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A Study of Prospects and Scope of Deep Learning in the Prediction of Heart Diseases - A Review

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***Abstract*---In today's fast and rapid technological advancement the use of Artificial Intelligence, has put the remarkable impact on the prediction of diseases in medical field. The use of AI and its techniques had given tremendous benefits for the early diagnosis and prediction of Heart Disease. The machines are being defined more precisely to perform, by the use of Machine Learning, a subset of AI. But with the use of biological functionality of human brain, we can expect more accurate and best results. The use of Deep Learning, built and designed on ANN, uses the data in various forms, and store it for various application and purposes in a random manner, makes more intelligent decisions of its own and helps to make accurate result about the disease. This aim of this paper is to compare the scope and prospects of using Deep Learning approach with the previous techniques of Machine Learning in the prediction of Heart Disease**

***Keywords*---Artificial Intelligence, Machine Learning, Artificial Neural Network, Deep Learning, Heart Disease**

I. INTRODUCTION

The Human is the best creature created on earth and being living organism, have the ability to do various tasks. The anatomy of human body comprises of various organs due to which they can think, visualize, learn and compete with others. They had even various other organs which gives them best results with animals too.

Besides the many organs presented in human body, the role of heart plays a major role. It is extremely important organ which should always be healthy and fit. The life span of any human body is analyzed with its proper pumping and heart beats. The accurate diagnosis and prediction of any heart disease, before it causes threat to life, is a challenging task in medical field.

Although the timely prediction not only saves life but also helps practitioner to start early treatment for speedy and timely recovery, and hence had opted the various other ways for it. With the latest technological advancement in the field of Computers, the medical field has changed a lot. Today the use of Computer based approaches had paved a way for the cure of many diseases early. The use of Artificial Intelligence (AI) is such a recent advancement in the medical field, had given a boost, both to the medical personnel and patients.

[A] MACHINE LEARNING

The AI, a field of Computer Science, makes a machine to think, find and compare by its own. It is responsible to make a machine critically think and logically decide.

Machine learning (ML),as the name suggest, is the sub set of AI, in which the machine is made to learn and perform the different operations without being programmed, by using the various algorithms and statistical models. Being a part of AI, it had therefore, shown a remarkably good performance by avoiding the use of human intervention. It actually relies on patterns, and inferences as the machine learns by its own and is capable enough to give results, which can be analyzed further for decisions.

Although it processes the data by its own and every time predicts to find the correct value, without making any programs, it makes the certain errors and hence learns automatically to detect, from data it provide. Due to this excessive learning, it has certain disadvantages, as it requires extreme resources and massive computational power for training huge datasets for interpreting accurate results.

ML algorithm is applied and used in medical field, when certain problems where huge requirement both of time and effort is needed for the accurate prediction, and

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cannot be solved by means of classical approaches of human diagnosis. On that basis, the various algorithms of ML can be classified as: learning based algorithms and algorithms on the basis of output as follows:

[i] Learning based Algorithm

On the basis of learning, algorithms of ML can be classified as:-

1. **Supervised learning:** is a type of learning in which the machine learns by its own, by taking the input from the huge datasets, and processes to give the output. The every task that the machine proceeds is being predicted by a teacher beforehand, and knows the desired output. The machine compares every time, the obtained output with the target output and learns from it. This approach tries to minimize the error as the machine learns by its own every time and hence helps to find the accurate response.
2. **Unsupervised Learning:** It is a type of ML algorithm in which no teacher or desired output is known to the machine in advance. The machine every time obtained the output and compares to minimize the error rate. The algorithm is repeated several time through which the machine learns until the error rate is minimum.
3. **Reinforcement Learning:** is a form of ML algorithm which resembles the supervised learning. Like Supervised Learning algorithm, it contains the advanced information about the desired output, but does not give any indication about the closeness with actual output. It only helps the machine to learn that, whether the output obtained is correct or not, thus creating the error as binary.

[ii] Output based Algorithm

Another classification of ML algorithms is on the basis of desired output of a system:

1. **Classification:** This type of algorithm is based on the concept, that the input data used is being divided into two or more classes, and the machine learns to produce a model, which uses it to classify into multi-label classification. It is a way of supervised learning.
2. **Regression:** It is based on the concept where the output is continuous, rather than discrete. It is also a type of supervised learning and can be applied where outputs are of Linear and Polynomial approaches.
3. **Clustering:** This algorithm is used when a set of input is divided into the different groups, and none of them is to be known beforehand. Due to this it widely resembles the unsupervised approach of learning. Based on this, it can also be further divided into Support Vector, PCA and K Means.

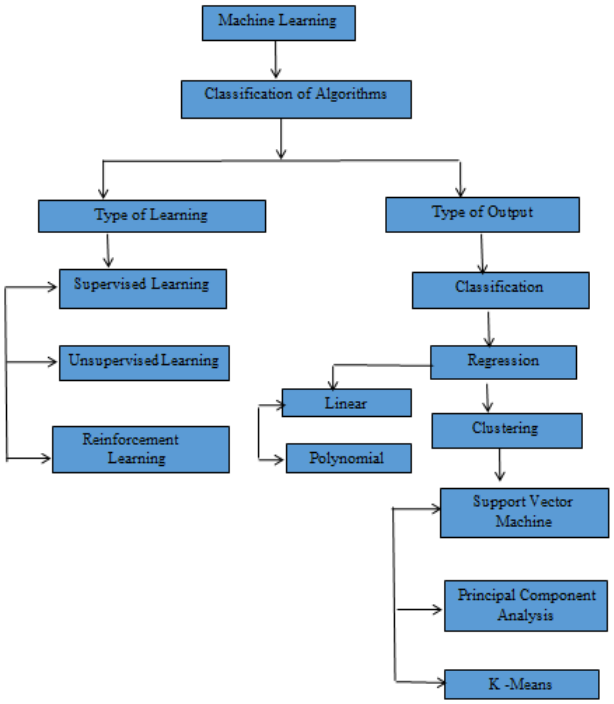

Fig 1: Machine Learning

[B] DEEP LEARNING

The Deep Learning (DL) is another field of Computer Science, which is based on the concept of AI. The DL is actually a superset of AI and has revolutionized the use of Computers for the application of many complex real time problems. The word DL came to light in 1986, in the context of binary threshold neuron by Rina Dechter, but was used much before in 1971 with eight layers for data handling algorithm.

The DL or sometimes also referred, as Deep Neural Network (DNN) is based on the concept of biological brain. It imitates the processing and functioning of human brain by taking the input in the form of layers. The input layer takes the input in the form of neurons, processes it with connection weights, and passes to hidden layer, which is a middle layer, between the input and output layer. The DL comprises of number of hidden layers, which passes this input with the desired activation function to give the final output. The DL although uses the same concept of Artificial Neural Network (ANN), which is widely used for application in various complex problem. Like ML the ANN is also not being programmed and hence gives true and accurate results. The only difference

between the ANN and DL lies only in the number of hidden layers, as the former uses only single layers while latter uses many multiple types.

The use of DL in many different fields of AI, had shown the remarkably success in the field of medicine. The use of DL can be used to predict the accurate prediction of various types of Heart Disease. It overcomes the previous approaches used by practitioners, as it gives the precise and accurate diagnosis of it, which helps him to find the actual cause of it, to start the treatment early. It not only saves the resources and effort, but saves the life of patient. The DL is hence a good approach to predict the Heart Disease.

II. LITERATURE REVIEW

The DL is vastly a suitable approach for the complex unstructured data, where the it is used to detect features of data, to correlate and combine it, for the promotion of faster learning without being programmed. It solves and find the end-to-end results by finding suitable results.

The Heart is the major organ of human body, and changes in modern life style had made it a cause of concern, and hence, created the biggest challenge for medical professionals. According to a various researches, the leading cause of death all over the world is Heart Attack. But the advancement of AI has made algorithms to be used in medical science for its efficient working. The DL algorithms are having a vast scope and application in medical field, where the prediction of accurate disease is not applicable beforehand.

As the high death rate occurs due to various diseases of heart, therefore it is required that some computer based assistance is needed for medical personnel as suggested by Mohd Ashraf, M. A. Rizvi and Himanshu Sharma [1]. But, since a lot of automated support systems are present for the detection and prediction of heart attack in humans, therefore, ML techniques are compared on data set.

They observed that by using ML the true potential of algorithm is not reflected, and it also suffers from anomalies like accuracy, and manual pre-processing. Due to these limitations, they proposed DL for making an automated system which will predict the heart attack, and test it on various dataset to find its potential and accuracy.

They found that using DL had removed all the anomalies and make efficient prediction. The accuracy achieved through DNN is much higher on any type of data set. Also, their work laid an emphasis that heart attack prediction, with help of ML and DL, has a good scope and a lot of research has been applied to the medical dataset. They also found that DL used to evaluate heart attack prediction is obtained, by taking mean square error and accuracy, plotted graphically. It is hence, concluded by them, on the basis of comparison with various other ML algorithms, which were used earlier for predicting heart attack, that using DNN is super messy, and in future, this work can be extended for achieving better result of accuracy.

Since ML techniques are the essential elements of medical imaging, and DL has recently emerged as a latest approach to solve previously intractable problems, by enhancing the performance of existing algorithms. Therefore another researcher [2] found that DL can contribute significantly in it. They studies the prospects of using DL in medical imaging, and describe its potential for future research, by first, finding an overview of how traditional ML algorithms have evolved, and how it can be enhanced to DL. Second, they surveyed the application of DL, and how the software tools for DL cane be reviewed, and finally studied the limitations of future use of DL in medical imaging.

In all their study they found that DL is widely used in many applications in medical imaging, and will also benefit immensely using it. They concluded that besides some limitations, the advantages of using DL, removes the shortcomings of medical imaging, and should integrate to become a tool for the prediction and prognosis of precision medicine.

With the recent revolution of DL, Cardiovascular Imaging has changed substantially, and it is therefore, needed to have an impact on clinical practice. Another researcher [3] in his work, reviews the general concepts of DL algorithms in Cardiovascular Imaging. As applications of DL is used to determine different clinical parameters of cardiovascular images, therefore it is used to identify patients with heart failure. But, since the applications of DL is not limited, and is therefore, used in enhancing the quality of image by reducing noise, making super resolution or by merging of different imaging modalities. Hence it indicates the possible tasks DL can streamline to diagnose the flow of work.

Since the role of DL is also used in the prediction of prognosis of patients on imaging data, but these applications are limited, as it is easily identifiable, and prognosis requires large datasets. It also includes the use of confounding factors, such as lifestyle, age, and genetic traits for consideration, but such datasets are not easily available, and is also a very challenging task for collection. Due to all these, the use of DL creates limited application in cardiovascular imaging.

Since the previous research uses some applications

without the use of multicenter datasets, and mixing of imaging data with clinical information is not used. In reality, the cardiologists uses many information for the diagnosis, besides the image of data, and therefore found, that it can be analyzed using DL.

The role of DL played a major role for the researchers without having a previous medical history, and hence they will act as end-users for the developed algorithms, and will therefore guide the system developers to mix algorithms with clinical workflow to achieve maximum impact. It is observed that the Cardiologists play an important role in collecting the data and performing annotation, which is needed to ensures that the rights of patient are treated in an ethical manner. As the use of DL in cardiovascular imaging has big impact, both in research and industry, it is also known that DL is not a panacea, and its algorithms had minimized the performance in some medical tasks.

DL in Cardiovascular Imaging can perform any task that human can do, and hence, many scientists believe that DL can only be the solution. However, DL thrives in such scenarios of cardiovascular imaging.

Another researcher [4] founded that medical field is different from other sectors, and is on priority due to the expectation of people besides being costly. But after the arrival of DL in real world applications, it is a good solutions with high accuracy for medical imaging, and a key approach in future applications of medical field.

During their investigation they found that in recent years, DL has attained the central approach for the advancement in our daily life, and had shown improvements with regard to ML algorithms. It is also believed that using it in many applications will put it above humans. But, the use of DL in medical field, especially in medical imaging is quite slow, as compared to other real time problems, due to the unavailability of annotated database, and enough training data.

In their investigation, they found that bigger the data, the better the result will be on other application, and concluded that, due to the sensitivity of complex healthcare data, efficient DL algorithms is a good choice.

Another researcher [5] in his work, studies that due to Cardiovascular Diseases, or Congestive Heart Failure many deaths occur all over the world yearly. Although many traditional ML learning methods have been implemented previously, but they proved to be a little step to control the spread of the disease for reducing the number of deaths. In their work they proposes the use of algorithms, like Boosted Decision Tree (for detection), CNN (for subtype estimation) and, finally predicting possible unfortunate events.

In his studies they find, by proposing and developing a useful system, which is be able to help the doctors, in evaluating the medical condition of a patient. It is specifically able to detect, if a patient is having more chances of heart failure or not, and is also able to predict accurately, the type of heart failure, and its severity. They used a boosted decision tree and, the CNN module, for the purpose of detection of heart failure, which gives an estimate to the patient being prone to heart failure. They also used other algorithms with ANN, to detect type of heart failure, and obtained a higher accuracy by using the latter.

Since ML algorithms has gained attention over the few years, and the current use of it occurs recently, when DL began to perform better, than other established models of it on a number of benchmarks. DL is used now across a variety of areas, from image analysis to natural language processing, and also deployed in academia and industry. These developments marked its way for medical imaging technology, medical data analysis, medical diagnostics and healthcare.

Another Researcher [6] studies the use of DL in MRI, and the challenges faced by using ML in medical image processing and analysis. The main aim of this study is: (i) to give a brief introduction of DL (ii) to indicate the use of DL be applied to the full MRI processing chain, i.e. from data acquisition to image retrieval and, from segmentation to disease prediction; (iii) and, to start experimentation & contribution of DL in medical imaging. During their investigation, they concluded that using DL it becomes easier for the classification of problem to most promising approach of solution (i) to get end-to-end results, (ii) to combine it with other techniques, (iii) or to not use it at all for any solution.

Since DL is best suited for getting electronic health record data, for analyzing sources of data, by using different architecture, to obtain target applications. Another researchers [7] studies the current models for getting the data of electronic health record and, found that using DL for finding the raw data, for obtaining the preprocessing and to get feature engineering, helps to improve the results of many analytical tasks. However, several challenges remain there, as there is a need to get the good quality of generated data and labels. But, for data getting increased augmentation, it suffers due to: 1) lack of good variety of generated data, 2) making of data biased toward the prediction task, and 3) a need for the preservation and evaluation of utility and privacy of generated data.

Since DL models are not clear to find uncertainties,

and make it less robust in dealing changes in data distribution. Therefore, there is a drawback for applying these models, in which the real electronic health record data can invalidate these models' predictions making it inappropriate in medical field. However, to use DL models built from such data, into real time applications, the operation of model must be achieved. During their study they concluded that the use of DL based model must be considered for direct clinical impact, deployment and automation.

The basic cause of the occurrence of heart disease, is the inability of heart, to pump the sufficient amount of blood and pass it to other parts of the body. It is therefore, necessary to have an accurate and timely diagnosis, for its prevention and treatment. The analysis of various diseases of heart by using previous symptoms and medical history, is not a best choice. Therefore, to classify the healthy people, with others having heart disease, ML is being used, and is being considered a reliable and efficient solution.

Another researcher [8] in his work obtained a diagnosis system based on ML, by using the dataset of heart disease. They used seven ML algorithms, with three feature selection algorithms, the cross-validation method, and the seven performance evaluation metrics, like classification accuracy, specificity, sensitivity, Matthews' correlation coefficient, and execution time. In their study they evaluated the performance of proposed system, using all features and some features, and concluded that designing a decision support system by using ML is suitable for the diagnosis of heart disease. Otherwise, using some irrelevant features will try to reduce the performance and increase the computation time of system.

During various studies it is obtained that using deep convolutional neural network is a best option and has also performed well on many tasks of computer vision tasks, and these networks are dependent on big data, to avoid overfitting. It therefore, refers to the phenomenon when a network learns a function with a very high variance to model training data. But, in many applications it has no access to big data, such as medical image analysis.

Another researcher [9] focuses this issue of data augmentation, a problem due to the solution of limited data-space. The data augmentation is a collection of techniques that increases the size and quality of training datasets, such that better DL models can be built. While, the algorithms of image augmentation include geometric transformations, color-space augmentations, kernel filters, mixed images, random erasing, feature space augmentation, adversarial training, generative adversarial networks, neural style transfer, and meta-learning. In addition to these, it also includes test-time augmentation, resolution impact, final dataset size, and curriculum learning, and found that these solutions exist with the problem of overfitting, and to avoid it, these models rely on big data.

Since data augmentation emerge as a useful technique for making better datasets, it can be classified as data wrapping or oversampling technique.

As the layered architecture of DL gives many opportunities for data augmentation, it is believed that it operate in input layer. They concluded that applications of image data can be expanded to other data domains, and the use of data augmentation cannot overcome the problem of biases present in a small dataset, besides the lighting, occlusion, scale, background.

As in recent years, the use of DL, which is a new approach of ANN, had transformed the daily lives, industries, and various other scientific applications. It hence, represents a significant progress in making the ability of ANN to self-detect relevant features of problem, and capture the complex distributions of data.

Another researcher [10] therefore studies, that DL can be used in interdisciplinary areas like water science, data discoverability and hydrologic scaling. They find that DL is beneficial for scientists and hydrologists, and have been used by various physical and geo-scientist to address the issues of data, to improve the efficiency, and to gain the insights of scientific work. In their work, they found that DL is a fastest approach for many scientific disciplines, and also have the ability to find features, and needed to capture high-dimensional multimodal data distributions for practical benefits. They also found that DL-based applications, avoids the problem of many scale representations, overfitting, and have efficient computing platforms for obtaining exponential growth.

They concluded that in water sciences, DL can be used for performing two functions: (A) to build models with accurate predictions and greater processing capability with reduced human expertise, and (B) can be used as a data mining tool to support discoveries that can expand the capabilities of present knowledge.

Using the past experience of many disciplines, if the objective is to get information from images or sequential data, then the architecture of using CNN is a good choice, but if the data organization is in 2-D or 3-D images then many elements are needed to get the design of network. And, if the aim is to get the inverse of emergence, the architectures of network needs to be designed from base.

As, DL arises from AI, and focusses on many issues,

therefore many scientists are paying attention for making the network and developing the standard methodologies. Also, there are many opportunities of research in using these methodology for making the network decisions. But since the hidden layer store the representation in a distributed manner, only the effects of activation is capable to get the correct outputs. The interpretation for getting the effects of particular activations can give the incomplete and inconclusive analysis and the relevance of backpropagation methods can point to inputs which cause these events, and are applicable for the problems with spatial dimensions, as similar to image recognition. Due to this, it is difficult to implement the recurrent networks and a strong collaboration with scientists is needed.

Another Researcher [11] predicts that heart disease like Ischemic heart disease, arrhythmia can be effectively classified by electrocardiography signal, which describes the condition of patient for diagnosis and treatment of various types of cardiac diseases. It is found that one diseases of heart is related with other and will be major if it's proper classification is not done, therefore, it is preferred to implement CNN algorithm. In their studies, they proposed that the system gives the small rate of error, for the signal recorded short, but having a larger number of samples, i.e. if training is done using the CNN, the correctness of classification is higher, and the normal and abnormal can be classified with great accuracy. They also found that such an implementation over the simple CNN will limit the necessity to extract manual features, and creates pre- and post-processing implementation for monitoring and detecting the anomaly in heart disease. They concluded that using this approach, very high accuracy is achieved and, distinct patients can be treated efficiently once the CNN is trained, to obtain the record of electrocardiogram.

Another Researcher [12] proposed an efficient convolutional layers of ANN, to classify the imbalanced class of clinical data, for the prediction of occurrence of coronary heart disease. As the majority of the ML models have been used on different classes of data, and are limited to class imbalance, even after the adjustment of class-specific weights. The two-layer CNN shows no change in the imbalance with least relation in class performance, but in order to obtain improvement in classification under supervised learning, it is a necessary to train a ANN architecture with an excess of data and test the network on small data.

For the analysis of this, they used the two-step approach, the first being less absolute shrinkage, with the use of selection operator based on weight assessment of feature, and second, in which the important features are homogenized by using a fully connected layer, before passing the output to successive convolutional stages. For all this, they proposed a training routine of per epoch, like simulated annealing process, to boost the classification accuracy, and hence by using it, found that CNN can be used to implement the prediction of clinical datasets, which contains the imbalanced number of positive and negative classifications.

Also it can be used as a model for transfer learning, and the last two dense layers can be retrained with the new data. During their investigation, they concluded that it is good option to perform testing, if the extension of shallow CNN models, implements the ANN based learning on clinical data sets, both in terms of architecture and data sampling, to improve the accuracy of classification process.

With the recent technological advancement, the medical field is producing more data which the physicians are unable to convert and use, makes cardiology and medicine as human independent, and hence, brings it closer to an automated AI. The AI will reach the point where it uses real-time physical scanning for the detection of diseases, but also interpret ambiguous conditions, for the precise phenotype complex diseases and making medical decisions.

Another Researcher [13] in his studies finds the benefits and limitations of applying DL in cardiology. They concluded that since DL has emerged as an accurate and effective technology for the wide range of medical problems, like diagnosis, prediction and intervention, its complete knowledge is still not available. They concluded that detail understanding of the strengths and limitations of the working of DL is needed to put its place in day to day clinical use.

Since Heart disease is one of the cardiovascular disease, and is a disease of heart and blood vessel system for which a large amount of research is needed. To get various aspects of heart disease a huge amounts of data, and the combination of ML, Data Mining, and DL provide the best way to extract knowledge for decision making. For all this another researcher [14] conduct a systematic review of the applications of ML, DL techniques, and tools used in the field of Heart disease, with respect to Complications, Prediction, and Diagnosis. They conducted the study by characterizing ML & support vector machines with high percentage, and by DL with remaining percentage, with the use of Clinical datasets. On the basis of these, they concluded that the benefits of applying ML and DL is useful to extract the knowledge for

the reduction of disease rate and death failures, and, it is needed for the understanding and investigation in cardiovascular disease.

Although many researchers have found that DL techniques are beneficial for predicting heart disease, as compared to the use of others, and suggested that to overcome the cause of deaths, sound analysis of heart beat is a convenient way for its diagnosis. But the sound of heartbeat and its classification is a problem of segmentation and feature extraction. To overcome it with based model another researcher [15] proposed an approach heartbeat classification, based on data framing, down-sampling, and on recurrent neural network for dataset.

The proposed approach found that detection of signal of heart beat gives the idea for deciding, whether the need for treatment is necessary or not. By using it, the noise is cleaned by filtering, and the data framing is used to convert the sampling rate of frame for each audio file into a frame rate of fixed size, which is used to decrease the dimension of down-sampling, for the extraction of more discriminative features.

III. CONCLUSION

The use of AI had created fast technological advancement in various field of Medical Science. The various different algorithms of ML has been applied for the prediction of various diseases. But due to the limitation of using ML, in the prediction of disease, the use of DL is a better choice for it. The DL gives more accurate and timely prediction with reduced cost. This paper studies the use of DL in the medical field, and concluded that the application of DL algorithms gives best results, both in terms of prediction, diagnosis and accuracy and by using it, the medical practitioners can be most beneficial.

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