silk, cotton, blends), thread counts (90–200 TPI), yarn strength, and dye use. Common defects link to chemical dyes, while Handloom Mark and GI tags affirm authenticity.

ID 121	Bayesian-optimized AutoDisCNN framework achieves 97.8% accuracy with 22ms processing time, revolutionizing automated EV battery recycling through a multi-resolution curriculum learning approach.
ID 122	A two-week fabrication based furniture studio using precision laser cutting and CNC machining significantly improved students' critical evaluation and contextual design skills while identifying prototyping accuracy as the primary area for further development and demonstrated a replicable framework for integrating Industry 4.0 tools into design education.
ID 123	Kinetic façades significantly improve sustainability, comfort, and aesthetics while facing cost and maintenance challenges, yet 90% of professionals foresee their crucial future role, recommending adoption with material and technological advancements.
ID 124	The study finds fully automated "dark" apparel factories inevitable, but contingent on overcoming soft material handling constraints, high capital costs, and workforce disruption through phased adoption to ensure industry readiness.
ID 125	ProVital demonstrates that low-cost IoT-enabled wearables can reliably monitor SpO_2 and heart rate, providing real-time alerts that enhance worker safety in industrial environments.
ID 128	This paper explores the wooden toy heritage of Sawantwadi, its challenges, and suggests integrating CAD, CNC, Laser Cutting, and AI to improve efficiency, preserve culture and sustain the craft's future.
ID 129	In MBBRs, biofilm maturity reduces the influence of biocarrier geometry on removal efficiency; however, reactor scale effects remain important, and glucose feeding should be avoided due to sludge bulking risks.

TWEETS

ID 133	Smart glasses equipped with AI and edge computing translating Indian Sign Language gestures into multilingual speech, enabling inclusive, real-time communication for hearing-impaired individuals in Industry 4.0 environments.
ID 137	This study explores integrating 3D clay printing into traditional terracotta and ceramic crafts, enhancing precision, efficiency, and design possibilities while preserving cultural authenticity, fostering sustainability, and creating new economic opportunities for artisans.
ID 142	This research demonstrated that a virtual training system for lathe operations enhanced with haptic feedback resulted in better perception of realism and performance compared to traditional training methods
ID 146	Our novel, 3D-printable compliant folds utilize torsion for bending, achieving a greater than 99% reduction in reaction force compared to direct flexure, enabling flexible, monolithic origami-inspired structures.
ID 147	This study bridges sustainability theory and practice by proposing an implementable framework that identifies integration barriers and offers stage-wise, validated workflows, enabling sustainability in services, influencing user behavior, and reducing digital-service carbon footprints.
ID 154	Nexura improved industrial VR use with 15% faster tasks, 18% fewer errors, 21% higher satisfaction, and 22% greater effectiveness, demonstrating enhanced usability through role-adaptive interfaces and real-time data visualization.
ID 156	Infusing microorganisms from limestone growth in caves like Stalactites in concrete to give it self healing properties and reduce its carbon footprint

ID 160	Integrating telehealth, AI-assisted ECG analysis, and user-centered interfaces reduced cardiovascular diagnostic delays by up to 36%, improving access, accuracy, and efficiency in underserved Indian healthcare settings.
ID 169	LLMs achieved accuracy in detecting anomalies comparable to or exceeding traditional machine learning models using multi-shot prompting on serialized bearing vibration data without requiring training or feature engineering.
ID 170	The paper finds that while AI enhances fashion design education through efficiency and ideation, it risks bias, creativity loss, ownership disputes, and inequality—necessitating ethical frameworks, inclusivity, and balanced human–AI collaboration
ID 177	The two-step ANSYS simulation for Electromagnetic-Crimping has been fully automated through interactive Python scripting. This can be used to generate a large amount of accurate data for an ANN model
ID 178	Auxetic piezoelectric energy harvesting boosts power output up to 6 times and will revolutionise self-powered MAVs, NAVs, PAVs and morphing airfoils for aerospace applications.
ID 180	This research employs Neural Optimization Machine (NOM) to design optimized auxetic metamaterials with superior properties, matching NSGA-II performance, and enabling scalable, AI-driven, Industry 4.0-aligned frameworks for high-performance material design.
ID 181	Multi-modal expiry indicators combining color changes and iconography significantly improve medicine expiry visibility, enhancing safety and accessibility for elderly, illiterate, and visually impaired users

TWEETS

ID 185	Metaverse adoption in supply chains enhances agility, resilience, and performance through technological readiness, organizational agility, stakeholder collaboration, and competitive strategy, fostering digital transformation in Industry 5.0.
ID 188	This study demonstrates that Design for Additive Manufacturing enablers, ranked through degree centrality, play critical interconnected roles in advancing Industry 4.0 with improved efficiency, innovation, and sustainability.
ID 190	PCA is employed to reduce the dimensionality and obtain the features for predicting the microstructure of parts produced using the L-PBF process to support the construction of its digital twin.
ID 194	In this work a deep learning-based approach for optimizing the Selective Laser Melting process parameters and predicting melt pool dimensions in 3D metal printing has been developed.
ID 196	Micropillar compression showed higher strength than bulk compression, with strength increasing from 2050 MPa to 3720 MPa as the d/l ratio decreased from 0.8 to 0.6, highlighting significant size-dependent effects.
ID 200	A key contribution of this paper is the five stage simplified Industry 4.0 readiness assessment method that digitizes manufacturing data sources and defines measurable metrics.
ID 204	Developing sustainable cement particle boards by incorporating bio-agro wastes like wood and sugarcane bagasse, with graphene as an additive to reduce cement usage and lower the carbon footprint.
ID 215	A benchmark process for quality optimizing of existing inhaler with releasing time of 2.5 s. The Inhaler provides facility of data logging, reminder and dosage amount.

ID 217	Coconut-shell packaging combines tradition with modern sustainability goals. It reflects the importance of balancing cultural practices with environmental responsibility. The findings of this research emphasize its potential to create a positive impact.
ID 226	Printable three-dimensional (3D) functional prototype circuit using multi-material components within an integrated multi-process additive system on a single platform.
ID 229	AI can bridge the gap between ideation and implementation, helping teams rapidly generate and evaluate design concepts that align with manufacturing constraints, reducing iteration cycles and enhancing design feasibility.
ID 231	This study evaluates four crucial parameters influencing helmet impact performance: anvil inclination, helmet–anvil friction, helmet–head friction sensitivity, and helmet–headform size mismatch on head kinematics, including peak linear and rotational accelerations which would help in designing more safer helmets.
ID 232	Finite Element modelling of the Laser Powder Bed Fusion process to study melt pool; a novel meshing technique is proposed to depict the melt pool morphology at lower computational cost.
ID 233	We demonstrated that by combining container orchestration, self-healing mechanisms, and real-time monitoring, an edge computing system can attain high levels of fault tolerance and availability in a manufacturing setting.
ID 234	A novel Data-driven Live DOM (Document Object Model) editing technique was introduced that empowers stakeholders to create and test prototypes of web pages, without the direct involvement of engineering teams.

TWEETS

ID 239	Sustainability awareness in packaging is rising, but lacks clarity, rules, and collaboration. Clear standards, innovation, education, and interdisciplinary efforts are crucial to achieve circular packaging and eco-friendly consumer practices.
ID 243	AI and automation give colleges staff do less manual work, improve their performance in handling administration, improved data security access, helps the campus to become smarter and ready for future.
ID 244	The paper finds that AI and automation can significantly streamline publishing by enhancing efficiency in formatting, editing, translation, and SEO, but human oversight remains essential for creativity, credibility, and linguistic sensitivity.
ID 245	Design an app based medical services for people living in remote areas like hilly areas of Uttarakhand in India: A case study and solution
ID 246	The packaging design industry has the opportunity to implement smart tech enabled practices that can better respond to the current speed of modern markets to provide appropriately timed packaging design solutions
ID 255	This study implements the design considerations for making the die and punch of the blanking operation. These design decisions such as easiness of manufacturability, standardization of components, tolerance strategies, and cost-efficiency can be applied in production.
ID 256	The current research dealt with the development of cubic spline trajectory planning for an autonomous surface vessel considering its kinematic constraints.
ID 272	Decision Support Problem with the goals of satisfying conditions for Quantum Image Representation, with the anticipation that this work will contribute towards increased efficiency in deploying resources for large-scale agriculture.

ID 279	Industry 4.0 reshapes product design and manufacturing, requiring new pedagogical approaches. This paper proposes a conceptual framework for value-driven smart product design, and supports educators and researchers in engineering education.
ID 282	Traditional farming and modern tech with AI-driven tools like weather forecasting, disease detection, and market access can empower Indian farmers.
ID 285	By combining decentralized trading, smart monitoring, and subsidy integration, SolarHub transforms the use of renewable energy in India and positions individuals and companies as active participants in a sustainable energy revolution
ID 289	The TiN−20wt% TiB2 and TiN−20wt% Si3N4 nanocomposites processed through pressureless microwave (hybrid heating) sintering at high heating rates resulted in moderately dense composites with intact initial phases and minor oxides.
ID 293	The study finds that steep learning curves, fragmented software ecosystems, limited access to advanced equipment, costly training, and misaligned curricula collectively hinder Education 4.0 from effectively preparing students for Industry 4.0 readiness
ID 297	The paper demonstrates that an AI-driven, Industry 4.0-enabled assistive headset significantly improved visual acuity and reading ability in visually impaired users, highlighting the transformative potential of personalizing assistive devices.
ID 298	Integration of digital modelling, CNC machining, and vacuum forming enabled the successful development of a precise, manufacturable prototype, showcasing the effectiveness of combining traditional and modern techniques.

TWEETS

ID 300	The most important finding is that limited therapy hours and low autism care awareness hinder progress, AR /VR based parental training enables ongoing at home support, bridging this critical gap in caregiver engagement.
ID 301	The most important finding is that wearable sensors can enhance posture accuracy in classical dance, enabling global learning, preserving authenticity, and making technology integration a game changer in cultural education.
ID 304	Auxetic structures enhance energy absorption in steel hat sections, delay buckling and increase strength, offering potential for lighter, safer automotive designs through simulation-driven approaches
ID 307	Generative AI framework integrating CVAE, FOA-CatBoost, and NSGA-II achieved 50–80% cost savings and over 40–50% carbon reduction in concrete mix design without compromising compressive strength.
ID 311	The study indicates that servant leadership most effectively fosters Organizational Citizenship Behavior, which mediates leadership's influence on employee retention, thereby enhancing innovation, cohesion, and sustainability within startup organizations.
ID 316	A social robot with voice recognition, emotion-displays interface, and touch interaction has been designed for preschool learning, aligning with Industry 4.0 by providing digitalized, interactive, and emotion-responsive learning situations.
ID 325	Random analogy triggered disruptive thinking dares the mind to draw varied magnitude of inferences from mundane things by holding logical reasoning and idea negation at bay, facilitating innovative idea generation.

ID 335 Bamboo strips, rather than whole culms, effectively harness bamboo's tensile strength to create a structurally robust, lightweight, and innovative bicycle frame through creative design exploration.

ID 341 The study proposes a unified Design Task ontology and syntax to frame design tasks of varied complexity to be administered for the assessment of Design Competence beyond skill, across disciplines.

TWEETS

KEYNOTE SESSION: 1

Prof. Sunil Jha

Mechanical Engineering,
IIT Delhi

Future-Proofing the Workforce: Integrating Digital Twins and Extended Reality (XR) into Advanced Manufacturing Education

Chair: Prof. B. Gurumoorthy
Timing: 9:00-10:30 AM
Location: Main Hall, J N Tata Auditorium

Prof. Sunil Jha

Mechanical Engineering, IIT Delhi

Bio: PhD in Manufacturing Science from IIT Kanpur, with over 18 years of experience in teaching and research in manufacturing processes and automation. Developed unconventional super-finishing processes and filed 12 patents, several of which have been successfully commercialized. Previously worked at TATA Motors, Jamshedpur, in the area of CAD/CAM, contributing to the digitization of engine components and development of foundry tooling. Has extensive experience in manufacturing automation. Currently teaches Computer Aided Manufacturing and Industrial Automation to undergraduate and postgraduate students at IIT Delhi, conducts training programs for industry and engineering faculty, and has developed online courses on Industry 4.0–related technologies. Actively integrates emerging technologies into teaching and pursues state-of-the-art research. Currently leads the IITD–AIA Foundation for Smart Manufacturing at IIT Delhi, working closely with industry to support technology adoption and readiness for the next industrial revolution.

Abstract: The transition to Industry 4.0 is creating a profound skills gap in the advanced manufacturing sector, demanding a workforce proficient in cyber-physical systems, data analytics, and digital collaboration. This keynote addresses how two transformative technologies—Digital Twins and Extended Reality (XR: AR/VR)—can be integrated into educational and training frameworks to future-proof the manufacturing workforce. Digital Twins offer a risk-free, high-fidelity 'sandbox' for conducting complex training scenarios, predictive maintenance drills, and process optimization exercises. Concurrently, XR technologies, specifically Augmented Reality (AR), can provide on-the-job guidance and remote expert assistance, while Virtual Reality (VR) simulates dangerous or high-cost manufacturing operations for immersive learning. The lecture will propose a scalable collaboration model between research institutions and industry to co-develop curricula utilizing real-world industrial data and simulation tools. Ultimately, this presentation will outline policy recommendations for national educational and industrial bodies to accelerate competence development and effectively bridge the critical skills deficit required for a globally competitive advanced manufacturing ecosystem.

KEYNOTE SESSION: 2

Mr A.N. Chandramouli

ANCM Management Consultants, India

Lean 4.0 - an integration framework of Lean Automation and Digital transformation of Lean

Chair: Prof. B. Gurumoorthy, IISc, Bengaluru
Timing: 9:00-10:30 AM
Location: Main Hall, J N Tata Auditorium

Mr A.N. Chandramouli

ANCM Management Consultants, India

Bio: A. N. Chandramouli is a senior manufacturing leader and management consultant with over four decades of industrial experience spanning machine tools, automation, precision manufacturing, and operational excellence. He is a Mechanical Engineering graduate from NIT Trichy and holds a Postgraduate degree in Management from IIM Calcutta. He has held top leadership roles including Managing Director and Board Member of Starrag India for 12 years, CEO of Makino India for 6 years, and senior executive positions at LAPP India, Cooper Bussmann India, Amtrex Hitachi Appliances, Unilever Exports, and Tata Motors. Across these roles, he has led greenfield manufacturing ventures, established state-of-the-art factories and technology centres, launched Make-in-India machine tool platforms, and driven large-scale precision machining, automation, and Industry 4.0 initiatives. Deeply involved in skill development and industry–academia collaboration, he has contributed to vocational training centres and Industry 4.0 skill academies covering factory automation, additive manufacturing, and smart manufacturing. Since 2017, he has been running ANCM Management Consultants, advising MSMEs, startups, and institutions in Industry 4.0, Industrial IoT, operational excellence, sales excellence, and technology-led transformation. Chandramouli has served in several national and regional leadership and advisory roles, including with IMTMA, ASSOCHAM, CII, QCFI, Capital Goods Skill Council, Aerospace and Aviation Skill Council, and government initiatives such as Samarth Udyog Bharat 4.0, with a strong focus on world-class manufacturing, lean and JIT practices, customer-centric organizations, and future-ready industrial ecosystems.

Abstract: In spite of several virtues, Lean Manufacturing(LM) has some limitations, the most important challenge is due to fixed manufacturing sequences and slow responsiveness, associated with increasing pressures from customer expectations regarding product variability, LM may not meet the new needs, and its suitability for future value chains can be limited. Industry 4.0 attempts to overcome this handicap- through Lean 4.0- which is nothing but a coherent integration of various Lean concepts, tools and techniques with various appropriate Digital and Automation technologies and techniques under the banner of Industry 4.0. The purpose is to enhance, augment and reinforce Lean and not displace Lean.

KEYNOTE SESSION: 3

Prof. Suryakumar S

Mechanical & Aerospace Engineering,
IIT Hyderabad

Large Area Metal Additive Manufacturing

Chair: Prof. Vishal Singh, IISc, Bengaluru
Timing: 14:15-16:00 PM
Location: Main Hall, J N Tata Auditorium

Prof. Suryakumar S

Mechanical & Aerospace Engineering, IIT Hyderabad

Bio: His research interests include Additive Manufacturing of Metallic Objects, particularly large sized; Design for Additive Manufacturing; Circular Manufacturing and Industry 4.0. He has developed the largest metal 3D printer in India with a capability of three-meter component height. Beyond the current focus on Additive Manufacturing, he shares a broad passion for manufacturing/ fabrication domain and held various responsibilities related to Innovation & Startups. He is the recipient of Excellence in Teaching award by the Institute for the year 2013 and Excellent in Research award for the year 2020.

Abstract: With the growth of metallic Additive Manufacturing (AM), processes capable of producing large components (more than 1m in size) with high deposition rates have been of particular interest. On this front, arc based deposition processes stands out among the metallic AM processes with their high deposition rates, high material and power efficiency, lower investment costs, simpler setup and less demanding environment requirements. The essential weld-deposition AM system consists of a wire-based weld unit and a multi-axis motion system. This version of AM, usually referred as WAAM (Wire-Arc Additive Manufacturing), yields high deposition rates and large parts can be produced in significantly lesser time. WAAM produced parts are larger in size and surface. Challenges typical with AM like residual stress and distortion, non-uniform properties in build direction, stair stepping effect, and poor surface finish will have to be dealt with here also. Our research focus has been to develop systems capable of depositing large components and addressing various related challenges like: (a) achieving high deposition rates (b) realizing complex geometries either using higher axis kinematics or hybrid approaches (c) thermal management strategies for reducing distortion (d) understanding the microstructure evolution. The presentation will discuss the strategies adopted to address challenges for scaling up of Metal AM.

KEYNOTE SESSION: 4

Prof. David Inkermann

Clausthal University of Technology, Germany

From Design for X to Data and Simulation-Driven Engineering

Chair: Prof. Dibakar Sen, IISc, Bengaluru

Timing: 14:00-15:30

Location: Main Hall, J N Tata Auditorium

Prof. David Inkermann

Clausthal University of Technology, Germany

Bio: Professor Dr.-Ing. David Inkermann has been leading the Chair of Integrated Product Engineering at Clausthal University of Technology since 2021. He earned his PhD from TU Braunschweig in 2016 and subsequently established and headed the Integrated Product Engineering Division at the Institute of Engineering Design. His research focuses on Intelligent and Model-Based Systems Engineering, Reflective and Collaborative Engineering Practice, and Circular Systems and Lifecycle Engineering. At the Institute of Mechanical Engineering, he is building the Circular Design Lab to advance design automation with additive manufacturing. He serves on the board of the Center for Digital Technologies at TU Clausthal (DIGIT), directs the Master's program in Intelligent Manufacturing, and contributes to the Lower Saxony Future Lab for Circular Economy.

Abstract: Product development is undergoing a fundamental shift: Design for X approaches—rooted in heuristics and static expert knowledge—are no longer sufficient for addressing the flexibility and adaptability of modern production. Cyber-Physical Production Systems enable a new way of engineering in which products, processes, and production systems continuously collect and exchange real-time data, simulate alternatives, and learn from one another. This keynote highlights how data- and simulation-driven approaches are redefining engineering practice. Two use cases highlight this transition: simulation and path planning in Selective Laser Melting, and the integration of used components into new product generations. The keynote outlines emerging research needs and implications for future engineering education.

KEYNOTE SESSION: 5

Prof. Dr.-Ing. Eckhard Kirchner
Technische Universität Darmstadt, Germany

Sensorless Sensing Concepts for Mechanical Engineering Applications

Chair: Dibakar Sen, IISc, Bengaluru
Timing: 14:00-15:30
Location: Main Hall, J N Tata Auditorium

Prof. Dr.-Ing. Eckhard Kirchner

Technische Universität Darmstadt, Germany

Bio: Prof. Kirchner received his PhD in Mechanical Engineering from Darmstadt in 1999 for a thesis on shape optimization in nonlinear solid mechanics. Afterwards, he spent 16 years in the automotive industry with increasing management responsibility at GM and its joint ventures and Schaeffler Technologies. His last industrial station was senior technology manager transmission systems in the vehicle electrification unit of Siemens. Since 2016 he holds the chair for product development and machine elements at TU Darmstadt, he is a board member of the German scientific society for product development and spokesmen of the special research program “Sensor integrating Machine Elements”. Recently, he finished his assignment as Dean of the Faculty of Mechanical Engineering.

Abstract: The demand for reliable data in digitalization drives the investigation of sensorless sensing strategies based on machine elements. These exhibit characteristic electrical properties that can be exploited for in-situ condition monitoring. Preceding research suggests sensing possibilities rivaling conventional ex-situ measurements. This contribution outlines, how in rolling element bearings, impedance measurement provides access to operational data, enabling condition monitoring and early damage detection. For gears, distinct impedance responses reveal meshing interactions, surface modifications, and enable novel approaches for lubrication monitoring. This approach opens a pathway toward embedded sensing capabilities directly within core machine components, making further sensor integration unnecessary.

KEYNOTE SESSION: 6

Prof. Kannan Govindan

Centre for Sustainable Operations and
Resilient Supply Chains (CSORSC),
University of Adelaide, Australia

Transition from Traditional to Digital Circular and Net Zero Supply Chains

Chair: Prof. Manish Arora
Timing: 16:00-16:45
Location: Main Hall, J N Tata Auditorium

Prof. Kannan Govindan

Centre for Sustainable Operations and Resilient Supply Chains (CSORSC), University of Adelaide, Australia

Bio: Prof. Kannan Govindan leads the University of Adelaide Strategic Research Centre for Sustainable Operations and Resilient Supply Chains (CSORSC). His research focuses on sustainable and digital supply chains, Industry 4.0, circular economy, and sustainable development, with over 20 years of experience in global logistics and supply chain network design. He develops decision-making models and interactive decision support systems for sustainable and intelligent manufacturing.
He is one of the world's leading researchers in sustainable supply chains, recognised as a Highly Cited Researcher in Engineering for eight consecutive years (2018–2025). He has published over 475 journal articles with 74,660+ citations (h-index 143) and serves in senior editorial roles, including Editor-in-Chief of Cleaner Logistics and Supply Chain and Executive Editor of Journal of Cleaner Production.

Abstract: Global supply chains are at a critical turning point. Traditionally, supply chains have been optimised for cost, speed, and efficiency, moving products from raw materials to customers with minimal disruption. However, this traditional model often entailed significant environmental costs: high carbon emissions, resource depletion, and waste generation at every stage of production and logistics. Today, the focus is shifting toward net zero and circular supply chains, systems designed not only for economic performance but also for climate responsibility, regenerative, long-term resilience, and digital connectivity. This transition represents a paradigm shift from linear "take-make-dispose" models to digital circular ecosystems, where resources are kept in use for as long as possible, materials are recovered and reused, and digital intelligence enables transparency and accountability across the entire value chain. In this keynote, we will explore: The characteristics of traditional supply chains and their processes; the drivers accelerating the shift toward net zero, such as regulation, investor pressure, technology, and consumer demand; the strategies and innovations enabling decarbonization, including circularity, renewable energy, digital traceability, and carbon accounting; and finally, the challenges and opportunities organizations face in aligning profitability with planetary boundaries. By understanding this transition, we can see how supply chains are becoming the backbone of climate action, a transformation essential not only for achieving global net-zero goals but also central to building the resilient, regenerative economies of the future.

8 January 2026 | 14:15-16:00

PANEL DISCUSSION

PANEL DISCUSSION: 1

Supporting Manufacturing Innovation

Prof. B. Gurumoorthy (Chair),
Department of Design and Manufacturing,
IISc, Bengaluru

Prof. Eckhard Kirchner
Technische Universität Darmstadt,
Germany

Prof. Suryakumar S
Mechanical & Aerospace Engineering,
IIT Hyderabad

Dr. T. Parasuraman
GD Naidu Chair Professor,
SRM Institute of science and Technology, Chennai

Dr. S. Devarajan
Sr. Vice President,
TVS Motor Company

Mr. A.N. Chandramouli
CEO,
ANCM Management Consultants, India

Col K Joshil Raj (Retd), Ph.D
CEO, Centre of Excellence in Design,
IISc, Bengaluru

PANEL DISCUSSION: 2

Supporting Manufacturing Education

Prof. Satish Vasu Kailas (Chair),
Department of Mechanical Engineering,
IISc Bengaluru

Prof. Arlindo Silva
Singapore University of Technology and Design,
Singapore

Prof. David Inkermann
Integrated Product Engineering,
TU Clausthal, Germany

Prof. Kannan Govindan
Centre for Sustainable Operations and Resilient Supply Chains (CSORSC),
University of Adelaide, Australia

Dr. Nagahanumaiah
Director,
Central Manufacturing Technology Institute (CMTI)

Prof. Apurbba K Sharma
Head of Department, Department of Design,
IIT Roorkee

Prof. S. Vinodh
Department of Mechnaical Engineering,
NIT Trichy

9 January 2026 | 17:00-18:00

PANEL DISCUSSION

DAY 1
WORKSHOP - 1

DeScIn

DeScIn
Academy of Design Sciences
Foundation India
&
DRM Gurukooll

Dr. Shakuntala Acharya &
Dr. Srinivasan Venkataraman

Timing: 16:30-18:30 PM
Location: JN Tata Main Hall

DAY 2
WORKSHOP - 2

Springer Author Workshop

Swati Meherishi

Timing: 11:00 AM - 13:00 PM
Location: JN Tata Hall C

9 January 2026 | 11:00-13:00

WORKSHOPS

Notes:

DAY 1

PARALLEL SESSIONS

8 January 2026 | 11:15-13:15

Tracks

Digital Manufacturing: JN Tata Main Hall
Chair: Dr Koushik Viswanathan

Materials Processing & Joining: Hall A
Chair: Dr Subhas C Mandal

Industry X.0: Hall B
Chair: Dr Arlindo Silva

Sustainable Manufacturing: Hall C
Chair: Dr Monto Mani

ARTEMIS: A VR based application to train Clinicians and Lab Technicians with techniques to deal with Antimicrobial Resistance

***Rithvik Ramadas (1), Nandini Louganee (1), Pavan Kumar (2), Akhil Guthula (1) and *Srinivasan KK (1)*

(1) Optum Global Advantage – Digital Experience Team
(2) Arcesium

AMR or Antimicrobial Resistance is a serious issue that is happening across the globe where multiple strains of pathogens like bacteria, viruses, amoeba and fungi develop resistance to all known antibiotics. This happens due to overprescription of antibiotics and due to global warming, we observed the former happened a lot during the Covid 19 pandemic where there were multiple reports that indicated that bacteria had developed antimicrobial resistance. This resulted in several patients losing their lives due to exposure to such pathogens. It is anticipated that future pandemics could happen due to AMR resistant straiacns of various pathogens. There are solutions available to tackle such strains like phage therapy, bacteriocins, antifungal compounds secreted by competing microorganisms, however there is lack of knowledge among clinicians and lab technicians alike. Moreover, the cost of training and the cost of kits used to produce these new age therapeutics is very costly and requires multiple number of them to train clinicians. Considering the promise of VR based training that increases learnability and saves cost; to solve this problem we introduce ARTEMIS a VR application to train clinicians and lab technicians on manufacturing techniques to deal with a variety of AMR resistant pathogens. ARTEMIS stands for Antibiotic Resistance Termination and Epidemic Mitigation Information Source, in this study we present how we designed this application, the background study of the problem and the summary of the Usability Test of this application deployed on a Meta Quest 2 with Clinicians and Lab Technicians.

Sustainable EV Battery Recycling: Robotic Disassembly via Bayesian-Optimized Multi-Resolution CNN

**Chiranjibi Champatiray (1), Sonali Samal (2), Gokulhari Mahanta (3), Amruta Rout (1) and Mva Raju Bahubalendruni (4)*

(1) Christ University
(2) Alliance University
(3) National Institute of Technology Patna
(4) National Institute of Technology Puducherry

As the number of electric vehicles (EVs) grows, recycling EV batteries efficiently and safely becomes increasingly vital. Manual disassembly is slow and hazardous. In this work, we propose an automated approach for robotic disassembly that integrates Bayesian-optimized curriculum learning with a multi-resolution aware Convolutional Neural Network (CNN). The Proposed method integrates advanced computer vision with curriculum learning to enable accurate, real-time detection and classification of battery components under challenging conditions. At the same time, Bayesian optimization fine-tunes the model to maximize accuracy and minimize inference time with minimal computational overhead. The method is suited for industrial deployment in commercial recycling operations, as evidenced by the consistently good performance under various environmental circumstances. A practical and safer way to recycle EV batteries is with the AutoDisCNN (Automated Disassembly Convolutional Neural Network), which promotes a circular economy in the automotive industry.

Casting Quality Improvement using AutoCAST Simulation

*Amar Yekane (1) and *Simran Mukadam (2)

(1) Finolex Academy of Management and Technology
(2) Emirates Solutions

Quality is the important aspect of a foundry to manufacture acceptable casting in a cost effective manner. Improving quality offers many financial benefits to the foundry. For the high quality, necessity of process control has been discussed in this work. By using casting simulation, an optimum gating system can be designed to improve the quality of the casting. This paper presents work on analysis of a real world industrial casting for quality improvement and defect elimination. A commercially available software AutoCast has been employed for this purpose. Simulation technique has been used to predict the shrinkage porosity defects in the casting and its effects on casting quality and rejection. The modifications suggested in this paper resulted in 4.50% decrement in rejection at overall foundry level. Considerable improvement in quality has been realized.

Implementation of Data Analytics and Quality Prognosis System in Vertical Centrifugal Casting

*Dhaval Anadkat (1) and Amit Sata (1)

(1) Marwadi University

Data analytics and Quality Prognosis in Vertical Centrifugal Casting plays a significant role in defect identification and prediction. This paper presents a novel approach for design and development of DAQPS in VCC. The system leverages real-time data capture and sophisticated analytical models to enhance monitoring, control, and prediction of casting quality. Through the integration of various sensors, critical process variables such as temperature, speed and direction of rotation are continuously monitored. The system not only collects the data, but also detects the patterns that can cause potential defects and enables predictive control to control the same during the manufacturing process, all by using the data received through the sensors embedded to the IoT system. The prognosis system offers insights into the quality of the components and intimates for the probable defects at early stages in the production stage minimising the waste and optimising the production yield. Implementation of such system enables manufacturer to realise the dependencies on various parameters and make the necessary changes to avoid the quality issues. This data-driven strategy design marks a significant milestone in the digitalization of centrifugal casting with better process optimization and quality control.

Human-Centric Automotive Interface Design: Enhancing Safety and Usability through DFX in Industry 4.0

**Vignesh Medchalam (1), Anoop Saxena (1), Bhaktadas Bora (1) and *Bisheshwar Haorongbam (1)*

(1) Industrial Design, National Institute of Design Assam

Design for X (DFX) is a fundamental enabler of Industry 4.0, driving advancements in safety, usability, and manufacturability across various sectors. Modern automotive interfaces increasingly rely on touchscreen controls, raising significant concerns over driver distraction and accessibility. Recognizing this issue, Euro NCAP has announced new safety regulations effective from January 2026, emphasizing the need for intuitive physical interfaces over purely digital controls. Research in human-machine interaction (HMI) highlights that haptic feedback and tactile inputs significantly reduce cognitive load, enhancing ease of use and overall driving experience. This project focuses on redesigning the HVAC (Heating, Ventilation, and Air Conditioning) system by replacing touch-based controls with physical, user-friendly mechanisms that provide immediate feedback and improve interaction efficiency. The approach integrates seamless dashboard placement, ergonomic accessibility, and minimized visual demand, ensuring that drivers can operate the system without prolonged attention shifts. Through a user-centered design process, informed by primary research with drivers, the outcome prioritizes enhanced functionality, safety, and regulatory compliance, reinforcing the role of physical interfaces in future automotive interaction.

Eco-friendly Air Purifiers Using Smart Design and Manufacturing Practices

*Angana Sutradhar (1) and *Ram Krishna (2)

(1) Department of Mechanical Engineering, NIT Jamshedpur
(2) Department of Metallurgical and Materials Engineering, NIT Jamshedpur

The present paper proposes a novel design and fabrication concept for a 3D-printed spherical air filter integrated with a built-in micro vacuum system to address the increasing demand for a sustainable and people-friendly air cleaning solution. Its sculptural design and highly functional features make the device a smooth and unobtrusive fit within contemporary living interiors. The spherical shape has a double-finish surface with an aesthetically patterned air intake ring that gives optimum airflow with a dust collection feature. An onboard vacuum system offers an automatic collection of particles settling on the surface of the filter and globular perforations with optimum long-term performance. The vacuum operates on a micro-turbine mechanism, routing dust to a detachable collection chamber for easy disposal. Environment-friendly materials such as PLA (polylactic acid) for 3D-printed parts reinforce the device's green philosophy. Other technologies like ambient lighting, touch controls, and modularity also improve user experience. This revolutionary air purifier combines the dual objectives of improved indoor air quality and lower environmental footprint, a quantum leap in indoor air cleaning technology.

Mixed Reality-Driven Interactive Digital Twin for Manufacturing Systems

*Suveg V Iyer (1), *Kuldip Singh Sangwan (1) and Dhiraj Sangwan (2)*

(1) Birla Institute of Technology and Science Pilani
(2) CSIR – Central Electronics Engineering Research Institute, Pilani

The rapid adoption of Industry 4.0 technologies such as IoT, digital twins have created major skill gaps in the manufacturing workforce. To overcome these challenges, this paper proposes an Interactive Digital Twin (DT) enhanced with Mixed Reality (MR) framework. The framework is based on an IoT data acquisition system that feeds real-time operational data inputs to both the DT and MR interface. This facilitates for the dynamic visualization of machine parameters through MR, and deeper analytical insights through the DT. The framework was validated in an Industry 4.0 compliant assembly process chain. The paper also discusses the use cases for the proposed solution highlighting how human resources interact with holographic models, receive real-time guidance, and solve problems faster. By combining real-time IoT data with immersive MR training and DT analytics, this solution aims to address the skill gaps in modern manufacturing. It empowers workers to make better decisions, speeds up hands-on learning, and streamlines complex processes. The proposed approach increases workforce adaptability, promotes safer and more cost-efficient operations in a manufacturing environment.

From Sketch to Simulation: How AI is Revolutionizing Fashion Prototyping

*Sameer Sutar (1), *Suyash Malwadkar (1) and *Nitin Hadap (1)

(1) Symbiosis International (Deemed University)

The integration of artificial intelligence (AI) into fashion design is revolutionizing the industry by enhancing creativity, efficiency, and sustainability. AI-driven tools, machine learning algorithms, and digital design software are transforming the creative process, enabling designers to generate patterns, predict trends, and optimize supply chains with unprecedented accuracy. AI facilitates trend forecasting through data analytics, automates design generation using neural networks, and enhances digital fabrication with smart textiles and 3D printing. Furthermore, AI contributes to sustainable fashion by minimizing waste, optimizing material usage, and advancing eco-friendly production practices. AI-driven analytics allow brands to predict consumer preferences by examining social media trends, search patterns, and purchasing behaviors. Companies like IBM and Google have developed AI models that assist fashion houses in making data-driven design decisions. Generative AI tools like Adobe Sensei and CLO 3D create innovative patterns and recommend fabric choices, streamlining the design process. Smart textiles embedded with AI-driven functionalities offer new possibilities, including temperature-regulating fabrics and interactive clothing. Despite its many advantages, AI adoption in fashion presents challenges. Ethical concerns, data privacy issues, and the potential loss of traditional craftsmanship are significant considerations. Additionally, high implementation costs may limit accessibility for smaller fashion brands. However, as AI technology continues to evolve, it holds immense potential to drive innovation, efficiency, and sustainability in fashion. This paper explores AI's impact on the fashion industry, its applications, challenges, and future prospects. By embracing AI, fashion designers and brands can enhance their creative processes, improve sustainability efforts, and meet evolving consumer demands, ultimately shaping a more technologically advanced and eco-conscious fashion landscape. This study adopts both qualitative and quantitative research, including expert interviews and industry reports. AI-based trend analysis and case studies examine AI's exert influence on design automation and sustainability. The findings highlight AI-driven breakthroughs, difficulties, and potential possibilities in the fashion business.

Experimental and Analytical Studies on the Influence of Bamboo Fiber Forms on the Bamboo Fiber Reinforced Polymer Matrix Composite Lamina

**Vishwash B (1), Shivakumar N. D. (1), Sachidananda K. B. (2) and Rajath S (1)*

(1) Indian Institute of Science, Bangalore
(2) Sri Krishna Institute of Technology

Bamboo fibers can be isolated from the bamboo culm in single form, bundle form, and strip form. They can also be processed to obtain other forms, like yarn and woven mat forms. In this study, we considered three different forms of bamboo fibers, namely strip form, bundle form, and yarn form, to study their influence on the tensile strength and engineering constants of the polymer matrix composite lamina when used as reinforcements. The bamboo fibers under study were extracted from the bamboo culms grown in the western coast plains of India, locally known as ‘Pannangi’, having a biological name ‘D.stocksii’. The study was conducted on the bamboo fiber-reinforced epoxy matrix composite lamina at varied fiber volume fractions and orientations. Experimental and analytical studies were conducted on the bamboo-epoxy composite lamina using the mechanics of composite materials. Each category of lamina, namely ‘strip form bamboo fiber reinforced epoxy lamina’, ‘bundle form bamboo fiber reinforced epoxy lamina’, and ‘yarn form bamboo fiber reinforced epoxy lamina’, showed unique merits and demerits concerning the processing of bamboo fibers, manufacturing, and performance of lamina under tensile load. Based on the results of the study and considering the manufacturing feasibility and performance aspects of bamboo epoxy composite lamina, the study concludes that bamboo fibers in yarn form are the most suitable form to be used as reinforcement in polymer matrix composite lamina. At 40% fiber volume fraction, yarn-form reinforced lamina exhibited an increase in tensile strength and Young's modulus of epoxy by 305% and 445% respectively.

Optimizing Weld Bead Geometry in Flux-Bounded TIG Welding of Al 6061: Effects of Flux Composition, Current, and Flux Gap

**Mir Abul Hassan (1), *Subhas Chandra Mondal (1) and Debasish Das (1)*

(1) Indian Institute of Engineering Science and Technology, Shibpur

Aluminum 6061 is widely used due to its high strength-to-weight ratio and good corrosion resistance, making it a suitable material for structural, automotive, and aerospace applications. Conventional TIG welding offers very little capability to produce full penetration in thick aluminum plates. To address this, Flux-Bounded TIG (FBTIG) welding was employed to enhance the weld penetration of 6 mm thick aluminum 6061 plates using CaO flux. This research examined the impact of welding current (AC, 150–210 A), flux gap (2–4 mm), and gas flow rate (12–14 L/min) on the geometry of weld beads. The results indicated that FBTIG welding significantly improved penetration depth compared to traditional TIG welding, with as much as 214%. Among the process variables, welding current had the most significant influence on bead width and penetration depth, followed by flux gap and gas flow rate. The minimum bead width noted was 9.53 mm, and the highest penetration depth of 6.30 mm was obtained under ideal conditions using CaO flux. Statistical studies employing ANOVA supported the idea that welding current is the primary factor influencing weld quality, with flux gap and gas flow rate having relatively minor effects. Regression analysis demonstrated excellent conformity with experimental data, and although support vector machine (SVM) modeling was explored, regression outperformed SVM due to limited training data. To fully validate such findings, further research is needed to investigate the welds' microstructural evolution and mechanical properties. Such studies would gain a more in-depth understanding of the FBTIG process and its welding capabilities for thick aluminum plates.

Design and Development of Enhanced Lightweight Shock Absorbing Structures using Additive Manufacturing

*Manajit Saha (1), *Ajeet Kumar (1) and Sandipan Datta (1)*

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Additive Manufacturing as a process has allowed the enhancing of complex structures. Shock absorbing components which are essential for protective gears and impact mitigation systems across industries such as sports, automotive, and aerospace, is also one of its important domains. The limited flexibility and effectiveness of conventional shock absorbers may be caused by their rigid designs or high material consumption. This research is primarily concerned with the exploration and development of lightweight, optimum shock-absorbing solutions through the use of 3D printing. Existing research demonstrates the efficacy of metamaterials and cellular structures, although they are constrained by manufacturing limitations. This study optimizes lattice structures using digital design and simulation tools validated by experiments. To make sure these optimized structures not only fulfill performance requirements but also support sustainability, a variety of design iterations are assessed through modelling and physical testing based on variables including deformation behavior, energy absorption, and structural resilience. Thus, this methodology showcases the potential of innovative design in practical safety solutions. This research contributes to the growing field of advanced materials by showcasing the feasibility of shock-absorbing solutions using Additive Manufacturing. For industries seeking efficiency with lightweight and adaptable mitigation technologies, this paves the way for coming generations.

Additive Manufacturing: A Way of Making Customised Jewellery with Reduced Lead Time

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Additive manufacturing (AM) has revolutionized various sectors, enabling the fulfilment of previously unattainable requirements. The jewellery industry stands out as a potential beneficiary of AM, particularly revolutionizing the customized jewellery segment. AM simplifies the direct creation of wax patters for custom-designed-sized jewellery pieces, overcoming complexities inherent in traditional wax mould production along with being highly labour intensive. The present research explores the synergistic integration of 3D printing and investment casting for manufacturing complex, customized jewellery pieces, addressing the limitations of traditional jewellery production. The methodology encompassed CAD modelling, 3D printing optimization, in terms of printing orientation, support structures requirement and surface finish, followed by lost wax casting to achieve the final product. Utilizing Stereolithography (SLA) 3D printing with specialized castable wax resin, highly detailed wax patterns were produced with exceptional precision, capturing intricate features of the jewellery designs. The subsequent application of lost wax casting methods yielded final products with superior dimensional accuracy. The overall results indicate that the integration of SLA 3D printing with investment casting offers a promising pathway for creating highly customized jewellery pieces with enhanced design complexity and reduced lead times, revolutionizing the jewellery manufacturing process.

Feasibility of Torsion-based Compliant Linkage System for Origami 3D Printing

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Due to the necessity of multiple materials and intricate designs, which can complicate production and affect performance, fabricating complex flexible structures such as origami inspired designs through 3D printing often presents challenges. This study introduces a new approach that mitigates such complexities by using a single, uniform material. By using torsion to distribute forces more effectively, we have developed an innovative compliant linkage system that reduces stress during bending. We accomplished this by conducting an in-depth analysis of compliant structures and their inherent ability to reduce stress concentrations. We iteratively refined our design and performed Finite Element Analysis (FEA) on the bridge structure to evaluate load distribution and identify potential failure points; its mechanical performance was subsequently verified through tensile testing. The results showed that by utilizing torsion for more effective load distribution, the proposed compliant linkage system reduces the force required by approximately 99% when compared to a standard dog-bone specimen of the same material and dimensions. Furthermore, our analysis demonstrates that the structure exhibits a predictable and linear response to loading, rendering it ideal for applications that demand durability and flexibility, including origami-based 3D-printed structures. In conclusion, this study demonstrates the efficacy of a torsion-based compliant linkage system for reducing bending stress while maintaining a simple, single-material design. This approach offers a practical and effective solution to the problems of complex flexible structures, especially in the development of 3D-printed origami.

Wastewater 2.0: The Rise of 3D-Printed Biocarriers in Biological Wastewater Treatment Systems

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Novel physically engineered biocarriers for moving bed biofilm reactor process with different shape, size and structure were developed using 3D printing technology. The influence of media shape, size, surface area, and specific surface area was studied using institutional (university) wastewater (WW), comparing with commercial biocarrier Hel-X 13 Biomedium. Using 500 mL reactor volume and filling ratio of 20%, organic loading rate (OLR) was increased from 0.2 to 4.6 kg COD/(m^3·d) by increasing WW flowrate, and dissolved oxygen of 5–6 mg/L was maintained. Throughout the study, all the carriers showed similar COD removal efficiencies ranging in between 87.23% and 91.1%, respectively. However, at the end of the study period, total dry biomass was determined, with accumulating from 0.33 g to 1.54 g. However, all biocarriers showed comparable performance during substrate uptake rate studies. All the reactors showed similar reductions in total nitrogen attributable to simultaneous nitrification-denitrification and primarily influenced by organics content in the feed water. Structural variations and differences in pore sizes gave thin biofilms in some carrier, which could have facilitated better access to substrates and oxygen in its biofilms, in turn leading to enhanced performance of in some of the tests but testing of biocarrier in synthetic feed having glucose as an main carbon source is not at all suitable which leads to favourable condition for the growth of filament bacteria.

Comparative Analysis of Bulk and Nanomechanical Properties of Copper

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Micropillar compression testing has become a widely used technique for evaluating the mechanical properties of materials at small scales, particularly in micro- and nanostructured materials. However, discrepancies between the results of micropillar compression and conventional bulk compression testing raise concerns regarding the influence of size effects, deformation mechanisms, and experimental conditions on the measured properties. This study compares the variation in mechanical properties, such as yield strength, elastic modulus, and strain hardening, between micropillar and bulk compression tests. By analysing the differences in deformation behaviour, stress-strain responses, and potential size-dependent effects, this research will provide insights into the reliability and applicability of micropillar testing for predicting bulk material behaviour. The findings will contribute to a better understanding of scaling effects in mechanical testing and inform the development of more accurate predictive models for material performance at different length scales.

Automating Ansys Mechanical with Python for Electromagnetic Crimping (EMC) of Cu-SS Tubes

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Multi-material components play a crucial role in advanced manufacturing, providing benefits such as lightweight design, electrical conductivity, and corrosion resistance within a single part. However, joining dissimilar material such as aluminum to stainless steel (Al-SS), copper to aluminum (Cu-Al), copper to stainless steel (Cu-SS), and D9-SS316LN through traditional fusion welding poses challenges. These challenges arise from mismatched physical and mechanical properties, which often lead to issues like hot cracking. Electromagnetic joining (EMJ) is a solid-state, high-speed process that offers a promising alternative aligned with Industry 4.0 principles by avoiding melting and metallurgical bonding. This paper presents an automated, data-driven workflow for electromagnetic crimping (EMC) of copper to stainless steel (Cu-SS) tubular joints using ANSYS Mechanical. The automation is achieved through Python scripting and enables the execution of 625 parametric simulations by varying several parameters, including flyer and base tube thicknesses, input voltage, and working length. This automated simulation pipeline integrates into a digital manufacturing environment, generating large-scale, high-fidelity simulation datasets with minimal user intervention, thereby reducing human error and computational time. The generated datasets are used to train artificial neural network (ANN) models, which facilitate predictive modeling and intelligent decision-making—essential components of data-driven and autonomous manufacturing systems. The dual solver integration automated process, which involves axisymmetric EMC simulation followed by tensile testing of the crimped joint, addresses the current lack of established tools for automating high-strain-rate multiphysics simulations. The results validate the feasibility of this workflow for rapid exploration of design spaces and the development of AI models. This research supports the implementation of cyber-physical systems and intelligent process optimization in next-generation manufacturing environment.

Innovative AI/ML Recommendations for Real-time Arrival of Passengers and Aeronautical Processes at an Airport

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Ensuring timely arrival at the airport is a critical phase for every air traveler, often disrupted by unpredictable traffic conditions, weather variations, dynamic airline schedules, and fluctuating wait times at the airport checkpoints. In this paper, arrival delays to the airport can lead to missed opportunity for boarding the flights. This may lead to the increased stress for passengers, and operational inefficiencies for airports, such as delay in baggage, immigration, and security check-ins and then congestion. Despite these challenges, there is a lack of real-time, personalized solution that provides optimized departure and arrival time recommendations to the passengers. This paper proposes a comprehensive AI/ML-driven solution designed to enhance the passenger experience by addressing challenges from every passenger's location to flight boarding. The system operates in two interconnected phases. Pre-Airport Phase: Focus on predicting the Recommendation Time to Start (RTS) by calculating travel time (using an AI Cantor set) between the passenger's location and the airport terminal, ensuring timely arrival. Post-Airport Phase: Focus on determining the Recommendation Time of Arrival (RTA) at the airport by factoring check-in, security clearance, and boarding processes, through minimizing unnecessary wait times by queuing networks and AI/ML predictions. The proposed solution leverages AI/ML techniques to dynamically adjust departure and arrival recommendations based on real-time traffic patterns, weather conditions, and airport congestion, and then effectively address the following key challenges. Passenger challenge: Unpredictability of airport city traffic and weather conditions and absence of real-time personalized departure recommendations from the passenger's location leading to late arrival at the airport. Airport challenge: Inefficiency of baggage, immigration, and security check-in processes will lead to congestion at the airport terminal and then impact the flight boarding process. By and large, the proposed AI/ML RTS–RTA system will improve the airport operational efficiency.

A digitally supported methodical approach for the holistic development of sensor modules for sensor-integrating machine elements

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Due to Industry 4.0, the integration of sensory functions into (existing) technical systems is becoming increasingly important. A promising approach for the integration of sensory functions is the use of Sensor-integrating Machine Elements (SiME). SiME build upon the mechanical functions of conventional machine elements and extend them with sensory capabilities. SiME offer a range of advantages that make them particularly attractive for practical application, e.g. in retrofitting existing machinery for Industry 4.0.
Although SiME are in the focus of the current Priority Program 2305 in Germany, the development of sensor modules for SiME – the core components that enable sensory functions – is still methodically insufficiently supported. Hence, in this contribution, a digitally supported methodical approach for the holistic development of sensor modules for SiME is proposed. First, a detailed functional structure of sensor modules for SiME is systematically derived based on existing SiME. Then, suitable electronic components are identified and assigned to subfunctions, such as data acquisition and signal transfer, creating a corresponding database. Based on user-defined requirements, an algorithm is developed that combines suitable components into sensor modules that meet the specified needs. The algorithm and database are embedded in a GUI, enabling systematic and accessible development of sensor modules for SiME and thus supporting the digital transformation of technical systems.

Analysis of factors influencing transition of Industry 4.0 to Industry 5.0 in the context of automotive component manufacturing organisation: A case study

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As industries are experiencing fourth industrial revolution (I4.0) and ideating towards fifth revolution, lot of technology based developments are in progress. Industry 5.0 (I5.0) is an extended form of I4.0 characterised with achieving digitalisation. However, Industry 5.0 shifts the paradigm by collaborating human intelligence, creativity, and innovation with technologies for organisational development, and societal well-being. The transition is an evolution rather than a revolution, which aids organisation in overcoming the inhibitors of Industry 4.0 and emphasizes the convergence of digital technologies with humans. Industrial maturity and readiness of I4.0 organisation facilitate the adoption and implementation strategies for the transition. Increasing demand for more personalised products, availability of technological infrastructure, high computational competency, smart systems, collaboration between man and machines, and organisation strategy towards implementing I5.0 and integrating with existing technologies is some significant driving factor for transition along with the involvement of people both as an employee and as a customer. Significant outcomes of the transition will be restoration of balance between humans and technologies. The important question is: What are the influencing factors for an organisational transition from Industry 4.0 to Industry 5.0 for an automotive component manufacturing organisation, and what is their influence level towards transition. The aim of this study is to identify and analyse those factors. A set of influencing factors are identified from existing studies and through expert discussion and analysed using MCDM method. The findings of the study will provide valuable insight for top management, decision makers, stakeholders, and academicians to approach the transition. The priority order of factors will facilitate organisation in meeting the challenges of advances in industrial development.

Opportunities in Smart Manufacturing and Industry 4.0 technologies implementation based on small medium enterprise (SME) perspectives in the precision engineering cluster in Singapore

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This study aims to identify the challenges and opportunities encountered by small and medium enterprises (SMEs) in Singapore as they implement Industry 4.0. This paper reviews the progress realized in other countries concerning the adoption of Industry 4.0 technologies among SMEs. An online survey was disseminated to SMEs within the precision engineering sector. The majority of respondents identified skills and knowledge, costs, and organizational processes as the principal barriers to implementing Industry 4.0. It is observed that smaller organizations, employing a workforce of 50 or fewer, struggle to attract or retain the requisite skills and experience necessary to pursue innovative concepts or technologies. The literature suggests that human resources are critical for most organizations and countries. Nevertheless, if processes are not clearly defined, technology integration will continue to pose challenges. SMEs must standardize their practices and concentrate on aspects that provide value to customers. Once these elements are clearly articulated and realized, these organizations will have an enhanced likelihood of success in the impending industrial revolution. We advocate for the establishment of an SME Center of Excellence (COE) that supports small and medium-sized enterprises needing technical resources. Through government grants, local institutions can provide support from industrial experts to assist SMEs by delivering technical assessments and solutions.

A Comparative Analysis of Manufacturing Processes for Orthopedic Metal Implants in South Asia: Evaluating SMART Foundry, Machining, and Sand Casting

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The increasing prevalence of musculoskeletal disorders and an aging population in South Asia have created a growing demand for orthopedic metal implants, yet selecting an appropriate manufacturing process remains difficult due to trade-offs involving cost, material properties, design complexity, and biocompatibility. This study evaluates conventional machining, sand casting, and the emerging SMART (Sustainable Metal Casting using Advanced Research and Technology) Foundry approach for the production of orthopedic implants. Machining offers high precision and reliable material properties, but is limited by high costs and lengthy processing times. Sand casting offers relative cost advantages but faces challenges in accuracy, surface quality, and customization. The SMART Foundry approach incorporates automation, data-driven monitoring, and efficient casting practices, aiming to achieve a balance between cost, customization, and process performance. To support this evaluation, comparative matrices were developed covering cost, quality, production time, and adaptability, structured according to the Pugh Matrix framework. These matrices represent a key contribution of this work, offering a systematic and transparent method for assessing alternative manufacturing routes. The comparative analysis indicates that machining remains advantageous for precision requirements, sand casting retains relevance for low-cost and simple components, and SMART Foundry shows potential to combine efficiency with flexibility. A hybrid approach integrating machining with SMART Foundry may therefore provide a feasible pathway for improving orthopedic implant manufacturing in South Asia. The study emphasizes that structured evaluation using decision-support matrices can guide balanced process selection without overstating the performance of any single method, while supporting future improvements in implant accessibility and affordability.

Reinforcement Learning for Perishable Supply Chains: A2C and UCB Under Cost Tradeoffs

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This paper presents a comparative analysis of an Advantage Actor-Critic (A2C) reinforcement learning agent and an Upper Confidence Bound (UCB) bandit agent in a simulated perishable inventory control environment with cost-sensitive dynamics. The environment models a single-product supply chain with stochastic gamma-distributed demand and a fixed product shelf life, incorporating holding, shortage, and wastage costs to reflect real-world perishable inventory challenges. An A2C agent is implemented as a neural network actor–critic learner that optimizes ordering decisions via temporal-difference updates and advantage estimates, using state information (inventory levels and age composition). In parallel, a UCB agent employs a stateless multi-armed bandit strategy, selecting a fixed ordering policy based on an exploration–exploitation formula that maximizes expected reward (minimizing cost) with upper-confidence-bound optimization. Both methods are tested across three cost scenarios (low, medium, and high penalties) using 100 simulation runs for each case. Performance is evaluated based on total and component costs, with statistical validation using the Mann–Whitney U test. Key results indicate that the UCB agent consistently outperforms the A2C agent, achieving lower total costs and more stable (lower variance) outcomes across all scenarios. The A2C approach exhibits higher cost variability and underperforms in the high-penalty scenario, indicating reliability issues when shortage and wastage costs dominate. This highlights the trade-offs between adaptive deep reinforcement learning and simpler bandit-based strategies. In cost-sensitive supply chains, a well-tuned bandit method can exceed the performance of a complex RL approach, underscoring the importance of aligning algorithm complexity with problem structure for effective real-world deployment.

Smart Glasses for Indian Sign Language (ISL) to English Conversion

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In the context of Industry 4.0, we are trying to develop smart glasses which have the capability of converting Indian Sign Language (ISL) gestures into English text and then voice. The primary purpose of this is to bridge the gap between individuals with hearing disabilities with modern wearables and make them feel inclusive in the society. Once the ISL gestures are converted into English text, we will integrate an API to further translate and convert the text into other languages, ensuring a more global reach. The proposed solution of smart glasses would have a small camera and speaker, where the camera would be reading the sign language gestures and converting them to speech which will be the speaker output. Camera captures the video data and sends it to the nearby connected device (Mobile/Laptop) over WiFi or Bluetooth. Smart Glasses use Fog computing where the data is sent to a nearby Mobile/Laptop for processing and results are sent back to the smart glasses. We are using the MediaPipe framework for hand gesture recognition, with deep learning models and object detection API or models for the classification of the gestures. Finally we would deploy it on the wearable using TensorFlow Lite or TinyML for high performance with minimum computing. The need for an efficient GPU, limited availability and quality of ISL Dataset, and the optimization of latency and frame rate are some of the challenges that we have. A core tenet of this initiative is developing a product that's not only useful, but also human-centered. Through frugal innovation we want to integrate the use of wearables. This paper presents a novel approach to create a scalable, sustainable, human-centric solution for ISL translation. The future development would be developing a wearable that is affordable and appealing to the general public, making it accessible to a broader audience.

Leveraging Augmented and Virtual Reality for Parental Training in Autism Care: A Digital Solution for Therapy at Home Authors

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Parents of children with autism often struggle with performing therapeutic exercises at home, including physiotherapy, sensory activities, and speech therapy. Although healthcare professionals provide guidance, it can be difficult for parents to accurately replicate these exercises without direct supervision, hindering their child's progress. This paper explores how Augmented Reality (AR) and Virtual Reality (VR) technologies can improve parental training and caregiving precision. By integrating AR and VR, parents can engage in immersive learning environments that guide them through physiotherapy exercises, demonstrating correct postures and movements in real-time. VR simulations can also be tailored for sensory and speech therapy, creating interactive and visual scenarios that replicate therapeutic activities. These technologies offer parents the opportunity to practice in a low-pressure, virtual setting before applying the exercises in real life. Additionally, the system can provide real-time feedback and progress tracking through digital platforms, allowing parents to adjust their approach and enhance the accuracy of the exercises. The integration of these technologies reduces the cognitive burden on parents and offers a more personalized, accessible method for home-based therapy.
Ultimately, AR/VR solutions enhance the caregiving experience by improving therapy accuracy, increasing parental confidence, and making it easier for parents to provide effective care for their children, all while ensuring the child's progress is tracked and supported.

A Framework for Assessing Sustainability Conflicts in the Design of Medical Devices

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Medical devices are essential in healthcare, improving patient outcomes and life expectancy; however, their sustainability poses challenges due to conflicts among the three pillars—environmental, economic, and social. Current practices often prioritize economic or social aspects, such as cost reduction or usability, at the expense of environmental sustainability, or vice versa, and despite growing awareness of these issues, a comprehensive framework to assess and quantify sustainability conflicts in medical devices is lacking. This paper presents a framework designed to identify and quantify conflicts among the three sustainability pillars within medical devices by first identifying potential conflicts through evaluation of the impact of design choices on each sustainability pillar, highlighting areas where trade-offs may arise. Once conflicts are identified, the framework quantifies these impacts by integrating Multi-Criteria Decision Analysis (MCDA) and sustainability assessment methods, generating an overall sustainability score that reflects the relative contributions and trade-offs from all three pillars, allowing for a balanced evaluation of design options. This work aims to contribute to the development of a standardized methodology for assessing sustainability in medical devices by proposing a framework to quantify trade-offs among the three pillars, supporting data-driven decision-making in the design process, and by addressing conflicts among the pillars, the research seeks to improve the sustainability of medical devices while ensuring that functional, ethical, and regulatory requirements are met.

Fashion in the Metaverse: The Digital Solutionism Dilemma and the Sustainability Perception Gap

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The rise of the Metaverse has sparked a revolution in the fashion industry, creating new opportunities for brands and consumers to explore digital fashion, NFTs, and AI-driven designs in immersive virtual spaces. Advocates of Metaverse-based fashion argue that it offers a sustainable alternative to traditional garment production by eliminating material waste, reducing carbon footprints, and promoting circular business models, and by shifting focus from physical to digital garments, proponents suggest that the environmental impact of clothing production, particularly its contribution to textile waste and pollution, can be mitigated. However, this vision is deeply rooted in digital solutionism—the belief that technological innovation can singularly address sustainability challenges- and the assumption that digital fashion is inherently more sustainable overlooks the environmental costs associated with the infrastructure supporting these virtual spaces. The energy demands of AI, blockchain technologies, and data storage contribute significantly to the environmental footprint of Metaverse fashion, often shifting the focus from tangible production processes to the hidden environmental toll of digital systems. This paper critically examines the gap between perceived and actual sustainability in Metaverse fashion, addressing whether digital clothing genuinely reduces environmental impact or simply redistributes concerns to less visible, energy-intensive sectors. A mixed-methods approach is used, combining consumer perception surveys and industry case studies to understand both public opinion and the practical implications of virtual fashion, and preliminary findings reveal a significant disconnect between consumer perception and the actual environmental consequences of digital fashion, underscoring the need for increased transparency, standardized sustainability metrics, and a more holistic approach to evaluating the environmental impact of virtual garment production.

Revolutionizing Fashion Manufacturing: A Novel Approach to Least Pattern Making

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The fashion industry's growing environmental impact has prompted the investigation of sustainable manufacturing practices, as traditional pattern-making techniques frequently generate significant fabric waste, contributing to landfill overflow and resource depletion. This paper proposes a novel approach to least pattern making that reimagines traditional design methodologies, introducing a method and technique consistent with sustainable manufacturing principles while emphasizing versatility, flexibility, and productivity in garment production. The proposed approach optimizes fabric usage while maintaining design integrity and aesthetic appeal, and the paper describes the entire process of this innovative least pattern-making system from concept to final garment prototype, providing insights into pattern efficiency, scalability, and mass production feasibility. The approach used in this research combines experimental design processes, digital simulations, and prototyping to evaluate and modify the proposed techniques, with data collection including fabric utilization metrics, production efficiency analysis, and stakeholder feedback via structured interviews and surveys. Furthermore, the study investigates the economic and environmental benefits of minimal pattern-making, such as cost savings, a lower carbon footprint, and alignment with circular fashion principles. To ensure that the proposed method is practical, the results are validated with key stakeholders in the manufacturing industry, including designers, production managers, suppliers, and sustainability consultants, and this validation process provides critical insights and feedback to refine the approach and ensure its feasibility at different production scales. This paper seeks to bridge the gap between theoretical sustainability concepts and practical implementation, serving as a valuable resource for designers, manufacturers, and academics looking to adopt responsible and resource-efficient production methods, while the novel approach presented challenges traditional practices and paves the way for a more sustainable future in the fashion industry.

A Study of the Sustainable Manufacturing Process of the Bamboo Craft of Burud Ali Cluster in Pune

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Industrialization and the widespread use of plastic and other synthetic materials have disrupted India's sustainable handicraft markets. India has a rich tradition of handicrafts dating back over 5,000 years to the Harappan civilization. Historically, artisans used naturally available materials such as wood, stone, clay, local soil, and shells to create utility items. Since synthetic materials had not yet been developed, craftsmen innovatively utilized these resources for their needs. With the advent of technology, industrialization, and the emergence of man-made materials, the production of both utility and decorative items has significantly increased. Mass-produced products, made using machinery and low-quality, often hazardous materials, are more affordable, leading to a decline in the demand for sustainable, handcrafted goods. This shift has adversely affected Indian artisans and their livelihoods. However, with growing awareness of global warming and the visible impact of environmental and health hazards, society is once again moving towards a greener, more sustainable lifestyle. One such sustainable material, bamboo, has been traditionally used for making baskets and is now gaining recognition in construction and architecture. Bamboo products serve as an excellent eco-friendly alternative to plastic, as they are highly sustainable and completely handcrafted by skilled artisans across India. This study documents the lesser-known bamboo craft practiced in Pune, Maharashtra. The research focuses on a cluster of artisans known as Buruds, who create handcrafted, sustainable products in the heart of the city yet struggle for recognition and financial stability. The study employed the snowball sampling technique to gather data on their craft and economic conditions. Since bamboo is an eco-friendly material, many environmentalists are advocating for Pune's bamboo artisans, encouraging consumers to support their work. This renewed interest offers a ray of hope for the artisans of Burud Ali, potentially revitalizing their traditional craft and livelihood.

The Future of Fashion: Advancing Zero-Waste Design and Circular Economy Practices in Industry 4.0 – A Case Study of Baramati Textile Park and Garment Manufacturing Units in Pune

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The paper focuses on the fashion industry, which is a major contributor to global waste and pollution; some unorganized industries with traditional production methods generate significant amounts of textile waste, while some industries have adopted Industry 4.0 practices. The paper is based on a case study of Baramati Hi-tech Textile Park Ltd and garment manufacturing units around the Pune district. In recent years, there has been a growing interest in zero-waste fashion globally, a design and manufacturing approach that aims to minimize or eliminate textile waste throughout the garment's lifecycle. This paper provides a comprehensive overview of zero-waste methods in Indian garment industries, with special reference to the Pune district as a case study. The present research explores various techniques and strategies for reducing waste in the design, pattern-making, cutting, and sewing stages and discusses the benefits of zero-waste fashion, including reduced environmental impact, cost savings, and increased creativity. Additionally, it examines the challenges and limitations of implementing zero-waste practices, such as the need for specialized skills and equipment, as well as the potential impact on garment design and aesthetics. The methodology adopted includes survey methods, qualitative, quantitative, and mixed research approaches. Finally, the paper offers recommendations for promoting the broader adoption of zero-waste fashion, including education and training programs, industry collaborations, and consumer awareness campaigns. By embracing zero-waste principles and Industry 4.0, the fashion industry can move towards a more sustainable and circular economy, reducing its environmental footprint and contributing to a healthier planet.

Deconstructing the Cement Industry: Challenges and Solutions for a Low-Carbon Future

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Cement was invented around the 19th century, and it changed the definition of construction concerning speed, durability of houses, and strength of a structure, enabling dream shapes to materialize in buildings. With continuous experimentation, the height of structures increased, and connectivity improved through cemented roads and bridges. Today, the rate of urbanization is at its peak, transforming natural landscapes into concrete cities. Cement is a non-pervasive material that prohibits groundwater recharge, leading to soil dryness. Additionally, large cement surfaces contribute to the urban heat island effect. In developing countries, reconstruction has intensified due to aging structures that are 50–70 years old. Cement is non-biodegradable, and construction debris cannot be easily disposed of, further contributing to pollution. Concrete is one of the major contributors to global warming through pollution, accelerated environmental degradation, and rising temperatures. Recognizing these challenges, architects, engineers, and designers are exploring and adopting sustainable construction materials. Advancements in biotechnology have led to material innovations such as mycelium, offering eco-friendly alternatives. Additive manufacturing methods like 3D printing are also emerging to minimize debris and waste during construction. This research explores various eco-options to reduce the environmental impact of construction. Online research and literature review methods were adopted to identify sustainable materials and practices. A set of questions was formulated and validated through discussions with practitioners, stakeholders, and clients. Analysis of the collected data evaluates the effectiveness of various sustainable strategies. Through real-world applications, the study provides insights into challenges and potential solutions that encourage eco-friendly construction practices.

Glass Reimagined: Consumer Perceptions and their Purchase Intention Towards Sustainable Glassware Made from Upcycled Liquor Bottles

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Growing concerns towards the environment and sustainability have given rise to numerous upcycling and repurposing initiatives that address waste management issues. This research focuses on transforming empty discarded liquor bottles into functional and sustainable eco-friendly products such as glassware, lamps, platters, and storage jars. Innovative upcycling solutions reduce landfill burden, lower recycling costs, and promote a circular economy. This study examines the challenges, barriers, and motivations behind converting waste glass bottles into high-value products, thereby creating wealth from waste. A mixed-methods approach was adopted. Qualitative data was collected through semi-structured interviews with key stakeholders, including company founders and artisans, providing insights into design processes, sourcing materials from garbage collectors, and challenges faced during production. Quantitative data was gathered through a survey (n=163) of Indian consumers, offering insights into consumer perception and market potential for upcycled glass products. The study highlights successful entrepreneurship, employment generation for local artisans, and significant reduction of glass waste in landfills. Challenges include sourcing discarded bottles, minimizing breakage, and maintaining quality control. Compared to conventional glass recycling, this process is energy-efficient with minimal pollution and carbon emissions. The insights encourage similar initiatives across industries to promote a greener economy.

A Study of Sustainable Craftsmanship: Documenting the Rich Heritage of Banarasi Wooden Toys with a Focus on Eco-Friendly Materials and Traditional Processes

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Wooden toys, a centuries-old craft from Varanasi in Uttar Pradesh, symbolize the region's rich artistic and cultural history. Crafted sustainably from locally sourced sheesham (Indian rosewood) and mango wood, these toys are known for their shapes, intricate carvings, vibrant eco-friendly dyes, and skilled handcrafting techniques. Local artisans follow traditional methods passed down through generations, using hand tools to create idols, dolls, animals, mythological figures, and miniature household items. Lacquer polishing, a unique feature of Banarasi wooden toys, enhances durability and visual appeal. Beyond play, these toys serve as collectibles and decorative items reflecting India's artisanal excellence. This study aims to document and promote this sustainable craft, which faces extinction due to industrialization, declining artisan numbers, and competition from mass-produced plastic toys. Primary qualitative data was collected using the snowball sampling technique from artisans in the Varanasi cluster. Currently, only five families across six generations continue this practice. Despite challenges, initiatives such as promotion of sustainable handicrafts, government-led Geographical Indication (GI) tagging, and increasing consumer awareness have contributed to revival efforts. By leveraging digital platforms and implementing bans on plastic toys, Banarasi wooden toys can sustain their relevance, support artisan livelihoods, and promote sustainable development.

Notes:

DAY 1

PARALLEL SESSIONS

8 January 2026 | 16:30-18:30

Tracks

Digital Manufacturing: JN Tata Hall C
Chair: Dr Senthilkumaran Kumaraguru

Materials Processing & Joining: Hall A
Chair: Dr Apurbba K Sharma

Industry X.0: JN Tata Hall B
Chair: Dr Amar K Behera

DeScIn Academy & DRM Gurukooll Workshop: JN Tata Main Hall
Chairs: Dr Shakuntala Acharya &
Dr Srinivasan Venkataraman

A Hybrid Dimensional Analysis and Neural Network Approach for Process Modeling in Laser Powder Bed Fusion

*Fabian Rahn (1) and *Eckhard Kirchner (1)

(1) TU Darmstadt, Germany

Identifying suitable non-standard process parameters for any additive manufacturing (AM) process is often accompanied by extensive, resource-intensive parameter optimization that does not generalize well across different processing conditions. Calculations and simulations, as alternatives, face significant limitations when applied to highly complex multiphysics problems. Artificial intelligence (AI), particularly its predictive capabilities, combined with large-scale data collection, can enhance process control, offering a promising solution to this challenge. To leverage this potential, a novel hybrid methodology is developed based on the guiding example of laser powder bed fusion (PBF-LB). This methodology combines the mathematical concept of dimensional analysis (DA) with AI. In the first step, the Buckingham Pi-theorem is used to reduce the complexity of the high-dimensional PBF-LB process by identifying physically meaningful Pi groups representing the underlying physics. The resulting dimensionless numbers are then used to train neural networks (NNs) to predict process outcomes. It is demonstrated that a strict application of DA improves the performance of NNs modeling the PBF-LB process outcomes. This enables the derivation of process adaptations for PBF-LB. With minor adaptations, this methodology is also applicable to other AM technologies and potentially even to other manufacturing processes. Ultimately, this approach contributes to more sustainable manufacturing while enhancing both productivity and efficiency and aligns with Industry 4.0 paradigms.

Design of a sustainable Tea/coffee Table using Bamboo and Bamboo/Paper Waste Composite

*Sejal Rastogi (1), Yashasvi Soni (2), Akshay Chandekar (3), Rajnish Mallick (4), Awani Bhushan (5) and *Bisheshwar Haorongbam (1)*

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(3) United World Institute of Design, Karnavati University, Gandhinagar Gujarat, India
(4) Indian Institute of Information Technology, Design and Manufacturing, IIITDM Kancheepuram, Chennai, India
(5) School of Mechanical Engineering, Vellore Institute of Technology, Chennai Campus, India

Since time immemorial, man has been using bamboo for his basic needs. Bamboo and paper waste-based composites have witnessed significant informal innovations in design. In this paper, the use of bamboo and bamboo waste (scrap) as design material is explored. Bamboo culms are used to make the frame of the tea/coffee table. The composite using bamboo scrap/grass clippings with resins/adhesives is utilized to build the tabletop. The adhesive in the form of Fevicol Marine with paper pulps made from waste papers is also tried to bind the bamboo scrap. Additionally, two resins, namely General-Purpose Polyester resin and Clear Epoxy resin, are also tried as binding materials to make laminates for initial explorations.

Towards Three-Dimensional (3D) Printing of Electronic Interconnects using Combined Pneumatic Extrusion and Laser Melting

*Arun Kumar Sivakumar (1) and Manish Arora (1)

(1) Department of Design and Manufacturing, Indian Institute of Science, Bangalore, India.

Three-dimensional (3D) printing of functionals electronic devices is active area of research owing to recent advances in combining conductive and non-conductive materials in 3D printing. In this work, we present an experimental investigation of 3D printing conductive interconnects for fabricating 3D electronics. 3D printed conductive interconnects can enable higher design freedom, form consistency, and compact design as compared to in-layer 2.5D printing. Our methodology for constructing the 3D conductive interconnects consist of depositing the metal powder paste material (Sn96.5/Ag3.0/Cu0.5) and selectively melting the deposited material using a focused laser beam (2.1W, spot size 130µm). The continuity and conductivity of the printed 3d conductive interconnects are crucial for functional performance of the 3d printed electronics. We explore the effect of the laser power and scan speed of the laser on the continuity and conductivity of the 3d printed interconnects. This study opens a new way of 3d print functional electronic devices using combination of simple material extrusion-based additive manufacturing techniques and laser processing.

Dynamic Architecture: Exploring the Impact and Potential of Kinetic Facades in Sustainable Building Design

**Smruti Raghani*

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Kinetic facades represent a significant advancement in sustainable architecture, offering dynamic solutions to enhance building performance by responding to environmental conditions. This study explores the concept of kinetic facades, emphasizing their role in optimizing energy efficiency, occupant comfort, and aesthetic adaptability. By actively adjusting to external factors such as sunlight, wind, and temperature, kinetic facades reduce reliance on mechanical heating, cooling, and ventilation systems, thereby lowering energy consumption and minimizing the carbon footprint of buildings. The research employs a mixed-methods approach, combining literature review, case study analysis, and computational simulations to assess the performance and feasibility of kinetic facade systems. The literature review provides an in-depth understanding of various technologies and materials used in these systems, including motorized panels, shape-shifting surfaces, and biomimetic designs. Case studies of notable projects worldwide are examined to evaluate real-world applications, performance outcomes, and challenges. Furthermore, computational simulations are conducted to analyze the thermal performance and energy savings of selected kinetic facade configurations under different climatic conditions. Key findings reveal that kinetic facades significantly enhance indoor environmental quality by optimizing natural ventilation, daylighting, and thermal regulation. However, challenges such as high initial costs, complex maintenance requirements, and integration difficulties with existing architectural frameworks remain significant barriers to widespread adoption. The study underscores the importance of technological innovation, interdisciplinary collaboration, and cost-effective design strategies in advancing kinetic facade applications. By investigating both the functional and aesthetic dimensions of kinetic facades, this research highlights their potential as a transformative element in sustainable, smart, and responsive architecture, paving the way for more adaptive and energy-efficient built environments.

Product Design Considerations for Blanking Operation: A Case Study on Bell Crank Plate

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Bell crank is basically used for changing input movement by any angle from 0° to 360° but the most common angles being 90° or 180°. It is mostly found in applications in brakes, suspension and steering mechanisms. Since the plate is being cut out from a large aluminium sheet of thickness 5 mm, the operation can be called as blanking operation. Therefore, it is highly essential to design punch and die to perfume error free blanking operation. In this paper, a typical bell crank plate that is used for steering mechanism is taken and the design considerations are applied for making the die and punch of the blanking operation.

Finite Element Modelling of Melt-pool Evolution during Laser Powder Bed Fusion Processing of Ti6Al4V Alloy

**Love Kush Tak (1), *Shakti Kumar (1), *Manish Arora (1) and *Prosenjit Das (1)*

(1) Indian Institute of Science Bangalore

The present study reports development of a Finite Element (FE) based numerical model for the prediction and comprehensive analysis of the melt pool forms in the Laser Powder Bed Fusion (LPBF) processing of Ti6Al4V alloy. The present model studies heat transfer coupled with phase change within the melt pool of single-track build of Ti6Al4V alloy, wherein phase change of both powder and substrate into liquid is accounted for. Experimental validation is performed by comparing melt pool width of single track Ti6Al4V alloy at high laser powers of 310 W and 330 W, and a high scanning speed of 850 mm/s. Different values of laser absorption coefficient (α) are tested at 310 W power and later validated at 330 W. The results confirmed the closest value of melt pool width compared to experimental findings is achieved at an α value of 0.7. The developed FE model deals with a computationally efficient meshing strategy wherein the computational domain is discretised in three different mesh types i.e., coarse, fine and extremely fine. This approach reduces the total number of mesh elements and hence the computational time. Moreover, it produces smooth temperature profile resulting in accurate melt pool prediction. Further, a transient study of phase change is also conducted within the melt pool to understand the temporal evolution of its dimensions, wherein a reasonable agreement of melt pool dimension (width) is achieved with the experimental measurements.

Generative Artificial Intelligence Guided Sustainable Cementitious Material Design

*Teiboklang Chyne (1) and Biranchi Panda(1)

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Existing approaches to enhance concrete sustainability are slow, costly, and often inefficient methods of trial and error. This paper presents a new optimization approach that uses generative models such as variational autoencoders (VEP) to automatically formulate new sustainable concrete mixes. By testing on the available dataset, the results support the effectiveness of the framework in varying concrete mix designs for sustainability and strength factors, and further suggests that VEP method can be easily integrated into new material development task and other engineering applications.

Processing and Characterization of TiN -TiB2 and TiN-Si3N4 Nanocomposites using Microwave Energy with High Heating Rate

**Chintam Suresh Kumar (1), *Apurbba Kumar Sharma (1), Zgalat-Lozynskyy Ostap (2) and Andrey V Ragulya (2)*

(1) IIT Roorkee, India
(2) Frantsevich Institute for Problems in Material Science, Ukraine

Nanocrystalline TiN based nanocomposites with addition of nano-sized TiB2 and Si3N4 particles as reinforcements were sintered using microwave energy. Pre alloyed powder mixtures of TiN−20wt% TiB2 and TiN−20wt% Si3N4 with average particle size ~ 50 nm were consolidated by microwave hybrid heating technique in argon inert atmosphere. Compacts were sintered by exposing to 1100 W microwave power at 2.45 GHz frequency with high heating rates (~200 ℃/min) with and without holding time. Effects of microwave energy on relative density, phase transformation and mechanical properties were studied. X-ray diffraction analysis revealed that the major TiN phase was retained, however, partial or full decomposition of reinforcement phases was also observed. Microstructural evaluation confirmed the compacts retained their nanocrystallinity due to high heating rates and less overall processing time. The structure and mechanical properties of TiN-TiB2 and TiN-Si3N4 nanocomposite systems were characterized. Vickers hardness of the sintered materials were recorded around 2 – 5 GPa, while the structure was moderately dense.

Promoting Eco-Conscious UX Adoption in Industry 4.0: Integrating Behavioral Insights and Empirical Pathways

*Akshada Siddhanti (1) and *Om Singh (1)*

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The rise of AI, cloud computing, and IoT has driven ICT-related emissions to 3.7% of global totals, with data centers alone consuming over 200 TWh annually. Poorly optimized digital design—like autoplay videos and heavy UI—further increases environmental impact. This study explores how sustainable UX/UI, accessibility, and performance strategies can reduce this harm. Using literature frameworks (Karlskrona Manifesto, WCAG 2.1, Fogg Behavior Model) and a LinkedIn Full vs. Lite app case study, it examines the trade-offs between usability and sustainability. Findings show that while lite apps can cut data and energy use, poor execution can reduce trust and accessibility. Barriers include user resistance, business short-term goals, and limited developer support. The study concludes that sustainable UX must be systemic—integrated into design, development, and business values. Embedding eco-conscious decisions into everyday digital interactions can cut emissions and improve user experience. Future work should prioritize inclusive testing, behavior-driven design, and cross-disciplinary collaboration.

Reducing Diagnostic Delay: Exploring the Potential of Innovative Interventions

**Niral Desai (1), Arjav Dave (2) and Srushti Adani (2)*

(1) Karnavati University, India (2) Wellnest Health Monitoring Pvt Ltd, India

The present research paper investigates novel approaches to minimize diagnostic delays in healthcare in the western part of India. The study focuses on three key areas: telehealth and remote diagnostics, artificial intelligence-powered diagnostics, and patient awareness. In the telehealth and remote diagnostics domain, the authors explore the use of telehealth technologies to improve access to specialized care, especially in geographically underserved areas. The aim is to assess the potential of telehealth platforms for facilitating early diagnosis through timely consultations with specialists and reducing unnecessary referrals. Second, it explores the utilization of artificial intelligence (AI) algorithms for analyzing medical data. The objective is to develop and validate AI tools capable of identifying patterns in medical records, imaging studies, and other clinical data. These tools are designed to provide early alerts, aiding healthcare professionals in making accurate and timely diagnosis. The study thus seeks to explore the potential of AI in expediting diagnostic procedures. The third focus area involves patient awareness. It aims to develop and evaluate resources that empower patients to advocate for themselves and navigate the healthcare system effectively. The effectiveness of these interventions in raising patient awareness regarding symptoms, fostering communication with healthcare providers, and encouraging timely seeking of medical care. By exploring these interventions, the study aspires to contribute to the development of a comprehensive approach to minimizing diagnostic delays. It attempts to enhance early diagnosis and timely access to appropriate healthcare. This multidimensional approach recognizes the interconnected roles of technology, artificial intelligence, and patient awareness in addressing the complex issue of diagnostic delays in healthcare.

Can LLMs Detect Numerical Outliers : LLM Aided Machine Prognosis (LAMP)

*Chitranshu Harbola (1) and *Anupam Purwar (1)*

(1) AIGurukul, India

LLMs are well known for their ability to retrieve knowledge from data sources and generate text at scale taking benefit from their Decoder based architecture; however, their capability to handle long, numerically intensive telemetry datasets remains largely unexplored. In this paper, we study the behavior of LLMs in the analysis of industrial machinery telemetry to explore their ability to identify patterns in bearing vibration datasets. For the vibration data, characteristic frequency metrics have been derived using classical physics-based formulas, and synthetic anomalies have been introduced through controlled signal perturbations. Anomaly detection in industrial machinery telemetry is essential for early fault identification and predictive maintenance across a wide range of equipment types. In our experiments, LLMs demonstrated varying performance depending on the model's capabilities in reasoning and mathematical tasks. We benchmarked LLM's performance against established machine learning models. Since machine learning (ML) models are based on numerical computations and loss function minimization, they are generally expected to perform better in detecting anomalies. However, in our experiments, we observed that LLMs, when asked for multishot serialized telemetry data, matched the precision and recall of traditional ML models and, in some cases, exceeded the accuracy by up to 9.09%. We propose an LLM-aided machine prognosis (LAMP) framework, to utilize the growing capability of LLMs for analysis of complex machinery telemetry dataset using conversational natural language.

An Artificial Intelligence-Based Design Framework of Optimal Auxetic Metamaterial Structures

**Vishal Singh (1), Navdeep Malik (2), Bisheshwar Haorongbam (3), Dineshkumar Harursampath (1), Manoj Sahni (4), *Anshul Sharma (2) and *Rajnish Mallick (5)*

(1) Indian Institute of Science, Bengaluru, India (2) National Institute of Technology, Hamirpur, India (3) National Institute of Design, Jorhat, India (4) Pandit Deendayal Energy University, Gandhinagar, India (5) Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram, India

Auxetic metamaterial structures are a type of mechanical metamaterial which exhibits negative Poisson ratio with programmable mechanical properties such as enhanced specific energy absorption, impact resistance, and adaptability. These unique mechanical properties make auxetic structures an ideal candidate for myriad aerospace, biomedical, automotive, and robotics applications, which demand unconventional specific strength, stiffness, and auxeticity. However, conventional design methods often lead to suboptimal structures that fail to maximize their full potential due to limitations in parameter selection and structural optimization. In this research work, a neural-network-based approach is proposed for the design and development of optimal auxetic mechanical metamaterial structures with enhanced auxeticity and improved mechanical properties, which we named Neural Optimized Mechanical Metamaterial Structures (NOMMS). These Neural metamaterial structures will push the design and digital manufacturing envelope of aerospace wing design, biomedical devices, energy absorption structures in automobiles, and robotics. This approach also provides a computationally scalable and data-driven framework for tailoring mechanical metamaterial properties to specific application requirements and ensuring superior performance in dynamic and high-stress environments. Structural analysis and the 3D-printed NOMMS lattice design will also be demonstrated in the full-length paper.

Design for Additive Manufacturing: An Enabler for Industry 4.0

**Gopi Gopal (1) and *Senthilkumaran Kumaraguru (1)*

(1) IIITDM Kancheepuram, India

This paper presents the Design for Additive Manufacturing (DfAM) as an enabler for the fourth industrial revolution (I4.0). There are two approaches in DfAM, primarily based on whether a redesign is for an opportunity to optimise the design to take advantage of the design freedom or the redesign is necessary to address the process constraints. This paper argues the reasons for additive manufacturing as an enabling technology for I4.0, considering the redesign opportunities in products and systems. An overview of additive manufacturing-enabled opportunities in time compression, part consolidation, mass customisation, decentralisation, product simplification, functionalisation, servitisation, personalisation, localisation, and dematerialisation are presented with case studies. From the exemplified case studies, the techno-commercial advantages of the different paradigms are compared to highlight significant improvements in existing products, processes and systems through the adoption of DfAM tools and techniques.

Measurement Dimensions for Industry 4.0 Readiness Assessment

Venkatakrishnan Sankaran (1), Suveg V Iyer (1) and Kuldip Singh Sangwan (1)

(1) Birla Institute of Technology and Science Pilani, India

A comprehensive Industry 4.0 readiness assessment model for Indian manufacturers must evaluate both technological and organizational dimensions. These include strategy and leadership for assessing commitment to digital transformation; technology by examining IoT, automation, and analytics adoption; operations by analyzing process efficiency; products and services focusing on smart features; people and culture by addressing workforce skills; and governance for ensuring compliance with regulations. However, Indian manufacturers face significant hurdles, including limited financial resources, skill shortages, poor digital infrastructure, and complex regulatory frameworks. These challenges are particularly acute for SMEs and rural enterprises. This paper proposes a simplified Industry 4.0 readiness assessment methodology starting with digitizing manufacturing data sources and establishing measurable metrics. The proposed method involves (i) self-evaluation by rating organizations capabilities across defined dimensions; (ii) data analysis to identify strengths and gaps. (iii) benchmarking, and (iv) action planning by developing strategic initiatives to address identified gaps. This approach provides a foundation for building maturity models tailored to the Indian context. The proposed solution by digitizing manufacturing data offers a pragmatic first step toward building maturity models, enabling organizations to measure progress and drive transformation. By focusing on tangible data points through machine connectivity and process efficiency manufacturers can establish a baseline for improvement and scale their efforts systematically.

Enabling Active Participation of AI in Design Thinking Sessions

*Amar Kumar Behera (1) and *Samir Kumar Dash (2)

(1) Indian Institute of Technology, Kanpur, India (2) Accenture, India

A web-based AI tool was developed to explore the role of artificial intelligence (AI) in enhancing the quality and speed of outcomes during in- person design thinking sessions by positioning AI as both a facilitator and an active participant. The effectiveness of AI in overcoming key challenges such as superficial engagement due to time constraints and translating abstract ideas into feasible and actionable solutions was assessed. This study demonstrates how AI can bridge the gap between ideation and implementation, helping teams rapidly generate and evaluate design concepts that align with manufacturing constraints, reducing iteration cycles and enhancing design feasibility.

Resilient Edge Computing Architecture for ML and AI Workloads in Industrial Manufacturing

*Maruti Muthu (1), *Rex Jesu Das (2) and Parth Chokshi (1)

(1) Edge Computing, LTIMindtree, India (2) Edge and Industrial AI, LTIMindtree, India

This paper presents novel architecture for a self-healing edge computing cluster designed to support machine learning (ML) and artificial intelligence (AI) workloads in industrial manufacturing environments. As industries increasingly rely on real-time data analytics and automated decision-making, maintaining system resilience is critical. Our proposed framework leverages distributed industrial edge nodes with intelligent fault detection and autonomous recovery mechanisms. These self-healing capabilities enable the system to dynamically address hardware and software failures, thereby minimizing downtime and maintaining optimal performance. The authors detail the hardware, network and software architecture of the cluster, along with the integration of advanced container orchestration, real-time monitoring, and AI-driven anomaly detection, that collectively enhance the robustness of ML and AI applications deployed at the edge.

IoT-Enabled Wearable Technology and Real - Time Health Monitoring System for Manufacturing and Construction Environments in Gujarat, India.

**Arth Prabhukeluskar (1), Shilpi Bora (1), Arpita Kumar (1), Arnav Pathak (1) and Kishan Chavda (1)*

(1) Unitedworld Institute Of Design, Karnavati University, Gujarat

Workers in manufacturing and construction environments are often exposed to physically demanding conditions that can lead to exhaustion, hypoxia, or cardiac distress due to the unawareness of their body's limitations. This study investigates the vitals [blood oxygen levels (SpO2) and heart rate] of the workers (both male and female) in manufacturing and construction environments. The study used a quantitative research methodology which includes primary research through field visits and worker surveys (23 females and 38 males in Gandhinagar, Gujarat) as well as secondary research on health risks related to physically demanding jobs. Research observations and findings indicate that female workers are more prone to exhaustion and hypoxia due to biological differences, while male workers also encounter same problems but less frequently. The recommended solution is called ProVital, a smart wearable arm strap that uses IoT-enabled health monitoring application which rigorously monitors blood oxygen levels (SpO2) and heart rate of the workers. It comprises of a wearable device combined with an application that provides real time health data visualization and instant warnings in case of abnormal readings. When readings are inappropriate, the device immediately triggers vibration and visual (red light) warnings, instigating the worker to take necessary safety measures, at the same time the app sends notifications to supervisors for instant intervention. A wearable arm strap was developed as proof of concept (POC), Figma for User Interface (UI) design, and Arduino IDE software with C++ programming language for coding of the product have been used for the study. Therefore, this study reflects the design, application, and possible suggestions of ProVital (an IoT device health monitoring system) in workplace, signifying how wearable technology can enhance occupational health standards and reduce worker health risks in manufacturing and construction environments.

Design and Development of a Haptic-Enhanced Virtual Training System for Industrial Workers in Lathe Turning Operations

*Banibrata Datta (1) and *Prasad Onkar (1)

(1) IIT Hyderabad, India

Virtual training systems offer comprehensive training approach for machine tool (MT) operations, helping to mitigate risks associated with unskilled use and prevent machine damage due to operational errors. Currently, most training systems in industry and academia primarily rely on audio-visual interaction. Prior research suggests that incorporating haptic feedback enhances user immersion, making training more effective. However, existing haptic-enhanced virtual training systems for machine tools lack detailed integration of various materials and cutting tool parameters. To address this gap, this paper presents the design of a virtual training system for lathe turning operations with haptic feedback. A virtual environment (VE) simulating different cutting tools and materials, enabling trainees to experience realistic machining scenarios has been developed. The VE is developed using OGRE, with the Virtuose 6D device providing haptic feedback. A geometry-based force rendering algorithm differentiates force feedback for various cutting tools, while material simulations produce distinct force responses. Trainees can feel the force required to hold the cutting tool against the workpiece with preselected feed rates and depths of cut. To evaluate the system, a study comparing the effectiveness of virtual training against conventional instruction on a real lathe, has been conducted. Both training groups are assessed based on task completion time and error count. Initial results indicate that the virtually trained group performed relatively better than those trained through traditional methods.

Embracing Innovation in Craftsmanship: Traditional to Digital Manufacturing Process of the Kolhapuri Copper Jewellery

*Anandita Goenka (1) and Tanmay Kulkarni (1)

(1) Symbiosis Institute of Design, Symbiosis International (Deemed University)

The Kolhapuri copper jewellery symbolises the city's rich history, cultural heritage, and artisanal excellence. Renowned for its ghungroos, or intricately crafted metal anklet bells, this craftsmanship has evolved to include a diverse range of products that integrate traditional motifs with contemporary designs. The jewellery is identified by detailed engravings and symbolic patterns and employs age-old techniques such as embossing and etching, beginning with the careful selection of high-quality copper sheets. Beyond design and the use of technology, Kolhapuri copper jewellery is distinguished by its sustainability, as copper is recyclable, durable, and environmentally responsible, offering a strong alternative to mass-produced ornaments made from synthetic materials. This research explores how the integration of modern technologies, specifically Computer-Aided Design and Computer-Aided Manufacturing, has enhanced design precision, efficiency, and versatility while maintaining the originality of the craft. The study is based on qualitative analysis of artisans representing up to eight generations of inherited expertise. The findings highlight that contemporising traditional designs and expanding accessibility through digital platforms can safeguard the craft and broaden its global appeal. In an era that increasingly values authenticity, craftsmanship, and sustainability, Kolhapuri copper jewellery epitomises heritage while contributing to sustainable development goals. The novelty of the study lies in its proposed framework of preservation, which presents detailed insights into cultural preservation, technological intervention, and sustainable livelihoods that coexist and move beyond solely ensuring economic viability for artisans in global markets.

Optimizing Industrial VR Usability for Enhanced Operational Efficiency and Worker Safety in the Industrial Metaverse

*Janhavi Namewar (1) and *Om Singh (2)

(1) Karnavati University
(2) Bennett University

As industries adopt immersive technologies, optimized VR usability is crucial for operational success. Existing leading solutions like Siemens COMOS Walkinside, AVEVA XR, Hexagon SmartPlant Review, and Dassault 3DEXPERIENCE provide virtualized training, system monitoring, and asset management but face usability challenges, including limited spatial navigation, requiring manual asset location; fragmented real-time data integration, forcing users to switch systems for live monitoring; and non-adaptive interfaces for different user roles, causing information overload for technicians. Nexura, a next-generation industrial VR platform, addresses these limitations by enhancing real-time machine diagnostics, spatial navigation, and immersive maintenance workflows. It integrates a heads-up display (HUD) with system monitoring, a mini-map for navigation, and dynamic hazard alerts—such as fire warnings or restricted zone notifications—ensuring worker safety. Additionally, spectator tracking displays real-time information on nearby workers, improving situational awareness and collaboration. A User-Centered Design approach identified key usability challenges through industry reports, expert interviews with plant supervisors, maintenance managers, and safety officers, and direct user studies with industrial workers. A Goal-Directed Design methodology developed user personas and real-world scenarios, refining workflows through iterative prototyping and UI improvements. Preliminary usability testing with industrial workers, including engineers and field operators, used Heuristic Evaluation to assess improvements in navigation, task efficiency, and user engagement. As per the findings, it indicates approximately 15% reduction in task completion time and a 20% increase in user satisfaction, improving real-time system monitoring. Real-time sensor data integration with predictive maintenance insights and heatmaps, reduce manual diagnostics and enhance collaboration. By addressing key usability gaps in industrial VR, this system bridges real-time operational needs with immersive digital environments, setting a new industry standard for optimizing training, monitoring, and problem-solving in the Industrial Metaverse.

Design and development of Piezoelectric Auxetic Energy Harvesting Devices for Engineering Applications

**Navdeep Malik (1), Vishal Singh (2), Anshul Sharma (1), *Rajnish Mallick (3), Bisheshwar Haorongbam (4) and Dineshkumar Harursampath (5)*

(1) National Institute of Technology, Hamirpur
(2) Thapar Institute of Engineering and Technology
(3) IIIT-DM
(4) National Institute of Design, Jorhat
(5) Indian Institute of Science, Bengaluru

Auxetic structures, characterized by their negative Poisson's ratio, have attracted substantial attention in piezoelectric energy harvesting (PEH) due to their capacity to concentrate stress and boost power production. The work investigates new auxetic substrates to improve strain energy concentration in piezoelectric materials, hence improving energy harvesting efficiency. Comparatively to traditional designs, cantilever-based PEHs combined with auxetic substrates have shown significant power amplification. Some suggested designs in literature reach power increases up to 14.61 times that of simple substrates. Additionally, tapered auxetic designs assist distribute stress more effectively, leading to increased power density, whereas gradient auxetic structures encourage a more uniform strain distribution, boosting power generation without producing excessive stress concentrations. These developments make PEH systems highly effective even at ultra-low frequencies (1–20 Hz), which is particularly valuable for aerospace applications where low-frequency vibrations are widespread. A prominent potential application of these enhanced PEH systems is in the actuation of auxetic core-based morphing airfoils. Morphing airfoils, which can adapt their shape in real time to enhance aerodynamic performance, require flexible, tunable structures. Auxetic substrates, with their ability to amplify strain and adjust stiffness, can improve the performance of piezoelectric actuators embedded in these airfoils. By exploiting ambient vibrations, these systems can offer self-powered actuation, minimizing dependence on other power sources and boosting overall efficiency. In summary, adding auxetic structures into PEH systems offers a significant technique to enhance power output and efficiency. Their application in aerospace, notably in morphing airfoils, could lead to revolutionary advancements in adaptive wing technology, making next-generation aircraft lighter, more energy-efficient, and self-sustaining.

Data-Driven Microstructure Prediction as a Buidling Block Towards Construction of a Full-Scale Digital Twin for Powder Bed Fusion Process

*Gopi Gopal (1) and *Senthilkumaran Kumaraguru (1)*

(1) Indian Institute of Information Technology Design and Manufacturing, Kancheepuram

The digital twin integrates multi-physics simulations, machine learning algorithms, and advanced analytics to create a comprehensive virtual replica of the Laser Powder Bed Fusion (L-PBF) process, thereby optimizing process parameters and reducing material waste due to experimentation. The major issue with the digital twin of the L-PBF process is establishing a robust structural-property relationship. This work proposes a data-driven microstructure prediction model to develop and optimize a full-scale digital twin for the metal-based Laser Powder Bed Fusion (L-PBF) additive manufacturing process. The proposed model employs the Principal Component Analysis (PCA) method to reduce the dimensionality and extract features (principal components) from the data generated through the Stochastic Parallel PARticle Kinetic Simulator (SPPARKS) based on the KMC technique. The extracted features predict the microstructure and its corresponding mechanical properties for AlSi10Mg material through the Hall-Petch relationship. The data-driven PCA model demonstrates the potential to develop a full-scale digital twin with the reliability, efficiency, and scalability of PBF technology, paving the way for its broader adoption in high-value industries such as aerospace, automotive, and healthcare.

A Benchmark Process for Designing User Centric Smart Respiratory Inhaler System

*Angana Sutradhar (1) and *Basanta Bhowmik (1)

(1) Department of Mechanical Engineering, NIT Jamshedpur

The present paper demonstrated benchmark process for improving the existing inhaler that significantly used to treat the diseases such as asthma and chronic obstructive pulmonary disease (COPD). We have incorporated, digital technology with display facility on the existing conventional inhalation devices which may have the potential to solve widespread problems like low drug compliance and incorrect inhalation technique. Features included in the present product are reminders, data logging, and wireless transmission to mobile apps. For product design and sustaining the product quality, our benchmarking process is as follows; (i) Initially, we divided into two groups for existing inhaler market survey, (ii) Survey was conducted in hospitals as well as NIT Jamshedpur. 210 peoples (patient or family member of patient) were participated in the survey process, (iii) all the data from three groups were collected and made a single data table, (iv) From the final data table, gaps were identified and corresponding features were added for improving than that of the existing inhaler. However, the present device showed flow rate of 0.49 L/min in one shot. The releasing time was 2.5s and recovery of the device was found to be 15s. It suggests that, patient has to wait 15s after taking first dose.

Key Design Parameters for Helmet Impact and the Influence of Rotational Acceleration on Head Kinematics

*Manish Kumar (1), Puneet Mahajan (2) and Sanjeev Sanghi (2)

(1) Netaji Subhas University of Technology
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Helmet design plays a crucial role in mitigating head injuries during impact events, particularly in reducing rotational acceleration, which has been identified as a significant factor in assessing brain injury severity. Traditional helmet impact tests primarily focus on linear acceleration; however, emerging research highlights the importance of rotational kinematics in determining the risk of traumatic brain injuries (TBI) and concussions. This study presents an in-depth analysis of critical design parameters influencing helmeted impact performance, emphasizing the necessity of reducing rotational acceleration to enhance head protection. The paper evaluates various head kinematic parameters, including peak linear acceleration, peak rotational acceleration, and their induced effects on the head during oblique impacts. By examining these kinematic responses, the study provides insights into optimizing helmet designs to minimize the risk of brain injuries. The findings contribute to the advancement of next-generation helmet technologies aimed at improving safety standards and injury prevention strategies.

Notes:

DAY 2

PARALLEL SESSIONS

9 January 2026 | 08:30-10:30

Tracks

Digital Manufacturing: JN Tata Main Hall
Chair: Dr Devika Kataria

Controls, Autonomous Systems & Robotics: Hall A
Chair: Dr B.B.V.L. Deepak

Industry X.0 and Policy & Entrepreneurship: Hall B
Chair: Dr Pradipta Biswas

Training and Education: Hall C
Chair: Dr. Abhay K Kuthe

The Metaverse Effect: Transforming Industrial Supply Chains through Emerging Digital Technologies

*Mukunth K G (1), Uma Maheshwari B (1) and *Eniyavan A J (1)*

(1) PSG Institute of Management

The innovations and advancements pertaining to Industry 5.0 have changed the overall supply chain landscape, with digital technologies such as artificial intelligence, blockchain, augmented reality, virtual reality, mixed reality, and digital twins leading the way in efficiency and resilience. In this context, the Metaverse is at the forefront, offering real-time decision-making, greater flexibility, and better collaboration. Though the industry acknowledges its capability and potential in the long run, its implementation in supply chains remains largely unexplored. The objective of this research is to identify the aspects that drive the adoption of the Metaverse and its impact on industrial supply chains. A systematic literature review is conducted using the PRISMA framework to identify these factors. The findings were validated through interviews with industry experts experienced with these technologies. The study presents a “Metaverse-Driven Supply Chain Transformation framework” based on the findings. The study revealed that technological readiness, organizational agility, perceived operational benefits, stakeholder collaboration, and market competition were significant drivers of implementing Metaverse in supply chain initiatives. The study also revealed the impact of implementing Metaverse technology, characterized as 'the Metaverse effect,' suggesting that these technologies enhance supply chain transparency and enable real-time analytics. They can also increase efficiency through artificial intelligence-driven insights. Additionally, they enhance operational sophistication without necessarily raising costs, making them a valuable frontier in future-ready supply chain ecosystems. The framework presented could be further validated and explored in future research.

Use of AI and Smart System in the Packaging Industry to Create Effective and Real-Time Solutions for an Ever-Evolving Market

**Manohar Desai (1), *Nitin Gawai (1), *Girish Charwad (2), *Mahi Sharma (1) and *Liyana Fathima (1)*

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(2) Bharati Vidyapeeth's College of Fine Arts, Pune, India

The packaging design industry has experienced significant growth over the past decade. Advances in printing technology have enabled designers to experiment more effectively with materials, colors, and forms. In response to new challenges and increasing competition, it has become essential for the industry to evolve in order to remain competitive in a dynamic marketplace. This research aims to examine the current design and manufacturing processes in the packaging industry, with a focus on identifying opportunities for technological interventions that can optimize efficiency and effectiveness. As the consumption of both physical and digital products has surged in the information age, companies are continually updating and evolving their products to stay relevant. Intense market competition has driven businesses to generate increasingly innovative packaging designs; however, the shelf life of these innovations has shortened as consumer loyalty quickly shifts from one product to another. Recognizing the urgency of these market dynamics, the packaging design industry must develop an ecosystem that supports the rapid delivery of relevant designs and expedited manufacturing processes. This study seeks to explore various aspects of the packaging design and manufacturing sectors to pinpoint current shortcomings. It proposes a smart framework—incorporating automation, AI, and other intelligent systems—to streamline the entire process, ensuring that solutions are not only more effective but also aligned with the ever-evolving needs of users. Additionally, the research will identify specific phases where the integration of automation and AI can enhance process efficiency, while also investigating the role of smart systems in minimizing errors. Ultimately, this study aims to provide actionable insights that will help the packaging design industry offer faster, more adaptive solutions to meet the demands of a rapidly changing marketplace and evolving consumer expectations.

Digital Twin for Crop Health Monitoring using Quantum Image Representation

*Siavash Mandegari (1), Mayank Bhalerao (1), Farrokh Mistree (1), *Devika Kataria (2) and *Jyoti Prakash Naidu (3)*

(1) University of Oklahoma, United States
(2) JK Lakshmipat University Jaipur, India
(3) SleepLabs, Ottawa, Canada

Quantum computing leverages superposition and entanglement for rapid data processing. It is hoped that Quantum Computing will assist in areas where classical computing has difficulty in terms of computation speed, particularly in domains involving large-scale data processing and intensive computations, such as image processing [Ruan et al.,2021] We report on our preliminary investigation into the potential application of Quantum Image Processing (QIP). We exploresome of these challenges, particularly in the context of processing large satellite-captured images. We report on the deployment of a satisficing approach [Guo et. al., 2024], applied typically where Karush-Kuhn-Tucker (KKT) conditions for optimization are not satisfied, to further economize the image processing costs. Crop health monitoring is a well-known issue, critical for successful implementation of India's ambitious crop insurance. This problem is considered as a test case application of QIP. It has a relatively simple image processing challenge, called NDVI (Normalized Difference Vegetation Index) a graphical indicator used to analyze drone-based or satellite-based imagery to assess the presence and quality of live green vegetation. As a preliminary proof-of-concept, a 3x3 pixel image converted to a flexible representation of a Quantum Image. Digital twins can be used to store these images and deploy them for various computations as predictions or real time simulations for monitoring crop health. We conclude that as the scale and volume of data collected is huge, Quantum Computing based AWS platform can be an ideal implementation platform, aligning with the conference's themes of cloud computing and digital manufacturing infrastructure.

Bridging the Knowledge and Accessibility Gap in Industry 4.0: Challenges and Opportunities in Advanced Manufacturing Education

*Lakhe Shridhar (1), Raguraman Munusamy (2), Muskan Somani (1), *Bisheshwar Haorongbam (1) and Rajnish Mallick (2)*

(1) National Institute of Design Assam, India
(2) IIITDM Kancheepuram, India

The rapid advancements in Industry 4.0, driven by connected intelligence and cutting-edge manufacturing technologies such as robotics and additive manufacturing, have significantly transformed industrial landscapes. However, a critical gap persists between industry demands and the preparedness of the youth in terms of knowledge, awareness, accessibility, and hands-on experience. This paper examines the disconnect between aspiring professionals and the competencies required for advanced manufacturing, analyzing key factors such as the lack of structured education, limited access to industry-grade equipment, and insufficient mentorship. Through a systematic review of existing literature and empirical data, learners are categorized into three broad groups—experienced professionals, industry enthusiasts, and struggling learners—each facing unique challenges in acquiring expertise. A case study on 3D printing exemplifies the extensive learning curve associated with advanced manufacturing, from software proficiency to material science and machine operations. By identifying the barriers to skill development in Industry 4.0, this study aims to be a base for innovations in strategic interventions for fostering a more inclusive and human-centric approach to industrial education, ensuring that emerging professionals can effectively contribute to the future of manufacturing.

Enhancing Visual Perception with Industry 4.0: An AI-Driven Assistive Headset for the Visually Impaired

**Abhishek Bharadwaj (1), *Saumya Kumari (1) and *Amar Kumar Behera (1)*

(1) Indian Institute of Technology Kanpur, India

Visual impairment significantly impacts the quality of life, particularly among the aging population. According to the World Health Organization, over 2.2 billion people worldwide experience vision impairment, with India alone accounting for approximately 21 million visually impaired individuals, including 2.4 million who are blind. This study explores the transformative potential of Industry 4.0 technologies—artificial intelligence (AI), augmented reality (AR), gaze tracking, and wireless sensor networks—in developing advanced assistive devices for visually impaired individuals. Leveraging cutting-edge tools such as computer-aided design (CAD), 3D printing, and rapid prototyping, we designed and fabricated an AI-driven headset aimed at enhancing visual perception. The device integrates high-resolution cameras and advanced optics, enabling users to customize their visual experience by adjusting zoom, contrast, and brightness. User feedback was collected through a structured survey conducted in a seminar setting, and quantitative vision improvements were measured using the Snellen chart. The results underscore the remarkable potential of Industry 4.0 technologies and digital manufacturing in revolutionizing assistive devices, offering enhanced autonomy and improved quality of life for visually impaired individuals.

Design and Development of a Modern Speaker through the Integration Traditional and Modern Manufacturing Techniques

*Kaveri Nilesh Mane (1), Dipanka Boruah (2), Anindya Deb (3), *Bisheshwar Haorongbam (1), Navdeep Malik (4) and Rajnish Mallick (5)*

(1) Industrial Design, National Institute of Design Assam, India
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The present study focuses on the design and prototyping of a modern speaker inspired by the silhouette of an owl. The goal was to create a functional prototype that emphasizes detailed form exploration and manufactureability. The process began with carving a 1:1 scale model from a plaster of Paris block to study the three-dimensional form. This physical model served as a reference for creating a refined digital 3D model using Autodesk Fusion 360, ensuring the design was optimized for manufactureability. To produce the prototype, a mold was crafted from medium-density fiberboard (MDF) using Computer Numerical Control (CNC) machining. The CNC process divided the speaker's form into nine sections, which were then layered and sanded to achieve a smooth surface. This mold was subsequently used in vacuum forming to create the speaker's outer body. The final prototype successfully met the intended design and functional requirements. The study highlights the integration of digital modeling, CNC machining, and vacuum forming in the product prototyping process. It underscores the importance of precision and problem-solving in developing complex product forms. The completed prototype not only fulfilled its design objectives but also demonstrated the effectiveness of combining traditional and modern manufacturing techniques in product development.

Numerical Investigation into the Behavior of Auxetic Structure Filled Steel Hat Sections under Axial Loading

*Navdeep Malik (1), Rajnish Mallick (2), Anindya Deb (3), Muskan Somani (4), *Bisheshwar Haorongbam (4) and Raguraman Munusamy (2)*

(1) National Institute of Technology, Hamirpur
(2) IIIT-DM, Chennai
(3) Indian Institute of Science, Bangalore
(4) National Institute of Design, Assam

Auxetic structures are materials or geometries characterized by a negative Poisson's ratio, meaning they expand laterally when stretched and contract when compressed. This unique property makes them highly effective for energy absorption, as they dissipate energy through their deformation mechanisms. The present study explores the behavior of auxetic structures made of Acrylonitrile Butadiene Styrene (ABS) plastic, which are used to fill steel hat sections under axial loading. Steel hat sections, whether single or double, are commonly found in automotive body structures such as front rails, B-pillars, and rockers in unitized-body vehicles. These thin-walled, closed-section components play a critical role in absorbing impact energy during collisions, thereby enhancing occupant safety. To meet stricter emission standards and improve fuel efficiency, automotive manufacturers are actively seeking ways to reduce vehicle weight. This is achieved by using lighter materials like aluminum or fiber-reinforced composites, replacing traditional mild steel parts with high-strength steel of lower gauges, or combining both strategies. However, reducing material thickness can lead to structural instability due to early inelastic buckling. This instability presents an opportunity to incorporate auxetic structures made of ABS into structural members. Filling hollow steel sections with ABS delays local buckling and increases the overall strength of the structure. The study investigates the quasi-static axial crush behavior of single- and double-hat sections filled with ABS using finite element modeling and analysis through the explicit non-linear LS-DYNA code. The load-displacement histories of ABS-filled hat sections are compared with those filled with polyurethane foam to evaluate their performance. The findings highlight the potential of ABS-filled auxetic structures in enhancing the energy absorption capabilities of automotive components while addressing weight reduction and structural stability challenges.

Next-Gen Cycling: Pioneering Sustainable Solutions for Kids' Bicycles

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(1) National Institute of Design, Assam, India
(2) Tezpur University Napaam, Assam, India
(3) RS Design Studio, Bangalore, India

Bicycling is a regular activity for all kinds of people in our society, and it builds strength and improves endurance and health. Bicycles are manufactured mostly using different materials, i.e., aluminium, steel, titanium, chromium, and plastic. They are mostly mined materials that require lots of energy and processes to produce, and while doing so, they harm the environment by emitting harmful substances to the environment. In this regard, locally sustainable materials can be used to make bicycle frames. In this regard, a bamboo-made bicycle frame design was tested at the National Institute of Design Assam, Jorhat. It was designed based on the anthropometry of a kid aged between four and eight. Bamboo is an available material in Assam, northeast India, where bamboo-made handicraft items are sold in the markets. Apart from furniture, there are a few other products that add value to bamboo. The aim of the project is to use the tensile strength of bamboo as a replacement for other materials to make designs that can be mass-produced and to provide economic benefits to the people associated with bamboo. The structure of the members is circular in cross-section and straight; bamboo cannot be easily bent using heat and pressure. However, if the whole bamboo is cut longitudinally and the thickness is reduced, it can be bent using heat and applying pressure. Moreover, clamping these bamboo strips with metal or wooden fixtures and applying heat and pressure takes various shapes. The research work aims to construct a novel innovation in two-wheeled transportation using bamboo. This kind of sustainable material-led industrial design will not only protect the environment but also support livelihoods.

Human Centric Approach to Energy Efficient Light Management

*Aayush Dutt (1), Shreyansh Gupta (1), Nithin Gopal V.S (1), Arun R (1), Anoop Saxena (1), *Bisheshwar Haorongbam (1)*

(1) National Institute of Design Assam

In modern work environments, managing natural light is crucial for both energy efficiency and occupant comfort. Traditional manual blinds often lead to inconsistent lighting conditions and increased reliance on artificial lighting, resulting in higher energy consumption. To address this, an automated blind control system was developed that dynamically adjusts to environmental changes, optimizing natural light usage and reducing energy dependence. The present system incorporates an expressive interface that communicates its status and intentions to users, enhancing satisfaction and acceptance. Experimental results demonstrate that the approach not only improves occupant comfort but also achieves significant energy savings, offering a sustainable solution for modern building management.

Cuckoo: A Smart, Affordable, and Adaptive Home Automation Solution

*Vignesh Medchalam (1), Rohit Antony (1), Aayathollah Easa Zafri (1), Muhammed Yaseen (1), Anoop Saxena (1), *Bisheshwar Haorongbam (1)*

(1) Industrial Design, National Institute of Design Assam

Many households still rely on traditional switchboards, making smart home upgrades costly and complex. Existing smart switches require rewiring, limiting accessibility for renters, elderly individuals, and non-tech-savvy users. Cuckoo addresses this gap by offering a non-invasive, retrofittable solution that automates existing switches without requiring expensive modifications. By bridging the gap between fully automated smart home setups and traditional homes, this attachment enables users to experience smart automation without replacing their entire system. Current automation solutions are often expensive and difficult to implement, creating a barrier to wider adoption. Aligning with SDG Goals 7—Affordable and Clean Energy—and 10—Reduced Inequalities, Cuckoo promotes affordability and accessibility in home automation. Utilizing control systems, autonomous mechanisms, and real-time automation, Cuckoo enhances everyday interaction by allowing users to operate switches manually, via a mobile app, or through voice commands. The system adapts to room temperature and other environmental conditions, optimizing energy efficiency. The final outcome is a working prototype integrating Node MCU and precision motor control, enabling seamless interaction between users and physical switches, ultimately contributing to the future of intelligent living spaces.

Biomimetic Soft Robot Design Inspired by Seahorse Tail

*Bedanta Mandal (1) and *Ajeet Kumar (1)*

(1) DAMI lab, Indian Institute of Technology, Guwahati, India

The study presents the design and fabrication of a novel soft robot inspired by the unique biomechanical properties of the seahorse tail. Our research focuses on developing a hybrid structure that mimics the seahorse's combination of a sturdy skeletal system and flexible body, using additive manufacturing technologies for rapid prototyping and iteration. The design process involved multiple iterations, starting with a detailed analysis of seahorse tail anatomy and biomechanics. We use additive manufacturing technology to make the rigid skeletal body and the surrounding soft, flexible components. The rigid framework is printed using high-strength polymers to replicate the seahorse's bony plates, while the soft segments are fabricated with silicones to emulate muscle and skin tissues. The experimental results predicts better design and application for real world scenarios and morphological performance for picking delicate and fragile objects.

Future of Automation in Apparel Manufacturing: Robotics and Dark Factories – Exploring Feasibility, Challenges, and Benefits

*Abhishek Yugal (1) and *Nilima Topno (2)

(1) NIFT Delhi, India
(2) NIFT Patna, India

“यन्त्राणि कार्यं कुर्युः, परं मनुष्यः तत्संवर्धनं कुर्यात्”
(Machines perform tasks, but it is humans who enhance and evolve them.) Future of Automation in Apparel Manufacturing: Robotics and Dark Factories – Exploring Feasibility, Challenges, and Benefits Co-Authors Dr. Nilima Regina Topno, Associate Professor, Department of fashion Technology, NIFT Patna Abhishek Yugal, Managing Partner, Groyyo Consulting | M.F.Tech (Pursuing), NIFT Delhi As Industry 4.0 redefines manufacturing paradigms, automation and robotics are progressively penetrating the apparel sector, an industry traditionally reliant on manual dexterity. While other sectors such as automotive and electronics have seamlessly integrated robotics, apparel manufacturing continues to grapple with challenges owing to the intricate nature of garment construction. This research investigates the feasibility of fully automated apparel manufacturing units—commonly referred to as Dark Factories—where robotics, artificial intelligence, IoT, and cloud computing converge to create a production ecosystem with minimal human intervention. The study systematically explores the evolution of automation in apparel, current technological advancements in robotic sewing and fabric handling, and the economic and socio-environmental implications of transitioning to a fully automated model. Through primary insights from industry leaders and secondary research, the paper identifies key bottlenecks in achieving large-scale automation, including the complexity of soft material manipulation, high capital investments, and workforce transition challenges. Furthermore, this research proposes a structured model for implementing Dark Factories, integrating learnings from cross-industry automation while assessing its scalability for small, medium, and large apparel manufacturers. The findings provide a roadmap for the industry, policymakers, and technology providers to collaboratively drive innovation while balancing efficiency, sustainability, and workforce evolution. In an era where digital manufacturing is a necessity rather than a choice, this research bridges the gap between aspiration and implementation, redefining the future of apparel production in the age of Industry 4.0.

Biosynthesis of Nanomaterial Infused Lime Based Concrete and Bricks with Self-Healing Properties

**Rithvik Ramadas (1), *Anirban Chowdhury (2), Akaash Balaji Manjula Bashini (2), Samprithi Sabesan (2) and Aditya Das (2)*

(1) Optum Global Advantage-Digital Experience Team, India
(2) Alliance University, India

The field of nanotechnology has shown tremendous potential in several areas including civil engineering where nanomaterials are added to building materials to improve their strength, durability and enhance their overall lifespan. Bacteria, viruses and fungi are used in nanomaterial fabrication, as they can be grown with very little investment hence it makes them a viable source for construction firms. Buildings that are built using limestone for example the Pyramids are said to last a lifetime, additionally researchers from MIT and Harvard proved that buildings like the Pantheon which was built by ancient Romans have self-healing properties due to incorporation of lime in their concrete recipe. Limestone bacteria and fungi like Sphingomonads, Pseudarthiobacter, Cephalosporium lamellaecola and others found in caves aid in the growth of structures known as Stalagmites and Stalactites that are full of nanomaterials and grows overtime without any external intervention, the same structures grow faster in man-made structures due to the abundance of silica and calcium. In this paper we explore the potential of such microbes isolated from cellars and caves to help in nanomaterial fabrication of concrete and bricks that have enhanced strength durability and self-healing properties in comparison with regular concrete. We will classify the various microbes used in this process, their origin, source and their role in giving the construction material extra strength. We will also give a recipe for a lime based concrete and brick infused with microbes that can help in construction of building that withstand damage and stand the test of time.

Developing an Integrated Framework for Physical and Digital Publication with the Use of AI and Advanced Technologies for Effective Mass Communication

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The publication industry has long served as a cornerstone for mass communication, continuously evolving by adopting new technologies, materials, methods, and mediums. Over time, technological advancements have made mass communication more effective and efficient, transforming traditional publication methodologies. The increasing demand for rapid printing and frequent releases has driven the industry to integrate innovative technologies, resulting in more consistent publication cycles over shorter periods. The industry still largely depends on human labour and mechanical machinery, with computers and smart systems not yet fully embraced. There is an urgent need for an advanced, smarter publication system capable of supporting fast, real-time output across both physical and digital platforms. The integration of artificial intelligence—including generative AI—and other smart technologies has the potential to fundamentally change how publications are produced. With these systems, it is possible to achieve consistent output without compromising quality. Furthermore, understanding the distinct requirements of physical versus digital publication platforms is critical in designing optimized processes for each medium. This research aims to explore various smart systems, AI applications, and big data analytics that can build an efficient ecosystem for publication in the Industry 4.0 era. It also seeks to identify sustainable strategies for adapting to the rapid pace of technological change within the industry. By examining the current state of the printing sector and assessing available technological advancements, the study will map different phases of industry evolution. This mapping will help pinpoint specific areas that can be optimized for improved efficiency. Ultimately, the research aspires to propose a new, integrated ecosystem that enhances both physical and digital publication processes, thereby enabling more effective and targeted mass communication while preparing the industry for the challenges of a rapidly evolving digital landscape.

Trajectory Planning of an Unmanned Water Surface Vessel Subjected to Kinematic Constraints

*Jalumuru Nalini (1), *Dibya Prakash Jena (1), *B B V L Deepak (1) and P Kamalesh (1)

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This study uses MATLAB to visualize and analyse the position, velocity, and acceleration of an object moving along a two-dimensional path. The time-dependent data for position, velocity and acceleration were processed into graphs, providing insights into the system's motion. The position profile shows steady motion with significant change in the xy-direction, indicating vertical movement. The velocity and acceleration profiles exhibit smooth, wave-like transitions, suggesting controlled, gradual changes in speed without abrupt spikes, reflecting stable motion. The angles and position with respect to which the Unmanned Water Surface Vessel is moving in the given plane is calculated with the help of trajectory planning equations and they are given as input parameters to make the trajectory graph. In conclusion, the MATLAB model effectively demonstrates the system's behaviour and can be used to analyse and optimize the motion of robotic systems, improving efficiency, stability, and performance in engineering applications.

Development of Emotional Skills in Pre-School Students through Human-Robot Interaction and Companion Robotics

*Amruta Rout (1), Marian Daun (2), Golak Bihari Mahanta (3), Chiranjibi Champatiray (1), Sai Madhukar K (1) and Anis S (1)

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With the rapid growth of technologies, nowadays it is hard to remain out of integration of digital platforms and advanced technologies such as robotics in education systems. In this research, design and development of a companion robot particularly for pre-school students has been presented for development of emotional, societal, cognitive skills among them. Generally, it is extremely important to achieve emotional and cognitive ability at the early age for integrated development of a child. The designed companion robot in this research work is incorporating facilities such as speech recognition, displays for ex-pression for different emotions specially for learning good touch and bad touch. The robot can be used for different tasks such as story telling, role playing, companionship, meaning of different emotions and word learning etc. By the developed companion robot, pre-schools can create more creative and interactive environment for the students. By testing the real-world applications of this robot, this research work helps to develop a useful teaching tool that can be implemented with the traditional teaching methodology

An AI-Based Framework for Assessing Sustainability Conflicts in Medical Device Development

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The increasing demand for sustainable medical devices necessitates a structured approach to balancing environmental, economic, and social considerations. However, identifying conflicts among these three sustainability pillars remains challenging when conducted manually. Traditional methods rely heavily on expert judgment, which is prone to cognitive biases, incomplete trade-off awareness, and difficulties in processing complex, multidimensional data. Consequently, many sustainability conflicts go undetected, leading to suboptimal design choices that compromise one or more pillars. Existing sustainability assessment approaches often lack standardization and struggle to integrate diverse data sources, such as lifecycle assessments, supply chain information, and regulatory requirements. The dynamic nature of medical device development, including evolving material innovations and shifting market demands, further complicates conflict identification. Additionally, current methods are limited in their ability to systematically quantify trade-offs, leading to inconsistencies in sustainability evaluations. This paper proposes an artificial intelligence (AI)-driven framework to automate the identification of sustainability conflicts in medical device design. By leveraging machine learning (ML), natural language processing (NLP), and predictive analytics, the framework systematically assesses design parameters, regulatory constraints, and sustainability metrics to detect potential conflicts. Multi-Criteria Decision Analysis (MCDA) is integrated to generate a sustainability score that quantifies trade-offs among the three pillars, enabling a data-driven evaluation of design choices. The proposed AI-based approach aimed at enhancing accuracy, efficiency, and objectivity in sustainability assessments. By automating conflict detection and quantification, this research contributes to the development of intelligent decision-support tools for medical device designers, addressing key limitations in existing methodologies.

Analysis of Industry 4.0 Implementation Challenges in Product Development – An Aerospace Perspective

Sriram K. V. (1), Vinodh Sekar (2) and Samuel Mathews P (1)

(1) GTRE, DRDO, Bangalore, India
(2) National Institute of Technology, Tiruchirappalli, Tamil Nadu, India

The fourth industrial revolution, known as Industry 4.0 (I4.0) offers tremendous technological advancements for complex product development by integration of advanced information technologies and smart product systems. Aerospace components are of highly complex in nature as well as they have to meet stringent quality requirements.Aerospace manufacturing offers an excellent platform for I4.0 for product development with innovative designs.However, there are many challenges in integration of I4.0 for Aerospace and Defense solutions viz. product complexity, technology requirements, integration limitations etc. Hence a thorough understanding of the aspects of challenges and opportunities of I4.0 is utmost important in aerospace manufacturing.In this context, this paper focuses on various implementation issues of I4.0 in aerospace product development scenario.A systematic literature survey is done for collecting challenges. The challenges are categorized different aspects related to product, process, manufacturing technology, data management & integration, data volume, data security, interoperability & standardization, skill level of the workforce, complexity of Cyber physical systems, risk management, Management behavior, Environment impact, Change Management, Integration with Additive Manufacturing and Legacy systems. The main contribution of this paper is towards analyzing challenges using Multi Criteria Decision Making (MCDM) method and prioritize them according to various needs of aerospace component manufacturing particularly during the development stage like limited prototype constraints, product complexity, technology readiness and Certification requirements etc. The results indicate that the integration of I4.0 is embedded with significant challenges in integration of advanced technologies, upskilling of workforce, Product complexity and Certification regulations.The study has practical relevance as it is being executed in the case of a manufacturing scenario of typical aerospace components.

The Cultural and Economic Importance of Transitioning Terracotta and Ceramic Products from Traditional Techniques to Contemporary Methods

**Shovan Kanti Kar (1), *Deepak John Mathew (1) and *V Vishnu Srinivasa Prasad (1)*

(1) Indian Institute of Technology Hyderabad

This paper examines the gradual shift of terracotta and ceramic products from conventional manufacturing practices toward modern, technology-driven methods that emphasize sustainability, adaptability, and multifunctionality. The core objective of the study is to incorporate 3D clay printing into the design and production process of clay-based artifacts, thereby enhancing precision, shortening manufacturing cycles, and broadening design opportunities, all while ensuring that the cultural authenticity and heritage embedded in these crafts remain intact. The research adopts a multi-faceted methodology comprising literature reviews, detailed case studies, market evaluations, and practical workshops. These workshops focus on testing a variety of clay types sourced from different regions of India to determine their suitability for 3D clay printing and to assess the broader implications of integrating this technology into traditional practices. Findings reveal that 3D clay printing offers scalable, customizable, and highly accurate production processes while retaining the artisanal essence that defines handcrafted clay products. By streamlining the initial stages of production, the technology allows artisans to allocate more time to creative exploration and intricate detailing, thereby enriching the artistic value of the final products. The implications of this study are particularly valuable for artisans and small-scale enterprises, as the adoption of 3D clay printing creates new opportunities for economic resilience, cultural preservation, and sustainable alternatives to synthetic materials increasingly dominating the market. By merging time-honored craftsmanship with digital fabrication technologies, 3D clay printing emerges as a transformative and forward-looking approach with the potential to redefine clay product manufacturing and strengthen cultural heritage in a rapidly changing industrial landscape.

Ethical Implications of AI in Design Education

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The integration of Artificial Intelligence (AI) into design education has ushered in transformative changes, offering new opportunities for creativity, efficiency, and personalized learning. However, this technological shift also brings forth significant ethical challenges that demand critical examination. This paper investigates the ethical implications of AI in design education, focusing on key issues such as algorithmic bias, the potential suppression of human creativity, intellectual property (IP) concerns, and the exacerbation of the digital divide among students. Drawing on case studies and stakeholder interviews, the study reveals that while AI tools like generative design software and adaptive learning platforms can enhance educational outcomes, they also pose risks that could undermine the integrity and inclusivity of design education. One of the primary ethical concerns is algorithmic bias, which can perpetuate stereotypes and inequities in design outputs. Additionally, the over-reliance on AI-generated solutions may stifle students' creative thinking and problem-solving skills, raising questions about the role of human agency in the design process . Intellectual property issues further complicate the landscape, as AI-generated designs challenge traditional notions of authorship and ownership. Moreover, the digital divide—unequal access to AI tools and technologies—threatens to widen disparities between students from different socioeconomic backgrounds, as noted in UNESCO's 2021 report on AI and education. To address these challenges, the paper proposes a multi-stakeholder approach involving educators, policymakers, and AI developers. Ethical guidelines, transparency in AI algorithms, and inclusive pedagogical frameworks are essential to ensure that AI serves as a tool for empowerment rather than exclusion. The study concludes by emphasizing the need for ongoing dialogue and collaboration to navigate the ethical complexities of AI in design education, ensuring that its integration aligns with the principles of equity, creativity, and responsibility.

Smart Packaging for Medication: Enhancing Expiry Date Visibility for User Safety

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Medications became part of life due to the lifestyle and the stressful, busy schedules. It is noted that many adults rely on medications to control conditions caused by the same. Most consumers ignore the expiry dates mentioned on medicinal tablets at the time of purchase or consumption. It is also documented on various surveys and information that there are unethical retailers who hide the expiry date. Poor packaging design is another issue that creates problems since vital information regarding expiry dates is often printed in tiny, illegible fonts, which makes it challenging for older consumers and people with visual impairment to check for expiry dates. The consumption of expired medications can lead to severe outcomes, from decreased efficacy to side effects. This research will help tackle that critical issue by proposing innovative design solutions, including the idea of color-changing technology for medicinal tablet strips. This study will discuss smart packaging solutions with clear, intuitive, and in-time visual pointers for the expiration of the medication, thereby guaranteeing user safety. The study will take a user-centered approach to the design proposal. Because of practical constraints, the survey will be carried out on a small scale on elderly users, illiterate users, and the visually challenged. Feedback from these groups will be analyzed to understand their problems. Despite previous dissemination campaigns and publications highlighting the risks of expired medication, these efforts have not been sufficient to create widespread behavioral change. This research assesses already available solutions in the pharmaceutical packaging industry. Such a study may contribute to supporting the particular age group users, bringing health risks posed by expired drugs down to acceptable levels.

Data-Driven Prototyping in the AI Era: Leveraging Live DOM Editing for Rapid Validation and Reduced Costs

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In the AI era, prototyping web user experiences (UX) faces significant challenges, particularly when real-time data integration is essential. Traditional prototyping methods often fall short as they fail to accurately reflect user interactions in the absence of real data. Features that depend heavily on real data, such as personalized recommendations and data visualizations, are particularly challenging to prototype effectively without access to authentic datasets. Furthermore, with the increasing adoption of AI in web applications, the necessity for data-driven outcomes to be thoroughly tested during the prototyping phase has become paramount. This research paper introduces a novel approach termed Prototyping with Data-driven Live DOM Editing (ProDaLiDE).This paper evaluates the impact of a novel prototyping and validation approach that empowers non-technical stakeholders, such as product managers (PMs) and designers, to independently create and test prototypes with real-time, data-driven live DOM editing, without the direct involvement of engineering teams. The method was implemented in a two-month experiment with three startup groups from Bengaluru and Rourkela, focusing on the benefits of faster prototyping, cost reduction, and improved resource allocation.
The method was tested over two months with three startup groups from Bengaluru and Rourkela. The results revealed a faster iteration on prototypes, allowing for rapid testing and refinement without engineering input. There was also a reduction in development costs, as engineers focused on core development tasks rather than early-stage prototyping. Additionally, resource utilization improved, with PMs and designers independently handling prototyping and testing. This approach not only accelerated the development process but also fostered better collaboration and efficient resource allocation.

SolarHub: A Game-Changer in Smart Renewable Energy Management

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India's growing emphasis on renewable energy highlights the need for efficient solar energy utilization in households and businesses. Despite increasing solar adoption, users face challenges in monitoring energy production, optimizing consumption, and managing solar panel efficiency. This research explores SolarHub, a digital product designed to bridge these gaps by providing a smart, AI-powered solar energy management system that enhances sustainability and cost-effectiveness. The SolarHub mobile application offers key features such as an AI-driven solar panel health check, real-time energy tracking, smart grid integration, and a peer-to-peer (P2P) energy trading system, allowing users to sell excess energy efficiently. It also incorporates government incentives and subsidy tracking, enabling more people to transition to clean energy affordably. Through IoT-based smart meter integration, users can receive detailed insights on energy consumption, ensuring optimal usage and financial savings. Additionally, predictive AI models suggest energy-saving strategies based on user patterns, while blockchain ensures secure and transparent energy transactions. This study adopts a qualitative and quantitative research methodology, including user surveys, expert interviews, and pilot testing in urban and rural settings. The findings highlight the app's potential to increase solar energy efficiency, reduce dependence on fossil fuels, and promote decentralized energy production. Pilot programs indicate that real-time monitoring and AI-powered maintenance prediction significantly improve solar panel longevity and user engagement. The study concludes that SolarHub not only advances India's renewable energy goals but also fosters economic benefits for users by reducing energy costs and generating revenue from surplus energy sales. Its scalability in smart cities, potential integration with electric vehicle (EV) charging infrastructure, and future AI-driven predictive analytics position it as a transformative solution in sustainable energy management. By empowering individuals with accessible, data-driven energy insights, SolarHub contributes to a greener, smarter, and self-sustaining future for India.

Exploring the Role of Startup Leadership in Leveraging Organizational Citizenship Behavior (OCB) as a Strategic Tool for Employee Retention: An Employee Perspective

**Sanjeevini Gurjar (1), *Ramchandra Alias Ameet Chate (1) and *Jyoti Jamnani (1)*

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Unlike established organizations, startups rely heavily on leadership strategies to foster engagement and commitment among employees. Employee retention is a persistent challenge in startup ecosystems due to high levels of uncertainty, resource limitations, and intense job demands. This makes it crucial for startup leaders to adopt strategic approaches to retain talent. One such approach is leveraging Organizational Citizenship Behavior (OCB)—voluntary, extra-role behaviors that enhance organizational effectiveness. This study explores how startup leaders can strategically utilize OCB to address retention challenges and create a culture where employees are motivated to stay and grow with the organization. Startup leadership styles—transformational, servant, and participative leadership are examined in relation to the dimensions of OCB. In startups, where agility, collaboration, and innovation are critical, they create a strong foundation for organizational stability and employee engagement. Through these leadership approaches, startups can create an environment where OCB thrives, leading to improved job satisfaction and reduced turnover. For this purpose, a quantitative research approach was employed to examine the relationship between startup leadership, OCB, and employee retention from an employee's perspective. Primary data was collected through structured questionnaire which was distributed to 250-500 employees working in startup companies across sectors. The survey included Likert-scale-based questions assessing leadership styles, OCB dimensions, and their impact on employee retention. Correlation and Regression analysis was applied to test the hypothesized relationships and assess the mediating role of OCB.The outcome of the study is expected to demonstrate that positive leadership impact like transformational and participative leadership styles in startups are likely to enhance OCB among employees. Considering OCB as a mediating factor it is expected to observe Higher OCB will positively influence employee retention by fostering a supportive work culture. Startups that actively promote OCB through leadership practices may experience lower turnover rates and higher employee engagement

Beyond the Call of Duty : R.E. Engineering

*Abhaykumar Kuthe

Industrial Design, National Institute of Design Assam

The teaching institutes in higher education are facing the challenge of producing engineers who are employable in the industry. The industry demands engineers capable of upgrading it to Industry 4.0, where the focus is on achieving zero-defect products in a single attempt and optimizing resource utilization. The competition is intense, as every industry strives to establish itself as a global leader. There is a strong need to upgrade faculty in higher technical institutes, emphasizing education in advanced manufacturing. This upgradation must be linked to innovative teaching methodologies that go beyond the information readily available to students through the internet and other media. It is strongly felt that research in technical fields equips faculty members to design their own teaching methodologies, making classroom learning more engaging and preventing students from developing pseudo-confidence due to easy access to information online. The author firmly believes that research and education should go hand in hand in the era of Industry 4.0. The author has implemented research on 3D printing in teaching casting processes within subjects like Manufacturing Processes and has observed that students develop an interest in independent thinking. They approach assignments more creatively, particularly when innovative products are involved. This paper discusses innovative education strategies to train students in the Industry 4.0 ecosystem. A greater emphasis on research-oriented teaching also encourages students to think outside the box in their respective fields, often leading to the establishment of startups after graduation. Traditionally, faculty members have been trained to teach in conventional ways, but the time has come for them to go beyond their standard teaching duties. They should actively engage in both research and teaching (R.E.), fostering an entrepreneurial mindset. This can be achieved by embracing the philosophy of "Engineer Your Research for Startups" (Engineering).

The Missing Link: Integrating Design for Manufacturing (DFM) Principles in Product Design Curriculum

**Prasanna Prakash Halbe*

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The design for manufacturing (DFM) is a critical aspect of the product design and development cycle. However, DFM is often overlooked by design schools in product-design curricula. Because design schools primarily emphasize aesthetics, creativity, and user experience, graduates often have a weak understanding of manufacturing constraints, leading to ineffective design, increased manufacturing costs, and compromised useability. This study explored the possibilities of integrating DFM into the product design curriculum and proposed effective pedagogical strategies to bridge this gap. The study highlights the disconnect between the current design education and manufacturing realities by comprehensively reviewing existing curricula and expectations from industries and modern technologies. The results of surveys and interviews conducted with students, faculty, and industry experts show that merely imparting theoretical knowledge of manufacturing is not sufficient for the survival of the industry. Hands-on experience with manufacturability analysis, digital simulation tools, and real-world constraints is essential but lacking among students. This study also revealed how the latest CAD-integrated analysis and simulation tools improve learning. This study proposes a structured approach to teaching DFM, including project-based learning, digital simulation, and industry-collaborative projects. Key recommendations include an introduction to collaborative learning with engineering students and hands-on workshops using additive manufacturing for rapid prototyping. The study also explores how advancements in Industry 4.0, such as AI-driven optimization and sustainable manufacturing practices, can be used to make DFM learning more relevant to design students.Making design for manufacturing an integral part of the design curricula will ensure that the graduating students possess the skills to design innovative, manufacturable, cost-effective, and sustainable products. This study aims to contribute to the evolving landscape of design education by bridging the gap between creativity and feasibility.

From Concept to Connectivity: Developing Smart Design Skills in Interior Design Students in the Age of Industry 4.0

*Kishori Dalwadi (1) and Mira Patel (1)

(1) Karnavati University

The industry 4.0 revolution is reshaping the design landscape through the integration of advanced technologies like the Internet of Things (IoT), real-time data analytics, and responsive systems. Due to this rapid growth, there is an increasing need to integrate advanced technologies into design practices. This rapid revolution necessitates that future interior design students develop skills that adapt to the evolving industry demands and create innovative, technology-driven design solutions. This paper aims to demonstrate an experimental structured approach on an “Applied Design Methodology” (ADM) has been used as a methodology to help students understand advanced technologies, which can be integrated into the con-venational design. The study was conducted with 99 third year interior design students enrolled in IoT system course that focused on addressing IoT in shaping future interactions and its impact on connectivity, security, and the integration of intelligent systems in everyday life for Interior Design Students. The approach taken through design thinking sessions facilitated students to follow the design thinking process - empathize, define, ideate, prototype, and test to develop user-centered smart furniture solutions. The novelty of this paper highlights the im-portance of incorporating advanced technology-driven education to prepare interior design students for Industry 4.0. By integrating design thinking with technologies, the teaching process not only develops students' technical capabilities but also equips them to create smart, sustainable design solutions for future spaces.

Designing for Adaptability: A Student-Centric Approach to Scalable Furniture in Advanced Manufacturing

*Aakanksha Batra

Karnavati University

In the evolving landscape of Industry 4.0, demand for adaptable and scalable design solutions has become increasingly relevant. Scalable furniture, characterized by its modularity, multifunctionality, and ease of recon-figuration offers a dynamic response to changing spatial needs and diverse user contexts. As manufacturing technologies advance the design and production processes, developing skills in these methods for students has become crucial. This paper looks into the ways in which design students engage with scalability by integrating advanced manufacturing processes into their design process. With the furniture domain increasingly moving towards modularity, the Scalable Furniture module aimed to bridge design with hands-on making. A two-week intensive studio at UnitedWorld Institute of Design brought together 20 third-year students who were introduced to laser cutting, CNC machining, and 3D printing applications to transform concepts into tangible prototypes. The project framework was structured around four categories: stackable, nested, modular, and RTA furniture, enabling students to experiment with various methods of assembly, form development, and functionality. Students developed understanding of material efficiency, structural integrity, and user experience while working with laser-cut components and CNC elements. The module focused on a blend of technology and design, challenging students to create furnitures that offered aesthetic appeal and practical benefits like ease of assembly and reconfiguration. The results demonstrate strong student achievement across 6 course objectives, with notable progress in critical evaluation and contextual design application. Students produced functional prototypes that revealed how manufacturing constraints can drive innovation rather than limit creativity. This experiential learning approach highlights the significance of well-structured academic modules in preparing students to navigate real-world manufacturing where technical skills and creativity must work together. The outcomes align strongly with Industry 4.0 principles, demonstrating how strategic design education can help students to innovate within design, ultimately fostering designers capable of blending design thinking with technological insights

Smart ecosystem for effective data management in higher education

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The education sector is expanding rapidly, with universities witnessing a significant rise in student enrolment and an increase in the variety of courses offered. This growth necessitates the efficient and effective management of educational processes. Every day, universities process vast amounts of data—for purposes such as university rankings, accreditation, infrastructure optimization, human resource management, and record-keeping—which currently relies heavily on human labour. However, as the volume of data continues to surge, traditional manual methods become increasingly unsustainable. This research aims to identify opportunities for enhancing system efficiency by incorporating smart systems, artificial intelligence (AI), and automation into data management processes. The goal is to propose a new framework for the creation, management, and maintenance of educational data systems, one that minimizes human effort and errors while optimizing performance. A critical aspect of the study is to differentiate the unique requirements of physical and digital data platforms, thereby designing tailored, optimal mechanisms for each. Furthermore, the research will examine areas within the system where data transparency is paramount, as well as explore strategies to ensure robust data security. By integrating advanced technologies, universities can develop a more resilient and automated ecosystem for data handling, significantly reducing processing times and the labour required to access and manage data. This enhanced system promises to create a transparent, sustainable, and universally accessible environment within the education sector, ultimately preparing institutions to better meet future challenges and support continued growth Education Industry.

Integrating Smart Product Design into Engineering Design Education: A Conceptual Framework

*Apoorv Naresh Bhatt (1) and David Inkermann (1)

(1) TU Clausthal

The era of Industry 4.0 is highly relevant to both product development and manufacturing as it leads to increasing interactions. While Industry 4.0 con-cepts are more prominent in the context of manufacturing, advancements have been made in smart product design over the past decades. These point out the various aspects, such as the customer and business values, functional capabilities, and data characteristics of smart products, to be addressed in the design process. Following this paradigm results in the question of how to evolve teaching product development, particularly in terms of the engineer-ing design process and required activities. In this paper, we explore the peda-gogical process of teaching smart product design, following these questions: 1. How can smart products be effectively understood, and what core aspects are essential to guide their design? 2. How can smart functionalities and the means to realize them be systematically integrated within the conventional engineering design process? To address these questions, the paper first pro-vides a review of the literature on smart product characteristics and smart product design methodologies. The insights gained from this review are con-textualized within an educational framework, culminating in the proposal of a conceptual model for teaching smart product development. This frame-work is intended to serve as a valuable resource for educators teaching smart product design in undergraduate and graduate engineering courses, as well as for researchers in the field of engineering education.

Building Creative Capacity through Flexible & Disruptive Thinking to Drive Innovation in Industry 4.0

*Sharmila Sinha (1) and *B. K. Chakravarthy (2)*

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Demands on the creative competence of individuals is becoming more pressing than ever before to propel innovation. Theories and studies in creativity have revealed the associative mode of the minds working when solving problems through unrelated linking. Understanding this mechanism will help in the exploration of novel ideas. Therefore a critical step in producing quality innovative ideas is to leverage the multi-dimensional aspects of technology, manufacturing processes, trends, user needs, socio-cultural influence etc. and bring out new and unexplored out of the box ideas that can drive innovation. The cognitive process of disruptive ideation and the mechanisms underlying it is important in finding out how to operationalize it continually at the individual level of ideation. The aim is to articulate the influencing effect of the disruptive triggers, that factor in the idea generation process by challenging the traditional norms of thinking and manifest meaningful benefits specifically in the context of industry 4.0. By assessing classroom design projects, the disruptive process ofanalogy triggered ideation to steer innovative thinking, and breaking the inertia of creative block is analysed to draw a conclusive operative framework.

Understanding the Construct of Design Competence

*Sona M (1), Abhijit Biswas (1) and Amaresh Chakrabarti (1)

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Design Competence (DC) is the ability to effectively perform a given design task specific to its context. The study reported in this paper aims to clarify the nature of design tasks that an educator may administer to assess this competence. For this purpose, a suitable existing model was identified and evaluated using the Kipling method of qualitative analysis, viz., 5Ws1H to measure if and how well it explains any design situation, specifically the – what, when, where, whom for, why, and how of the task “to design”. Based on the observations, it was revised and hence, the Design Task ontology with six dimensions namely, artefact, implementation, techne, focus, need, and stakeholder was proposed. Towards assessing DC, a Design Task syntax was modelled, and subsequently applied in the field of architecture to demonstrate its use. Steering towards the design process rather than its outcome, it expands the scope of DC beyond skill by acknowledging associated knowledge and attitude, unlike existing models. Thereby, it not only unifies the foundations of designing removed from the traditional regime of disciplines but also empowers control on the complexity of the design task itself. Moreover, its standardisation potential in knowledge sharing and dissemination across design disciplines can be promising for Industry 4.0, in addition to its original focus on assessment in academia.

Notes:

DAY 2

PARALLEL SESSIONS

9 January 2026 | 11:00-13:00

Tracks

Policy and Entrepreneurship: JN Tata Main Hall
Chair: Dr. ND Shivakumar

Supply Chains: Hall A
Chair: Dr. Debashis Majumder

Sustainable Manufacturing: Hall B
Chair: Dr. Debashis Majumder

Springer Author Writing Workshop: Hall C
Chair: Dr Swati Meherishi

The Impact of Creative Support Systems on Fuzzy Front-End Phase in a Hardware-Based Tech Startup

**D.P.K. Muthukumaraswamy (1) and Mungila Hillemane Bala Subrahmanya (1)*

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Recent technological progress and the rise of the industry 4.0 paradigm have facilitated the widespread adoption and evolution of hardware-based technologies, such as the Internet of Things (IoT), cyber-physical systems, and robotics. This trend has motivated many technology entrepreneurs to engage with and leverage the ongoing digital transformation. During the Fuzzy Front End (FFE) phase, opportunities are identified, new ideas are conceived and evaluated, and critical decisions regarding product concepts are made. The outcomes of the FFE phase greatly influence the overall success of the innovation process, prompting entrepreneurs to explore multiple solutions for the same challenge continuously. Ultimately, only those ideas that can be successfully transformed into viable businesses contribute to the emergence and growth of startups. However, the generation of new product ideas is often the most overlooked phase in the development process, as noted by Sowrey (1987). Many startups face difficulties in producing a diverse range of ideas and tend to become overly attached to their initial concepts, even when these ideas present significant flaws or obstacles. This study aims to empirically investigate the processes and strategies employed by hardware-based tech startups in India, established post-2011, to generate a variety of ideas that can be transformed into viable business opportunities. Utilizing PLS-SEM analysis, the research will examine the influence of Creative Support Systems (CSS) during the idea-generation phase, focusing on how CSS affects the creativity, feasibility, and quantity of ideas, as well as its role in facilitating idea exchange. Additionally, the study will identify empirical methods for enhancing Idea Performance for Relevance.

Assessing the role of Entrepreneurial Setback Experiences to build Entrepreneurial Resilience through mediation analysis

*Sukriti Pandey (1), Ruchika Khetrapal (2) and Satya Ranjan Acharya (1)

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Throughout the entire entrepreneurial journey of new venture creation, entrepreneurs encounter multiple experiences, both positive and negative. It further depends on the entrepreneur how he/she channelizes these setbacks to overcome the uncertainties and implement the learnings to make their new venture more sustainable. The study draws upon the experiential learning theory, which posits that an individual has a cycle of learning from the experience followed by reflecting, thinking, and acting. The study assesses the relationship between Entrepreneurial Setback Experiences (ESE) and Entrepreneurial Resilience (ER) through the mediating role of Entrepreneurial Alertness (EA) and Emergent Learning (EL) through a quantitative approach. The research sample includes serial entrepreneurs who dissolved their previous firm owing to losses, mergers, acquisitions, or any other reasons. Data was acquired using a questionnaire survey method. The sample size is 244 serial entrepreneurs with at least one firm or startup experience. Data was analysed using Smart PLS and Structural Equation Modelling. From the findings of the study, the structural model assessment indicates that all the direct relationships are showing significant results with high t-values and low SE values. The strongest relationship is observed between ESE and EA ($\beta = 0.763$, $T = 30.477$), highlighting that setbacks enhance an entrepreneur's ability to recognize opportunities. Further, highlighting the relationship between ESE and ER ($\beta = 0.621$, $p < 0.000$) is significant. Mediation analysis reveals the impact of Entrepreneurial setback experience on Entrepreneurial resilience through the mediation effect of Entrepreneurial Alertness and emergent learning, as shown in the mediation path ESE → EA → EL → ER ($\beta = 0.053$, $T = 3.489$, $p < 0.001$). Thus, the study validates that there is a partial mediation effect and further suggests practical and theoretical implications based on the findings.

Cracking the Code: Examining the Entrepreneurial Ecosystem within Academic Institutions

*Raunak Gupta (1) and Satya Ranjan Acharya (1)

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This study explores the factors that create an entrepreneurial ecosystem within academic institutions/universities and nurture entrepreneurial actions among their students. Using an exploratory multiple-case study design approach, six Indian institutions varying in terms of the number of teams won but similar in terms of winning at least 80% of the time in Smart India Hackathon across all seasons were analyzed in this study. The data was collected through semi-structured interviews with faculty members and students of these institutions. Through analysis of these interviews, this study identifies ten key dimensions: Entrepreneurship education and pedagogical approach, Entrepreneurial learning communities, activities, and culture, Research mobilization, Industry collaboration, Unconventionality, Community interaction support, Intellectual property, technology transfer, and commercialization, Business incubation and development support, Regular mentoring, and Management support, policies, and frameworks of creating an entrepreneurial ecosystem. The findings highlight significant disparities in the level of support provided by the institutions to their students for innovation and entrepreneurship. Management support and intellectual property (IP) creation and commercialization were identified as major differentiators in the entrepreneurial ecosystem across these institutions. This study emphasizes the importance of regular mentoring, industry partnerships, and policy-level interventions to transfer student-led innovations to the market.

Predicting Entrepreneurial Action: Role of Entrepreneurial Readiness, Intentions and Family Support

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Entrepreneurship is being chosen as a career opportunity by a large number of youths. Enterprise creation has been considered a result of the entrepreneurial intentions and entrepreneurial behavior of an individual. The present study aims to analyze to what extent entrepreneurial readiness, a positive intention to start a venture, and family support can lead to a successful action. The study draws upon the Theory of Planned Behaviour and Social support theory. For this purpose, the study assesses the relationship between Entrepreneurial Readiness (ER) and Entrepreneurial Action (EA) with the mediating role of Entrepreneurial Intention (EI) and Family Support (FS). The present study is quantitative in nature, under which primary data was collected using surveys from 528 students affiliated with multidisciplinary educational backgrounds to generalize the findings for students' entrepreneurship. For the data analysis, the study uses the Smart PLS software to assess the relationships of the latent variable through the structural equation modeling approach. Interestingly, the findings highlighted that there is no direct relationship between entrepreneurial intentions and actions. However, with the complete mediation of family support, intentions are translated into the entrepreneurial behavior of youth. Moreover, entrepreneurial readiness significantly enhances the intentions of youth to start a business. This is one of the pioneering empirical studies that emphasize the role of ER and FS in the interaction between EI and EA among Indian students. Furthermore, the study reveals that entrepreneurial readiness, intention, and family support play important roles in explaining students' entrepreneurial action.

The Triple Helix in Action: How Communication, Trust, and Goals Generate Collaborative Innovation

*Mahita Kaushik (1) and Amit Kumar Dwivedi (1)

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The Networks of Government-Academia–Industry Collaboration is becoming more and more important to national economies. Initiatives such as Make in India and Startup India have spurred innovation, but gaps persist in integrating academia, industry, and government to create a cohesive innovation ecosystem. Existing research has identified the obstacles and facilitators of government-university-industry cooperation, but our comprehension of the development of these collaborations remains restricted, which limits our capacity to foster their growth and innovation. This study examines the formation of a successful government-university-industry collaboration. It considers various perceived obstacles and facilitators among different phases of the triple helix framework. Using a qualitative research methodology, the study examined five government officials, ten companies and eight university institutions participating in an innovation collaboration. The findings show that certain barriers and facilitators of government-university-industry collaboration appear at different times. Some of the barriers are trust issues and unwillingness to share knowledge. The study emphasizes the significance of public investment and its allocation among members in order to foster industrial evolution and competitiveness. The Government-University–Industry Collaboration has grown into a global centre of excellence, drawing in new members and network-specific investments.

Translation of Traditional Khovar Wall Art of Jharkhand, India, for a Contemporary Context

*Pramod Priya Ranjan (1) and Saurav Khuttiya Deori (1)

(1) Department of Design Indian Institute of Technology, Hyderabad

The study examines the traditional Khovar wall art of Jharkhand, India, an indigenous, ritual-based, dichromatic art form created by women artisans during marriage ceremonies using the sgraffito technique. Despite receiving a Geographical Indication (GI) tag, the art form has been found to face challenges in contemporary adaptation, with artisans having limited access to contemporary design knowledge. While Sohrai wall art, another traditional wall art of Jharkhand, has seen wider contemporary translation, Khovar remains evidently underrepresented in public spaces and products. Using a participatory action research approach grounded in constructivist philosophy, the study engaged traditional women artisans, NGOs, designers, and fine artists. It successfully translated traditional motifs onto textiles and terracotta using silk screen printing, ensuring visual fidelity to the sgraffito aesthetics. This design-led intervention aimed to manage the desirability, viability, and feasibility of traditional practice in contemporary contexts. The research advocates for culturally sensitive, inclusive strategies to empower artisans and sustainably promote Khovar art in evolving social and economic landscapes.

Corporate Entrepreneurship within Public Sector Enterprises: Effect of National Culture and Intrapreneurial Behavior

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Corporate entrepreneurship is an essential practice within an organization to create a new enterprise within the organization or undertake new business opportunities such as innovation or initiate strategic renewal for ensuring long term growth and gaining competitive advantage. Growth has always been referred as dynamic rather than static as the pace of change in the internal and external business environment is disproportionate to the existing business conditions. So, what organizations need to do? To balance the pace of change and outperform against their competitors, organizations need to constantly innovate. Now a days, with the increasing pace of globalization as world is becoming interconnected through single source of supply chains, organizations are forced to rely on innovation so as to differentiate in terms of product quality or services. For more than three decades, corporate entrepreneurship has been gaining traction from researchers as well as industry practitioners throughout the globe. One reason for this is organizations are becoming hyper sensitive to changing business scenarios which opens new doors for research in areas related to innovation by setting up R&D labs, undertaking strategic renewal, new business venture activity and proactiveness. Our research paper will explore how corporate entrepreneurship is practiced within public sector enterprises and effect of national culture through Hofstede framework and intrapreneurial behavior on corporate entrepreneurship. We would also draw some insights from cross-cultural practices carried out on corporate entrepreneurship through employee entrepreneurial activity.

Bridging Digital Gaps: An AI Augmented Unified Solution For Sustainable Growth in Start-Ups and SMEs

**Saashi Agarwal (1), Sanjana Dutta (1), Manohar Desai (1), Nitin Gawai (1) and Bhumika Godase (1)*

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It is seen that in the dynamic business world, start-ups and small enterprises play a significant role in driving innovation and economic development. Most start-ups start with a small group of people and each person performs different tasks, from marketing to client servicing. To ensure a boost in efficiency, these companies use digital resources for branding, communication, and outreach. The business sector heavily relies on social media sites, automation tools, and data analytics to assist and help build their presence, engage with audiences, and expand their operations. The small-scale businesses rival in fast-changing markets despite restricted resources, in finance and manpower. Despite using digital tools, the mentioned companies still struggle to manage several social media channels, effectively analyze data, create lasting relationships, and maintain a consistent brand positioning. Time and knowledge shortfall lead to losses for entrepreneurs through ineffective campaigns and lost growth opportunities. The space needs to be filled with an integrated digital solution that optimizes AI-based automation, data, and easy design to streamline marketing, branding, and engagement as efficiently. Data collected is driven by cost saving, ease of access, and easy design. This allows even start-ups with limited resources to utilize contemporary technology to simplify processes, improve visibility, and promote sustainable business expansion. The procedure for addressing problems is guided by extensive primary and secondary research, integrating both qualitative and quantitative systems to provide a thorough understanding of start-up operations and requirements. By conducting surveys, industry analysis, as well as user behavior research, insightful practical knowledge regarding the difficulties encountered in digital marketing and brand management, will be obtained. Moreover, conducting user testing and iterative prototyping will enhance our platform's usability, sustainable business approach, and problem solving features. Utilizing AI automation and data-informed decision-making, our platform will guarantee a cost-effective, scalable, sustainable, and user-specific solution for 360-degree growth.

The Transformative Impact of Supply Chain Integration on Organizational Performance: A Holistic Analysis of Supplier, Internal, and Customer Synergies

**Ramchandra Alias Ameet Chate (1), Uttam Deshpande (2) and Ravi Lingannavar (3)*

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The complexity of today's business environment necessitates seamless integration across all facets of the supply chain. This study investigates the transformative impact of supply chain integration (SCI) on organizational performance, emphasizing the synergistic effects of supplier, internal, and customer integration. The research is grounded in 5 hypotheses aiming to elucidate the multifaceted benefits of SCI and its role in fostering competitive advantage across industries. Hypothesis 1 (H1) posits that supplier integration positively influences organizational performance by fostering collaboration, enhancing responsiveness, and reducing lead times. H2 explores the role of internal integration, emphasizing its potential to optimize resource allocation, improve process efficiencies, and drive organizational agility. H3 asserts that customer integration enhances product and service quality through improved communication, customized solutions, and responsiveness to market dynamics. H4 consolidates these dimensions, proposing that SCI as a holistic construct contributes significantly to an organization's competitive advantage, sustained growth. Finally, H5 examines inter-industry variations; impact of SCI may differ based on sectoral characteristics, operational priorities, and competitive pressures. Data for this study were collected through a structured survey administered to supply chain professionals across diverse industries like Rubber and Plastic, Electrical, Metal and Automotive industries capturing insights into their practices, integration levels, and organizational outcomes. Correlation and Structural equation modeling (SEM) were employed to validate the proposed hypotheses and assess the direct and mediated relationships among the constructs. Findings confirm that supplier, internal, and customer integration have distinct yet complementary effects on organizational performance. Supplier integration emerged as a critical driver of supply chain responsiveness, while internal integration significantly enhanced operational efficiency. Customer integration was strongly linked to improved product and service quality, highlighting the role of demand-side alignment in achieving customer satisfaction. The analysis also revealed significant inter-industry differences, with industries exhibiting varied emphasis on specific integration aspects based on their operational context.

Comparative Analysis of Optimization Techniques and Machine Learning Algorithms for Anomaly Detection in Aircraft Weight and Balance Metrics

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Anomaly detection for aircraft has been an active research area lately. Detection of anomalies is important to ensure operational safety and efficiency of an aircraft. However, research has been done on different flight datasets, like UAV data, ADS-B trajectory data, and so on, with different deep learning-based and clustering-based techniques, though aircraft's weight and balance data is not explored yet. This paper focuses on the aircraft's weight and balance dataset and explores the different categories of anomalies, like structural, performance-based, and operational-based, using PCA and One-Class SVM, and also employs optimization techniques like Whale Optimization (WO) and Particle Swarm Optimization (PSO) to enhance the model's performance. For comparative analysis, evaluation metrics like anomaly score and reconstruction error were considered, as the dataset is unsupervised. The results show that WO performs better than PSO for anomaly detection across different categories.

Enhancing Handloom Supply Chains with AI-Driven Inventory Systems.

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Handloom industry, deeply rooted in India's cultural and economic land-scape, struggles with inefficient inventory management, manual tracking er-rors, and supply chain disruptions. Traditional inventory practices often lead to material shortages, overstocking, and financial losses, highlighting the need for modernization. This study explores the integration of AI-powered smart inventory management systems, incorporating RFID (Radio Frequency Identification) technology, barcode tracking, and Blockchain technology to enhance efficiency, and optimize resource utilization in handloom supply chains. By integrating barcode, RFID and block chain -based tracking, real-time monitoring of yarns, dyes, and finished fabrics can be achieved, reducing discrepancies in inventory records. The study utilizes an experimental re-search approach. Stakeholder interviews with weavers, suppliers, and ware-house managers provide qualitative insights into the system's usability and adoption. This paper discusses how AI-enabled scanning systems, using RFID and cloud-based inventory management in handloom supply chain can help overcome these drawbacks. By investigating three different scenarios, frameworks are developed for addressing these challenges and improve stock accuracy, minimize discrepancies, and enhance material handling effi-ciency. The integration of automated scanning and real-time tracking reduces processing times and mitigates supply chain disruptions, preventing both stockouts and overstocking The findings indicate. The integration of automated scanning and real-time tracking reduces processing times and mitigates supply chain disruptions, preventing both stockouts and overstocking. In addition to examining differ-ent approaches, a combined framework is proposed. This proposal reflects the best characteristics that can demonstrate the versatility of RFID for track-ing products, Inventory management.

Life Cycle Assessment and Digital Product Passport (DPP) for Fashion Industry in India

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Abstract Background: A life cycle assessment (LCA) of fashion waste in India can help identify the environmental impacts of the fashion industry, from raw materials to disposal. LCAs can help fashion brands and manufacturers make more sustainable decisions. LCAs consider the entire life cycle of a product, from raw material extraction to production, use, and disposal. LCAs measure aspects like water consumption, greenhouse gas emissions, and waste production.
Gap and Focus: In the context of sustainability and SDGs (Sustainable Development Goals) in the fashion industry in India and a formalized DPP module, little work has been done, which lays greater stress on organized and unorganized manufacturers to implement DPP for fashion goods.
Methodology: Data Collection: Secondary data was sourced from academic literature, sustainability reports from fashion brands, and case studies on brands transitioning to the Industry 5.0 model.
Data Analysis: A comparative thematic analysis was conducted to analyze the data and form key patterns and prompts for design considerations. Design thinking and co-design were applied to generate an IOT-based, app-controlled platform to create. Digital Product Passport for fashion goods, tracing, 3R, and end of life.
Design and Testing: An IOT-enabled app-based DPP system for organised fashion manufacturers has been designed on figma and tested with 30 respondents for TAM (Technology Acceptance Model —perceived ease of use and perceived usefulness). The system was also tested for 5E's of usability and System usability scale.
Conclusion:The concept of DPP for fashion manufacturers in India demonstrates a positive response in light of Industry 5.0 and has the potential to revolutionize sustainability practices in the fashion industry. Future research by academics and practical implementation by industry professionals is essential to fully harnessing its benefits.

A Two-Phase MILP Framework for Joint Economic and Environmental Decision-Making in Multi-chelon Agri-Food Supply Chains.

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Governments across the globe are increasingly promoting sustainable supply chains through targeted initiatives and policy frameworks in sectors such as agriculture, manufacturing, and logistics. This study proposes a two phase Mixed-Integer Linear Programming (MILP) model to support sustainable de-cision-making in the food grain supply chain. In the first phase, the model assists farmers in selecting optimal crop rotation strategies and cultivation practices—specifically between carbon-smart crop protocols—CSCP-1 and CSCP-2—by maximizing profit while accounting for production-related costs and yield, and compares these outcomes with those obtained when the same model is solved with the objective of minimizing emissions to provide rele-vant recommendations as per the requirements of the user. The second level focuses on procurement and distribution, formulating a MILP to minimize the overall supply chain cost, which includes transportation, inventory, and facility location costs. This model is also evaluated under an environmental objective, minimizing emissions generated from transportation, facility loca-tion, and inventory holding. The formulation captures several real-world complexities, including a multi-echelon structure, multi-period planning, multi-modal transportation, multiple products, average delivery times be-tween each set of nodes, and capacity limitations at warehouses. The model is solved using the Gurobi Optimizer and offers practical insights for stake-holders such as farmers, procurement agencies, and logistics providers to make informed decisions. The integrated framework enables data-driven de-cision-making that supports both economic efficiency and environmental re-sponsibility in the agri-food supply chain.

A Decision Support Framework for Optimizing Transport Modes and Sustainable Packaging in the Consumer Goods Supply Chain

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The consumer goods industry is the fourth largest sector in the Indian economy. This supply chain faces issues related to inefficient storage, inadequate rural supply chain infrastructure, and logistical bottlenecks leading to significant losses and delays, affecting the delivery and increasing costs and emissions. To push the supply chain towards sustainability and reduce the emissions and cost, this study aims to develop a recommendation system that will give recommendations for choosing the mode of transport, options for storage location and suitable packaging material based on the product fragility. This study leverages machine learning models to give such recommendations. This system evaluates critical factors like delivery modes, commodity availability, emissions, transport distance and packaging material suitability. The recommendations will benefit all the echelons of the supply chains. Wholesalers will have options to introduce sustainable packaging and will have options to transport products based on the mode of transport available. Also, they will have options to group their products when sent to the same locations. Retailers will benefit from optimized delivery options and shipment strategies. This study will act as a communication portal where the supply chain entities can get recommendations based on the commodity required. This decision support system aims to reduce operational costs, minimize emissions, and improve supply chain efficiency. This study offers a robust decision support tool to support an environmentally responsible efficient supply chain.

From Tradition to Technology: AI's Impact on the Handloom Supply Chain

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Artificial intelligence (AI) has revolutionized the fashion and apparel industry by transforming various aspects of supply chain management (SCM). AI-driven technologies, including machine learning, expert systems, and computer vision, have been integrated into SCM processes such as supplier selection, risk prediction, demand estimation, production planning, inventory management, transportation, and sustainability. These innovations have improved decision-making, inventory control, and customer experiences in both B2B and B2C contexts. Despite the advancements in AI-driven SCM, the handloom sector, known for its rich heritage and craftsmanship, faces significant challenges. Inefficient supply chain operations, lack of real-time data, and high operational costs hinder its competitiveness in the modern market. This exploratory study investigates the potential of AI and machine learning (ML) to enhance the handloom supply chain. The study focuses on key objectives such as demand estimation, inventory optimization, supply chain visibility, and overall efficiency improvements in the handloom industry. By leveraging AI and ML tools, stakeholders can address inefficiencies, reduce costs, and ensure a more streamlined and responsive supply chain. The findings of this research highlight the transformative impact of AI in traditional industries and its potential to bridge the gap between heritage craftsmanship and modern technology-driven supply chain management.

Design an app based medical services for people living in remote areas

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People living in remote areas like hilly areas of Uttarakhand face a lot of challenges, particularly in medical services. As there are no hospitals, emergency services, or doctors, any service from the city takes a long time to reach. The aim of the project is to develop app-based services that people can use in remote areas and avoid delays in emergency medical services. Most of the hilly, remote areas in India face the same problems. Government-run ambulances (like 108 services) often don't cover remote areas well. Private ambulance services are too expensive for many rural residents. There is an acute shortage of medical manpower, and people heavily depend on traditional healers due to a lack of trained personnel. Poor mobile network coverage makes calling for help difficult. Monsoons, floods, and landslides can block roads and isolate villages. A survey has been conducted among local residents, students, and doctors. The important parameters affecting this scenario are identified, and their affinity diagram is prepared. The solution through a service design approach is worked out. The implementation through mobile apps and user interfaces is worked out. This will have overall features of live ambulance tracking, first aid tips, 24/7 emergency healthcare transit, instant ambulance booking, and real arrival monitoring. This helps and guides people in remote areas to also get prepared for emergency conditions.

Evolution of Sawantwadi's Wooden Toy Industry: Integrating Technology for Sustainable Production

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Sawantwadi's traditional toys, popular in Maharashtra for their durability and use of natural paints, have long been crafted with great care. Skilled artisans dedicate significant time to developing each toy. Traditionally, the entire process was carried out using manual cutting tools, but with the advent of electronic cutting machines, the industry adopted these technologies to save time and reduce human effort. More recently, the introduction of AI-based laser cutting machines has further streamlined production by enabling precise shaping of toy components. Additionally, as production volumes have increased, the painting process has also become machine-assisted. The toy industry is continuously evolving, incorporating new materials and designs. The Indian market has seen a surge in Chinese toys, which are cheaper and visually appealing due to their vibrant colors and added functionality. However, concerns over toxic chemicals and poor durability have led to bans on these toys in some countries. In contrast, artisans in the traditional sector emphasize the sustainability of wooden toys, branding them as eco-friendly alternatives painted with natural colors. As demand has grown beyond Maharashtra, the sector has increasingly integrated machinery to accelerate manufacturing. This study explores the industry's evolution, particularly in production processes, through surveys and interviews that capture user opinions. While plastic toys may be more affordable, they lack sustainability and environmental friendliness. Wooden toys, crafted from seasoned wood and painted with natural dyes, offer a notable finish with a glossy appearance and carefully selected color shades, allowing them to compete with plastic

Deep Learning Prediction of Meltpool Dimension in the 3D printing process

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Selective Laser Melting (SLM) is an additive manufacturing process that uses a high energy laser to selectively melt and fuse metal powder layers together to create complex 3D parts. During the process, a high-energy laser selectively melts and fuses the powder across the build platform, which moves down by one layer thickness and new layer of powder is spread and the process is repeated. The melt pool refers to the molten metal created by the laser during the SLM process. The size, shape and behavior of the melt pool directly impact the microstructure and properties of the final printed part. Larger melt pools can lead to coarser grain structures and more defects like porosity and cracking. Smaller, more controlled melt pools result in finer, more uniform microstructures with improved mechanical performance. The melt pool dimensions are influenced by laser power, scan speed, layer thickness, and powder properties. Monitoring and analyzing the melt pool dimensions in Selective Laser Melting (SLM) can provide valuable insights that help improve the quality and performance of 3D printed metal parts. This study aims to develop an advanced predictive modeling approach for the dimensions of melt pools using deep learning techniques. Separate lightweight machine learning models can potentially be used to simultaneously predict the width and depth of melt pools in metal 3D printing. Predicting width and depth separately allows for more targeted optimization of the 3D printing process parameters to control each melt pool dimension independently. This can enable fine-tuning the process to achieve the desired melt pool characteristics for improved part quality and performance.

An innovation in developing a sustainable building material using Graphene as an additive for a cement-based material

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Research in construction industry has given newer avenues for exploring building materials and its use. The global construction sector, is consuming around 3000 MT/ year of raw materials, accounting for almost 50% by weight, and is a significant contributor to an unsustainable environment. Everyday a new material or a technique is discovered to replace the existing material to make it better and more recently environmentally friendly. Exploring the use of organic materials becomes environmental friendly and can level up the climate change. Graphene a wonder material of this decade has profound implication and have exceptional results in every application field. Graphene and its derivatives can effectively be used in building materials and this research work uses a scoping and compressive study on the mapping of graphene along with agricultural waste in creating a newer building material. Selection of a natural material based on its occurrence, availability and usability was taken as the criteria and different materials were shortlisted based on natural occurrence, agricultural and biodegradable waste. The probable building material which was targeted in the present study was prefabricated cement based particle board. Cement is an inevitable building material which gives strength and durability. This study was thought to focus on the reduction of cement by incorporating additional material organic in nature and graphene as additives and testing the resulting product was carried out. The property of graphene has prospected in the present study. The use of graphene and organic wastes with cement to produce a cement particle board was researched and parameters were set in and assessed.

Using Coconut Shell as a Sustainable Packaging Material with Reference to Temple Culture of India

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Indian traditions and culture center around coconuts, especially in temples. Coconut shells are easily accessible near temple sites because they are donated to the gods during prayers. Coconuts are widely used in events and food preparation, and India is the world's greatest producer. Coconut shells are frequently thrown away as garbage. This study investigates how coconut shells might be used as a sustainable packaging material, especially in temple areas, where they might take the place of plastic packaging for items like dry snacks, perfumed sticks, flowers, and prasad (blessed food). However, the widespread use of plastic in nearby of temple complexes in recent years has created environmental problems. An eco-friendly, biodegradable, and long-lasting substitute is provided by coconut shells. With easily accessible simple equipment, they require very little processing. This project aims to reduce plastic waste and advance sustainability by turning used coconut shells into packaging. Additionally, because it addresses contemporary environmental problems while expressing traditional values, coconut-shell packaging is in line with temple culture. In this study, coconut-shell packaging for a range of products is sampled, tested, and compared to traditional plastic packaging. The survey examines how the general public feels about both solutions' environmental impact, usability, and visual appeal. The findings show that local merchants and craftspeople close to temples have a great chance of accepting coconut-shell packaging. Additionally, this strategy offers small-scale businesses and artisans' financial opportunities, motivating them to develop practical and visually appealing packaging solutions. Packaging made of coconut shells is unique, reasonable, and recyclable. By encouraging eco-friendly behaviors and lowering dependence on plastic, it advances sustainable development goals. This project focuses on educating urban, semi-urban, and rural people about the value of using environmentally friendly packaging. It promotes the creation of a model in which local artisans and temple sellers work together.

Eco-efficient Packaging Trends: Innovations in Materials, Processes, and Consumer Behavior

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Packaging as a concept and industry has existed for centuries, though it has taken different dimensions with the Industrial Revolution. The role of packaging is multifunctional, from structural and damage protection to carrying usage information, branding, marketing, and visual appeal. Also, it involves many facets like material selection, printing technology, mass manufacturability, durability, transport friendliness, space efficiency, etc. However, sustainability from an ecological perspective has never been a core element of packaging. This contributes to waste generation and pollution, which are leading to the climate crisis. Non-biodegradable materials, multi-layered material compositions, heterogeneous structures, toxic inks for printing, polluting processes, and energy- and resource-intensive manufacturing are the key contributors to non-sustainable packaging practices. The packaging industry has acquired an important position today, equivalent to the base product. Hence, avoiding packaging is impossible in today's time of globalization in economy-centric businesses. However, making packaging eco-friendly through different approaches can help reduce pollution. The methodology adopted here is to deep-dive into the green aspects of packaging through sustainability certification standards. Attributes for eco-packaging have been derived from the certification standards and guidelines. The perceptions, understanding, and practical issues of sustainability in packaging are received from the different stakeholders of the packaging ecosystem through questionnaires, in today's Indian scenario. This led to finding the gaps in the current packaging system. The research aims to find gaps and possible directions to help designers and users shift to maximum green options to reduce waste generation and ensure circularity.

IoT for Sustainable Indian Agriculture

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India is an economy which is very dependent on the agricultural industry. It employs about 50% of the total population. The industry faces a lot of challenges, such as climate variability, poor irrigation, poor soil health, soil management and real time data access. Traditional farming practices often lead into wastage of a lot of resources and result in lesser yields, so this study proposes a solution integrating technology, IoT (Internet of Things) which can revolutionize Indian Agriculture, enabling precision farming, optimizing usage of resources and increase in productivity. The proposed solution will be capable of tracking soil moisture, temperature and even suggest optimal irrigation scheduling and better resource management, utilizing IoT. With real time data driven insights, farmer will be able to make well informed decisions with clarity, reduce water wastage, fertilizer wastage, and have higher crop yields. Farmers will also be able to communicate with other fellow farmers, engage in collaborative problem solving, resource exchange, labor sharing, and so cost reducing and enhancing productivity can be achieved. The research will empower the farmers and fill the gap between traditional agriculture and modern agriculture to ensure sustainability, profitability and efficiency of agriculture. This will ultimately drive agricultural industry towards a steady growth in the Indian economy.

Sustainable Illumination: Assessing the Role of Bioluminescence in Environmental and Economic Contexts

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As a sustainable lighting substitute for traditional illumination, this study evaluates the financial and environmental benefits of bioluminescent lighting systems. This study aims to commercialize the value of using naturally occurring biological light-emitting processes in view of the growing worldwide awareness of energy consumption and environmental effects. This evaluation employs a mixed-methods approach that includes cost-benefit analysis to ascertain economic viability and life cycle assessment (LCA) to evaluate environmental impact. Taking resource consumption and environmental impact into account, the environmental study contrasts the carbon footprint, energy consumption, and light pollution of bioluminescent and conventional lighting. In order to determine long-term viability, the economic analysis looks at starting costs, operating expenses, maintenance requirements, and potential energy savings. To provide in-depth analysis, data is gathered from government statistics, industry records, and scientific research. According to studies, bioluminescent technologies have the potential to significantly reduce energy use and emissions, which would lessen their negative effects on the environment and the amount of light pollution they cause, therefore improving ecological balance. Even while the initial investment may be greater, the long-term operating expenses due to reduced maintenance and energy consumption offer an alluring return and allow for widespread deployment. Through a quantitative assessment of the economic and environmental benefits, this study highlights the potential of bioluminescence for sustainable development and contributes valuable knowledge to the field. This study informs researchers, business, and government on the possibilities of bioluminescence. It is recommended that further study be done to optimize system design, increase efficiency, and look into different applications in order to increase system adoption and realize its full economic and environmental potential.

Integrating Sensor Technology in Classical Dance Training:Preserving Authenticity while Enhancing Posture Accuracy

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India's classical dance forms require precision in posture, movement, and alignment, which are traditionally imparted through in-person training and long-term practice under a guru. While these methods preserve cultural authenticity, they often limit scalability, accessibility, and objective feedback for learners, particularly in remote or digital learning contexts. This study explores the integration of wearable sensor technology into classical dance training to enhance posture accuracy while preserving the authenticity of traditional practices. The proposed system employs sensor-based data capture combined with digital human modelling and simulation techniques to analyse body posture and movement patterns in real time. Visualisation tools provide immediate feedback to dancers, enabling self-correction without replacing the role of the instructor. The framework supports precision in movement, reduces the risk of posture-related injuries, and facilitates remote instruction and scalable training environments. By balancing technological intervention with cultural sensitivity, this work demonstrates how sensor-enabled systems can augment classical dance pedagogy while maintaining the integrity of traditional dance forms.

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I-4AM 2026

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