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Indian Institution of Industrial Engineering (IIIE)

67th National Convention
9th International Conference
& National Productivity Contest

AI-DRIVEN INDUSTRIAL ENGINEERING FOR SUSTAINABILITY

8-9 August, 2025

Book of Abstracts

Editors

Dr. Bijulal D.
Dr. Sini V. Pillai
Dr. Suresh Kumar C.

Organized by

Indian Institution of Industrial Engineering (IIIE) Trivandrum Chapter

in Association with

Department of Mechanical Engineering & CET School of Management College of Engineering Trivandrum

67th National Convention of IIIE, 9th International Conference on IE and National Productivity Contest

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GOVERNMENT OF KERALA

Pinarayi Vijayan

CHIEF MINISTER

No. 651/Press/CMO/25 25 July, 2025.

MESSAGE

I am happy to know that the Indian Institution of Industrial Engineering, Thiruvananthapuram chapter, is conducting the 67th National Convention and the 9th International Conference on Industrial Engineering at Trivandrum, on the theme *'Industry 5.0: AI driven industrial engineering for sustainability'*.

I hope that the conference will help in discussing the industrial engineering techniques and interventions aimed at enhancing efficiency and productivity through the optimization of complex systems.

My best wishes.

Pinarayi Vijayan

The President
IIIE
E-mail: iiie.trivandrum@gmail.com

141, 3rd Floor, North Block, Government Secretariat, Thiruvananthapuram Pin 695001 T 0471 2333241, 2333812, 2333610 F 0471 2333489
E chiefminister@kerala.gov.in facebook.com/cmokerala twitter.com/cmokerala
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MINISTER FOR
LAW, INDUSTRIES & COIR
GOVERNMENT OF KERALA

THIRUVANANTHAPURAM

Date..26.07.2025.....

Message

I am pleased to note that the Indian Institution of Industrial Engineering (IIIE) is organising its 67th National Convention and 9th International Conference on Industrial Engineering in Thiruvananthapuram. It is heartening that this prestigious event is returning to our capital city after 18 years.

The theme, "Industry 5.0: AI-driven Industrial Engineering for Sustainability", is both timely and relevant. As industries around the world embrace AI and data driven tools, it is essential that we equip our engineers, professionals, and researchers with the capabilities to lead this transformation while upholding principles of sustainability and inclusive growth.

Kerala is steadily advancing in sectors such as artificial intelligence, sustainable manufacturing, and industrial innovation. Events like this provide a valuable platform to strengthen that momentum by bringing together thought leaders, researchers, and professionals from across the country.

I am confident that the deliberations, technical presentations, and expert interactions at this convention will contribute meaningfully to shaping the future of industrial practices in India. I extend my best wishes to all delegates and organisers for a successful and impactful convention.

P Rajeeve

Office : Secretariat North Sandwich Block, 3rd Floor, Room No. 301
Government Secretariat, Thiruvananthapuram-695 001.
Res. : "USHUS", Nanthancode, Thiruvananthapuram-695 003
Phone-Office : 0471-2336866, 2336966 Mobile : 9400077333
E-mail : min.ind@kerala.gov.in, min.law@kerala.gov.in

MESSAGE

Rahul Sahai
Chief Executive Officer
Kirloskar Engines Limited
President, IIIE

As the president of the Indian Institution of Industrial Engineering, it is my great pleasure to welcome the delegates to the 67th National Convention held at Thiruvananthapuram. The National Convention provides a common platform to the industrial engineering practitioners to exchange their experiences, the best practices, and the role models in engineering applications and innovations. It is interesting that the theme of the current convention is Industry 5.0: AI-driven Industrial Engineering for Sustainability. The theme reflects the need of the industries in the era of artificial intelligence and it is selected in such a way that the new era industrial engineers will discuss the challenges experienced while in practice.

The international conference in its ninth edition provides the platform for the researchers to present their innovative and outstanding contributions that can address the issues faced by industries when the focus shifts to sustainability. The productivity contest in its new edition will showcase how the productivity of systems is improved in the fast changing industrial systems.

I wish all delegates, contestants, and presenters a warm and comfortable stay and successful participation in the convention.

(Rahul Sahai)

MESSAGE

N. Narayana Moorthy
President, IIIE, Trivandrum Chapter
Chairman, Keltron Group of Companies

I feel extremely happy and proud that Indian Institution of Industrial Engineering (IIIE), Thiruvananthapuram Chapter is hosting the 67th National Convention of the Indian Institution of Industrial Engineering and organizing 9th International Conference on Industrial Engineering at Trivandrum on 8–9 August 2025. As part of the event, a National Productivity Contest is also planned.

As President of the Thiruvananthapuram Chapter, I am thrilled to extend a heartfelt welcome to all of you to Thiruvananthapuram and to the conference. The conference theme "Industry 5.0: AI-driven Industrial Engineering for sustainability" is highly relevant in the current industry echo-system in India. I am sure that the convention and conference will serve as a vibrant platform for interaction with leading industry experts and academic researchers. It will also open out a unique opportunity to expand knowledge on business transformation strategies using Industrial Engineering approaches and AI-enabled tools, while also enabling participants to broaden their professional knowledge and networks.

May this conference be source of inspiration, knowledge and collaboration that propels us towards new horizons in Industrial Engineering and its applications to the Indian Industries especially for industries in Kerala.

(N. Narayana Moorthy)

AI-driven Industrial Engineering for Sustainability | ISBN: 978-93-89947-90-8 (eBook)

MESSAGE

Dr. AVV Prasada Raju, Ph.D, CEng(I)
FIIE, FIIM, FIE, FMTC, FCAE, SMISE
Chairman, IIIE National Council

It's really a proud movement for all of us in Industrial Engineering fraternity, we are organising our 67th National Convention, 9th International Conference and National Productivity Contest on 8th & 9th August 2025 in God's Own Country Thiruvananthapuram, Kerala hosted by IIIE Trivandrum Chapter in association with Department of Mechanical Engineering and CET School of Management, College of Engineering Trivandrum.

Several distinguished dignitaries, eminent speakers, paper presenters and productivity contestants from all over the country and abroad would be sharing their thoughts on "Industry 5.0: AI driven Industrial Engineering for Sustainability" and innovative skill, knowledge and experience on productivity movement in their respective fields, which would be immensely beneficial to the participants.

I wish this national convention, international conference and productivity contest a great success.

(Dr. Alluri VV Prasada Raju)

MESSAGE

Dr. Sunderesh Heragu
Ph.D, Oklahoma State University,
USA President, IISE

The Institute of Industrial and Systems Engineers (IISE) is pleased to know that the Indian Institution of Industrial Engineering (IIIE) is organizing its 67th National Convention. We applaud you and all those who join with IISE worldwide to advance Industrial Engineering. As a JV partner organization, your dedication towards making societal systems effective and efficient is to be praised. Best wishes as you continue to promote and support the industrial and systems engineering profession for the benefit of humankind.

(Dr. Sunderesh Heragu)

MESSAGE

Dr. Suresh K.
Principal, College of Engineering Trivandrum,
Thiruvananthapuram

It is with immense pleasure and pride that the College of Engineering Trivandrum hosts the 67th National Convention of the Indian Institution of Industrial Engineering (IIIE). Alongside the convention, the 9th International Conference and the National Productivity Contest are also been organised.

IIIE is a premier organization of professionals dedicated to the field of Industrial Engineering, playing a crucial role in empowering Indian industries to adapt and thrive in this rapidly evolving, technology-driven era. Events like these offer valuable opportunities for participants to explore emerging technologies, learn best practices, and engage with experts from across the country and beyond.

The theme of this year's convention is especially relevant, as we collectively strive to achieve the Sustainable Development Goals (SDGs) through advancements in Artificial Intelligence and related technologies.

I am confident that this event will be a resounding success, driven by the enthusiastic participation of all stakeholders. On behalf of the College of Engineering Trivandrum, I extend a heartfelt welcome to all delegates attending this prestigious program.

(Dr. Suresh K.)

MESSAGE

Catherine Karakatsanis
P Eng, Fcae, Fce,
Lld President

The Canadian Academy of Engineering
Ottawa, Canada

Dear Dr. Alluri Raju, FCAE

I am delighted and honored by the invitation to write the message to the National Convention, International Conference of Indian Institution of Industrial Engineering (IIIE) on "Industry 5.0: AI-driven Industrial Engineering."

We, CAE hope that you will have successful and fruitful conference.

(Catherine Karakatsanis)

MESSAGE

Dr. Sio-Iong Ao, Ph.D
Secretary General

International Association of Engineers
London, UK

Dear Dr. Raju Alluri,

I am pleased to receive your invitation to give a keynote presentation at the 9th International Conference during your 67th National Convention and National Productivity Contest in the second week of August this year at Hotel Dimora Thiruvananthapuram, Kerala.

I would not be able to attend as I am occupied with the forthcoming World Congress on Engineering and Computer Science 2025 (WCECS 2025), composed of 15 conferences will be held in San Francisco, USA, 22-24 August 2025.

I wish you and your team good luck in organizing triple events the convention, conference and contest.

(Dr. Sio-Iong Ao)

MESSAGE

Dr. Alan Hoi Shou Chan
Professor & HOD

Industrial & Production Engineering City
University of Hong Kong, China

On behalf of the Industrial & Production Engineering Division, The City University of Hong Kong, I am delighted to congratulate The Indian Institution of Industrial Engineering for organizing its 67th National Convention, 9th International Conference and National Productivity Contest. We are looking forward to broadening and strengthening our institutional interaction in the future, and wish you a very successful National Convention, International Conference and Productivity Contest in August 2025.

(Dr. Alan Hoi Shou Chan)

MESSAGE

Prof. KVSG Murali Krishna
Former Vice Chancellor
JNTUK Kakinada

Heartiest Congratulations to the Indian Institution of Industrial Engineering (IIIE) on the occasion of their 67th National Convention along with 9th International Conference and Productivity Contest at Thiruvananthapuram on 8th & 9th of August 2025 wherein many professionals both from India and abroad would participate and deliberate on important theme of the event. I am sure that this platform will provide an excellent opportunity for exchange of knowledge and practices by professionals from both industry and academia.

I extend my warm greetings and felicitations to all those associated with IIIE and International Conference.

(Prof. KVSG Murali Krishna)

MESSAGE

Prof. Dr. Saiful Islam
MSc Engg, Ph.D, FIET
Vice Chancellor

American International University
Dhaka, Bangladesh

Dear Chairman,

I am overwhelmed with delight to know that the Indian Institution of Industrial Engineering is conducting its 67th National Convention during August 2025.

Your upcoming international conference on Industry 5.0 with the theme that focuses on " AI-driven Industrial Engineering for Sustainability" is a very good thought.

I, once again, would like to congratulate you and your team who are putting their best efforts in propagating the sustainable industries a grand success.

(Prof. Dr. Saiful Islam)

FOREWORD

As we stand at the cusp of a new industrial revolution, Industry 5.0 signifies a transformative shift—merging the power of Artificial Intelligence, advanced technologies, and human creativity to build smarter, more sustainable, and human-centric industrial ecosystems. Unlike its predecessor, Industry 5.0 emphasizes not just technological advancement, but also prioritizes human-centric innovation, environmental responsibility, and social well-being. The integration of AI into Industrial Engineering is empowering industries to develop adaptive, efficient, and resilient systems of production and operations.

It gives me great pleasure to present this Book of Abstracts for the 9th International Conference on Industrial Engineering, themed **"**Industry 5.0: AI-Driven Industrial Engineering for Sustainability," organized in conjunction with the 67th National Convention of the Indian Institution of Industrial Engineering (IIIE). This conference provides a vital platform to explore, deliberate, and disseminate forward-thinking ideas aimed at transforming industrial processes and systems to meet the challenges and opportunities of this new era.

The abstracts compiled in this volume reflect cutting-edge research, applied studies, and innovative practices contributed by scholars, practitioners, and students from across the country. The topics span a wide spectrum—ranging from intelligent manufacturing and AI-driven decision-making to sustainable operations, human-machine collaboration, supply chain logistics, and the socio-economic dimensions of an evolving industrial landscape.

A notable feature of this publication is the inclusion of case studies from the National Productivity Competition, which highlight real-world applications of Industrial Engineering principles. These cases demonstrate measurable improvements in productivity, efficiency, and sustainability, and serve as compelling examples of how IE methodologies continue to deliver value in increasingly complex, technology-driven environments.

We extend our heartfelt gratitude to all contributors for their valuable submissions, and to the technical committee and reviewers for their meticulous evaluation. We also acknowledge the unwavering support and guidance of the organizing team and the leadership of the IIIE, whose dedication has brought this event to fruition.

We hope this compilation not only documents the intellectual engagements of the conference but also serves as a lasting source of insight and inspiration for continued research, innovation, and application of Industrial Engineering toward a sustainable, AI-empowered future.

Dr. Anil B.
Organising Chair
9th International Conference on Industrial Engineering

PREFACE

Changes in technology have forced the industry to adopt them before the value declines. This has created the need for change in the thinking process as well. The ease and speed of getting the tasks completed have increased drastically that warrants for new skill sets in the new era of rapid industrial changes. Addition of skills to the existing staff has become the focus of industries to cope up with the pace of technology. This in turn has created a push on the academia by the industry to focus on skills over and above the knowledge level. The Sustainable Development Goals of the UN paves the path to future developments based on the sustainable goals. This forms the new challenge to industries to adopt sustainable technologies and follow sustainable practices.

The ninth International Conference on Industrial Engineering as part of the 67th National Convention and Productivity Contest of the Indian Institution of Industrial Engineering (IIIE) provide a common platform to discuss the progress of research by the academia and the adoption of research outcomes by the industrial world. This book provides the essence of the changes that the industrial world undergoes and that it is going to face in the near future.

As part of the development of technology, the role of Artificial Intelligence (AI) is inevitable. Along with automation happened in industries decades back, the man-machine systems have evolved to new heights that the human intelligence can be replicated by machines for specific low intellect tasks. The deliberations in the conference focus on how AI is going to help the Industrial Engineering practices in the present and the future. The fields of application of AI in the recent research and the possible implementation for industrial development through productivity and quality that are discussed by the academia and the industry are the essential parts of this book.

This book recognises the efforts of many people from the very beginning, the inception of the conference as part of the 67th National Convention of the IIIE. We acknowledge the sincere efforts made by the authors in providing their contributions to the conference and allowing us to bring this book into a reality.

Dr. Bijulal D.
Organising Secretary, IIIE NC 2025
Principal-in-charge, Govt. Engg. College, Barton Hill
Thiruvananthapuram

ABOUT

INDIAN INSTITUTION OF INDUSTRIAL ENGINEERING (IIIE)

Yogesh Dipnaik
Hon. Secretary
IIIE National Council

The **Indian Institution of Industrial Engineering (IIIE)** is a national-level professional body with a distinguished legacy of 68 years. It is committed to the advancement of Industrial Engineering (IE) education and the scientific application of IE knowledge and practices. The Institution strives for systemic improvements across various sectors including industry, business, government, academia, and society at large.

IIIE aims to create awareness among practicing industrial engineers about evolving technologies and modern management practices. By actively disseminating information and promoting knowledge related to Industrial Engineering, IIIE contributes significantly to enhancing productivity at both individual and organizational levels. Today, it boasts a membership base of over **10,000 professionals** and more than **200 organizational members**. The Institution operates through **33 Chapters** across the country, each catering to the specific needs of its members.

The major activities of IIIE include the Industrial Engineering Graduateship Examination, National Conventions, the Chief Executive Officers (CEOs) Conference, Convocations, Regional Conferences and Meetings, Publications, Professional and Institutional Memberships, and various Honours and Awards. These initiatives foster professional development, networking, and academic excellence in the IE community.

The **National Convention**, held annually in different regions of the country, focuses on urgent and relevant industrial themes. The convention also convenes professionals from both the public and private sectors, along with academicians, to present research papers and discuss significant issues concerning the Industrial Engineering profession.

IIIE is also a leading publisher of technical and professional literature. Its **Industrial Engineering Journal**, a monthly peer-reviewed publication, aims to bridge the gap between academic research and industry application. It covers interdisciplinary topics in Industrial Engineering and Management Science across both manufacturing and service sectors in the public and private domains.

The Institution is currently led by **Shri Rahul Sahai**, CEO of Kirloskar Oil Engines Ltd., who serves as the President. **Dr. A.V.V. Prasada Raju** chairs the National Council and steers the academic and developmental activities of the Institution.

Thank you.

(Yogesh Dipnaik)

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Dr. Vineetha S. Das

Mr. Ratheesh S.

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Contents

1

[ICIE003]

Partial Ranking Methodologies for Noisy Measurement Data and their Application in Business Process Analysis

[1]Aatika Sinha and [2]Ramgopal Reddy

[1]Penn State University, Main Campus
[2]The LNM Institute of Information Technology, Jaipur

Email: [1]aatikasinha99@gmail.com
[2]argr.0903@gmail.com

Abstract—This paper addresses the challenge of ranking sets of noisy measurement data while accounting for ties, which introduces non-transitive relationships and multiple reasonable ranking possibilities. We propose three methodologies for partial ranking. Methodology 1 generates a partial ranking with an arbitrary number of ranks. Methodology 2 refines the ranking from Methodology 1 to reduce the number of ranks, avoiding ties caused by single variants overlapping with well-separated variants. Methodology 3 further optimizes the process to produce a partial ranking with the minimum possible number of ranks. The paper highlights the potential of these methodologies in identifying performance differences among business process variants, specifically using the Purchase-to-Pay (P2P) process as an example. This analysis can serve as a foundation for developing models that automatically distinguish between process variants, even when performance metrics are not directly available.

Keywords: *Partial Ranking, Noisy Measurement Data, Business Process Variants, Non-Transitive Relationships, Purchase-to-Pay (P2P) Process*

2

[ICIE009]

Ethics in Every Dose: A Hybrid Two–Stage Framework for Sustainable Vaccine Sourcing

[1]S.S. Appadoo, [2]Y. Gajpal, and [3]M. Venkatesh

[1,2,3]University of Manitoba, Winnipeg, Manitoba, Canada R3T-5V4

Email: [1]SS.Appadoo@umanitoba.ca
[2]Yuvraj.Gajpal@umanitoba.ca
[3]Mani.Venkatesh@umanitoba.ca

Abstract—This paper introduces a two-stage dynamic methodology for vaccine selection, addressing critical gaps in sustainable healthcare supply chain management. In the first stage, suppliers are systematically evaluated against some predefined sustainability standards, enabling the objective elimination of non-compliant suppliers before further assessment. The second stage integrates a hybrid weighting approach combining the MEREC and CRITIC methods, generating robust, data-driven criteria weights that balance decision-maker preferences with objective data insights. While MCDM techniques are well-established in general supply chain contexts, their application in healthcare, particularly for vaccine procurement, remains underexplored. To bridge this gap, the Two-Stage Acceptable-Feasible Solution (TS-AFS) strategy prioritizes both sustainability compliance and data objectivity in a unique manner. Our methodology ensures that selected suppliers meet ethical and environmental benchmarks and align with quantitative performance metrics. Numerical illustrative examples are provided towards the end. The study advances theoretical frameworks in sustainable supply chain management and offers actionable insights for healthcare organizations to optimize vaccine selection while adhering to global sustainability standards.

Keywords: *Data-Driven, TS-AFS strategy, MCDM, Merec, Objective Decision Making.*

3

[ICIE010]

Study of Gear Hobbing Process under Flooded and MQL Conditions using Mineral and Vegetable-based Cutting Oils: Opportunities and Challenges

[1]Arif Pathan, [2]Dhananjay R. Dolas, and [3]Shrikrsihna Pawar

[1,2,3]MGM University, Chhatrapati Sambhajinagar

Email: [1]apathan@mgmu.ac.in
[2]ddolas@mgmu.ac.in
[3]spawar1@mgmu.ac.in

Abstract—The Gear Hobbing process is widely used to produce spur gears with dimensional accuracy in batch production for automotive and machine tool applications. Dimensional accuracy and surface finish of gears are important surface characteristics for transferring motion and power among shafts. The surface characteristics of the gears are important for their life and smooth operation, and for maintaining these characteristics, cutting oils are used while manufacturing gears. The objective of this paper is to study the gear hobbing process under flooded and MQL conditions using various cutting fluids in order to find and discuss the opportunities and challenges in the gear hobbing process. This study comprises a comprehensive critical literature review of scholarly research papers and an analysis of practices within the gear manufacturing industry. In this study, it is found that MRR, dimensional accuracy, Ra, cutting temperature, cycle time and hob wear are mostly selected as important performance measures, as these measures provide a balanced performance combination of quality, cost, and productivity. Also in this study, it is found that the range of process parameters (hob speed, feed, depth of cut), type of cutting fluid (Mineral, Vegetable, synthetic) and cutting condition (Flooded, MQL) is selected based on gear material and hob cutter in order to optimize the cost.

Keywords: *MQL, Flooded, MRR, Dimensional accuracy, Machining Cost, Cutting Temperature.*

4

[ICIE011]

Wireless Attack Simulation using Python: A Real-Time Evaluation of Common Wi-Fi Threats

[1]Abhyudaya Tiwari, [2]Ayush Pareek, [3]Piyush Bafna, [4]Archana Ratnaparkhi, and [5]Anuj Baheti

[1,2,3,4,5]Department of Electronics and Telecommunication, Vishwakarma Institute of Information Technology, Pune, India

Email: [1]abhyudaya.22211596@viit.ac.in
[2]ayush.22211400@viit.ac.in
[3]piyush.22211595@viit.ac.in
[4]archana.ratnaparkhi@viit.ac.in
[5]anuj.22211559@viit.ac.in

Abstract—Wireless networks are more and more susceptible to numerous types of cyber-attacks because they are open and shared. This work addresses the simulation in real time of four prominent wireless network attacks: Packet Sniffing, Deauthentication Attack, Man-in-the-Middle (MITM) Attack, and Evil Twin Attack. Utilizing Python and its networking libraries, we create an interactive system that simulates these attacks with randomized parameters to simulate real-world variation. The simulation provides dynamic feedback on attack success, detection probability, and possible data loss, enabling real-world analysis of each technique's effect. Our approach closes the gap between theoretical security models and real-world network contexts and offers an educational and research-based environment to study wireless vulnerability. Performance outcomes identify attack patterns under varied network settings and the capability of the framework to represent attacker strategy and network resilience.

Keywords: *Wireless security, Packet sniffing, Deauthentication, MIT M, Evil twin, Python simulation, Cyberattack modelling, Network vulnerabilities*

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[ICIE017]

Image Captioning-using InceptionV3-GRU: A Deep Learning Approach

Anjani Kumar
Cluster Innovation Centre, University of Delhi, Delhi, India
Email: akumar@cic.du.ac.in

Abstract—Image captioning is an engaging artificial intelligence problem that utilises two techniques to identify objects in an image and a language model from the field of natural language processing to convert the image's content into a sequence of words in the correct order. In this paper, a method that uses a pre-trained convolutional neural network (CNN) to extract features from an image, and then integrates the features with an attention mechanism and creates captions using a recurrent neural network-GRU (GRU), which in this paper was a gated recurrent unit. The proposed model is constructed using a CNN-CNN as the encoder and GRUs as the decoder. The experimental results in the Flickr 8K dataset show that the proposed model has less loss and, thus, has higher performance as compared to the CNN, CNN-RNN, and CNN-LSTM models.

Keywords: *Deep learning, Image Captioning, CNN, GRU, InceptionV3*

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[ICIE021]

Security and Performance Analysis of Wi-Fi Encryption Protocols: Simulated Attacks and Real-World Risks in IoT and Smart Networks

[1]Kunal Magar, [2]Vallabh Mahajan, [3]Shrihari Parulekar, [4]Samiksha Nagrale, and [5]Archana Ratnaparakhi

[1,2,3,4,5]Department of Electronics and Telecommunication, B.R.A.C.T's Vishwakarma Institute of Information Technology, Pune, India

Email: [1]kunal.22210124@viit.ac.in
[2]vallabh.22210826@viit.ac.in
[3]shrihari.22210957@viit.ac.in
[4]samiksha.22210779@viit.ac.in
[5]archana.ratnaparakhi@viit.ac.in

Abstract—In the era of ubiquitous wireless connectivity, ensuring secure communication over Wi-Fi networks is paramount, particularly with the increasing proliferation of IoT devices and smart systems. This paper presents a comprehensive security and performance analysis of four major Wi-Fi encryption protocols (WEP, WPA, WPA2, WPA3) through simulated brute-force attacks and analytical modelling. Leveraging a Python-based simulation environment, we estimate protocol-specific time-to-crack metrics using a range of attack speeds that mimic both low-end CPUs and high-performance GPUs. We define a novel "Strength Score" metric based on logarithmic scaling of computational cracking time, allowing for clear comparative security profiling. Further, we explore real-world implications, including backwards compatibility vulnerabilities, WPA3 transition mode pitfalls, and threats specific to constrained IoT hardware. Experimental results indicate critical weaknesses in legacy protocols and validate WPA3 as the most secure, albeit not yet widely adopted due to hardware limitations. Our methodology supports protocol benchmarking for cybersecurity policy and device manufacturing standards.

Keywords: *Wi-Fi Security, Rute-Force Attack Simulation, Strength Score, Wireless Encryption Protocols, IoT Security, Smart Networks, Cryptographic Vulnerability, Attack Surface Analysis.*

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[ICIE022]

Comparing Deep Neural Networks for Semantic Segmentation

Shubham Raj
Software Engineer, Strand Life Sciences, Bengaluru, India
Email: shubham124.raj@gmail.com

Abstract—Accurate understanding of road-scene topology is essential to the perception stack for autonomous-driving systems. This research undertakes a controlled comparison of two popular encoder–decoder convolutional neural-network (CNN) structures, SegNet and U-Net, on the KITTI Road/Lane Benchmark. The networks were both trained from scratch with the identical hyperparameters, with only image normalisation and a single left–right flip for data augmentation; no other pre- or post-processing was performed. SegNet consistently outperformed U-Net. On a held-out validation split, SegNet achieved 86.9% pixel accuracy versus U-Net's 76.6% and produced meaningful road masks after just a few epochs, whereas U-Net frequently converged to background-only predictions. On the official KITTI birds-eye-view evaluation tool, SegNet generated the highest F1-measure with a maximum of 75.8% and average precision of 62.1%, of significance to illustrate SegNet's greater relative robustness to illumination difference, dynamic movement and variable lane-mark relationship. These findings underscore the critical role of architectural design in resource-constrained, in-vehicle inference and suggest that modest data pipelines can suffice when the network topology is well matched to the task. Future work will explore lightweight attention modules and domain-adaptation strategies to generalise across diverse road environments. This research contributes to the ongoing efforts in semantic pixel-wise segmentation, particularly in the context of autonomous vehicles.

Keywords: *Semantic Segmentation; SegNet; U-Net; KITTI; Autonomous Vehicles*

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[ICIE032]

Lean Manufacturing in Action: Assessment on the Integration of National Guidelines into Kerala's MSME Development Policies

[1]Mr. Joshy Ma and [2]Angelo Mathew

[1]Research Scholar, University of Kerala

[2]Asst. Professor, Dept. of Personnel Management, Loyola College of Social Sciences

Abstract—The competitive landscape for small and medium-sized enterprises (SMEs) in India, particularly in Kerala, is increasingly influenced by global market dynamics. To navigate these challenges, the adoption of lean manufacturing principles has emerged as a crucial strategy for enhancing operational efficiency, product quality, and overall profitability. Empowering Micro, Small, and Medium Enterprises (MSMEs) through lean manufacturing has become a strategic priority in India's industrial policy, reflecting the government's emphasis on sustainable, inclusive, and innovation-led growth. MSMEs contribute approximately 30% to GDP, 45% to manufacturing output, and 48% to exports, yet face persistent inefficiencies, owing to resources and process management. Despite these national efforts, state-level adoption remains inconsistent. Kerala, with its 3.3 lakh MSMEs, 96.2% literacy rate, and strong digital infrastructure, is well-positioned for lean transformation. However, the Kerala Industrial Policy 2023, while focused on modernization and digitalization, lacks specific strategies for promoting lean adoption among MSMEs. This study examines Kerala's readiness for lean integration, identifies policy level implementation bottlenecks through fuzzified logic, and proposes targeted strategies to align state and national frameworks. By leveraging Kerala's existing strengths and drawing insights from the National Productivity Council, the research offers a roadmap for enhancing regional MSME competitiveness, sustainability, and resilience in a globalized market. The findings generated underscore the transformative potential of lean manufacturing as a strategic lever for MSME empowerment in Kerala, if aligned with specific variables identified from India's broader policy objectives.

Keywords: *Lean Operations, Lean Manufacturing, MSME, Make in India, Industrial Policy of Kerala, Industrial Policy of India.*

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[ICIE034]

A Study on Service Quality Dimensions in Ai-Integrated Extended Reality (Xr) and Its Impact on Next-Gen User Experience

[1]Harisankar M. and [2]Vijaya S. Uthaman

[1,2]CET School of Management, College of Engineering Trivandrum

Abstract—AI-integrated Extended Reality (XR)—which includes Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR) is transforming user experiences across industries such as retail, education, gaming, healthcare, and tourism. By combining immersive environments with AI capabilities like real-time object recognition, behavioural analysis, gesture recognition, and natural language processing, AI-integrated XR enables intelligent and adaptive user interactions. While existing literature on XR largely focuses on user acceptance, satisfaction, and attitudes, research on the service quality aspects of AI-enhanced XR remains limited. This study addresses this gap by identifying and validating the key dimensions that influence the service quality of AI-integrated XR and examining their impact on next-generation user experience. Data were collected from users experienced in AI-driven XR applications across diverse settings. Using SPSS and Partial Least Squares Structural Equation Modelling (PLS-SEM), the study identified six key service quality dimensions, initially measured using 30 items, which were refined to 28 after excluding two low-loading items. A second-order confirmatory factor analysis was conducted to validate the construct structure. The results show that System Quality, AI Quality, and Pragmatic Quality significantly affect user experience, with System Quality emerging as the most influential. All six dimensions had a positive and significant relationship with user experience.

Keywords: *Service quality, AI integration, Extended reality, Augmented reality, Mixed reality, Virtual reality, Immersive technology*

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[ICIE035]

Revolutionizing Business with Salesforce: A Cloud-Based CRM Approach for Growth and Efficiency

Venkata Kalyan Mandali
University of Bridgeport, Connecticut CT 06604, USA
Email: Mandalivenkatakalyan@gmail.com

Abstract—Salesforce has emerged as the canonical example of Software-as-a-Service (SaaS) disrupting traditional, on-premises customer-relationship-management (CRM) platforms. This paper analyses the techno-economic foundations that underpin Salesforce's prominence and longevity, focusing on its multitenant architecture, elastic cloud infrastructure, and ecosystem-centric business model. We synthesise vendor documentation, peer-reviewed literature, and practitioner case studies to evaluate how the platform enables data-driven decision-making, workflow automation, and omnichannel customer engagement. Opportunities are identified in low-code/no-code development, industry-specific verticals, and expanding data residency options, while threats stem from intensifying competition (e.g., Microsoft Dynamics 365, HubSpot CRM), tightening privacy regulation, and macroeconomic pressure on IT budgets.

Empirical evidence from three multinational deployments indicates average sales-cycle reduction of 18%, service-case resolution acceleration of 23%, and marketing ROI uplift of 15% within the first year of adoption. These gains are attributed to unified customer data, advanced automation with Flow Builder, and AI-assisted forecasting. Stakeholder interviews further highlight cultural shifts towards agile, experiment-driven operating models. We conclude that Salesforce continues to act as a catalyst for digital transformation, particularly in organisations seeking rapid time-to-value without heavy infrastructural investment. Future work should examine carbon-aware cloud deployment strategies and quantify the long-term total cost of ownership relative to emerging open-source alternatives. Additionally, longitudinal studies could explore the platform's role in fostering ecosystem-wide innovation and talent development initiatives.

Keywords: *Cloud, Customer Relationship, Salesforce, Business, Industry*

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[ICIE036]

WiFi Signal Strength Analysis and Optimization

[1]Shlok Lawand, [2]Sandeep Limbure, [3]Shreeyash Pasalkar, [4]Atharva Patil, and [5]Archana Ratnaparkhi

[1,2,3,4,5] Department of Electronics and Telecommunications, Vishwakarma Institute of Information Technology, Pune, Maharashtra, India

Email: [1]shlok.22211558@viit.ac.in
[2]sandeep.22210245@viit.ac.in
[3]shreeyash.22211553@viit.ac.in
[4]atharva.22210208@viit.ac.in
[5]archana.ratnaparkhi@viit.ac.in

Abstract— WiFi networks are an indispensable part of communication today, but their performance relies heavily on aspects like signal power, interference, and environmental obstructions. The following paper explores a simulation approach for visualizing and analysing the WiFi signal power of various IEEE 802.11 standards (a, b, g, n, ac, ax). With Python, we create and interpolate random values of signal strength to produce heat maps illustrating the effect of obstacles and interference on network performance. We also compare different WiFi standards in terms of speed, range, and vulnerability to interference. The findings illustrate the compromises between speed and coverage, the impact of growing device density on signal quality, and the effect of frequency harmonization in minimizing interference. This research presents knowledge on enhancing wireless network performance via signal mapping and interference control.

Keywords: *WiFi signal strength, IEEE 802.11 standards, Heatmap simulation, Interference analysis, Network optimization.*

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[ICIE037]

AI-Driven Attribute Recognition: A Multi-Layered Approach for E-Commerce Catalog Structuring

Venkata Kalyan Mandali
University of Bridgeport, Connecticut CT 06604, USA
Email: Mandalivenkatakalyan@gmail.com

Abstract— Efficient product classification is crucial for accurate search, personalised recommendations, and real-time inventory control on large-scale e-commerce platforms. Existing rule-based or shallow-learning pipelines struggle with the sheer volume, heterogeneity, and rapid evolution of product descriptions. We propose a scalable, multi-layered framework that automatically extracts and predicts fine-grained attribute–value pairs from unstructured text. The core of the system is a hierarchical transformer that first maps raw descriptions to category-level embeddings, then refines these representations to generate candidate attributes. To increase robustness, we embed a reinforcement-learning loop that rewards correct attribute assignments under weak supervision, and a contrastive objective that pushes semantically related products closer in representation space while separating noise. Because new attributes appear continuously, we augment the model with an ensemble of lightweight student networks trained through knowledge distillation. This ensemble adapts quickly to emergent vocabulary without retraining the full transformer, cutting incremental update time by 62%. Extensive experiments on a 2.3-million-item dataset spanning fashion, electronics, and home goods show an F1 improvement of 9.4 percentage points over state-of-the-art baselines. Ablation studies confirm that reinforcement signals mitigate class imbalance, whereas contrastive learning captures cross-category dependencies. Finally, a production-scale deployment benchmark demonstrates that the complete pipeline processes 1.7 million listings per hour on a 16-GPU cluster, meeting latency requirements for near-real-time catalogue ingestion. The proposed approach thus offers a practical, adaptable solution for maintaining high-quality product metadata in dynamic e-commerce ecosystems.

Keywords: *Inventory Management, E-Commerce, Consumer Behavior, Shipping and Logistics, Online Retail*

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[ICIE039]

Sustainable Manufacturing Initiatives for Productivity Improvement

[1]K. Balasubramanyam and [2]M. Rajesh

[1]Indian Institute of Industrial Engineering, Bengaluru Chapter, India

[2]M S Ramaiah Institute of Technology, Bengaluru, India

Email: [1]balasubkrish@yahoo.com

[2]mrajeshiem@msrit.edu

Abstract—"Work Smarter" is the present-day manufacturing buzzword, and unlike in the past, present-day manufacturing practices are based on the customer-defined specifications and items are only launched in appropriate quantities at the right time (Just in Time) to avoid wastes from overproduction and subsequent cost of storage. (Lean and 5S) The rapidly diminishing earth resources need to be preserved with a combination of Artificial Intelligence (AI) and Industrial Engineering (IE) techniques. Green techniques including Green raw materials, Green supply chains, Renewable energy utilization and Waste recycling, contribute to better manufacturing practices. Systems engineering, incorporating Life Cycle Management, is set to be a major contributor to realizing Sustainable Development Goals (SDGs) as it has key interaction with Industrial Engineering and Industry 5.0. to provide innovative rethinking on design at the component level and maintain simultaneously the project overall costs within limits to enable value-added development through efficient and reliable methods. Projects consist of complex systems that need to be realized through a holistic and interdisciplinary approach with advanced manufacturing techniques such as 3D Printing. This paper describes, through a Case Study Methodology the details of sustainable initiatives incorporated in Project Manufacturing using eco-friendly materials and processes to accomplish desired Productivity Improvements.

Keywords: *Sustainable Manufacturing, Productivity Improvement, Artificial Intelligence and Industrial Engineering, Sustainable Development Goals, Green Materials and Supply chains.*

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[ICIE043]

Sustainability without Borders: Aligning Global Climate Goals with Local Development Imperatives

[1]Darsana H. and [2]Sini V. Pillai

[1,2]Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala), Thiruvanathapuram

Email: [1]darsana.dhres24@duk.ac.in
[2]sini.pillai@duk.ac.in

Abstract—India is the largest producer of dairy on a global scale, contributing to the financial security and dietary landscape of the country. Despite its scale, this industry requires a focused, context-sensitive framework to quantify and enhance sustainability across the environmental, social, and governance (ESG) realm. Existing ESG frameworks in India are mainly designed for multinational corporations and are often not suitable for localised dairy systems in India. This paper puts forward a sustainability and ESG framework designed for the Indian dairy industry. For this study, a descriptive and conceptual approach was used, reviewing global ESG standards (GRI, SDGs, ESRS), reports of major players in the industry globally, Indian regulatory mandates (BRSR, NDDB), and operational modes of Indian dairy cooperatives. The framework was developed through conceptual synthesis and benchmarking techniques, with an emphasis on inclusivity and adaptability. A four-pillar ESG structure is adopted for India's dairy context in this study: Environmental Stewardship, Socio-Economic focus, Technology & Innovation, and Governance & Reporting.

Keywords: *ESG framework, Cooperative models, Green economy, Dairy governance, Sustainable agriculture*

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[ICIE044]

Critical Success Factors of Lean-Thinking that Influence the Adoption of Healthcare 5.0 Technologies

[1]Arya Ajith A. and [2]Mithra Manmadhan

[1,2]CET School of Management, College of Engineering Trivandrum, Kerala

Email: [1]itzme.aryarishi@gmail.com

[2]mithramohan18@gmail.com

Abstract—The rapid digitization of the healthcare industry, driven by Industry 5.0 practices, is generating new methods of smart, patient-centred, and collaborative care systems, which are referred to as Healthcare 5.0. The use of technologies such as Artificial Intelligence, the Internet of Medical Things (IoMT), robotics, and big data analytics has the potential to improve the delivery of healthcare. However, the successful implementation of these technologies is dependent on a range of organizational and strategic enablers. One of these enablers is lean thinking. This study attempts to identify, analyse and rank the key critical success factors of lean-thinking that significantly influence the adoption of Healthcare 5.0 technologies. The Decision-Making Trial and Evaluation Laboratory technique is applied to identify the cause-effect relationships of the critical success factors and establish a hierarchical model of interdependencies. Data was obtained from experts in healthcare operations, lean implementation and digital transformation in healthcare through the Delphi technique. The results indicate a series of overarching causal factors, such as commitment from the top management, a lean leadership mentality, staff education and engagement, standardizing processes, and a continuous improvement culture that serve as the major enablers to create a readiness to adopt Healthcare 5.0 technologies. The effect factors, such as seamless technology integration, patient service design, and data-driven decision-making, were shown to be highly dependent upon the lean practices of the causal factors. This research adds to the theoretical association of lean-thinking and the adoption of frameworks in Healthcare 5.0 and offers another practical perspective on successfully implementing digital transformations in healthcare ecosystems.

Keywords: *Lean-thinking, Healthcare 5.0, Digital Transformation, Process Improvement*

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[ICIE045]

Adoption of Metaverse in Employee Training and Development in IT Sector

[1]Roshin Jacob and [2]Sabu K.

[1,2]CET School of Management, College of Engineering Trivandrum, Kerala, India

Email: [1]roshinjacob18@gmail.com

[2]sabu@cet.ac.in

Abstract—The implementation of the metaverse in employee training and development is transforming human resource management in the IT sector. By incorporating immersive technologies like virtual reality (VR), augmented reality (AR) and artificial intelligence (AI), organizations can deliver interactive, personalized and cost-effective training experiences. These technologies offer better interactivity combined with adaptable learning capabilities and effective knowledge retention while providing cost-efficient and flexible solutions. This study aims to identify and analyse the key factors influencing the successful adoption of metaverse training environments in the IT sector. Using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) methodology, the research ranks and analyses the causal relationship among these key factors. The data was collected from the industry experts, and results indicate that technological infrastructure, organizational readiness, resistance to change, and cost and budget constraints act as the causal factors. On the other hand, user engagement, skill adaptability, and data privacy concerns are identified as the effect factors. The research indicates that metaverse adoption can improve through investments in VR/AR hardware together with high-speed internet systems, change management solutions and cybersecurity protocols. By addressing these factors, IT organizations can improve employee training and development and can remain competitive in the rapidly evolving digital landscape.

Keywords: *Metaverse Employee Training; Virtual Reality; Augmented Reality; DEMATEL; Human Resource Management*

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[ICIE046]

Evolving Employer Priorities in Graduate Recruitment in the Post-Pandemic World

[1]Shilpa Merin Joy and [2]Bindu Kumar K.

[1]Research Scholar, APJ Abdul Kalam Technological University, Kerala, India
[1,2]Department of Mechanical Engineering, Government Engineering College, Barton Hill, Thiruvananthapuram

Email: [1]shilpamerinjoy@gmail.com
[2]bindukumar@gmail.com

Abstract—The post-pandemic period has seen rapid technological development and an accelerated reformation in workplace dynamics, changing what employers look for in new graduates. This research explores how the perceived significance of graduate qualities has changed over the past decade between the pre-COVID, during COVID, and post-COVID periods using feedback from HR professionals working in Technopark, Trivandrum. Ten graduate attributes were grouped into four primary dimensions: Cognitive and Problem-Solving Ability (Critical Thinking, Innovation, Problem-Solving), Personal and Motivational Qualities (Perseverance, Initiative, Learning Curiosity), Flexibility and Social Competence (Adaptability, Interpersonal Skills), and Experiential Learning (Hands-on Projects, Internship Experience). The research outcomes demonstrate a higher focus on adaptability, initiative, and experiential learning in today's hiring process. Respondents supported an increased dependence on industry certifications and a transition toward project-based evaluation rather than conventional interviews. Although employer requirements have changed significantly, this transition is credited not to the pandemic alone but to the surging needs of an innovation-led and technology-centric world that trailed it. In addition, the majority of HR professionals concurred that new graduates today encounter more challenges in finding placements than before the COVID era. These results underscore a permanent shift in recruitment needs and indicate an increasing need for comprehensive and applied competencies. The research provides insight into the skill development programs that is timely, and it advises re-designing curricula and training systems to more closely meet changing industry requirements in a new world context.

Keywords: *Recruitment, Graduate attributes, Employer expectations, Human Resource perspectives*

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[ICIE048]

Comparative Analysis of the Impact of Financial Distress on Portfolio Selection

[1]Vineetha S. Das and [2]Sarath R.

[1,2]Department of Mechanical Engineering, College of Engineering Trivandrum, India

Email: [1]vineetha@cet.ac.in

[2]sarathr7475@gmail.com

Abstract—Portfolio selection is a critical component of investment decision-making, as it directly influences an investor's ability to achieve long-term financial goals while effectively managing risk. This study explores how integrating financial distress indicators can enhance portfolio selection strategies. It constructs and analyses two distinct portfolios to evaluate the impact of financial distress screening. The first portfolio includes all the constituent stocks of the NIFTY 50 index, while the second, referred to as the Safe Zone portfolio, consists exclusively of companies deemed financially stable, based on their consistent performance across four distress prediction models: Altman Z-score, Springate model, Zmijewski model, and Grover model. Both portfolios are optimized using the Hierarchical Risk Parity (HRP) method. The findings reveal that the Safe Zone portfolio delivers superior performance, achieving a higher expected annual return of 18.2%, compared to 16.5% for the full NIFTY 50 index. It also demonstrates lower annual volatility, recording 15.9% as opposed to 16.6% for the complete index, along with a higher Sharpe ratio of 1.15, indicating stronger risk-adjusted returns. These results emphasize the importance of incorporating financial distress forecasting in constructing more resilient and efficient investment portfolios.

Keywords: *Portfolio Optimization, Financial Distress Prediction, Hierarchical Risk Parity, Sharpe Ratio, Risk-Adjusted Performance.*

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[ICIE049]

Tackling Uncertainty in the Vehicle Routing Problem with Time Windows: A Simheuristics Approach

[1]Seema S. and [2]Unnikrishnan V.S.

[1] College of Engineering Trivandrum
[2] Rajiv Gandhi Institute of Technology, Kottayam

Email: [1]seema.sarojini@gmail.com
[2]unnikrishnanvs@rit.ac.in

Abstract—Vehicle routing problem is a combinatorial optimization problem which finds application in the logistics and transportation field. As the problem is NP-hard, metaheuristic techniques are used to obtain near-optimal solutions in an acceptable amount of time. Though it can be helpful in uncertain situations, simulation, which is frequently used to model complicated systems, cannot aid in optimisation. Because of weather or traffic, travel times are frequently stochastic rather than deterministic. Simheuristics, which combine simulation and metaheuristics, can be very helpful in resolving uncertainty-based optimisation problems. The vehicle routing problem under uncertain conditions can be successfully solved by combining simulation techniques like Monte Carlo simulation with metaheuristic approaches like Ant Colony optimisation, Genetic Algorithm, Particle Swarm Optimisation, Tabu Search, Simulated Annealing, etc. In this study, the capacitated vehicle routing problem with time windows under trip time uncertainty is solved by combining Ant Colony Optimisation with Monte Carlo simulation. The ACO-MCS algorithm is tested using the Solomon benchmark dataset for the VRPTW.

Keywords: *Vehicle routing problem, Monte Carlo Simulation, Metaheuristics, Simheuristics, uncertainty, Travel time*

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[ICIE050]

Deep Fusion of Intensity and Depth Data for Automated Spalling Detection in Tunnel Infrastructures

Shruti Bagde
Civil Engineering, Columbia University, New York (USA)
Email: shrutibagde1617@gmail.com

Abstract—The paper introduces a deep learning-based methodology for the automated identification of spalling defects in tunnel linings, emphasising the fusion of intensity and depth information. A novel network architecture is presented, leveraging Mobile Laser Scanning (MLS) data to generate a dataset of paired intensity and depth images. The network effectively integrates these multi-modal inputs to enhance the precision of spalling segmentation. Results demonstrate the superior performance of the proposed approach in comparison to methods relying solely on intensity data, highlighting the critical role of depth information for accurate defect characterisation in complex underground environments. Experimental findings indicate that the combination of depth and intensity data significantly outperforms methods that solely use intensity data. By identifying geometric differences that intensity data alone might overlook, depth features improve the ability to discriminate between structural problems. The significance of multi-modal data integration for reliable defect characterisation is highlighted by the suggested network's exceptional accuracy in detecting spalling zones. This study demonstrates the potential of deep learning methods for infrastructure inspection, especially in situations when labour-intensive manual evaluations are required. The results provide a scalable approach for automated tunnel maintenance and highlight the crucial role that depth information plays in increasing the accuracy of defect detection. Future studies in multi-sensor data fusion for civil infrastructure monitoring can build on the suggested methodology.

Keywords: *Deep-learning, Spalling defects, Tunnel linings, Multi-model inputs, Segmentation precision.*

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[ICIE057]

Time Window Decomposition for Job-shop Scheduling with Answer Set Programming

Balaji Natarajan
Dr. MGR Educational and Research Institute
Email: nbalaji1983@gmail.com

Abstract—This paper explores the application of time window decomposition techniques to solve the Job-shop Scheduling Problem (JSP) using Answer Set Programming (ASP). The proposed methodology involves partitioning the scheduling problem into smaller subproblems based on time windows, enabling efficient optimization of partial schedules. The effectiveness of various decomposition strategies is evaluated, demonstrating the approach's ability to generate high-quality schedules within runtime constraints, particularly for large-scale JSP instances.

Keywords: *Job-shop Scheduling Problem (JSP), Answer Set Programming (ASP), Scheduling optimization. Partial schedules, Runtime efficiency*

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[ICIE058]

Sustainable Investment: Prioritizing Key Factors Influencing Investor Decision

[1]Dhiya K. Rajeev and [2]Jisha Gopi
[1,2]CET School of Management, College of Engineering, Trivandrum, India
Email: [2]jishagopi@cet.ac.in

Abstract—Over the past years, the investing landscape has drastically changed as sustainability has become more important to investors. With growing concerns about climate change, carbon footprint and ethics, investors are moving from traditional financial techniques to assess the long-term investment. Sustainable investing, also called socially responsible investment or environmental, social, and governance investing, combines the generation of financial returns with a positive effect on society and the environment. The Environmental criteria examine a business's resource utilization, waste management, and carbon footprint, among other environmental practices. With an emphasis on labour practices, human rights, and community involvement. The social criterion assesses how a business handles its interactions with its workers, suppliers, consumers, and the communities in which it operates. The Governance criterion evaluates a company's shareholder rights, executive compensation, transparency, and leadership. Businesses and investors are growing increasingly conscious of how their choices today may impact their future investments. Several factors that affect investment decisions are responsible for this tendency. These changes are influenced by many factors, including environmental, regulatory, social, governance, and technological factors. Through this study and using experts' opinions, we can understand the most important factors that influence the investors' decision to make long-term investments. By understanding these factors, investors can make informed decisions that align with their financial goals and sustainability objectives.

Keywords*: Sustainability; Sustainable investing; Investment; Long-term Investment*

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[ICIE059]

An Exploratory Study on the Mediating Role of Engagement in the Relationship between AI-based Learning and Students' Critical Thinking Skills among University Students

[1]Varsha Babu, [2]Roshna Varghese, and [3]Hareendrakumar V.R.

[1,2]School of Management and Business Studies, MG University, Kottayam, India
[3]CET School of Management, College of Engineering Trivandrum, India

Email: [1]varshababu552@gmail.com
[2]roshnavarghese@mgu.ac.in
[3]hari.vr.kumar@gmail.com

Abstract—This study investigates the influence of AI-supported learning on students' critical thinking skills, with student engagement as a mediating variable. It addresses a critical gap in higher education research by exploring how emerging AI technologies influence cognitive learning outcomes among university students. Data were collected from undergraduate and postgraduate students enrolled in three universities in Kerala, India. A total of 700 valid responses are analysed. Due to the absence of established scales tailored to this context, the researchers developed new measurement scales through an extensive literature review and validated them using exploratory factor analysis (EFA). Structural equation modelling (SEM) was employed to test the hypothesised relationships. The results indicate that AI-supported learning significantly impacts both student engagement and their critical thinking skills. Moreover, student engagement partially mediates the relationship between AI use and critical thinking, indicating that the effect of AI tools on cognitive outcomes operates both directly and indirectly through increased engagement. This study contributes to the development of empirically validated scales for measuring AI-supported learning, engagement, and critical thinking and provides a conceptual foundation for understanding the pedagogical value of AI in higher education. The insights provide valid inputs to policymakers and institutional leaders in prioritizing investments in technologies that are pedagogically grounded and aligned with student-centred learning approaches.

Keywords: *AI Tools; Engagement; Critical thinking; University students; Pedagogical value.*

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[ICIE063]

Towards Cognitive Health 5.0: A Conceptual AI-driven Mental Health Monitoring for Human-Centric Workplaces in the Era of Industrial Revaluation

[1]Soumyajit Das, [2]Bivash Mallick, [3]Manik Chandra Das, and [4]Santanu Das

[1,2,3]Department of Industrial Engineering and Management, Maulana Abul Kalam Azad University, West Bengal, India 741249
[4]Department of Mechanical Engineering, Kalyani Government Engineering, West Bengal, India 741235

Abstract—The transition to Industry 5.0 highlights a shift toward human-centric, sustainable, and resilient industrial ecosystems. With increasing automation and cognitive workload, mental health has emerged as a critical but often overlooked dimension of workplace safety. This study presents a conceptual AI-driven mental health monitoring framework—Cognitive Health 5.0—designed specifically for industrial environments. Wearable sensors, facial expression recognition, natural language processing (NLP), and machine learning algorithms, the proposed system continuously evaluates workers' psychological states in real time. The study aims to detect early signs of stress, fatigue, anxiety, and burnout, enabling timely interventions through human resources or health services. A conceptual model integrating physiological, behavioural, and contextual data is introduced, supported by ethical considerations such as privacy preservation, informed consent, and algorithmic transparency. By integrating physiological sensors, computer vision, NLP, and machine learning within an ethical and human-centred framework, this system addresses the growing cognitive workload in industrial environments. It not only enhances workplace safety but also improves operational efficiency. The study suggests AI-enhanced mental comfort systems can significantly reduce absenteeism, increase productivity, and promote a safer and more supportive workplace. By aligning cognitive health with the values of Industry 5.0, this study underscores the importance of augmenting human capabilities—not replacing them—with intelligent systems. The findings of this systematic study emphasize the need for ongoing innovation and user-focused design to fully connect the AI-driven monitoring system, enhancing good work-culture settings. The study also outlines future directions involving adaptive learning models, federated data architectures, and integration with immersive technologies.

Keywords: *Industry 5.0; Cognitive Health; Artificial Intelligence; Conceptual Framework; Workplace health and safety.*

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[ICIE064]

AI-Driven Sustainable Maintenance Systems – Next Generation Maintenance Approach

Ramakrishna Duvvu
IIIE Visakhapatnam Chapter
Email: rkwin2007@gmail.com

Abstract—The industrial landscape is undergoing a significant transformation, driven by the integration of Artificial Intelligence (AI) into core operational processes. This presentation explores how AI-driven sustainable maintenance systems are revolutionizing industry, primarily by optimizing costs and enhancing overall operational efficiency. Traditional maintenance approaches often rely on reactive fixes or time-based schedules, leading to suboptimal resource utilization, unexpected downtime, and inflated expenses. In contrast, AI leverages advanced analytics, machine learning algorithms, and predictive modelling to anticipate equipment failures, optimize maintenance schedules, and prolong asset lifespans. These intelligent systems analyse vast datasets from sensors, historical performance, and environmental conditions to identify subtle patterns indicative of impending issues. This shift from reactive to predictive and prescriptive maintenance minimizes costly breakdowns, reduces the need for extensive spare parts inventories, and significantly lowers labour expenditures associated with emergency repairs. Furthermore, by ensuring assets operate at peak efficiency, AI-driven systems contribute to sustainability goals through reduced energy consumption and waste generation. The result is a more resilient, cost-effective, and environmentally responsible industrial operation, fundamentally reshaping how businesses approach asset management and long-term profitability. The widespread adoption of these systems is not merely an incremental improvement but a foundational shift towards a smarter, more efficient, and sustainable industrial future.

Keywords: *Maintenance systems; Sustainable maintenance; Maintenance with artificial intelligence; Maintenance cost reduction; Maintenance manpower utilisation;*

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[ICIE065]

Design and Simulation of a Lead-Free kSnC1 3 /CsSnI 3 Perovskite Solar Cell with Enhanced Performance

[1]Saneha B. Sharma, [2]Kritika Tiwari, and [3]Saurabh Mishra

[1,2,3]Centre for Advanced Studies, Lucknow

Email: [1]Snehasharma3080@gmail.com
[2]Kreetikatiwari303@gmail.com
[3]Saurabhm@cas.res.in

Abstract—Addressing the toxicity concerns associated with lead-based perovskite solar cells, this study explores a lead-free alternative using inorganic perovskite material, potassium tin chloride. The research focuses on designing and simulating a high-efficiency solar cell using SCAPS-1D software, incorporating multiple functional layers and novel materials. The proposed device structure consists of ITO /KSnC1 3/ CsSn1 3 (n)/CsSn1 3 (P)/SWCNT, where each layer is defined with specific optoelectronic parameters, including band gap energy, electron. and hole mobilities, thickness, and defect types. Indium tin oxide serves as the transparent conductive front contact, while KSnC1 3 acts as the electron transport layer due to its wide band gap and favourable charge extraction characteristics. Caesium tin iodide in n-type and p-type forms a dual perovskite absorber system, enhancing light absorption and efficient charge separation. Single-walled carbon nanotubes are employed as the hole transport layer, leveraging their exceptional conductivity, stability, and compatibility with the perovskite interface. Defect engineering was implemented for each layer to reflect realistic conditions and improve charge transport and recombination dynamics. The simulation results reveal optimized performance metrics, including significant power conversion efficiency, short-circuit current density, and open-circuit voltage. This study highlights the potential of combining inorganic perovskites and carbon-based materials to develop high-efficiency, lead-free, and thermally stable perovskite solar cells. Such materials demonstrate key advantages including tenable band gap energies, allowing for optimization across different spectral ranges.

Keywords: *Perovskite Solar Cell, SWCNT, Quantum efficiency, SCAPS-1D.*

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[ICIE070]

Carbon Nanotube-Reinforced Magnesium Alloys: A Review of Mechanical and Functional Advances Towards Sustainable Engineering

[1]Namita Aniket Dhundre and [2]Santosh D. Dalvi

[1,2]Mechanical Engineering Department, LTCE

Email: [1]thangan.namita@gmail.com
[2]santoshddalvi@gmail.com

Abstract—The growing demand for lightweight, sustainable materials in industries such as aerospace, automotive, and renewable energy has driven innovation in magnesium (Mg) alloys, which offer exceptional strength-to-weight ratios and eco-friendly advantages over traditional metals. However, their broader adoption is hindered by inherent limitations in mechanical strength, ductility, and functional performance. This review critically examines the transformative potential of carbon nanotube (CNT)-reinforced magnesium alloys as a next-generation sustainable material. By synthesizing recent advancements in fabrication techniques including powder metallurgy, stir casting, and additive manufacturing, analyse how CNT integration enhances tensile strength, wear resistance, and thermal/electrical conductivity while retaining Mg's inherent lightweight benefits. A key focus is the interplay between CNT dispersion, interfacial bonding, and matrix microstructure, which dictates composite performance. Comparative assessments with conventional aluminium alloys reveal CNT-Mg systems as competitive alternatives, achieving comparable or superior mechanical properties with reduced environmental footprints due to Mg's abundance and lower energy processing requirements. Environmental and economic considerations are addressed through lifecycle analyses, highlighting the sustainability gains from material efficiency and recyclability. Challenges such as CNT agglomeration, scalability of synthesis methods, and cost-effectiveness are critically discussed to outline future research priorities. This review underscores the viability of CNT-reinforced Mg alloys as a dual solution for advancing material performance and sustainability, providing a roadmap for their integration into high-stakes engineering applications.

Keywords: *CNT, Magnesium alloys, Composites, Mechanical, Functional, Properties, Sustainable engineering*

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[ICIE072]

Experimental Investigation on Solar-Powered Proton Exchange Membrane Fuel Cell

[1]Rajesh G. Bodkhe and [2]Rakesh L. Shrivastava

[1]Department of Mechanical Engineering, Yeshwantrao Chavan College of Engineering, Nagpur-441110, Maharashtra

[2]Consultant & Trainer, Indian Institution of Industrial Engineering (IIIE), Nagpur Chapter, Maharashtra

Email: [1]rgbodkhe@gmail.com

Abstract—The purpose of this research study is to improve the sustainability and exploitation of renewable energy sources by presenting an experimental investigation on a solar-powered fuel cell. The system converts solar energy into hydrogen, which is then used to generate power by combining photovoltaic (PV) technology with a proton exchange membrane fuel cell (PEMFC). The design incorporates sophisticated control systems for real-time performance optimization and monitoring, with the goal of maximizing the efficiency of Energy conversion and storage. This research study provides a thorough examination of the PEMFC's electrochemical performance under various operating situations, including power density, efficiency, and current-voltage characteristics. Comparing the optimized design to conventional hydrogen fuel cells, experimental results show notable gains in fuel usage and stability, as well as efficient conversion rates. It highlights the performance of individual single PEM fuel cells and those from PV- integrated PEMFC systems concerning their theoretical efficiency and power output. The chapter also discusses the performance comparison between fuel cell and PV-integrated systems and discusses their advantages and limitations about one another. The research acknowledges and discusses practical implications while considering the potential that the system has to contribute to sustainable energy generation.

Keywords: *Solar Energy, Photovoltaic, Fuel Cell, voltage, Proton Exchange Membrane, Fuel Cell.*

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[ICIE073]

Analysis of Barriers to Implement Reconfigurable Supply Chain in Healthcare: SAW Approach

[1]Harshal Rajan Salvi, [2]Milind Shrikant Kirkire, and [3]Mahadev Laxman Naik

[1,2,3]Finolex Academy of Management and Technology, Ratnagiri, Maharashtra

Email: [1]harshal.salvi@famt.ac.in
[2]milind.kirkire@famt.ac.in
[3]mahadev.naik@famt.ac.in

Abstract—The healthcare manufacturing industry operates in a highly dynamic environment marked by volatile demand, strict regulatory standards and the need for swift responses to disruptions such as pandemics, geopolitical tensions and supply chain bottlenecks. In this context, Reconfigurable Supply Chains (RSCs) have emerged as vital for enhancing resilience, agility and efficiency. RSCs enable dynamic adjustments in production, sourcing and distribution, ensuring continuous access to critical medical supplies. However, the adoption of RSCs in healthcare manufacturing remains limited due to several challenges. This study identifies, categorizes and prioritizes 13 key barriers to RSC adoption through a systematic literature review and Multi-Criteria Decision-Making (MCDM) approach. Using the Simple Additive Weighting (SAW) method, expert feedback was integrated and weighted by experience to determine the most critical barriers. These include the lack of a data-driven culture, weak top management commitment and sourcing uncertainties caused by geopolitical instability. To address these challenges, the study proposes the integration of Industry 4.0 technologies such as AI, big data analytics, blockchain, modular production systems and IoT-enabled monitoring. This research makes a significant theoretical and practical contribution by being among the first to systematically prioritize RSC barriers in healthcare manufacturing using a literature-backed, expert-driven methodology. However, the study acknowledges limitations, including a relatively small expert sample and focus on one sector. Future research should expand validation, test digital solutions in practice and explore RSC challenges in other industries. Overall, the study provides a strategic framework to support healthcare manufacturers in implementing RSCs for greater resilience and adaptability.

Keywords: *Reconfigurable Supply Chain, Healthcare, SAW, Industry 4.0*

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[ICIE077]

Hybrid Optimization for Traveling Salesman

Sahil Sekhri
Golden Dots International Pvt Ltd
Email: SahilSekhri8@gmail.com

Abstract—The Travelling Salesman Problem (TSP) is a complex combinatorial challenge, where the objective is to find the shortest route to visit each city exactly once and return to the starting point. Traditional methods like exhaustive search are computationally infeasible due to their factorial time complexity. Particle Swarm Optimization (PSO) and Simulated Annealing (SA) are two metaheuristic approaches that have shown promise in optimization tasks. However, PSO struggles with discrete problems like TSP. This paper introduces a hybrid approach combining PSO and SA to enhance PSO's effectiveness in solving TSP. By integrating SA's ability to explore suboptimal regions, the hybrid method improves solution quality compared to standalone PSO. Performance evaluations on benchmark TSP instances demonstrate that this hybrid technique consistently produces shorter routes, highlighting the benefits of combining these metaheuristics for complex optimization problems.

Keywords: ***Travelling*** *Salesman Problem (TSP), Combinatorial Optimization, Particle Swarm Optimization (PSO), Simulated Annealing (SA), Hybrid algorithm, Metaheuristic*

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[ICIE080]

Analysis of Barriers to Effective Public Transport: A Multi-Criteria Decision-Making Approach

[1]Bhadranandan N. and [2]Kavilal E.G.

[1]Department of Mechanical Engineering, SCT College of Engineering, Kerala, India

[2](Affiliated to APJ Abdul Kalam Technological University, Kerala, India)

Email: [1]bhadranandan1969@gmail.com

Abstract—Efficient public transportation (PT) offers significant opportunities as an environmentally friendly, affordable, and inclusive mobility option. It contributes to reduced vehicle emissions, decreases reliance on fossil fuels, and increases accessibility, particularly for low-income individuals who are often captive users of PT. Despite these benefits, PT systems globally usually fall short of meeting their key performance indicators (KPIs). The underperformance is largely attributed to a variety of barriers that adversely hamper strategic planning, execution, and system optimization. A comprehensive understanding of these barriers and their interactions is valuable for policymakers and PT operators seeking to develop strategies and policies to maximise the potential of PT systems. In response to this situation, the present study identified 23 barriers affecting the effectiveness of PT through an extensive literature review and consultations with industry experts. The barriers identified were then structured hierarchically using interpretive structural modelling (ISM) and categorised using "Matrice' d'Impacts Croises Multiplication Appliqué an Classment" (MICMAC) method. The analysis identified "financial constraints", "lack of strategic visionary leadership", "excessive trade unionism and political interference", "high implementation and maintenance costs", and "inadequacy of designed training programs" as the most influential barriers within the PT system. Policymakers need to address these highly influential barriers through robust regulatory interventions and strategic plans to unlock the full potential and create a sustainable, resilient, and competitive PT system.

Keywords: *Public transport, Barriers, Policy, Interpretive structural modelling, ISM, MICMAC.*

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[ICIE081]

Development and Validation of a Scale to Measure Key Workplace Conflict Types for HR Professionals: An Integrated Fuzzy AHP and Delphi Approach

[1]Mamata C. and [2]Kavilal E.G.

[1,2]Dept. of Mechanical Engineering, Sree Chitra Thirunal College of Engineering (SCTCE) Affiliated to The APJ Abdul Kalam Technological University (KTU), Thiruvananthapuram

Email: [1]mamatachandramohan@gmail.com
[2]kavilal2001@gmail.com

Abstract—Understanding the nature of workplace conflicts is critical for effective conflict management and organizational performance. This study aimed to develop a valid and reliable scale to measure five key types of workplace conflict: task, process, relationship, role, and value conflicts. Initially, ten conflict types were identified through a literature review and reduced to five using the Fuzzy Analytic Hierarchy Process (FAHP), with expert input from HR professionals. A comprehensive item pool was generated, and a two-round Delphi method involving HR experts was employed for item refinement, resulting in a preliminary 20-item scale. The scale was then administered to 265 HR professionals, and Exploratory Factor Analysis (EFA) was conducted, leading to a final 18-item scale with strong reliability (Cronbach's alpha > 0.7) across all constructs. The study provides a methodologically rigorous and practically relevant tool for assessing workplace conflict, with implications for HR practitioners and researchers. It offers original contributions by integrating FAHP and Delphi techniques in conflict scale development, enhancing both theoretical clarity and application in organizational settings.

Keywords*: Workplace conflicts, Measurement scale, Fuzzy-AHP, Delphi, Exploratory factor analysis.*

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[ICIE082]

Transformation of Lean Manufacturing Practices Implementation Models from Industry 3.0 to Industry 5.0 through Industry 4.0 Technologies

[1]Krishnadev C. and [2]Sajan M.P.

[1]Department of Mechanical Engineering, Government Engineering College, Thrissur
[2]Department of Mechanical Engineering, Rajiv Gandhi Institute of Technology, Kottayam

Email: [1]krishnadev3695c@gmail.com
[2]sajanmp@gectcr.ac.in

Abstract—The transformation from Industry 3.0 to Industry 5.0 has resulted in cumulative modifications in lean manufacturing practices. When Lean focused on minimising waste and maximising value-added activities in Industry 3.0, Industry 4.0 environments ensured improved digital environments, along with real-time analytics, enhanced business, automation, and service-oriented production environments with interconnectivity. Very little research has been performed on the effects of Industry 4.0 technologies on the Lean paradigm. However, there has been a growing demand for research on Industry 5.0, focusing on a human-centred, flexible, and sustainable type of manufacturing, which indirectly suggests that Lean needs to evolve to the next dimension, emphasising its pattern of practice. This paper examines the adoption of Lean practices to transition from Industry 3.0 to Industry 5.0 through Industry 4.0 and their scope in the current scenario and a frequency-based analysis of more than 40 journals regarding Lean tools like Value Stream Mapping, Just-In-Time, Kaizen, and Total Productive Maintenance and its evolution in combination with Industry 4.0 technologies like Internet of Things, Artificial Intelligence, Big Data Analytics, and Cyber Physical Systems to the Industry 5.0 era with the introduction of collaborative and human-in-the-loop manufacturing technologies. The findings from this study regarding the transformation phases of Lean practices and corresponding implementation models pave the way for awareness for industrial professionals and Lean practitioners to collaborate on Lean practices with the human-centric and ethical Industry 5.0 visions.

Keywords: *Lean Manufacturing, Industry 4.0, Industry 5.0, Sustainability*

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[ICIE084]

An AI-powered Predictive Analytics Approach for Early Detection of Entrepreneurial Failures

[1]Sreekar V. Pai, [2]Sini V. Pillai, and [3]Antony Satyadas

[1,2]Kerala University of Digital Sciences, Innovation and Technology, (Digital University Kerala),

[3]Innovation Incubator Holding,

Email: [1]sreekar.dhres24@duk.ac.in
[2]sini.pillai@duk.ac.in
[3]antony@innovationincubator.com

Abstract—Entrepreneurial failure remains a persistent challenge across global markets, with a substantial proportion of startups ceasing operations within their initial years. Despite growing interest in understanding the underlying causes, there remains a significant gap in effective tools and methodologies that can help predict and prevent such failures. This research paper aims to explore how recent advancements in Artificial Intelligence (AI), particularly predictive analytics, can be leveraged to anticipate and detect these failures through data-driven insights. The focus is on the application of AI techniques to forecast business performance and identify early warning signals of failure. These advanced AI methodologies allow for in-depth pattern recognition and trend analysis, offering critical foresight into potential risk factors. The review synthesises findings across diverse methodological frameworks, identifies common predictors of entrepreneurial failures, financial instability, team dynamics, market misalignment, and highlights the most frequently used datasets. It also assesses the scalability and adaptability of these technologies across different stages of startup development. The research also reveals how AI tools support proactive, early-stage interventions and decision-making processes by enabling entrepreneurs to make timely strategic adjustments. The insights generated from this review are valuable for entrepreneurs seeking to enhance business resilience, investors aiming to assess risk more accurately, and policymakers or incubators developing supportive infrastructures that foster long-term startup sustainability and success.

Keywords: *Entrepreneurial failure, AI, Predictive analytics, ML, Early Risk detection, Startup risk assessment*

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[ICIE085]

Workforce Optimization in Industry 5.0: Reskilling, Collaboration, and Ethical AI Integration

[1]S.D. Dalvi, [2]M.S. Bhadane, [3]M.S. Devtale, and [4]S.M. Satav

[1,2,3,4]Mechanical Engineering Department, LTCE

Email: [1]santoshddalvi@gmail.com
[2]bhadanems@gmail.com
[3]milinddeotale@gmail.com
[4]sunilsatao8@gmail.com

Abstract—The advent of Industry 5.0 emphasizes the integration of human-centric approaches with advanced technologies such as AI, collaborative robotics (cobots), and IoT to enhance productivity, creativity, and sustainability in smart manufacturing. Effective workforce management (WFM) in this paradigm requires adaptive strategies to address human-machine collaboration, reskilling, and dynamic task allocation. This study explores the challenges and opportunities in WFM for Industry 5.0, focusing on worker well-being, real-time decision-making, and flexible production systems. Through a systematic review of case studies and emerging frameworks, we analyse AI-driven workforce scheduling, cognitive ergonomics, and decentralized autonomous systems that empower workers while maintaining operational efficiency. Key findings highlight the need for continuous learning ecosystems, digital twin-assisted training, and ethical AI governance to balance automation with human expertise. The paper proposes a hybrid workforce model that leverages augmented reality (AR), predictive analytics, and human-robot teamwork to optimize performance in Industry 5.0 environments.

Keywords: *Industry 5.0, Workforce Management (WFM), Human-Centric Manufacturing, Collaborative Robotics (Cobots), AI*

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[ICIE088]

Environmental Impact Assessment of Informal End-of-Life Vehicle Recycling in India

[1]G.J. Badwe, [2]R.L. Shrivastava, and [3]K.R. Shrivastava

[1]Department of Mechanical Engineering, S.B.M. Polytechnic, Mumbai, India
[2]Department of Mechanical Engineering, Y.C.C.E., Nagpur, India
[3]Indian Institute of Technology, Kharagpur, India

Email: [1]tpo.sbmp@gmail.com
[2]rlshrivastava@gmail.com
[3]krshrivastava@iitkgp.ac.in

Abstract—India's automobile market is growing at a rapid pace, which is causing a sharp increase in the number of End-of-Life Vehicles (ELVs). Economic opportunities are brought about by this growth, but there are also significant environmental problems. A significant amount of ELV recycling in India is done by the unorganised sector, which frequently lacks the environmental protections, technical know-how, and appropriate tools required for safe disassembly and disposal. Because of this, recycling in these unofficial hubs greatly deteriorates the environment. Engine oil, brake fluid, coolant, and other hazardous fluids are regularly spilt onto the ground, contaminating the soil and groundwater. Rubber and plastic interiors are examples of non-metallic parts that are frequently burned outdoors, releasing harmful gases and adding to air pollution. The high environmental costs of uncontrolled ELV recycling, such as harm to ecosystems, water pollution, toxic emissions, and human health, are reflected in this circumstance. The issue is made worse by inadequate regulatory enforcement and inadequate waste management infrastructure. The study highlights how urgently India must switch to a more environmentally friendly method of recycling ELVs. Stricter adherence to environmental laws, formalization of the recycling industry with adequate infrastructure and training, and enhanced cooperation between public and private sectors are all examples of this. India can move toward a cleaner, safer, and more sustainable system for managing automotive waste and lessen the environmental impact of ELV recycling by tackling these problems.

Keywords: *End-of-Life Vehicles, Environmental problems, Human health, ELV management practices, Artificial Intelligence*

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[ICIE089]

The Impact of Blockchain Adoption on Circular Supply Chain Performance: The Mediating Roles of Transparency and Traceability

[1]Divyasree M. and [2]Syama K.S.

[1,2]CET School of Management, College of Engineering Trivandrum

Email: [1]divyasree11sisiram@gmail.com

[2]syamaks2014@gmail.com

Abstract—Emerging technologies such as blockchain hold significant potential to facilitate the transition from traditional linear supply chains to more sustainable circular supply chains. This has caught the attention of researchers and practitioners; however, there is limited empirical evidence for how blockchain adoption affects circular supply chain performance. Hence, this study aims to explore the effect of blockchain adoption on circular supply chain performance by promoting transparency and traceability within the system. An explanatory research design was employed, using a cross-sectional quantitative approach. Primary data was collected from 135 supply chain professionals across diverse industries utilizing a structured questionnaire. The collected data is analysed using the Partial Least Squares - Structural Equation Modelling (PLS-SEM) technique with SmartPLS software to test the hypothesised relationship among the study variables. The results revealed that blockchain adoption has a direct positive impact on the circular supply chain performance. Furthermore, traceability was found to have a significant mediating effect between blockchain adoption and circular supply chain performance, while the mediating effect of transparency was not statistically significant. These results suggest that the blockchain adoption enhances circular supply chain performance primarily by improving traceability within the system.

Keywords: *Blockchain Adoption, Circular Supply Chain, Traceability, Transparency*

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[ICIE090]

Impact of Augmented Reality on Purchase Intention: Exploring Mediating Role of Brand Equity

[1]Surya Thampy and [2]Sujatha G.S.

[1,2]CET School of Management, College of Engineering Trivandrum

Email: [1]suryathampi99@gmail.com

[2]Sujahari2002@gmail.com

Abstract—Augmented reality (AR) has become a powerful tool, allowing brands to find the gap between the physical and digital world. This technology offers a unique experience that can increase customer engagement and product understanding. Brand equity serves as a crucial factor influencing consumer behaviour. It encompasses the overall perception of each brand, which includes its reputation, brand image, and customer loyalty. Strong brand equity fosters trust and positive associations, making consumers more receptive to new initiatives like AR experiences. The present paper attempts to investigate the potential mediating role of brand equity in the relation between AR and Purchase intention. Understanding this mediating role can provide important insight for marketers. The objectives of this study were to analyse the relationship between the adoption of augmented reality and purchase intention, analyse the relationship between brand equity and purchase intention. This paper also tries to determine the mediating role of Brand Equity on Augmented Reality and Purchase Intention. The methodology adopted for the study is primary data, which was collected by circulating a structured questionnaire to a sample of 260 respondents. The outcome of the study reveals that there are positive relationships among the constructs Augmented Reality, Brand Equity and Purchase Intention.

Keywords: *Augmented Reality, Purchase Intention, Brand Equity.*

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[ICIE091]

Managing Smartphone-Induced Digital Fatigue for Sustainable Workforce Productivity: A Study on Doomscrolling, Self-Regulation, and Digital Detox in the Age of Industry 5.0

[1]Aneez and [2]Shanuja S.V.

[1,2]Digital University Kerala

Email: [1]aneez.dhres24@duk.ac.in
[2]shanuja@duk.ac.in

Abstract—Smartphones have become deeply embedded in daily routines, leading many users to compulsively scroll through emotionally overwhelming online content, a behaviour known as doomscrolling. This habit often results in mental fatigue, disrupted work routines, and lower productivity. In academic and research environments, where clear thinking and sustained productivity are essential, understanding how doomscrolling may affect performance is critical, particularly as workplaces adopt the human cantered principles of Industry 5.0. This study aims to investigate how doomscrolling might contribute to procrastination and reduced productivity. It also explores whether psychological well-being acts as a mediator in this relationship, and if self-regulated digital detox practices could moderate the potential negative impacts. Participants will include staff, students, and researchers from academic and research institutions across Kerala. Data collection will involve structured, validated questionnaires. Correlation, regression analysis, and Structural Equation Modelling (SEM) techniques will be employed to explore the relationships between doomscrolling, psychological well-being, procrastination, and productivity. It is anticipated that frequent doomscrolling could increase procrastination and decrease productivity through compromised psychological well-being. However, individuals practicing regular digital detox and having strong self-regulation skills may exhibit greater resistance to these effects. If confirmed, these findings will guide Human Resource departments and institutional policymakers toward effective digital wellness programs. Promoting healthier screen habits and improved self-regulation can support employee productivity and well-being, aligning with the sustainable workforce goals emphasized by Industry 5.0.

Keywords*: Doomscrolling, Digital Detox, Productivity, Psychological Well-being, Industry 5.0*

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[ICIE093]

Investigation on Minimization of Burr and Foot Formation in Shaping Operation

[1]P. Adhikary, [2]S. Tah, and [3]Santanu Das

[1,2,3]Department of Mechanical Engineering, Kalyani Government Engineering College, Kalyani- 741235, West Bengal, India

Email: [3]sdas.me@gmail.com

Abstract—Shaping burrs are produced at the edge of a workpiece when a cutting tool exits it. It is caused by to gradual rotation of the positive shear plane to the negative shear plane, where less backup support is provided. Burr and foot formation causes difficulties in manufacturing and assembly stages. Several attempts were made to minimize burr and/or foot formation during machining to suppress deburring to improve productivity. Deburring of the surface in shaping or other machining operation in railway industry and other industries is a great problem. In the present work, a rectangular aluminum-silicon carbide composite sample has been used for shaping operation by brazed HSS tipped broad nose tool by varying cutting velocity and by exit edge bevelling in a shaping machine to minimize the amount of burr and/or foot formation so that amount of burr produced is negligible and no deburring process should be needed. Dimensions of burr and foot have been measured by using a Stereo Microscope. It has been found that for proper accuracy in dimensions, surface finish, etc., it is needed to select proper process parameters. Amount of burr and foot is found to be greatly dependent on cutting velocity, and it is minimized when suitable edge bevelling is provided.

Keywords: *Machining, Shaping, Burr, Foot, Burr minimization.*

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[ICIE094]

Critical Factors Influencing Customer Engagement of AI-Powered Virtual Influencers

[1]Aswin Krishna P. and [2]Abhijith R.

[1,2]CET School of Management, College of Engineering Trivandrum

Email: [1]aswinkrishnap7@gmail.com
[2]abhijithrajkumar@cet.ac.in

Abstract—The increasing phenomenon of social media marketing and digital marketing has given rise to personas like AI-powered virtual influencers who require investigation into the variables that affect user interaction. Digital influencers expand content distribution through various networks but require users to have a deeper understanding of the way they operate and engage their audience. This research examines appearance and interaction alongside perception and perceived trust as essential components for social media users in Kerala. Digital analysis of demographics supports research on AI-generated personas to track their effects on consumer-brand relationships. The research reveals that appearance and perception have the strongest impact on user engagement, followed by interactivity and trust. The research also demonstrates how people form stronger connections through the use of personalized and transparent communication. A primary data analysis using PLS-SEM structural modelling provides empirical support for optimizing virtual influencer marketing strategies.

Keywords: *AI-powered virtual influencers, Customer engagement, Influencer marketing, Social media, Perceived trust, Perception, Interactivity, Kerala*

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[ICIE095]

Factors Influencing Resilience in Tourism Supply Chain

[1]Gayathri Ranjit, and [2]Govind S.D.

[1,2]CET School of Management, College of Engineering Trivandrum

Abstract—This paper highlights the factors influencing the resilience of the tourism supply chain in regions frequently impacted by natural disasters. Understanding the key drivers that enhance disaster preparedness and sustainability in tourism supply chains is crucial for multiple stakeholders. Tourism operators and local businesses can utilize these insights to strengthen operations and minimize disruptions. Policymakers, disaster management authorities and researchers can build on this framework for future research on disaster risk reduction in tourism. The study explored five main criteria affecting supply chain resilience: risk awareness and preparedness, environmental sustainability and climate adaptation, infrastructure development, technology adoption and digital resilience, and governance and policy support. Using the Analytical Hierarchy Process (AHP) methodology, the study revealed that risk awareness and preparedness are the most significant factors, highlighting the importance of disaster training, early warning systems, and emergency measures. Environmental sustainability and climate adaptation, and infrastructure development also emerged as key drivers, reflecting the need for eco-friendly infrastructure, climate adaptation strategies, and reliable transport systems. While technology adoption and governance had relatively lower weights, they remain essential for improving coordination and regulatory support. To capitalize on these findings, local authorities and tourism stakeholders can refine their resilience strategies by implementing targeted training programs, developing climate-resilient infrastructure, and enhancing early warning systems. Additionally, investing in digital platforms and creating inclusive governance frameworks will further strengthen the tourism sector. By acting on these insights, a robust tourism supply chain capable of withstanding future disruptions and contributing to long-term sustainable development can be built.

Keywords: *resilience, Supply chain, Disaster preparedness, Environmental sustainability, Analytic hierarchy process*

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[ICIE096]

Exploring Consumer Motivation to Convert from Freemium to Premium in OTT Platforms

[1]Abhinaya Vijayan and [2]Sabu K.

[1,2]CET School of Management, College of Engineering Trivandrum

Email: [1]abhinayavijayan162@gmail.com

[2]sabu@cet.ac.in

Abstract—The rise of Over-the-Top (OTT) platforms has revolutionized the entertainment industry, offering consumers access to vast digital content through freemium and premium models. Though freemium models tend to attract more viewers than the premium, persuading such freemium viewers into premium subscribers is always a challenge for service providers. This study investigates the factors influencing consumer motivation for transitioning from freemium to premium subscriptions in OTT platforms. The research employs a quantitative approach using Partial Least Squares-Structural Equation Modelling (PLS-SEM) to assess the relationships between core variables, where customer satisfaction acts as a mediating variable, and the intention for a premium subscription serves as a dependent variable. The finding shows the strong influence of the independent variables such as perceived usefulness, perceived value, convenience and social gratification on the premium subscription, highlighting the importance of content quality, service experience, and pricing strategies in consumer decision-making. The study also gives practical recommendations for OTT service providers in reviewing existing subscription models for enhancing user experience and sharpening retention strategies.

Keywords: *OTT Platforms, Freemium, Consumer Motivation, Subscription Intention, Perceived Value, Perceived Usefulness, Convenience, Social Gratification.*

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[ICIE097]

System Reliability and Life Cost Modeling: A Comprehensive Study

[1]Sarfraz Ali Quadri, [2]Varsha Jadhav, and [3]Dhananjay R. Dolas

[1]Mechanical Engineering Department, JNEC, MGM University
[2]AI&DS, Vishwakarma Institute of Technology, Pune
[3]Mechanical Engineering Department, JNEC, MGM University

Abstract—In the current global climate, particularly after the pandemic, the dependability of individual parts and the entire system is crucial. This is because reliability directly impacts cost savings and customer happiness. This paper offers a systematic review of research focused on system reliability and life cost modelling within the manufacturing industry. We have outlined existing research using a five-step methodology. The identified studies were then examined both qualitatively (using template analysis) and quantitatively (through Bibliometric analysis). Our in-depth analysis clearly shows the extent to which reliability analysis has been adopted in life cost modelling for manufacturing. This review also highlights significant contributions and future research areas necessary to improve reliability assessments and cost modelling. This review highlights key scholarly contributions and points towards necessary areas for future research to enhance reliability evaluation and cost modelling. While other reviews exist for system reliability and life cost modelling separately, very few have specifically evaluated how system reliability affects life cost modelling in manufacturing. This review aims to provide valuable insights for reliability professionals, managers and researchers to enhance their work.

Keywords: *System Reliability, Life Cost Modelling, Manufacturing Industry, Life Data etc.*

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[ICIE098]

Impact of Green Finance and Fintech on Sustainable Development in the Service Sector

[1]Abhimanew S.K. and [2]Jnaneswar K.

[1,2]CET School of Management, College of Engineering Trivandrum

Email: [1]abhimanewsk5@gmail.com

[2]jnaneswar@gmail.com

Abstract—Sustainable development is defined as an economic development that helps to conduct present activities without depleting the natural resources of future generations. Green Financing refers to the provision of financial resources to support environment-friendly projects and initiatives like renewable energy and energy management. Fin tech is defined as a disruptive innovation that uses digital technologies to offer quick, affordable, and more attainable financial solutions, bridging the gap between traditional banking services and modern consumer demands. Due to the growing climate change effects, which include warmer temperatures and weather irregularities along with resource exhaustion, service companies must adopt more environmentally friendly procedures. Extant literature reveals that there is a paucity of research on green finance, fintech and sustainable development in the service sector. Therefore, the primary objective of this study was to assess the impact of green finance and fintech on sustainable development in the Indian service industry. The present study adopted a cross-sectional research design, and the data were collected from 203 employees from different organisations in the Indian service industry. For assessing the relationship between dependent and independent variables, Partial Least Squares – Structural Equation Modelling, was used. Results revealed that both green finance and Fintech have a positive impact towards sustainable development. Results also showed that the impact of Fintech was greater on sustainable development compared to green finance. The findings of the present study add new knowledge that can be used to enhance sustainable development practices of organizations.

Keywords: *Sustainable development, Green finance, Fin tech, Sustainability*

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[ICIE099]

Enhancing Portfolio Optimization through Stock Selection Techniques and Advanced Volatility Models: Evidence from India

[1]Milan Sam Mathew and [2]Unnikrishnan V.S.

[1]CET School of Management, College of Engineering Trivandrum
[2]Rajiv Gandhi Institute of Technology, Kottayam

Email: [1]milansam@cet.ac.in
[2]unnikrishnanvs@cet.ac.in

Abstract—This study explores modern portfolio optimization by integrating advanced stock selection strategies with robust risk modelling techniques. Four distinct methodologies—Principal Component Analysis (PCA), Minimum Spanning Tree (MST), Hierarchical Risk Parity (HRP), and a 4-Factor Model—are employed to select stocks from the NIFTY 50 index. These methods aim to identify stocks with diverse interrelationships, risk exposures, and sensitivities to key market factors. The selected stocks are subsequently used as inputs for portfolio construction using four optimization models: Mean-Variance Optimization (MVO), GARCH(1,1), Dynamic Conditional Correlation GARCH (DCC-GARCH), and Copula-GARCH. These models are utilized to capture both individual and joint risk characteristics of the assets, including time-varying correlations and tail dependencies. The performance of each portfolio is assessed based on annualized return, volatility, and Sharpe ratio. The findings highlight that the choice of stock selection methodology and risk modelling framework significantly influences portfolio outcomes. Notably, models that account for dynamic correlations and non-linear dependencies—such as DCC-GARCH and Copula-GARCH—tend to deliver superior risk-adjusted performance when combined with effective stock selection strategies.

This research provides valuable insights for both portfolio managers and academics, emphasizing the importance of aligning stock selection techniques with appropriate risk models for enhanced portfolio performance.

Keywords: *Stock Selection, Optimization, GARCH*

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[ICIE100]

The Factors Determining Digital Risk of Financial Assets

[1]Amrutha Shaji and [2]Abhilash V.S.

[1,2]CET School of Management, College of Engineering Trivandrum

Email: [1]shajiamrutha20@gmail.com

[2]abhilash746@gmail.com

Abstract—The development in technology poses stability and security of financial instruments in the digitalized financial ecosystem. There are concerns regarding the variables affecting asset owners' opinions of document digitalization. The aims of this research are to ascertain the variables that impact asset owners' opinions on document digitization and to examine and pinpoint the risk factors associated with those opinions. Prioritizing the factors according to their efficiency was done using the AHP tool. Regarding digital risk in financial assets, cybersecurity threats, data security and privacy, the presence of unclear regulations and illicit activity with digital currencies are the significant factors ranked respectively. Inadequate current infrastructure and systemic vulnerabilities to financial markets were deemed the least important considerations. To reduce the risks related to cybersecurity threats and data breaches, the research suggests putting strong cybersecurity protections and data privacy regulations in place based on its findings. It also recommends improving digital intelligence within organisations, creating thorough risk assessment and modelling frameworks specific to digital financial assets, exploring the integration of cutting-edge technologies like artificial intelligence and machine learning to enhance risk management practices, and continuously monitoring and adapting to changing regulatory landscapes to address regulatory uncertainties. The results offer insightful guidance on how asset owners, legislators, and financial institutions can successfully manage the intricacies of digital risk.

Keywords: *Financial Assets, Digitalisation, Digital Risk*

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[ICIE103]

Unlocking Data's Potential: A Survey of AI-Driven Automation for Data Quality and Feature Engineering

[1]Nishita Toshi, [2]Akash Rastogi, [3]Sunil Kumar Pandey, and [4]Sreejit Panicker

[1,2,3,4]MS Techment Technology Pvt. Ltd.

Email: [4] sreejit.panicker@techment.com

Abstract—The efficacy of data-driven models across various domains is critically dependent on the quality and relevance of input data, a challenge often summarized by the "garbage in, garbage out" adage. Data preparation, encompassing data quality management and feature engineering, remains a labour-intensive, time-consuming, and often subjective bottleneck in the machine learning lifecycle. The survey paper presents a comprehensive review of recent advancements in AI-driven approaches designed to automate these crucial pre-processing stages. We examine novel methodologies for the automatic detection, cleansing, and imputation of missing or erroneous data, covering statistical anomaly detection techniques. Furthermore, the paper delves into the latest in field of automated feature engineering, exploring how AI can autonomously discover and construct relevant features from diverse data sources. We analyse various techniques, such as meta-learning, reinforcement learning, and generative models, that aim to transform raw inputs into powerful predictors. The objective of this survey is to synthesize current research, highlight emerging trends, and identify the strengths and limitations of contemporary AI-powered solutions. By addressing the fundamental challenges of manual data preparation, these automated approaches promise to significantly reduce development effort, accelerate the model building process, and ultimately enhance the quality and robustness of predictive analytics and AI systems across industries.

Keywords: *Data quality, Data preparation, Feature engineering, Data source*

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[ICIE104]

Exploration of EV Driving Modes and SOC Variations with Changing Speeds

[1]M. Sushama and [2]T. Harsha

[1,2]Dept. of EE, JNTUH-University, College of Engineering Science and Technology, Hyderabad

Email: [1]m73sushama@jntuh.ac.in
[2]harshakathiluck@gmail.com

Abstract—Vehicular emissions significantly contribute to global warming, prompting serious global initiatives toward cleaner transportation technologies. Among the various alternatives, battery electric vehicles (BEVs) have emerged as the most promising solution for both the present and the immediate future. This paper focuses on the design, simulation, and dynamic performance evaluation of a four-wheeled electric vehicle using MATLAB/Simulink. The primary objectives include evaluating the vehicle's performance under various modes of operation and different velocity profiles, maintaining battery and motor temperatures within safe limits, and continuously monitoring battery charge levels and vehicle load conditions. By achieving these goals, the paper ensures enhanced monitoring of critical parameters related to battery health, motor efficiency, and energy consumption. Another outcome which is essential is to calculate the driving range of the vehicle when operating under different modes. By predicting the real-time vehicle movements that can improve operational safety. One of the most vital contributions in this paper is the pre-emptive user and driver safety concerning fire risks related to overheating. In addition, optimizing energy management improves vehicle efficiency, which, in turn, enhances the lifespan of the vehicle. This paper offers a comprehensive framework for designing, simulating, and evaluating the performance of electric vehicles and will greatly aid in the development of future technologies in this field.

Keywords: *Four-wheeler electric vehicle, Driving range, Velocity profiles and driver safety, State of charge (SoC).*

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[ICIE110]

Application of Industrial Engineering Techniques for Conveyor Belt Jointing Activity at EPC Mode CHP in Coal Mining Company

[1]K. Radha Nagabhushanam, [2]Nayudupalli Yohan and [3]Vamaravalli Mani

[1]SE(IE), IED, KGM Area, SCCL
[2]Dy GM (IE), IED, KGM Area, SCCL
[3]MT (IE), IED, KGM Area, SCCL

Email: [1]krnbushan@gmail.com
[2]ied_kgm@scclmines.com
[3]ied_kgm@scclmines.com

Abstract—SCCL is a pioneer in the introduction of scientific management techniques. It is aimed to produce 72 MT of coal per annum. JVR CHP is a part of the JVR OC mine and has having handling capacity of 10 MT per annum and dispatches the coal extracted from the mine. It plays a crucial role in the smooth operation of power plants that rely on coal from the mine. It is established under EPC (**E**ngineering, **P**rocurement and **C**onstruction) mode on 28-05-2022. As an infant mortality under the bath tub curve, conveyor belts commissioned in JVR CHP have undergone severe failures (snapping). In order to join the belts at a large number of places, SCCL placed an order with M/s Thejo Engineering. As a part of the agreement, SCCL has to do some of the preparatory works in the belt joints. In order to estimate the man shifts required for each belt joint, a Work study is conducted on the belt jointing activity. A network diagram is drawn using the Critical Path Method (CPM) and the Critical Path is determined. Notional Cycles were drawn and standard man shifts to be deployed per joint is arrived.

Keywords: *Infant mortality, Bath tub curve, Work Study, Network Diagram, Notional Cycles*

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[ICIE112]

Integrating Blockchain for Enhanced Supply Chain Traceability and Sustainability: A Review

[1]Sreekumar R. and [2]Nidhi M.B.

[1,2]Research Scholar, Mar Baselios College of Engineering and Technology, Thiruvananthapuram

Email: [1]sreerpil@gmail.com
[2]nidhi.mb@mbcet.ac.in

Abstract—Modern supply chains face growing pressure to improve sustainability, efficiency, and transparency, especially in response to issues like illegal trade, unethical labour, and product recalls. Traceability—the ability to track and verify the origin, movement, and use of goods—is essential to support sustainability claims and reduce information asymmetry across complex, multi-tier networks. Blockchain technology has emerged as a promising tool for enabling traceability through its decentralized, tamper-proof ledgers that enhance data security, real-time visibility, and stakeholder trust. However, its implementation raises concerns about energy use and environmental impact. This paper reviews current literature and frameworks on blockchain adoption in sustainable supply chains. It analyses both conceptual models and practical case studies from sectors including textiles, multimodal logistics, and emergency supply chains in smart cities. Special focus is given to multi-objective optimization models that address trade-offs among economic cost, CO_2 emissions, and social equity. The role of smart contracts, consensus algorithms, and distributed ledgers is examined for their contribution to transparency and fraud prevention. The paper also explores how blockchain influences product quality, pricing, and consumer choices—highlighting the role of price sensitivity and perceived quality in adoption. Future-oriented approaches, such as integrating Carbon Capture, Utilization, and Storage (CCUS) technologies, are also discussed.

The paper concludes that while blockchain holds transformative potential, its sustainable deployment requires balancing technological capabilities with environmental and socio-economic considerations.

Keywords: *Blockchain Technology, Supply Chain Traceability, Sustainability, Multi-Objective Optimization, Carbon Emissions*

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[ICIE113]

Decarbonising Port Logistics: Evaluating the Transition from Diesel to Hydrogen-Powered Trucks using System Dynamics

[1]Gabby George James, [2]N. Firoz, and [3]Vinay V. Panicker

[1,2,3]Supply Chain and Systems Simulation Laboratory,
National Institute of Technology Calicut
[3]Department of Mechanical Engineering, TKM College of Engineering, Kollam, India

Email: [1]gabbygjz@gmail.com
[2]firozn12@gmail.com
[3]vinay@nitc.ac.in

Abstract—Seaports are major hubs of global trade, but also contribute significantly to greenhouse gas emissions, mainly through the use of diesel-powered trucks for cargo transportation. This study investigates the transition from diesel-powered to hydrogen-powered trucks at an Indian port using a system dynamics (SD) modelling approach. The model captures the complex interactions between economic performance, environmental impact, and infrastructure investment over time. Hydrogen fuel, particularly green hydrogen produced from renewable sources, offers a promising solution to reduce emissions. However, its adoption faces challenges due to high costs, limited availability of hydrogen-powered trucks, and the need for new refuelling infrastructure. The model developed in this study includes various factors such as port investment, conversion rates, hydrogen fuel types (green and grey), and their effects on carbon emissions and port profitability. Four scenarios are analysed: Business-as-Usual (BAU), No Green Hydrogen Investment (S1), Low Green Hydrogen Investment (S2), and High Green Hydrogen Investment (S3). Results show that while the BAU scenario achieves the highest profit due to no additional investments, it results in the highest CO_2 emissions. In contrast, the scenario S3, which includes a higher share of green hydrogen, significantly reduces emissions but requires higher investment, leading to lower short-term profitability. The study provides valuable insights for policymakers, port authorities, and industry stakeholders. It highlights the importance of balancing economic feasibility and environmental benefits to achieve sustainable port operations. The model can also serve as a decision-support tool for planning future low-carbon port strategies

Keywords: *Green Hydrogen, System Dynamics, Diesel Truck, Green Transportation, Sustainable Port.*

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[ICIE114]

Leveraging the Kano Model to Drive Digital and IoT Strategy in Industry 4.0 Organizations

Kunal Ghodake
Advik Hitech Pvt. Ltd, Chakan, Pune, Maharashtra, 410501
Email: kunal.ghodake@advik.co.in

Abstract—The Internet of Things (IoT) stands at the forefront of Industry 4.0, enabling the development of smart factories through a network of intelligent, connected systems. This paper analyzes the role of IoT in advancing sustainable digitalization within smart manufacturing by applying the Kano Model—a customer-centric framework that classifies features into Must-Be, Performance, Attractive, Indifferent, and Reverse qualities. By mapping key IoT applications—such as predictive maintenance, energy efficiency, automated quality control, workplace safety, inventory management, and real-time logistics—onto the Kano framework, the study identifies their impact on user satisfaction and sustainability outcomes. Performance needs like predictive maintenance and energy monitoring are found to enhance resource efficiency and equipment longevity, supporting both operational excellence and environmental goals. Must-be features such as safety and quality systems are critical for compliance and stakeholder trust, while attractive features—like AI-driven learning systems and real-time shipment tracking—drive innovation and user delight. By aligning digital capabilities with sustainable practices through the Kano lens, this research provides strategic direction for building resilient, efficient, and environmentally responsible smart factories in the era of Industry 4.0.

Keywords: *Internet of Things, Kano Model, Smart Factories, Sustainable Digitalization, Industry 4.0*

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[ICIE115]

Overall Equipment Effectiveness (OEE): A Tool for Holistic Monitoring Performance of Equipment: A Case Study of NCL

[1]Manoj Kumar Singh and [2]Vijeesh M.V.

[1]General Manager (IE), NCL
[2]Dy. Manager (IE), NCL

Abstract—Northern Coalfields Limited (NCL) operates a large fleet of expensive, high-capacity equipment, including 33 cum Draglines, 20 cum Shovels and 190T Dumpers, where downtime or idle time results in significant monetary losses. As such, it becomes very important to continuously monitor the performance of these HEMMs for optimizing their Performance. Traditionally, Availability, Utilisation and Efficiency of Operation are measured separately to assess the performance of Equipment. However, each of these parameters provides only a partial view of the performance of the equipment. Industrial Engineering Department of NCL has developed a new parameter for evaluating the overall effectiveness of equipment, Overall Equipment Effectiveness (O.E.E.). The OEE assesses how effectively any equipment is utilized by considering all three parameters together, i.e. Availability, Utilisation, and Efficiency of Operation. This case study of NCL has focused on the Overall Equipment Effectiveness (OEE) of different models of 190T Dumpers and 20 cum Shovels. Analysis of OEE at NCL highlights opportunities to enhance productivity by focusing on reducing maintenance downtime, improving utilization through effective supervision and training, and optimizing operational practices to match and surpass normative production parameters. Further, NCL maximizes its equipment utilization and reduces its cost of production by employing techniques such as KAIZEN, SMED, proper payload management, etc. Thus, OEE serves as a powerful tool to identify bottlenecks, implement best practices, and drive continual improvement in its operations, thereby strengthening its ability to efficiently extract and produce coal while optimizing resources and reducing waste.

Keywords: *Overall Equipment Effectiveness, Heavy Earth Moving Machinery, Utilisation, Bottlenecks*

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[ICIE119]

Human Reliability in Human-Centric Industry 5.0 Systems: Reimagining Industrial Engineering for Sustainable Collaboration

[1]Skanda Moda Gururajarao, [2]Manjunatha B., and [3]Neetha K.

[1,2]Department of Industrial and Production Engineering, SJCE, JSS Science and Technology University, Mysuru
[3]Department of Mechanical Engineering, SJCE, JSS Science and Technology University, Mysuru

Email: [1]skanda.rao@sjce.ac.in
[2]manjub@sjce.ac.in
[3]dr.neethak@jssstuniv.in

Abstract—Industry 5.0 is not just about smarter machines. It is about bringing people back to the centre of industrial systems. Instead of replacing human workers, Industry 5.0 aims to build thoughtful partnerships between people and advanced technologies like AI and cyber-physical systems. The goal is to create workplaces that are not only efficient and adaptive but also meaningful, inclusive, and resilient. This paper explores how the role of the human operator is evolving in these intelligent, technology-rich environments. We shift the focus from seeing human error as a problem to be eliminated to viewing human reliability as a powerful asset, something that can guide, correct, and complement machines. By examining traits like cognitive flexibility, adaptability under pressure, and the ability to recover from mistakes, we propose a framework that allows smart systems to learn from and adjust to the human beings who work within them. Since Industry 5.0 is still in the early stages of adoption, we propose a framework that can be integrated into emerging implementations, particularly in contexts where human reliability can enhance system responsiveness and resilience. The paper closes with practical suggestions for engineers and policymakers to design workplaces that value human strengths, making Industry 5.0 not just intelligent, but also humane and sustainable.

Keywords: *Industry 5.0, Human-Centric Systems, Human Reliability, Socio-Technical Systems, Collaborative Automation*

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[ICIE121]

Comparative Analysis of Performance Measures in Warehouse Layout Design through Simulation using AnyLogic

[1]Adithya Anil, [2]Alan Jaison Mangan, [3]Alvin J. Manuel, [4]Deepak Rajesh, and [5]Pradeepmon T.G.

[1,2,3,4,5]Department of Mechanical Engineering, National Institute of Technology Calicut, India

Email: [1]adithyaanil7ekm@gmail.com
[2]alanjm339@gmail.com
[3]alvinjmanuel19@gmail.com
[4]dpu.rajesh@gmail.com
[5]tgpradeep@gmail.com

Abstract—Efficient warehouse design is essential for keeping up with the growing demands of modern supply chains. This work focuses on evaluating the performance of different warehouse layouts, including traditional layouts, fishbone designs, chevron configurations, among others. The goal is to understand which layout would be most efficient under different conditions and parameters. The performance of these layouts would be analysed using various KPIs such as picking time, picking efficiency, storage utilization and cost savings. The study employed AnyLogic, a simulation tool, to model and test the different layouts. Discrete Event Simulation Modelling (DEM) was used in the study to simulate the movement of goods, or more importantly, the flow of a series of events happening in the warehouse. The storage utilization is highest for the traditional layout (30,000 pallet locations), owing to the fact that all alternative layouts sacrificed some of this capacity to create more direct picker travel paths. The picking efficiency of the leaf layout shows a 15.8% increase over the corresponding traditional layout, with a cost reduction of 13.7%.

Keywords: *Warehouse Layout Design, Traditional Layout, Fishbone Layout, Chevron Layout, Leaf layout, Discrete Event Simulation Modelling, AnyLogic*

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[ICIE128]

Network Deconvolution for Causal Inference in Production Flows

Balaji Natarajan
Dr. MGR Educational and Research Institute
Email: nbalaji1983@gmail.com

Abstract—This thesis introduces a methodology based on network deconvolution to uncover causal relationships within production systems. The approach separates direct and indirect effects to understand how variations propagate through production flows. The algorithm's robustness is analyzed, and extensions for mixed random variables and mutual information estimation are presented. The method is applied to simulated production data, demonstrating its ability to infer causal structures and quantify the influence of individual processes.

Keywords: *network deconvolution [ND], Density-based Mutual Information Estimation [MI], Copula entropy [CE], Sensitivity analysis*

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[ICIE132]

Development of an AI-Driven Conversational Agent for Academic Support in Education

[1]Mulla Gouse Basha, [2]K.V. Narasimha Reddy, [3]Y. Chandana, [4]K. Suresh, and [5]S.K. Nagoor Babu

[1,2,3,4,5]Narasaraopeta Engineering College, Narasaraopeta, India

Email: [1]m.gousebasha@gmail.com
[2]narasimhareddynec03@gmail.com
[3]chandana.nrtnec@gmail.com
[4]sureshkunda546@gmail.com
[5]sknagoorbabu786@nrtec.in

Abstract—Artificial Intelligence (AI) is transforming the education sector by enabling intelligent tutoring systems that provide instant and reliable academic support. Students often struggle with understanding complex concepts, finding relevant study materials, and preparing for exams. This paper introduces a Retrieval-Augmented Generation (RAG) Document-Based Chatbot, leveraging GPT-4o, to assist students by retrieving relevant academic information and generating insightful, well-structured responses. In addition to providing accurate answers, the chatbot will return references and sources from academic documents, enabling students to explore the original materials, textbooks, and research papers for deeper understanding. This feature fosters critical thinking and self-learning, ensuring students rely on credible sources rather than generic AI-generated answers. The AI-powered Chatbot, powered by GPT-4o, is designed to revolutionize the way students access academic knowledge. By retrieving relevant educational content, generating insightful explanations, and providing direct references, this chatbot ensures that students not only receive instant answers but also have access to credible study materials for deeper understanding. This paper contributes to the future of AI-driven education, fostering independent learning, improving academic performance, and making quality education more accessible to students worldwide. In conclusion, the proposed RAG-based chatbot enhances the learning experience by combining intelligent retrieval with generative capabilities. It represents a scalable and impactful solution for AI-driven, self-directed education, promoting academic excellence and equitable access to quality educational resources.

Keywords: *Artificial Intelligence; Retrieval-Augmented Generation; GPT-4o; Chatbot.*

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[ICIE146]

AI ENABLED Supply Chain Performance for Sustainable Tourism

[1]Ghanashyam K. Shenvi Kerka, [2]Milind J. Sakhardande, and [3]Kabir K. Shirgaonkar

[1,2]College of Engineering, Goa (affiliated to Goa University)
[3]Department of IT E&C – Goa

Email: [1]gkskerkar.alcon@gmail.com
[2]milind@gec.ac.in
[3]kshirgaonkar1@gmail.com

Abstract—Tourism is a human social activity since time immemorial. Impact of tourism on the places of visit is substantial- socially, culturally and environmentally. With all the means of travel now available readily, there is a boom in tourism activities to the places of interest for leisure and other multiple social fulfilments. Religious tourism is a recent trend. With tourism places getting overwhelmed due to the influx of tourists, the sustainable tourism concept is a must. As the volume of incoming tourists cannot be controlled directly, tourist place has to adjust and adopt sustainable measures which will improve their bearing capacity to the best possible potential. Supply chain is the key to achieving such sustainable tourism potential. Dynamics of a sustainable Supply chain can be measured through its performance parameters. This paper showcases the use of AI and AI-enabled tools for the measurement of supply chain parameters that help in making the best decisions towards sustainable tourism.

Keywords: *Sustainability, Tourism, Circular economy, Supply Chain, Hospitality*

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[ICIE148]

The Role of Industry 4.0 Technologies for Smart Manufacturing in the Indian Scenario

[1]Prajakta Chandrakant Kandarkar and [2]V. Ravi

[1,2]Department of Humanities and Social Sciences, Indian Institute of Space Science and Technology, Thiruvananthapuram, Kerala, India

Email: [1]kandarkarpc21@gmail.com
[2]ravi.iist.isro@gmail.com

Abstract—The fourth industrial revolution brought a paradigm transition in the manufacturing sector by emphasizing digitization, automation, and information technologies. It introduced various Industry 4.0 technologies, which enabled the manufacturing industry to become smarter and more adaptable to the dynamic business environment. However, there is a lack of comprehensive research on the crucial role of technology in achieving performance in manufacturing operations. The aim of this study is to investigate the latest advancements in manufacturing systems and provide a thorough analysis of their connection with Industry 4.0 technologies. This study proposes a conceptual framework for a smart manufacturing system based on integrating Industry 4.0 technologies with manufacturing operations. This framework is made up of six domains, namely, smart design, smart production, smart inventory, smart quality, smart maintenance, and smart delivery. The finding of this study shows that adopting Industry 4.0 technologies facilitates energy optimization, resource consumption, productivity enhancement, quality improvement, and shorter lead time in smart manufacturing systems. The applications of smart manufacturing systems in the context of Indian industrial sectors are outlined in this research. This study can help researchers and managers understand the mechanism of smart manufacturing while achieving higher performance in the industry. The recommended research direction can serve as a path for researchers to conduct further research in this area.

Keywords: *Industry 4.0, Smart Manufacturing, Digitization, Supply Chain Management, Digital Transformation*

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[ICIE149]

From Disclosure to Action: ESG Ratings as Drivers of Industry 5.0 Transformation

[1]Promod Mani and [2]Veeksha Rao Ponakala

[1]IREL (India) Limited
[2]Tattva ESG Solutions

Abstract—As global industries pivot toward the principles of Industry 5.0 - human-centricity, resilience, and sustainability, ESG (Environmental, Social, and Governance) ratings are emerging as critical drivers of strategic and operational transformation. This paper examines how third-party ESG assessments and disclosures, such as CDP, EcoVadis, and BRSR, influence real change beyond disclosures, enabling businesses to integrate sustainability into their manufacturing, supply chains, and workforce systems. Drawing from case studies across sectors, we identify key mechanisms through which ESG feedback leads to tangible shifts: reengineering of production processes for resource efficiency, restructuring of workforce policies to align with social sustainability metrics, and prioritization of technology investments that meet both environmental and productivity goals. We propose a practical framework mapping ESG maturity to Industry 5.0 readiness, supported by qualitative indicators and sector-specific insights. Our findings demonstrate that companies proactively engaging with ESG ratings are more likely to innovate responsibly, attract mission-aligned talent, and build adaptive systems resilient to environmental and social disruptions. For industrial engineers, sustainability professionals, and policy thinkers, this work offers both strategic direction and actionable models to embed ESG as a performance catalyst in the era of Industry 5.0.

Keywords: *Industry 5.0, CDP, EcoVadis, BRSR*

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[ICIE150]

Exploring the Synergy of 3D Printing and Composite Materials: A Critical Review

[1]Amey Naik Dessai and [2]Rajesh S. Prabhu Gaonkar

[1,2]Mechanical Engineering Department, Goa College of Engineering
(Affiliated to the Goa University)

Email: [1]asd1.p22@gec.ac.in
[2]rpg@gec.ac.in

Abstract—This review paper provides a comprehensive investigation into the synergy between 3D printing and composite materials, with a particular focus on polymer matrices, such as Polylactic Acid (PLA), Acrylonitrile Butadiene Styrene (ABS), and Polyethylene Terephthalate Glycol (PET-G) reinforced with diverse fillers. The study summarizes the latest developments in technology, materials, and research trends that characterize the nexus between polymer composite science and additive manufacturing. The compatibility of different composite formulations with 3D printing processes, such as Fused Deposition Modeling (FDM) and Stereolithography (SLA) are highlighted in this review, focusing on the mechanical, thermal, and morphological behaviour of reinforced thermoplastics. By combining the versatility of 3D printing with advanced composite formulations, the synergy enables the production of highly customizable materials tailored to specific applications, from consumer goods to structural components. This review also demonstrates the promise of these composites in applications ranging from consumer goods to structural components by looking at case studies that use natural fibres, nanoparticles, and industrial waste as reinforcements. Furthermore, it highlights current initiatives to get past obstacles, including anisotropy, printability constraints, and uneven filler distribution, by using material processing techniques and design optimization. Ultimately, this review shows the transformative role of 3D printing in enabling the sustainable, functional, and customizable fabrication of composite materials, serving as a guide for researchers seeking to advance the field.

Keywords: *Polylactic Acid, 3-Dimensional Printing, Acrylonitrile Butadiene Styrene, Polyethylene Terephthalate Glycol, Fused Deposition Modeling, and Stereolithography.*

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[ICIE151]

Integration of SCOR Model with AI for Optimized Supply Chain Performance in Industry 5.0

[1]Sreeraj C., [2]Mathew Cherian, and [3]Joby George

[1]The Kerala Minerals and Metals Ltd (KMML), Chavara, Kollam, Kerala
[2]Former Professor in Mechanical Engineering, CUSAT, Cochin, Kerala
[3]Amal Jyothi College of Engineering, Kanjirappally, Kottayam, Kerala

Abstract—The Supply Chain Operations Reference (SCOR) model serves as a standardized framework for optimizing supply chain operations, and its integration with AI-driven technologies in Industry 5.0 enhances visibility, resilience, and efficiency. Industry 5.0 emphasizes human-machine collaboration, and combining SCOR's structured processes with AI enables predictive analytics, automation, and data-driven decision-making. This collaboration enables organizations to optimize their operations, lower expenses, and enhance customer satisfaction while managing intricate supply chain issues. The present study explores how SCOR, as a standardized framework, fosters improved collaboration among stakeholders by providing a common language and process alignment. Additionally, AI-powered analytics enhance SCOR's performance metrics, enabling real-time insights and agile responses to dynamic market conditions. The findings reveal that leveraging SCOR alongside AI technologies enhances supply chain excellence, mitigates risks, and supports sustainable growth in the Industry 5.0 era. The research highlights key benefits, including standardized processes for seamless communication, AI-driven optimization for operational efficiency, and increased adaptability to disruptions. Furthermore, the study suggests future pathways for a more profound integration of SCOR with innovative technologies like IoT and blockchain to improve traceability and automation. It also suggests incorporating sustainability and social responsibility metrics into the SCOR framework to align with evolving industry demands. Applying SCOR to global supply chains can further optimize cross-border operations and minimize risks. In conclusion, the fusion of SCOR and AI-driven advancements positions organizations to achieve superior supply chain performance, ensuring competitiveness and long-term success in Industry 5.0. Future research should focus on expanding SCOR's applicability across diverse technological and sustainable supply chain ecosystems.

Keywords: *SCOR model, Industry 5.0, AI-driven supply chain, Supply chain resilience*

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[ICIE152]

Data-Driven Forecasting of Food Grain Allocation: A Climate-Sensitive Machine Learning Model for Indian States

[1]Johns Joseph and [2]Pradeepmon T.G.

[1,2]Department of Mechanical Engineering,
National Institute of Technology Calicut, India

Email: [1]johnsjoseph325@gmail.com
[2]tgpradeep@gmail.com

Abstract—Ensuring timely and adequate food distribution across diverse geographic regions in India remains a critical policy objective, particularly in the context of increasing climate variability. This study develops a machine learning framework to forecast state-wise food grain allocation using historical meteorological and distributional data. The model integrates daily rainfall parameters, including actual rainfall, normal rainfall, percentage deviation, and reservoir storage levels, alongside historical food allocation records from 2009 to 2024. Monthly aggregates were computed, and lag features were engineered to capture temporal dependencies. State-wise identifiers were one-hot encoded to accommodate regional heterogeneity. An XGBoost regression model, optimized via hyperparameter tuning, demonstrated strong predictive performance with a Mean Absolute Error (MAE) of ₹62,550 and a coefficient of determination (R^2) of 0.758. The model was subsequently employed to forecast food allocation for a 24-month horizon under simulated average rainfall conditions. The results highlight the viability of using climate-informed machine learning models for anticipatory public resource planning. This approach offers a scalable and data-driven decision-support tool for government stakeholders tasked with managing food security and supply chain resilience across Indian states.

Keywords: *Food Grain Allocation, Machine Learning, XGBoost Regression, Public Distribution System (PDS)*

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[ICIE153]

Influence of Customer Perception on Strategic AI Adoption in Service Organizations: A Conceptual Framework

Manoj M.
CET School of Management, Trivandrum

Abstract—This research explores the influence of customer perception on strategic AI adoption in service organizations. While global AI adoption, including in India, is rapidly growing, existing models primarily focus on technological, organizational, and environmental determinants. These models often ignore the critical role of customer perceptions in the service sector, where direct customer interaction is significant. A key gap exists in integrating customer-centric variables into AI adoption frameworks. Customer concerns like privacy, transparency, and loss of human touch can lead to resistance, while perceived benefits such as convenience and personalization can drive demand. Understanding how these perceptions shape AI adoption is a noteworthy addition to current literature. To address this, the research will extend the Technology-Organization-Environment (TOE) model by adding a Customer-Centric Layer. This layer will incorporate customer trust in AI, customer acceptance and concerns, and customer experience feedback. Perceived customer risk or opportunity will mediate the relationship, influencing strategic AI adoption decisions. The study aims to integrate customer-centric variables into existing AI adoption models and examine the mediating role of perceived customer risk or opportunity. This research will fill a theoretical gap and offer strategic insights for firms and policymakers.

Keywords: *AI adoption, Customer perception, Service organization, TOE model*

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[ICIE154]

Resilient and Sustainable Approach for Risk-Driven Project Scheduling under Uncertainty

[1]Venugopal V.G. and [2]Regi Kumar V.

[1]Mechanical Engg. Department
[2]CET School of Management (Department of Business Administration),
College of Engineering Trivandrum, Thiruvananthapuram, India

Email: [1]venugect@gmail.com
[2]regikumar@cet.ac.in

Abstract—In contemporary project management, uncertainty and risk present significant challenges, particularly in large-scale, complex projects characterized by interdependent tasks and dynamic external factors. This article addresses the need for a structured, data-driven approach to risk mitigation through the development of a hybridized project risk modelling framework. The objective is to improve forecasting accuracy, optimize resource allocation, and minimize the impact of risks on project cost and schedule. The proposed approach integrates deterministic (network scheduling), probabilistic (Monte Carlo simulation), and optimization techniques (Linear and Non-Linear Programming). Nonlinear programming is specifically applied to quantify Liquidated Damages (LD) for schedule delays, accounting for conditional penalty rates and caps. The model operates in three stages: (i) network development and risk identification, (ii) simulation-based risk quantification and impact analysis, and (iii) optimization of resource allocation within a predefined contingency budget using linear programming. This framework was implemented on a live infrastructure project valued at AED 12.25 million (approx. INR 270 million) over 337 calendar days. Results demonstrated optimal cost allocation to risk mitigation strategies, eliminating schedule delays and preventing cost overruns. The Monte Carlo simulation enabled probabilistic forecasting, while optimization methods ensured strategic prioritization of high-impact risks. Key contributions include the integration of quantitative methods with traditional planning to achieve resilient, cost-effective project outcomes. The approach enhances proactive decision-making in uncertain environments and supports adaptive risk control. Additionally, by enabling efficient use of resources and reducing rework or delays, the approach contributes to project sustainability economically, through cost control, and operationally, by promoting long-term performance reliability. This article presents a novel hybrid methodology that advances the field of project risk management and offers practical implications for managing complex projects under uncertainty.

Keywords: *Risk, Sustainability, Risk Mitigation, Contingency Cost*

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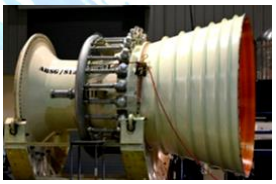

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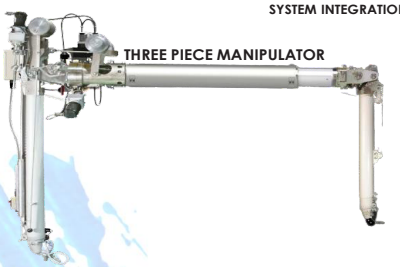

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- Developing a 2 lakh sq.ft. Common Facility Centre and R&D Centre
- 15 acres of land for allotment to investors on lease

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- Being executed by MSME/GOI
- Proto Manufacturing Support
- Skill up training & Entrepreneurship Consultancy

Aerospace Industry Cluster, Kochi

25 acres of land in Kakkanad being alloted
- Common Facility Centre
- Land for allotment to investors on lease

Integrated Defence Industrial Park (IDIP)

100 acres of land being acquired
- Common Facility Centre
- Metallic and non-metallic manufacturing units
- Explosives and Propellant processing Units

Aerospace Control Systems Complex-Veli

60 acres of land, near VSSC, being acquired
- Aerospace Control Systems Complex
- Aerospace Inertial Navigation & Guidance Complex
- Aerospace Avionics Complex
- Precision and Micro Manufacturing Complex
- Common Facility Centre

Liquid Propulsion and Allied Systems Complex-Valiamala

13.5 acres of land, near LPSC and IIST, being acquired
- Liquid Propulsion and Allied Systems Complex
- Innovation and Product Development Centre
- Centre of Excellence in Drone Technology

Aerospace Composites Centre-Thonnakkal

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- Aerospace Structural Plastics Centre
- Common Facility Centre

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The Editors

Dr. Bijulal D. is Professor in the Mechanical Engineering Department at the Government Engineering College Barton Hill, Thiruvananthapuram. He has the M.Tech. From IIT Kharagpur in Industrial Engineering and Management and Ph.D from IIT Bombay from the inter-disciplinary centre; Industrial Engineering and Operations Research. During the 28 years of teaching and research, Dr. Bijulal D. has acquired experience and expertise in Work System Design, Supply Chain Management, System Simulation, Quality Systems, System Dynamics, Operations Research, Optimisation Techniques, and Data Analytics. With several international publications and one single authored book in Operations Research in his credit, Dr. Bijulal D. is a reviewer for many journals and member of editorial board for one international journal. The contributions in academics include active involvement in curriculum development for the UG and PG programs in Industrial Engineering of the University of Kerala and the APJ Abdul Kalam Technological University, Thiruvananthapuram. He is active in research as guide and member of the doctoral committees.

Dr. Sini V. Pillai is Assistant Professor and Faculty Chair - Training and Placement at Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala). She is a result-oriented Management professional with experience in Industries of Education, and Banking domains excelling in meeting objectives using independent action, prioritisation, and leadership skills. She brings over 15 years of academic and practical insight into how technology can be harnessed to advance business goals. Her research has been published in top-tier journals, focusing on digital transformation, technology-enabled product development, and strategic management. Outside academia, she consults with organisations, translating technical expertise into practical strategies that foster organisational growth.

Dr. Suresh Kumar C. is an Outstanding Scientist, retired as Deputy Director of Liquid Propulsion Systems Centre, ISRO, Trivandrum in May 2024. He Joined ISRO in 1987 as Scientist/ Engineer after completing B Tech from Kerala University and M Tech from NIT, Calicut. Subsequently acquired MBA from ICFAI and did Ph.D in Management from the Kerala University. He is active in the professional societies: Aeronautical Society of India, Indian Institution of Industrial Engineering, and Institution of Engineers India.

He held many key positions like Group Director of Earth Storable Stages Group of LPSC, Project Director of L110 Project, and finally elevated as Dy. Director of SRQA, LPSC. He has received ISRO team excellence award two times. He held key positions in developing largest liquid booster stage (designated as L110 stage) in India and lead the team as Project Director in realising L110 stage for LVM3-M4 mission which launched Chandrayaan3. His area of interest and research are System Engineering, Project Management, Configuration Management and Quality Management. He has many publications in national and international journals.

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