

Overview: Technology Roadmap of the Future Trend of Metaverse based on IoT, Blockchain, AI Technique, and Medical Domain Metaverse Activity

Md Ariful Islam Mozumder*, Muhammad Mohsan Sheeraz*, Ali Athar*, Satyabrata Aich*, Hee-Cheol Kim*

* Department of Computer Engineering/Institute of Digital Anti-Aging Healthcare/u-HARC, Inje University, South Korea
arifulislamro@gmail.com, Sherazmohsin257@gmail.com, ali.athar1401@gmail.com, satyabrataaich@gmail.com, heeki@inje.ac.kr,

Corresponding Author: heeki@inje.ac.kr

Abstract— Metaverse is defined as a collection of technology gadgets and metaverse connected to IoT, Blockchain, Artificial Intelligence, and all the other tech industries including the medical area. IoT and Metaverse are the digital twins, Metaverse is using maximum IoT devices in their virtual workstation. This data has a unique identifying tag and is used as traceable data in the blockchain-based Metaverse. In the Metaverse, such data is becoming a valuable resource for artificial intelligence. Metaverse uses artificial intelligence and blockchain technology to build a digital virtual world where you can safely and freely engage in social and economic activities that transcend the limits of the real world, and the application of these latest technologies will be expedited. In this paper, we are going to describe what technologies metaverse is using and metaverse potentiality in medical healthcare.

Keywords— Metaverse, IoT, Blockchain, Artificial Intelligence, Healthcare

I. INTRODUCTION

In this era, technology is rapidly changing the way we interact with the physical world around us. The Metaverse is a virtual shared space that everyone can access. It's a catch-all term that refers to the entire digital and virtual world [1]. It's the convergence of physical, augmented, and virtual reality in a shared online space. Metaverse's core branches are Healthcare, Entertainment, Military, Real estate, Manufacturing, and Education. Within a metaverse, each user has their perspective on the virtual world, with the underlying environment presenting a consistent state to all users [2,3]. Metaverse Virtual Reality (VR) and Augmented Reality (AR) are invading healthcare, medicine, and innovative technologies based on AR and VR are emerging to improve medical education and training as well as processes and procedures [4-6]. VR is a technology that substitutes one's vision of the physical world with a digitally produced scene using software and headgear devices [7]. AR is a technology that combines the digital and physical worlds. It uses computer vision techniques such as object recognition, plane detection, facial recognition, and movement tracking to recognize real-world surfaces and

objects. The term "mixed reality" refers to a combination of augmented and virtual reality. Using VR, AR, and MR technology doctors make their dream smart digital operation theatre healthcare, where everyone can watch live patient operation which looks like real operations [8-11]. Unlike games, the virtual environment of a metaverse is not fixed and can be modelled and altered by some or all the users who inhabit it. Each user's avatar can be enabled to portray the personality of the owner. This allows long-term changes to the environment to be retained in perpetuity. It also allows users to form relationships by proxy, with each avatar being used to convey a user's in-world persona [12-16].

II. METAVERSE TECHNIQUES

The Metaverse contains elements of all four scenarios. In the same way, as a mirror world map inside a virtual world, or a heads-up display AR system, or an object or user lifelog inside a mirror or virtual world, their technologies substantially overlap. There are also more general overlaps between the scenarios. Figure 1 shows the technological roadmap of Metaverse.

A. Communication Computing Infrastructure

The manufacturing field has been evolving rapidly with the help of IoT Technology and metaverse core-stream also working as an IoT device. Figure 2 shows the IoT and Internet for Metaverse. According to our study, 43% of manufacturing companies reveal that VR will become mainstream in their organization within the next two to three years, AR also working on industrial applications rather than consumer software. Metaverse is the next version of the internet and most companies already using 5G and 6G for developing their infrastructure.

1) Internet: The foundation for connectivity is the Internet. Although the internet is currently making progress very rapidly, researchers are constantly making many innovations in internet technology, such as 5G and 6G technology.

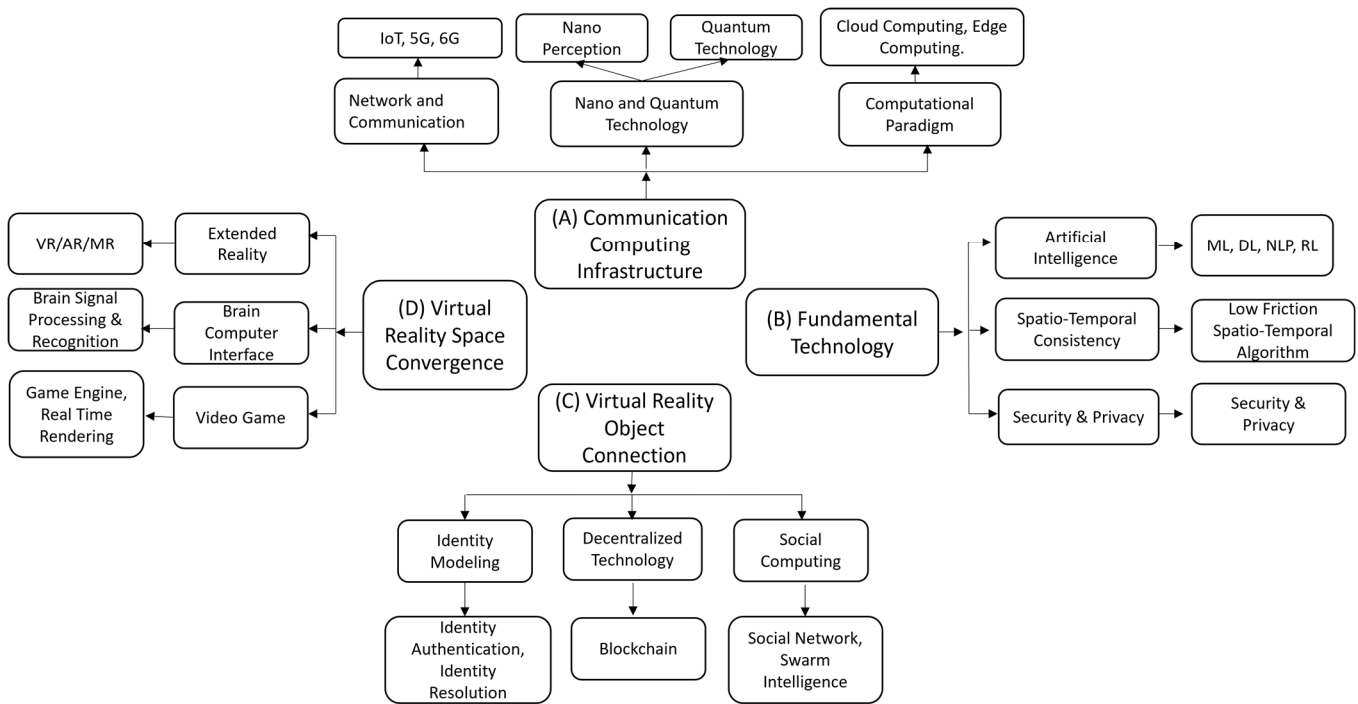


Figure 1. A complete Technological Roadmap of Metaverse

2) Infrastructure: There are hardware components that help us to have authentic experiences. In addition to nano and quantum (Nanotechnology can improve the performance of sensors or actuators) components, the technologies to form the metaverse are also in this layer. Content- On this layer, we will have Medicine, healthcare, games, and applications that help users immerse themselves in one or more different worlds, for the most vivid experiences. Metaverse- when the lower layers develop to a certain extent, we will have a true Metaverse.

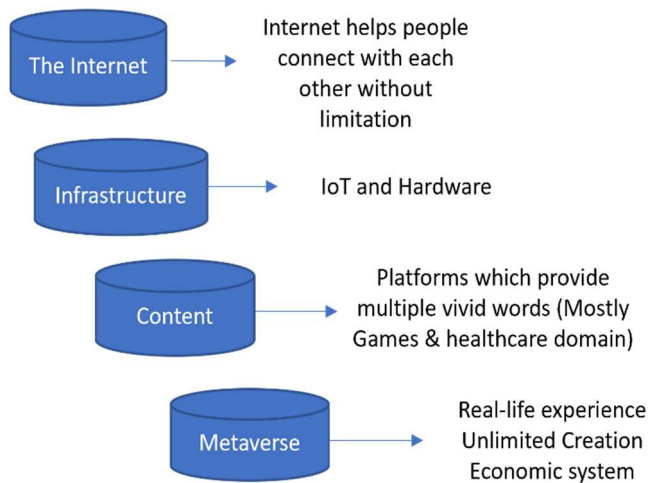


Figure 2. IoT and Internet for Metaverse

Metaverse services can be used without modifications, either to access services in the existing cloud environment, where all services are provided by centralized servers over the internet, or to access services hosted in the decentralized edge computing deployments, shown in Figure 3.



Figure 3. Edge Computing in the Metaverse

B. Fundamental Technology

The metaverse is defined as a virtual space where users can interact with 3D digital objects and 3D virtual avatars of each other in a complex manner that mimics the real world, hold thing developed using artificial intelligence techniques. Figure 4 shows the five AI phases in the Metaverse.

1) Accurate Avatar: Users are at the Centre of the metaverse, and the accuracy of your avatar will affect the quality of your and other participants' experiences. An AI engine can evaluate 2D user photos or 3D scans to create a simulated reproduction that is extremely lifelike. To make the avatar more dynamic, it may plot a range of facial expressions, emotions, hairstyles, aging features, and so on.

2) Digital Humans: Digital humans are 3D versions of chatbots that exist in the metaverse. Digital humans are built entirely using AI tech and are essential to the landscape of the metaverse. From NPCs in gameplay to automated assistants in VR workplaces, there are myriad applications, and companies like Unreal Engine and Soul Machines have already invested in this direction. Multilingual Accessibility- AI can help break down natural languages like English, convert them into a machine-readable format, perform analysis, arrive at a response, convert the results back into English and send it to the user.



Figure 4. Five Artificial Intelligence use cases in the Metaverse

The best part is that, depending on the AI's training, the results might be translated into any language, allowing users from all over the world to access the metaverse. Expansion of VR and AR- With new input, human feedback, and machine learning reinforcement, AI's output will improve with time. AI will be able to complete the task and produce results nearly as good as humans. AI is being trained by companies like NVIDIA to develop complete virtual worlds. This breakthrough will be instrumental in driving scalability for the metaverse, as new worlds can be added without the intervention of humans using AI ensemble VR and AR. Intuitive Interfacing- AI can also assist in human-computer interactions (HCI). When you put on a sophisticated, AI-enabled VR headset, its sensors will be able to read and predict your electrical and muscular patterns to know exactly how you'd want to move inside the metaverse.

3) Spatio Temporal Algorithm: Spatio Temporal AI algorithm is a collection of digital tools, models, and methods that can be deployed to increase people's understanding of how, where, and why people locate and move in metaverse virtual cities. It also enables people to develop new virtual procedures for designing and managing the future metaverse virtual city so that it can become more sustainable, equitable, and efficient.

4) Metaverse Security and Privacy: Since the data and avatars of users of the Metaverse platform are located on different servers around the world, Metaverse handles different personal data processing in each country using AI techniques.

C. Virtual Reality Object Connection

1) Identity Modelling: Digital identity and personalization in the metaverse are your unique avatar, with the rise of Web 3.0, crypto wallets will also play a role in defining our identity. In a wallet, we might find traces of someone's gaming preferences and love for digital art. These unique avatars are a way to give your digital identity visual representation in 3D worlds: they are your identity in the metaverse.

2) Decentralized Technology: Every single piece in the metaverse incorporates the core concept, shown in Figure 5.

- **Decentralized Computation:** Decentralized Computation- In a metaverse virtual reality, everything is data and everything happening is computing. Decentralized computation gathers all the powers together to provide all the calculations people need to build their perfect world. The computation will be efficient and accurate.
- **Decentralized Storage:** Inside the metaverse, we have land, space, energy, power, buildings, medical healthcare

materials, and many more. Everything is safe here for the reason of metaverse data storage is fully decentralized, it is owned by everyone, it is managed by everyone, and everyone together will ensure its existence like the metaverse will build upon it. Also, we will have full features on the data: everyone will be confident that the data won't be modified by the others because of storage decentralization.

- **Decentralized Database:** It will provide a solid base for metaverse citizens to organize their data so they can use them to build anything that they can imagine enriching the universe. And at the same time, they will have full confidence that the data is always there for us.
- **Blockchain:** To ensure the decentralized nature of metaverse, blockchain is the core of all the infrastructure. Blockchain will ensure the decentralized data, decentralized database and decentralized computation is fully trustful and ensure only the citizens of the metaverse have ownership of everything in the virtual space.

3) Social Computing: Metaverse social computing included avatar description, avatar identification, avatar interaction, and avatar organizational work.

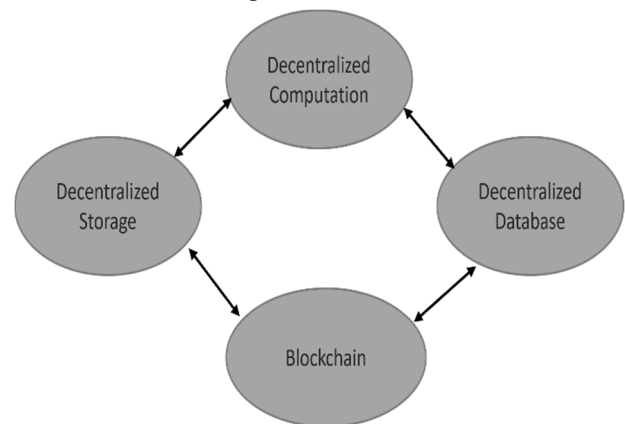


Figure 5. Metaverse decentralized technology

D. Virtual Reality Space Convergence

1) Metaverse Extended Reality: Since the data and avatars of users of the Metaverse platform are located on different servers around the world, Metaverse handles different personal data processing in each country using AI techniques. Figure 6 shows the extended reality in Metaverse.

- **Virtual Reality:** It is a technology that substitutes one's vision of the physical world with a digitally produced scene using software and headgear devices.

While wearing full-coverage headsets, you are entirely cut off from your surroundings and the actual world. A computer-generated virtual environment is reflected by the LCD screens inside the lenses of these headset devices, and your viewpoint is replaced.

- **Augmented Reality:** It is a technology that blends the digital and real worlds. It uses computer vision to recognize real-world surfaces and objects using technologies such as object recognition, plane detection, facial recognition, and movement tracking, among others. The computer then overlays computer-generated data like graphics, sounds, images, and messages on these previously recognized planes.
- **Mixed Reality:** It is a hybrid of augmented reality and virtual reality. It's also known as Hybrid Reality since it incorporates both real-world and digital aspects. While MR is primarily a technology for combining the physical and virtual worlds, the most appealing technology is the lifelike interaction between users and digital items. These three technologies are also used in the healthcare domain.

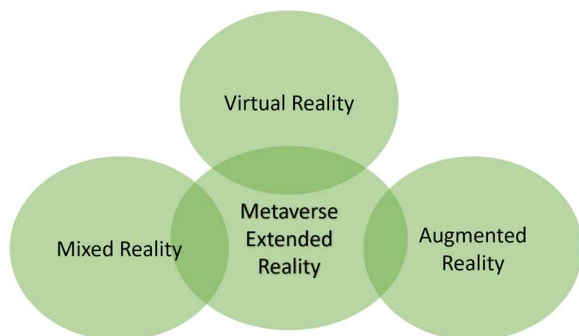


Figure 6. Metaverse extended reality

2) **Brain-Computer Interface:** Since the data and avatars of users of the Metaverse platform are located on different servers around the world, Metaverse handles different personal data processing in each country using AI techniques.

- **Acquisition:** These signals are acquired from the brain and then amplified and tuned, and noise is removed to convert the input signal into a format that can be digitized and sent to a system that can be further interpreted.
- **Feature Extraction:** This step involves extracting certain characteristics and footprints that indicate the presence or absence of a particular intent. These characteristics can be time-triggered EEG or ECoG response amplitudes and latencies, power within specific EEG or ECoG frequency bands, or firing rates of individual cortical neurons, etc.
- **Feature Interpretation:** In this step, the characteristics obtained in the previous steps are analyzed, and a conclusion is made as to what may be the intent of the user. Since the human brain is extremely fast and complex, these translation

algorithms must be dynamic and adaptive to new signals and features in real-time.

- **Output:** The output can be experienced in various forms like visual outputs, including moving of cursor on the screen or changing of channel, audio outputs may change the volume of a device, etc.

3) **Real-Time Rendering:** Real-time rendering is a field of computer graphics focused on analyzing and producing images in real-time. Metaverse video game platform using the real-time rendering for metaverse avatar, because of the reality of avatar. 3D rendering is the process of producing an image based on three-dimensional data stored on our computer. It's also considered to be a creative process, much like photography or cinematography, because it makes use of light and ultimately produces images. With 3D rendering, computer graphics convert 3D wireframe models into 2D images with 3D photorealistic, or as close to reality, effects. Rendering can take from seconds to even days for a single image or frame.

III. METAVERSE IN MEDICAL DOMAIN

The use of augmented reality in the healthcare sector has a significant impact on the training and improvement of future medical professionals' skills and knowledge bases. Surgical assistive tools are technology like the Microsoft HoloLens that surgeons utilize to help them with and speed surgical procedures. AR headsets are utilized to see vital real-time patient data such as heart rate, body temperature, blood pressure, and breathing rate, in addition to pre-operative images from CT, MRI, and 3D scans. Augmented reality is currently being used by nurses and physicians to improve vein detection. This solves the challenge of finding a vein for many people, even if their skin is heavily pigmented or their blood veins are small. Visual-driven technology such as X-rays and CT scans is common in the healthcare industry. Simply said, they help medical professionals detect, diagnose, and treat patients by allowing them to peek inside their bodies. Many medical institutions started using metaverse technology. Figure 7 shows the activities of Metaverse in the medical domain.

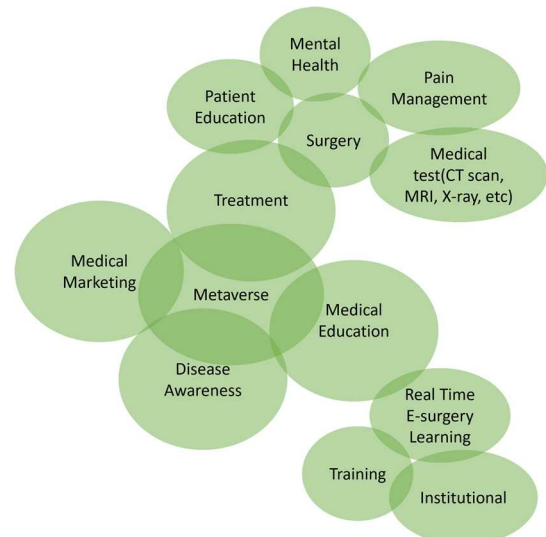


Figure 7. Metaverse in Medical Domain

A. Metaverse Activities in Healthcare

- Remote surgery, telepresence, augmented reality surgery
- 3D human anatomy models for education, visualization diagnosis, and planning
- Architectural design for healthcare facilities
- Preventive medicine and patient education
- Haptic aided rehabilitation
- Visualization of massive medical databases
- Treatment planning
- Medical therapy
- Pain control
- Psychotherapy through Virtual Reality
- Virtual patients
- Surgery simulation

B. Proposed Process of Patients General Treatment using Metaverse Technology

The applications treatment metaverse is applied to speed up the training process without any awe and risk. It is used to apply in the medical field for a wide range of diseases. Metaverse future technology opens a useful role to improve the performance of the medical field. Metaverse is a useful and effective technology to raise the satisfaction of trainees and the patient. This technology provides an applicable solution using its process in the medical field, Metaverse is an essential technology for the development process that uses customized and advanced software and hardware. We can define the specific objective of the required treatment and collect the patient's background information. Different hardware and software are used to create 3D virtual data that creates a 3D virtual environment. The metaverse virtual reality and augmented reality of the required medical data is created and identified with the best possible procedure. This procedure is applicable to plan the treatment and finally helps to perform the actual Treatment. Figure 8 shows the process of patient general treatment using Metaverse technology.

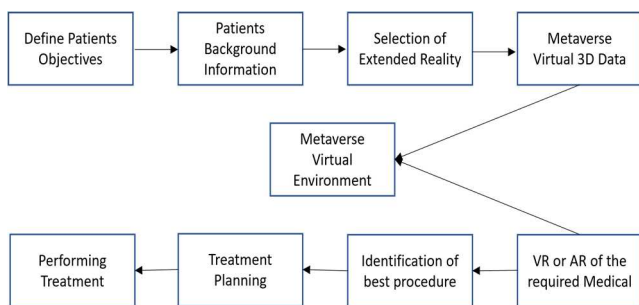


Figure 8. Metaverse technology in the medical domain

IV. CONCLUSIONS

We are very stoked that we can contribute to the beautiful new world. On a final note, technology giants such as Facebook, Microsoft, Apple, Google, and many gaming companies have ambitious plans for materializing the metaverse. With the engagement of emerging technologies and the progressive development and refinement of the ecosystem, metaverse

virtual worlds will look radically different in the upcoming years. However, there exist still many challenges to be overcome before the metaverse becomes integrated into the physical world and our everyday life. In this paper, we discuss the technological roadmap of metaverse technology and the medical domain activity of the metaverse. In the future, we will propose, metaverse for smart healthcare facilities.

ACKNOWLEDGMENT

This work was supported by the Commercialization Promotion Agency for R&D Outcomes (COMPA) grant funded by the Korean Government (Ministry of Science and ICT)” (R&D project No.1711139492).

REFERENCES

- [1] Lee, L. H., Braud, T., Zhou, P., Wang, L., Xu, D., Lin, Z., ... & Hui, P. (2021). All one needs to know about metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda. *arXiv preprint arXiv:2110.05352*.
- [2] Ayiter, E. (2012, September). Further dimensions: Text, typography, and play in the Metaverse. In *2012 International Conference on Cyberworlds* (pp. 296-303). IEEE.
- [3] [Internet]. Available: [MetaVRse Engine - MetaVRse](#) “A Guide to The Medical Metaverse”.
- [4] Claudio, P., & Maddalena, P. (2014). Overview: Virtual reality in medicine. *Journal of Virtual Worlds Research*, 7(1).
- [5] [Internet]. Available: [www.healthmanagement.org](#). “Facebook’s Metaverse Could Revolutionize Healthcare”, 2021.
- [6] Andrews, C., Southworth, M. K., Silva, J. N., & Silva, J. R. (2019). The extended reality in medical practice. *Current treatment options in cardiovascular medicine*, 21(4), 1-12.
- [7] Dionisio, J. D. N., III, W. G. B., & Gilbert, R. (2013). 3D virtual worlds and the metaverse: Current status and future possibilities. *ACM Computing Surveys (CSUR)*, 45(3), 1-38.
- [8] Duan, H., Li, J., Fan, S., Lin, Z., Wu, X., & Cai, W. (2021, October). Metaverse for social good: A university campus prototype. In *Proceedings of the 29th ACM International Conference on Multimedia* (pp. 153-161).
- [9] Falchuk, B., Loeb, S., & Neff, R. (2018). The Social Metaverse: Battle for Privacy. *IEEE Technology and Society Magazine*, 37(2), 52-61.
- [10] Suzuki, S. N., Kanematsu, H., Barry, D. M., Ogawa, N., Yajima, K., Nakahira, K. T., ... & Yoshitake, M. (2020). Virtual Experiments in Metaverse and their Applications to Collaborative Projects: The framework and its significance. *Procedia Computer Science*, 176, 2125-2132.
- [11] [Internet]. Available: [www.sagentiainnovation.com](#) What does the metaverse hold for healthcare? | Sagentia Innovation.
- [12] Han, Y., Niyato, D., Leung, C., Miao, C., & Kim, D. I. (2021). A Dynamic Resource Allocation Framework for Synchronizing Metaverse with IoT Service and Data. *arXiv preprint arXiv:2111.00431*.
- [13] [Internet]. Available: <https://www.xrtoday.com/virtual-reality/artificial-intelligence-in-the-metaverse-bridging-the-virtual-and-real/>
- [14] Ferrari, V., Klinker, G., & Cutolo, F. (2019). Augmented reality in healthcare. *Journal of healthcare engineering*, 2019.
- [15] Javadi, M., & Haleem, A. (2020). Virtual reality applications toward the medical field. *Clinical Epidemiology and Global Health*, 8(2), 600-605.
- [16] Eckert, M., Volmer, J. S., & Friedrich, C. M. Augmented Reality in Medicine: Systematic and Bibliographic.



Md Ariful Islam Mozumder is pursuing his Master's in Institute of Digital Anti-Aging Healthcare from Inje University. He has previously worked on multiple real-life projects related to computer vision, data sciences, Smart IoT systems, and text mining. His research interest aligns with Computer Vision, Artificial Intelligence, Bio Signal Processing, Algorithms, and Blockchain.



Muhammad Mohsan Sheeraz is pursuing his Master's in Institute of Digital Anti-Aging Healthcare from Inje University. His research interest's area includes Blockchain and Machine Learning.



Ali Athar is a Ph.D. student at the Institute of Digital Anti-aging and healthcare at Inje University. His research interest's area includes Image Processing, Deep Learning, and Machine Learning.



Satyabrata Aich is working as a research professor in the field of computer engineering. He has published many research papers in journals in the realms of Machine learning, Text mining, and Supply Chain Management. His research interests are NLP, supply chain management, Bioinformatics, Artificial Intelligence, Blockchain.



Hee-Cheol Kim BSc at the Department of Mathematics, MSc at the Department of Computer Science in SoGang University in Korea, and Ph.D. at Numerical Analysis and Computing Science, Stockholm University in Sweden. He is a professor and Head of the Department of the Institute. Digital Anti-aging Healthcare, Inje University, S: Korea. His research interests include Machine learning, Text mining, Bio Informatics.