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# Machine Learning in Industry 4.0

Manju Payal<sup>1</sup>, Dr. T. Ananth Kumar<sup>2</sup>, K. Suresh Kumar<sup>3</sup>

Software Developer, Academic Hub Ajmer, India<sup>1</sup>

Department of Computer Science and Engineering, IFET College of Engineering, Tamilnadu, India<sup>2</sup>

Department of Electronics and Communication Engineering, IFET College of Engineering, Tamilnadu, India<sup>3</sup>

**ABSTRACT :** In the field of medicine, machine learning algorithms are making use of the ever-increasing amounts of patient data. Detection, diagnosis, and prognosis are all central concerns in a number of these areas of study. The number of applications that make use of machine learning is rapidly expanding in the field of health care, and this trend has the potential to have a significant influence on the sector. The management of common chronic conditions as well as the exploitation of patient health data are two examples of the many applications of machine learning in the healthcare industry. Machine learning is a cutting-edge technical application that is currently being utilised on a large scale and has recently emerged as a major trend in the business world. There are many different contexts in which one might employ machine learning. It has implications in a wide range of fields, including finance, the life sciences, and defence, among others. The ability to accurately predict illness is one of the many benefits provided by machine learning, which is used to extract patterns from various medical data sources.

**KEYWORDS:** Machine learning; Artificial intelligence; Industry4.0; Automation

## I. INTRODUCTION

Machine learning is a driving force behind significant advancements and innovations in the healthcare industry. It has applications in clinical operations, surgical research, drug development, and data management, all of which are reaping the benefits of the technology. [1] Currently, the field of machine learning is being utilised in a variety of settings within the healthcare industry. These settings include the enhancement of pre-existing medical procedures, the administration of patient records and data, and the treatment of a wide variety of illnesses. [2] The use of machine learning could assist healthcare providers in meeting an increased demand, lowering costs, and improving processes. Machine learning (ML) is a subset of artificial intelligence that has had a significant impact on numerous fields and industries all over the world, including healthcare and medicine. [3]

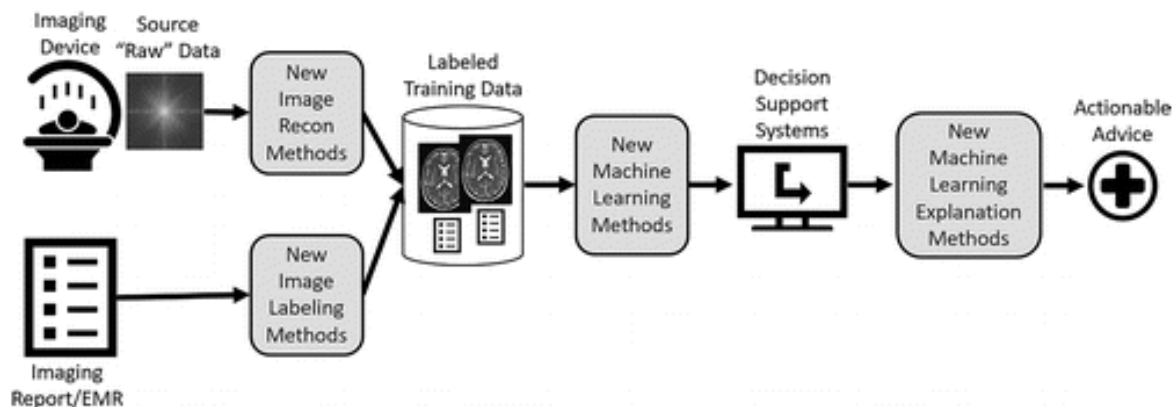


FIG. 1. Automation System in industry 4.0

The combination of visuals and narrative reports to create decision support systems that provide actionable guidance is depicted in this diagram. In medical imaging research, ML has a number of applications (shaded boxes).

The term "electronic medical record" refers to a computerised medical record.[4]The healthcare industry has long been a user of technological advancements, and it has reaped many benefits as a result. Machine learning, which is a subset of AI (Artificial Intelligence), is crucial in health-related issues. Machine-learning advancements have resulted in improved data and record management, the invention of novel medical techniques, and the treatment of chronic diseases.[5]

### 1.1. Major applications of machine learning in healthcare

Machine-learning technologies have shown to be a benefit for the healthcare business, from increasing hospital efficiency to providing precise diagnoses. Here are some of the most important machine learning applications in the healthcare business for greater user engagement and revenue generation.[6]

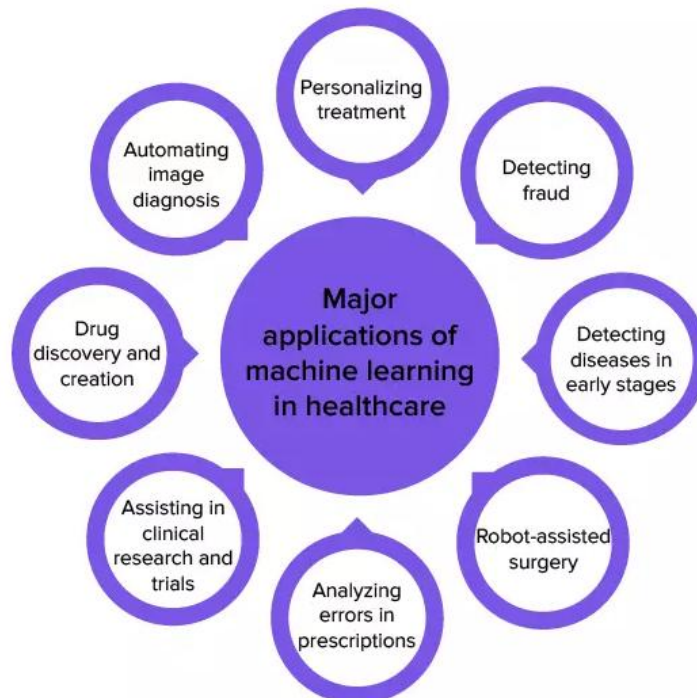


Fig. 2. Applications of Machine Learning

#### a. Personalizing treatment

Medicine is making remarkable strides with machine learning. IBM Watson Oncology stands out as a pioneer in this field, offering a variety of therapy options based on a patient's medical history.[7]When it comes to developing individualised treatment plans, things are going to get even better as improved biosensors become more widely available. This will provide more data for algorithms, which in turn will make things even better. [8]

The provision of individualised treatments is one of the applications of machine learning that arises most frequently in the field of healthcare. It makes it possible for healthcare organisations to provide individualised patient care by analysing the medical histories, symptoms, and tests of individual patients. Using machine learning in medicine and healthcare, physicians are able to develop individualised treatments for their patients and prescribe medications that specifically target the disorders that each patient suffers from. [9] Obtaining analyses based on the electronic health records of a patient can also be done through the use of machine learning by healthcare companies. Because of this, clinicians are able to make quicker decisions regarding the treatment option that will benefit the patient the most. In addition, the application of machine learning in the medical field can assist clinicians in determining whether or not a patient is prepared for a change in their prescription. This makes it much simpler to obtain the appropriate treatment as soon as possible. [10]



b. The Detection of Fraud

The United States Department of Justice estimates that there is unethical behaviour associated with approximately 3% of all healthcare claims made in the region. This results in a loss of one hundred billion dollars each and every year. The healthcare industry can use machine learning models to identify claims that are not valid before they are paid, which speeds up the approval process, the processing of valid claims, and the payment of those claims. In addition to preventing theft of patient information, machine learning safeguards against fraud committed against insurance companies. [11]

AI and machine learning are being used by some of the most reputable healthcare organisations, such as Harvard Pilgrim Health, to fight fraud in the healthcare industry. In order to identify claims and detect suspicious behaviour, they make use of fraud detection algorithms that are based on machine learning. [12]

c. Early diagnosis and treatment of infectious diseases

There is a wide variety of diseases that need to be identified in their earliest stages in order to devise an effective course of treatment and guide patients toward leading healthier lifestyles. A mixture of supervised and unsupervised algorithms is used to assist medical professionals in the early diagnosis of diseases. This type of learning falls under the umbrella of machine learning. [13] ML compares newly collected data to previously collected data on a specific illness; if the symptoms indicate a red signal, then clinicians can take the necessary steps to treat the condition.

d. Operation with the assistance of a robot

Both the accuracy and the speed of surgery have been significantly improved thanks to the use of machine learning-powered surgical robots. With the help of these devices, even the most complicated surgical procedures can be carried out with less risk of pain, blood loss, and other adverse effects. Additionally, recovery time after surgery is reduced, making it much simpler and quicker. [14]

Maastricht University Medical Center is one of the best examples of machine learning in use within the healthcare industry. An ML-powered surgical robot has been used to sew together small blood arteries with a thickness of less than 0.03 millimetres. [15]

In the fields of medicine and healthcare, the application of machine learning enables medical professionals and surgeons to acquire real-time information and insights into the current health condition of a patient. As a consequence of this, medical professionals are able to make educated decisions prior to, during, and after treatments in order to achieve the best outcomes that are humanly possible. [16]

e. Investigating mistakes made in prescriptions

In the United States, between 5,000 and 7,000 people lose their lives annually due to errors in prescriptions. These errors are frequently the result of faulty EHR interfaces, which lead to clinicians selecting the incorrect medications from a drop-down menu or becoming confused about dosing units. In these kinds of predicaments, machine learning technology can be a lifesaver. The new prescriptions are compared to the EHR data from the past using ML models. The prescriptions that deviate from the standard practise are highlighted, which enables medical professionals to examine and modify them as necessary.

For instance, in order to recognise potential prescription issues, the Brigham and Women's Hospital uses a system that is based on machine learning. The system identified 10,668 potential errors over the course of a year, of which 79 percent were clinically useful. As a result of these discoveries, the hospital was able to reduce its operating expenses by \$1.3 million. [17]

A mistake detection system that is powered by machine learning can improve the quality of care by reducing the risk of drug overdose and other health concerns, in addition to saving money.

f. Contributing to medical studies and research in a clinical setting

Both the clinical trials and the research themselves are time-consuming and costly endeavours. This is for a very good reason: before new pharmaceuticals and medical treatments can become widely used, they need to have their safety thoroughly investigated. However, in certain situations, such as when administering vaccinations against COVID-19, the solution needs to be made available as quickly as is practically possible.

Fortunately, algorithms that use machine learning can make the process go more quickly. These algorithms can assist in the selection of the most suitable trial sample, the collection of additional data points, the analysis of ongoing data from trial participants, and the reduction of errors that are based on the data. [18] g. The development of new medications and their discovery

This is without a doubt one of the most significant benefits that can be gained from applying machine learning in the medical field. Machine learning has the potential to find new medications that have significant economic benefits for patients, hospitals, and pharmaceutical companies. In addition to this, it makes the process of developing new drugs more productive and economical.

Atomwise is one example of this type of startup company in the pharmaceutical industry. The company uses supercomputers to derive therapies from molecular structure databases. In 2015, Atomwise utilised their deep learning technique in order to determine which existing drugs could potentially be modified in order to treat the Ebola virus. They found two medications that have the potential to help reduce the risks associated with the epidemic. The technology that is based on Atomwise ML made it possible to complete an analysis that would have taken years in just a single day. [19] Automating image diagnosis

Machine learning is used in healthcare facilities like hospitals and clinics to identify potential issues in a variety of medical images, such as MRI and radiology scans. Image recognition allows medical professionals to make a number of important diagnoses, including malignancies, infections of the liver and kidneys, and improvements in cancer prognoses. The tool that is used at the University of Virginia Hospital is the most successful example of ML-powered visual perception. The programme uses machine learning algorithms to analyse biopsy photos of children in order to differentiate between celiac disease and environmental enteropathy. In doing so, the programme achieves the same level of accuracy as clinicians.

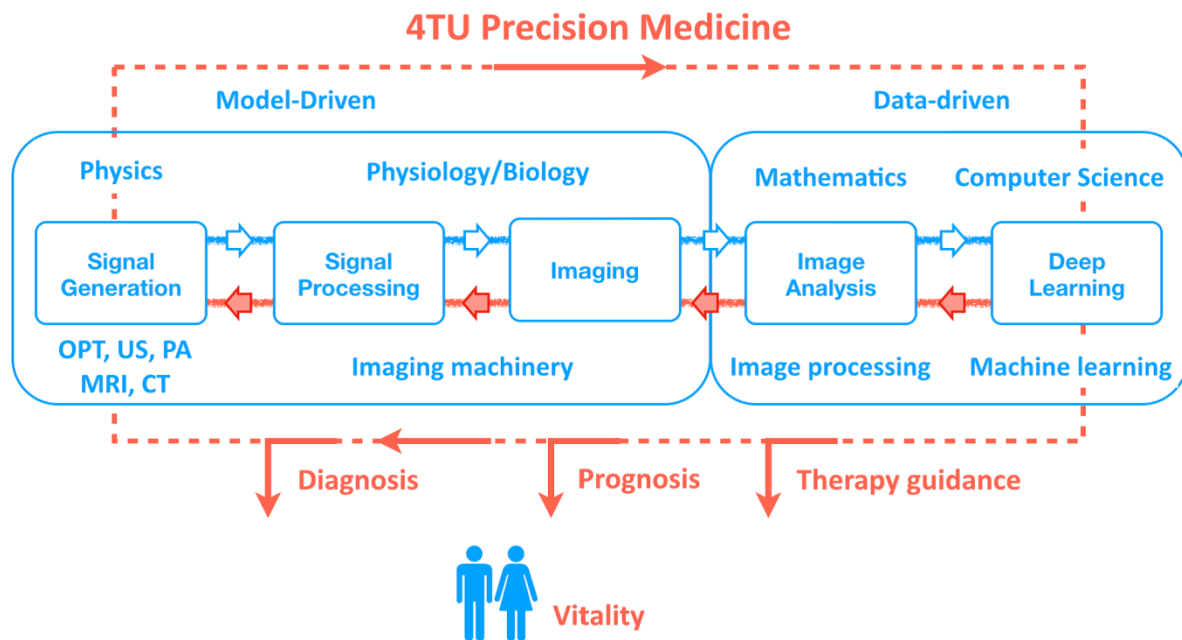


Fig. 3. Automation in Healthcare Industry

Enhance the precision of diagnosis, prognosis, and treatment options. On the one hand, the use of advanced imaging technology in large studies, combined with advanced data-driven approaches such as deep learning, holds the current promise of precision medicine, i.e. individualised prognosis and treatment tailored to the individual patient, as shown in the diagram below. State-of-the-art physics-driven clinical imaging modalities, including as CT, MRI, optical, and ultrasound imaging, on the other hand, can give various structural and functional information at high resolution.[20]

*Precision Medicine* is a paradigm change in medicine from a one-size-fits-all strategy to a tailored and personalised approach. This is important for early detection and delivering the right treatment in the right method at the right time to give patients a better prognosis. It has the potential to improve quality of life while lowering health-care expenses at the same time.[21]



## II. LITERATURE SURVEY

The Authors proposed a method for making decisions for heart patients. In order to diagnose cardiac disease, physicians must make the correct decision and prescribe the appropriate treatment. For heart data patients, Rough Set Theory is employed to make a reliable judgement. The rough set technique provides rules that provide greater clarity and accuracy, allowing the cardiologist to determine whether or not the patient has a heart condition. They looked into the fundamentals of machine learning in the healthcare field. The healthcare process and its different phases are briefly outlined in the first step of this paper. The healthcare process is divided into four sections, according to: prevention, detection, diagnosis, and treatment. The machine learning process is then briefly introduced, followed by a presentation of various machine learning algorithms, such as supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning. The author then looked at machine learning applications for diagnosing diseases, developing pharmaceuticals, performing robot-assisted surgery, and analysing medical data. The author of this work focuses on medical data analysis and the issues that it presents. The researchers [29] discussed how artificial intelligence-based technologies can be used for diagnosis, therapy, patient monitoring, disease severity detection, digital image processing, medicine development, and investigating the COVID-19 disease epidemic. This paper's proposed taxonomy consists of five sections. (1) Clinical applications of machine learning-based techniques for COVID-19 diagnosis, treatment, and monitoring; (2) ML applications for chest image processing; (3) Machine learning-based methods for studying Coronavirus and its specifications; (4) Machine learning-based schemes for modelling the COVID-19 outbreak, including epidemic prediction, monitoring pandemic, controlling, and managing pandemic; (5) Exploring the dataset available in this area. The writers sought to cover all research works available in this subject in this paper. This review study aids researchers in bettering their understanding of the condition.

### **2. Businesses in the healthcare area that use machine learning to increase the well-being of their patients and providers include:**

#### ***a. CIOX HEALTH***

**Location of the company:** Alpharetta, Georgia

**In healthcare, machine learning is applied in the following ways:**

Ciox Health is utilising ML to improve the management and alteration of health data in order to simplify clinical data access, revolutionise workflows, and improve the flow and accuracy of health statistics.[20]

**The company's impact on the industry:**

This company recently worked with Chicago-based Memorial Healthcare to improve Northwestern Memorial's ROI release of information process by bringing transparency and efficiency to it.

#### ***b. KENSCI***

**Location of the company:** Seattle, Washington

**In healthcare, machine learning is applied in the following ways:**

KenSci employs ML to prediction disease and therapy, assisting physicians and predicting public health risk by categorising patterns, modelling disease development, and identifying high-risk markers, among other things.[21]

**The company's impact on the industry:**

KenSci has lately partnered with T3K Health, a healthcare access company, to focus on assisting caregivers in integrating machine learning and ML into various health records and workflows.

#### ***c. QUANTITATIVE INSIGHTS***

**Location of the company:** Chicago, Illinois

**In healthcare, machine learning is applied in the following ways:**

Quantitative Insights' computer-assisted breast MRI QuantX has improved the accuracy and speed of breast cancer detection. The objective is to enhance patient outcomes by having radiologists perform higher-quality detection.[22]



*d. PathAI*

**Location of the company:** Cambridge, Massachusetts

**In healthcare, machine learning is applied in the following ways:**

PathAI's technology employs ML to assist pathologists in doing more accurate and timely analyses, as well as detecting patients who might benefit from novel medications and treatments.[23]

**The company's impact on the industry:**

In a series of investment rounds, the company raised roughly \$11 million, bringing its total to around \$15 million in 2017.

*e. PFIZER*

**Location of the company:** New York, New York

**In healthcare, machine learning is applied in the following ways:**

Pfizer employs IBM's Watson Artificial Intelligence technology in an immuno-oncology study to learn about the body's immune system in order to combat cancer.[24]

**The company's impact on the industry:**

Pfizer has extended its collaboration with XtalPi, a Chinese technology startup, to develop an artificial intelligence platform for creating and discovering small-molecule pharmaceuticals.[25]

*f. MICROSOFT*

**Location of the company:** Redmond, Washington

**In healthcare, machine learning is applied in the following ways:**

Microsoft's InnerEye project employs machine learning to discern between healthy anatomy and cancers, using 3D radiological imagery to aid medical practitioners in surgery planning and treatment, among other things.[26]

**The company's impact on the industry:**

In the United Kingdom, InnerEye is being used to harvest 3D images to determine tumours' exact position and promote improved and targeted treatment.

*g. BIOSYMETRICS*

**Location of the company:** Boston, Massachusetts

**In healthcare, machine learning is applied in the following ways:**

Biosymetrics has enabled its clients to achieve data pre-processing and automated ML using its machine-learning policy Augusta, which can improve accuracy and eliminate a time-consuming task that is usually completed by individuals in various segments of the healthcare industry, such as precision medicine, biopharmaceuticals, hospital technology, and health systems.[27]

**The company's impact on the industry:**

Biosymetrics has declared the formation of a Strategic Advisory Board to assist the company's management team in furthering R&D improvement and healthcare through the use of integrated analytics ML.[28]

*h. NSITRO*

**Location of the company:** San Francisco, California

**In healthcare, machine learning is applied in the following ways:**

When data science and machine learning are combined with cutting-edge laboratory equipment, they can aid in the development of new startupinsitro medications that aim to cure patients quickly and at a low cost.[29]

*i. ORDERLY HEALTH*

**Location of the company:** Denver, Colorado

**In healthcare, machine learning is applied in the following ways:**

According to Orderly Health, it is a 24/7 automated concierge that provides healthcare via email, SMS, video conferencing, and Slack. By making it simple for the public to identify the least expensive providers and understand their paybacks, the company hopes to aid its insurers and employers in saving money and time on healthcare. This



would enable their members or employees to recognise the value of their support and seek for the lowest-cost solutions.[30]

**The company's impact on the industry:**

Orderly combined TreeHouse Health's stable of companies in 2017 and received investment to extend its operations a few months later.[41]

*j. CONCERTO HEALTH AI*

**Location of the company:** New York, New York

**In healthcare, machine learning is applied in the following ways:**

Concerto Health ML analyses oncology data with ML, providing insights that enable pharmaceutical businesses, clinicians, oncologists and payers to practise precision medicine and enhance health assemblies.[31]

**The company's impact on the industry:**

This offers a new platform called Eureka Health Oncology that combines deep data from electronic medical records to provide Artificial Intelligence solutions for clinical data delivery, management, and application.[32]

*k. BETA BIONICS*

**Location of the company:** Boston, Massachusetts

**In healthcare, machine learning is applied in the following ways:**

The iLet is a wearable robotic pancreas developed by Beta Bionics. It helps Type 1 diabetes patients manage their blood sugar levels.[40]

**The company's impact on the industry:**

The NIDDK (National Institute of Diabetes and Digestive and Kidney Diseases), which is part of the National Institutes of Health, recently awarded this company \$2 million in SBOR funding.[33]

*l. MD INSIDER*

**Location of the company:** Santa Monica, California

**In healthcare, machine learning is applied in the following ways:**

The MD Platform makes usage of ML to enhance patient-doctor matching.

**The company's impact on the industry:**

This company joined ConsumerMedical not long ago in order to strengthen their ability to refer medical doctors.[34]

**3.1. The future of ML in healthcare**

The application of ML in the field of healthcare has a bright future. Despite the challenges, machine learning is improving not only the patient experience but also clinical medicine practise and business operations in the pharmaceutical industry. And we've barely scratched the surface here. According to Grand View Research's projections, the global market for AI and machine learning in healthcare will expand at a compound annual growth rate of 38.4 percent between the years 2022 and 2030.

The growing databases of patient health-related digital information, the rising desire for individualised treatment plans, and the rising demand for more affordable medical care are some of the primary factors that are driving the expansion of the market[35]. In addition, within the next few years, it's possible that programmable robots will be able to offer assistance to surgeons in the operating room. In the field of medicine, artificial intelligence-driven solutions can assist clinicians in lowering patient risk during procedures by directing attention to the most minute aspects of the process [39].

In the field of medicine, artificial intelligence (AI) and machine learning could potentially provide earlier warnings for illnesses such as seizures and sepsis, the diagnosis of which frequently requires in-depth analysis of large datasets. [38].

In the field of medicine, machine learning is paving the way for "virtual biopsies" and contributing to the development of the cutting-edge field of radiomics. The use of machine learning and artificial intelligence to gain insights can assist medical professionals in providing alerts that are both more timely and accurate[36]. Using machine learning for risk rating, providing clinical decision assistance, and providing early warnings are some of the major areas of development that are being focused on for this game-changing method. In the years to come, machine learning will





almost certainly increase its footprint in the healthcare industry. As a consequence of this, medical professionals and clinicians have no choice but to initiate the process of utilising machine learning to their advantage. [37]

### III. CONCLUSION

The ability of artificial intelligence and machine learning to work precisely with large amounts of complex data in the healthcare industry adds value. Being incapable of making errors caused by being human is a significant asset in clinical settings. When applied appropriately, robots that make use of machine learning have the potential to significantly improve healthcare outcomes by accurately diagnosing patients and providing treatment to them much more quickly than human medical teams. This includes the field of surgery, in which robots can assist or even replace human surgeons, possibly outperforming them even in the most difficult procedures.

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