

**Artificial Intelligence’s Significance for Industry 4.0 and Healthcare**

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**Abstract**

Artificial Intelligence (AI) is rapidly gaining popularity as a logistical tool in digital technology, with a wide range of applications in preventive medicine and management. Smart hospitals, also known as Hospital 4.0, are a must-have in today's COVID-19 scenario. The Industrial Internet of things (IIoT) known as the fourth industrial revolution served to be at rest during the COVID-19 crunch. The purpose of this article is to shed light on Industry 4.0's smart system during the COVID 19 pandemic by giving improved digital techniques without causing threats to healthcare. This article discusses how AI and Industry 4.0, when used together, can transform the entire scenario of our medical procedures and healthcare systems, as well as many other technologies that are now being used in the medical industry 4.0.

**Keywords-** Artificial intelligence, COVID-19, IIoT, Smart technologies, Industry 4.0.

**Artificial intelligence: An Overview**

Machine learning is a sort of artificial intelligence in which the intellect and the machine are integrated. Machines that demonstrate human intelligence are essentially artificial intelligence, but they must also act, react, and think like humans in every manner possible. Object reasoning, representation, planning, realization, and manipulation are some of the objectives of AI research. Artificial intelligence (AI) is a term that refers to the use of technology to instruct machines and human intellect to imitate and simulate human actions. AI is a science fiction technology based on high-tech robots that can be terrifying to some. In industries where there are shortage of trained personnel and people die due to a lack of resources, AI has a lot of potential. AI is a broad subject in today's day, and it has the potential to deliver a developed and better future in the field of **healthcare**<sup>1</sup>.

**Types of Artificial Intelligence**

AI is divided into three categories, which are outlined and explained below:

<b>Artificial Narrow Intelligence (ANI)</b>	<b>Artificial General Intelligence (AGI)</b>	<b>Artificial Super Intelligence (ASI)</b>
ANI is a class of artificial intelligence devices that can easily execute routine tasks and appear to work in the same way that a human does with his restricted area of the brain. It is unable to multitask at the same time. As a result, we can conclude that this sort of AI is less capable than others. These are primarily used for checking the weather, playing computer games, and so on.	AGI is a machine-based representation of a human being. These systems have all of a human's powers and abilities encoded via software programmes. These systems are capable of comprehending and learning any task that humanity can carry out. Self-driving automobiles and other smart systems are examples of smart systems.	ASI refers to systems that can appear to be miracles in the face of any human difficulty and are far smarter than humans. For the time being, these will be the most brilliant and brilliant human minds.

**Industry 4.0: An Introductory Overview**

Industry 4.0 is a buzzword that refers to an increased rate of innovation not just in academics but also in industry. In the medicine field, IIoT has a wide range of applications, including personalized implants, Hospital 4.0, pharmaceuticals, and medical devices. In terms of information transparency<sup>2</sup> and interconnection, this revolution has a worldwide influence. As a result, it opens up new logistical possibilities and manufacturing solutions, and with the help of the internet<sup>3</sup>, these advancements are virtually spread to everyone. Artificial Intelligence (AI) is rapidly gaining popularity as a logistical tool in the Industry 4.0 era. The only technology that can be utilized in robotics to learn new abilities<sup>4</sup> is AI.

Artificial intelligence systems are made up of smart sensors that allow machines to connect with one another. They also aid in generating profits by lowering manufacturing costs and increasing production yields with greater efficiency<sup>5,6</sup>. Industry 4.0 connects digital production<sup>7</sup> by bringing IT (Information Technology) and OT (Operational Technology) together. Big data and data analytics, machine-to-machine communication, cloud solutions, simulation, end-to-end software integration, digital twin, smart industries, smart objects, mobile devices, wireless networking, and 3D printing<sup>8</sup> are all included in this category. It employs AI technology to enable better robots in hospitals to diagnose and monitor tasks digitally. It is used by a variety of enterprises to increase product efficiency and quality, as well as cost budgeting and user satisfaction<sup>9,10</sup>. By preserving structured electronic health data<sup>11</sup>, digitization has played an important role in minimizing the load of endless health documentation. Patients are monitored using smart gadgets such as wearables. Smartphones are now being used as diagnostic tools.

**The following are the stages of Industrial Revolutions and Other Industrial Era Transformations:**

Early/Primary Industrial Era	Secondary Industrial Era	Ternary Industrial Era	Fourth Industrial Era
Europe and the United States were the only places where the First industrial revolution took place (1760 -1840). The merchandized industrial system arose as a result of mechanized production. Textile and iron industries gained prominence <sup>12</sup> . The steam engine was invented with the discovery of coal, and hydro-power was widely used.	The Second Industrial Revolution (late 19th and early 20th centuries), often known as the Technological Revolution, was a period of synergy and mass production. Electric power, steel, automobiles, railroads, aviation, and telegraphs were among the many innovations that considerably enhanced the level of living <sup>13</sup> .	The move to renewable energy and digital technology were key to the Third Industrial Revolution (second half of 20th century). Digital transformation is another name for it. Thermodynamic efficiency enabled new 3D entrepreneurs to emerge.	Industry 4.0, also known as the cyber revolution, is a merging of the digital, biological, and physical realms that will begin in 2020 and will make use of new technologies such as nanotechnology, biotechnology, material science, quantum computing, and enhanced wireless technologies (Briggs and Buchholz 2019, Schwab 2016). It has the ability to raise global income levels, so assisting in the upgrading and refinement of living standards.

**Applications and Impact of AI on Health sector and Industry 4.0**

IIoT is a method for building digital hospitals that aids in the creation of a holistic and smart ecosystem that meets the demands of the health sector while saving time and money. It is a major issue in the growth of medical supplies, where automation and cybernation produce efficient solutions. AI is proving to be a boon to the healthcare industry. During the COVID-19 pandemic, wearable medical gadgets proved to be an effective tool for detecting health issues. AI aids in the detection of chronic diseases and patient mental states, as well as the provision of necessary therapeutic therapy in a faster timeframe. AI has also devised answers for doctors in terms of drug

selection and doses. The wide range of industries, including healthcare, have benefited from artificial intelligence. Doctors, patients, and administrators are all benefiting from it. The following are a few examples of AI applications:

**1. Robotics-** Robots can easily aid in menial, monotonous, and risky jobs. In the current Covid 19 scenario, robots acted as a barrier between patients and medical personnel. Surgical robots do surgeries with greater precision. Robots can assist patients in a variety of ways, including supplying mental strength, measuring venous pressure, temperature, and blood glucose levels.

**2. Use of holography-** Holography is an effective tool for using 3D images to examine various body parts such as bones, teeth, cornea, cochlea, chest, and skull. Using holography, several surgical operations such as valve renewal, joint replacement, and heart hole closure have been successfully done. Holography loupes, holography prints, digital holograms, and holography software have all been meticulously created.

**3. Sensors-** Sensors assist clinicians in assessing the patient's health status using data generated through reports. Sensors can aid in sleep monitoring, heartbeat detection, pulse rate monitoring, and oxygen level monitoring. Sensors can be installed in hospital beds, battery-operated infusion pumps, and homecare wearable devices, among other places, to meet the needs of the medical business.

**4. The Internet of Everything-** Healthcare is becoming increasingly expensive. Although digitalization and technology will not be able to stop the spread of diseases, they can make it more cost-effective. By making medical exams more convenient at home, IoT can help to improve the quality and efficiency of treatments. Smartphone apps are used to collect health data, which may then be quickly shared with the appropriate physician. Doctors could simply track and monitor the reports and provide immediate therapy and care to the patient.

**5. Massive amounts of data in health care-** Wellness is a multilateral system that was created with the goal of preventing, diagnosing, and treating clinically connected problems. Health IT is the key to storing Electronic Medical Records (EMR) received from patients<sup>14</sup> and therefore readily monitoring patient health. Doctors and patients have complete openness regarding sickness and illness symptoms, with little errors.

**6. Medical applications of artificial intelligence-** Many clinical problems are ideal for AI applications, thanks to advances in computer power and the huge volume of data created in healthcare. Patient diagnosis is aided by deep learning algorithms (CT, MRI, genomes, and proteomics). As a result, intelligent retrieval aids in the detection of diseases, the enhancement of medications, the personalization of therapies, and even the editing of DNA.

### **Implementation of Industry 4.0 in Medical Sector**

Industry 4.0 demonstrates the limitless possibility of unlocking breakthroughs in healthcare manufacturing devices and enabling the creation of customized grafts and medical equipment. Accurate and enhanced gadgets are meant to provide high-quality products that meet the needs of the customer. Patients can aggregate data with IoMT, allowing clinicians to get a more precise picture of a patient's health<sup>15</sup>. During the Covid 19 period, virtual live discussions between doctors and patients proved to be beneficial.

**1. Removing the human element-** 'Perhaps the most important prominent African ethical perspective is the importance of community<sup>15</sup>,' according to the designer. As a result, one can wonder whether AI, which has the potential to replace the human component in its functioning. Working the human component within the application of care, practitioners are able to demonstrate empathy, compassion, and care for their patients, and should be able to detect certain psychological indicators in their patients that an AI device might not be able to detect. Patients and practitioners can communicate with the program in a variety of ways (SMS, voice notes, and online electronic communication services),

and ask questions about the current stock of medicines, as well as additional stock of a specific drug that has been ordered and is ready to use, how to dispose of medical waste, and how to treat minor injuries<sup>16</sup>.

**2.Data bias and Security-**To safeguard data and cloning, a number of security methods are available. With the growing number of medical records being collected for nefarious purposes, cybersecurity has become a hot topic. Hackers with advanced skills are attempting to steal surgical procedures, test and study results, patient data, and drug formulae. The industrial internet of things and big data analytics<sup>17</sup> both rely heavily on cybersecurity to protect personalized data.

**3.Quality control -** The importance of quality assurance cannot be overstated. Industry 4.0 is a smart factory 4.0 that monitors and delivers high-quality medical goods that are integrated, collaborative, and evolving throughout their supply chain. Various models have been adapted to maintain product standards with the fewest potential errors<sup>18</sup>. Medical-surgical equipment, diagnostic devices, implants, and a variety of other disposables, sensors, AI, machine learning, and robotics are all technology that can help enhance healthcare. Quality testing ensures product effectiveness based on input from social media sites, allowing for quality excellence with minimal flaws and waste<sup>19</sup>.

**4.Customization of implants& provide implants in lesser time-** Anatomically, patient-specific implants mirror the detected area of the body. Both the surgeon and the patient benefit from customized implants combined with bio-models<sup>20</sup>. Cranial implants, Maxillofacial implants, Mandibular implants, and orthopaedic implants are the four types of implants available. Patients benefit from 3D printed lightweight implants that fit their needs and bond with the body, resulting in a minimal risk of infection<sup>21</sup>. In the fabrication of implants, 3D printing technology is commonly used. There have been several reports of successful procedures using 3D printed implants to replace parts of the skull. A number of personalized hip, elbow, knee, and jaw implants have been successfully manufactured<sup>26</sup>. Implants and other medical models are made at a lower cost and in less time<sup>27</sup> using innovative approaches and technologies.

**5.Digital hospitals-** Hospitals can now be computerized and modernized for better clinical care thanks to digital transformation. Covid has played a critical part in the management of the smart hospital's infrastructure via online patient portals. Hospital4.0 improves patient satisfaction and customer service. Patient and employee well-being designs, safer, healthier, and greener surroundings, reduced documentation and administrative effort, continuous clinical focused therapies, mobility, augmented and virtual reality, and well-being designs<sup>22,23</sup>.

**6.Intriguing and fabrication of surgical devices-** In the field of medical tool manufacturing, technology is redefining and boosting efficiencies. Medical supplies for critical care, surgical sterilisers, drug delivery, implants, suturing materials, and ophthalmic tools are among the products being developed. Healthcare equipment can be single-use or reusable<sup>24</sup>, and factories with real-time intelligence are developing and designing them.

**7.Management during a medical emergency-** Medical emergencies can occur at any time and without warning. Hospitals serve an important role in the provision of health care and are primarily responsible for saving lives. Doctors and therapists provide individualized treatment based on the severity<sup>25</sup> of the condition.

**8.Cost-effective for the hospitals-** In every industry, smart manufacturing improves decision-making effectiveness and cost efficiency considerably. "Not Impossible," a research firm that creates medical instruments, technologies, and prosthetic limbs<sup>28</sup> using low-cost opensource methods.

**9.Improved accuracy as per patient match-** It aids in the organization of patient identification as well as their medical history records. The Vax Beads concept is introduced. Each Vax Bead represents a victim, and a medical report with their initials, date of birth, and an identifying number<sup>29</sup> may be printed off. These beads also aid in the administration of medications, including dosages, to patients.

**10. Multi-material implants, tools, and devices with tremendous strength-** In the manufacture of medical implants, a wide range of materials are used. Silicon, surgical mesh, polyethylene, titanium, polyurethane foam, polylactic acid, and emerging 3D printed **bio-materials**<sup>30</sup> are among the most frequent and innovative materials. Using additive manufacturing, high-strength biochemical implants with optimised geometry and **mass**<sup>31</sup> can be created.

**11. Provide flexibility-** Industry 4.0 refers to a new era of flexible manufacturing, allowing for the creation of logistically and value-added integrated health and care services. Industrial products, medical equipment, and cultural **artefacts**<sup>32,33</sup> that are flexible to shape, affordable, and mass customized.

**12. Improved research and development-** To improve the research and development sector, a variety of tactics are used. Digitized R&D contributes significantly to increasing efficiency and reducing risk<sup>34</sup>. The Materials Innovation Factory (MIF) has a devoted team of researchers and scientists who have designed numerous computer-aided materials, solid-state materials, and **material chemistry**<sup>35</sup>.

**13. Precise for surgeons-** A smart manufacturing method ensures that all of the medical parts and components are exact and tailored. The surgeon serves as a co-pilot, managing all scenarios and gathering data on **patient**<sup>36,37</sup>. Surgical robots will aid surgeons and improve surgical outcomes.

**14. Improve communication-** In healthcare, technology has a liberating effect. Patients' well-being and wellness are managed using smart medical devices, wearables, electronic health records, the internet of things, electronic chips, big data, and online patient portals. **Wi-Fi**<sup>38</sup> is used to exchange data with doctors and provide feedback to patients. A chatbot can collect data from patients and provide it straight to their primary care **physician**<sup>39</sup>.

**15. Reduces surgery risk & Inventory of Implants-** Surgery 4.0 incorporates robots, which aids in the reduction of pharmaceutical errors and surgical hazards. Models for dynamic risk management are being **developed**<sup>40</sup>. Industry 4.0 forces researchers to develop the right geometry of implants and create models for them. Reduce inventory costs, increase flexibility, and reduce implementation time. Implants are extremely durable, and the IIoT eliminates paperwork by collecting patient data **digitally**<sup>41,42,43</sup>.

**16. Identifies the level of diseases-** Big Data aids in the storage and collection of patient data from a variety of sources. It is feasible to forecast the effect of a medicine on infected tissues and cells using this technique. **Mindstrong**<sup>44</sup>, based in California, recently published a study demonstrating how their technology can detect sadness and mental problems by monitoring how individuals use their smartphones.

**17. Virtual reality & complete monitoring-** The healthcare industry is using virtual reality simulations to teach doctors, nurses, and health staff to deal with the expected surge of COVID-19 patients in **India**<sup>45</sup>. Aids in the visualization of a three-dimensional representation of the patient's data. Enhances the design and quality of intelligent products. Provide the ability to electronically develop and test medical equipment and medications, discovering flaws and fixing inadequacies without significant expenditure or **labour**<sup>46</sup>. Patients' heart rates and relaxed states are affected by musicotherapy when **VR devices**<sup>47</sup> are used. The IIoT benefits by following the patient's treatment progress and capturing all data. Its mission is to monitor public health issues and provide an appropriate and optimized response using various healthcare devices and technologies. Improve the quality of medical care with **cost-effective management**<sup>48,49</sup>.

**18. Holography-** Holographic technology allows medical data from the entire patient to be framed in a three-dimensional representation. It translates body information into digital format, allowing doctors to accurately visualize patient data in a multi-angle view. Holography is a strong medical technique with applications in orthopaedics, cardiac electrophysiology, radiological treatments, and surgical **procedures**<sup>50</sup>. As a result, the technology is producing better patient results.

## Applications of internet in health care

Things have not been normal in the midst of this pandemic, and we are doing everything from distance, despite the fact that we all know that healthcare is not an option, but rather a must. As a result, we must develop methods to ensure that doctors do not become infected and that medicine is delivered to patients quickly. The following are a few of the modified techniques:

**1. Telemedicine-** This technique is viewed as a lifesaver in those situations since it reduced time, increased effectiveness, and allowed medical services to be delivered in a much shorter period and in greater numbers. Some equipment that can assist with this technology are now available on the market, and they can quickly do routine body checks and upload a patient's record to the internet, making it easy for everyone to keep track of it. These can be used to detect blood types, test blood pressure, and keep track of glucose levels, among other things. Our government has also begun various mobile programs in order to improve and expand this technology, which is also a significant change in our lives<sup>52</sup>.

**2. An intelligent personal assistant for homes-** Nowadays, many residents in metro cities don't have enough time to look after one another, leading to many elderly and children living alone and need assistance. As a result, these virtual assistants serve as their personal assistants, allowing them to communicate with their loved ones via audio or video. It features timers for everything from meals to meditation to medicine, and it also allows them to contact all of their family members with a single call. As a result of its virtual nature, this technology is seen as professional and is primarily<sup>52</sup>.

**3. Preventive medical observation-** Some individuals forget these things owing to acute conditions such as schizophrenia, aging-well, dementia, Alzheimer's, and so on, as well as old age, and here is where technology comes in. For example, Otsuka Pharmaceuticals and Proteus Digital Health proposed Abilify Mycite, a tracking system that can easily keep track of which medicine was taken, how much of the drug has already been given, and how much more is to be given, making it easier for the patient's family and doctor to remember. This system includes a patch that can be worn on the hand and detects pills and provides data<sup>52</sup>.

**4. Prompt response systems during emergency-** Some technologies are now available that can monitor the patient's pulses, blood pressure, and other vital signs, and any drop in the pulse automatically alerts the system, which activates the emergency assistance and alert mode, allowing connected family members and doctors to understand the patient's current condition and easily assist them when needed. This is especially useful in situations of Alzheimer's and other dementias.

**5. Detection of skin cancer-** Melanoma (skin cancer) is a disease that affects the skin cells that create melanin. The AI algorithms determine whether scanned data is indicative of a malignant skin disease, such as melanoma<sup>51</sup>. In fact, according to the findings of one study, AI is 8-9 percent more successful than human doctors. It produced performance outcomes of up to 95%, demonstrating the usefulness of AI in melanoma diagnosis. Some newer apps, such as Skin Vision and Mole Mapper, allow you to take aerial images of your moles and follow them over time and helps in aid in long-term disease detection and make the journey easier<sup>54</sup>.

**6. Redefining eye health using AI-** The eyes are the most significant part of our body. As a result, eye health becomes crucial to consider, and as we all know, if a problem can be found early on, the chances of curing the disease increase, and an issue like vision loss can be avoided. To overcome it, a combination of ophthalmology and AI is the best solution. Artificial intelligence (AI) will change eye care in the coming years, and the first area to gain from AI enhanced Health is diabetic retinopathy and diabetic macular edema screening. Retinopathy of Prematurity (ROP), Macular Degeneration, Glaucoma (which has received less research than retinopathy), and identifying refractive error from fundus photographs are the fields that are gaining the greatest ground (for increasing the percentage of accuracy of physicians). As a result, we can plainly see how ophthalmologists, in conjunction with AI, can revolutionize the healthcare industry<sup>55 (A)</sup>

**7. Developmental processes of a drug-** AI, as a technical helper, provides far more precise and accurate findings than humans. AI quickly recognizes the target and its starting materials, as well as all available information about the case study, ongoing research on the topic, progress made to that point, all clinical trials, and the problem of idiosyncratic symptoms and how they can affect the patient's body, tissues, and so on, which brings the correct location from which the job must be begun and on which path we must strive to achieve more effective results, making the production process faster and easier to meet each and every need<sup>55 (B)</sup>.

**8. Stimulation of a patient in unconsciousness (coma)-** The brain dead (unconscious), is the only state in which the human mind cannot anticipate whether a person will be able to return their original state or whether they will never be able to do so. However, if AI identifies the condition of cells, muscle flows, and blood flow rates, among other factors, and then offers an exact result based on all of those factors, it was discovered that AI has an accuracy of 90% by retaining the patient's brain activity record. And it was discovered that the results were very accurate, with all of the predictions coming true 98-99 percent of the time in several cases<sup>56</sup>.

**9. AI advancement to emotions: Identification of Depression-** Because the person does not want to be exposed in these stages, keeping a record of the sickness is difficult, but we can follow it using AI. Our cellphones, which are the devices closest to humans nowadays, can also track it; it keeps a record of what we see, click on, and how we browse through our feed, which effectively tracks our moods and, over time, may also track disease (as per magazine article *-Mindstrong- California based*)<sup>57</sup>. According to the results of a study, persons who had chat secession with AI experienced fewer mental disease symptoms<sup>58</sup>. As a result, AI can aid in the detection and treatment of depression.

**10. AI Robots as medical professional-** Artificial people, in comparison to humans, are better capable of storing data on a larger scale. We can learn anything, but it takes time to grasp everything. AI, on the other hand, can absorb more information in less time and store enormous amounts of data. As a result of this advantage, it can study the human body faster and remember it, as well as preserve records of the patient's ailments, including all research results connected to that sickness and all possible cures. As a result, we can conclude that robots can perform the functions of a doctor and provide more accessible results<sup>59</sup>.

**11. A large amount of data for health care-** Every year, each country in the world offers its budget, which outlines how much money has been spent on healthcare and how much more or less has to be added or cut based on the previous year's situation. AI<sup>60</sup> is required to maintain a track record, to push these problems to alternate payment models, and to prevent capital waste.

**12. The solution to this amount of data: Alternative payment models (APM)-** The National Comprehensive Cancer Network (NCCN) is in charge of gathering all cancer patient data and overseeing their treatment. Evidence blocks have been established to raise the rate of growth in terms of accuracy, safety, quality, affordability, and so on. The main purpose of these blocks is to choose the best value in terms of "preferred regimens" and "alternative regimens." Similarly, the ASCO has developed a paradigm in which a scorecard based on toxicity and medical progressive advantages, known as the Net Health Benefits (NHB) score, is supplied to assist patients and clinicians in making decisions<sup>60</sup>.

**13. Keeping record of patients by using advances digitized classification systems-** The *John Theurer* Cancer Center has developed a new computerized cancer classification system called COTA Nodal Address (CNA), which saves all records in one place using a password-protected code and the patient identification number. This information is more accurate, and these studies can be used as primary research or secondary research in the future. COTA records co-morbidities, drug effectiveness, poisoning effects, how the patient is reacting (i.e, response), next appointment date, previous/progression-free survival, quality of life, and cost.

**Healthcare by using contemporary devices or machines**

**1.3-Dimensional printing-** 3D printing, also known as additive printing, is a method of printing materials with the exception that we do it in 3D or physical mode. This technology is being applied in the healthcare area to create helpful medical devices, such as retainers that can be customized to the user's needs. The best application these days is in the pharmaceutical area, where we need to adapt the drug dosage, size, or release substance according to the needs of the user, e.g., small dosages for children and medium doses for adults, and they may also choose a color that is easier to swallow<sup>61</sup>. Since 2015, this technique has been employed in medicine under the name **Spritam**<sup>62</sup> (the first 3-D created drug used by people internally).

**2. Robotics in healthcare-** Robots are superpowers in transforming the clinical landscape and bridging the gap between health care providers and patients. Robotics has the potential to improve the accuracy, efficacy, and financial cost of healthcare. The ideal combo for healing a person with 100 percent certainty value is to employ technologies like VR, AR, and AI in conjunction with the human brain. The da Vinci Surgical **System**<sup>63</sup> has been employing this for several years and has treated about 3 million patients globally through **surgery**<sup>64</sup>. Artificial intelligence and robots are currently being combined to deliver a golden key to the healthcare business.

**3. Unmanned aerial vehicles-** Drones have taken over the **world**<sup>65</sup>. In terms of healthcare, this can be more efficient in terms of moving medical supplies, vaccines, and other supplies during an emergency. According to experiments conducted in the United States, drones were capable of delivering critical quantities of blood and rarely used medications, particularly in situations when speed was **critical**<sup>67,68,69,70</sup>. As a result, we can see that unmanned aerial vehicles (UAVs) have a bright future in the healthcare **industry**<sup>71-81</sup>.

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