Two Weeks Advanced FDP

on

Digital Twin for Smart Manufacturing: Applications and its Challenges

25th November 2024 –07th December 2024)

Tamil Thai Vazhthu: The Advanced FDP commenced with the Tamil Thai Vazhthu, evoking a sense of respect and pride among the attendees.

Welcome Address

Dr. Chitra extended a warm welcome to all attendees, expressed heartfelt gratitude for their participation, and highlighted the importance of the FDP's theme in tackling modern energy challenges.

Presidential Address

Dr. Selvakumar delivered the Presidential Address, emphasizing the importance of leveraging digital twin technology for Smart Manufacturing and highlighting the pivotal role of academia in adopting innovation in this domain. A total of 45 participants attended the FDP titled Digital Twin for Smart Manufacturing: Applications and its Challenges.

Inaugural Address

Chief Guest

Mr. M. Thirumalai Kumar
Associate Vice President & Head of Research Group Autonomous Systems & Control – India, Siemens Technology and Services Pvt. Ltd., Bengaluru

The inaugural session of the Faculty Development Program (FDP) titled *"Digital Twin for Smart Manufacturing: Applications and its Challenges"* was marked by an insightful address delivered by Mr. M. Thirumalai Kumar, Associate Vice President & Head of Research Group Autonomous Systems & Control – India, Siemens Technology and Services Pvt. Ltd., Bengaluru.

In his address, Mr. Thirumalai Kumar emphasized the transformative potential of digital twin technology in smart manufacturing. He elaborated on how digital twins serve as virtual replicas of physical systems, enabling real-time simulation, analysis, and optimization of manufacturing processes. Highlighting their role in improving productivity, ensuring quality, reducing costs, and promoting sustainability, he underscored the growing importance of this technology in Industry 4.0.

Mr. Thirumalai Kumar also discussed the integration of digital twins with emerging technologies such as artificial intelligence, machine learning, and the Internet of Things (IoT), which are paving

the way for autonomous systems. He addressed the associated challenges, including data security, integration complexities, and the urgent need for a skilled workforce capable of leveraging these advancements.

Concluding his address, Mr. Kumar commended the efforts of the organizers in curating an FDP on such a relevant and impactful theme. He encouraged participants to actively engage in the sessions and explore ways to bridge the gap between academic research and industrial applications, advancing innovation and collaboration.

Day -1, Session- I, 25/11/2024: Industry 4.0 – Digital Factory Solutions

Resource Person: Mr. M. Thirumalai Kumar

Associate Vice President & Head of Research Group Autonomous Systems & Control – India Siemens Technology and Services Pvt. Ltd. Bengaluru

The session- I began with a welcome note by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Mr. M. Thirumalai Kumar, Associate Vice President & Head of Research Group Autonomous Systems & Control – India Siemens Technology and Services Pvt. Ltd. Bengaluru

Mr. M. Thirumalai Kumar took over the session and provided an insightful talk on the following topics:

- The concept and core principles of Industry 4.0.

- Key components of digital factory solutions.

- Leveraging IoT, AI, and robotics for smart manufacturing.

- Enhancing productivity through real-time data monitoring and analytics.

- The role of automation in reducing operational costs.

- Customization and scalability of digital solutions for various industries.

- Importance of cybersecurity in interconnected systems.

- Challenges in implementing Industry 4.0 solutions in legacy systems.

The session was highly interactive and provided participants with a comprehensive understanding of digital factory solutions under Industry 4.0.

Day -1, Session- II, 25/11/2024: Digital Twin - Model Based Simulation and Engineering (MBSE)

Resource Person: Mr. M. Thirumalai Kumar, Associate Vice President & Head of Research Group Autonomous Systems & Control – India Siemens Technology and Services Pvt. Ltd. Bengaluru

The session- II commenced with a warm welcome by Dr. L. Chitra, HoD/EEE, and an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for the session was Mr. M. Thirumalai Kumar, Associate Vice President & Head of Research Group Autonomous Systems & Control – India, Siemens Technology and Services Pvt. Ltd., Bengaluru.

Mr. M. Thirumalai Kumar took over the session and provided in-depth insights into the following key topics:

- Fundamentals of digital twin technology and its importance in engineering.

- Overview of Model-Based Simulation and Engineering (MBSE) methodologies.

- Role of digital twins in product design, testing, and lifecycle management.

- Integration of MBSE for system modeling, simulation, and optimization.

- Applications of digital twin in enhancing predictive maintenance and operational efficiency.

- Leveraging digital twin technology for real-time monitoring and decision-making.

- Overcoming challenges in implementing MBSE across various industries.

- Future directions and innovations in digital twin and MBSE technologies.

The session was highly interactive, providing participants with a comprehensive understanding of the transformative potential of digital twins and MBSE in modern engineering practices.

Day -2, Session- III, 26/11/2024: Digital Twin for Process Automation: SIMIT: A Hands-On Approach

Resource Person: Mr. Vinoth Subramanian, Head of Systems Support for Process Automation, Siemens Technology and Services Pvt. Ltd. Bengaluru.

The 2nd day, Session-III began with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for the session was Mr. Vinoth Subramanian, Head of Systems Support for Process Automation, Siemens Technology and Services Pvt. Ltd., Bengaluru.

Mr. Vinoth Subramanian led an engaging hands-on session on the following topics:

- Introduction to Digital Twin technology in the context of process automation.

- Overview of SIMIT: A simulation platform for testing and validating process automation systems.

- Practical applications of Digital Twin in process automation and control systems.

- Benefits of using SIMIT for testing process models and reducing errors before real-world implementation.

- Real-time simulation and its role in optimizing automation processes.

- Integration of Digital Twin with process control systems for predictive analytics and maintenance.

- Hands-on demonstration of SIMIT software for creating and simulating process automation models.

- Addressing challenges and best practices in implementing Digital Twin for process automation.

The session provided participants with practical insights into the use of Digital Twin and SIMIT software, enhancing their understanding of its applications in process automation and control. The

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hands-on approach ensured that the participants could directly experience the potential of these technologies in real-world scenarios.

Day -2, Session- IV, 26/11/2024: Digital Twin for Process Automation: Semantic DCS: A Hands-On Approach

Resource Person: Mr. Thavasuraman Palaniappan, Head of Customer Support for Process Automation, Siemens Technology and Services Pvt. Ltd. Bengaluru

The 2nd day, Session-IV started with a warm welcome by Dr. L. Chitra, HoD/EEE, and an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for the session was Mr. Thavasuraman Palaniappan, Head of Customer Support for Process Automation, Siemens Technology and Services Pvt. Ltd., Bengaluru.

Mr. Thavasuraman Palaniappan delivered a comprehensive session on the following topics:

- Introduction to Digital Twin in the context of Distributed Control Systems (DCS).

- Overview of Semantic DCS: A semantic approach to process automation and control.

- Role of Digital Twin in enhancing DCS performance and providing real-time system insights.

- Applications of Semantic DCS for improving process optimization, safety, and control accuracy.

- Integration of Semantic DCS with Digital Twin for seamless data flow and analysis.

- Hands-on demonstration of Semantic DCS in a process automation scenario.

- Practical challenges and solutions in implementing Semantic DCS for process control systems.

- Best practices for integrating Semantic DCS with existing automation infrastructure.

The session provided valuable hands-on experience with Semantic DCS and its integration with Digital Twin technology, offering participants a deeper understanding of how these systems can

improve process automation and control. The hands-on approach allowed attendees to apply the concepts directly to practical situations.

Day -3, Session- V, 27/11/2024: Digital Twin for Process Industries

Resource Person: Dr.Vijayarajeswaran R, Managing Director, VI Micro Systems Pvt. Ltd.

Chennai

The 3rd day, Session-V commenced with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Dr. Vijayarajeswaran R, Managing Director, VI Micro Systems Pvt. Ltd., Chennai.

Dr. Vijayarajeswaran R led an insightful session on the following key topics:

- Introduction to Digital Twin technology and its significance in process industries.

- Role of Digital Twin in optimizing operations and enhancing the efficiency of process industries.

- How Digital Twin enables real-time monitoring and predictive analytics for process optimization.

- Integration of Digital Twin with Industrial Internet of Things (IIoT) to enhance operational insights.

- Applications of Digital Twin in industries such as chemical, petrochemical, and manufacturing.

- Challenges faced by process industries in adopting Digital Twin technology.

- Case studies showcasing the successful implementation of Digital Twin in process industries.

- Future prospects and innovations in Digital Twin applications for process industries.

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The session was informative, offering participants practical insights into the transformative impact of Digital Twin technology on the operations and performance of process industries. Dr. Vijayarajeswaran's expertise provided valuable perspectives on overcoming challenges and leveraging Digital Twin for industrial advancement.

Day -3, Session- VI, 27/11/2024: Glimpses on Development of UAVs for Multifaceted Environments and Applications

Resource Person: Dr. E. Balasubramanian,

Professor, Department of Mechanical Engineering, National Institute of Technical Teachers Training and Research, Chennai, Government of India.

The 3rd day, Session-VI began with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Dr. E. Balasubramanian, Professor, Department of Mechanical Engineering, National Institute of Technical Teachers Training and Research, Chennai, Government of India.

Dr. E. Balasubramanian provided an insightful session on the following key topics:

- Introduction to Unmanned Aerial Vehicles (UAVs) and their significance in modern technology.

- Overview of the development and design considerations for UAVs, including aerodynamics, propulsion systems, and control mechanisms.

- UAVs for multifaceted environments: applications in agriculture, surveillance, disaster management, and industrial monitoring.

- The evolution of UAV technology in response to diverse environmental challenges.

- Integration of sensors, data analytics, and real-time monitoring in UAV systems.

- Applications of UAVs in challenging environments such as mountainous, coastal, and urban areas.

- Challenges in the development of UAVs for specific applications, including regulatory, technological, and environmental constraints.

- Future trends and advancements in UAV technology and its expanding role in various sectors.

The session was both informative and engaging, providing participants with a deeper understanding of the diverse applications of UAVs in various environments. Dr. Balasubramanian's expertise offered valuable insights into the technical and practical aspects of UAV development and its growing significance in solving real-world challenges.

Day -4, Session- VII, 28/11/2024: Real-Time Applications of Embedded Systems for Drone Technologies

Resource Person: Dr. Uppu Ramachandraiah, Professor of Research,

Rajalakshmi Engineering College.

The 4th day, Session-VII began with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Dr. Uppu Ramachandraiah, Professor of Research, Rajalakshmi Engineering College.

Dr. Uppu Ramachandraiah delivered a comprehensive session on the following topics:

- Introduction to embedded systems and their critical role in modern drone technologies.

- Overview of the components and architecture of embedded systems used in drones, including microcontrollers, sensors, and communication systems.

- Real-time applications of embedded systems in drone technologies for various sectors such as agriculture, surveillance, logistics, and environmental monitoring.

- The integration of real-time data processing, control systems, and navigation algorithms in drone systems.

- Challenges in the development of embedded systems for drones, including power consumption, system reliability, and real-time performance.

- Case studies showcasing the application of embedded systems in autonomous drones for real-time mission execution.

- The role of embedded systems in ensuring safety, stability, and accuracy in drone operations.

- Future developments in embedded systems for next-generation drone technologies, including AI and machine learning integration.

The session provided participants with a detailed understanding of the real-time applications of embedded systems in drone technologies. Dr. Ramachandraiah's expertise helped illuminate the integral role of embedded systems in advancing drone capabilities, and the session emphasized both the potential and challenges of these technologies in real-world applications.

Day -4, Session- VIII, 28/11/2024: Powering E-Vehicles and Smart Manufacturing through Advanced Electronics and Drives

Resource Person:

Dr. B.Chitti Babu,

Associate Professor, Head of the Department (ECE)

Indian Institute of Information Technology, Design and Manufacturing, Kancheepuram

The 4th day, Session-VIII began with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Dr. B. Chitti Babu, Associate Professor, Head of the Department

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

Dr. B. Chitti Babu conducted an informative session on the following topics:

- Introduction to the role of advanced electronics and drives in powering electric vehicles (E-Vehicles) and smart manufacturing.

- Key technologies in E-Vehicle powertrains, including battery management systems, electric motors, and power electronics.

- The integration of drive systems in E-Vehicles for improved efficiency, performance, and sustainability.

- Smart manufacturing systems: Overview of automation, robotics, and the role of electronics and drives in optimizing industrial production.

- How advanced electronics enable real-time monitoring, control, and data analytics in smart manufacturing environments.

- The impact of drive technologies in enhancing precision, energy efficiency, and productivity in manufacturing.

- Case studies on the implementation of advanced electronics in E-Vehicles and smart manufacturing setups.

- Challenges in the development and integration of advanced electronics and drive systems, and future trends in the industry.

The session provided valuable insights into the applications of advanced electronics and drives in the evolving fields of electric vehicles and smart manufacturing. Dr. B. Chitti Babu's expertise highlighted the transformative role of these technologies in achieving energy efficiency, sustainability, and improved industrial performance.

Day -5, Session- IX, 29/11/2024: Overview of Technomatix Plant Simulation

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Resource Person: Mr. Sivasankaran I, Tamilnadu Smart and Advanced Manufacturing Centre, A Joint Initiative & the Government of Tamil Nadu and Siemens Industry Software India, Pvt. Ltd.

The 5th day, Session-IX commenced with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Mr. Sivasankaran I, Tamilnadu Smart and Advanced Manufacturing Centre, a joint initiative of the Government of Tamil Nadu and Siemens Industry Software India Pvt. Ltd.

Mr. Sivasankaran I led an insightful session on the following key topics:

- Introduction to Technomatix Plant Simulation and its role in optimizing manufacturing processes.

- Overview of the features and capabilities of Technomatix Plant Simulation software in digital manufacturing.

- How Plant Simulation enables the modeling, analysis, and optimization of production systems, improving throughput and efficiency.

- The integration of Plant Simulation with real-time data to enhance decision-making in manufacturing environments.

- Applications of Plant Simulation in industries such as automotive, electronics, and consumer goods manufacturing.

- Benefits of using Plant Simulation for layout planning, resource utilization, and material flow optimization.

- Hands-on demonstration of Technomatix Plant Simulation for creating digital models of manufacturing processes.

- Challenges and best practices in implementing Plant Simulation in various manufacturing sectors.

The session provided participants with valuable insights into the capabilities of Technomatix Plant Simulation and its practical applications in improving manufacturing performance. Mr. Sivasankaran I's presentation highlighted how simulation-based approaches can enhance operational efficiency and reduce costs in modern manufacturing systems.

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Day -5, Session- X, 29/11/2024: Hands on Training in Technomatix

Resource Person:

Mr. Sivasankaran I,

Tamilnadu Smart and Advanced Manufacturing Centre, A Joint Initiative & the Government of Tamil Nadu and Siemens Industry Software India, Pvt. Ltd.

The 5th day, Session-X started with a warm welcome by Dr. L. Chitra, HoD/EEE, and an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Mr. Sivasankaran I, Tamilnadu Smart and Advanced Manufacturing Centre, a joint initiative of the Government of Tamil Nadu and Siemens Industry Software India Pvt. Ltd.

Mr. Sivasankaran I led an engaging hands-on training session focused on the practical application of Technomatix Plant Simulation software. The session covered the following key aspects:

- Introduction to the Technomatix software interface and basic functionalities.

- Step-by-step guide to creating digital models of manufacturing processes using Technomatix.

- Techniques for simulating material flow, resource allocation, and production line performance.

- How to conduct layout planning and optimize manufacturing systems using simulation models.

- Real-time adjustments and optimizations in simulated environments for enhanced decision-making.

- Best practices for building models that accurately reflect real-world manufacturing systems.

- Troubleshooting common challenges in simulation-based optimization and analysis.

- Hands-on exercises where participants applied their learning to create and simulate basic manufacturing scenarios.

The session provided participants with the opportunity to gain practical experience in using Technomatix Plant Simulation. Mr. Sivasankaran I's expert guidance allowed attendees to explore the powerful capabilities of the software, reinforcing the value of digital simulation in modern manufacturing processes.

Day -5, Session- XI, 29/11/2024: Hands on Training in Technomatix Plant Simulation

Resource Person:

Mr. Vignesh SA

Tamilnadu Smart and Advanced Manufacturing Centre, A Joint Initiative & the Government of Tamil Nadu and Siemens Industry Software India, Pvt. Ltd.

The 5th day, Session-XI began with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Mr. Vignesh SA, Tamilnadu Smart and Advanced Manufacturing Centre, a joint initiative of the Government of Tamil Nadu and Siemens Industry Software India Pvt. Ltd.

Mr. Vignesh SA led an interactive hands-on training session focused on advanced features of Technomatix Plant Simulation software. The session covered the following topics:

- A brief recap of the core concepts and tools in Technomatix Plant Simulation.

- Hands-on exercises focusing on creating and simulating more complex manufacturing systems.

- Techniques for optimizing resource utilization, production lines, and logistics using simulation models.

- Advanced features such as scenario analysis, throughput optimization, and batch process simulations.

- How to simulate different production scenarios and analyze system performance under various conditions.

- Methods to visualize manufacturing process improvements and identify bottlenecks through simulation.

- Real-time data integration for dynamic simulation and decision-making.

- Troubleshooting and resolving simulation issues to improve the accuracy of results.

The session provided participants with practical experience in leveraging Technomatix Plant Simulation for advanced manufacturing applications. Mr. Vignesh SA's guidance allowed participants to deepen their understanding of how to effectively use the software for simulating, analyzing, and optimizing real-world manufacturing processes. The hands-on approach gave participants confidence in applying these skills to optimize their own manufacturing systems.

Day -6, Session- XII, 30/11/2024: Exploring the impact of AI on Manufacturing Challenges

Resource Person:

Mr. C.S. Sivakumaar,

Vice President - Generator Business,

Siemens Gamesa Renewable Power Private Limited

The 6th day, Session-XII began with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session

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was Mr. C.S. Sivakumaar, Vice President - Generator Business, Siemens Gamesa Renewable Power Private Limited.

Mr. C.S. Sivakumaar delivered an insightful session on the following key topics:

- Overview of Artificial Intelligence (AI) and its transformative role in the manufacturing sector.

- How AI-driven technologies are addressing common manufacturing challenges such as production inefficiencies, downtime, and resource optimization.

- Applications of AI in predictive maintenance, process automation, and quality control in manufacturing.

- The integration of AI with IoT (Internet of Things) and machine learning for real-time data analysis and decision-making.

- Case studies demonstrating successful implementations of AI technologies in manufacturing plants, particularly in energy and renewable sectors.

- AI's role in enhancing supply chain management, reducing operational costs, and improving product quality.

- Challenges in implementing AI solutions in manufacturing environments, including data quality, integration issues, and workforce adaptation.

- Future directions for AI in manufacturing: trends in autonomous systems, digital twins, and advanced analytics.

The session provided participants with a deep understanding of the potential and challenges of integrating AI into manufacturing processes. Mr. Sivakumaar's expertise and real-world examples helped highlight the significant benefits AI can bring to the manufacturing industry, such as increased efficiency, improved product quality, and enhanced decision-making capabilities.

Day -6, Session- XIII, 30/11/2024: Industry 5.0 : Human centric Approach

Resource Person:

Dr. Dnyaneshwar S. Mantri,

Professor, Department of E&TC, SIT, Lonavala,

Sinhgad Institute of Technology.

The 6th day, Session-XIII began with a warm welcome by Dr. L. Chitra, HoD/EEE, followed by an introduction of the guest by Mrs. Vanitha, AP (Gr-II)/EEE. The resource person for this session was Dr. Dnyaneshwar S. Mantri, Professor, Department of E&TC, SIT, Lonavala, Sinhgad Institute of Technology.

Dr. Dnyaneshwar S. Mantri conducted a thought-provoking session on the following key topics:

- Introduction to Industry 5.0 and its key principles, with a focus on the human-centric approach.

- Comparison of Industry 5.0 with Industry 4.0: Transitioning from automation-driven systems to systems that prioritize human involvement and collaboration.

- The role of advanced technologies such as robotics, AI, IoT, and big data in empowering human workers within Industry 5.0 frameworks.

- How Industry 5.0 aims to balance the strengths of automation with the creativity, flexibility, and emotional intelligence of human workers.

- Case studies highlighting the successful implementation of human-centric approaches in modern industries.

- Ethical considerations in Industry 5.0, including the impact on job roles, worker well-being, and the evolution of work environments.

- The role of collaborative robots (cobots) and AI assistants in augmenting human decision-making and productivity.

- Future trends in Industry 5.0 and how it will shape the future workforce, particularly in manufacturing, healthcare, and service sectors.

The session provided a comprehensive understanding of Industry 5.0 and how it is redefining the interaction between humans and machines in industrial settings. Dr. Mantri's expertise and engaging discussion offered valuable insights into how technology can be used to enhance human potential, ensuring that workers remain central to innovation and production processes.

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Day -7, Session- XIV, 02/12/2024: DCS and IIOT for Smart Manufacturing

Resource Person:

Dr. L. Chitra,

Professor & Head, EEE, AVIT

The 6th day, Session-XIV commenced with a warm welcome by Mrs. Vanitha, AP (Gr-II)/EEE, followed by an introduction of the guest, Dr. L. Chitra, Professor & Head, EEE, AVIT, who was the resource person for the session.

Dr. L. Chitra delivered an insightful session, covering the following key points:

- The role of Distributed Control Systems (DCS) in smart manufacturing and its capability to automate complex industrial processes.

- How DCS has evolved into a flexible and scalable platform capable of integrating modern technologies for optimized production environments.

- The integration of Industrial Internet of Things (IIoT) with DCS to enable real-time monitoring, data collection, and actionable insights for smarter decision-making in manufacturing.

- Benefits of combining DCS with IIoT, such as predictive maintenance, process optimization, and enhanced operational efficiency.

- Case studies demonstrating the successful implementation of DCS and IIoT in industries like automotive, energy, and food manufacturing, highlighting improvements in productivity and cost-effectiveness.

- The challenges faced in implementing DCS and IIoT, including issues related to cybersecurity, system integration, and the need for skilled personnel.

- Future trends in DCS and IIoT, including advancements in AI, machine learning, and data analytics that will further enhance smart manufacturing capabilities.

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Dr. L. Chitra's session provided a comprehensive understanding of how DCS and IIoT are transforming the manufacturing sector, enabling more intelligent, efficient, and connected systems. The discussion emphasized the future potential of these technologies in shaping the next generation of manufacturing processes.

Article summary

The following papers were selected for Article discussion and summary.

1. Ahmad, H. M., & Rahimi, A. (2022). Deep learning methods for object detection in smart manufacturing: A survey. Journal of Manufacturing Systems, 64, 181-196. https://doi.org/10.1016/j.jmsy.2022.06.011
2. Feng, Q., Zhang, Y., Sun, B., Guo, X., Fan, D., Ren, Y., Song, Y., & Wang, Z. (2023). Multi-level predictive maintenance of smart manufacturing systems driven by digital twin: A matheuristics approach. Journal of Manufacturing Systems, 68, 443-454. https://doi.org/10.1016/j.jmsy.2023.05.004
3. Friederich, J., Francis, D. P., Lazarova-Molnar, S., & Mohamed, N. (2022). A framework for data-driven digital twins of smart manufacturing systems. Computers in Industry, 136, 103586. https://doi.org/10.1016/j.compind.2021.103586

4. Jyeniskhan, N., Keutayeva, A., Kazbek, G., Ali, M. H., & Shehab, E. (2023). Integrating machine learning model and digital twin system for additive manufacturing. IEEE Access, 11, 71113-71126. https://doi.org/10.1109/access.2023.3294486

5. Leng, J., Zhu, X., Huang, Z., Xu, K., Liu, Z., Liu, Q., & Chen, X. (2023). ManuChain II: Blockchained smart contract system as the digital twin of decentralized autonomous manufacturing toward resilience in industry 5.0. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 53(8), 4715-4728. https://doi.org/10.1109/tsmc.2023.3257172

6. Ma, S., Ding, W., Liu, Y., Ren, S., & Yang, H. (2022). Digital twin and big data-driven sustainable smart manufacturing based on information management systems for energy-intensive industries. Applied Energy, 326, 119986. https://doi.org/10.1016/j.apenergy.2022.119986

7. Qamsane, Y., Moyne, J., Toothman, M., Kovalenko, I., Balta, E. C., Faris, J., Tilbury, D. M., & Barton, K. (2021). A methodology to develop and implement digital twin solutions for manufacturing systems. IEEE Access, 9, 44247-44265. https://doi.org/10.1109/access.2021.3065971

8. Su, C., Han, Y., Tang, X., Jiang, Q., Wang, T., & He, Q. (2024). Knowledge-based digital twin system: Using a knowlege-driven approach for manufacturing process modeling. Computers in Industry, 159-160, 104101. https://doi.org/10.1016/j.compind.2024.104101

As part of the **ATAL Academy Sponsored Two Weeks Advanced Faculty Development Programme (FDP)** on "Digital Twin for Smart Manufacturing: Applications and its Challenges," the participants were given an opportunity to present summaries of articles they had researched and analyzed throughout the course. These article presentations were aimed at reinforcing the concepts learned during the FDP and encouraging participants to engage deeply with current trends and challenges in digital twin technology and smart manufacturing.

Day -7, Session- XV, 02/12/2024: Digital Twin for Smart Manufacturing

Resource Person: Dr.Vijayarajeswaran R, Managing Director, VI Micro Systems Pvt. Ltd.

Chennai

Department of Electrical and Electronics Engineering

The 7th day, Session-XV began with a warm welcome by Mrs. Vanitha, AP (Gr-II)/EEE, followed by an introduction of the guest, Dr. Vijayarajeswaran R, Managing Director, VI Micro Systems Pvt. Ltd., Chennai, who was the resource person for this session.

Dr. Vijayarajeswaran R conducted an engaging session on the following key points:

- The concept of Digital Twin and its significance in the context of smart manufacturing.

- How Digital Twin technology creates virtual replicas of physical assets and processes to simulate and optimize real-time operations.

- The benefits of using Digital Twin for predictive maintenance, performance monitoring, and process optimization in manufacturing systems.

- How Digital Twin integrates with IIoT, AI, and data analytics to create intelligent manufacturing environments that adapt to changing conditions.

- Case studies highlighting the successful application of Digital Twin technology in industries such as automotive, aerospace, and energy.

- The role of Digital Twin in improving product design, testing, and quality control by providing a comprehensive view of manufacturing systems.

- Challenges in implementing Digital Twin technology, including data integration, system compatibility, and resource allocation.

- Future trends in Digital Twin technology and its evolving role in advancing Industry 4.0 and smart manufacturing systems.

Dr. Vijayarajeswaran R's session provided valuable insights into how Digital Twin technology is revolutionizing smart manufacturing by enabling more efficient, data-driven, and adaptive manufacturing processes. The session showcased how virtual models of physical systems can be used to improve operational performance and innovation in industries.

Day -7, Session- XVI, 02/12/2024: Digital Twin for Smart Manufacturing

Resource Person:

Dr. K. Govardhan K,

Associate Professor Sr.,

Vellore Institute of Technology, Vellore.

The 7th day, Session-XVI commenced with a warm welcome by Mrs. Vanitha, AP (Gr-II)/EEE, followed by an introduction of the guest, Dr. K. Govardhan K, Associate Professor Sr., Vellore Institute of Technology, Vellore, who was the resource person for this session.

Dr. K. Govardhan K led a detailed session covering the following key points:

- An in-depth explanation of Digital Twin technology and its pivotal role in smart manufacturing environments.

- The creation of virtual replicas of physical manufacturing systems to monitor, analyze, and optimize operations in real-time.

- How Digital Twin technology helps in enhancing predictive maintenance, reducing downtime, and improving process efficiency in manufacturing systems.

- The integration of Digital Twin with IIoT, AI, and machine learning to build smart factories that can self-optimize and adapt to real-time changes in production.

- Case studies from various industries, including automotive, electronics, and consumer goods, showcasing successful implementations of Digital Twin technology.

- The significance of Digital Twin in accelerating product development, improving quality assurance, and enabling better decision-making through data-driven insights.

- Challenges in implementing Digital Twin solutions, such as data synchronization, system compatibility, and scalability across different manufacturing processes.

- Emerging trends and the future of Digital Twin technology in the context of Industry 4.0, highlighting its potential to revolutionize manufacturing, supply chains, and operational models.

Dr. K. Govardhan K's session provided participants with a thorough understanding of how Digital Twin is reshaping the future of manufacturing by allowing industries to simulate, optimize, and predict the behavior of manufacturing processes. The session emphasized the technology's role in improving efficiency, reducing costs, and fostering innovation in smart manufacturing systems.

Day-8 (03/12/2024)

The industrial training at Tamilnadu Smart and Advanced Manufacturing Centre (TANSAM), TIDEL PARK, Chennai, commenced with a detailed introduction to the center and its training programs. Mr. A. Parthiban, a representative from TANSAM, elaborated on the various software available at the center and their applications in smart manufacturing. He also discussed how TANSAM is helping improve the employability of candidates through its various schemes. The session continued with an introduction to TECNOMATIX PLANT SIMULATION, highlighting the software's key features and its importance in optimizing manufacturing processes. Participants gained a fundamental understanding of the software and its potential applications.

- Exercise 1: Designing a simple plant layout focusing on space optimization and logical workflow.

- Exercise 2: Integrating manpower resources into the plant layout to improve efficiency.

Day-9 (04/12/2024): Introduction to TECNOMATIX PLANT SIMULATION Software

The session continued with Mr. R. Ganesh Kumar, who provided an in-depth training on TECNOMATIX PLANT SIMULATION SOFTWARE. He demonstrated various use cases and examples, ensuring that participants understood the software's capabilities for simulating production systems. The session focused on the creation of virtual models of factories and assembly lines, offering participants practical experience in designing production layouts. Mr. Ganesh Kumar also introduced concepts of performance analysis and how TECNOMATIX helps identify and address potential inefficiencies in manufacturing systems.

- Exercise 1: Implementing a Pick and Place Robot for sorting parts based on acceptance and rejection percentages.

- Exercise 2: Working with multiple human resources, creating work pools, and integrating them into the plant layout.

Day-10 Report (05/12/2024): Hands-on Exercises with TECNOMATIX Plant Simulation

On the third day, participants engaged in hands-on exercises with TECNOMATIX PLANT SIMULATION to gain practical experience. The exercises included:

- Exercise 1: Integration of an assembly station with containers, and understanding product orientation in containers.

- Exercise 2: Implementing AGVs (Automated Guided Vehicles) for transportation across the plant, integrated with pick-and-place robots.

These exercises provided participants with the practical skills needed to optimize production processes using the simulation software.

Day-11 (06/12/2024): Advanced Exercises and Key Takeaways

The final day of the training focused on advanced exercises and applications of TECNOMATIX PLANT SIMULATION.

- Exercise 3: Part Painting with Exchangeable Graphics, allowing participants to modify 3D structures of components.

- Exercise 4: Integration of individual models into a complete plant layout.

- Exercise 5: Constructing a simple plant layout with roof, entry/exit points, and other structural specifications.

- Exercise 6: Designing a Gantry Loader system for handling parts across four stations, highlighting its impact on workflow efficiency.

The training concluded with a discussion on key takeaways, including discrete event simulation, model building, data integration, performance analysis, and the application of advanced features such as scripting and object-oriented modeling. Participants left the training with a solid understanding of how to use TECNOMATIX to simulate and optimize manufacturing systems for improved operational efficiency.
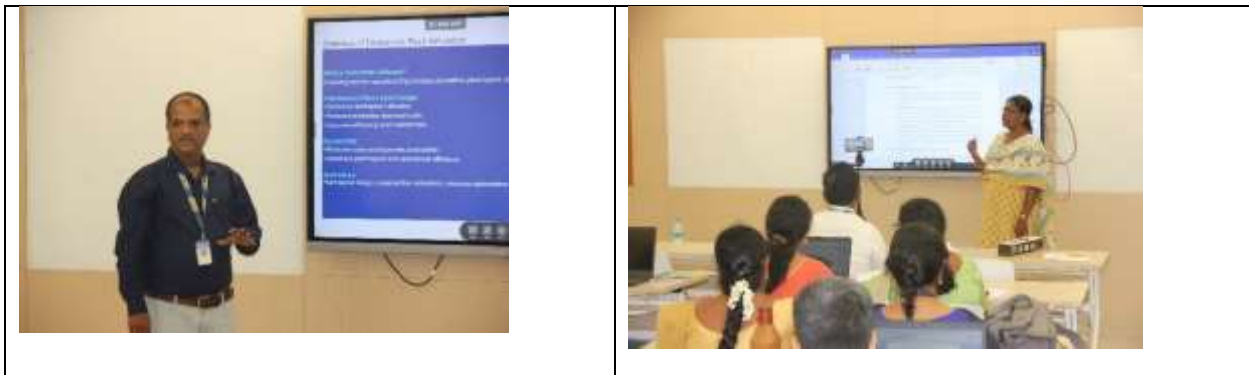
Day 12: Team wise presentation of the output

As part of the ATAL Academy Sponsored Two Weeks Advanced Faculty Development Programme (FDP) on "Digital Twin for Smart Manufacturing: Applications and its Challenges," participants attended a four-day industrial training at Tamilnadu Smart and Advanced Manufacturing Centre (TANSAM), TIDEL Park, Chennai, from 03/12/2024 to 06/12/2024.

To conclude the training, participants were divided into teams to present their collective learning outcomes. The team-wise presentations provided an opportunity for participants to demonstrate their understanding of the topics covered and their ability to apply the concepts in real-world scenarios.

Day 12: Reflection Journal

Participants of the **ATAL Academy Sponsored Two Weeks Advanced Faculty Development Programme (FDP)** on "Digital Twin for Smart Manufacturing: Applications and its Challenges" maintained reflection journals to document their learning, insights, and practical applications throughout the program. The journals captured key takeaways from sessions on **Digital Twin**, **Industry 4.0 and 5.0**, **IoT integration**, and hands-on training with **TECNOMATIX Plant Simulation**, highlighting the practical relevance of these technologies in areas like **process automation**, **energy optimization**, and **supply chain management**. Participants detailed their plans to apply these concepts in teaching, research, and industry collaborations while also reflecting on challenges such as initial difficulties in using simulation tools and adapting digital twin technologies in traditional manufacturing

systems. The journals underscored how hands-on exercises enhanced understanding and confidence, enabling participants to explore innovative solutions to real-world manufacturing challenges.

Valedictory Function

The Valedictory Function of the ATAL Academy Sponsored Two Weeks Advanced Faculty Development Programme (FDP) on "Digital Twin for Smart Manufacturing: Applications and its Challenges" was held with enthusiasm and gratitude.

The event began with an introduction to the Chief Guest, Mr. C.S. Sivakumaar, Vice President - Generator Business, Siemens Gamesa Renewable Power Private Limited, delivered by Dr. L. Chitra, Coordinator. Mr. Sivakumaar shared a compelling valedictory address, emphasizing the transformative potential of digital twin technologies and their role in shaping the future of smart manufacturing. He lauded the participants for their dedication and encouraged them to apply the knowledge gained during the FDP to address industrial challenges and drive innovation.

Dr. G. Selvakumar, Principal of AVIT, extended his best wishes to the participants in his valedictory address, congratulating them for their active engagement and highlighting the significance of bridging academia and industry through such programs.

The event concluded with a heartfelt vote of thanks by Dr. K. R. Devabalaji, Co-Coordinator, who expressed gratitude to the Chief Guest, resource persons, organizing team, and participants for making the FDP a success. He acknowledged the contributions of ATAL Academy and AVIT in facilitating this advanced learning experience. The program ended on a positive note, with participants expressing their appreciation for the enriching sessions and hands-on training.

Dr. L. Chitra

Convener