Industry 5.0 for Smart Healthcare Technologies: Utilizing Artificial Intelligence, Internet of Medical Things and Blockchain

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Abstract. Smart Healthcare is helpful for personal diagnostics with the assistance of AI, IoT, Digital twins etc. The evolution targeted on accurate diagnose using AI, and patient-centred care, utilizing AI diagnostics, IBM Watson for Oncology, health monitoring wearables, surgical robots. Trust in Digital Healthcare is improved through Blockchain Technology. Real-time emotional AI robots provide virtual therapies and mood tracking, while VR and AR technologies treat anxiety and PTSD. Healthcare 5.0 creates unprecedented imbalance, high-cost-implementing-ethical-issue problems. The system enhances sustainable, intelligent, and human-centered care for physical and mental health. This evolution Healthcare 5.0 enhances the lightweight, efficient, and enjoyable healthcare system, reducing human resource dependency while increasing patient-centered outcomes.

Keywords: Health 5.0, Industry 5.0, Digital Twin, Smart Healthcare, Artificial Intelligence in Healthcare.

1 Introduction

Now a days, the healthcare systems are facing many challenges. The reasons for these challenges are rapid growth of the global population, rising prevalence of chronic diseases, aging societies, and limited availability of skilled medical professionals. The traditional healthcare systems rely majorly on manual approaches. This manual approach cause many problems such as delayed diagnostics, centralized data storage, and reactive

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treatment models, which often lead to inefficiencies, high operational costs, delayed decision-making, and inconsistent quality of care. Although Industry 4.0 introduced automation and digitalization concepts into healthcare, it primarily focused on machine-centric operations, overlooking the critical role of human expertise, empathy, and personalized care.

Smart Health Industry 5.0 is the next level of advancement in various industries and aims to combine the concepts of ingenuity and smart, efficient machinery to streamline manufacturing processes and use resources more efficiently compared to Industry 4.0. Smart Health Industry 5.0 is intended to advance in producing and deliver personalized products in a timely and effective manner with the means of emerging technological

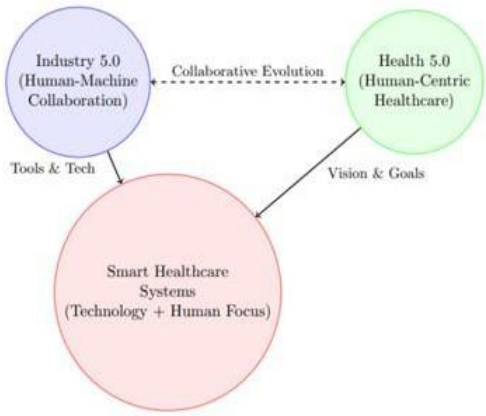


Fig. 1. Conceptual relationship between Industry 5.0 and Healthcare 5.0 for Smart Healthcare Systems

advancements [1]. The Industrial Revolution can be divided into five distinct generations, each marked by significant technological advancements and transformations in manufacturing processes. The very starting Industrial Revolution (Industry 1.0) started in the late 1700s in the United Kingdom, approximately 1760. With inventions such as textile machines and the steam engine, it made machines useful.

Basically, in the 19th centuries and early in 20th centuries (1870-1914) United States and Germany faced next phase of Revolution of Industries (Industry 2.0). It characterized by the wide use of mass production of technology and electricity. Massive advancement in the area of production of steel, communication technologies like telegraph and Industries of chemical is noticed during this phase.

The primary contributors were United States and Western Europe took place in the mid-to-late 20th century (1960s-1990s) as third Revolution in Industries (Industry 3.0). Advancements in this period included the introduction of electronics, computers, and automation in manufacturing. Germany started the Fourth Revolution in Industry (Industry 4.0) around the early 21st century, focusing on 2010. It deals with the blending of systems of cyber-physical, IoT, and the use of big data and AI in manufacturing.

The upcoming Fifth Industrial Revolution (Industry 5.0) intends to combine imagination of human and advanced technology. It also differs from Industry 4.0, which emphasizes total mechanization. Industry 5.0 (I5.0) focuses upon human-centered production,

customization, and eco-friendliness. The production of collaborative robots (cobots), AI, and other technologies designed for human-machine collaboration are designed to transform production methods by offering the human factor and resource-efficient and eco-friendly sustainability, problem-solving. Each revolution in industry has driven advanced, smarter, and more eco-friendly development in manufacturing, technology, society, and economies. [2] [3], [4]

Figure 1. predicts conceptual relationship between Healthcare5.0 where Industry 5.0 provides enabling technologies like Artificial Intelligence, Robotics, human- machine collaboration frameworks and IoT. On the other hand, Health 5.0 outlines the goals of personalized, inclusive, and sustainable healthcare. Consequently, Smart Healthcare Systems emerge as the integrated outcome, applying Industry 5.0 tools to achieve Health 5.0 objectives.

The 17 Sustainable Development goals aims at creating the integrated framework of human, social, and environmental development. Particularly SDG 3, which seeks to promote well-being and ensure healthy lifestyles for people of all ages, I5.0 in healthcare might significantly promote the Sustainable Development Goals (SDGs). By combining Advance Health technology, I5.0 can directly help to achieve the goal by changing patient care and so personalizing and simplifying health services [5]. Healthcare 5.0, influenced by *Industry 5.0*, prioritizes sustainability, people-centered care, and user-to-advanced-tech collaboration. It focuses on improvement of outcomes of patient with customized treatments, using robotics, AI, and IoT while keeping human oversight. While keeping human inaccuracy, it utilizes AI, IoT and cobotics to enhance outcome of patients by providing prioritize human care. Wearable instruments and Digital Twin provide intense health care management and Data analysis. Block chain Technology sustains privacy of patients Data and on the other hand AI ensures balanced decisions [6].

2 Related work

This paper highlights main challenges of HealthCare 5.0 which needs attentiveness of protection of data, complication of regulatory, cost effectiveness, and dealing with moral [7]. The study of paper shows smart sensors are helpful in precise and individual care. Various technologies such as AI, robotics additive manufacturing affects trauma and orthopaedics. It also increase surgical accuracy, individualized care with cutting edge technologies [27].

All are transitioning into a generation of AI, Blockchain, IoT. Cloud Computing, drones turning dream into reality of virtual offices, remote monitoring etc [28].

Taking inspiration from Industry 5. 0 and expanding on the work of Healthcare 4.0, the authors of this paper [29] are the first to define Healthcare care 5.0. One of the main contributions is a thorough analysis of Healthcare 1.0- 4.0 based on CIoT in relation to Industry 1.0 -4.0 emphasizing connections between the two. Furthermore, the authors offer distinctive perspectives on the core of Industry 4.0 and its impact on Healthcare 5.0's development. They examine cutting-edge fog/cloud computing technologies based on CIoT in Healthcare 4.0 and offer recommendations for their potential uses in Healthcare 5.0. Lastly, they talk about the prospects and difficulties in

developing Healthcare 5.0 research fields. The identification of human diseases, especially deadly malignancies, is discussed in this work [30] as a crucial issue in the age of the intelligent Healthcare Sector 5.0. For precise and dependable prediction of disease, a learning method with safe transfer based on the Internet of Medical Things (IoMT) is suggested, utilizing Deep Convolutional Neural Network (CNN) of GoogleNet. The approach places a strong focus on security and privacy in IoMT networks, which have developed quickly all over the world. This technology outperforms earlier state- of-the-art techniques in cancer prediction within the smart healthcare sector, attaining a stunning 98.8% success rate and great accuracy in predicting deadly cancer diseases.

The evolutionary role of the Internet of Medical Things (IoMT) in Health- care 5.0 is discussed in this paper [31], with a focus on how smart medical devices may revolutionize patient care, disease management, and healthcare procedures. Incorporating Wireless Sensor Networks (WSNs) for data collection and transmission, IoMT enables cloud-based applications for data interchange, surveillance of patient, and management of sanitation in hospitals. One of the proposed solutions is the new energy-efficient routing protocol (ECC-EERP) using elliptic curve cryptography. It addresses patient safety and privacy concerns. The system claims to maintain energy efficiency and the highest standard of secured encrypted data.

3 Revolution in healthcare 5.0

3.1 Collaboration robots

Cobots, or collaborative robots, are made especially to work with people. These robots can increase human potential and productivity, particularly in the health- care industry. Supporting medical personnel and enhancing patient care can be greatly aided by these cobots. With the use of real-time data, these cobots can help surgeons and increase precision. When it comes to precise activities like creating incisions or positioning surgical equipment, the cobot could assist the physician. Cobots could be used to observe

Table 1. Examples of Technologies for Industry 5.0

Field	Technologies Used	Examples	References
Healthcare	AI, Robotics, IoT, Big Data Analytics	IBM Watson for Healthcare, Da Vinci Surgical System, Wearable Health Devices (e.g., Apple watch)	[7], [8]
Agriculture	IoT, Drones, AI, Robotics, Big Data	Precision Farming, John Deere's Automated Tractors, Crop Monitoring with Drones	[9], [10], [11]

Manufacturing	Robotics, AI, IoT, Smart Sensors, 3D Printing	Human-Robot Collaboration, Smart Factories, 3D Printing for Customized Products	[12], [13], [14]
Logistics	AI, Automation, IoT, Big Data, Robotics	Amazon's Robotic Warehouses, Self-Driving Delivery Vehicles, AI-Optimized Supply Chains	[15], [16]
Retail	AI, AR, IoT, Big Data, Robotics	Personalized Shopping with AI, AR for Virtual Try-ons, IoT- enabled Smart Shelves	[17], [18]
Construction	Robotics, AI, 3D Printing, Drones	Autonomous Construction Robots, 3D Printed Buildings, Drone Surveys	[19], [20]
Energy	Smart Grids, AI, Renewable Energy Technologies, IoT	Smart Grids for Energy Management, Solar Panel Farms, Wind Energy Management with IoT	[21], [22]
Automotive	Robotics, AI, IoT, Autonomous Driving, Electric Vehicles	Self-Driving Cars, Tesla's Electric Vehicles, AI-powered Vehicle Safety Systems	[23]
Education	AI, AR, VR, IoT, Cloud Computing	AI-Powered Learning Platforms, AR/VR in Classrooms, Remote Learning with Cloud Computing	[24], [25]
Finance	AI, Machine Learning, Blockchain, Big Data Analytics	Fraud Detection with AI, Blockchain in Banking, AI-driven Financial Planning	[26]

essential signs of patient in real time and, by evaluating data from several sensors, even anticipate possible problems. The daVinci Surgical System, a well-known example of a cobot in surgery, uses robotic arms that the operator controls to help perform minimally invasive surgery with greater precision [32].

Cobots are designed to work alongside people rather than rather than replacing them. These robots are useful to augment capabilities and usefulness in the health-care sector. These adjacent workflows are supportive rather than replacing the personnel and enhancing care given to the patients. Collecting real time data and working with these robots can assist in higher precision during surgical procedures. During surgeries, the

robots can assist with delicate tasks, taking the lead on tasks like making defined cuts and moving the surgical apparatus to better positions. These robots can monitor and evaluated several sensors and anticipate problems in real time to critical patients. The daVinci Surgical System is a famous surgical cobot. It uses robotic arms which medical personnel can control to perform minimally invasive surgeries. In rehab and physical therapy, cobots are designed to offer individualized aid during recovery from surgery, strokes, and injuries. In rehab, patients are able to perform specific tasks and regain movement with the aid of assistive robots and robotic exoskeletons. Cobots provides assistance to disabled people and elderly in daily activities such as walking, dressing, medication schedule [33][38]. It also automates the tasks of delivery of drugs, by transporting sample of patients, disinfecting equipment and many more. Cobots can disinfect hospital environments with means of UV-C light which provides safe environment for patients and healthcare workers. Cobots can analyze medical images, including X-rays, MRIs, and CT scans assisted by artificial intelligence and algorithms of Machine Learning, such as Aidoc and Zebra Medical Vision.

Table 2. Role of Industry 5.0 in Technology and Healthcare with the help of Examples

Role in Healthcare	Technology Used	Example
Collaborative Robots in Surgery	Robotics, Human Expertise	DaVinci Surgical System: Assists surgeons with precise, minimally invasive surgeries.
Personalized Medicine	AI, Big Data Analytics	IBM Watson for Oncology: AI-driven analysis for personalized cancer treatment plans.
Remote Patient Monitoring	IoT Sensors, Wearable Devices	Wearable devices like Apple Watch or IoT sensors monitor real-time vital signs and detect heatstroke risks.
Telemedicine and Remote Care	Telecommunication, AI, AR	Platforms like Teladoc Health enable virtual consultations, improving healthcare access in remote areas.
Drug Discovery and Development	AI, Machine Learning (ML), Data Analytics	Benevolent AI accelerates drug discovery timelines, identifying effective drug compounds faster.
3D Printing for Prosthetics	3D Printing, AI-based Design	Companies like Open Bionics create customized bionic limbs and dental implants.
Medical Training and Treatment	Virtual Reality (VR), Augmented Reality (AR)	Osso VR provides realistic surgical simulations; VR therapy aids in PTSD and anxiety treatments.

Sustainability in Healthcare	AI, IoT, Green Technology	Smart hospitals use IoT-based systems for energy management, reducing environmental impact.

3.2 3D printed prosthetics and implants

3D printed protheses is example of state-of-the-art technology in medical field and supporting accessibility and sustainability. Additive manufacturing employs 3D printed implants and prosthetics delivers medical equipment on the request of each patient. As compare to conventional implants, 3D customized joint replacement for the human jaw was developed and tested. It provides various advantages such as improve safety of surgical by decreasing intraoperative nerve injury. The contribution of 3D printing in dent implant technologies is remarkable; it offers tailored, precise, and high quality solutions in metallic, polymer, and ceramic materials.For better dental fixtures, it merges scanning and CAD systems, speeds up production, and lowers waste. MRI compatibility, functional integrity, and material biocompatibility are still issues, though. Overcoming these challenges and developing bio- functional tissue-engineered solutions for restorative procedures are key to the future of 3D printing in dentistry [35].

3.3 Personalize physical and mental healthcare

It learns from Practices 5.0, Healthcare 5.0, and blends man with machinery is the ultimate combination. Internet of Things (IoT), Artificial Intelligence (AI), robotics and digital twins are combined in order to tailor desperately physical and mental healthcare just as if they were a garment made to measure. Tailored treatments mean that people receive 'wellcare' as opposed to 'illcare' Monitoring for the earliest visible signs and dealing them with tailored treatment plans [36] are available. Artificial intelligence Driven diagnostics such as IBM Watson for Oncology [36] can provide fine, evidence-based recommendations to assist patients with chronic diseases, also improving outcomes of their treatments. Despite some challenges, AI in surgery has some promising advancements. 3D printing extends E- Health services into ever more precise fields, creating patient-specific prosthetic apparatus or implants that feel better and functionally can go better. AI-driven platforms provide real-time mood monitoring system as well as intervention in mental health system. Such as, Emotive AI and robotics support therapy sessions through friendship, cognitive behavioural help to patients. The framework for this kind of framework is showing in figure 2.

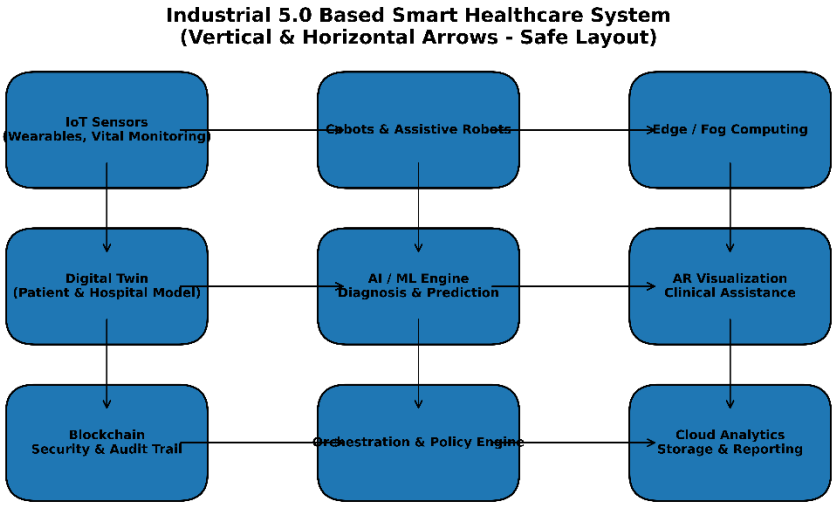


Fig 2: Components related to integrating healthcare and industry 5.0

The Figure 2. displays a conceptual Healthcare Framework based on Industry 5.0, where advanced technologies work collaboratively with human intelligence to deliver personalized, efficient, and patient-centric medical services. At the very first level or layer different data generating sources are deployed these sources can be wearable devices, IoT-based medical sensors, smart hospital equipment, and patient monitoring systems continuously collect physiological data including heart rate, blood pressure, oxygen levels, body temperature, and activity patterns. This data is further sent to an upper layer i.e. intelligent processing layer . This layer integrates Artificial Intelligence (AI), Machine Learning (ML), Big Data Analytics, and Edge Computing. It helps in enabling fast decision-making close to the data source while reducing latency and congestion.

In the next very step, Industry 5.0 tools such as collaborative robots (cobots), digital twins, cyber-physical systems, and intelligent automation interact with healthcare professionals rather than replacing them. This human-machine collaboration which is feature of industry 5.0 supports tasks like precision surgery, automated drug dispensing, real-time diagnosis assistance, rehabilitation support, and remote patient care. The framework has to be eqipped with a secure cloud layer. This layer helps in long-term storage, electronic health records (EHRs), and predictive analytics. It also ensures data accessibility for doctors and healthcare providers anytime and anywhere. The output layer supports decision support systems, alerts, and visualization dashboards.

Telemedicine and remote counselling services enable access to mental health care in places where it has never before been available. Using VR/AR technologies, mental health treatment becomes like "being there": immersive therapy for anxiety, stress disorders, or post-traumatic stress disorder. Blockchain technology, by ensuring security

and confidentiality around patient data, helps digitized health systems gain patient trust. Combined with human-centred care, Health Care 5.0 focuses on technology advanced to the point that it impacts the body and also alters the spirit, providing hope and relief; alleviating suffering tailored to the individual.

4 Conclusion

The combination of Smart Industry 5.0 technologies offers User-Centered, individualized modern Healthcare 5.0. With the aid of the IoT, AI, digital twins, robotics, and blockchain, real-time health monitoring, personalized therapies, and precision medicine are possible. The provision of personalized healthcare is enhanced through AI diagnostics, healthcare wearables integrated with the IoT, and blockchain secure data management and cloud storage. Cobots not only increase the precision of surgical and rehabilitation procedures but also decrease the error margin, while enhanced 3D printing technology provides patient-centered customizable prostheses and implants. AI applied in mood monitoring coupled with cognitive therapy and immersive virtual/augmented reality for treating pain, anxiety and PTSD is innovating mental health care. Remote care and telemedicine services provide needed health services in medically underserved areas. Nonetheless, various crucial issues like data, costs, ethics, and professional training are still there that needs to be solved and discussed. For adopting 5.0, there is need to be overcome these critical issues which intend to provide healthcare that is safe, sustainable, accessible.

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