iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** V **Month of publication:** May 2022

DOI: https://doi.org/10.22214/ijraset.2022.42604

Digital Twin Technology Transforming Modern Healthcare Industry

Sakshi Parate[1], Aniket Bhivgade[2], Dr. Manisha Bharati[3]
[1]Student at Savitribai Phule Pune University, Department of Technology
[2]Student at, Savitribai Phule Pune University, Department of Technology
[3]Associate Professor at Department of Technology, Savitribai Phule Pune University

Abstract: Digital Twin Technology is an emerging concept that has captured the attention of both industry and academics in recent years. The advancement in industry 4.0 context requires strong and reliable anomaly detection techniques. The Digital Twin is expressed in a variety of ways, but it is best described as the seamless integration of data between a physical and virtual system in any state. Realistic models of complex equipment are now possible because to advances in Digital Twin technology. AI, IoT, and Digital Twins today has huge spectrum for use, and supported by various aiding technologies, although we still have a long way to go. A review of recent studies on Digital Twins is conducted, resulting in a categorical review. The study assesses the enabling technologies, difficulties, and ongoing research in the field of Digital Twins particularly in healthcare domain.

I. INTRODUCTION

In recent years, there has been a growing trend to equip technical machinery with sensors to continuously monitor their functioning, ranging from single machines to entire buildings and manufacturing plants, notably in the context of Industry 4.0 strategies. Digital Twin is at the forefront of the industry 4.0 revolution, which is made possible by powerful data analytics and IoT connectivity. The Internet of Things has boosted the amount of data that can be used in manufacturing, healthcare, and smart city environments. The IoT's rich environment, when combined with data analytics, provides an invaluable resource for predictive maintenance and fault detection, to name a few, as well as the long-term health of manufacturing processes and smart city developments, as well as anomaly detection in patient care, fault detection, and traffic management in a smart city. Through the establishment of a connected physical and virtual twin, the Digital Twin can address the difficulty of seamless integration between IoT and data analytics. Rapid analysis and real-time decisions are possible in the Digital Twin Environment because to reliable analytics. This paper presents an overview of Digital Twin Technology and its applications in healthcare.

This paper uses a range of an academic sources found through keywords related to IoT and data analytics, but with an overall aim of identifying papers relating to Digital Twin.

This Journal consists of five major sections. The number of pages may vary depending upon the topic of research work These are:

1) Abstract
2) Introduction
3) Definition
4) Scope for Digital Twin Technology
5) Challenges
6) Conclusion

II. DEFINITION

A Digital Twin is a virtual representation of a physical thing that is meant to properly mirror it. A wind turbine, for example, is equipped with several sensors that provide data on many elements of the physical object's performance, such as energy output, temperature, weather conditions, and so on. This information is subsequently sent to a processing machine, where it is applied to the digital copy. The Digital twin concept gained recognition in 2002 after challenging advisory has hosted a presentation for Michael Greives in the University of Michigan on Technology. The topic of the talk was the creation of a product Lifecycle Management Center. While the language may have evolved over the years, it had all the recognized features of the digital twin, such as real space, virtual space, and the spreading of data and information flow across real and virtual space. The concept of combining a digital and physical twin into a single entity has remained unchanged since its inception. While digital twin technology is popularly assumed to have been developed in 2002, it has really been in use since the 1960s.

The concept of using a "twin" came from NASA's Apollo mission, which built two identical space vehicles. The "twin" vehicle, which stayed on Earth, was configured to duplicate the state of the spacecraft during the voyage. To support astronauts in crucial situations, models of space spacecraft that remain on Earth during flying missions have been utilized to mimic alternatives, reflecting data on flight conditions. This application demonstrates how virtual simulation can be used to connect actual and virtual locations. A virtual simulation model accurately mimics the limits of physical assets and can be used to extract relevant solutions through virtual simulations. As a result, it is an effective tool for extracting powerful actions for physical assets, and it is more time and cost effective than performing trial and error on a physical asset because problems with physical assets can be solved in advance through trials. Virtual simulation, on the other hand, cannot generate or "twin" because it does not require linking data between the physical and cyber worlds. As a result, virtual simulation cannot be considered Digital Twin.

As previously stated, Michael Grieves initially introduced the notion of DT in a PLM executive course at the University of Michigan in the United States. A Digital Twin Model, according to Greives, consists of three essential pieces.

1) Physical Space containing physical objects.
2) Cyber space containing cyber objects.
3) Link for data and information to flow from physical space to cyber space to synchronize the physical and cyber systems by exchanging data.

Although digital representation was new at the time, technology was inadequate, therefore there was insufficient information to reflect physical things as digital representations. The reason for this is that the data collected during the manufacture of physical products was restricted.

Cloud services, IoT, AI, bigdata, and other new generation information technologies have rapidly evolved in the decade after the introduction of DT, allowing for the collection of data on the manufacturing site, i.e., the physical world. As a result of several research on DT across a variety of fields, it was named in Garther's Top 10 Strategic Technology Trends from 2017 to 2019, demonstrating its prominence as an important technology.

III. SCOPE FOR DIGITAL TWIN TECHNOLOGY

The digital twin's potential is simply incredible. The collaborative and predictive value of digital twins cannot be overstated as the concept and technology grow. Consider industrial chemical reactors as an example. Assume a business has built its digital doppelganger. Assume the reactor is intended to carry out a specific chemical reaction. However, the percentage of chemicals that must be blended was inaccurate due to operator error. The control mechanism of the Digital twin detects the same odd sensor input as breaching the danger threshold.

Aerospace, automotive, heavy machinery, consumer goods and electronics, power and energy, and other industries benefit from digital twins. While digital twins are most commonly associated with manufacturing, they are also being used in fields as diverse as healthcare, supply chain, and even smart cities.

According to projections, the market for digital twins would increase at a rate of more than 30% each year from 2020 to 2025.

The demand for digital twin technology will be fueled by a rise in demand for IoT and Cloud-based platforms, as well as a desire to be globally competitive. India and other countries are already investing in IIoT, and digital twin is another step further.

IV. DIGITAL TWIN TECHNOLOGY IN HEALTHCARE

The healthcare industry is starting to adopt digital twins to improve personalized medicine, healthcare organization performance, and new medicines and devices. Although simulations have been around for a while, medical digital twins are a significant step forward. These digital twins can generate helpful models based on data from wearable devices, omics, and patient records, allowing patients, clinicians, and healthcare organizations, as well as drug and device manufacturers, to connect the dots across processes.

Although it is still early days, breakthroughs in real-time data inputs and machine learning are propelling the field of digital twins forward swiftly. As a result, digital twins may have a significant impact on how we diagnose and treat patients, as well as realign incentives for better health. Some advocates compare the current stage of digital twins to that of the human genome project, claiming that it will take a similar large-scale effort to completely develop. Different types of digital twins can be created for example, twins of the entire human body, a single body system or function, a single body organ, or finer body component levels (e.g., cellular, subcellular, or molecular levels). Digital twins can also be developed for a specific disease or disorder as well as for other relevant species. As a result, digital twins of hospitals can be used to create facility copies, which allows optimal resource management and risk management.

A. Personalized Medicine

Digital twins have a lot of potential in terms of making it easier to tailor medical treatments to individuals based on their genetic makeup, anatomy, behavior, and other aspects. As a result, academics are beginning to call on the medical community to work together to scale digital twins from one-off studies to mass personalization platforms comparable to today's advanced customer data platforms.

B. Virtual Organs

Virtual hearts that may be personalized to individual patients and updated to understand the evolution of diseases over time or the response to new medications, therapies, or surgical interventions are being developed by several companies. Starting with the company's ultrasound technology, Philip Heart Model simulates a virtual heart. Siemens Healthineers has been developing a digital twin of the heart to help with pharmacological therapy and cardiac catheterization simulations. FEops, a European firm, has already commercialized the FEops Heartguide technology after receiving regulatory permission. It improves the investigation and treatment of structural heart disorders by combining a patient-specific heart replica with AI-enabled anatomical analysis. In 2014, Dassault Systems announced the Living Heart Project, a crowdsourced virtual twin of the human heart. The initiative has expanded into an open-source partnership between medical researchers, surgeons, medical device businesses, and pharmaceutical companies.

C. Genomic Medicine

Swedish researchers have mapped the RNA of mice to create a digital twin that can anticipate the effects of various types and doses of arthritis medicines. The idea is to use RNA to personalize human diagnosis and therapy. The researchers discovered that roughly 40% to 70% of the time, medicine does not work. Human T-cells, which play an important role in immunological defense, are also being studied using similar techniques. Many common diseases can be diagnosed early when treatment is more successful and less expensive.

D. Personalized Health Information

The pandemic has aided the emergence of digital health services that use artificial intelligence to assist individuals identify and treat simple medical ailments. Babylon Health's Healthcheck App, for example, converts health data into digital twins. It works with manually entered data including health histories, a mood tracker, and symptom tracker, as well as automatic data collecting from fitness equipment and wearables like the Apple Watch. The digital twin can assist guide priorities and interactions with clinicians to manage more severe or persistent diseases.

E. Customize Drug Treatment

The Empa research institute in Switzerland is developing digital twins to help people with chronic pain get the most out of their medications. Age and lifestyle are used to customize the digital twin to forecast the effects of pain drugs. Furthermore, patient fee

F. Scanning the Whole Body

Most digital twin systems rely on current technology to collect the necessary data, but Q Bio's innovative Gemini Digital Twin platform begins with a full-body scan. The business claims that it can capture a whole-body scan in 15 minutes without utilizing radiation or breath holds, and that it can do so using new computational physics models that are more precise than traditional MRI for many diagnoses. Andreessen Horowitz, Kaiser Foundation Hospitals, and others have invested over $80 million in the startup. Q Bio is also working on integrating data from genetics, chemistry, anatomy, lifestyle, and medical history to improve these models.

G. Planning Surgery

Dassault Systems digital heart has been collaborating with a Boston hospital to optimize surgical operation planning and monitor the outcomes thereafter. They can also use the digital twins to create the shape of a cuff between the heart and the arteries.

Sim&Size is a digital twin developed by Sim&Cure to assist brain surgeons in treating aneurysms using simulations to increase patient safety. Aneurysms are enlargements of the blood vessels that can cause clots or strokes. These digital twins can help doctors plan and conduct less invasive surgeries that use catheters to place custom implants. Individual patient data is used to customize simulations that run on an Ansys embedded simulation program. The requirement for follow-up surgery has been drastically reduced based on preliminary results.

H. Improving Caregiver Experience

Caregivers can use digital twins to capture and locate information communicated among physicians and specialists. "We're collecting more data than ever before," said David Talby, CTO of John Snow Labs. "No one has time to sort through it all." When a person visits their regular primary care physician, for example, the doctor will have a basic awareness of the patient, their medical history, and their prescriptions.

When a patient visits a specialist, they may be asked many of the same questions again and again.

A digital twin can model the patient and then utilize technologies like natural language processing (NLP) to decipher all of the data and cut through the clutter to summarize what's going on.

I. Driving Efficiency

The GE Healthcare Command Center is a major initiative to Virtualize hospitals to assess the impact of different decisions on overall organizational performance. Modules for analyzing changes in operational strategy, capacity, staffing, and care delivery models are included, as well as modules for determining which measures to take objectively. They've created modules to estimate the impact of different bed arrangements on care levels, optimize surgical schedules, improve facility design, and optimize staffing levels, for example. Managers can now test numerous concepts without needing to conduct a pilot. GE claims that dozens of organizations are already using the platform.

J. Value-based Healthcare

The rising cost of healthcare has many nations exploring new incentive models to better align new drugs, interventions, and treatments with outcomes.

Value-based healthcare is one approach that is growing in popularity. The basic idea is that participants, like drug companies, will only get compensation proportionate to their impact on the outcomes. This will require the development of new types of relationships across multiple players in the health delivery systems. Digital twins could provide the enabling infrastructure for organizing the details for crafting these new types of arrangements.

K. Supply Chain Resilience

The pandemic demonstrated how vulnerable today's supply systems can be. Due to shutdowns and limitations imposed by nations such as China, healthcare organizations experienced immediate shortages of necessary personal protective equipment. Digital twins of a supply chain can assist healthcare businesses better understand how to plan for new occurrences, shutdowns, and shortages by modeling their supply chain relationships. In an emergency, such as the recent pandemic, this can help with planning and talks with government officials. According to a recent Accenture survey, digital twins are becoming increasingly important to their organization's ability to participate in strategic ecosystem alliances.

L. Faster Hospital Construction

Digital twins could potentially speed up the design of medical facilities that must adapt to quick changes, such as those witnessed during the pandemic. Atlas Construction created a digital twin platform to help organize healthcare construction specifics. Long before the pandemic, Atlas founder Paul Teschner noticed how difficult it was to have new facilities erected in remote parts of the world. The platform aids in the coordination of the design, procurement, and construction stages. It is based on Oracle Cloud and the Primavera Unifier asset lifecycle management solution.

M. Streamlining Call Center Interactions

Customer support personnel may find it easier to understand and communicate with patients using digital twins. A huge insurance company, for example, used a TigerGraph graph database to combine data from over 200 sources to build a complete longitudinal health history for each of its members. TigerGraph healthcare industry practice lead Andrew Anderson commented, "This degree of detail offers a clear picture of the members' current and previous medical situation."

TigerGraph claimed that a holistic view of all diagnoses claims prescriptions, refills, follow-up visits, and outstanding claims reduced call handling time by 10%, resulting in anticipated savings of over $100 million. Shorter but more relevant talks between agents and members have also improved Net Promoter Score and reduced turnover.

N. Software-as-a-Medical Device

The FDA is developing regulations that will allow corporations to certify and sell software as a medical device. The core concept is to create a patient-specific digital twin using various data sources such as lab tests, ultrasound, imaging equipment, and genetic tests. Digital twins can also aid in the optimization of software in medical devices like pacemakers, automated insulin pumps, and innovative brain treatments.

O. Classifying Drug Risks

Digital twins are being used by pharmaceutical researchers to investigate the heart risks of various medications. This could be a more cost-effective way to improve medication safety for individual pharmaceuticals and drug combinations than manual testing. They've created a basic model for 23 different medications. Extending this technique could help cut the $2.5 billion cost of developing, testing, approving, and launching new medications.

P. Simulating New Production Lines

Siemens collaborated with several vaccine manufacturers to develop and evaluate several vaccine production line configurations. New mRNA vaccines are delicate and must be produced utilizing microfluidic production lines that combine nanoscale-sized particles properly. They were able to build and evaluate manufacturing devices, scale these processes, and reduce the launch time from a year to five months thanks to digital twins.

Q. Improve Device Uptime

Philips has introduced a predictive maintenance service based on data collected from over 15,000 medical imaging devices. The company hopes that digital twins would increase uptime and assist engineers in customizing new equipment to meet the needs of various clients. Furthermore, it hopes to apply the same ideas to all of its medical equipment.

R. Post-market Surveillance

As part of a procedure known as post-market surveillance, regulators are beginning to place a greater emphasis on device producers monitoring the results of their equipment after it has been sold. This necessitates either hiring costly specialists to maintain the equipment or incorporating digital twin capabilities into the device itself. PTC CTO Steve Dertien told VentureBeat that Sysmex worked with PTC to include performance testing into their blood analyzer to secure a waiver from these new standards. This paved the way for smaller clinical environments to be built closer to patients, allowing for faster diagnosis.

S. Simulating Human Variability

The ideal human is frequently shown in skeletons and atlases. Real-life persons, on the other hand, often have tiny variances in their muscles or bones that go undiscovered. As a result, medical device manufacturers struggle to understand how frequent anatomical variances affect the fit and function of their products. Virtonomy has created a library of typical variants to assist medical device manufacturers in conducting tests to see how these variations affect the performance and safety of new devices. Instead of individuals, they imitate traits that represent typical variations in each group.

T. Digital Twin of a Lab

Thousands or millions of options must often be tested in a highly controlled environment in modern medication development. These facilities could benefit from a digital duplicate of the lab. It can also aid in the prioritization of tests in reaction to new information. Experiments could also be more reproducible across labs and across lab employees using digital twins. Artificial recently received $21.5 million in series A funding from Microsoft and others to create lab automation tools in this pursuit. The company believes that unified data models and platforms will help them gain a competitive advantage in the $10 billion lab automation sector.

U. Improving Drug Delivery

As part of the Virtual Human System project, Oklahoma State researchers have been working with Ansys to construct a digital twin to optimize medicine administration utilizing models of simulated lungs. Many medications only reached 20% of their objective, according to their findings. They were able to modify the drug's particle size and composition properties using the digital twins, resulting in a 90 percent increase in delivery efficiency.

V. LIMITATIONS

At the moment, some of the most significant obstacles for digital twins in medicine and healthcare are clear data visualization, ease of access and accessibility, data removal due to privacy breaches or recognized flaws in the data, and integration into clinical workflows.

Currently Digital Twins technology may face similar challenges and obstacle as Data Analytics and Modern AI. Data availability and quality issues; data integration and interoperability issues; data sharing issues, including worries about intellectual property; data privacy and security across platforms and systems; and reproducibility issues are among the obstacles and challenges that digital twins confront.

Digital twin technology for personalized treatment may not be available to every person or community, resulting in a new type of 'digital gap' between individuals and groups. Furthermore, tendencies discovered across a population of digital twins may lead to unacceptably segmented and discriminated groups. Individuals with digital twins should have their rights protected, data privacy and protection of people's personal biological information should be guaranteed, and data utilization and any resulting advantages should be transparent and fair at both the individual and societal levels.

Overcoming the obstacles may be a ray of hope for the future of Digital twin technology, which will assist not only the healthcare industry but also other sectors of modern society.

VI. CONCLUSION

We learned about digital twin technology and how it can benefit the healthcare system, from storing patients' specific health information to identifying drug hazards, from speedier hospital building to scanning the entire body, from individualized medicine to surgical planning, and so on. Predictions cannot be a black box; we must explain how models can make suggestions and provide evidence for why those recommendations were made. Finally, software connects these Digital Twins and keeps them "alive" with real-time data flows. The healthcare digital twin system is made up of these three aspects. To gain a true picture of the patient's health and prescribe the proper care at the right time, we can combine domain knowledge with numerous forms of data such as sensor readings, social activity, environmental factors, and so on.

REFERENCES

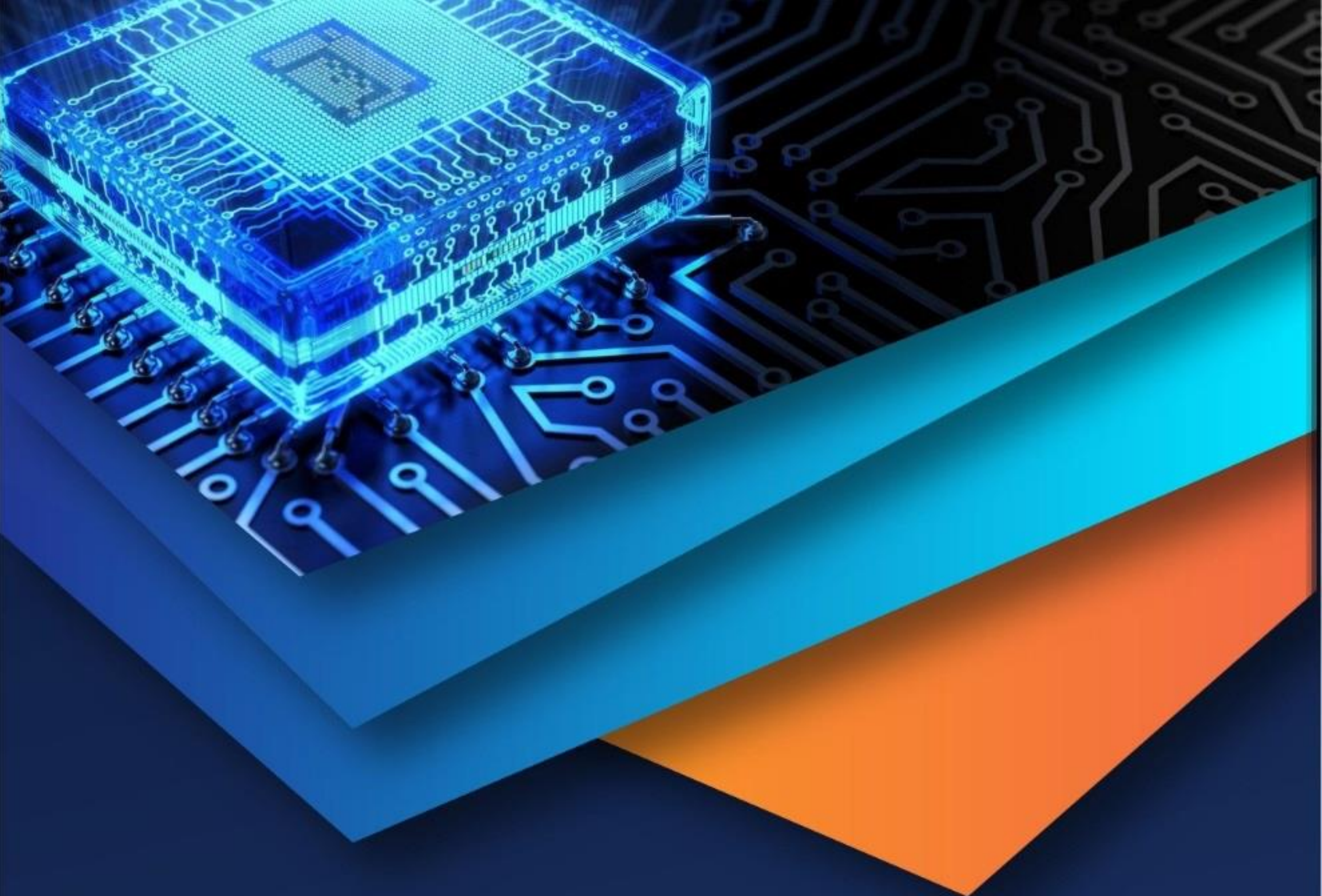
[1] Digital Twin: Enabling Technologies, Challenges and Open Research - Aidan Fuller, Zhong Fan, Charles Day, Chris Barlow, November 2020
[2] Real-World Anomaly Detection by using Digital Twin Systems and Weakly-Supervised Learning - Castellani Andrea, Schmitt Sebastian, Stefano Squartini, October 2020
[3] Digital twins based on bidirectional LSTM and GAN for modelling the COVID-19 pandemic - Cesar Quilodran-Casas,Vinicius L.S Silva, Rossella Arcucci, Claire E, Heaney, Yike Guo, Christopher C.Pain, May 2021
[4] Graph representation forecasting of patient's medical conditions : Towards A digital Twin - Pietro Barbiero, Ramon Vinas Torne, Pietro Lio, September 2020
[5] Machine learning Based-Intrusion-Prediction-System PENSEE Journal, Volume51, Issue 01, January-2021
[6] Digital Twin approach to clinical DSS Explainable AI- Persistent System Ltd. – Dattaraj Jagdish Rao, Shraddha Mane, September 2020
[7] Gated Recurrent Unit Deep Neural Network-Based-Intrusion-Prediction- to-Classify-Network- Attacks, PENSEE Journal, Volume51, Issue 01, January 2021.
[8] Network Intrusion Detection System Based on Deep and Machine Learning Frameworks with CICIDS2018 using Cloud Computing, International Conference on Smart Innovations in Design, Environment, Management, Planning Computing (ICSIDEMPC 2020) IEEE.
[9] Classification of Network Traffic using Ensemble Methods to Secure Internet, International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC 2020)-IEEE.
[10] Deep Convolutional Neural Network Based Intrusion Detection System, International Journal of Multidisciplinary Educational Research (IJMER).
[11] Zhang, P.; Boulos, K.M.N. Chapter 50-blockchain solutions for healthcare. In Precision Medicine for Investigators, Practitioners and Providers; Faintuch, J., Faintuch, S., Eds.; Academic Press: Cambridge, MA, USA, 2020; pp. 519–524.
[12] Patrick, B. Meet boston's digital twin. Esri. Newsroom Blog. 2018.
[13] Schwartz, S.M.; Wildenhaus, K.; Bucher, A.; Byrd, B. Digital twins and the emerging science of self: Implications for digital health experience design and "small" data. Front. Comput. Sci. 2020,
[14] Masison, J.; Beezley, J.; Mei, Y.; Ribeiro, H.; Knapp, A.C.; Vieira, S.L.; Adhikari, B.; Scindia, Y.; Grauer, M.; Helba, B.; et al. A modular computational framework for medical digital twins. Proc. Natl. Acad. Sci. USA 2021, 118, e2024287118.
[15] World Health Organization. Ethics and Governance of Artificial Intelligence for Health: WHO Guidance; World Health Organization: Geneva, Switzerland, 2021;
[16] Rao, D.J.; Mane, S. Digital twin approach to clinical DSS with explainable AI-reducing subjectivity in liver disease diagnosis using domain knowledge and machine learning. arXiv 2019, arXiv:1910.13520v1.

AUTHORS

First Author – Sakshi Parate, BSc (Mathematics, Physics, Electronics), PGD Data Science &AI, sakshiparate42@gmail.com.

Second Author – Aniket Bhivgade, B. Tech Mechanical Engineering, PGD Data Science &AI, External Auditor for ISO13485:2016 Medical Devices,
aniket.bhivgade@outlook.com.

Third Author – Dr. Manisha Bharati, Associate Professor at Department of Technology, Savitribai Phule Pune University, manishaprakashbharti@gmail.com.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

TOGETHER WE REACH THE GOAL

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY