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Predictive Human Heart Anomaly Detector

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Abstract
Cardiovascular diseases (CVDs), commonly known as heart attack or strokes are the number 1 cause of death globally, taking an estimated 17.9 million lives each year, accounting to about 31% of total deaths across the world every year, according to the World Health Organization. One of the primary reasons behind CVD is hyper homocysteinea, that is higher level of an amino acid name homocysteine, causing blood clots in the arteries which results is a heart attack. This work proposes a novel system to detect homocysteine level in a non-invasive way through detection of hypothyroid as well as Vitamin B-12 deficiency. Neural networks have been used in this predictive model with an accuracy of 80%.

Keywords: *homocysteine, hypothyroid, vitamin b12, neural network*

1. Introduction

Cardio vascular disease is one of the major illnesses presently belong to the human being. The number of cardio vascular disease patient is increasing daily and according to the World Health Organization more than 30% deaths are because of heart failure. There have been many techniques invented before to detect the condition of hearth before it collapses.

Cardio vascular disease is mainly elevated because of high level of total plasma homocysteine (t-Hcy) which is present in human blood. Homocysteine is an amino acid produced when proteins are fragmented down. A high homocysteine level, also called hyperhomocysteinea, can increase the damage of arterial damage and blood clots in human blood vessels. Elevation of total plasma concentration of homocysteine (t- Hcy) is a significant and independent risk factor for cardio- vascular disease. Hypothyroidism is possibly also allied with an increased risk for coronary artery disease, which may be related to atherogenic changes in lipid profile [14]. A normal level of homocysteine in the blood is less than 15 micromoles per liter (mc-mol/L) of blood. Higher levels of homocysteine are split into three main categories: Moderate: 15-30 mc-mol/L, Intermediate: 30-100 mc-mol/L, Severe: greater than 100 mc-mol/L. An increased level of homocysteine is mainly theindicationofvitaminB-12orvitaminB-6deficiency.There are several proofs also that increased level of homocysteine is related to hypo thyroidism.

Below table 1 demonstrate the relation between homocysteine and cardiac risk level [13].

In bio-medical research, classification techniques place a vital role in decision making process by the physician to monitor and diagnose the Diseases.

Table 1: Homocysteine and Cardiac Risk

Homocysteine Level (mc-mol/L)	Cardiac Risk Level
< 6.3	< 1x greater risk
6.3	1x greater risk
10	2x greater risk
15	4x greater risk
20	9x greater risk

Physical verification and data analysis done by the practice is difficult due to increase OPD. There lies a need in classifying the data system automatically and rapidly with accuracy, diagnose of medical data accurately and consistently[2].

To overcome this situation Artificial Intelligence and Artificial Neural Network has been a great savior as it is capable of detecting and predicting the human anomalies. ANNs have the ability to distinguish between groups of signals, which were used to categorize different types of diseases and illnesses. This is allied to their characteristics of self-learning, self-organization,

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nonlinearity, and parallel processing related with linear traditional classifiers. Feed forward neural networks suffer from some limitations when dealing with temporal pattern [3].

In spite of improvements in real-time detection of anomalies, there has been a missing motivation on the early prediction of forthcoming negative health events, which can be probable with the unsupervised or supervised analysis of health signals in intervals before the event onset. Physiological and environmental deviations are identified through health sensors can be an early sign for the onset of a negative health event in the near future[1].

This project work aims to build a system which can detect the abnormalities in human body and predict the illness beforehand and can be able to take the necessary actions based upon the severity levels. In the golden hour the maximum possible care and treatment is needed, building a system which can predict the serious illness beforehand and also based upon the severity levels the system should be able to perform few tasks. The rest of the report is organized in the following manner, the Section-2 represents the literature survey and previous work, Section-3 Proposed System and methodology, Section-4 gives the details about Experimental Setup, Section-5 is about Result and Discussion, Section-6 is Conclusion and Section-7 is bibliography.

2. Literature Survey

Heart disease has become one of the most important research fields; there are many dataset available which is open source. Many works have been done to detect or predict the heart disease using supervised and as well unsupervised algorithm of machine learning.

The objective of this project work is to detect the level of homocysteine in a non-invasive way; works related to this is not yet done. That's reason the related works of detecting thyroid and basic theory of Vitamin B12, also prediction using machine learning algorithms and neural network related works have been discussed below.

To start with, M. Malathi et al. [6] proposed a technique for non-invasive detection of Thyroid type using Infrared sensor. The authors have used a low cost smart sensing system to sense the human relative skin temperature through non-invasive method for detecting thyroid. Thyroid can be of two type hypothyroidism and hyperthyroidism. The proposed system has achieved an accuracy of 83.3% of detecting Thyroid non-invasively.

Further, Sundaravadivel et al. [8] introduced the use of energy effective sensor for thyroid monitoring through the IoT authors have done a model of the temperature sensor along with the controller which performs the calibration is designed using Simulink®. Thyroid can be detected using basal body temperature or using blood samples.

A system proposed by Lekshmy et al. [9] relates the existing biomarker with the imaging modality forthe initial stage diagnosis of thyroid disorder; the classifier gave an accuracy of 98.4%.

Another approach by Robert c. et al. [7] related to Vitamin B-12 has discussed Vitamin B12 (cobalamin) deficiency is a common cause of macrocytic anemia and has implicated in a spectrum of neuropsychiatric disorders, the role of B12 deficiency in hyperhomocysteinemi.

Gitte Wennecke et al. [12] deals with Hematocrit reviews on the different analytical methods to detect blood hematocrit level using hemoglobin and other blood particle is considered as base of detecting hematocrit in this project. Lower value of hematocrit indicates the deficiency of vitamin B-12 which is also discussed in the review paper.

With the significant increase of application of artificial intelligence in healthcare in recent times, neural networks have been used for these type of predictions The past, present and future of Artificial intelligence along with the current status ofAI in health care is discussed in the survey by Fei Jiang,Yong et al.[10].

One recent prominent work by Anahita Hosseini et al. [1] predicts the negative health event ahead of time. Their study tells that observations on the faults of widely adopted anomaly detection methods in the discovery of changes prior to a negative health event. The proposed unsupervised method achieved 1.3 minutes ahead of time with 68% accuracy score.

Hamidreza et al. [2] proposed an ensemble classifier to detect the cardiovascular disease. For this work data has been collected from the UCI Laboratory, is utilized for applying discovery pattern algorithms including Decision tree, Neural Networks, Rough Set, SVM, Naive Bayes, and compare their accuracy and prediction. They have proposed a hybrid algorithm to increase the accuracy of these algorithms. Based on the results, the suggested hybrid method has achieved an F-measure of 86.8% which outperforms other competing methods.

Karayilan et al. [3] proposed an artificial neural network backpropagation algorithm for this work they have used 13 clinical features to train the neural network with backpropagation algorithm. The proposed work hasachieved95%accuracyscore.

Another work by Bandarage et al. [4] uses data mining and neural network techniques to predict heart disease. It presents a comparative analysis of different data mining and neural network classification techniques that can be used to predict heart disease based on the risk factors. The different classification techniques that have been mentioned in survey paper are Neural Network, K-NN, Decision tree, Logistic Regression and Naïve Bayse. The accuracy of these above mentioned methods are respectively 78%, 75%, 77%, 82% and 87%. Among these algorithms Naive Bayes algorithm shows higher accuracy.

SP Rajamhoana et al. [5] presented a review of neural network based systems for heart disease prediction system; the authors have considered the previous works

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done for prediction and classification of heart disease. They have compared different algorithm techniques and hybrid systems and finally have concluded with better technique.

3. Proposed System

The proposed system is designed to detect homocysteine level in human blood in non-invasive manner. Present method of detecting homocysteine is through blood test since it is an amino acid present in blood. In the proposed system the homocysteine level of human body can be determined using sensors but indirectly by finding thyroid level and vitamin B - 12 levels. Figure 1 represents working of the proposed system. As per the figure this system is the association of hardware as well as software (i.e. prediction part using neural network). The data will be collected from the hardware and then storing the data in comma separated value (CSV) format for further use in prediction application. CSV file data is transferred via Bluetooth module of Arduino uno board which is then preprocessed or cleaned before feeding to neural network. Based on the prediction value this system is able to show the nearby hospitals using mapbox api and continue to check the health condition.

A. Methodology

Homocysteine is an amino acid present in blood which is directly related to a person's cardiac health. Most labs report normal ranges of homocysteine as about 4-15 µml/L, high level of homocysteine is the main cause of cardiac arrest in humanbody. High levels of homocysteinec and amagearteries, which can ultimately lead to hardening and narrowing of the arteries (atherosclerosis) and blood clots that could lead to heart attacks. The non-invasive way of detection homocysteine is quite unachievable, since it is an amino acid. The normal way to detect the amino acid is via blood test. In this proposed method of non-invasive detection of homocysteine can be achieved by detecting deficiency of vitamin b-12 and deficiency of thyroid hormone.

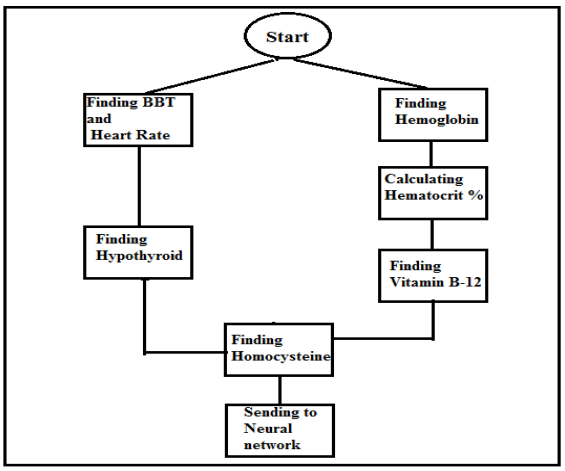

Figure 1: Working Flow of Proposed System

Since High level of homocysteine is strongly related to vitamin B-12 deficiency and thyroid deficiency (hypothyroidism) [11] [14]. Methodology of the proposed system is categorized into three sections, 1. Detection of Vitamin B-12, 2. Detection of Hypothyroidism and 3. Artificial neural network.

1) Detection of Vitamin B-12: The deficiency of vitamin b-12 is the main cause of a particular anemia in human body called megaloblastic anemia. Megaloblastic anemia is considered by red blood cells that are larger than normal. There also aren't enough of them. It's known as vitamin B - 12 or folate deficiency anemia, or macrocytic anemia, as well [12]. This type of anemia can be detected from hematocrit (Hct%) in blood. Lower value of hematocrit (Hct%) indicates the deficiency of vitamin B-12 in human body, while the normal range of hematocrit in Men is 45% - 52% and in Female is 37% - 48%, anything lesser than these ranges consider to be the lower range of it. Hematocrit is directly related to the total concentration of blood hemoglobin[12].

$$Hct\ \% = 2.941 * Hb \quad (1)$$

To detect the human blood hemoglobin level two infrared LEDs of 940 nm and 660nm are used which acts as a emitter and OPT101 transmitter is used as receiver. The application of these LEDs and OPT 101 is explained in the next section.

2) Detection of Hypothyroidism: In the previous work [6] an IR temperature sensor and pulse rate sensor to detect thyroid in human using non-invasive methods. It is also known that the basal body temperature (BBT) of human body tends to be low in case of hypothyroidism. Normal BBT of human is generally accepted between 97 F to 98.6 F, whereas is case of hypothyroid patients the normal body temperature ranges between 92.2 F to 94 F which is very low compare to normal body temperature. Another aspect of hypothyroid patients is, resting heart (pulse) rate (RPR). The normal RPR ranges for two different age groups are a) ages 6 to 15 (70-100 bpm) and b) 18 and over (60-100 bpm). In hypothyroid patients RPR ranges between 60 to 70 bpm, basically 10 to 20 bpm lesser than normal heart rate. These two factors are approved by doctors for detecting hypothyroidism in human. To achieve this method a near infrared sensor AS7263 and heart rate ppg sensor MAX86150 are used which is explained in the next section.

3) Artificial Neural Network: Artificial neural network and deep neural network are now used in medical projects for predicting the illness beforehand. Since there is a constant need of earlier detection of serious illness like heart attack artificial intelligence has played a major role in this. This system is also used deep neural network for the prediction of homocysteine level. The method used in prediction is binary classification using Keras library of python. Since only two outcomes are there that is possibility of cardiac arrest equals to 1 and no possibility of cardiac arrest equals to 0, binary classification is used. In deep learning method three layers of neurons are used input layer, dense layer or

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hidden layer and output layer. In this project 3 features are used in input layer for a single output. These features are gender Hypothyroidism, VitaminB–12 deficiency as input or independent feature and homocysteine as output or dependent feature. The input layer consists of 102 neurons and 2 hidden layers are consisting 16 and 20 neurons respectively. Another library named mapbox is used after prediction to show the nearby hospitals of that particular location by taken the latitude and longitude of that location.

4. Experimental Setup

A. Thyroid Experiment

As discussed in the methodology section, thyroid functioning is basically done with the help of basal body temperature and heart rate detection. This experiment is done using near infrared sensor AS7263, which is having inbuilt function to measure body temperature from a distance or by touch. AS7263 near infrared sensor is connected with Arduino Uno board and the output is visible on Arduino monitor. Along with this MAX86150 heart rate sensor which is basically a PPG sensor is connected with Arduino board. MAX86150 is a proto central sensor which can measure accurate PPG signal as well as ECG for a person. The sensor after turning on blinks RED and IR LEDs to measure heart rate by touch. Arduino board is connected with both the sensor as shown in the figure2 as a circuit diagram. Both of the sensors can work simultaneously and their output is visible on Arduino monitor.

B. Vitamin B-12 Experiment

This experiment consist of emitter as LEDs, with wave lengths of $\lambda 1$=660nm, $\lambda 2$=940nm. These two wave lengths are chosen because at 660nm wavelength absorbance of deoxyhemoglobin significantly (hemoglobin that is not bonded with Oxygen) exceeds the absorbance of oxyhemoglobin (hemoglobin that is bonded with Oxygen)while at 940nm wavelength absorbance of oxyhemoglobin significantly exceeds the absorbance of deoxyhemoglobin.

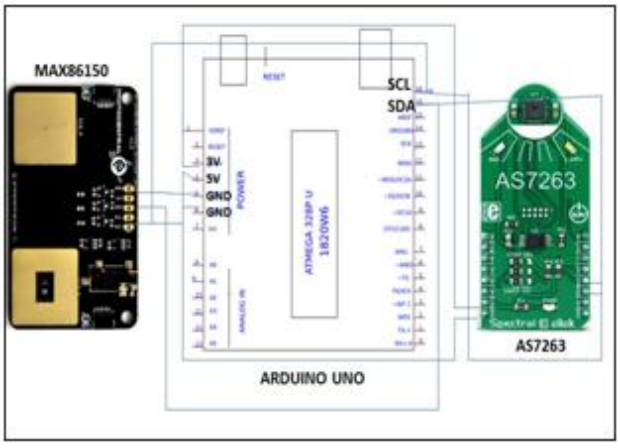

Figure 2: Circuit Diagram of Thyroid Experiment

These LEDs are fixed in the upper shell of a finger clip. To perceive the transmitted light OPT101 transimpedance amplifier is used as detector. The OPT101 is a uniform photodiode with on-chip transimpedance amplifier. This single receiver photo diode is fitted in the lower shell of the finger clip. The probe is placed to the patient's body usually on the finger as shown in figure3. The Red and infrared light is then emitted sequentially through the body tissue. The transmitted light is sensed by photodiode. This method is used to detect the hemoglobin of a person through the voltages that OPT101 generated after receiving the emitted LED lights. Through hemoglobin detection megaloblastic anemia can be detected which is caused by Vit B-12 deficiency.

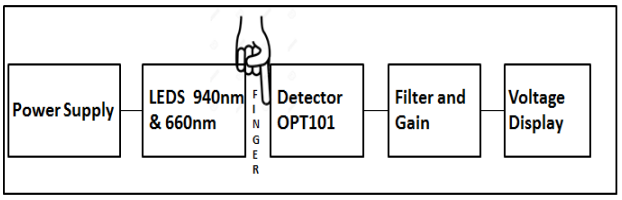

Figure 3: Process of Vitamin B-12 Experiment

5. Result and Discussion

This experiment is successfully performed on 10 adult people named as subject whose ages are among 25 to 40. They all do not have any serious illness as per their medical report. So the first experiment done on them is hemoglobin checking. They kept the hand on the finger clip having two LEDS and one receiver, the output generated is received asthe voltage which is transferred to hemoglobin level using the below formula (2).

$$Hb = \left(\frac{AC+DC}{DC}\right) * 10 (2)$$

The collected hemoglobin unit is in gram per deciliter which is then converted to hematocrit (Hct%) equation (1). The table 2 represents the result of detected hemoglobin and calculated hematocrit and as well as vitamin B-12 deficiency based on hematocrit range. The normal range of hematocrit in Men is 45% - 52% and in female is 37% - 48% [12]. If the calculated value of hematocrit is lesser than the mentioned range both in the case of male and female then it is considered as vitamin B-12 deficiency in blood. In the experiment 6 people turned as vitamin b-12 deficient and 4 people do not have deficiency.

Table 2: Result of Vitamin B-12

Subject	Gender	Hemoglobin	Hematocrit(%)	Vitamin B-12
Subject 1	Male	14.6	42.93	Low
Subject 2	Female	10.2	29.9	Low
Subject 3	Female	11	32.35	Low
Subject 4	Male	15.4	45.29	Normal

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Subject 5	Male	16	47.05	Normal
Subject 6	Female	12	35.29	Low
Subject 7	Female	10.6	31.17	Low
Subject 8	Female	13	38.23	Normal
Subject 9	Male	14.8	43.52	Low
Subject 10	Female	12.7	37.35	Normal

Another experiment of hypothyroidism done on same 10 people and the result is also recorded as per the previous experiment. In this experiment subjects are instructed to put their finger on both of the sensor simultaneously and their respective basal body temperature and heart rate is recorded. As discussed in the above section people with lesser body temperature and less heart beat is detected as hypothyroidism. The table 3 presents the result of two sensors and based on them calculates hypothyroidism. In this experiment 7 people are detected as hypothyroid patient and 3 people have normal range. This result is confirmed with the doctor for more accuracy.

Now the separate experiments are done and while combining it is found that 6 people in both the experiment have vitamin b-12 deficiency as well as hypothyroidism. These 6 people have the higher ranges of homocysteine since high level of homocysteine is dependent on hypothyroidism and vitamin b-12 deficiency. The table 4 depicts the combining result.

This collected result is then transferred to neural network for prediction. The accuracy of the neural net achieved at most 80% since the amount of data is very less. Table 5 represents the accuracy, precision and recall of the neural network.

Table 3: Result of Hypothyroidism Experiment

Subject	Gender	Body Temp	Heart Rate	Hypothyroidism
Subject 1	Male	93.79	70	Yes
Subject 2	Female	93.83	69	Yes
Subject 3	Female	92.35	71	Yes
Subject 4	Male	98.91	72	No
Subject 5	Male	93.26	69	Yes
Subject 6	Female	92.40	72	Yes
Subject 7	Female	94.50	68	Yes
Subject 8	Female	96.92	73	No
Subject 9	Male	93.76	72	Yes
Subject 10	Female	97.21	90	No

Table 4: Result of Homocysteine

Subject	Hypothyroidism	Vitamin B-12	Homocysteine
Subject 1	Yes	Low	High
Subject 2	Yes	Low	High
Subject 3	Yes	Low	High
Subject 4	No	Normal	Normal
Subject 5	Yes	Normal	Normal
Subject 6	Yes	Low	High
Subject 7	Yes	Low	High
Subject 8	No	Normal	Normal
Subject 9	Yes	Low	High
Subject 10	No	Normal	Normal

The existing system of homocysteine detection is using blood test that means it is an invasive way of detection. The proposed system can detect and predict homocysteine level in human body in noninvasive way. The accuracy of invasive detection is significantly higher than the proposed system since proposed method not yet started working globally with larger amount of people. This noninvasive detection of homocysteine is better than the invasive process since the invasive detection process is more time consuming as well as more costly. This proposed system is cost effective and takes very less time around 2 minutes to detect and predict homocysteine level. This proposed system is also portable while the available invasive system is not portable. The table 6 distinguishes these two system based on the three parameters.

Table 5: Accuracy of Neural Network Model

	Precision	Recall	Accuracy
0	0.80	1	0.80
1	1	0.80	–

Table 6: Comparison

Parameters	Existing System	Proposed System
Time Effective	No	Yes
Cost Effective	No	Yes
Portable	No	Yes

6. Conclusion

The number of heart disease among humans in the world is increasing every day and the most number of people dies every year because of heart disease. This project has successfully detected homocysteine level in human blood in a noninvasive way since high homocysteine is one of

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the major causes of heart attack in human. This project is also predicted the chances of high homocysteine in human based on thyroid measurement and vitamin b-12 measurement. The future scope of this project is to make this system for large number of people and to achieve more accuracy in prediction using neural network.

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