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AI-DRIVEN DIAGNOSIS OF HEART CONDITIONS: A COMPARATIVE STUDY ACROSS NEURAL NETWORKS AND TRADITIONAL MODELS

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Abstract

Timely prediction of cardiac illnesses is crucial for life preservation. Traditional approaches to prediction have often struggled with issues including increased prediction cost, longer calculation times, and increased complexity with increasing data volumes, all of which have a negative impact on forecast accuracy. For this reason, several ML (Machine Learning) and DL (Deep Learning) algorithms have been included into AI (Artificial Intelligence) systems for the purpose of cardiac illness diagnosis. Improved detection is a result of its ability to learn from large datasets that include patients' ages, weights, blood pressures, and other risk variables, and then extract relevant information based on user input. The analysis of illness incidence from historical data is substantially aided by the storing of greater data using AI. To that purpose, this study will survey the literature on artificial intelligence (AI) based algorithms used for cardiac illness prognostication and highlight its merits. It evaluates and compares things in the same way that conventional research in the field has, with an emphasis on accuracy and making the most of algorithms. Aims of future research include identifying the dimensions with high and low prediction accuracies so that relevant studies can be conducted, with the paper's main findings highlighting the development and ongoing exploration of AI techniques for heart disease prediction. The article concludes with a section on future research that should serve as a catalyst for more studies into the use of AI in the identification of heart diseases.

Keywords: Heart disease; prediction; artificial intelligence; machine learning; deep learning

1. Introduction

Heart disease prediction at an earlier stage is essential to prevent the severe progression of the disease and reduces the rate of mortality. Many conventional methods in detection of heart diseases have been found to be expensive and lacked with the generalization ability when new data is being loaded into the training dataset. In addition to that, the process of diagnosis with larger dataset is still complex in analysis since the rapid improvement in digital technology has increased the utilization of database for storing large amounts of data. In order to extract and perform efficient processing, AI based algorithms play an important role in analysing different data from clinics [1]. The methods and algorithms of AI derive significant inferences from the dataset. AI based CDSS (Clinical Decision Support System) has the ability to assist physicians for diagnosis of heart failure. The application of AI in medicine has the potential of predicting the heart problems in advance in order to prevent death. Suggested study has utilized decision tree based learning method named as CART (Classification and Regression Tree) model for early diagnosis and prognostication of heart failure. CAD (Coronary Artery Disease) is one among the heart diseases which has been reliably diagnosed through CART structure and

achieved accuracy in diagnosis and has classified normal and CAD patients through the dataset. The classification technique utilized in the recommended study has developed the decision taking system in diagnosing CAD [2]. In order to achieve better performance in classification, ensemble based learning and classifiers have been used. Recommended study has concentrated on ensemble classifiers used for classification. It has been operating through majority voting process for the prediction of appropriate components. It has used homogeneous ensemble learning with weighted aging classifiers. Moreover, the method has involved mean based splitting process for partitioning datasets into smaller group of subsets. The risk of heart diseases has been effectively predicted through the ensemble approach. Many machine learning and deep learning algorithms have been widely used in the healthcare sectors for the effective diagnosis of diseases nowadays. The complexity of processing massive data has been solved through ENDPP (Enhanced New Dynamic Data Processing) for the prediction of early stages of heart diseases [3]. Quality of decisions taken through medical diagnosis has been improved through the considered technique. Data processing method has considerably reduced the complexity and has the potential to figure out the similar hidden patterns in the huge volume of data which eliminated utilization of conventional methods for analysis. Optimal solution with accuracy remains to be a problem in complex datasets. In order to overcome the difficulty, considered research on data mining for accurate prediction of heart diseases has utilized the combined approach of MOPSO (Multi Objective Particle Swarm Optimization) and RF (Random Forest) algorithm. It has produced diverse decision trees for the determination of optimality [4]. Several training datasets with different samples and features for training each tree has been generated and acquired solutions have improvised accuracy. To forecast the disease in its earlier stages along with the factors leading to the disease, DL has proved its efficiency in several health applications. Suggested study has utilized the DL based method namely RFRFILM (Recursion Enhanced Random Forest with Improved Linear Model for the diagnosis of heart diseases [5] and has diagnosed factors that leads to the disease. With the use of DL algorithms, the study has predicted significant features for the prediction of cardiovascular diseases and also has added various combined form of features and classification methods. It has achieved better level of prediction in terms of precision. Through data analysis and comparison of certain variables, it has indicated that CAD has been developed often at older age people. In addition to that, high levels of blood pressure and diabetes also remains to be the reason for the disease outbreak. Even though studies have performed diagnosis with different methods for cardiac failure, the system must be robust and should be portable and adaptable to all type of computing devices in order to serve the remote area people where there is a lack of medical experts. Diagnosis of cardiac disorders in the recommended study has used CNN (Convolutional Neural Network) for diagnosing multiple cardiac diseases and has been effectively worked on all devices which has been found to be helpful in remote health care centres. It has the ability of predicting the heart diseases through the heart sounds. It has utilized the data augmentation methodologies for accuracy even under noisy atmosphere and for classification of various cardiac diseases. Due to its reduced time complexity, the system has the potential to be applied in real time applications. Along with that, CNN has been combined with BI-LSTM (Bi-directional Long Short Term Memory) [6] architecture for accuracy enhancement . Along with that, utilization of Bayesian optimization for the hyper- parameter tuning has increased the accuracy level in prediction. It has been validated with

performance metrics specifically ROC (Receiver operating characteristic) curve for determination of presence or absence of cardiac disease with the optimal value. Several studies have been conducted in the same way for heart disease prediction and have implemented various algorithms and techniques for improving the accuracy rate of cardiac disease prediction. This review paper intends to discuss about role of some traditional methods and influence of different AI algorithms in prognosticating heart diseases along with its challenges. The main contribution of the paper is

- To deliberate the need for early diagnosis of heart diseases.
- To address the conventional methods used for cardiac disease prognostication and the challenges faced in the medical field.
- To deliver the progress of AI with its evolving methods and its influence in prediction of heart related diseases.
- To perform the comparative analysis of various machine learning and deep learning algorithms utilized for diagnosis.
- To execute critical assessment in prediction accuracy of various AI algorithms.

2. Compelling necessity for early heart disease diagnosis

Heart failure occurs due to high blood pressure, high level of cholesterol or atrial fibrillation. Lower density lipo-protein cholesterol levels, smoking, diabetes, obesity and unhealthy diet practices are determined as certain features lead to heart diseases. Reducing the use of tobacco, reduction of salt in diet with intake of vegetables and fruits reduce the risk of cardiac disease. Social, economic and cultural changes along with hereditary factors influence heart diseases greatly. Appropriate treatments on diabetes, high level of blood-lipids and hypertension reduces the risk of attacks. Certain common important features of heart failure are included with swollen ankles, dyspnoea, physical metabolic intolerance and fatigue. Shortness of breath, wheezing and irregular heart-beat are also certain symptoms involved and diagnosing such clinical features at an earlier stage is adequate to reduce further complications. Heart attacks, heart valve issues, stroke and arrhythmia are certain forms of cardiovascular disease complications. Failure in the functioning of heart reduces the supply of adequate amount of blood to other body parts needed to complete the basic functionalities of organs. Early diagnosis of cardiac failure is predominantly important in order to reduce the disease progression or otherwise ultimately ends up in mortality [7]. Through being conscious about the early signs of the heart disease, persons used to gain a better chance in grasping threats early on. It is highly complex for predicting heart disease since it requires appropriate experience and adequate knowledge. Computing devices in healthcare systems provided diagnosis and prognostication of heart diseases. The life threatening cardiac diseases have certain symptoms included with chest pain, swollen feet, breathing difficulties, body weakness and the risk of chronic disease increases due to unhealthy diet, higher level of cholesterol, deficiency in exercises or smoking habits [8]. The lifestyle of humans play a major role in preventing from the risk of heart related diseases. Heart diseases are classified into congenital heart disease, congestive heart failure, heart rhythm complications and cardiovascular diseases. Echocardiography is the diagnosis method which helps in the assessment of the acute or dynamic changes that occurs due to the disease. Hypertensive cardiac diseases lead to organ damage with robust independent prognostic implication. Myocardial functions have to be

assessed regularly to identify cardiac alterations in patients with hypertensive difficulties. The left ventricular hypertrophy is the initial stage in the development of stroke, heart failure and sudden death. Heart failure is the problem commonly occurs in the elder person but diagnosis is often not taken. Patients with heart failure needs to diagnosed with valvular disease, haemodynamic and myocardial functions. The contagious heart disease occurs with cardiac symptoms that happens to the dynamic changes in the health of the person. Those significant changes pave the way for several severe cardiac problems when it has not been treated properly or misdiagnosed. Early prediction minimizes the risk of cardiac failure. Several studies have found that cardiac arrest has been observed due to various changes and factors like older age, smoking or alcohol habits, stress related issues or due to diabetes or high blood pressure Conventional diagnosing methods have suffered with difficulties which have been overwhelmed with AI.

3. Traditional clinical procedures for predicting heart disease

This particular section discusses on various diagnosing methodologies practices in earlier days. Traditional way of heart disease diagnosis and conclusions from the findings have been derived from the fundamental statistics and later, predictions have been analysed with various methods like logistic regression, linear regression and other techniques according to the severity of the problem. CVD has been detected through plasma ceramides. These elements accumulate into the tissues during metabolic mis-function and has been found to be the predictor of cardiac diseases in the considered study. It has taken four types of ceramides for verification of severe cardiac events to various group of patients who has been referred for angiography. The presence of plasma ceramides has been measured before the process of angiography. It has been inferred that ceramides have not only been associated with the coronary artery disease but also has been linked with stroke, myocardial-infarction and coronary artery diseases. The concentration of ceramides increases with high cholesterol level, age factors, serum glucose levels, hypertension and family history of cardiac diseases .

3.1. Challenges in the conventional medical diagnosis

Heart diseases are experienced at all ages in recent years. Even though traditional methods have taken much of their efforts in diagnosis, prevention and treatment, premature death occurs around the world . Due to the increasing population, the traditional clinical methods have faced many difficulties in the accurate prediction of heart disease. The following are the challenges that have been faced with the conventional cardiac diagnosis techniques.

- The major difficulty that has been faced with the traditional approaches were the consequent arrival of larger amount of data for analysis in cardiology. The data processing platforms have failed in effective operation with the newer data into the datasets. The process of sequential extraction and reorganization of data has helped in returning valuable output which has been found to be a drawback in the traditional data storage and retrieval strategies in the cardiovascular therapies. There are numerous information needed directly from the patients in order to make diagnosis of their healthcare effectively. The data related to health, medical imaging and diagnosed information along with lifestyle related data are highly beneficial in the heart disease diagnosis. Privacy is an important factor for both individuals and also to groups in order to maintain confidential identity which also has to be considered while sharing information.

- The traditional diagnosis method namely 12-lead ECG (Electrocardiography) has faced the difficulty of lower level of sensitivity in prediction of cardiac diseases. It also has examined with the lower predictive value of left ventricular systolic dysfunction and screening results have resulted with severe progression of heart failure.

Figure 1. Limitations of manual techniques

4. Evolution and advancements of AI in medicine

In order to overcome all challenges addressed in traditional techniques, AI has been evolved and advancements in AI algorithm has found effective outcomes in prediction. Since heart failure occurrence has increased and the complex disease syndrome has resulted from the functional disorders in heart and its proper diagnosis has been a challenging task. Many conventional methods have attempted for diagnosing the disease with minimal level of prediction accuracy. Proper diagnosis of the disease is significant for providing proper treatment. In order to overcome the issues [9], AI has initiated an important role in cardiology. It has thrown out huge advancements in the technology such as easier storage, data acquisition and recovery of data. The decision-making feature in AI algorithms has provided decision tree algorithms for making clear clinical decisions. AI (Artificial Intelligence) is the broad group of computational algorithms that have the ability of mimicking the intelligence of humans in the way of learning, making decisions and also the potential of solving problems. AI has made some tremendous and substantial advancements in the field of cardiology due to its ability to detect heart diseases, treat strokes faster and more accurate than the traditional approaches. For instance, CAD (Coronary Artery Diseases) risk assessment fundamental in the efforts to reduce the future CVD events. Traditional prediction methods have limitations which includes disparities among the validation cohorts and absence of important variables. Thus, need for robust prediction tools for accurate prediction of CAD burden and the recent advancements in AI led to development of ML based risk prediction models. ML algorithm was superior to the conventional risk prediction score in both moderate and high risk for CAD groups. Furthermore AI has been utilized for developing predictive models to gauge the risk of CVD. Implementation of AI algorithms can generate the personalized risk score by assisting the clinicians to detect the patients who are on the verge of higher risk of heart disease. By doing so, early intervention and preventive measures can be taken and potentially shrinks the incidence of CVD events [10].

Hence, these are some of the dimension of AI in clinical therapies for heart diseases. Figure 2 Advanced medical diagnosis approach of AI compared to traditional methods. Prompt development of AI technology in the medical field has attracted medical experts to provide

reliable and efficient treatment methods with good quality health care. Particularly to cardiac medicine as depicted in Figure 1, imaging has been considered to be the main focus of detection and management of patients in healthcare. Most of the traditional methods HAVE BEEN designed on the focus of average group of patients and however the general rules which has been designed has found to be inadequate due to certain complexities. But such guidelines would not work efficiently to all patients. There came the need and evolution of AI in medicine. Therefore, AI techniques are used, as AI technology has the ability to enhance the detection and prediction accuracy for heart disease prognostication by examining huge amount of patient's data which encompasses of medical records of the patients, test results and scans of the patients. AI techniques possess the capability to detect the patterns and correlations which may not be easily decipherable by manual approaches and medical professionals. AI techniques specifically Machine Learning (ML) and Deep Learning (DL) has helped in the development of predictive structures that subsequently assists the cardiologists with the guidelines specific to particular patients and decision making has been performed accordingly. The applications of AI with ML and DL algorithms have gained popularity due to the improved level of accuracy and efficiency in making predictions.

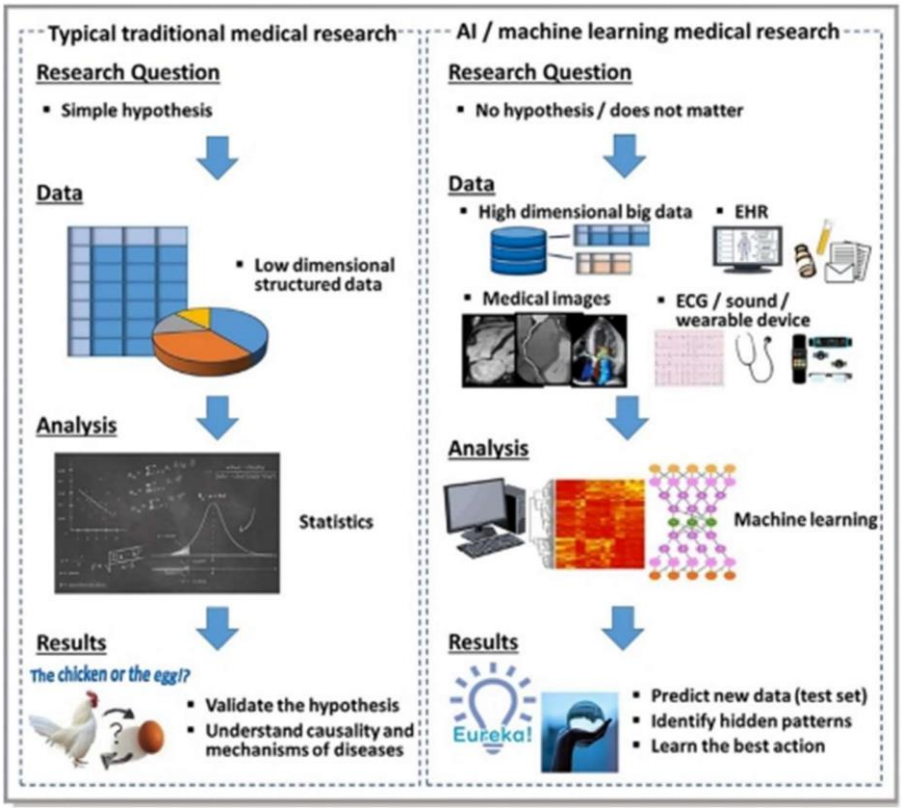

Figure 2. Advanced medical diagnosis approach of AI compared to traditional methods

5. Different AI algorithms for predicting heart disease

AI is the technical concept of constructing intelligent machines that has ability to think like humans and can learn from the observations and execute actions without direct instructions. ML and DL algorithms are subsets of AI which has been used at every phases of patient heart care from discovery of disease through diagnosis to selection of appropriate therapies [11]. It has provided efficient, convenient and effective treatment. After ML, DL has been arrived

which also comes under the family of learning algorithms which has been utilized for learning complex prediction structures. Problems with multi-layer neural network can be solved with DL efficiently. Particularly in heart diseases, CNN (Convolutional Neural Network) has the potential of mapping image data into the output which helps out in better prediction and classification of type of cardiac disease . Under DL, there are subset of learning algorithms which is categorised based on their learning capability such as supervised, semisupervised, and unsupervised and reinforcement learning which is represented under Figure 4. ML and DL strategies are broadly classified into supervised or unsupervised learning methods as given in Figure 3. The unsupervised form of learning methods intends to discover the underlying structure or critical relationships between the variables in the dataset. The supervised learning technique is involved with the classification of observation into one or more categories. It needs a dataset with the predictor parameters and labelled outputs. In cardiac therapy, predictive modelling is significantly needed for labelling cases and controls and such observations has been made with the associated features like age, gender and clinical variables. The reinforcement AI learning is able to learn with the trial and error method. This algorithm is operated with the intelligent agent being interacted with the environment and provides decision making accordingly.

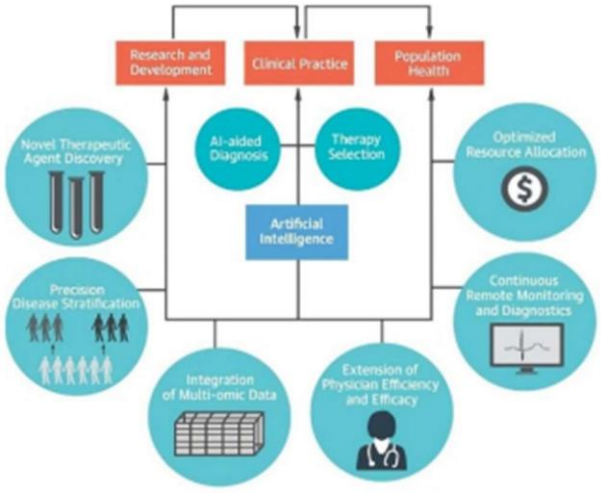

Figure 3. AI in cardiac care unit

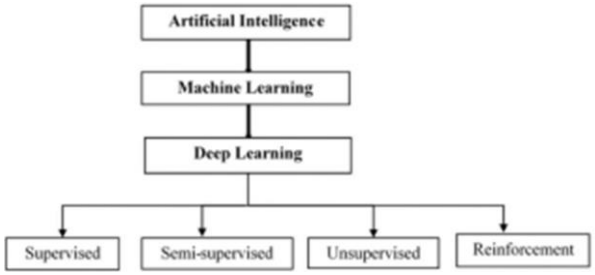

Figure 4. Major types of AI algorithms used for cardiac healthcare

Deep learning algorithms for heart disease prediction

DL architectures are generally composed of numerous hidden layers of neurons in which the algorithms run through all layers and each layer passes a simple representation of data to the next succeeding layer. It has the ability to learn more progressively about an image when it

passes through every layer [12]. Each and every layer has the potential to detect lower level features like edges and consequent layers are combined from the earlier layers into a complete representation Middle layers or hidden layers has the ability in identifying edges in order to detect parts of the object whereas the deep layer figures out the complete object. The skill of processing larger number of features makes the DL algorithms more powerful in dealing out with the unstructured data (Figure 6). DL architectures are consisted with three layers such as input layer, hidden layers and output layers and each layer performs detection with a more refined way as depicted in Figure 5. The input layer initially performs the edges and corner detection followed by the hidden layers which performs shape detection and the final output layer performs object detection. In the existing DL algorithms, CNN is considered as one of the commonly used algorithms for prediction of diseases. Convolutional neural networks (CNNs) are extensively used for image receptions and analysis because of their capacity to handle enormous amounts of unstructured data and retrieve significant characteristics automatically. The application of DL algorithms in diagnosis of heart diseases not only aids patients to prevent it but also helps the physicians to learn more about the root causes of the heart failure and prevents before actual occurrence. In, it has incorporated one of the DL methods namely CNN for heart failure prediction at its earlier stage. It also has performed diagnosis through heart sounds. Training and multiple classification of heart diseases have been performed through data augmentation methods in order to make the system robust. It has the capacity of automatic interpretation of medical imaging to assist clinicians. Moreover, in has utilized DL based classifiers in the task of prediction in cardiology. The pipeline form of supervised structure has focused relevant features and has developed network structures that has learned from both forms of labelled and unlabelled data in a more generalized manner. The prospects of DL in predicting disease at an earlier stage and classifying its stages have yielded efficient accuracy. Similarly CNN utilized in predicting and classifying Alzheimer's disease have predominantly achieved better classification outcomes. With the help of ML algorithms, heart related diseases can be easily diagnosed inn shorter time period and also in less cost. The suggested study has adopted four different ML methods such as RF (Random Forest), DT (Decision Tree), AB (AdaBoost) and K-NN (Nearest Neighbour) for the detection of cardiac diseases. The considered study has designed a system named as Streamlit, a cloud based platform for the analysis of relevant attributes that has contributed in the prediction of heart diseases. The computation on those strength scores has been indicated as the important predictors in the prognostication of Cardiac diseases. Moreover, recommended research have focused on developing the risk-evaluation structure based on hyper-parameter based optimization using ML algorithms. Group of risk parameters has been selected and has been ranked through recursive process of feature elimination. Such assigned rank and value on every attribute has been validated with the enhancement of deploying various algorithms like RF, K- NN, SVM and DT. Outcomes have revealed that optimized model of risk evaluation has achieved higher accuracy and greater efficiency. In addition to that, cardiac disease prediction has been handled through risk-evaluation structure in with the assistance of significant invasive and non-invasive risky parameters such as BP, age, physical activities, alcohol, smoking and hereditary elements. Reliability of the prediction model has been assessed through various feature-selection methodologies. The groups of ML techniques like DT, NB, KNN and SVM have been evaluated with the risk factors and error has been analysed. Moreover, disorders in

cardiovascular system have been identified through knowledge mining methodology and ML techniques .

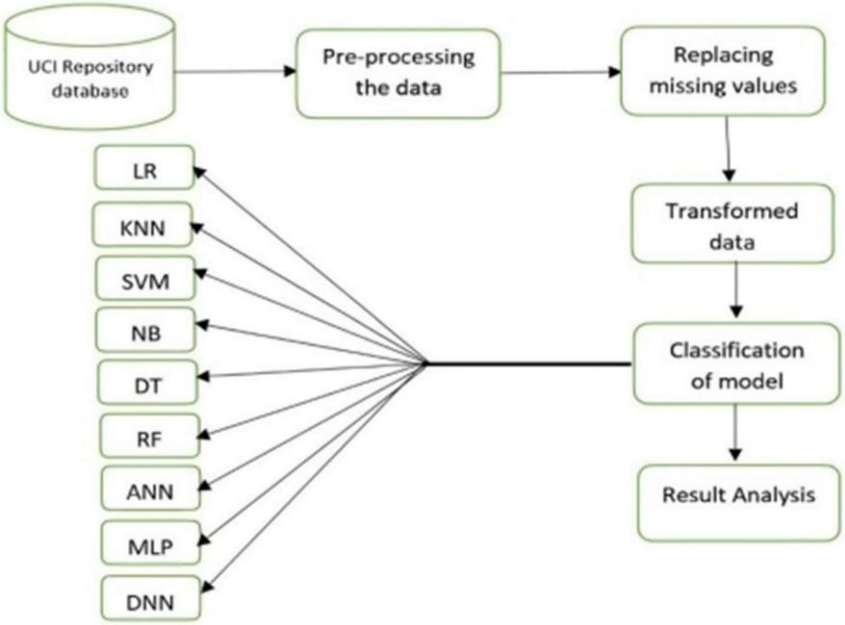

Figure 5. Different ML algorithms for heart disease prognostication

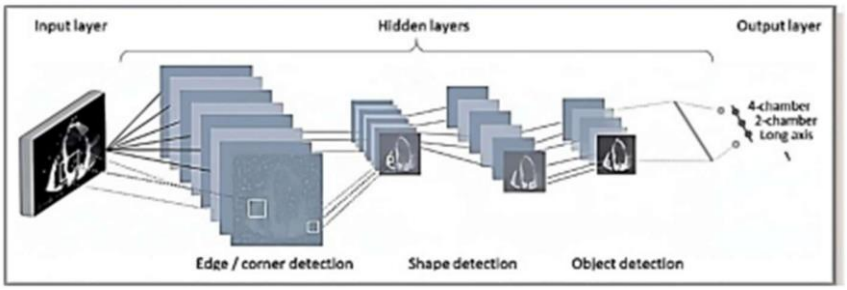

Figure 6. DL algorithms for cardiac disease diagnosis

7. Applications of AI

AI technology is utilized in cardiac care for better treatment and assessment of patients which have been performed in order to provide patients with finest possibilities. The following are the list of heart care sections where AI is used in diagnosis. It has numerous benefits in cardiology in the process of automatic diagnosis. AI is providing its utmost uses in the process of making automatic decisions and accurate suggestion on the clinical therapies. Its one of the biggest advantage is the minimal cost for diagnosis. Since conventional methods are highly expensive in diagnosis, poor patients suffered a lot and AI has taken efforts in providing effective diagnosis methods at minimal cost. There are various kinds of heart related diseases and AI is being used for diagnosis and prevention of such heart diseases. The following are some of the heart problems in which AI techniques are effectively utilized.

Cardiac arrythymias The detection of the particular cardiac arrhythmias is considered to be one of the significant uses of AI algorithm in cardiology. The prediction model has utilized different subprocesses such as extracting most relevant features, pre-processing of signals and classification techniques. Detection has been performed through direct analysis of images and

signals of various types of arrhythmia. AI methods considerably reduce the risk of death from this particular kind of cardiac disease.

Ischemic heart disease AI is estimating the risk of the disease from the population using the electronic clinical data for assessment. Additionally, the specific type of ischemic and coronary artery syndrome is being detected and tested using supervised learning AI methods through exploring findings from the datasets. Larger sample sizes with the various findings provided higher level of prediction results . AI is providing its utmost uses and it is clearly shown in Figure 8, in the process of making automatic decisions and accurate suggestion on the clinical therapies. Its one of the biggest advantages is the minimal cost for diagnosis. Since conventional methods are highly expensive in diagnosis, poor patients suffered a lot and AI has taken efforts in providing effective diagnosis methods at minimal cost. There are various kinds of heart related diseases and AI is being used for diagnosis and prevention of such heart diseases. The following are some of the heart problems in which AI techniques are effectively utilized.

9. Challenges of AI

The digital transformation in healthcare is providing enormous benefits to both physicians as well as patients. Particularly, AI has developed intelligent systems which has numerous advantages such as higher level of computing power, increased data storage capacity and learning capabilities altogether has enabled the systems to learn faster than humans and has the capacity of taking suitable actions at the particular situation. In order to develop such kind of intelligent mechanisms, however AI algorithms require dynamic learning abilities in co- ordination with the changing conditions. It has been taking many forms including with psychology, physiology, neuroscience, physics and even as mathematical optimisation for solving many kinds of problems. Even though AI has sophisticated techniques for exceeding the performance of humans, still AI needs advancements for providing perfect solution to all possible problems to reach a level of super-intelligence. AI based algorithms must be able to predict, diagnose and provide recommendations in treatment of complex medical conditions. Effective algorithms can be combined competently for effective cardiac diagnosis and feeding appropriate data into the system can potentially solve highly complex data than humans. AI has faced certain barriers in sharing data contained in electronic health records around the world. There has been certain regulations for the data protection in the medical department and has been following numerous restrictions on sharing health care related data and also been considering on effective data accessibility in the health care organizations.

10. Conclusion

The present review analysis was performed in accordance to various AI algorithms in the perspective of diagnosing the heart disease. From the analysis, it was found that ML algorithms used in heart disease prediction was utilized at maximum rate of 53%. Integration of several ML methods yielded greater accuracy of 99%. In contrast, the analysis of DL utilization in heart disease prediction has found limited attention at the rate of 47%. Thus, the critical analysis performed in present research benefits future researchers in focusing on areas to which further enhancements could be undertaken. Along with that, research gaps and future recommendations emphasized through this study have conclusively claimed that applications of AI in medicine have been evolving and continuous explorations on cardiac prediction certainly offer better outcomes. The major findings of the paper emphasized on the evolution

and continuous explorations of AI techniques for heart disease prediction. From the various existing that has been reviewed, it can be examined that, AI techniques performed well for Cardio vascular prediction it is primarily due to the capability of the AI approaches for handling huge amount of patients data and its ability to recognize subtle correlations and hazardous elements that are related to heart disease. Besides these existing factors, AI models can also provide more comprehensive assessment of risk profile of a patient by considering numerous factors concurrently due to implementation of effective AI algorithms. Finally, this review has offered new inspiration for researchers in assisting them to bring new innovations in the study AI in cardiac therapies.

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