International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

A Novel Deep Learning-Based Heart Disease Prediction System Using Convolutional Neural Networks (CNN) Algorithm

S. Gopalakrishnan[1*], M. Sahaya Sheela[2] , K. Saranya[3], J. Jasmine Hephzipah[4]

Submitted: 27/05/2023 **Revised**: 07/07/2023 **Accepted**: 26/07/2023

Abstract*:* Cardiovascular disease is a significant global health concern. A greater number of fatalities are seen at the first occurrence of a heart attack compared to other instances in the human population. However, its impact extends beyond heart attacks to include conditions such as breast cancer, lung cancer, some ventricular issues, and other related ailments. Heart failure occurs when the cardiac muscle is unable to adequately pump a sufficient volume of blood to meet the physiological needs of the body. It is possible to quantify symptoms, physical traits, and test results using the patient's computerized medical information that are readily available. And perform biometric analyzes designed to highlight patterns and correlations that physicians cannot detect. However, the existing system has some limitations. Healthcare plans should prioritize disease control efforts to reduce hospitalizations and mortality in individuals with heart failure. To forecast risk, we created a risk model. A patient's risk of death or hospitalization from heart failure using convolutional neural network algorithms (CNN) in a large health maintenance organization. The current potential of using deep learning algorithms in the early detection of heart disease. The primary objective of this research is to assess the accuracy of diagnosing a cardiac condition in individuals. In the recursive process of partitioning, the reordering of partitions is carried out in a greedy manner rather than seeking the optimal partition order. The suggested system utilizes a CNN to process input datasets for illness prediction. The system incorporates preprocessing, feature extraction, and classification techniques to analyze the data and provide relevant findings. Dimensionality reduction allows us to make more precise forecasts using the same data set. The majority of the time, many existing algorithms utilized in AI classifiers do not discover greater accuracy than Lasso or Ridge regression, which both produce superior results.

Keywords: *Deep learning, Heart disease prediction, Convolutional Neural Network, AI classifiers, Health Maintenance Organization*

1. Introduction

The medical industry has a substantial amount of unprocessed medical data. The use of data analysis is essential in the process of diagnosing and predicting heart disease, since the datasets employed for prediction purposes include latent patterns that are crucial for accurate assessments. According to the World Health Organization, the global prevalence of heart disease is estimated to be 12 million persons. In instances when there is an abnormality in the blood circulation inside the human body, it is possible for critical organs such as the heart and brain to experience cessation of their usual rhythmic contractions, ultimately resulting in mortality. There exist many prevalent risk factors associated with the development of heart disease, including advanced age, familial predisposition, tobacco use, alcohol consumption, and excessive body weight. the patient's cholesterol, blood pressure, the number of blocked main arteries, and other factors are used to diagnose heart disease. Additionally, it is dependent on the electrocardiogram (ECG) and echocardiogram (ECHO) test results for the patient and the doctor's expertise. Heart disease diagnosis is a challenging process that calls for extensive training and significant competence. Patient data prediction is the application of sophisticated algorithms to the extraction of knowledge, or important indirect historical data, from patient data. It has a history of success in the majority of medical specialties and outperforms other approaches in terms of accuracy and performance. Numerous scholars have found numerous novel data mining methods and methodologies when it comes to predicting. A. Current Cardiac Disease Prediction Methodologies There are now 11 heart disease prediction algorithms in use by different researchers, as mentioned

1Associate Professor, Department of Information Technology, Hindustan Institute of Technology and Science, Kelambakkam, Tamil Nadu 603103, India,
Email:drsgk85@gmail.com(Corresponding Author)*
2Assistant Professor, Department of Electronics and Communication Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology Chennai-600062, Tamil Nadu,
Email: hisheelu@gmail.com
3Associate Professor, Department of Computer Science and Engineering, Bannari Amman Institute of Technology, Sathyamangalam - 638401
Email: ksaranyacse@gmail.com
4Professor, Department of Electronics & Communication Engineering, R.M.K Engineering College,
RSM Nagar, Kavaraipettai-601206,
Email:jjh.ece@rmkec.ac.in

below. Heart attacks happen often, and heart disease is the most lethal illness that affects people globally. This disease and problem did not suddenly appear. Scientists and doctors have revealed that this is an ongoing process, the result of prolonged exposure to certain lifestyles and sudden onset of some basic and common symptoms. What ultimately happens in a heart attack is that the heart cannot the heart's ventricles' arteries are clogged, which prevents them from receiving enough blood to adequately nourish the heart while it pumps the necessary amount of blood to various regions of the body. It cannot be done. Succumb to cardiac failure. Comparatively speaking, the prevalence of heart disease is relatively high in the United States, and regrettably, the death rate from heart disease is also fairly high in India. Numerous heart disease indicators that might be utilized to help patients get a proper diagnosis were mentioned in the research. Improved cardiac and life safety depends crucially on the prompt and accurate detection of heart disease. According to the European Society of Cardiology, heart disease affects 26 million persons globally. Every year According to some studies, 50% of people with heart disease pass away. Within 1-2 years after diagnosis. Although some researchers use proprietary techniques to develop predictive models, most researchers try to combine multiple techniques to create hybrid models and achieve accuracy. This research paper aims to review studies in which he combined two or more techniques to create a hybrid model for predicting heart disease. A hassle that changed into observed is that the attributes that researchers use to make predictions approximately the data are incomplete. Therefore, in this article he proposes two things, forecasting data and giving various lifestyle related recommendations. Poor cardiac function is an indicator of heart disease. Physicians measure heart function through various parameters and the left ventricular ejection fraction. Accurate measurements of heart function are obtained with MRI, but Reading MRI pics is time-eating and requires a skilled health practitioner. Statistics technology could make the measurement procedure greater efficient and beautify doctors' predictive analysis of coronary heart sickness. We worked with a crew of statistics scientists to check extraordinary algorithms, eventually developing one to read heart scans.

2. Related Work

Detecting heart disease is often a little more complicated because doctors don't have enough knowledge and experience about the warning signs of heart failure. The medical field has an enormous amount of data. By adopting the most appropriate data mining technology, early detection and prevention of heart-related diseases can’t be achieved [1]. Both machine learning (ML) and data mining (DM) techniques have proven to be effective and important in the healthcare industry. The goal of current research activity is to examine various risk parameters that have been highlighted in heart disease research, and to discover multiple techniques for recognition and prediction of heart disease while assessing the shortcomings of existing studies [2]. It is intended to in this article, we summarize existing research on cardiac disease prediction using DM techniques and consider combinations of DM techniques to reveal the most appropriate and effective techniques. CNN, LSTM have been proposed for heart disease recognition and prediction, and their instant output is superior to other mainstream techniques [3].

The proposed method includes different levels of data set collection, training and testing, user symptom collection, secure data transfer utilizing AES, and finally generating results in PDF format. . The modern unbalanced lifestyle makes the human heart susceptible to several serious diseases. It can lead to serious illnesses and problems caused by diabetes, stress, and heavy smoking [4]. All these factors severely affect the human heart, causing various heart diseases. The primary etiology of heart disease is the occlusion of the coronary arteries, which are responsible for supplying blood to the heart. Moreover, this phenomenon results in a reduction in nutrient supply to the heart, namely the cells of the myocardium. In general, the heart receives its blood flow from three main arteries. The occurrence of a cardiovascular event such as a heart attack or stroke might be attributed to the presence of arterial obstruction. Consequently, the manifestation of life-threatening complications may arise, potentially leading to fatality in some instances. The sooner these symptoms are detected, the more likely they are to be treated promptly and save lives [5]. A requirement of DM technology is to facilitate the gathering of valuable data and information while considering multiple perspectives [6]. His current research activities combine predictive mining to build prediction and diagnostic systems for heart disease. Heart disease encompasses a range of pathological diseases that are intricately linked to the cardiovascular system. The term "medical condition" refers to a disproportionate health disorder and means direct effects on the human heart and other parts of the body [7].

Since heart disease is of great interest today, this paper aims to discover different techniques for identifying and predicting heart disease. The DM approach was used to summarize existing studies on cardiac disease prediction. Combining DM techniques will reveal the most appropriate and effective techniques. A naive Bayesian (NB) algorithm has been proposed for recognition and prediction of heart disease [8]. Adopting an ED&P approach and using machine learning (ML) techniques to build a data mining (DM) approach for the prophylactic detection and prevention of cardiac malignancies. Compared with other mainstream techniques, the NB method has increased improvisational output [9]. Current research work is divided into the following phases: An online dataset is assembled from the UCI medical dataset, followed by a classification process that includes training and testing, collecting user symptoms, and user-entered data is private data and is securely transferred via AES [10]. Stored in an open database and the final result is generated in PDF format. Performance of medical datasets compared to other ML techniques in predicting cardiac technology. The proposed technique is of great importance in that it handles classification very efficiently and approximates ML on NB models [11].

The classification of the works is as follows. I will describe the works of the previous author and their strengths and weaknesses. Aspects of techniques proposed for detecting heart-related diseases and various levels of machine learning methods are discussed. Finally, conclusions and recent research achievements are presented [12]. Diagnosing heart disease is a complex process, and multiple factors contribute to the delay in making the correct diagnosis. Many human organs other than the heart exhibit different clinical, functional, and pathological manifestations of heart disease, which often presents with a variety of symptoms [13]. Different types of heart disease may have similar symptoms. Methods for diagnosing heart disease have received a lot of attention from the academic community. Statistics technology and massive records gear have been actively deployed in predicting, stopping, and growing premiere treatment plans [14]. Cell gadgets, clever gadgets, sensors, and facts technological know-how are capacity predictors of coronary heart assaults. Statistics technological know-how and cloud computing have delivered the world's hospitals and cardiologists closer together. Those technology can be used inside the development of information-driven healthcare. Numerical facts are required for quantitative research. Numeric data may come from numeric data itself or from other graphs. Apply statistical techniques to it to get useful information out of the data [15].

3. Materials and Method

This article presents a proposed architecture for a classification algorithm aimed at predicting cardiac disease in patient data. In contrast to previous methodologies that used multi-stream classification to extract multi-scale features from data, our approach utilizes a CNN methodology to train discriminative scale features while minimizing computational expenses and parameter requirements. Steps are used as essential tools for extracting large-scale and high-dimensional data from predictive information. To achieve a comparable improvement in the overall performance of the model, it is necessary to make predictions for the class of coronary heart disease and conduct an analysis of patient data.

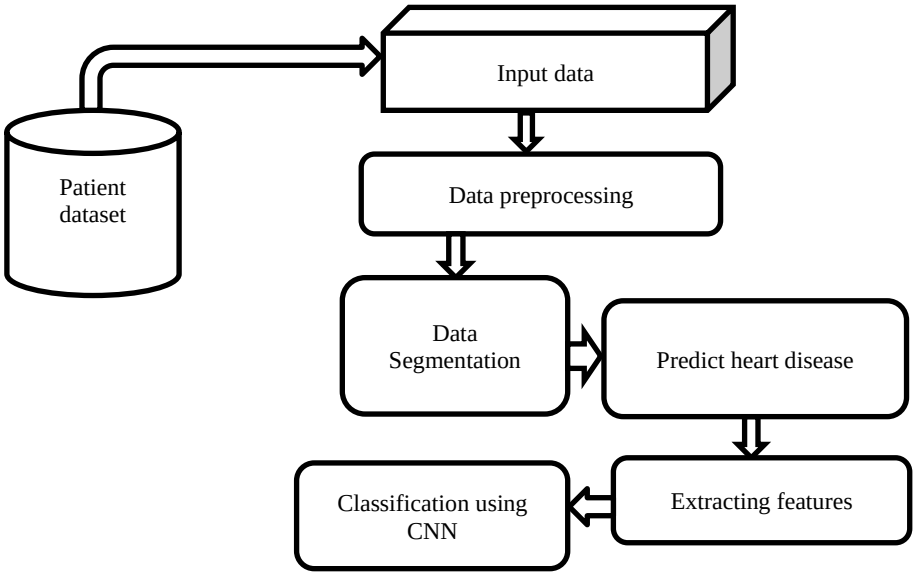

Fig 1: Proposed block diagram

The block diagram shown in Figure 1 illustrates the suggested method for risk assessment, which is based on CNNs. The diagnostic approach for possible malignancy of heart disease consists of five successive phases. The use of the input data set is situated within the domain of retrieving cardiac patient information. The technique that has been put out encompasses a series of essential stages: The proposed methodology consists of three main components: (1) preprocessing and risk reduction, (2) use of a thresholding technique to effectively separate lesions from the background, and (3) a data segmentation strategy tailored particularly for heart disease information. This work included the extraction of heart disease lesions from patient data descriptions. Following this, a CNN was used to assess the presence of abnormalities or normalcy in these lesions.

3.1 Dataset collection

The dataset of patients with heart illness is used to assess the efficacy of the suggested CNN technique. The dataset has a substantial number of observations and has been gathered from many healthcare facilities. Therefore, doctors must learn advanced diagnostic procedures to reliably foretell the start of cardiovascular disease in their patients. Acquiring and recording information systematically is the data-gathering process. Two heart

disease prediction using logistic regression datasets are available on Kaggle. Visit https://www.kaggle.com/code/neisha/heart-disease-prediction-using-logistic-regression to obtain the aforementioned datasets. There exists a pressing need to establish dependable diagnostic methods that may effectively decrease the duration required for diagnosis and provide assistance in both simple and progressively intricate diagnostic decision-making procedures. The focus of this discussion is on enhancing precision. The whole dataset has previously been categorized as either benign or malignant, according to the recommendations made by physicians.

3.2 Data Preprocessing

Patient data is used in computed tomography (CT) for the purpose of examining cardiovascular diseases. In order to mitigate the potential adverse effects of radiation, radiologists are required to reduce the administered radiation dosage. Radiation dose introduces risk and diminishes the quality of data. To aid in the detection of nodules, preprocessing plays a crucial role in enhancing the quality of raw data, reducing risks, and getting rid of artifacts. Data filtering methods can improve the efficiency of data preparation. Data modification is a fundamental process that involves altering data based on its values. Bilateral filters have similarities to Gaussian convolutions since they undergo averaging during preprocessing. However, they include considerations for intensity changes and maintain the integrity of data edges.

The bilateral filter

$$a_x + b = c \quad (1)$$

The variables r and s are used to describe the degree of filtering, whereas the initial expression represents the normalized weighted average. The spatial Gaussian Gs' serves to mitigate the impact of distant preprocessing, while the range Gaussian G_σr mitigates the impact of preprocessing using intensity values that vary from B_ Arrange. Here, the terms "spatial" and "range" refer to variables that reflect the location of data within a geographic context.

3.3. Heart disease segmentation

Following a preliminary preprocessing phase, data segmentation is a procedural step that involves partitioning data into distinct segments, hence facilitating the extraction of pertinent information from the incoming data.

The profession of medical data processing is characterized by the utmost significance of data segmentation. By using automated writing, he surpasses the Region of Interest (ROI). The process of segmentation involves dividing the data into distinct domains, with a specific focus on segmenting the body's organs and tissues.

One set of data, P1, has intensity values that are more than or equal to the threshold value, T; another set, P2, has intensity values that are less than or equal to the threshold value.

The threshold values for the data areas P1 and P2 are calculated using the average intensity values 1 and 2.

$$P(AuB) = P(A) + P(B) - P(AnM) \quad (2)$$

After achieving convergence, the threshold is designated as CT. The brightness preprocessing is applied to the data above CT, while the remaining data values are assigned a value of 1 for non-body preprocessing and 0 for body preprocessing. The process of calculating the T value may be replicated as required.

The output will be rewritten to adhere to academic writing conventions. The data generated at this stage is presented as threshold data. Simultaneously, the subsequent phase of segmentation involves the elimination of the backdrop.

3.4 Feature extraction

In order to accomplish this particular stage, the used methodology is the procedure. The histogram serves as a graphic representation of the distribution of visual intensity. This metric essentially denotes the quantity of preprocessing operations performed on each individual intensity value that is considered.

Computer data processing technology is used to enhance the contrast of a given dataset. This is achieved by the equitable dispersion of the most frequently occurring intensity values, hence expanding the range of intensity in the data. When information is represented using equal comparison values, this strategy often leads to an rise in the overall evaluation of the data.

$$f(x) = dF(x)\frac{dy}{dx} \quad (3)$$

$$\int_a^b f(x)d(x) \quad (4)$$

After acting segmentation, the segmented coronary heart sickness nodules are used for characteristic extraction. Characteristic extraction is a part of the dimensional discount technique, in which, an initial set of the raw statistics is divided and decreased to more viable agencies. So while you want to technique it is going to be easier. The most important feature of these massive facts sets is that they have got a massive range of variables. Those variables require a lot of computing assets to manner. So feature extraction allows to get the nice feature from the ones large records units with the aid of choosing and combining variables into capabilities, accordingly, efficaciously lowering the quantity of facts.

Begin
    Initialize the features population
    Calculate the feature fitness and weights
        Select global and local leader
    While (termination criteria is not satisfied) do
        Updated the position of classification based female (Sf)
            Updated the position of classification based male cooperative operators (Mf)
Perform matting processing
    Termination criteria
        Ite=iter + 1
End
Optimization solution

Stop

Forecasting and analyzing tiny cardiac vibrations for the goal of predicting heart illness is a topic of conversation between organizations and individuals. The distance and weight considerations used in this context to categorize the vibrations generated. The female classification tended to have the strongest vibration based on this metric.

3.5 Classification based on Convolutional Neural Network (AI-CNN)

The generation of feature maps in convolutional layers is achieved by the process of convolving different areas of data using learned kernels. Nonlinear activation functions, such as sigmoidal, tanh, or rectified linear unit (ReLU), might also be considered as viable alternatives. By aggregating layers, the computational workload may be further decreased. In essence, a subset is selected as the representative dataset, whereby the dataset or feature map is examined to identify the data with the highest value. This enables the transformation of a data grid into a single scalar value. The combination of convolutional layers with fully connected layers is often seen, typically occurring at the output stage.

Step 1: Initialize Dataset

Step 2: Collect a heart disease Dataset

Step 3: Next, preprocess the data using a kaggele filter on the dataset.

Step 4: Cleanup and data reduction of the heart disease

Step 5: Evaluate the Performance of the Proposed CNN Algorithm for heart Disease Prediction Using Artificial Intelligence

Step 6: Result was successfully prediction.

The various layers of the generalized neural network are represented as:

$$E[y|\boldsymbol{x}] = \frac{\int_{-\infty}^{\infty} y \cdot f(\boldsymbol{x}, y) \cdot \mathrm{d}y}{\int_{-\infty}^{\infty} f(\boldsymbol{x}, y) \cdot \mathrm{d}y} \quad (5)$$

The function F(x, y) represents the joint probability density function (PDF) of the variables x and y. Additionally, E[y] denotes the projected value of the output given the input x. The output value is denoted by the variable Y. It is proposed that the structure of the neural network be generalized.

$$y_j = \frac{\sum_{i=1}^{n} h_i w_{ij}}{\sum_{i=1}^{n} h_i} \quad (6)$$

The result is the vector wij, which is the "inverse" of the input vector xi. Where i represents the nucleus of a neuron, D2 represents the output of the buried layer. The regularization term (sometimes written as r or an) is a parameter that determines how smooth the final result is. In this context, e represents the squared Euclidean distance between the input vector x and the reference vector u. In this case, x is the input vector, and ui is the i-th training vector element. To determine this distance, we make use of the receptor function's length. A comparison study comparing the expected output to the training features is crucial for producing reliable heart disease forecasts. A value of 1 is considered abnormal and is often associated with cancer, in contrast to more typical data concerning cardiovascular disease. With this in mind, we evaluate how well incorporating the experimental results given in the next part into a heart disease prediction system might work.

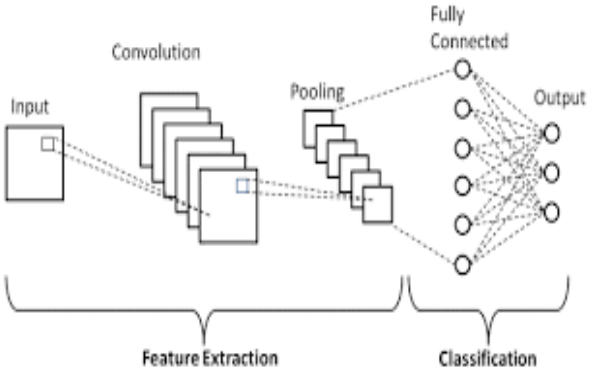

Fig. 2. CNN Architecture

In the context of networks, it is common practice to use kernel functions for the purpose of determining the output values of the dependent variable y in respect to the independent variable x. This is due to its enhanced ability to effectively classify characteristics. This network generally has many layers, including an input layer, a hidden layer, and an output layer, each of which serves a crucial role in generating the output. The significance of the data shown in Figure 2 is discussed in this section. The results and their implications are analyzed and interpreted.

4. Result and Discussion

The implementation of a CNN system is presented for the purpose of data processing in order to identify lung illnesses. The process of disease detection includes the use of data databases, data preparation techniques, and classification methods. Acquire proficiency in using leaf data for the purpose of detecting cardiac disease. Furthermore, we provide a methodology for the identification of cardiovascular disorders.

Table 1: Data Accuracy Performance

No. of data	SVM %	RNN %	CNN%
100	43	50	65
200	55	60	72
300	60	68	82
400	64	70	84
500	78	85	96

Table 1 presents a comparative comparison of the accuracy performance of the CNNs algorithm suggested in this study in relation to other methods.

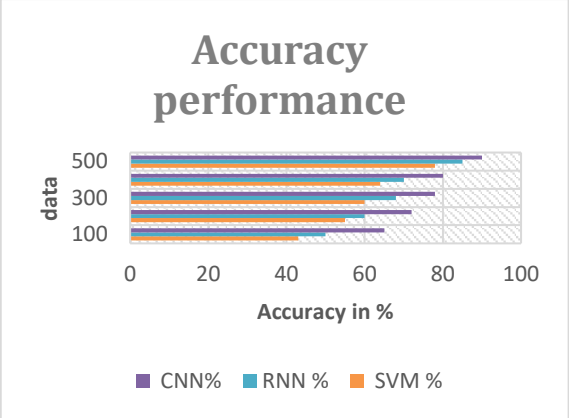

Fig. 3. Analysis of accuracy performance

Figure 3 depicts a CNN used in the evaluation of the suggested methodology's accuracy performance. The proposed algorithm demonstrates superior accuracy performance (90%) compared to the present system's SVM (78%), as well as the advanced characteristic selection method based on importance (85%) and the SVM used in the current system (85%).

Table 2: Analysis of heart disease Prediction performance

No. of data	SVM %	RNN %	CNN%
100	45	58	60
200	55	62	75
300	60	68	85
400	68	79	89
500	77	85	96

Table 2 presents an analysis of the performance of the proposed algorithm, CNN, in terms of prediction-level. The analysis compares the performance of CNN with other algorithms.

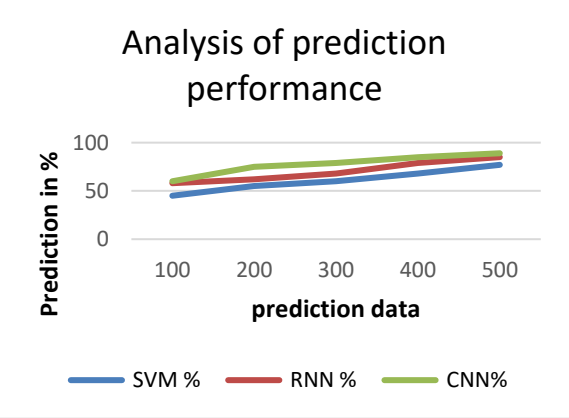

Fig. 4. Analysis of prediction performance

Figure 4 depicts a study of the performance of the proposed CNN algorithm in terms of prediction accuracy. The approach demonstrates a level of accuracy up to 85%. In a similar vein, the accuracy rate of the feature selection approach that incorporates eigenvector centrality is likewise found to be 85%. In contrast, the existing Support Vector Machine (SVM) system exhibits a notable improvement in its predictive capabilities, resulting in an 89% rise.**Table 3:** Analysis of time complexity performance

No. of data	SVM %	RNN %	CNN%
100	58	54	50
200	55	51	48
300	50	48	40
400	48	45	35
500	40	39	30

Table 3 presents a comparative analysis of the time complexity levels of the proposed CNN algorithm and other algorithms.

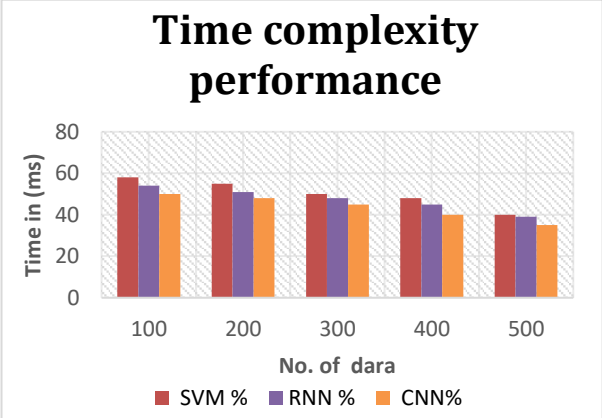

Fig. 5. Analysis of Time complexity

The examination of the temporal complexity performance of the recommended method, which incorporates a CNN, is shown in Figure 5. The outcome of using a feature selection method that relies on eigenvector centrality yielded a mean square (MS) value of 39, which is marginally lower than the MS value of 40 achieved by utilizing the support vector machine (SVM) in the preceding system. The temporal performance of CNN method under consideration was observed to be 30 milliseconds, signifying the least favorable performance when compared to the other algorithms that were examined.

5. Conclusion

It discusses heart disease, its causes and symptoms, cancer mortality and the world, and discusses Deep learning strategies and their applications in medicinal drug and cancer diagnosis and detection. Most researchers have advanced cancer prediction structures based totally on supervised getting to know techniques of convolutional neural networks (CNN) classification algorithms to produce accurate results. The emphasis is on deep learning and algorithms for medical data. The enhancement and extension of cardiac disease prediction and diagnostic systems may be achieved via the use of deep learning methods, which aim to enhance the precision of identifying and predicting coronary heart disease. This examine will assist researchers gain insight into diverse ML strategies implemented to coronary heart sickness. Within the

destiny, we are hoping to use deep mastering technology to predict heart disorder.

Reference

[1] Arpaia, P., Cicatiello, M., Benedetto, E. D., Anna Dodaro, C., Duraccio, L., Servillo, G., & Vargas, M. (2020). A Health 4.0 Integrated System for Monitoring and Predicting Patient's Health During Surgical Procedures. 2020 IEEE International Instrumentation and Measurement Technology Conference (I2MTC).

[2] Latha, R., & Vetrivelan, P. (2019). Blood Viscosity based Heart Disease Risk Prediction Model in Edge/Fog Computing. 2019 11th International Conference on Communication Systems & Networks (COMSNETS).

[3] Kumar, A., & Anjomshoa, H. (2018). A Two-Stage Model to Predict Surgical Patients' Lengths of Stay from an Electronic Patient Database. IEEE Journal of Biomedical and Health Informatics, 1–1.

[4] Mei, X. (2017). Predicting five-year overall survival in patients with non-small cell heart disease by reliefF algorithm and random forests. 2017 IEEE 2nd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC).

[5] Kasbe, T., & Pippal, R. S. (2017). Design of heart disease diagnosis system using fuzzy logic. 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS).

[6] Raju, C., Philipsy, E., Chacko, S., Padma Suresh, L., & Deepa Rajan, S. (2018). A Survey on Predicting Heart Disease using Data Mining Techniques. 2018 Conference on Emerging Devices and Smart Systems (ICEDSS).

[7] Castaldo, R., Melillo, P., Izzo, R., De Luca, N., & Pecchia, L. (2017). Fall Prediction in Hypertensive Patients via Short-Term HRV Analysis. IEEE Journal of Biomedical and Health Informatics, 21(2), 399–406.

[8] Beitel-White, N., Martin, R. C. G., & Davalos, R. V. (2019). Post-treatment analysis of irreversible electroporation waveforms delivered to human pancreatic cancer patients. 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC).

[9] Sudeshna, P., Bhanumathi, S., & Hamlin, M. R. A. (2017). Identifying symptoms and treatment for heart disease from biomedical literature using text data mining. 2017 International Conference on Computation of Power, Energy Information and Communication (ICCPEIC).

[10] Ed-Daoudy, A., & Maalmi, K. (2019). Real-time machine learning for early detection of heart disease using big data approach. 2019 International Conference on Wireless Technologies, Embedded and Intelligent Systems (WITS).

[11] Chauhan, A., Jain, A., Sharma, P., & Deep, V. (2018). Heart Disease Prediction using Evolutionary Rule Learning. 2018 4th International Conference on Computational Intelligence & Communication Technology (CICT).

[12] Qidwai, U. (2018). Fuzzy Data to Crisp Estimates: Helping the Neurosurgeon Making Better Treatment Choices for Stroke Patients. 2018 IEEE-EMBS Conference on Biomedical Engineering and Sciences (IECBES).

[13] Meena, G., Chauhan, P. S., & Choudhary, R. R. (2017). Empirical Study on Classification of Heart Disease Dataset-its Prediction and Mining. 2017 International Conference on Current Trends in Computer, Electrical, Electronics and Communication (CTCEEC).

[14] Pawlovsky, A. P. (2018). An ensemble based on distances for a kNN method for heart disease diagnosis. 2018 International Conference on Electronics, Information, and Communication (ICEIC).

[15] Gavhane, A., Kokkula, G., Pandya, I., & Devadkar, P. K. (2018). Prediction of Heart Disease Using Machine Learning. 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA).

[16] Hussain Bukhari, S. N. . (2021). Data Mining in Product Cycle Prediction of Company Mergers . International Journal of New Practices in Management and Engineering, 10(03), 01–05. https://doi.org/10.17762/ijnpme.v10i03.127

[17] Anupong, W., Yi-Chia, L., Jagdish, M., Kumar, R., Selvam, P. D., Saravanakumar, R., & Dhabliya, D. (2022). Hybrid distributed energy sources providing climate security to the agriculture environment and enhancing the yield. Sustainable Energy Technologies and Assessments, 52 doi:10.1016/j.seta.2022.102142