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Prediction Heart Attack using Artificial Neural Networks (ANN)

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Abstract *Heart Attack is the Cardiovascular Disease (CVD) which causes the most deaths among CVDs. We collected a dataset from Kaggle website. In this paper, we propose an ANN model for the predicting whether a patient has a heart attack or not that. The dataset set consists of 9 features with 1000 samples. We split the dataset into training, validation, and testing. After training and validating the proposed model, we tested it with testing dataset. The proposed model reached an accuracy of 98.01% on the Heart Disease Dataset.*

Keywords: Supervised Learning, Artificial Neural Networks, Classification, Heart Attack

1. Introduction

Cardiovascular diseases (CVDs) are the leading cause of death globally, taking an estimated 17.9 million lives each year. CVDs are a group of disorders of the heart and blood vessels and include coronary heart disease, cerebrovascular disease, rheumatic heart disease and other conditions. More than four out of five CVD deaths are due to heart attacks and strokes, and one third of these deaths occur prematurely in people under 70 years of age. Identifying those at highest risk of CVDs and ensuring they receive appropriate treatment can prevent premature deaths. Access to non-communicable disease medicines and basic health technologies in all primary health care facilities is essential to ensure that those in need receive treatment and counselling [1].

Neural networks, also known as artificial neural networks (ANNs) or simulated neural networks (SNNs), are a subset of machine learning and are at the heart of deep learning algorithms. Their name and structure are inspired by the human brain, mimicking the way that biological neurons signal to one another [2].

Artificial neural networks (ANNs) are comprised of a node layers, containing an input layer, one or more hidden layers, and an output layer. Each node, or artificial neuron, connects to another and has an associated weight and threshold. If the output of any individual node is above the specified threshold value, that node is activated, sending data to the next layer of the network. Otherwise, no data is passed along to the next layer of the network [2].

Neural networks rely on training data to learn and improve their accuracy over time. However, once these learning algorithms are fine-tuned for accuracy, they are powerful tools in computer science and artificial intelligence, allowing us to classify and cluster data at a high velocity. Tasks in speech recognition or image recognition can take minutes versus hours when compared to the manual identification by human experts. One of the most well-known neural networks is Google's search algorithm [2].

Neutral networks that can work continuously and are more efficient than humans or simpler analytical models. Neural networks can also be programmed to learn from prior outputs to determine future outcomes based on the similarity to prior inputs. [3].

Neural networks that leverage cloud of online services also have the benefit of risk mitigation compared to systems that rely on local technology hardware. In addition, neural networks can often perform multiple tasks simultaneously (or at least distribute tasks to be performed by modular networks at the same time). They are continually being expanded into new applications. While early, theoretical neural networks were very limited to its applicability into different fields, neural networks today are leveraged in medicine, science, finance, agriculture, or security [3].

2. Problem Statement:

Cardiovascular diseases, particularly heart attacks, continue to be a leading cause of morbidity and mortality worldwide. Despite advances in medical science, predicting the occurrence of heart attacks remains a complex and challenging task. Traditional risk assessment models are often limited in their accuracy and may not capture the dynamic and multifaceted nature of individual patient profiles. This problem is exacerbated by the growing prevalence of lifestyle-related risk factors and the need for timely intervention.

Artificial Neural Networks (ANNs) have shown promise in various medical applications due to their ability to learn complex patterns from large datasets. However, their application in accurately predicting heart attacks remains an underexplored area. The problem statement for this research is to develop and validate an ANN-based predictive model that can effectively utilize a comprehensive dataset of patient characteristics, clinical measurements, and lifestyle factors to forecast the likelihood of a heart attack.

This research aims to address the following key challenges:

- **Data Complexity:** The complexity and heterogeneity of cardiovascular risk factors require the development of an ANN model that can effectively handle large, multi-dimensional, and noisy datasets.
- **Prediction Accuracy:** The current risk assessment models often lack the precision required for timely intervention. This research aims to improve the prediction accuracy by harnessing the power of ANNs to identify subtle and non-linear relationships within the data.
- **Real-time Application:** The development of a predictive model that can provide real-time risk assessments is essential for timely interventions and patient care.
- **Generalization:** The research must ensure that the ANN model is generalizable across diverse populations, and it should be robust enough to handle variations in healthcare systems and data collection methodologies.

By addressing these challenges, this research seeks to contribute to the development of an effective and practical tool for predicting heart attacks, ultimately leading to improved patient outcomes and a reduction in the burden of cardiovascular diseases on healthcare systems and society.

3. Objectives:

A. **Development of an Effective ANN Model:**

- Design and implement an artificial neural network model capable of accurately predicting heart attacks by utilizing a comprehensive dataset of patient characteristics, clinical measurements, and lifestyle factors.

B. **Performance Evaluation and Comparison:**

- Evaluate the predictive accuracy and performance of the developed ANN model and compare it with traditional risk assessment models to establish its effectiveness in heart attack prediction.

C. **Generalization and Real-time Application:**

- Assess the ability of the ANN model to generalize across diverse populations and healthcare settings, and develop a real-time prediction system for timely risk assessments in clinical practice.

4. Literature review

Artificial Neural Networks and AI in general are becoming a crucial part in almost every field, Applications of ANNs in medical science include classification of data in medical databases (i.e. organizing or distinguishing data by relevant categories or concepts) [4], using a hybrid learning approach for automatic tissue recognition in wound images for accurate wound evaluations [5], and comparison of soft-computing techniques for diagnosis of heart conditions by processing digitally recorded heart sound signals to extract time and frequency features related to normal and abnormal heart conditions [6].

Applications for prediction included developing a risk advisor model to predict the chances of diabetes complication according to changes in risk factors [7], identifying the optimal subset of attributes from a given set of attributes for diagnosis of heart disease [8], and modelling daily patient arrivals in the Emergency Department [9].

ANN was applied for diagnosis of disease based on age, sex, body mass index, average blood pressure and blood serum measurements [10], comparing predictive accuracies of different types of ANN and statistical models for diagnosis of coronary artery disease [11], diagnosis and risk group assignment for pulmonary tuberculosis among hospitalized patients [12], and non-invasive diagnosis of early risk in dengue patients [13].

Other examples include exploring the potential use of mobile phones as a health promotional tool by tracking daily exercise activities of people and using ANN to estimate a user's movement [14], or using ANN to identify factors related to treatment and outcomes potentially impacting patient length of stay [15].

5. Methodology

a. Dataset

A public dataset from Kaggle was used [16], it contains more data on more than 1000 patients, containing the attributes that may relate to heart disease, and whether the patient suffered from a heart disease.

b. Input Variables

Table 1: Input Variables

#	Input Variable	Description
1	Age	Age (Years)
2	Gender	Male or Female
3	Impulse	Heart Rate
4	Pressure High	Systolic Blood Pressure
5	Pressure Low	Diastolic Blood Pressure
6	Glucose	Blood sugar (mg/dL)
7	kcm	CK-MB (ng/mL)
8	troponin	Test-Troponin (ng/mL

c. The Output Variable

The output variable is the class of whether a heart attack was present.

d. Data Preprocessing

The data was analyzed visually and numerically, 3 variables were heavily right skewed (Glucose, CKMB, and Troponin), so we applied Log Transformation to normalize the data, we applied one-hot encoding to the gender variables because it's not an ordinal attribute. Finally, the input variables needed rescaling so we scaled them using Scikit-learn's Standard-Scaler [17], which standardizes the features by removing the mean and scaling to unit variance, using this formula, where *x* is the sample, *u* is the mean of the training samples, and *s* is the standard deviation.

$$z = (x-u)/s$$

After that preprocessing we split the dataset into training and testing sets, with the test set containing 20% of the data.

e. Neural Network

The Neural Network was built using python with the TensorFlow library. It consists of 1 input Layer (9 nodes), 2 hidden layers with 16 and 8 nodes respectively, and finally an output layer with a single node.

We used the *Binary Crossentropy* loss function, and the *Adam* optimizer

The parameters of the model are as follows:

- Learning Rate: 0.001 Epochs: 300
- Batch Size: 16
-

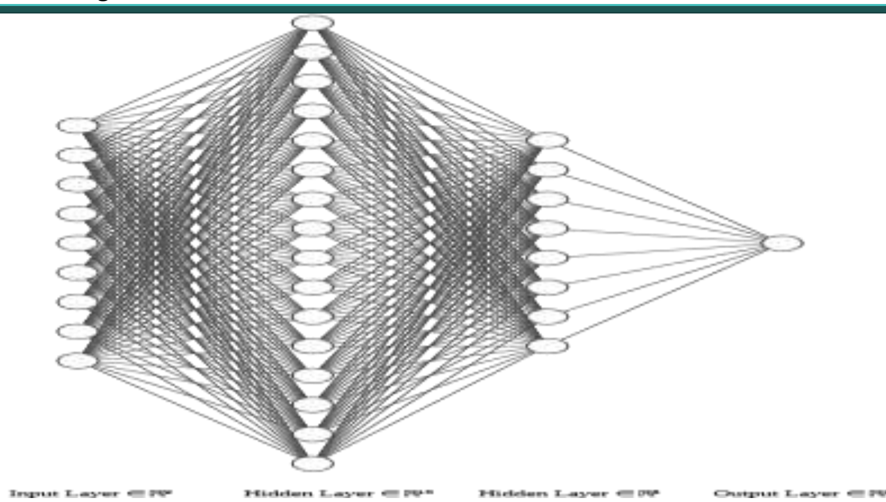


Figure 1: The ANN model

f. **Evaluation**:

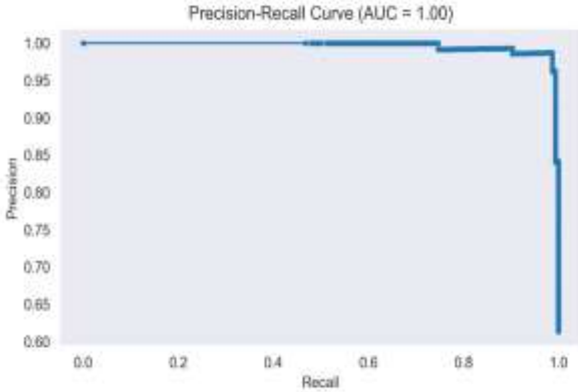
After 258 epochs, the model reached an accuracy of 98.01% on the test set.

Figure 2: Training and Validation accuracy and loss

We produced the classification report using scikit-learn, here's the report in detail:

Table 2: Evaluation Metrics

	precision	recall	f1-score
Negative	0.97	0.98	0.97
Positive	0.99	0.98	0.98



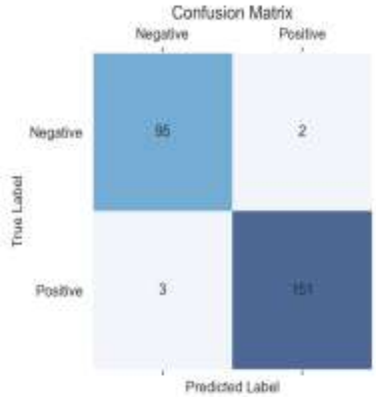


Figure 3: Classification Report

6. Conclusion

In this research paper, we harnessed the predictive capabilities of a neural network to discern the presence or absence of a heart attack in patients. Our constructed neural network exhibited a commendable accuracy of 98.01% in this classification task. To accomplish this, we employed Python, with the aid of TensorFlow, to create and train our neural network, which took the form of a feedforward Multi-Layer Perceptron (MLP). This MLP architecture comprised one input layer, two hidden layers, and one output layer.

The dataset utilized for this study was the "Heart Disease Classification Dataset," sourced from Kaggle. This dataset provides a comprehensive collection of patient information, including clinical measurements, lifestyle factors, and ultimately, the presence or absence of heart disease. By leveraging this data and employing a well-structured neural network model, we endeavored to contribute to the advancement of heart attack prediction models. Our objective was to create a highly accurate and practical tool for the early detection of heart attacks, which could potentially lead to timely interventions and improved patient outcomes.

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