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A machine learning approach for high blood pressure prediction and music control

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Abstract
High blood pressure (HBP) has been one of the major threats to human health. Lack of early detection and control of high blood pressure can cause severe damages to the heart which may lead to death. Most adults suffering from high blood pressure are unaware of the disease because it may have no warning signs or symptoms. This research focuses on the real time prediction of high blood pressure using a machine learning approach and control of high blood pressure using music. The study synchronizes a machine learning technique with a simulator to predict blood pressure and play low beat music if the blood pressure is high. The research was carried out using a large dataset with the following attributes (education, age, body mass index, current smoker and heart rate). Random forest algorithm was the machine learning technique used to construct and validate the prediction model. The prediction accuracy of the model exceeds 97% and the model was able to accurately predict blood pressure and play low beat music when the blood pressure is high.

Keywords: Machine learning, high blood pressure, heart rate, random forest algorithm

Introduction
High blood pressure (HBP) also known as hypertension is the abnormal increase in blood pressure. This occurs as a result of the amount of resistance the blood meets when the heart is pumping. This increase in blood pressure can cause a lot of damages to the blood vessels and organs especially the brain, heart and kidney. Research has shown that over 1.13 billion people suffer from hypertension and it is the major cause of premature death worldwide (Geneva, Hypertension, 2019) [1]. Hypertension diagnosis is made when the systolic or diastolic blood pressure readings exceed 120 mm Hg or 90 mm Hg for at least two visit (Daniel LaFreniere, Farhana Zulkernine, 2016) [19]. Hypertension is known to be a silent killer as symptoms may not be noticeable to some people (Geneva, 2019) [1]. Many people, do not undergo regular blood pressure test in order to prevent the disease. Hence, late detection and control of hypertension becomes exigent problem because they are not aware of the disease.

Today, artificial intelligence systems are widely used in different fields to solve one problem or the other. The rapid improvement in the field of machine learning enables researchers and healthcare innovators to develop intelligence systems that are able to diagnose disease. Machine learning (ML) has been applied in variety of areas such as diagnosis, personalized treatment, drug discovery, clinical trial research, radiology and radiotherapy, smart electronic health record, and epidemic outbreak prediction (Marcelo Gagliano *et al*, 2017) [2]. Machine learning algorithms are useful in medical diagnosis as they can quickly capture unforeseen patterns within complex and large datasets. Blood pressure checker (BP checker) is a web based intelligence system that synchronize machine learning technique with a simulator to predict high blood pressure in real time. BP checker have the ability to control high blood pressure by playing low beat music when the blood pressure is high. The proposed system (BP checker) can handle the problem of late detection of hypertension and it is capable to accurately predict hypertension based on the risk factors that can raise blood pressure reading which include education, age, gender, body mass index (BMI), history of smoking habit.

Music plays an important role to improve person's quality of life. Within the medicine field, music has serve as a natural remedy to treat anxiety and depression. Music has been used as an effective relaxation technique and it has been used as an intervention for various health

problems.

Music support healthy social development and the quality of life of young people. Research has shown that music altars the mood and behavior of a person thereby bringing about changes in human emotion. When the body is expose to slow beat music, the parasympathetic nervous system is stimulated which brings about decreases in heart rate (Suguna S, Deepika K, 2017) [3]. Therefore, this research aimed to properly handle the problem of late detection using machine learning and also classify low beat music to control high blood pressure.

Literature review

Hypertension is a serious life challenging disease that can damage organs if lately detected or even lead to death if left untreated. The rapid development in the field of machine learning (ML) allows technology and healthcare innovators to create intelligent systems which are used in variety of area within the healthcare industry (Marcelo Gagliano *et al*, 2017) [2]. Accumulating evidence which is discussed in this chapter shows how machine learning is used in combination with music to predict and manage increase HBP.

Prevalence of hypertension in Nigeria

Hypertension has been recorded as a threat to the health of people in Africa. Study has shown that, African Region has the highest prevalence of hypertension at 46% of adult between the age of 25 and above (WHO, 2013) [4]. A research conducted by (Okechukwu S Ogah *et al*. 2012) [5] shows that Nigeria experience an increasing prevalence of hypertension due to an increase in population. Currently, Nigerian's population is over 209 million (Worldometer, 2021) [6] and the prevalence of hypertension is increasing on a daily basis. In 2015, an overall estimate of hypertension prevalence of 28.9% (25.1, 32.8), with a prevalence of 29.5% (24.8, 34.3) among men and 25.0% (20.2, 29.7) among women was reported (Davies Adeloyea *et al*. 2015) [7]. Hypertension prevention and control has not been given adequate attention in Nigeria most especially in urban areas (Adediran Olufemi Sola *et al*. 2013) [8].

Hypertension Diagnosis

Hypertension diagnosis is one of the major problem scholars, scientist and medical professionals are working hard to solve as symptoms or signs are not noticeable until it gets to chronic stage. For instance, an individual with an increasing blood pressure will not notice any sign until it develops to a higher disease (such as stroke, heart failure, etc.). Regular blood pressure check is the first steps in hypertension diagnosis (Enid Wai-Yung Kwong *et al*. 2018) [9]. Hypertension diagnosis is made when the systolic blood pressure reading is above 140 mmHg and/or the diastolic blood pressure readings is above 90 mmHg on at least two different days of taking the measurement (WHO, Hypertension, 2019) [10]. Blood pressure measurement are always taken by medical practitioners using sphygmomanometer.

Application of machine learning (ml)/artificial intelligence (AI) in medical field

Artificial intelligence has become more popular and widely used in medical field because of its ability to solve complex problems. Several studies in the area of AI and machine learning has shown that, machine learning is used to build expert system which are widely used in the hospital by doctors and nurses to diagnose different diseases. Machine learning helps in fast and accurate medical diagnosis which is one of the important factor in reduction of mortality rate. According to Yeasmin (2019) [11], AI can diagnose disease by just using sensor to see the image of the affected area of the patient's body. According to Baraniuk (2016) [12], Google AI (Google DeepMind) will diagnose one in 75 men and one in 150 women with oral cancer. In the area of drugs prediction, Machine learning is use to predict drugs toxicity using computational method which provides very useful information at the early stage of drug design (Zhang *et al*, 2018) [13]. In 2019 a Clinical Decision Support System that can integrate heterogeneous health data from different sources (laboratory test result, etc.) was developed to help in identification of diseases (Carmela Comito *et al*, 2019).

Application of machine learning (ml)/artificial intelligence (AI) in hypertension diagnosis

Before now, sphygmomanometer was the only reliable and efficient instrument used by medical practitioners to take blood pressure reading. Recent studies have proven many other intelligence systems which are used by health workers to measure blood pressure with high accuracy (CO Manlises *et al*, 2016) [14]. Machine learning helps in developing accurate risk prediction models for patients with hypertension using important risk factors and also enhances treatment approaches for patients with hypertension (Thanat Chaikijurajai MD *et al*, 2020). Although studies demonstrate the usefulness of machine learning(ML)/ artificial intelligence (AI) in predicting hypertension risk factors, the use of AI tools for the prediction of hypertension risk factors and management is not widely adopted (Chayakrit *et al*, 2018) [15].

Classification algorithms in hypertension diagnosis

Classification is crucial to data analytics, pattern recognition and machine learning. It is a supervised machine learning technique, since it categories data from the existing information. According to (Osisanwo *et al*, 2017) [16], classification algorithm includes Linear Classifiers, Logistic Regression, Naïve Bayes Classifier, Perceptron, Support Vector Machine, K-Means Clustering, Boosting, Decision Tree, Random Forest (RF), Neural networks, etc. This section demonstrates how each machine learning algorithm has been used by researchers to diagnose hypertension and the accuracy of each algorithm taken to consideration.

The use of decision tree algorithm for the diagnosis of heart disease

Decision tree is a machine learning algorithm popularly used for disease diagnostic system due to its simplicity. It is a flowchart like a tree structure that includes a root node, branches, and leaf nodes. Each internal node denotes a test on an attribute, each branch denotes the outcome of a test, and each leaf node holds a class label (Himani Sharma, Sunil Kumar, 2013) [17]. In 2014 alternating decision tree approach was used to developed heart disease diagnostic system with 91.99% accuracy. The accuracy obtained from the model prove its usefulness in the diagnosis of the heart disease. C4.5 algorithm in decision tree was used to predict hypertension given some risk factors such as age, sex, smoke, sport, BMI, systolic blood pressure, diastolic blood

pressure, heart rate, diabetes mellitus, chronic kidney disease, etc. the prediction accuracy of about 80.0% was obtained. The C4.5 prediction model was developed to provide information about hypertension to those who suffer it (Gitarja Sandi *et al*, 2014) [18].

Artificial neural network for the diagnosis of hypertension

Artificial Neural Network is a machine learning algorithm that play an important role in solving various health problems like disease detection in the medical field. In 2016, Canadian Primary Care Sentinel Surveillance Network (CPCSSN) data set was used to develop an artificial neural network model for predicting hypertension. The model was developed to minimize the prediction errors from clinicians caused by incomplete or nosy data. About 82% accuracy was obtained after implementing the model (Daniel LaFreniere, Farhana Zulkernine, 2016) [19]. Another research conducted in 2011 demonstrate that the prognosis of early diagnosis of hypertension with artificial neural network models produce best result in large data sets (B. Sumathi, Dr. A. Santhakumaran, 2011) [20]. The prediction of blood pressure using important risk factors which includes age, BMI, exercise level, alcohol consumption level, smoking status, stress level and salt intake level yield 90% prediction accuracy which shows that artificial neural network is suitable for predicting hypertension (Enid Wai-Yung Kwong *et al*, 2018) [9]. Further research point out that, blood pressure reading is not always very accurate due to daily fluctuations, artificial neural network model can assist medical staff to achieved accurate blood pressure measurement.

Support vector machine (SVM) in hypertension prediction

Support Vector Machine is one of the most recent supervised machine learning techniques that is widely used to solve various classification task (Osisanwo *et al*, 2017) [16]. The use of SVM to diagnosis diseases in the medical field made SVM more popular due to the promising result obtained. According to the research conducted by (Stephen R. Alty *et al*, 2003), SVM can be used to predict the present of cardiovascular diseases in a patient. Infra-red light absorption detector was used to measure the patients' volume pulse and classification into high or low arterial stiffness was made using support vector machine. The classification result was found to be greater than 85% accuracy. The conclusion point out that, support vector machine is suitable for use by health professionals, such as GPs, as a casual screening facility for the prevention of cardiovascular diseases related injury and mortality for minimal cost to hospitals and health authorities.

The use of random forest for the diagnosis of hypertension

The application of random forest algorithm in hypertension diagnosis have shown an excellent performance as predictor variables of hypertension are randomly splitted in form of a tree. Research conducted by (Mario W *et al*, 2017) [21] on predicting high risk hypertension disorders in pregnancy compares other machine learning algorithm and found that random forest classifier perform better than other machine learning algorithm. Another research conducted by (Federico Wadehn *et al*, 2017) [22] shows that random forest classifier is stable and suitable for predicting hypertension with a sensitivity of 69.1% and specificity of 78.3%.

Methodology

Qualitative research methodology is the methodology used in this project. In this method, nonnumerical data was collected and analyzed for clear understanding of concept, opinion, or experience to solved and handle the underlying problem. The data used in this project is divided into training data, validation data and real time testing data. The training data used in this project was gotten from Kaggle.com (Aanya, 2020) [23]. The data was splitted into 75% for training the model and 25% for validating the model. The model learns from this data.

The real time data for testing the system was gotten from a simulator. The simulator generates the blood pressure variables and fit it into the system for prediction. If the prediction result is zero (0), it implies non-hypertensive, however, if the prediction result is one (1), the system notify the user by playing low beat music that can control increase in blood pressure. At every prediction, the system saves the details of the prediction result.

Result

Considering the complexity involved in taking accurate blood pressure reading manually, late detection of high blood pressure which may cause serious health issues, lack of proper management and control of high blood pressure and increase in premature death among youths, it is advantageous to adopt the system so as to control, manage and reduce death rate. Furthermore, the system save time and reduces errors when measuring blood pressure.

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