Non-Invasive Anaemic Detection

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ABSTRACT - *Anaemia is a serious health concern that is affecting a large population. If it is not diagnosed and cured at the earliest, it can lead to critical illness. The traditional invasive method of anaemic detection is time-consuming. It has the potential risk of contamination and therefore a biohazard. The proposed method uses a non-invasive technique for the detection of anaemia. In this method, lights of two different wavelengths of 660nm and 940nm are passed through the tip of the finger using a MAX30102 circuit. A nano arduino is connected to this IC and is used to transmit and receive data. The reflected light from the finger is obtained and is passed to the database using a Wi-Fi module. Using the equations provided, the haemoglobin count is calculated and hence can know whether the person is anaemic or not. The result is displayed on detectIR. The project also has two additional features of heart attack prediction and disease prediction. The user is asked to enter a few details about the heart and using machine learning (Support Vector Machine) the possibility of a heart attack is predicted. The disease prediction uses web crawling to predict the possible diseasebased on the symptoms entered by the user.*

Keywords: Anaemia, Disease prediction, Heart attack evaluation, Non-invasive, Biohazard

1. INTRODUCTION

Haemoglobin is the oxygen-carrying pigment and predominant protein in the red blood corpuscles. It forms an unstable and reversible bond with oxygen. It has many different functions, including:

- transporting oxygen from lungs to body tissues
- transporting carbon dioxide from tissues back to lungs
- maintaining the shape of the red blood cells

Like all the other proteins, hemoglobin is also coded by Deoxyribonucleic acid (DNA). Hence, mutations or changes in haemoglobin result in several blood related diseases like sickle cell anaemia. This signifies the underlying concept that structure determines the function.

Anaemia is a condition characterized by inadequate red blood cell volume and a low concentration of haemoglobin in the blood. The symptoms include:

- fatigue
- weakness
- dizziness
- shortness of breath

The most common causes of anaemia include:

- nutritional deficiencies
- iron deficiency
- haemoglobinopathies

The current haemoglobin measurement process is an invasive technique. This is a standard technique designed for haemoglobin estimation but is time consuming. This had led to the shift from highly invasive diagnostic and therapeutic procedures to non-invasive procedures. Non-invasive methods are generally defined as the type of haemoglobin estimation methods that has been introduced with the aim of preventing ache to blood donors. The advantages of non-invasive methods over the invasive method include reduced time to diagnosis, critical decisions making, and treatment as well as improved patient satisfaction.

The non-invasive method allows haemoglobin to be measured immediately without the need for intravenous access to blood. This method has been introduced with the aim of preventing ache to blood donors. Also it allows online patient monitoring with minimum risk of infection and provides real time data monitoring with immediate clinical reaction to the data measured. Moreover, this method helps to measure the haemoglobin in patients with active bleeding and detect occult bleeding. This method also minimizes the risk of infection for health care personnel, reduces the need for trained workers and is sampling error proof.

1.1 Literature Survey

Non-invasive methods in the assessment of health parameters are important for various kinds of patients, but only few expensive and inconvenient solutions are available. Few are quoted below:

Soumyadipta Acharya, Biomedical Engineering, Johns Hopkins University, Baltimore, Maryland United States cited in his paper "Non-Invasive Estimation of Hemoglobin Using a Multi-Model Stacking Regressor", a novel machine-learning based method to calculate total haemoglobin (Hb) using photoplethysmograms (PPGs) acquired in a non-invasive manner. Furthermore, it illustrates the feasibility of machine learning based on invasive haemoglobin measurement systems, especially for maternal anaemia detection. The regressor model has significantly better performance than the performance of individual regressors. But it was not able to predict the haemoglobin amount accurately and it is limited only to pregnant ladies not for all common people. [1]

In the research paper "Non-invasive prediction of hemoglobin level using machine learning techniques with the photoplethysmograms(PPG signal's characteristics features", A.Reşit Kavsaoğlu, Department of Biomedical Engineering, Faculty of Engineering, KarabukUniversity, Turkey mentioned haemoglobin level measurement device based on PPG signal.

They used many machine learning algorithms like classification and regression trees – CART, least squares regression – LSR, generalized linear regression – GLR, multivariate linear regression – MVLR, partial least squares regression – PLSR, generalized regression neural network – GRNN, MLP – multilayer perceptron, and support vector regression –SVR. The only advantage of this proposed method was that haemoglobin detection can be performed non-invasively. The patient would have to come to the clinic or lab to perform the test as it was not portable.[2]

M.R. Rakhshani, Department of Electrical Engineering, University of Zabol mentioned in the paper "High sensitivity label-free refractometer based biosensor applicable to glycated hemoglobin detection in human blood using all-circular photonic crystal ring resonators "that lab-on-a-chip integrated optical biosensors have shown useful in non-invasive detection of biomaterials. They are resistant to electromagnetic interference rather than to their electronic peers. By changing the optical characteristics of desired biomaterials, the resonance frequency of the resonator changes and due to its high-quality factor and sensitivity, a large amplitude difference appears in the output. This is used for detecting haemoglobin, but accuracy is not reliable and also it is expensive.[3]

Md Kamrul Hasan, Mathematics, Statistics and Computer Science Department, Marquette University, USA cited in his paper "Smartphone-based Human Hemoglobin Level Measurement Analyzing Pixel Intensity of a Fingertip Video on Different Colour Spaces", a non-invasive haemoglobin prediction model using smartphone that handle portability, accuracy and utility problems by using the high-resolution camera, computation ability, communication and storage facility of current smartphones. Features are extracted from all the combinations of ten different colours and applied to a Partial Least Squares (PLS) algorithm. The disadvantage of this method was that a specific pixel colour combination is required which cannot be obtained all the time. Therefore, it was not reliable due to accuracy issues. [8]

In order to increase the accuracy of such non-invasive detection methods, Jingze Yuan, State Key Laboratory of Applied Optics, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences mentioned in his paper "Research on improving the accuracy of near infrared non-invasive hemoglobin detection", that to optimize the accuracy of near-infrared non-invasive haemoglobin detection, high-performance instrument and prepossessing algorithm have been investigated. Using an InGaAs detector array with 16 pixels and plane grating spectrometer, a near infrared spectrophotometric system was constructed to obtain high signal noise ratio (SNR) spectral data. Two prediction tests were conducted to verify the effects of pre-processing algorithms improving the accuracy of near-infrared Hb detection and exclude the occasionalist of satisfactory results in a single trial. The independently-developed high-performance instrument and the method DOSC coupled with PLS are promising in non-invasive Hb detection clinical application. Here also, the device is not portable due to this size and weight. So, it is limited to clinical purpose only.

1.2 Study of Existing System

Clinical Approach

Existing clinical approaches to measure blood haemoglobin levels require specialized equipment. It has accuracy but is expensive and needs a lot of infrastructure requirements, all of which are especially problematic in rural and low-resources settings, where anaemia is more prevalent. Here, the blood sample of the person is taken, and then certain tests are conducted using

chemicals like Ethylenediaminetetraacetic acid (EDTA). It is not only time consuming but causes a lot of unnecessary pain to the person. Aside from being cost-prohibitive in resource-poor settings, the necessary invasive blood sampling to measure haemoglobin levels causes discomfort in younger pediatric patients. It also produces a lot of waste which is non-biodegradable. Therefore, it is not eco- friendly.

Aneamia Care Diet and Nutrition

Aneamia Care Diet Nutrition is an application mainly designed for tips and awareness for anaemic patients. This app covers information about haemoglobin count such as types, causes, risk factors, friendly foods and foods to avoid etc. Dieting ideas and tips have been carefully reviewed by experienced and professional dietitians carefully. But here we cannot determine the haemoglobin count. So, we are not able to detect whether the person is anaemic or not.

Sign and Symptom Anaemia

This application helps the patients to self-manage anaemia, using interactive tools. The Signs Symptoms Anaemia gives the patient important information regarding signs and symptoms of the disease and management of the Anaemia. This app also allows the patient to record and track anaemia levels along time with an incredible graphing option. The patient can show these records to the doctor and together improve the quality of life. This app also allows the patient to remember when and which medication to take to manage Anaemia. Some information provided may not be valid due to variations in medical practice and drug approval and indications. So, this app cannot be used as an efficient tool to predict whether the person is anaemic or not.

1.3 Drawbacks of Existing System

The standard way to measure the hemoglobin concentration is to prick one's finger or arm to acquire a sample of blood and this sample is later analyzed via one of the different chemical methods available. This is known as an invasive method for hemoglobin detections and this process pervades the body cavity. The most common chemical method is enzyme reaction that is used before the final concentration value is read.

The disadvantages of invasive method include:

•the results are not obtained instantaneously

•high chance for infection •include expensive reagents

The standard technique designed for hemoglobin measurement is economical but time-consuming. Simple techniques to measure hemoglobin exist but they are relatively expensive and require commercial reagents and good technical skills to interpret. Thus, invasive tests used to detect the haemoglobin count in the blood is inefficient as it requires sophisticated equipment with trained technicians. Therefore, the development and testing of non-invasive haemoglobin detection devices is more practical, economical and convenient.

2. PROPOSED SYSTEM

detectIR is an application that emphasizes real-time anaemic detection. The project consists of two parts: hardware and software. The hardware works based on a pulse photo metric measurement method. In this method, an area of skin on the fingertip is trans-illuminated by light which is emitted by a red LED and a green LED.This light passes through the tissues and is reflected back. The wavelength of the light reflected back from the tissue is recorded. The difference in wavelength is used to calculate the

hemoglobin count. Once the hemoglobin count is obtained, it is compared with the database containing normal hemoglobin level in the software to determine if the person is anemic or not. The software is an application named detectIR which contain a database for storing the optimal hemoglobin level, providing tips and articles based on the hemoglobin count, predicting the chance of heart attack using SVM algorithm in Machine Learning and providing additional information based on the symptoms entered by the person using Web Crawling.
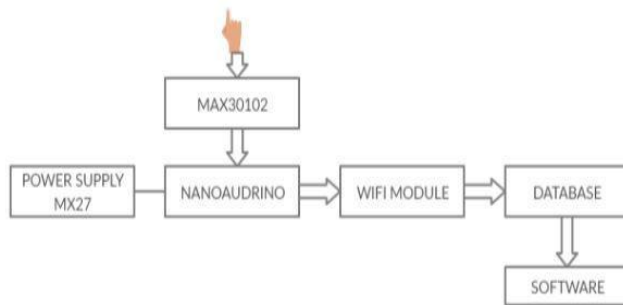
Figure 1: Block diagram of non-invasive anemic detection

The hardware is turned on by supplying power through MX27. The finger is placed on MAX30102 which is an integrated pulse oximetry and heart rate monitor module, which has the red and green LED inbuilt on it. The data received is transferred to a nano arduino. The received data is transferred to the database through a Wi-Fi module, NodeMCU12E. Upon reception of data in the database, values are compared for anemic detection and the result is shown on the android application. In the software the additional features of heart attack prediction and disease prediction also takes place.

Calculations

Hemoglobin Concentration is given as: -

$$OD = Log\ I0\ = \varepsilon cL$$

Mixture of oxygenated and

deoxygenated blood, equation: -

$$OD^{\lambda} = \{\varepsilon^{\lambda}{}_{HHb}\ [HHb] + \varepsilon^{\lambda}{}_{Hb O_2}\ HbO2\ \}L$$

$$\Delta[Hb]\ total = \Delta\ [HHb] + \Delta[HbO2]$$

2.1 Working

Hardware

The hardware of the system deals with procuring the input for the software. In order to turn on the hardware, a power supply is enforced. The finger of the user is positioned on MAX3010x from which the data is resettled to the Arduino board NANO_PCB. Employing NON MCU12, the data is shifted from hardware to software using a common database named hemoglobin. It is powered by the MX27.NXP Power Management Integrated Circuit (PMIC) MC13892 is used with MX27. The power supply of 12V must be converted to 5V for the system to operate accurately. This is attained by using PMIC.MAX3010x is the part of the hardware that detects the input. This is attained using the radiation emitted by MAX3010x that penetrate through the finger of the user. The LED inside MAX3010x plays an indispensable part in this project.MAX3010x is an integrated pulse oximetry and heart rate monitor module, which has a red and green LED inbuilt on it. These two-wavelengths are made use of for detecting anaemia. Values obtained from MAX3010x are transferred to the Arduino board. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino senses the environment by obtaining the required data from the sensors. It is also capable of controlling it's surrounding lights, motors, etc. NodeMCU12E is the open-source board and firmware that allows us to program the Wi-Fi module with LUA programming language or Arduino IDE. The 5V power must be converted to 3.5V for the functioning of NodeMCU12E and hence a Zener diode 1N4148 is incorporated into the system. It receives the data from the Arduino

board and transfers it to the software part. The database receives the data sent by hardware using the Wi-Fi module and transfers it to the software. The database serves as the integration point between hardware and software.

Figure 2: Circuit diagram of hardware

Software

The software part of the project is an application named detectIR. It consists of four modules:

- Anaemia Detection
- Tips and Articles
- Disease Evaluation
- Disease Prediction

Figure 3: detectIR application

Anaemia Detection

This module displays the hemoglobin count according to the information gathered while placing the finger over the hardware. The hemoglobin count is then compared with the database that contains the optimal hemoglobin level to determine if the person is anemic or not. If the hemoglobin count is less than the optimal level, the person is diagnosed with anaemia, otherwise not. In men, anaemia is typically defined as hemoglobin level of less than 13.5 gram/100 ml and in women as hemoglobin of less than 12.0 gram/100 ml.

Tips and Articles

This module enables the admin to add tips and articles on anaemia. The user will get vital knowledge about anaemia, anaemia detection, anaemia prevention, human blood and so on. These articles will mold the user to treat his own body in a wise manner. The articles will provide a proper diet, nutrition, healthcare that a person should follow in his life. The admin must specify the topic, content and user in order to add an article. It also gives permission for the admin to modify the article, if required.

Disease Evaluation

This module displays the diseases suffered by the patient using web crawling. The user inputs the symptoms and the list of diseases will get appeared with respect to the symptoms. The terms of the disease can be browsed using web crawling method. This will give a wide idea about the disease and a person can evaluate himself on his health condition.

Disease Prediction

This module predicts whether a user has a chance for heart attack using machine learning. It is implemented using PYTHON and PHP. Support-vector machines (SVM)are used as the learning algorithm. It is a

supervised learning model with associated learning algorithms that analyze data used for classification and regression analysis. The prediction uses a dataset of the patients which includes age, heart blood sugar, heart diseases, resting blood pressure, maximum heart rate, old peak, chest pain, serum cholesterol, resting electrocardiograph, exercise induced angina etc. Using this information in the dataset, the occurrence of heart attack can be predicted easily.

3. CONCLUSION

As anaemia is the most common blood disorder, its diagnosing is very crucial. The non-invasive method discussed here is an effective method for diagnosing anaemia. The problem of time consumption, bio-waste, infection from equipment and reagents etc. are solved here. The components used for making the hardware are cheap and easy to use and since the results are correct, it will prove to be a successful alternative to the present invasive methods of anaemic detection. Also, the addition of two features, heart attack prediction and disease prediction help to monitor their condition without having to visit a doctor. The articles provided will give an idea about home remedies and treatment and also the advancement of medical science. Therefore, detectIR will surely be a helpful companion to all people.

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