



Application of Artificial Intelligence in Healthcare: Chances and Challenges

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Authors' contributions

This work was carried out in collaboration between both authors. Author RM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SCK managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Use of Artificial intelligence (AI) has increased in the healthcare in many sectors. Organizations from health care of different sizes, types and different specialties are now a days more interested in how artificial intelligence has evolved and is helping patient needs and their care, also reducing costs, and increasing efficiency. This study explores the implications of AI on healthcare management, and challenges involved with using AI in healthcare along with the review of several research papers that used AI models in different sectors of healthcare like Dermatology, Radiology, Drug design etc.

Keywords: Artificial intelligence; healthcare; pharmacy; patient care; deep learning, machine learning.

1. INTRODUCTION

The recent improvements in the Artificial intelligence technologies across healthcare, made us wonder if AI tools will replace the human physicians in the future. Practically AI

tools may not replace the human physicians but can assist physicians to achieve better results and accuracy in medical field. One important support for this AI tools evolving in the medicinal field is availability of healthcare data. Artificial intelligence is not just a technology, it is a

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collection of technologies. Some among these technologies are widely used in healthcare, for example, machine learning. Machine learning is a technique where you train models using preexisting data, so that when someone feed the data that you are using for testing, based on pre learning, it will identify the test input. Machine learning is one of the commonly used forms of Artificial Intelligence [1].

In healthcare the most common place where machine learning is used is precision medicine. Precision medicine is predicting what treatment protocols will success on a given patient, and this is determined based on past data of patients [1]. This type of determining from previous learning will require training the model using datasets, and this approach is called supervised learning. Fig. 1 shows some areas where AI is used in healthcare and Pharmacy and they are detailed below:

1.1 Diagnosis and Treatment Design

Use of AI in designing treatment plans for patients has been growing in the healthcare. AI by analyzing data from the previous patients, can provide superior strategies for treating patients and monitoring treatment plans [2]. With the help of medical images like CT scans, MRI, X-rays, Ultrasound, AI has the ability to recognize signs of a disease more accurately and rapidly. It helps patients, with fast identification of disease accurately and more precise treatment choices. IBM's Watson recently got good attention in the media for its ability to focus on precision medicine, especially cancer diagnosis and treatment. Different types of AI techniques are being used for diagnosing different diseases like neural networks, support vector machines, and decision trees etc., ANN (Artificial neural network) showed more accuracy in classifying diabetes and CVD [3].

1.2 Electronic Health Records

Electronic health records are crucial in healthcare, as they help analyze the data from the very past to present and which in turn helps improve different types of treatments, and drug usage to a disease. AI can be used to interpret the records and provide information to the physicians. Algorithms can make use of EHR to predict the possibility of a disease based on the past information and family history. AI algorithms

are trained using large amounts of data, and in that process, algorithm creates certain set of rules that connects its observations to the concluded diagnoses. Next time when the data of new patient is given to AI, it can evaluate patient using its experience from previous data and predicts the likeness of a condition or disease [3]. From the past decade, data in the healthcare like information of patient, research findings, diagnosis information is being generated in massive volumes each day. With the help of analytical tools organizations were able to collaborate and achieve insights needed to treat patients efficiently and effectively.

1.3 Drug Interactions, and Discovery

Drug interactions pose a threat to the patients who are taking multiple medications simultaneously, the amount of risk involved increase with the number of medications being taken. It is hard to address all the drug interactions and adverse effects caused by them, but with the help of AI, algorithms were able to extract information on drug interactions and possible side effects from medical literature. Drug discovery and development is a time consuming process as it takes several years and costs several billion dollars. The drug discovery times are reduced greatly with the help of machine learning techniques [4]. AI might not be able to completely help throughout the steps involved in drug discovery, but few of the steps when it comes into play is, assistance in discovering new compounds that could possibly form the desired drug, it can also help in finding new applications of compounds that are tested previously.

1.4 Dermatology

Dermatology in healthcare majorly depends up on imaging. Deep learning has majorly helped in image processing. There are three imaging types in dermatology, contextual images, micro images, macro images. For each type of these images a great progress has been shown by deep learning. Convolutional neural networks have achieved an accuracy of 94% in classification of skin cancer from skin lesions.

1.5 Radiology

AI is being used in the field of radiology, and through using CT scans MR imaging X-ray the

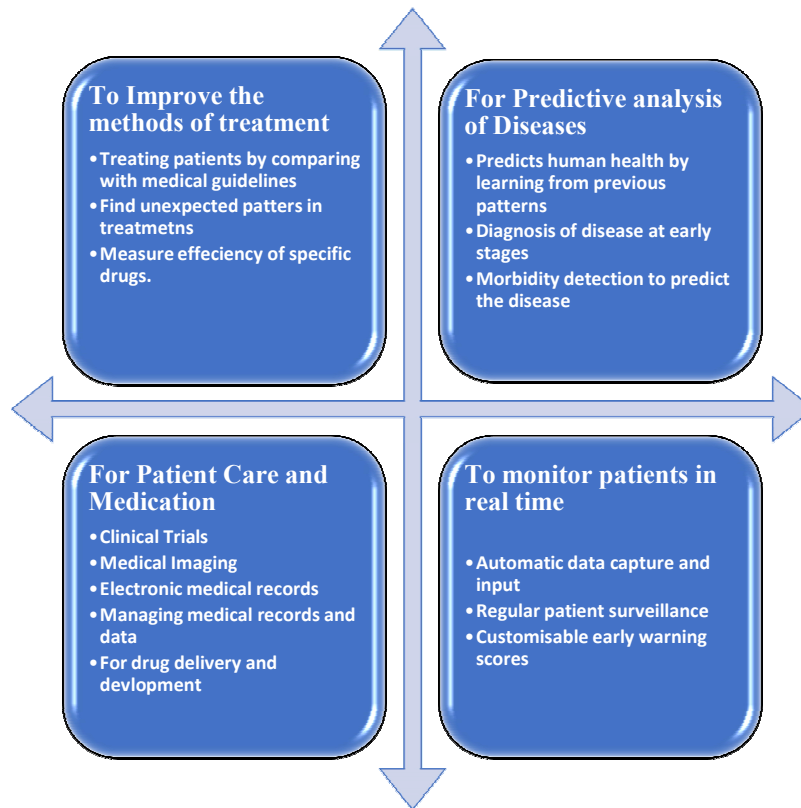


Fig. 1. The areas where AI is used in healthcare

diseases are diagnosed in the patients, and the number of research publication has been increasing from the past few years. An algorithm was created by Stanford which could detect pneumonia in patients with average F1 metric better than the radiologists who participated in the trial [5]. Robots that are developed using AI technologies can do X rays, CT scans faster and accurately. Another algorithm was developed by IBM which is called Medical Sieve [6], and the main aim of this is to build “cognitive assistant” with reasoning and analytical capabilities, and clinical knowledge.

1.6 Psychological Conditions and Primary Care

Chatbots with AI technology are being tested for depression and anxiety, by replicating human behavior. Psychologic conditions in children can be identified using latest development technologies of AI. Technology innovator right eye LLC has innovated AI powered autism experiment to detect Autism spectrum disorder at early stages by applying eye tracking technology [7]. Primary care is one of the key development

areas of AI. Several AI technologies are being developed to provide basic primary care to the patients, the view of practitioners on AI is being limited to administrative and routine tasks.

2. ARTIFICIAL INTELLIGENCE

Machine Learning, neural networks and deep learning are subsets of AI. Machine learning is applying artificial intelligence that will allow a system to learn and advance based in experience, with being preprogrammed. Fig. 2 shows different types of learning, by how a model/algorithm is trained:

- Supervised learning
- Unsupervised learning
- Semi-supervised learning
- Reinforced learning

2.1 Supervised Learning

This form of machine learning takes what it learned in the past and applies it to the new data set and uses labeled examples. This will require the outputs of the algorithm are already known

and the data that is being used to train the model is labeled with correct answers. And based on these answers the algorithm compares its actual output to the correct outputs, and if its wrong it will learn by it and improves its efficiency [8].

2.2 Unsupervised Learning

In unsupervised learning is used with data without any historical labels. The model will not be given any correlations between inputs and the outputs or more like a correct answer. Algorithm should learn on the fly by itself. This type of learning is complex and so is used a smaller number of times than supervised learning. Unsupervised lets the user perform more complicated processing tasks compared to supervised learning. And they are more unpredictable compared to other learning methods. Unsupervised learning algorithms include clustering, anomaly detection, neural networks, etc. The most common unsupervised learning method is cluster analysis, which is used for exploratory data analysis to find hidden patterns or grouping in data [8].

2.3 Semi-supervised Learning

This type of learning falls somewhere between supervised and unsupervised learning. This is used for the opportunity where the problems require a balance of both the supervised and unsupervised learning. Supervised learning uses data with labels, and unsupervised uses data

without labels, but semi supervised uses data with and without labels. The model will learn from the labelled data and applies the knowledge and patterns to the unlabeled data [8].

2.4 Reinforcement Learning

This type of learning used system of reward and punishment to train its algorithm. In this learning the model will receive rewards for performing correct and penalties for doing incorrectly, and so it will learn the greatest reward and by minimizing penalty.

Artificial intelligence, as opposite to intelligence of humans, it is intelligence of machines [9,10]. Artificial Intelligence is referred as situation where machines simulate human minds in analyzing and learning. This type of intelligence is referred to as machine learning [11]. Artificial intelligence is combination of both software and hardware. In terms of software AI is of algorithms. A conceptual framework that executes AI algorithms is called Artificial neural network [12]. It behaves like human brain, which is like a interconnected network of neurons, and between the channels it will have weighted communication [13]. The main aim of health-related AI applications is analyzing relationships between techniques for treatment or prevention and patient outcomes [14]. AI is mostly applied to practices like diagnosis processes, treatment protocol development, drug development, personalized medicine, and patient monitoring and care.

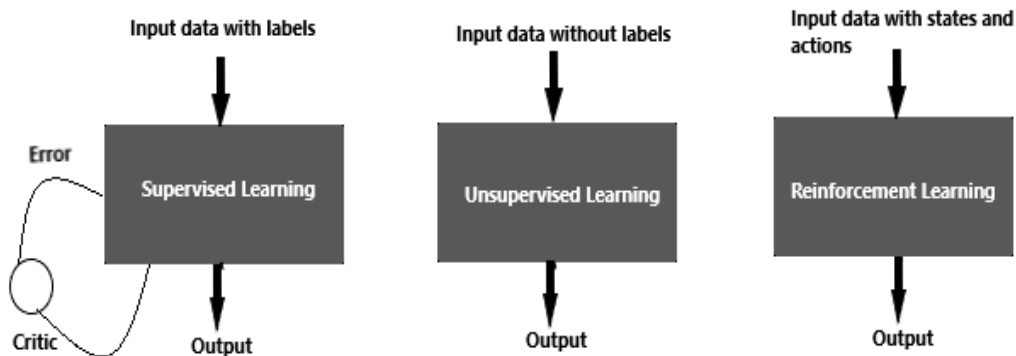


Fig. 2. Different types of Machine Learning

Even though use of AI in healthcare is increasing continuously, it is widely used mostly around few diseases, one is cancer classification [15], disease of nervous system [16], cardiovascular disease [17]. Support vector machine is used for classifying any given subject into two groups. Where the outcome Y_i is a classifier $Y_i = -1$ or 1 represents whether the i th patient is in group 1 or 2, respectively. The basic assumption is that the subjects can be separated into two groups through a decision boundary defined on the traits X_{ij} , which can be written as:

$$s_i = \sum_{j=1}^p W_j x_{ij} + b$$

where w_j is the weight placed on j th trait to manifest and affect the outcome of the others. An important property of SVM is to determine model parameters. The decision rule then follows that if $s_i > 0$, the i th patient is classified to group 1, that is, labelling $Y_i = -1$; if $s_i < 0$, the patient is classified to group 2, that is, labelling $Y_i = 1$. The class memberships are indeterminate for the points with $s_i = 0$.

2.5 Deep Learning

A set of machine learning methods, which are inspired by processing information and distributed communication in network of biological neurons is called as Deep Learning. Artificial Neural Networks should be trained in deep learning. ANNs are network of artificial neurons. Each ANN has a minimum of three layers, that is input layer that will take the input. Hidden layer that trains on the dataset fed to the

input layer. The output layer that given output depending on input that is fed. Deep learning has been gaining lot of interest in medicine, than any other machine learning technique. Convolutional networks which are a type of artificial neural networks are extensively used for image based applications and proved to have achieved better results than humans in determining and classifying objects.

3. DIFFERENT DEEP LEARNING ARCHITECTURES APPLIED IN HEALTHCARE

3.1 Neural Network

A neural network is a series of algorithms that recognizes underlying relationships in a set of data through a process which mimics human brain. Neural networks are also known as artificial neural networks are a subset of machine learning and are heart of deep learning algorithms. The layers in the neural networks are made of nodes. A place where computation happens, loosely patterned on a neuron in the human brain, and when it encounters sufficient stimuli, it fires up, and it is called node. A node combines input that comes from the data, with weights that either can amplify or dampen the input, and so it will assign significance to inputs in regard to algorithm it's trying to learn. Below is the diagram of what node looks like. A node layer looks like a row of these neuron like switches that will turn as on or off, when the input is fed through the net. The output of each layer is the input of the next layer [18]. Fig. 3 shows the node diagram.

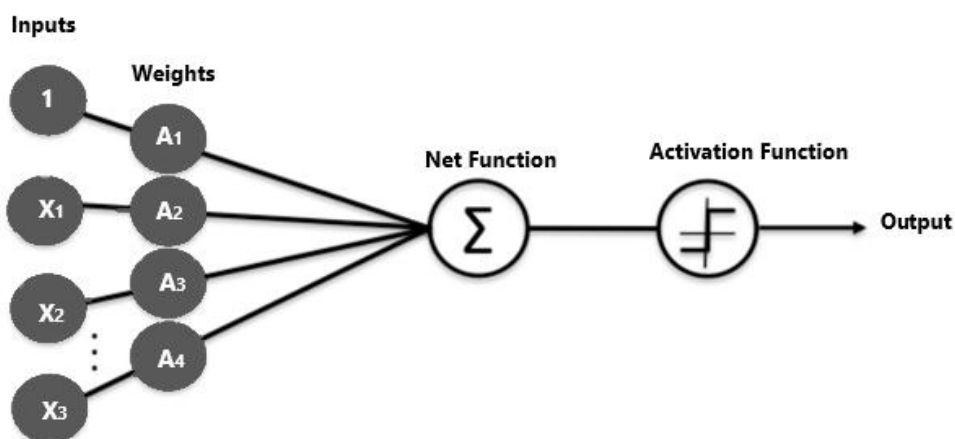


Fig. 3. Node Diagram

A **deep neural network** is nothing but an artificial neural network with multiple hidden layers between the input and the output layer. Fig. 8 shows a deep neural network with multiple hidden layers. Deep neural networks capitalize on ANN components, a deep neural network allows performance of the model to increase accuracy. Fig. 7 shows the rates at which these different models are being used in the research papers reviewed by us.

3.2 CNN (Convolutional Neural Network)

Description: CNN (Convolutional Neural Network) is an artificial deep neural network. CNNs are used for image classification, segmentation and recognition. Main tasks of CNNs are classifying visual content, Recognizing objects that are fed as input to it, and gathering the objects that are recognized into clusters. CNNs rely on connections and weights across the units, which is followed by subsampling [19]. A basic CNN architecture contains one convolutional layer and pooling layer, and also sometimes contains fully connected layers for supervised prediction. So, let us discuss the layers of CNN in detail as shown in Fig. 4.

3.2.1 Input layer

Input layer in the CNN should have the data of the image. Image data is nothing but three dimensional matrix which needs to be reshaped

into single column before feeding it as input. The output of each layer will be input to the next layer.

3.2.2 Convolutional layer (convo+ReLU)

Convolutional layer is the one where the action starts. This layer identifies the features of an image, like color shape, elements of an object etc., Extension layer of CNN is the ReLU layer. This layer helps increase the image's non linearity. Better feature extraction is achieved at this layer.

Pooling layer: Pooling layer reduces the spatial volume of the input image after coming through convolutional layer.

3.2.3 Fully connected layer

This layer contains weights, neurons and biases. Neurons in one layer are connected to neurons in other layer using fully connected layer. With the help of training images are classified into categories at this layer.

3.2.4 Softmax layer and output layer

These are the last layers in CNN. Softmax layers is next to the FC layer and is used for binary classification. In addition output layer will give the final output label of the input image fed into the input layer [19].



Fig. 4. Layers of a CNN

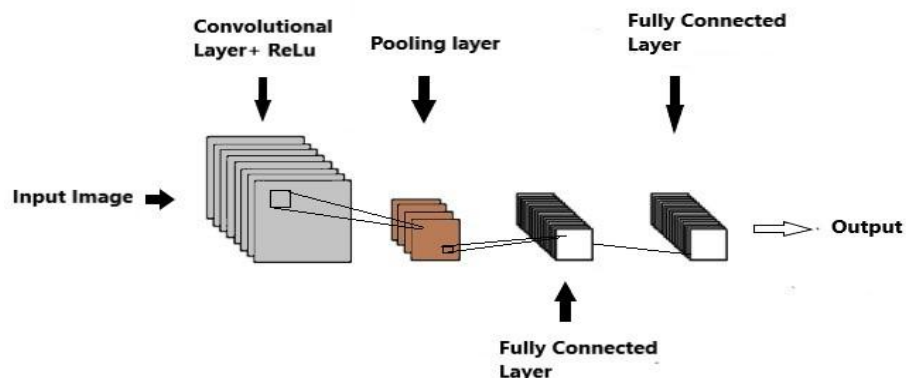


Fig. 5. Architecture of a simple CNN

Applications in Healthcare: In healthcare CNN is used for medical image analysis. Medical image classification using CNN helps detect anomalies on the MRI images and X-rays with precision higher than human eye. CNN is used in health risk assessment. In health risk assessment applications, CNN is used to calculate the probability of a disease occurrence and progression. This framework can also be used to add the treatment plan. Another important field of medicine where it CNN is used is Drug discovery. CNN can be used in developing plan of treatment for the patients, with the current existing drugs. CNN can be used to detect osteoarthritis, which is a disease that cannot be detected until the damage has already been done. It is also used for retinal imaging, skin cancer classification etc.,

3.3 RNN (Recurrent Neural Network)

Recurrent Neural Network is a type of neural network which is repeated overtime [19]. In general RNN at different steps share different parameters by allowing self-loop connections. RNNs are derived from feed forward neural network. A feedforward network maps vector of input into output vector, and an RNN maps sequence into sequence. RNN was first introduced in 1980, and since then many varieties of RNNs have been proposed. Fig. 6 shows basic recurrent neural network. Some variants of RNNs are:

- Echo state network is one of the varieties of RNN, which has sparsely connected random hidden layer. The only part of network that can be trained is the weights of the output neuron.
- Independently RNN is another variety of RNN. This RNN addresses the problems in the traditional fully connected RNN like

gradient vanishing and exploding problems.

- Recursive neural network is also a variant of RNN, which is created by applying similar set of weights recursively over a differentiable graph like structure by structure traversing in topological order.
- Long short term memory is a system of deep learning which avoids vanishing gradient problem and is a type of RNN. Recurrent gates called forget gates are used to augment LSTM. Backpropagated errors are prevented from vanishing or exploding by LSTM. Even when there are long delays between events, LSTM can still handle the signals that mix high and low frequency components.
- Gated recurrent units (GRUs) are gating mechanism in recurrent neural network. In terms of performance they are similar to LSTM (long short term memory), and they have few parameters than LSTM.
- Continuous time recurrent neural network is also another type of RNN which uses a system of ordinary differential equations, in order to model the effects on a neuron of the incoming spike train [19].

For a neuron i with activation y_i , the rate of change of activation is given by:

$$T_i y_i = -y_i + \sum_j^n \omega_{ji} \sigma(y_j - \theta_j) + I_i(t)$$

Where T_i is the postsynaptic node time constant
 Y_i are postsynaptic node activation
 y_j are presynaptic node activation
 W_{ji} It is the weight connection from pre node to postsynaptic node
 $I_i(t)$ is the input to node
 θ_j Bias of presynaptic node
 $\sigma(x)$: this means sigmoid of x (the value of x could be anything here x is taken as reference)

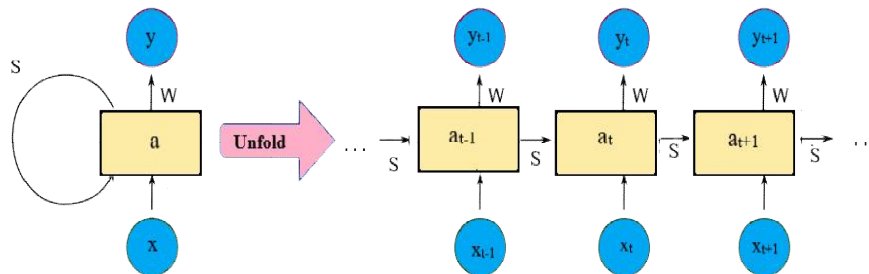


Fig. 6. Recurrent Neural Network

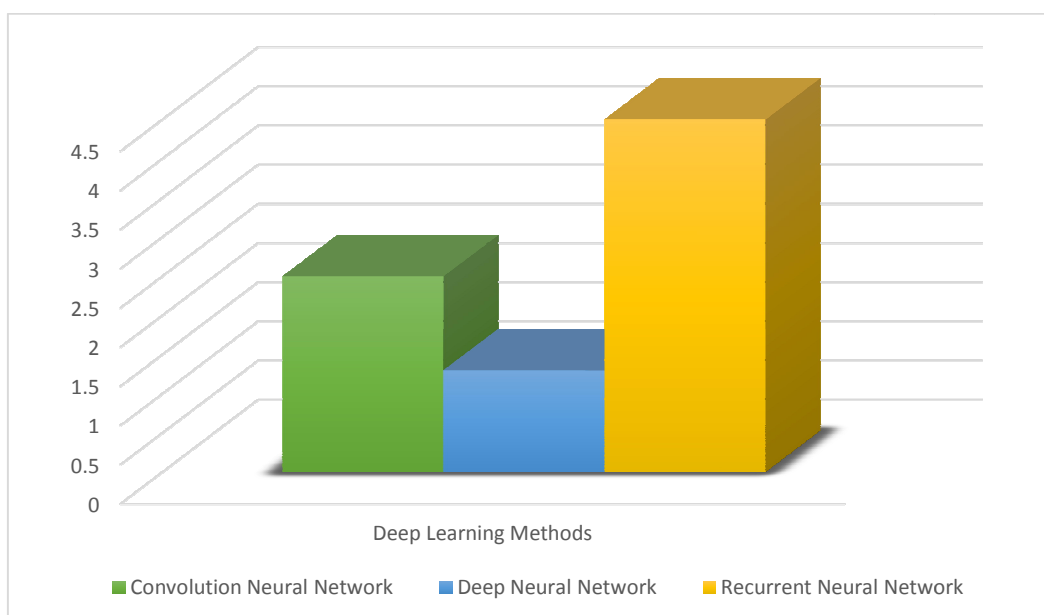


Fig. 7. Use of Deep Learning methods in healthcare related research papers collected and reviewed from various sources like PubMed, google scholar, MDPI for the year 2020

4. DISCUSSION

Some of the important field in medicine where AI is being used are treatment design, drug creation, skin cancer classification, MRI scans, assisted surgery etc. one important factor that needs to be considered while using AI in medicinal field is strong data management. It is the primary step in revolutionizing healthcare [20]. In healthcare industry data of patients like their information, diagnosis information and new research findings are generated in massive volume each and every day [21]. Using analytical data tools helped the organizations achieve the insights needed to collaborate effectively with patients, and take good decisions, and this can lead to benefits like hospital staff timing reduction, being able to remotely check patients [22]. AI is helpful in doing repetitive jobs like analyzing tests, x-Rays, CT scans [23]. The amount of time and data to examine in the fields of cardiology and radiology is some time complex and intense. AI presents them an opportunity to only look at the typical cases in the future.

With the advancement in the AI there is an advancement in healthcare treatments. AI has the ability to recognize and symptoms of a disease from medical images like MRI scans and CT scans x-rays and ultrasound. using this faster diagnosis is provided and time taken is reduced from weeks or days to hours. In mobiles, and

messaging apps, healthcare bots are used and facilitates patients quickly. These healthcare bots can also assist patients by managing their medications by providing information on type of medication and the dose that needs to be taken.

Another area in medicine where deep learning is being used is, skin cancer diagnosis. It was observed that by the time of 2021 there will be 6.3 billion people that will use subscriptions on mobile devices to diagnosis their skin cancer using deep learning [24]. Author [25] has used dataset from HAM1000, and they used these images to train and validate. Out of the total images they used eighty percent were used to train, and twenty percent were used to validate against the learning that has been done, and they used CNN models like DenseNet201, ResNet152, Inception_V4. They pretrained their models from ImageNet dataset. For Melanocytic nevus they achieved a confusion matrix of 0.96,0.96,0.96 65 with DenseNet201, ResNet152, Inception V4 respectively. For dermatofibroma they achieved a confusion matrix of 0.86,0.94,0.82 65 with DenseNet201, ResNet152, Inception V4 respectively. For melanoma they achieved a confusion matrix of 0.73,0.76,0.65 with DenseNet201, ResNet152, Inception V4 respectively. They achieved a 2% improvement in confusion matrix which is of 0.98 for Melanocytic nevus using DenseNet201 by cropping images for training and validation.

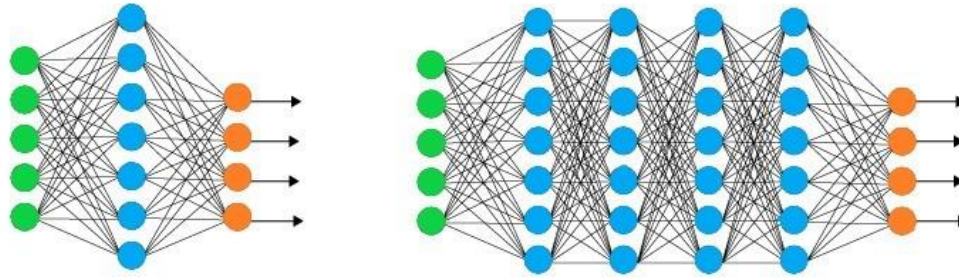


Fig. 8. Simple neural network vs Deep learning neural network with hidden Layers
Green: Input Layer; Blue: Hidden Layer; Orange: Output Layer

In a research work transfer learning was applied to AlexNet model in different ways [26]. one of the approaches is they replaced the classification layer with a softmax layer, another approach they used is fine tuning the weights of architecture, and the last one being augmenting data set by fixed and random rotation angle. Softmax layer is able to classify segmented color image lesions into nevus, seborrheic keratosis and melanoma. The data set ISIC containing 2000 images of which 374 are Melanoma, 254 Seborrheic Keratosis, 1372 images are Nevus were taken, and from Derm (IS & Quest) 206 images of skin lesion divided to 87 and 119 images for nevus and melanoma, and from MED-Node 170 total images out of which 70 and 100 images for melanoma and nevus images, are used in testing and verifying the proposed method. Accuracy achieved for ISIC is 95.91%, and for Derm (IS & Quest) is 97.70%, and for MED-NODE is 96.86%.

Research [27] used a CNN that is trained using 4867 clinical images and they obtained this dataset from Tsukuba hospital and these images are from the years 2003 to 2016, and the images has 14 malignant skin types. They compared the results against 13 certified dermatologists. The accuracy they achieved was 76.5% 89.5% specificity and 96.3% sensitivity. CNNs are proved effective, but there are some problems with the potentiality of these architectures. Incorrect classification is done by adversarial attack. Some of the factors that contribute to this is alterations in color balance and alterations in rotation image that is provided as input and translation lead to misclassification of melanoma as a benign naevus.

Study [28] has used public data that is available, and they used ResNet model, and they fine

tuned the model with 19,398 images for training purposes. They used this model to classify twelve different types of skin diseases. They achieved .96 for melanoma detection and 0.83 for squamous cell carcinoma, and 0.96 for basal cell carcinoma.

Several medical technologies are working on improving AI techniques to identify psychological conditions in children [29]. An AI powered autism experiment was conducted by a technology innovator in the recent times, and this helps recognize early stage of autism in kids with age ranging from twelve to forty [30]. In this process a device that uses eye tracking determines the health of brain for kids by using images [31]. Factors like environment conditions are important in many diseases like cardiovascular, pulmonary disease, cancer, and psychiatric disorders. AI technologies are being used to explore data for environmental conditions to better understand disease mechanisms and improve care quality. Author [32,33] studied the association between effects of air pollution on children's cognitive skills using Machine language models in United States. Used of this method seems much promising but it has one issue also. Collecting data around the world for patients and the environmental factors surrounding them is a difficult situation. Another important factor in medicine is medications, and they play a good role in healthcare. During the drug development the data collected at various stages will have insights on mechanism of disease and treatment.

Clinical trials are very important in developing drugs. Much importance will be given to patients that participate in clinical drugs development trails. This clinical data is very important for any pharmaceutical company and provide variety of information. AI is being used in clinical trial

design and data mining. Another work [34] used feed forward feature selection and gradient boosting in predicting depression from cross-trails. Using social media like Twitter, Facebook and Instagram has association of cardiovascular issues in humans. Furthermore [35] has found association in use of modern digital media and increase in hyperactivity disorder in adolescents between age of 15 and 16. Some researchers examined social analytics and mind health issues and they identified risks of suicidal ideation and depression [36].

Research [37] developed an approach in which a multivariate Cox least absolute shrinkage and selection operator to determine emission rates and rate of survival in cancer by using data from the past learning. Another approach author used is model based integration, in which each model is built using different and data and by aggregating model outputs.

A study developed a deep learning architecture of two stage for diagnosis of retinal disease [38]. During stage 1 a deep segmentation work was introduced to create a segmented image from 3D optical Coherence Tomography images. Later first stage a CNN is used to analyze the segmented images and diagnose the patients. The system is trained basically on 14,884 images and is used on patients in an ophthalmology clinic. This being double layered CNN and is compared to single layer CNN achieved better results. Challenges remain the same in using AI in medical imaging analysis, Analysis of these medical images depends heavily on deep learning architectures that were trained on natural images. sometimes these medical images are further fine tuned, this will enhance the ability of the model to classify the image better. Thus images which are raw taken with phone and camera, and at different lighting situations have effects on images. We usually talk about the importance of protecting privacy and security of public health data. Especially data of the individual patient. With an increase in Artificial intelligence usage in medicinal fields the security of data is at risk.

Screening for diabetic retinopathy (received FDA approval in 2018 and already in the market): Retina image of the patient is uploaded to the software and the system reviews the scan and returns a result of either 'More than mild diabetic retinopathy detected: refer to an eye care professional' or 'negative for more than mild

diabetic retinopathy; rescreen in 12 months [39,40].

5. LIMITATIONS AND DRAWBACKS

There are many challenges, and drawback associated with deep learning even though there is a lot of progress made in healthcare. One of the important factors for deep learning to work is amount of data. Many network parameters are needed for a neural network and to achieve this lot of data is needed. Usually for any neural network the number of parameters needed should be 10 times more than number of samples. In health care domain we often don't get many patients willing to cooperate to provide data, due to privacy concerns. Also understanding the variability of disease of each individual is much more complicated than other fields in AI [41]. Other fields in AI like vision speech, language etc., will have clean data and structured data, but the data from healthcare is ambiguous, noisy and incomplete. So it is little difficult applying AI in healthcare compared to other fields, but we are progressing in a good direction from the past few years.

Another factor is, clinicians are slow in adopting to the technological changes and its applicability in healthcare, and this needs to be improved. The applications that are being used in healthcare need to be user friendly so that it is easy to adopt for the health care workers.

6. CONCLUSION

The promise of AI in health care industry is evidenced in this literature. AI is on its way to become more useful at many levels, which leads to better and faster patient outcomes. Artificial intelligence, machine learning, deep learning can help us with proper care in assisting surgeries, diagnosing diseases like cancer at early stages etc. Some factors that need to be considered while doing research on AI is also mentioned in this paper. With the recent advancements in AI research, and with the help of support and resources from governments, it is highly likely that use of artificial intelligence in healthcare will grow extensively and there is huge potential for cost savings and improvement in the quality of service in healthcare.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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