Functionality of Digital Twin in Shopfloor Employees Training with AI and ML Technologies

Chandra Mohini C.P *[1], and V. Raghavendran[2]

[1] Research Scholar, Department of Computer Science, VISTAS, Chennai,
[2]Assistant Professor Department of Computer Science, VISTAS, Chennai.

mohinisuryan@gmail.com

Abstract. The Digital Twin Technology is one of the fascinating innovations that shape the future. Digital Twin is an exact clone of a physical product, it replicates, not just the physical object but also its behavior and its entire life cycle. Digital Twin can be considered as a combined version of emerging technologies such as artificial intelligence (AI), Machine Learning (ML), Internet of Things (IoT), and Data Analytics. Digital twin technologies can be used as a training aid for shopfloor employees and their skill development. This research focuses on how to design and develop training programs to elevate employees' skills for workforce development using digital twins of various machinery and equipment**.** Machine learning can be considered as a subset of Artificial Intelligence that allows computers to learn from data and experiences without special programming. Intelligent systems that are capable of handling difficult tasks can be developed using machine learning. Three primary categories of machine learning exist: reinforcement learning, unsupervised learning, and supervised learning.

Keywords: Digital Twin, Learning & Development, Adult Learning, Corporate Learning, Advanced Learning Technologies, Intelligent System, AI, Technology, Predictive Analytics, Manufacturing, Data Analytics, Decision Making, Research Opportunities, Shopfloor Employees, Training, Education, Skill Development.

1. INTRODUCTION

Digital Twin is a technique of representing a physical body or a process, where a physical entity is reproduced into a digitally simulated body. The twin body is a dynamic up-to-date digital replica of its original version.By integrating and visualizing data from around the world, this concept helps to make better decisions. With Digital Twins, Plans can be simulated before being implemented, exposing problems before they become a reality. Digital twin technology has the power to revolutionize employee training and skill development in different fields. By creating a virtual replica of the production line or manufacturing process, employees can gain

N. V. Suresh and P. S. Buvaneswari (eds.), *Proceedings of the International Conference on Digital Transformation in Business: Navigating the New Frontiers Beyond Boundaries (DTBNNF 2024)*, Advances in Economics, Business and Management Research 283,
https://doi.org/10.2991/978-94-6463-433-4_35

hands-on experience with the equipment and processes in a safe and controlled environment

Machine learning is more focused on the self-learning algorithm that derives knowledge from the data to predict outcomes. It can be defined as tools and technology that can be used to answer questions with the data we provide. Robots, self-driving vehicles, chatbots, and other intelligent systems are examples of systems that possess the ability to see, reason, learn, and act in complex and unpredictable settings. Intelligent systems require machine learning to be able to adapt to changing conditions and gradually enhance their performance. By utilizing existing datasets, Machines learn from previous experiences autonomously and construct models that are suitable for predicting future behavior.

2. Literature Review

In Digital twin as an enabler for an innovative digital shopfloor management system in the ESB Logistics Learning Factory at Reutlingen – University in the year 2017 by Beate Brenner, Vera Hummel provided detailed information on creating an exact digital replica of a shopfloor that integrates standardized languages to reduce complexity. At Reutlingen University research was conducted on creating an intelligent shopfloor management system and all the findings are stored in a cloud-based 3D experience platform and have created a seamless model.The paper from Marco Furini, Ombretta Gaggi, Silvia Mirri, Manuela Montangero, Elvira Pelle, Francesco Poggi, Catia Prandi Communications of the ACM, Digital Twins and Artificial Intelligence as Pillars of Personalized Learning Models in the year April 2022 aims to address the need of change in the educational sector. Authors address the importance of AI and the Digital twin in revolutionizing the education sector. They emphasize personalized learning so that students can progress at their own pace and drastically reduce the number of dropout rates.Susan Fourtané, in her article Future of Higher Ed: Digital Twin Technology on the Horizon, Jan 2022 provides a comprehensive overview of applications of Digital twin technology in various fields. The article addresses the need to integrate digital twin technology. The article Machine Learning Towards Intelligent Systems: Applications by Mohammad Noor Injadat, Abdallah Moubayed, Ali Bou Nassif, Abdallah Sham focus on large datasets and the ability of humans to process those, applications, opportunities, and the impact of Machine learning.

3. Shopfloor Employees and Digital Twin

Shopfloor employees are those who work in production areas. Shopfloor and the activities in it are essential for every manufacturing company. Shop floor management can be found in all manufacturing companies, and it plays an important role in ensuring competitiveness. Digital Twin is built with the help of real time data sent from sensors. Predictive analysis can forecast outcomes and can make decisions based on it. This way it helps shopfloor employees to test and better understand the product or process in the early stages by minimizing downtime thereby reducing the costs.

There is a constant update between the real one and the virtual entity, here the data is flowing constantly back and forth. Digital Twin training helps to simulate real-world activities, that allows learners to practice and develop skills in a safe, controlled testing environment which helps to improve learning outcomes and reduce the dangers associated with the training on tangible assets. Digital twin technology integrates AI Software analytics and machine learning data to create an up to date digital simulation model.

Following are some of the key applications of Digital Twin:

- Helps to predict setup and material requirements.
- Machine learning algorithms help to analyze historical data to predict future demands more precisely.
- Optimize resource allocation, predict downtime, anticipate bottlenecks, and ensure a smooth workflow.

It also helps in simulating and validating the production process in the 3D environment, reducing the need for physical prototypes.

Digital twin Technology coupled with Machine Learning mainly involves 7 steps:

- Data Gathering
- Data Preparation
- Data Wrangling
- Data Analysis
- Training
- Testing
- Deployment

One of the fundamental components of machine learning is the "model", which is a mathematical representation of the problem and the solution. To create a model, we need to provide it with "training", which is a set of examples that show the desired input-output relationship. However, data is required to train a model, therefore the life cycle begins with data collection. By training the model, we can improve its accuracy

and performance on new data. Data Preparation is a process where we use the collected data and use it for our machine learning training.

This step includes two steps:

Data exploration is used to understand the raw data and Data preprocessing to preprocess the analyzed data.

Data wrangling is the process of collecting, cleaning and converting the raw data into an understandable format. Data Analysis helps to build a model using various analytical techniques. Then build the model with the prepared data and evaluate the model. Next is to train the model where datasets are used along with various machine learning algorithms. Once training is done, we will validate the model using a test dataset. The final step is the deployment where we deploy the developed model in the existing production environment.

4. How Digital Twin Leverage Training Effectiveness

Digital Twins can provide more interactive and engaging training sessions when compared to the traditional methods. Trainers can interact with the learners more effectively and receive immediate feedback on the performances which allows to develop the skills more effectively. This reduces the risks associated with training with physical assets.

To further enhance the impact of training using Digital Twin consider the following steps.

- Investment is needed in the Digital Twin simulations to get accurate results.
- Ensure that it can be integrated with other training programs so that we can provide a comprehensive learning experience.
- Regular check for the technology
- Use effective learning analytics methodologies.

4.1 Learning Data Analytics

Learning from Data: This is focused on creating systems that can learn and improve from their own experience.
Adaptable and Generalizable System: The key strength of Machine learning is its ability to make predictions on new unseen data which is crucial for intelligent systems to perform well in diverse and dynamic environments.
Natural Language Processing (NLP): Field of AI that helps machines to understand human language.
Computer Vision: Machine learning approaches are employed in various computer vision domains, including image recognition and segmentation for objects. These

capabilities enable intelligent systems to interpret visual data from the environment.
Neural Networks and Deep Learning: Neural networks are computational models that mimic the structure and function of biological neurons, while deep learning is a technique that uses multiple layers of neural neurons which each layer learning to extract different features and patterns from the data.
Continuous Improvement: As machine learning-based intelligent systems are exposed to more and more data over time, their performance can improve significantly. Intelligent systems are distinguished by their ability to adapt and learn.

5. Skill-based Learning Approach

Studies show that a skill-based learning approach is more effective than traditional training methods. The learning is focused on individual skill development. By this, students or learners will experience what to do with the knowledge they acquired thereby leveling the skills that students need. Through this model, each learner is given an equal opportunity to master the necessary skills and become successful. Instead of focusing on grades this method of learning is focusing on how competent each learner is in the subject. Here each learner has different methods of learning, but they reach the same end goal. All are taught and supported based on their personal strengths and weakness, giving everyone the same chances for success. This method helps to achieve mastery on a topic Many schools have already adopted a competency-based education system. E.g.: Latins school of Chicago, Henrico County Public Schools, Virginia.

With skill development training we are creating an employable workforce for industry. Most of the skills that exist in today's workforce will soon become irrelevant. So upskilling, reskilling and cross-skilling are essential in an industry, thereby closing the skill gap. AI helps to identify skills gaps and future jobs. All training modules aim to increase organizations' productivity and return on investment. Evaluating the training effectiveness should be a continuous process and it will help us to understand the learning curve and can act accordingly.

The recommended model of Skill based Competency development model focuses on 3 major tenets. Refer to Fig. 1:

- Job Description and Functional Roles
- Job Roles and Competencies
- Skill Development with Role-based competency.
- Remedial Learning

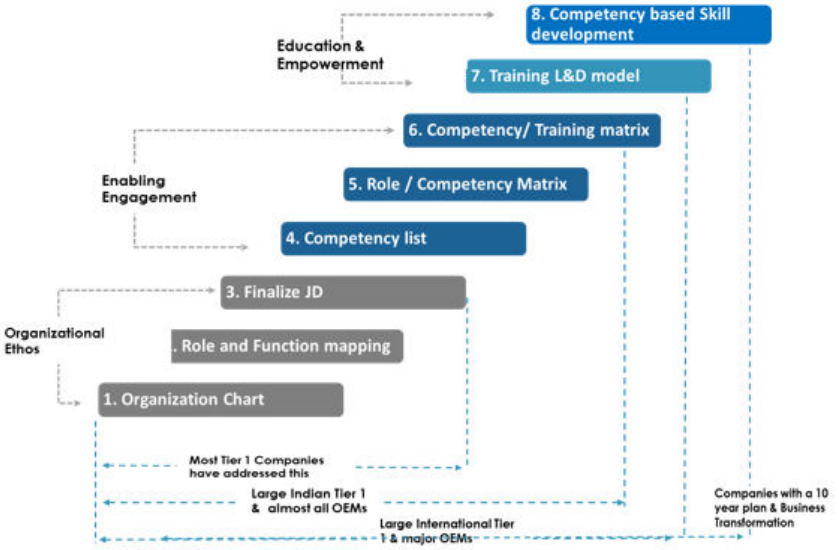

Fig 1. Recommended Model

Creating a training plan and implementing the plan in the workforce is very important to achieve the goal of the training program. Fig 2, 3, and 4 shows the steps for implementing Digital Twins for Personalized education and training and also analysis and outcome

Fig: 2 Learning Steps

Fig 3. Training plan vs actual

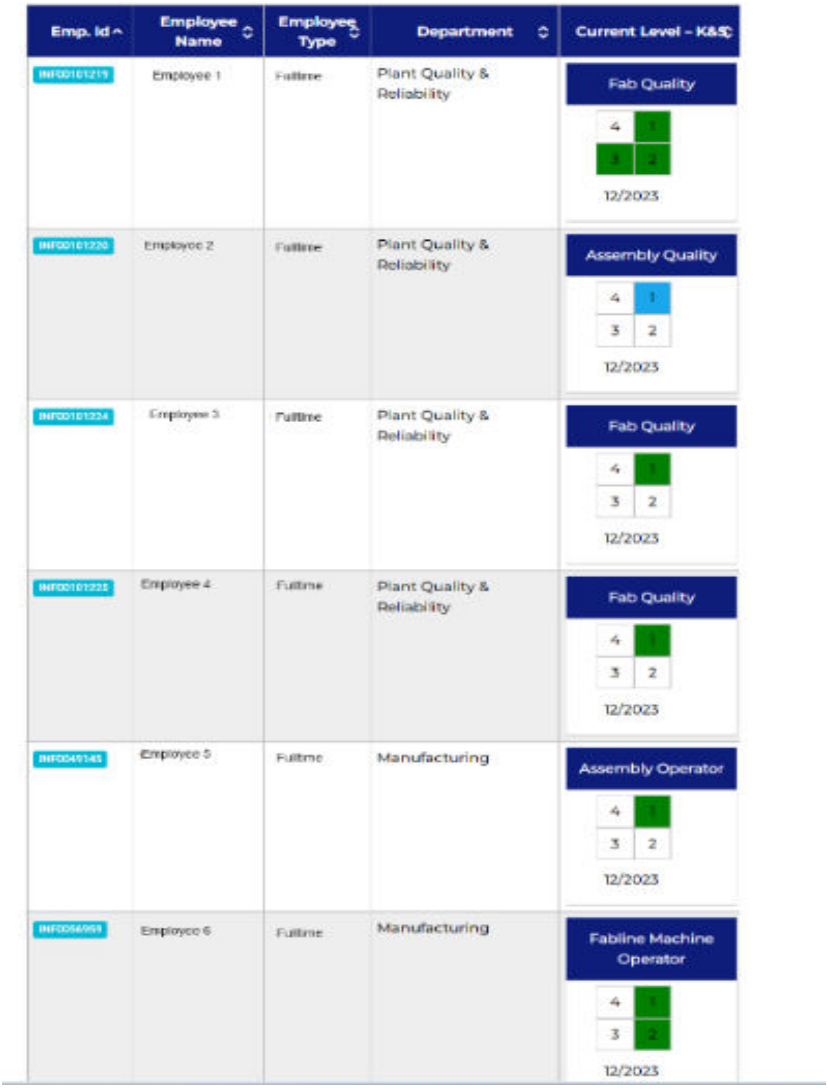

Fig 4: Training Analysis Report

6. ML Learning Programs and Types

Machine Learning models can predict more about the future and derive insights from data or both. Data storage, abstraction, generalization, and evaluation are four components of the learning process, whether it is done by humans or machines. See Fig. 5

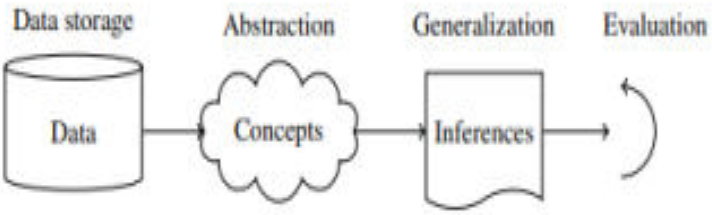

Fig.5. Components of the learning process.

1. Data Storage: Storing the data and retrieving huge amounts of data is a very key component of the learning process. Whether it is a Human or computer data storage is a foundation for advanced reasoning. The learning process is the same in both cases.
2. Abstraction: The process of obtaining information regarding stored data is called abstraction. Developing broad notions about the data is required for this. Training is the process of adjusting a model to fit in a dataset. Once the model is trained, the data is converted into an abstract form that condenses the original information.
3. Generalization: Here the stored data is transformed into a format that can be used for future actions is known as generalization. Finding the aspects of the data that will be most useful for the next tasks is the aim of generalization.
4. Evaluation: Evaluation is the process of gauging the usefulness of newly acquired knowledge that involves providing the user with feedback. The entire learning process is then improved by using this input.

ML has been applied to various domains and problems ranging from social media to education. The chart below shows the projected market size by region and application for the year 2028. After the spread of the COVID-19 virus, the market for application development software was estimated to be worth USD 131.4 billion globally in 2020, and between 2021 and 2028, it is expected to expand at a compound annual growth rate (CAGR) of 24.3% as in Fig 6

.

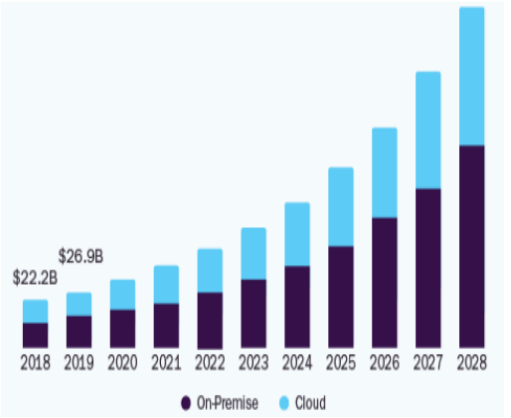

Fig 6. Market growth

Intelligent systems in machine learning can be mainly classified into three categories: Fig 7 shows a detailed categorization of Machine Learning.

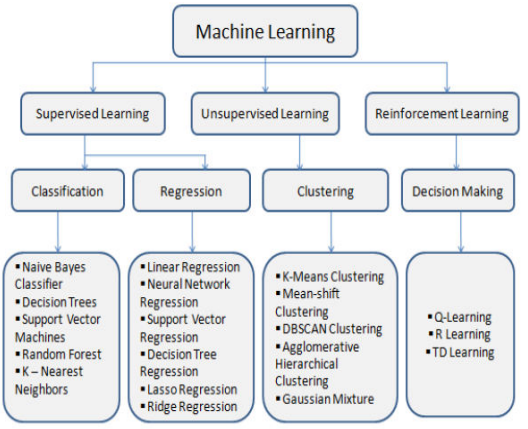

Fig 7. Machine Learning Categorization

7. Applications of ML Towards Intelligent Systems

Some characteristics of Intelligent systems are:

-They can adapt to changing environments and situations.

- They can interact with other systems and humans in natural and intuitive ways.

- They can process massive data and information from multiple sources and modalities. - Intelligent systems can help users make better decisions by providing recommendations, alternatives, feedback, etc.
- They can exhibit creativity and innovation in generating solutions and outcomes.
- Intelligent systems can understand and communicate in natural languages
- Intelligent systems can recognize and analyze images, such as faces, objects, scenes, etc.
- They can self-monitor and self-improve their performance and behavior.
- Intelligent systems can improve their performance and reduce errors by analyzing its own actions and outcomes.
- They can also perform tasks that need human intelligence like reasoning, planning, creativity, etc.

The increasing need for a range of software applications that leverage contemporary IoT technologies and cloud-based solutions to accelerate and simplify business processes is expected to fuel market development throughout the projected period.

8. Conclusion

Implementation of Digital Twins in training shopfloor employees along with emerging technologies creates a highly effective and immersive learning environment. Machine learning is not a magic bullet that can solve any problem automatically. It requires careful design, implementation, testing, and evaluation of the system, as well as human feedback and supervision. Machine learning and Artificial Intelligence with Digital Twin is a powerful tool that can augment our capabilities and intelligence, but it cannot replace them. Machine learning technology serves as a foundation that supports the development of intelligent systems by providing the ability make decisions in complex and dynamic environments based on the data collected. The synergy between machine learning and intelligent systems is the fundamental requirement for the development of artificial intelligence applications in various fields. It significantly enhances the learning curve, reduces training costs, and improves overall efficiency. By leveraging digital twin technology for shopfloor employee training, organizations can create a dynamic, engaging, and effective learning environment that enhances skills, promotes safety, and adapts to the evolving needs of the workforce.

Acknowledgements:

I am immensely grateful to my research supervisor Dr. V. Raghavendran, Assistant Professor, Department of Computer Science, VISTAS, Chennai for granting me a

chance to conduct research and for his invaluable guidance. He has taught me the necessary methodologies to carry out the research and helped me to present the research works as clearly as possible. It has been a great privilege and honor to have an opportunity to work and study under his guidance.

References

1. Zixin Tao & Guangtao Xu. Digital Twin Technology in the Field of Education—Take the Management of the HTC Vive as An Example, 12 August 2022
2. Witold Kinsner. Digital Twins for Personalized Education and Lifelong Learning September 2021.
3. Catherine, S., Rani, M. N., & Suresh, N. V. (2024). The Metaverse Economy: Transforming Money With Digital Currency. In Creator's Economy in Metaverse Platforms: Empowering Stakeholders Through Omnichannel Approach (pp. 202-209). IGI Global.
4. Audrey Azoulay, Towards an Ethics of Artificial Intelligence, December **2018**
5. ResearchAndMarkets.com, Digital Twins Global Market 2022-2027: By Technology, Twinning Type, Cyber-to-Physical Solutions, Use Cases and Applications - ResearchAndMarkets.com, March 17, 2022
6. Ziqi Huang ,Yang Shen, Jiayi Li ,Marcel Fey and Christian Brecher, A Survey on AI-Driven Digital Twins in Industry 4.0: Smart Manufacturing and Advanced Robotics, 23 September 2021
7. Abdlkarim Alsaleh, Kristina Eriksson, Shervin Behzad Far, David Stjern, Applying Digital Twin Technology in Higher Education: An Automation Line Case Study, April 2022
8. Lu Lian, Yao Yan, Digital Visual Sensing Design Teaching Using Digital Twins, 18 Jan 2022
9. Zhihan Lv, Shuxuan Xie, Artificial intelligence in the digital twins: State of the art, challenges, and future research topics, 24 Dec 2021
10. DavidJones, ChrisSnider, AydinNassehi,JasonYon, BenHicks , Characterising the Digital Twin: A systematic literature review, May 2020.
11. Anish Devasia, Digital Twinning: Leaders in the Emerging Technology, August 2020
12. Marco Furini, Ombretta Gaggi, Silvia Mirri, Manuela Montangero, Elvira Pelle, Francesco Poggi, Catia Prandi Communications of the ACM, Digital Twins and Artificial Intelligence as Pillars of Personalized Learning Models, April 2022
13. Susan Fourtané, Future of Higher Ed: Digital Twin Technology on the Horizon, Jan 2022.
14. Wu Chunlonga, Zhou Youchenga, Marcus Vinicius Pereia Pessôad , Qingjin Penge , Tan Runhua, Conceptual digital twin modeling based on an integrated five-dimensional framework and TRIZ function model July 2020.
15. Cem Dilmegani. What is Federated Learning? Techniques, Use Cases & Benefits
16. Ahmed Gad : Introduction to Federated Learning.
17. Thomas Davenport: The potential for artificial intelligence in healthcare
18. Mohammad Noor Injadat, Abdallah Moubayed, Ali Bou Nassif, Abdallah Sham.: Machine Learning Towards Intelligent Systems: Applications.
19. Tamer Eltaras, Wadha Labda , Khawla Alzoubi , Qutaibah Malluhi: Machine Learning for Healthcare Wearable Devices: The Big Picture.
20. elibor Božić: Using digital Twins in Training
21. Beate Brennera*, Vera Hummela: Digital twin as enabler for an innovative digital shopfloor

22. Suresh, N. V., & Rexy, V. A. M. (2024, February). An Empirical Study on Empowering Women through Self Help Groups. In 3rd International Conference on Reinventing Business Practices, Start-ups and Sustainability (ICRBSS 2023) (pp. 957-964). Atlantis Press.
23. Kesima, Yasin Ozarslanb: Augmented reality in education: current technologies and the potential for education
24. Suganya, V., & Suresh, N. V. (2024). Potential Mental and Physical Health Impacts of Spending Extended Periods in the Metaverse: An Analysis. In Creator's Economy in Metaverse Platforms: Empowering Stakeholders Through Omnichannel Approach (pp. 225-232). IGI Global.