Dr. Vishwanath Karad
MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

Seminar Report

On

"Use of Artificial Intelligence and Automation for Medicine and Healthcare."

By

Vaibhav Deodhe

1032170135

Under the guidance of

Prof. Dhanashri Wategaonkar

MIT-World Peace University (MIT-WPU)

Faculty of Engineering

School of Computer Engineering & Technology

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MIT-World Peace University (MIT-WPU)

Faculty of Engineering

School of Computer Engineering & Technology

CERTIFICATE

This is to certify that Mr. Vaibhav Deodhe of B.Tech., School of Computer Engineering & Technology, Trimester – IX, PRN. No. 1032170135, has successfully completed a seminar on

"Use of Artificial Intelligence and Automation for Medicine and Healthcare."

To my satisfaction and submitted the same during the academic year 2019 - 2020 towards the partial fulfillment of the degree of Bachelor of Technology in School of Computer Engineering & Technology under Dr. Vishwanath Karad MIT- World Peace University, Pune.

Prof. Dhanashri Wategaonkar	Prof. Dr. M.V.Bedekar
Seminar Guide	Head
	School of Computer Engineering & Technology

List of figures

List of Tables

Abbreviations

AI	Artificial Intelligence	ECG	Electrocardiogram
ML	Machine Learning	EEG	Electroencephalogram
DL	Deep Learning	AutoML	Automatic Machine Learning
NLP	Natural Language Processing	CNN	Convolutional Neural Net
EA	Evolutionary Algorithms	IP	Internet Protocol
WBAN	Wireless Body Area Network	DNN	Deep Neural Networks
WLAN	Wireless Local Area Network	GSM	Global system for mobiles
WAN	Wireless Area Network	WiMax	Microwave Access
IoThNet	Internet of Things - Healthcare Networks	m-IoT	Medical Internet of Things
EHR	Electronic Health Records	BMI	Brain-Machine Interface
ANN	Artificial Neural Networks	DNN	Deep Neural Networks

Acknowledgment

I am Vaibhav Deodhe, Panel-C, Roll No. 07, (PRN. 1032170135), I have studied and analyzed the concepts written in this seminar paper to the best of my abilities. This seminar paper consumed a huge amount of work, research, and dedication.

The rigorous learning I went through while researching about the seminar topic was one of the most fulfilling tasks of my academic career. For this paper, I referenced lots of articles, journals to make sure the outcome is as authentic as possible. In this paper I have cited references for each topic or subtopic below the topic itself.

I would like to express my sincere gratitude to the faculty of computer science who gave me this opportunity. I learned a lot during the process. I also want to thank Prof. Dhanashri Wategaonkar for her guidance and support. It was a great experience to complete this seminar paper.

Vaibhav Deodhe

Index

Abstract and keywords

Abstract:

Medicine is a field that is starting to gravitate towards the temptation to incorporate automation and artificial intelligence into medical practices. Recent developments in deep learning has increased the confidence of researchers in AI models to give better results. There are many use-cases of AI application in medical diagnosis today, e.g. pneumonia diagnosis through deep learning, symptoms analysis and diagnosis. AI models can be used to provide a diagnosis from remote places using just medical equipment and suitable technology.

AI technologies can be used to provide a better diagnosis of diseases in remote areas present with a lack of medical experts and accessibility to better healthcare. This seminar report will discuss the current state of AI and automation in Medicine and healthcare and it's future. It'll also discuss technologies that make this artificial intelligence-based medical diagnosis possible.

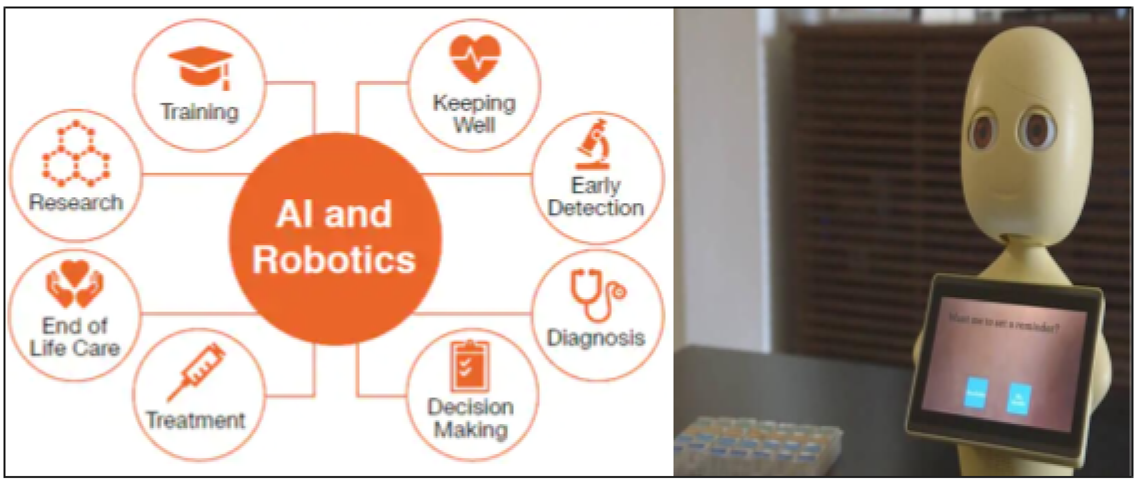
Keywords:

artificial intelligence, machine learning, deep learning, convolutional neural network, medicine, healthcare, automation, robotics

1. Introduction

AI began to be used for the convenience of medical diagnosis from the early 21st century. The advances were the result of incremental computational capacity (Moore's law & transistor count), significance on clarifying and unraveling solutions for definitive and unique problems, a new association between AI and other alternative fields like mathematics, statistics, etc. and an engagement of researchers to mathematical techniques and scientific approach.

What do we mean by AI in healthcare? In this report, we include applications that affect the care delivery, including both how existing tasks are performed and how they are disrupted by changing healthcare needs or the processes required to address them.



We also include applications that enhance and improve healthcare delivery, from day-to-day operational improvement in healthcare organizations to population-health management and the world of healthcare innovation. It’s a general definition that covers natural language processing (NLP), image analysis, and predictive analytics based on machine learning. As such, it illustrates a spectrum of AI solutions, where encoding clinical guidelines or existing clinical protocols through a rules-based system often provides a starting point, which then can be augmented by models that learn from data

2. Literature Survey

Artificial Intelligence in Medicine

https://www.sciencedirect.com/journal/artificial-intelligence-in-medicine

Artificial Intelligence in Medicine publishes original articles from a wide variety of interdisciplinary perspectives concerning the theory and practice of artificial intelligence (AI) in medicine, medically-oriented human biology, and health care.

National Center for Biotechnology Information, (National Institute of Health)

https://www.ncbi.nlm.nih.gov/

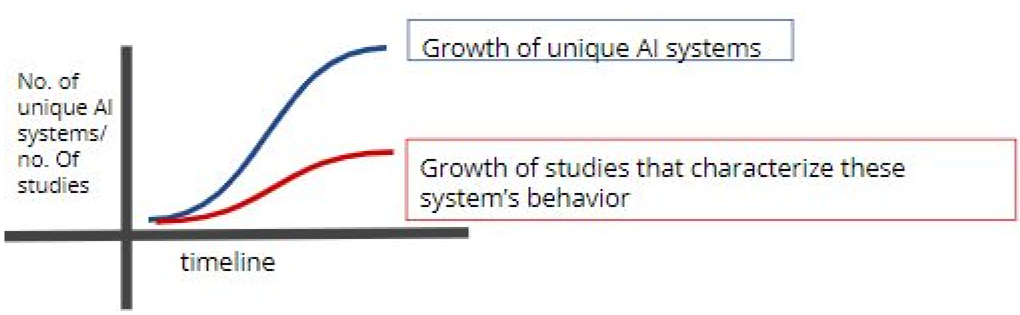
The NCBI provides open-source access to important scientific papers related to medicine and technology. The NCBI is part of the National Library of Medicine of National Health Institute, USA. The NIH aims to freely publish original research from reputed journals and provides access to scientific literature to the general population.

Wikipedia

AI	https://en.wikipedia.org/wiki/Artificial_intelligence
AI in healthcare	https://en.wikipedia.org/wiki/Artificial_intelligence_in_healthcare

As shown in the above table, these two Wikipedia articles are one of the most credible sources of information about the topic of this seminar report. They are backed by top journal references, AI textbooks. These two articles combined have more than 1000 references.

Research Gaps: AI researchers employ not only the scientific method, but also methodology from mathematics and engineering. This results in the AI Knowledge Gap: the number of unique AI systems grows faster than the number of studies that characterize these systems' behavior.



3.0 Details and analysis of Artificial Intelligence for medicine

AI refers to intelligence demonstrated by machines in contrast to natural intelligence. The term AI is also used to describe machines that mimic human cognitive functions such as learning and problem-solving.

3.1 Major goals of and approaches to artificial intelligence

It is best to understand AI by understanding what goals it accomplishes and what are the approaches it uses to accomplish those goals. Below are explained major goals of AI briefly.

Major goals of artificial intelligence

See [1]

Knowledge representation & reasoning: Knowledge representation & reasoning is a field of AI that is associated with representing knowledge about the world in a way the computer system can understand and utilize it to solve problems such as diagnosing medical conditions.

Planning: AI panning is a branch of artificial intelligence that involves setting up the action sequence for intelligent agents or autonomous robots. Given a problem where AI planning is needed, initial and final state for the problems are assigned. And planning is done from initial to final states assuming the best course of action accompanied by a reward function.

Machine Learning: Machine Learning is a study of computer algorithms that improve automatically with experience. ML algorithms use models based on sample data to make predictions on training data. Models are usually mathematical means in a sense they do optimization and search.

Natural Language Processing: NLP is an interdisciplinary field of linguistics, information engineering, and artificial intelligence that concerns the interaction between computer and human-natural languages. Challenges for NLP are natural language understanding and generation, speech recognition, etc.

Computer Vision: Computer vision is an interdisciplinary field that deals with computer's high-level understanding of digital images. It involves extraction, analysis, and understanding of high dimensional data such as image or sequence of images. Computer vision has both classical and AI algorithmic basis. It seeks to apply both its theories and models for machine vision systems.

Artificial General Intelligence: Artificial General Intelligence is the hypothetical intelligence that has the capacity to understand or learn any human task.

There is no certain unifying theory or standard that leads to research in AI. But instead there is a diverse set of approaches that are used in AI to mimic intelligence. These approaches are explained briefly below.

Approaches

See [2]

Symbolic: The Symbolic approach consists of a high-level representation of problems, logic, and search. Symbolic AI is also called good old-fashioned AI because it was the first approach used by scientists towards an understanding of artificial intelligence. One prime example of symbolic AI is an expert system that uses a network of production rules. A production rule consists of two parts, the first one is the sensory precondition(IF) and the second one is an action(THEN). Likewise, using multiple IF-THEN, a logic is written to solve a problem for an expert system.

See [3]

Deep learning: Deep Learning is a broader set of machine learning methods based on artificial neural networks with representation learning. Artificial neural networks are computing systems inspired by the human brain based on connected units called artificial neurons. In deep learning, learning can be supervised, unsupervised, or semi-supervised. Deep learning algorithms use multiple layers of neurons to extract features from data. They use deep neural networks for learning. Deep neural networks are a form of artificial neural networks with multiple layers between input and output layers.

See [4]

Bayesian networks: Bayesian network is a probabilistic graphical model that represents a set of variables and their conditional dependencies via a directed acyclic graph (DAG). For e.g. probabilistic relationship between diseases and their symptoms.

See [5]

Evolutionary algorithms(EA): In artificial intelligence, an evolutionary algorithm is a subset of evolutionary computation. The mechanisms used by EA are inspired by concepts of evolutionary biology like reproduction, mutation, recombination, and selection. EA is an optimization algorithm and it is a generic population-based metaheuristics algorithm.

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[1] See https://en.wikipedia.org/wiki/Artificial_intelligence#Challenges

[2] See https://en.wikipedia.org/wiki/Symbolic_artificial_intelligence

[3] See https://en.wikipedia.org/wiki/Deep_learning

[4] See https://en.wikipedia.org/wiki/Bayesian_network

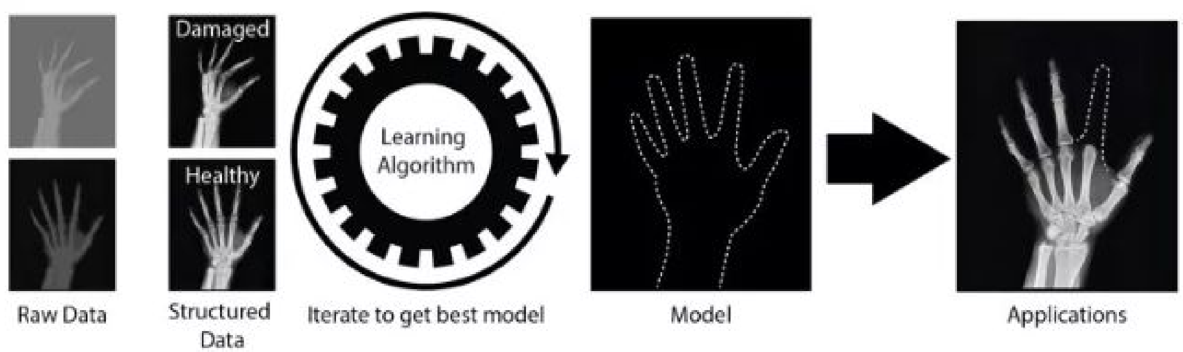
[5] See https://en.wikipedia.org/wiki/Evolutionary_algorithm

3.2 AI algorithms

An algorithm is a finite set of definite instructions that are computer implementable. Algorithms are generally used in computer science to solve mathematical or computationally heavy problems from wide range disciplines like biology, medicine, astronomy, etc.

Until AI came around, classical algorithms were viewed as a tool to attain efficiency. But classical algorithms were only helping system architects in a very definite and non-intelligent automation. This limitation of algorithms was overcome by the rise of artificial intelligence. AI algorithms started the renaissance of intelligent system design and development. Currently AI algorithms help developers solve the problems of machine-understanding and intelligence.

E.g.



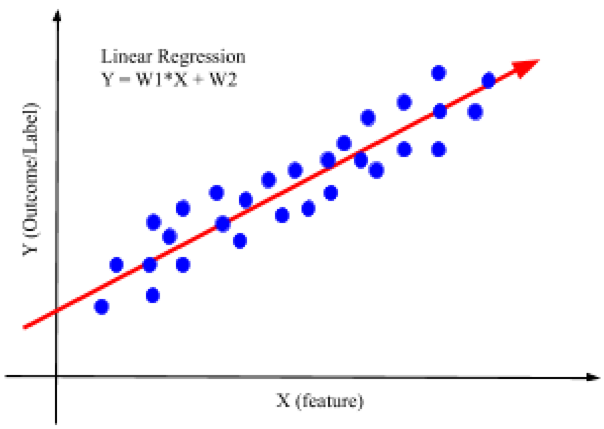
See [1] Figure: The above image shows an example of an AI algorithm that analyzes the hand's anatomy and recreates the part where part of the hand is missing. The input for an algorithm is a variety of X-rays and output is an image of an x-ray with tracing for a missing part. Such an AI algorithm could allow physicians to see the proper place to reconstruct a limb, or put a prosthetic.

To generate effective AI algorithms, computer systems are fed with structured and meaningful data points. These data points help the algorithm to learn from data. Then the performance of the algorithm is evaluated by measuring the accuracy of algorithms.

After the algorithm is exposed to enough sets of data points and their labels, the performance is analyzed to ensure accuracy. And this is just a high-level or abstract description of AI algorithms. AI algorithms are very complex. For different problems, different and unique algorithms are required.

AI algorithms are used for predicting outcomes given the examples. It could either be predicting a discrete value for a data point or predicting a class of data points or clustering data points into different clusters.

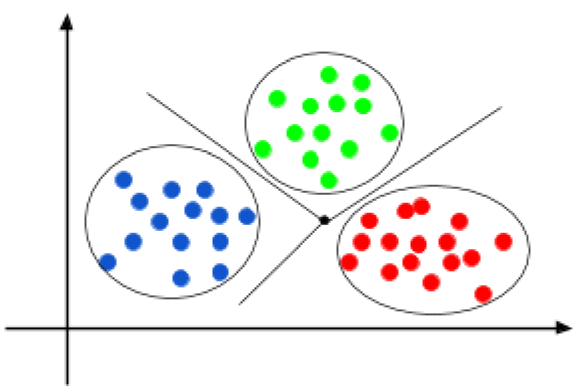
Some Types of AI algorithms



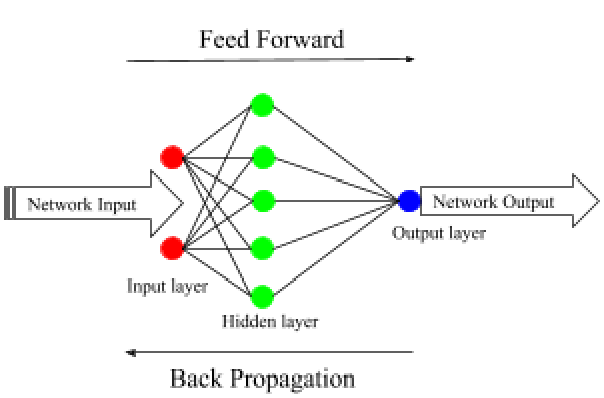
1. **Regression:**

Regression algorithms are used to predict the value of a label/outcome based on the known value of features associated with that data point. Regression analysis works on continuous data.

Regression is a method of statistics and it is adopted into machine learning because of its robust prediction capability.



2. **Clustering:** Clustering algorithms: Clustering algorithms are used for grouping multiple data points into clusters based on similar characteristics of those data points. Clustering is a preliminary data analysis. The foundation for clustering is the similarity function. The similarity function measures the homogeneity of data points. E.g, K-means clustering, K-medoid clustering



3. **Artificial Neural Network:** Artificial Neural Network: ANN is made up of layers called neurons. These neurons are core processing units of the network. First we've input layer which receives input and output layer which predicts final output. In between exists a hidden layer that performs most of the computation for the network. Neurons of one layer are connected to neurons of the next layer through channels. Each of these channels is assigned a numerical value known as weights. Each neuron is associated with a numerical value known as bias.

4. Deep Neural Networks(DNN): *See [2]* DNNs, also called convolutional networks, are composed of multiple levels of nonlinear operations, such as neural nets with many hidden layers. The methods of DL are focused on learning feature hierarchies. Higher levels of features are formed using lower levels of features. Currently DL methods outperform any other methods in AI. These are also the most widely used in medical diagnosis models.

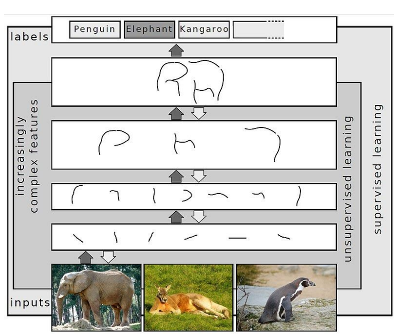
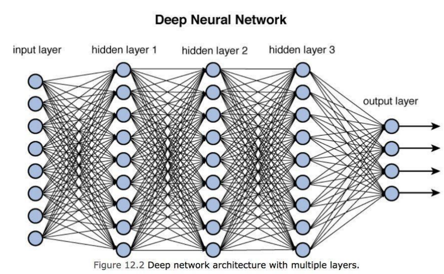
	

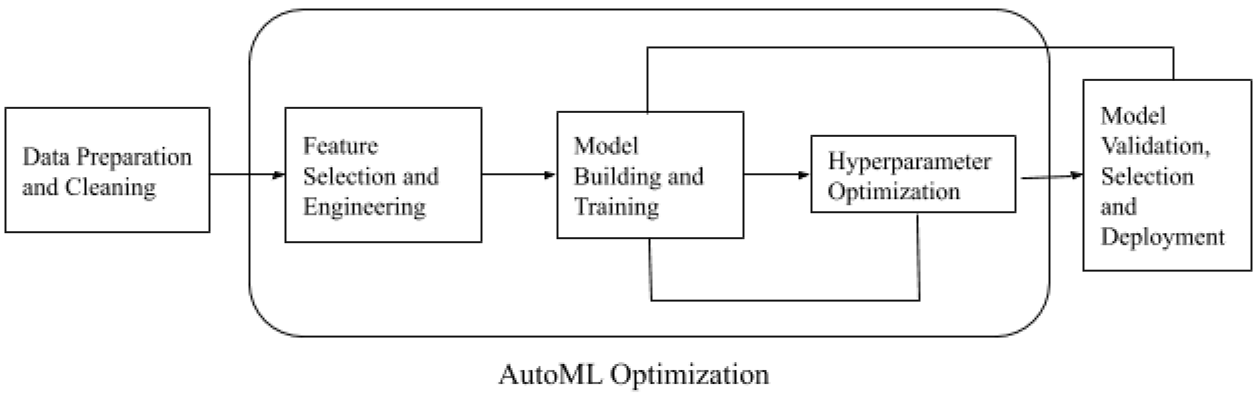
Figure: Multiple layers of abstraction in DL	Figure: Deep Neural Network Architecture

[1] See Artificial Intelligence in Medicine: Applications, implications, and limitation
Author: Daniel Greenfield **(June 2019)**
http://sitn.hms.harvard.edu/flash/2019/artificial-intelligence-in-medicine-applications-implications-and-limitations/
[2] https://www.sciencedirect.com/topics/computer-science/deep-neural-network

3.3 AI in practice for the ML model development

AutoML (abbreviated for automated machine learning) is a term preferred to describe automated processes of the machine learning lifecycle. AutoML attempts to automatically select, compose, and parametrize machine learning models. The ultimate goal of AutoML is to achieve optimal performance on a given dataset or task.

[1]



See [1] Fig. Typical flow of ML problem pipeline. The first step is preparing data, which involves making sure only eligible and quality data is kept, removing inconsistent data, applying transformations, encodings or normalizations if necessary. The next step is selecting features to use in the model and/or also using domain knowledge to create new features from existing features to help improve the ML model. This aforementioned process is also known as feature engineering. The next stages involve an iterative process in which one builds, trains, optimizes, validates, and selects a given machine learning algorithm to use for a given problem.

Data Preparation and cleaning

See [2] Data to be used to build a machine learning model can be incomplete(lacking attribute values or certain attributes of interest, or containing only aggregate data), noisy(containing errors, or outlier values that deviate from the expected), or inconsistent(). Even image data can be low quality, hence it is necessary to filter out lower quality data to be used in the model training to improve model accuracy.

Feature selection and engineering

See [1] The performance of a given machine learning algorithm is heavily dependent upon the quality of the input features. Features are predictive of the outcome of interest. The creation of these features often requires extensive domain knowledge and therefore is usually performed manually by a human expert in a trial-and-error fashion. This makes feature engineering a critical and time-consuming step in the machine learning pipeline.

Model building and training

In this phase, we take a prepared dataset and divide it into 3 parts, i.e. training data, testing data, and validation data. But here we only use training data to train a model and testing data to test a model after it is trained. Then we used the results a model is showing on the testing dataset to evaluate its parameters like accuracy, precision, recall, etc.

Hyperparameter optimization

Every machine learning model has two types of parameters: hyperparameters that the model designer must manually set prior to training, and normal parameters that are optimized in the training of the model. These hyperparameters are settings that control the behavior of the machine learning algorithm in some way, often in a way that is highly specific to that algorithm. The most basic task of AutoML is to automatically set these hyperparameters to optimize model performance.

Model validation and deployment

Model validation is performed before it is deployed. Model validation is sort of like the final check method before the model is used in real-world practice. To make a model available to medical practitioners, it needs to be deployed on suitable accessible platforms. Hence model deployment is usually done using the computing-intensive platform.

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[1] Automated machine learning: Review of the state-of-the-art and opportunities for healthcare Authors: Jonathan Waringa, Charlotta Lindvallc, Renato Umetona, ELSEVIER, (Apr 2020) https://www.sciencedirect.com/science/article/pii/S0933365719310437?via%3Dihub

[2] *An overview study on Data Cleaning, it's types and its methods for data mining*
Author: S.Lakshmi, International Journal of Pure and Applied Mathematics (2018)

3.4 Technologies that support AI integration for use-cases of medicine and healthcare

Wearable Computing See [1]

Wearable computing is a field of IT/computer science that facilitates research and development of computer devices which can be attached to an individual to assist them in procedures or tasks. Wearable computing is also referred to as automation technology because it helps to perform procedures or processes with minimal human assistance. Wearable computing devices are generally used for data gathering, processing, digital imaging, etc. and they are programmed to work on data.

Bioinformatics See [2]

Bioinformatics is a field that shares its domain with the field of information technology and biology. Application of bioinformatics integrates biological data into frameworks of information technology, performs computation and analysis on data, and produces insights and generates knowledge.

Augmented Reality(AR) See [3]

AR integrates digital information into the user's real-world environment. It offers a new approach for treatments and education in medicine. AR aids in surgery planning and patient treatment and helps explain complex medical situations to patients and their relatives.

Human Augmentics See[4]

Human augmentics is regarded as technologies that elevate the human capabilities. Today human augmentics is implemented mostly in the form of devices. Devices that aid handicapped in performing tasks that otherwise would not occur without those devices. Human augmentics uses a great deal of AI to train devices for the real-world environment. It uses data and machine learning to attained those capacities

Brain-Machine Interface(BMI) See[5]

BMI uses electrical signals from the brain and interprets them for more insights and scientific understanding. BMI is still a developing field. One company that works on the forefront in this technology is neuralink, founded by Elon Musk. Neuralink seeks to establish a brain-machine interface and it wants to be able to manipulate brain functions by electrical interference. Neuralink will be using AI to train the brain implantable-chips to recognize different brain activities by their electrical signals.

Summary: Artificial Intelligence technologies are more applicable to problems where we're dealing with meaningful knowledge and data. Due to the proximity of the aforementioned technologies *[1][2][3][4][5]* to data, these are highly suitable to use AI on.

[1] see Wearable Computing in Medicine Author: Olivier Wenker, MD
Internet Scientific Publications (2002) http://ispub.com/IJMI/1/1/9235

[2] see Bioinformatics Author: Ardeshir Bayat
MRC fellow, BMJ(2002) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1122955/#

[3] see Augmented Reality in Medicine: Systematic and Bibliographic Review
JMIR Mhealth Uhealth, (Apr 2019) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6658230/

[4] See Human Augmentics: Augmenting human evolution
Authors: Robert V Kenyon, Jason Leigh
IEEE (2011) https://ieeexplore.ieee.org/document/6091667

[5] See An integrated brain-machine interface platform with thousands of channels
Authors: Elon Musk, Neuralink
https://www.biorxiv.org/content/10.1101/703801v4.full.pdf

3.5 Current Applications of Artificial Intelligence for medicine

The advances in high-performance computing have made high-resolution data processing much easier for AI systems and AI applications for healthcare and medicine have also benefited from recent advances in deep learning. Below are two AI tools for medical diagnosis.

See [1]

The first of these applications is CheXNet. CheXNet is a radiologist-level Pneumonia Detection system. It is implemented by a group of Stanford researchers. CheXNet uses a chest x-ray to diagnose 14 chest related diseases. It uses 121 layers of convolutional neural networks. In 2017, the researchers tested the accuracy of CheXNet against radiologists and found that CheXNet performed significantly better at diagnosis than radiologists.

See [2]

The second application comes from researchers at Seoul National University Hospital and College of Medicine. They developed an AI algorithm known as Deep Learning-based Automatic Detection to analyze chest radiographs and detect abnormal cell growth, such as potential cancers. Algorithm's performance was compared with physicians and it turned out the algorithm outperformed physicians at detection.

See [3]

AI applications are vastly useful in places with large populations, scarcely resourced services. They are ideally suited for places where human expertise is lacking. As such, in many TB prevalent countries, there is a lack of radiological expertise in remote places or regions. In such cases radiographs can be uploaded on online AI systems which in turn give a correct diagnosis. A recent study shows that for pulmonary TB, AI diagnoses it with a sensitivity of 95% and specificity of 100%.

Below are the current applications of artificial intelligence in internal medicine.

See [4]

Branch of medicine	Use-case/s
Cardiology	• Prediction of risk of cardiovascular disease for e.g. acute coronary syndrome and heart failure.
Pulmonary Medicine	• AI-based software shows a more accurate interpretation of pulmonary function tests and also serves as a decision support tool.
Endocrinology	• Continuous glucose monitoring helps diabetes patients to optimize their blood glucose control.
Nephrology	• Prediction of the decline of glomerular filtration rate in patients with polycystic kidney disease. • Establishing risk for progressive IgA nephropathy.
Gastroenterology	• Diagnosis of gastroesophageal reflux disease, atrophic gastritis. Prediction of outcomes in gastrointestinal bleeding, the survival of esophageal cancer, inflammatory bowel disease, metastasis in colorectal cancer, and esophageal squamous cell carcinoma.
Neurology	• Intelligent seizure detection devices for seizure management through permanent ambulatory monitoring. • Quantitative assessment of gait, posture, and tremor in patients with multiple sclerosis, Parkinson disease, Parkinsonism, and Huntington disease through AI-based wearable devices.

Though there are a wide range of applications useful in practices of medicine, there are also some digital applications that use AI and aid in medicinal practices. Some of them are Remote Patient Monitoring, Patient Health Record Management, Virtual Nurses, etc. These aforementioned applications help medical practitioners in fulfilling basic medical care either in virtual or in-person presence. Thus increasing the efficiency of medical practice.

The core of these applications consists of a whole array of non-invasive digital technologies that support the implementation of services such as remote patient monitoring or virtual nurse. See [5] for more information about those technologies.

[1] see CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning
Pranav Rajpurkar, Jeremy Irvin, Kaylie Zhu, Brandon Yang, Hershel Mehta, Tony Duan, Daisy Ding, Aarti Bagul, Robyn L. Ball, Curtis Langlotz, Katie Shpanskaya, Matthew P. Lungren, Andrew Y. Ng
arXiv:1711.05225v3[cs.CV], (Dec 2017) https://arxiv.org/pdf/1711.05225.pdf

[2] see Artificial Intelligence in Medicine: Applications, implications, and limitation
Author: Daniel Greenfield **(June 2019)**
http://sitn.hms.harvard.edu/flash/2019/artificial-intelligence-in-medicine-applications-implications-and-limitations/

[3] see Artificial intelligence in medicine: current trends and future possibilities
Authors: Varun H Buch, Irfan Ahmed and Mahiben Maruthappu, **British Journal of General Practice (March 2018)** https://bjgp.org/content/bjgp/68/668/143.full.pdf

[4] Artificial Intelligence in Medicine: Today and Tomorrow
Authors: Giovanni Briganti, Olivier Le Moine, **Frontiers in Medicine (Feb 2020)**
https://www.frontiersin.org/articles/10.3389/fmed.2020.00027/full

[5]Remote Patient Monitoring via Non-Invasive Digital Technologies: A Systematic Review
Ashok Vegesna, Melody Tran, Michele Angelaccio, and Steve Arcona, **Telemed J E Health (Jan 2017)**
https://doi.org/10.1089/tmj.2016.0051

3.6 Brief survey of AI technologies

The brief survey and comparison of various current AI diagnostic tools is given in the table below. The technology mentioned in the table is just a nomenclature given to a diagnostic model by the researchers.

See [1], [2], [3], [4], [5] for more information about tools given in the following table.

Disease/Use case	Technology/Tool	Algorithm	Dataset
*[1]*Diagnosis of Appendicitis	AppendiXNet	3D residual network	646 Eligible CT scans
*[2]*Arrhythmia Detection	Computer Vision and Pattern Recognition	Convolutional Neural Networks	64,121 ECG records from 29,163 patients
*[3]*Cerebral Aneurysms	HeadXNet Model	Neural Network Segmentation Model	818 Eligible CTA scans
*[4]*Pneumonia Detection	CheXNet	121-layer CNN	100,000 frontal-view X-ray images with 14 diseases.
[5] Malaria Likelihood Prediction	Mobile Text Survey	Deep Reinforcement Learning	Dataset of 6481 households from the Kenya

Apart from the diagnostic tools given in the above table, some diagnostic tools use only symptoms data to give a formal diagnosis to patients. Such tools are widely used today in the form of mobile applications. They are also mentioned as AI chatbots. *(See [6])*

One example is U.K.-based startup Babylon Health is a health subscription-based service that has developed a chatbot for the prevention and diagnosis of disease. *(See [6])*

[1] see AppendiXNet: Deep Learning for Diagnosis of Appendicitis from A Small Dataset of CT Exams Using Video Pretraining, Pranav Rajpurkar, Allison Park, Jeremy Irvin, Chris Chute, Michael Bereket, Domenico Mastrodicasa, Curtis P. Langlotz, Matthew P. Lungren, Andrew Y. Ng & Bhavik N. Patel, **Scientific Reports, (March 2020)** https://www.nature.com/articles/s41598-020-61055-6

[2] see Cardiologist-Level Arrhythmia Detection with Convolutional Neural Networks
Pranav Rajpurkar, Awni Y. Hannun, Masoumeh Haghpanahi, Codie Bourn, Andrew Y. Ng
arXiv:1707.01836 [cs.CV], (July 2017) https://arxiv.org/pdf/1707.01836.pdf

[3] see Deep Learning–Assisted Diagnosis of Cerebral Aneurysms Using the HeadXNet Model
Allison Park, Chris Chute, Pranav Rajpurkar, **JAMA Network Open. (June 2019)**
https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2735471

[4] see CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning
Pranav Rajpurkar, Jeremy Irvin, Kaylie Zhu, Brandon Yang, Hershel Mehta, Tony Duan, Daisy Ding, Aarti Bagul, Robyn L. Ball, Curtis Langlotz, Katie Shpanskaya, Matthew P. Lungren, Andrew Y. Ng
arXiv:1711.05225v3[cs.CV], (Dec 2017) https://arxiv.org/pdf/1711.05225.pdf

[5] see Malaria Likelihood Prediction By Effectively Surveying Households Using Deep Reinforcement Learning,
Pranav Rajpurkar, Vinaya Polamreddi, Anusha Balakrishnan
arXiv:1711.09223v1[cs.LG], (Nov 2017) https://arxiv.org/pdf/1711.09223.pdf

[6] Machine Learning for Medical Diagnostics – 4 Current Applications
Author: Daniel Gaggela
Emerj - Artificial Intelligence Research and Insight (2020)
https://emerj.com/ai-sector-overviews/machine-learning-medical-diagnostics-4-current-applications/

4.0 Details and analysis of Automation technologies for healthcare

What do we mean by automating technologies in healthcare? In short, any type of technology that is feasible for use in clinical practice or healthcare, which is more efficient, requires less human oversight can be termed as automating technology. Automating technology ultimately involves minimal assistance to perform process or procedure.

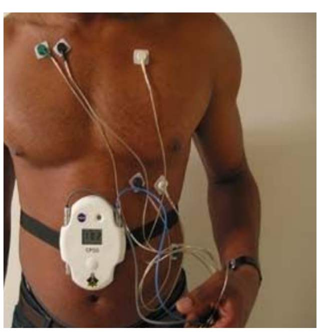
E.g. electronic health records, virtual nurse/health assistance, remote patient monitoring, m-IoT healthcare network, etc.

These technologies are an abstract combination of core computer science technologies and some invented standard technologies. Two of them are explained below, 1. WBAN, 2. IoThNet.

4.1 WBAN (Wireless Body Area Sensor Network)

See [1], reference for WBAN

Wired body area sensor networks are reliable and provide stable connections, but they also have some drawbacks. They have installation problems with users, have high cost and maintenance, and are uncomfortable to wear and the sensor may come off from the body due to gestures.



These networks have a central unit on the body which receives information from all sensors implanted on the body. This unit may or may not be connected to the cloud via the internet depending upon the application. If an application involves predicting the health condition from real-time physiological data then the cloud is used.

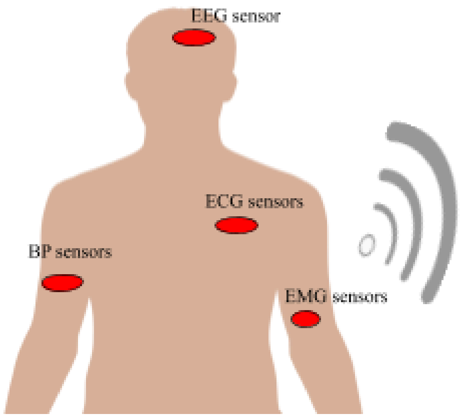


Fig. Wired sensor network

On the contrary, the WBAN(Wireless body area network) provides more mobility to the user as users don't have to worry about things flopping around or things coming off. It renders an easy application and expansion of the network. Sensors automatically connect to the network in WBAN.

For these types of networks, smartphones can also work as a sink for wireless data. These networks need energy for sensors. BAN may interfere with other BAN. The WBANs have mainly two major types of components,

1) sensors to collect data, and

2) data syncing devices to gather information from sensors. BAN uses IEEE 802.15.6 protocol. It provides low power, high reliability, quality of service.

Examples of applications served by the proposed standard are: EEG, ECG, EMG, vital signal monitoring, cortical simulators, disability assistant such as muscle sensing and stimulation, fall detection, aiding sports training.

Different types of sensors to be used in WBAN are wearable blood pressure sensors, wearable glucose sensors, wireless capsules for drug delivery, etc.

Opportunities and applications of WBAN

1. Ambulatory health monitoring *See [2]*

   It is real-time health monitoring that involves real-time recording and analysis of physiological parameters followed by an alert in case a person is in need of emergency medical help.

   An ambulatory health monitoring system is usually equipped with sensors like ECG sensors, body temperature sensors, and blood pressure sensors. Such a system uses an amplifier to preprocess the ECG signal due to the weak nature of ECG. Hardware components of such systems are microcontroller, data storage and display units, wireless circuit serial transfer (WCST) based on XBee. Software components are microcontroller software and PC software.

2. Computer-assisted rehabilitation *See [3]*

Rehabilitation is an action of restoring someone's health to normal through therapy or treatment after illness. Today computer-assisted rehabilitation is widely adopted and one of important technology they use is WBAN

WBAN can be used to constantly track the health of patients in rehabilitation and measuring physiological parameters along the way. The tracked data and measured parameters can be used to relay early warnings or guidance to the patient during rehabilitation through the graphical user interface.

[1] See System Architecture Of A Wireless Body Area Sensor Network For Ubiquitous Health Monitoring, Authors: Chris Otto, Aleksandar Milenković, Corey Sanders, Emil Jovanov, **Journal of Mobile Multimedia, (Jan 2006)**
http://www.ece.uah.edu/~milenka/docs/coamej_jmm06.pdf

[2] See Health Monitoring System Using Wireless Sensors Node
Authors: Mohamed Fezari, Rachad Rasra, Ibrahim M. M. El Emary
Science Direct, (Sept 2015)
https://www.sciencedirect.com/science/article/pii/S1877050915029129

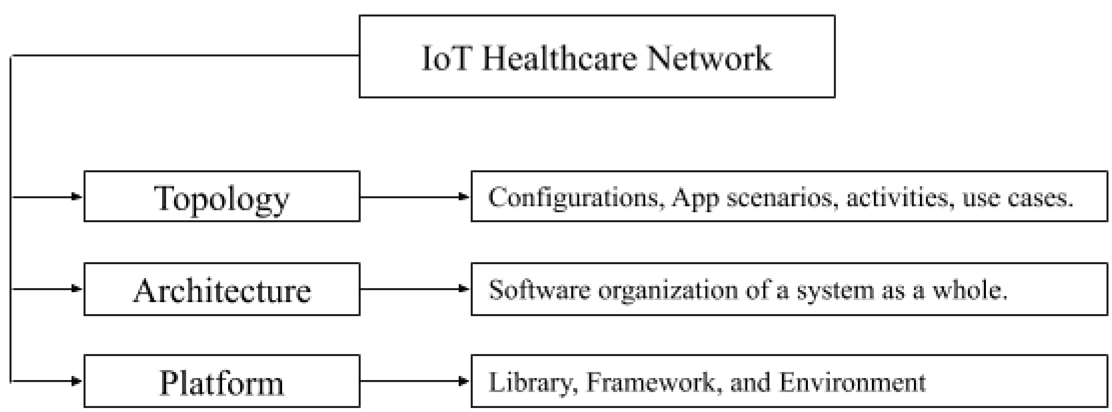
[3] See A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation
Authors: Aleksandar Milenkovic, Chris Otto & Piet C de Groen
Journal of NeuroEngineering and Rehabilitation volume 2, Article number: 6 (2005)
BMC(Biomed central) a part of Springer
https://jneuroengrehab.biomedcentral.com/articles/10.1186/1743-0003-2-6

4.2. IoT HEALTHCARE NETWORKS

For more information about IoTHNet See [1]

IoThNet is one of the important ways to provide automation applications in the healthcare ecosystem. It supports access to electronic medical devices e.g. monitoring sensors, aids the medical professionals in communicating information, and enables the use of healthcare-oriented communications.

IoThNet can be described in the context of three main terminologies, those are topology, architecture, and platform. Topology refers to an arrangement of nodes of a communication network. Architecture attributes to the design of the network. It is a framework for the software organization of the systems and the specification of parts of the network and their functionalities, and configuration, its operational systems and methods, communication protocols used, etc. Platforms consist of a library, framework, and environment for the network to operate on.



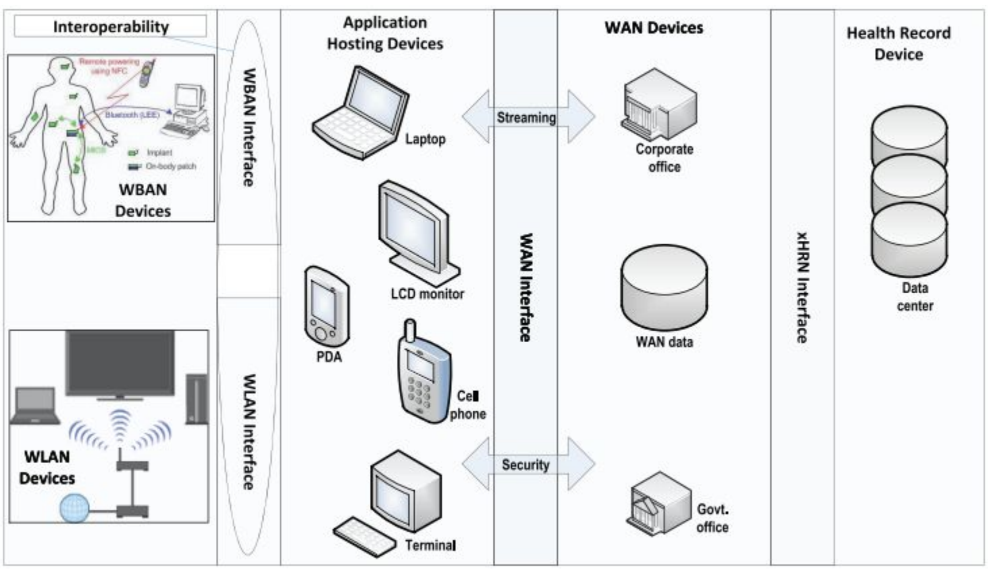
A. THE IoThNet TOPOLOGY

Topology indicates the layout of nodes in the network. It suggests how different components of a network interact with each other. It also shows functional dependencies between different components of a network. The following table describes the structure of network topology that shows the physical devices and sub-networks associated with devices.

Network	**Physical devices**
IP Network, 6LoWPAN, GSM Network, WiMax Network	Application hosting devices, WAN devices, Health record devices
WBAN, WLAN	Body Sensors, Local network devices

B. THE IoThNet ARCHITECTURE

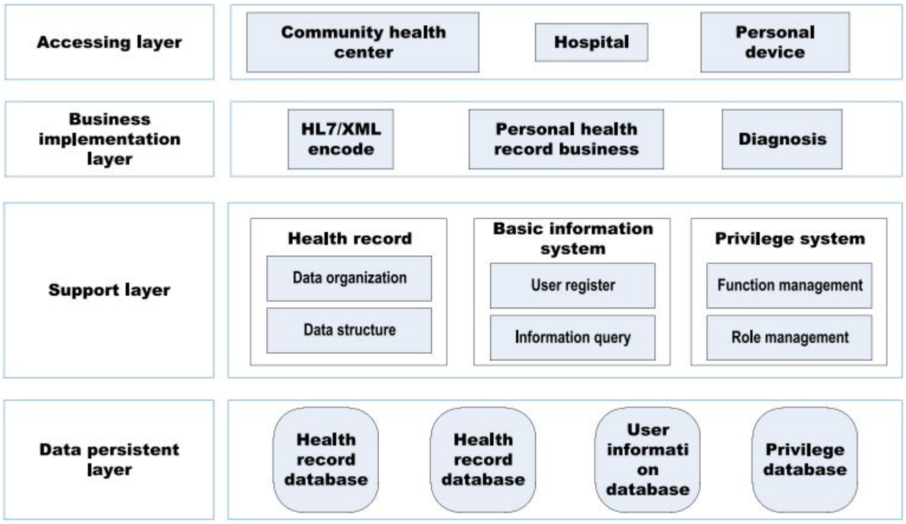
The IoThNet architecture outlines the layout of the physical components and functional organization of IoThNet. To understand IoThNet architecture it is important to analyze key issues associated such as interoperability of IoT gateways, Wireless Body Area Networks(WBAN), Wireless Local Area Network(WLAN), multimedia communication and secure communications between IoT gateways and users.



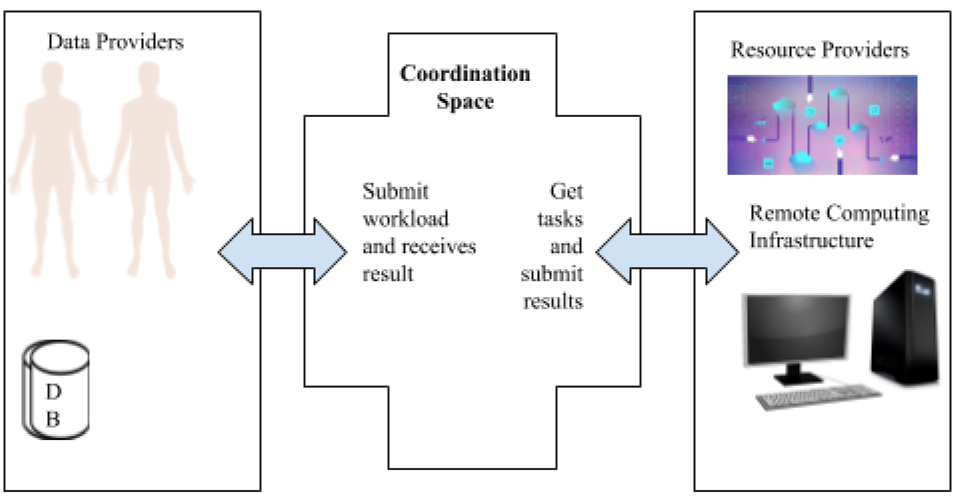
The figure above describes the architecture of IoThNet.

C. THE IoThNet PLATFORM

The IoThNet platform refers to both the network platform model and the computing platform. The below figure shows a systematic hierarchical model of how caregivers or agents can access various databases from the application layer with the help of a support layer.



The figure below illustrates the topology of the IoT healthcare network as a heterogeneous computing grid since various types of electronic devices are being used for computation and processing. The grid collects immense measurements about vital signs and sensor data like BP, ECG, etc.



See figure 3 in [1]

Figure: IoT based healthcare solution

[1] See The Internet of Things for Health Care: A Comprehensive Survey,

S. M. Riazul Islam, Daehan Kwak, Humayun Kabir, Mahmud Hossain And Kyung-sup Kwak, **IEEE ACCESS, 2015** https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7113786

4.3 Integrating Automation with an AI

Automation is the technology by which a process or procedure is performed with minimal human assistance and Artificial intelligence is a set of technologies by which we can perform processes intelligently. Using AI for automation makes the process both automated and intelligent.

Example of integration of AI and Automation

E.g. EHR(Electronic Health Records)

Approximately 4/5th of total healthcare records exist in an unorganized style and AI can interpret and comprehend such data and can provide great insights into this data for clinical purposes. AI’s capability to process natural language enables it to read, understand and learn clinical text from any source and identify, classify and code medical concepts and social notions.

Maintaining and keeping track of the patient’s medical record can be done manually with the help of files or folders and paper-based reports and prescriptions. This type of method involves plenty of human assistance and can cost doctors a lot of time for searching a report or making judgments or providing insights of data to the patient since this data exists in an unorganized, handwritten, or hardcopies form.

This problem can be overcome by EHR. EHR is the process of storing medical health records of individuals in digital form over static storage or cloud storage. This makes EHR accessible to anyone who wants to see it, especially doctors. Since data in EHR is stored in an organized way, it becomes easier for the doctor to search among the data.

But this data mostly exists in textual form. Henceforth interpreting and learning it is a challenging task for a doctor because this data is growing exponentially. This problem can be solved by natural language processing(NLP). NLP is a subclass of AI that involves the understanding of human language by a computer specifically how the computer can process and analyze the human language.

In this process, we're automating the access to the health record with EHR cloud storage and we're also using AI to interpret the unstructured data efficiently. The figure shown below represents how AI and automation together can be put to work together.

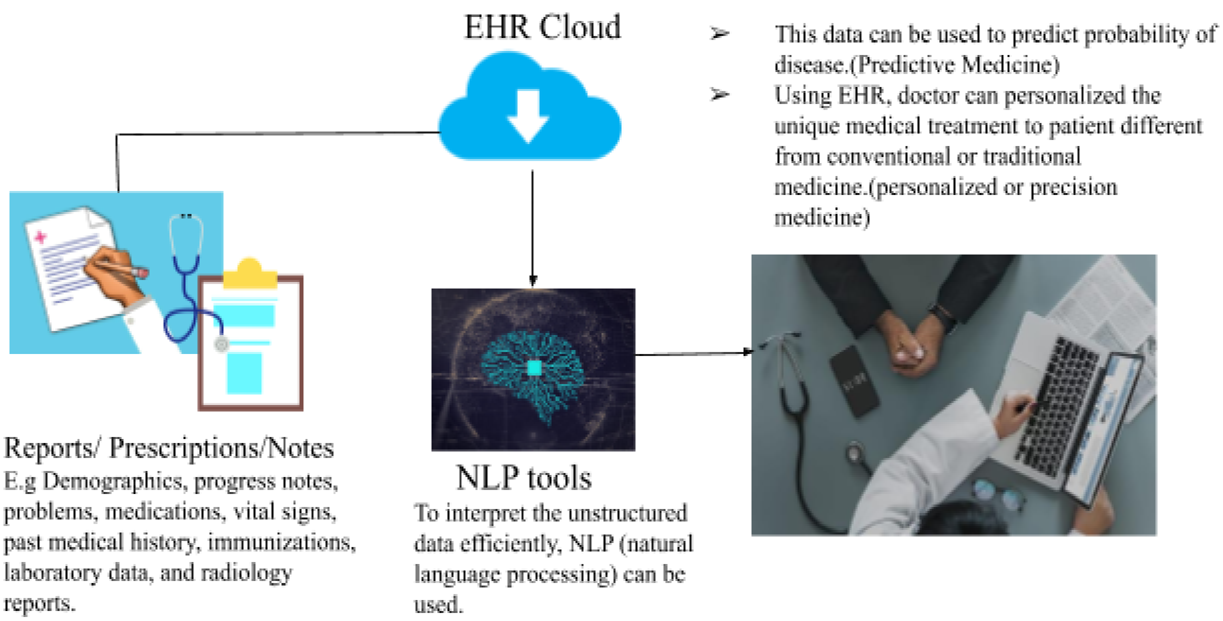


Figure 1.1

[1] Artificial intelligence in healthcare: past, present and future

Fei Jiang, Yong Jiang, Hui Zhi, Yi Dong, Hao Li, Sufeng Ma, Yilong Wang, Qiang Dong, Haipeng Shen, Yongjun Wang, **BMJ,(2017)** https://www.ibm.com/watson-health/learn/artificial-intelligence-medicine

[2] See Transforming Healthcare with AI

Mckinsey & Company, European Institute of Innovation and Technologies, (March 2020)
https://eithealth.eu/wp-content/uploads/2020/03/EIT-Health-and-McKinsey_Transforming-Healthcare-with-AI.pdf

4.4 Benefits of Applying Automation to Healthcare

Critics argue that automation can not replace doctors and nurses and they are right. But automation can be blended in the workflow of the healthcare ecosystem to improve the quality of care provided in hospitals and also to add efficiency in the work practices of hospital staff.

Below are six benefits of automation in healthcare.

1. Labor Savings

   Automation can reduce the workload of employees and elevate them to the higher-functioning roles.

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2. Improved Quality and Consistency

   Automation improves the precision of task execution hence it'll significantly affect the quality of healthcare.

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3. Increased Predictability of Outcomes

   Automation increases the accuracy of prediction because in an automated environment data is constantly collected and analyzed. Hence using massive data, machine learning models give more accurate predictability.

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4. Higher Throughput

   Using automation tools in hospital settings, massive time is saved and efficiency is increased, hence collectively increasing throughput of output.

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5. Data-Driven Insights

   Data collected in automated systems is useful to get feedback on hospital efficiency. It can be also used for constant improvement and optimization.

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[1] See 6 Big Benefits of Applying Automation to Healthcare
Author: James Dias
https://hitconsultant.net/2014/07/21/6-big-benefits-of-applying-automation-to-healthcare/#.XsQDrmgzbIU

5. Conclusion

In conclusion, AI and automation together are revolutionizing the healthcare industry and medicine as we know it.
Automating the basic tasks and providing digital solutions to healthcare will orient doctors to spend more time on patient care.
Algorithms are getting really good at interpreting images and diagnosing disease sometimes with greater accuracy than humans.
Advances in deep learning algorithms and computer vision will drive AI research.
AI saves costs and increases accuracy and saves lives, hence it'll be widely adopted by healthcare professionals around the world.

End of Report