



## **Disease Prediction for Smart Healthcare System using Supervised Machine Learning Approach: A Review**

**Afreen Khan, Dr. Pramalik Kumar, Dr. Manmohan Singh**

Department of Computer Science and Engineering

IES College of Technology, Bhopal

### **ABSTRACT**

Disease prediction plays a vital role in modern healthcare systems by enabling early diagnosis, timely treatment, and effective patient management. Traditional healthcare diagnosis methods are often time-consuming and highly dependent on medical experts, which may lead to delays and inaccuracies in disease identification. With the rapid growth of healthcare data and artificial intelligence technologies, supervised machine learning approaches have become highly effective for predicting various diseases using patient medical records, clinical parameters, and diagnostic datasets. This review study presents an analysis of different supervised machine learning algorithms used in smart healthcare systems for disease prediction applications. Various techniques such as Decision Tree, Random Forest, Support Vector Machine (SVM), Naïve Bayes, K-Nearest Neighbor (KNN), Logistic Regression, and Gradient Boosting are discussed based on their performance, accuracy, and applicability in healthcare diagnosis. The study also examines different datasets, preprocessing methods, feature selection techniques, and evaluation metrics used in disease prediction systems. Comparative analysis indicates that supervised machine learning models can significantly improve prediction accuracy, reduce diagnostic time, and assist healthcare professionals in decision-making processes. The review concludes that machine learning-based smart healthcare systems provide reliable, cost-effective, and efficient solutions for disease prediction and patient care management.

**Keywords:** -Machine Learning, Heart Disease, Smart Healthcare

### **1. INTRODUCTION**

Electronic Healthcare Records (EHR) consists of patients health related information collected from hospitals, healthcare centers, lab tests, etc. Representing this kind of data is available in structured and unstructured format. Considering this data, early disease diagnosis is possible, which can prevent severe health problems and reduce mortality rates. Machine Learning (ML) plays a vital role in creating useful insights from healthcare data. Disease classification with existing data is also an important problem in the healthcare sector. ML is also used to extract healthcare knowledge by applying innovative methods to improve classification performance [1, 2]. These classification models can improve patient care by enhancing the model decision. Recent studies have proved that classification using a single model obtains less classification accuracy compared to combined model classification. These combinations of multiple models are termed as Ensemble Learning (EL). The advantage of the ensemble is that it is a combination of the best models which perform well compared to the individual classifiers [3].

In several countries including United States, China, UK healthcare is a thriving domain that has industrialized as a leading sector related to economic growth and employment as well as functional



overheads. From the study of the global spending on healthcare, it is anticipated that the general healthcare expenditure will reach double in the following 5 years [4, 5]. In India, public health spending is expected to increase to ₹486000 crores by 2022 from ₹267000 crores in the year 2018 (Ministry of Health & Welfare 2017). The overall financial outlay to health and wellbeing is expected to rise 45% from the financial year 2018 to 2022. Non-value added and unproductive activities including diagnostic and medication errors, improper usage of antibiotics, readmissions, and deception create a substantial amount of spending for care. Approximately, 5.2 million Indians demise annually due to clinical faults and the consequences of malicious activities [6].

A suitable Clinical Decision Support System (CDSS) can handle these problems and accelerate the transformation towards a value-based clinical system to deliver passable care and high services [4]. Digital therapeutics has been recognized to be a renowned intervention for treatment in disease control, and both medical professionals and patients are benefitting from CDSS. At present, the healthcare industry is adopting information and communication technologies for its organizational venture to deliver high-quality care services in both commercial and technical aspects [7, 8].

## **2. LITERATURE REVIEW**

**H. El-Sofany et al. [1]**, proposed a machine learning-based technique for heart disease prediction integrated with Explainable Artificial Intelligence (XAI) methods to improve diagnostic transparency and clinical reliability. The study focused on developing an intelligent healthcare framework capable of accurately predicting heart disease using patient clinical data and supervised machine learning algorithms. Various preprocessing techniques such as missing value handling, normalization, and feature selection were applied to improve dataset quality and enhance prediction performance. The researchers implemented multiple machine learning classifiers including Decision Tree, Random Forest, Support Vector Machine (SVM), Logistic Regression, and ensemble learning approaches to identify the most effective prediction model. In addition to prediction accuracy, the study emphasized interpretability through Explainable AI techniques, allowing healthcare professionals to understand the influence of clinical parameters on disease prediction results. Experimental analysis demonstrated that ensemble-based machine learning models achieved superior accuracy, precision, recall, and F1-score compared to conventional prediction approaches. The integration of XAI methods improved model transparency and increased physician trust in automated healthcare systems. The study concluded that explainable machine learning models can significantly support smart healthcare systems by providing accurate, interpretable, and reliable heart disease prediction for early diagnosis and clinical decision-making.

**C. M. Bhatt et al. [2]**, presented an effective heart disease prediction system using various machine learning techniques for improving healthcare diagnosis and patient monitoring. The research primarily focused on analyzing the performance of supervised machine learning algorithms in predicting cardiovascular diseases from patient medical datasets. The study utilized clinical parameters such as blood pressure, cholesterol level, chest pain type, age, heart rate, and electrocardiogram results to train and test predictive models. Several machine learning algorithms including Naïve Bayes, Decision Tree, Random Forest, K-Nearest Neighbor (KNN), and Support Vector Machine (SVM) were implemented and compared based on prediction accuracy and computational efficiency. Data



preprocessing methods such as feature scaling, normalization, and data cleaning were applied to improve model performance and reduce classification errors. Experimental results revealed that ensemble and tree-based learning methods achieved higher prediction accuracy and better classification performance than traditional statistical approaches. The authors highlighted that machine learning-based prediction systems can assist doctors in early identification of heart disease, reduce diagnostic complexity, and improve healthcare service quality. The study concluded that supervised machine learning approaches are highly effective for smart healthcare applications due to their capability to process large medical datasets and provide fast and accurate disease prediction.

**O. Taylan et al. [3]**, proposed an early prediction framework for cardiovascular disease classification using machine learning, neuro-fuzzy systems, and statistical methods. The study aimed to improve early-stage diagnosis of cardiovascular diseases by integrating intelligent computational techniques with statistical analysis models. The researchers utilized medical datasets containing patient health information such as blood pressure, glucose level, age, heart rate, smoking habits, and other cardiovascular risk factors. The proposed framework combined machine learning classifiers, adaptive neuro-fuzzy inference systems, and statistical modeling techniques to improve prediction reliability and classification performance. Data preprocessing methods including normalization, feature extraction, and dimensionality reduction were applied to enhance the learning process and minimize data inconsistencies. The study evaluated the proposed models using different performance metrics such as accuracy, sensitivity, specificity, precision, and recall. Experimental findings showed that the hybrid neuro-fuzzy and machine learning-based models provided better prediction capability and higher diagnostic accuracy compared to standalone traditional approaches. The authors concluded that intelligent healthcare systems integrating machine learning and neuro-fuzzy techniques can effectively support early cardiovascular disease prediction, reduce mortality risks, and assist healthcare professionals in making accurate medical decisions.

**Khongdet Phasinam et al. [4]**, the history of data stored can be used to forecast potential patterns and help companies make competitive decisions to increase their success and benefits. Many analysts look at healthcare sector data to identify and forecast illnesses in order to benefit patients and physicians in a variety of ways. The study is concerned with the diagnosis and estimation of heart disease. Heart disease is one of the most dangerous illnesses for humans, leading to death all over the world. Many different groups of researchers have used knowledge exploration methods in diverse fields to forecast heart disease and have shown acceptable degrees of precision. There were no real-time methods for analyzing and forecasting heart disease in its early stages. For the prediction of heart disease, decision trees are used to analyze various training and evaluation datasets. Classification algorithms such as Naive Bayes, ID3, C4.5, and SVM are being investigated. The UCI machinery heart disease data set is used in experimental studies.

**Isfazzaman Tasin et al. [5]**, in diagnosis or detection of temperature variations in the human skin are obtained from good resolution thermal images captured by the highly sensitive thermal imaging system. Historically, the first thermal image of human was acquired with a British prototype system; the "Pyroscan" were made in London for research in rheumatology, chronic fatigue, and pain management between 1959 and 1961. The thermal imaging system has been utilized for many clinical



applications in hospitals since the late 20th century. The thermal imaging system has been used for mass fever detection localization of swelling in dentistry biometric authentication of facial signature and palm vein. Recently, it has also been utilized to record the presence and position of the fetus and other physiological factors associated with pregnancy. This technique is effectively utilized for screening of temperature variations in minimally symptomatic patients, during the outbreak of the coronavirus disease – 19.

**Olisah et al. [6]**, is characterized in the form of intensity differences on a thermal image. The difference in the thermal pattern of pixel intensities results in texture variations in an image. These texture variations can be extracted in the form of statistical features and used for classification. As the temperature distribution of DM patients is different from healthy subjects, asymmetry amongst the features may be analyzed to gather significant information about the pathology. The human examination of plantar thermal images is susceptible to faults owing to carelessness, color blindness, fatigue, and repetitive tasks. The utility of the textural and higher-order statistical features in finding the temperature distribution changes in plantar thermal images has been determined. These features have been utilized to differentiate diabetic feet from healthy ones.

**Deberneh et al. [7]**, in this work, many feature extraction approaches are explored to design and develop efficient machine learning frameworks intended for detecting diabetic feet in plantar thermal images. In extension to the broadly utilized asymmetry method using textural and temperature features, the subsequent feature extraction approaches are also analyzed, for plantar thermal images. When the performance of several extracted features could not be used seemingly, machine learning methods have been utilized for training and automated classification. Many CNN models are employed to automatically segment, classify diabetic foot ulcers from color (RGB) images. The most significant features are also extracted from different layers of the pre-trained CNN models using transfer learning.

**Nikos Fazakis et al. [8]**, the dataset contained nine variables, eight of which contained patient information. The ninth variable was the class that predicted whether patients would develop diabetes or not. Outliers and missing values make up the dataset. We have removed the outliers from the dataset using our proposed method. The mean filter method was used to impute missing values that were present in the dataset, preserving the dataset's consistency. Weka was used in each and every one of the experiments. It is used for “Data Mining” and classification purpose. Classification algorithms may be applied to a dataset. The other applications of weka are visualizing, regression, purpose of data mining methods. Full form of Weka is Waikato Environment for knowledge Analysis.

**Romany Fouad Mansour et al. [9]**, have new headways in Internet of Things (IoT), distributed computing, and Artificial Intelligence (AI) changed the customary medical services framework into savvy medical care. By consolidating key innovations, for example, IoT and AI, clinical benefits can be moved along. The union of IoT and AI offers various open doors in medical services area. In this view, the ebb and flow research article presents another AI and IoT union based illness analysis model for brilliant medical care framework. The significant objective of this article is to plan a sickness analysis model for coronary illness and diabetes utilizing AI and IoT union strategies. The introduced model incorporates various stages to be specific, information procurement, preprocessing,



characterization, and boundary tuning. IoT gadgets, for example, wearables and sensors license consistent information assortment while AI strategies use the information in sickness conclusion. The utilization of CSO helps in significant improvement in the symptomatic results of CLSTM model. The presentation of CSO-LSTM model was approved utilizing medical services information. During the trial and error, the introduced CSO-LSTM model achieved the greatest correctnesses of 96.16% and 97.26% in diagnosing coronary illness and diabetes individually. Consequently, the proposed CSO-LSTM model can be utilized as a suitable illness finding device for brilliant medical services frameworks.

**G. Muhammad et al. [10]**, pathology recognition framework is proposed in this review. The framework utilizes a profound convolutional network comprising of 1D and 2D convolutions. Highlights from various convolutional layers are combined utilizing a combination organization. Different sorts of organizations are examined; the sorts incorporate a multi-facet perceptron (MLP) with a fluctuating number of stowed away layers, and an autoencoder. Tests are finished utilizing an openly accessible EEG signal data set that contains two classes: ordinary and strange. The exploratory outcomes show that the proposed framework accomplishes more noteworthy than 89% precision utilizing the convolutional network followed by the MLP with two secret layers. The proposed framework is additionally assessed in a cloud-based structure, and its exhibition is viewed as practically identical with the presentation acquired utilizing just a nearby server.

### **Problem Formulation**

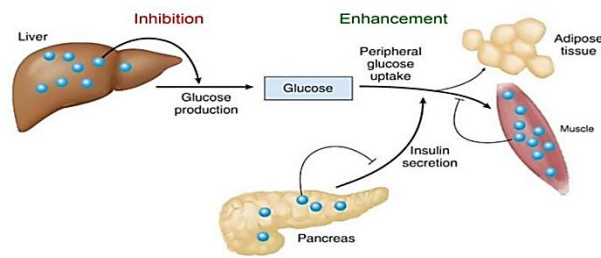
Following are the problems which are to be consider as identify from the Base Paper:

1. In medical science diagnosis of disease data involves of a number of medical tests which are needed to diagnose a certain disease and the diagnosis are depend on the surgeon experience, if a less experience surgeon can diagnose a problem incorrectly.
2. The number of False-positives is quite high in some specific cases, which can be further reduced.
3. The issue of overcrowding is a global issue and a public health problem that affects individuals irrespective of one's social class.
4. The occurrence of this problem is attributed to certain factors, including the inflow and outflow of patients, patients' waiting time, and efficiency of healthcare providers, agglomerations, and availability of resources.

## **3. DISEASE**

### **3.1 Diabetes Disease**

Diabetes falls under the category of metabolic diseases defined by hyperglycemia occurring due to imperfections in insulin emission, insulin activity, or the two of them. The ongoing hyperglycemia of diabetes is related with long haul harm, brokenness, and disappointment of different organs, especially the eyes, kidneys, nerves, heart, and veins [6, 7]. There are different pathogenic cycles engaged with the spread of diabetes. These beginning from immune system harm to the pancreatic b-cells and the later ensuing insulin shortfall to anomalies bringing about protection from insulin activity as shown in Fig. 1.



**Fig. 1: Effects of Insulin on Blood Glucose (Liver, Muscle, Fat)**

The anomalies springing in sugar, fat, and protein digestion in diabetes results because of the shortage activity of insulin over the designated tissues. The shortfall in insulin activity is because of the lacking insulin discharge as well as diminished tissue reactions to insulin at one or different places in the modern pathways of chemical activity. Brokenness in the insulin discharge and inconsistencies in insulin action often are seen together in the same patient, and there is generally no clarity on which dysfunction, if either alone, is the root cause behind the hyperglycemia [8].

In the non-managed state, both kinds of diabetes depict a rise in hepatic glucose yield and decreased glucose take-up in the muscles and fat tissue. Patients experiencing type 1 diabetes are at a risk of genuine lipolysis bringing about diabetic ketoacidosis [9]. The remainder of the insulin movement in type 2 diabetes by and large disturbs lipolysis and ketone generation in such a way that these patients are less pronto be affected with ketoacidosis but possibly can go to a hyperosmolar, non-ketotic state.

### **3.2 Heart Disease**

As of now, Heart Disease (HD) is considered as a significant justification for the expanded death rate. In light of the review announced by World Heart Federation Report, it is expressed that 33% of the demise rate can be diminished on account of before distinguishing proof of Heart Disease. Essential side effects of Heart Disease are chest torment, breathing issues, neck torment, jaw, throat, upper stomach, or back. Likewise, barely any restricting variables that help with limiting the dangers of HD are controlled Blood Pressure (BP), low cholesterol, abstaining from smoking, and routine activities. In the greater part of the cases, the HD couldn't be distinguished until a cardiovascular failure, or stroke happens. Thus, it is expected to notice the cardiovascular boundaries and examine with specialists [11]. The innovative improvements in information and registering have empowered the clinical space to accumulate and save persistent clinical information, which supports vital clinical choices [12].

The information which is put away may be analyzed to make fundamental clinical choices that could incorporate conclusion, line of medicines, expectation, and picture examination. The information accessible in the medical care framework are rich. DM strategies go about as a significant job in settling profoundly nonlinear expectation and grouping as well as mind boggling issues over the new many years. In this manner, it is likely to fabricate a model that could anticipate the nonattendance or presence of HD relying upon various side effects of heart-related highlights. It is an imperative need of any undertaking of infection expectation to unequivocally portion the undesirable and solid patient [13]. Else, a sound patient could under unnecessary treatment with an aftereffect of misclassification. It is profoundly vital for foresee any event of sickness precisely.



HD or cardiovascular disease is a chronic illness that threatens all over the world. Disease like a scourge-bubonic plague, yellow fever, and smallpox are not as critical as cardiovascular disease; it strikes down an imaginary fraction of the population without any symptoms but causes prolonged disability. Many kinds of research analyze the reason for cause of HD, diagnosing the disease, treatment for ailments, and preventing them happens rapidly. An explosive extension for understanding the structure and activities of cardiovascular system as well as the capability of evaluating the parameters in alive human being, sometimes in terms of models which needs penetration of the skin with improved accuracy, by non-invasive models [14, 15].

#### **4. MACHINE LEARNING ALGORITHM**

Uproarious information is available in the heap of substance that will be identified through the anomaly strategies. The information can be spatial or can be a transient method spatial connected with the geological conditions and worldly connected with the time perspectives [14, 15]. The principle point of exception identification is to deal with the loud information that is introduced in the heap of text. Different methods for recognizing abnormalities in Text are specified in below:

##### **Learning**

The main property of an ML is its capability to learn. Learning or preparing is a procedure by methods for which a neural system adjusts to a boost by making legitimate parameter modifications, bringing about the generation of wanted reaction. Learning in an ML is chiefly ordered into two classes as [16].

- Supervised learning
- Unsupervised learning

##### **Supervised Learning**

Regulated learning is two stage forms, in the initial step: a model is fabricated depicting a foreordained arrangement of information classes or ideas. The model developed by investigating database tuples portrayed by traits. Each tuple is expected to have a place with a predefined class, as dictated by one of the qualities, called to have a place with a reclassified class, as controlled by one of the traits called the class name characteristic. The information tuple are dissected to fabricate the model all things considered from the preparation dataset [17].

##### **Unsupervised learning**

It is the kind of learning in which the class mark of each preparation test isn't knows, and the number or set of classes to be scholarly may not be known ahead of time. The prerequisite for having a named reaction variable in preparing information from the administered learning system may not be fulfilled in a few circumstances.

Data mining field is a highly efficient techniques like association rule learning. Data mining performs the interesting machine-learning algorithms like inductive-rule learning with the construction of decision trees to development of large databases process. Data mining techniques are employed in large interesting organizations and data investigations. Many data mining approaches use classification related methods for identification of useful information from continuous data streams.

### **Nearest Neighbors Algorithm**

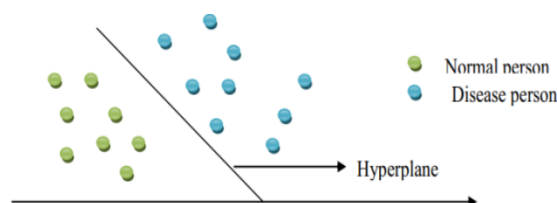
The Nearest Neighbor (NN) rule differentiates the classification of unknown data point because of closest neighbor whose class is known. The nearest neighbor is calculated based on estimation of  $k$  that represents how many nearest neighbors are taken to characterize the data point class. It utilizes more than one closest neighbor to find out the class where the given data point belong termed as KNN. The data samples are required in memory at run time called as memory-based technique. The training points are allocated weights based on their distances from the sample data point. However, the computational complexity and memory requirements remained key issue. For addressing the memory utilization problem, size of data gets minimized. The repeated patterns without additional data are removed from the training data set [18].

### **Naive Bayes Classifier**

Naive Bayes Classifier technique is functioned based on Bayesian theorem. The designed technique is used when dimensionality of input is high. Bayesian Classifier is used for computing the possible output depending on the input. It is feasible to add new raw data at runtime. A Naive Bayes classifier represents presence (or absence) of a feature (attribute) of class that is unrelated to presence (or absence) of any other feature when class variable is known. Naïve Bayesian Classification Algorithm was introduced by Shinde S.B and Amrit Priyadarshi (2015) that denotes statistical method and supervised learning method for classification. Naive Bayesian Algorithm is used to predict the heart disease. Raw hospital dataset is employed. After that, the data gets preprocessed and transformed. Finally by using the designed data mining algorithm, heart disease was predicted and accuracy was computed.

### **Support Vector Machine**

SVM are used in many applications like medical, military for classification purpose. SVM are employed for classification, regression or ranking function. SVM depends on statistical learning theory and structural risk minimization principal. SVM determines the location of decision boundaries called hyper plane for optimal separation of classes as described in figure 3. Margin maximization through creating largest distance between separating hyper plane and instances on either side are employed to minimize upper bound on expected generalization error. Classification accuracy of SVM not depends on dimension of classified entities. The data analysis in SVM is based on convex quadratic programming. It is expensive as quadratic programming methods need large matrix operations and time consuming numerical computations.



**Fig. 2: Support Vector Classification**



## **5. CONCLUSION**

In conclusion, supervised machine learning approaches have emerged as powerful tools for disease prediction in smart healthcare systems due to their ability to analyze large medical datasets and provide accurate diagnostic results. Various machine learning algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), Naïve Bayes, K-Nearest Neighbor (KNN), Logistic Regression, and Gradient Boosting have demonstrated significant effectiveness in predicting diseases such as heart disease, diabetes, cancer, and cardiovascular disorders. These techniques improve healthcare services by enabling early disease detection, reducing diagnostic errors, minimizing treatment delays, and supporting medical professionals in clinical decision-making processes. Furthermore, preprocessing techniques, feature selection methods, and explainable AI models enhance prediction performance and model interpretability. Comparative analysis from previous studies indicates that ensemble and hybrid machine learning models generally provide higher accuracy and reliability than traditional statistical methods. Therefore, machine learning-based disease prediction systems play an important role in developing intelligent, cost-effective, and efficient smart healthcare solutions. Future research can focus on integrating deep learning, Internet of Things (IoT), cloud computing, and real-time healthcare monitoring systems to further improve prediction accuracy and personalized patient care.

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