Towards IoT and ML Driven Health Care System

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Chapter 1

Introduction

1.1 Problem Definition

Cardiovascular Disease (CVD) and Coronary Artery Disease are two increasing cause of mortality nowadays in Bangladesh. Over the last few decades, the main reason of death has dramatically shifted from communicable disease e.g.Cholera, Smallpox to non-communicable e.g. Cardiovascular disease, Cancer, Blood pressure, Diabetes disease. Previously from a statistics of 1986 the morbidity and mortality for the communicable disease were 52% and for the non-communicable disease, it was 8% [1]. But according to some studies done in 2014, it has been found that the main cause of death has dramatically shifted to non-communicable disease from communicable disease, which is quite severe in the sense because non-communicable disease like Cardiovascular disease is the most fatal reason of death bearing the statistics of 17% alone [1]. The effect is higher in urban areas although the available treatment for cardiac disease is quite costly. So looking through different aspects of CVDs in our country it is safe to say that, this side needs some attention and some measures have to be taken to monitor the cardiac condition as well as to get useful suggestions or alerts for upcoming anomalies of a person's cardiac condition.

So, in this paper we want to describe such a prototype which will automate the whole task of data collection and transferring the data with the help of IoT devices to an application running a Machine Learning algorithm on the cloud, which will then calculate the result based on the inputs collected from different IoT devices and sensors connected to the patient or user-end in real time. The ML algorithm is provided with

12 parameters to get a prediction about the possible cardiac anomalies.

1.2 Motivation

Cardiac diseases are highly prevalent in Bangladesh. The death rate is increasing rapidly due to the rising amount of heart attacks, Coronary Artery Disease, Cardiovascular Disease (CVD). According to the Global Health Observatory data of the World Health Organization in 2017 Bangladesh is ranked 104 in the world with 14.31% of total deaths.

According to the recent Noncommunicable Diseases Country Profiles of Bangladesh provided by WHO, amount of people who are taking drug therapy to prevent heart attacks and strokes are negligible. People are barely conscious of noncommunicable diseases but these long-term and slowly progressive diseases are so severe in future that condition of the patient becomes too critical to handle. According to Bangladesh criteria, people hardly follow a regular checkup or feel the necessity to counsel a doctor even once a month. As a result, most of the people got a sudden heart attack or get to know about their disease when it is too late. So all of these situations motivated us to come up with IoT devices based ML driven heart condition monitoring system. A device that will take all the necessary sensitive and private data from human body such as Cholesterol, Heart rate, ECG, Blood sugar and Blood pressure and so forth with the help of IoT devices and our Machine Learning algorithm will calculate the result and provide the overall heart condition of the patient.

Blood pressure monitor, glucose meter devices are popular and useful among people as these devices measure blood pressure, blood sugar level which let people know their current health status within a minute. This service is not available yet for the non-communicable disease patients. Hence, a device that can let people learn about their current heart condition will be helpful to take the necessary preventive steps at the right time.

Chapter 2

Related Work

2.1 Blood Pressure and Heart Rate

There is a paper by Snehal Sanjay Kale et al. in [2] where they introduced BSN technology, which is consisted of low-power and lightweight wireless sensor nodes, such as temperature sensor, heart rate sensor to collect blood pressure and heart rate of a patient. This devices are placed on human body to monitor the health condition of a patient at home and all of these collected health-related parameters will be sent to their physician's server using a long-range wireless technology.

We-Care [3] is an IoT based health care system which introduced We-watch wristband using a SensorTag from Texas Instruments. This wristband is for elderly people which collects blood pressure, humidity from human body. It can also detect sudden fall of the patient. The Fall Detection system is implemented by reading the accelerometer data which is used to detect sudden movements, like falls, and also to track any movement activity performed by the elderly person.

A paper by P.Gupta [4] presented an IoT based system which provides emergency medical service by collecting data informations through health status monitors including heart rate, blood pressure and ECG. This information are sent to patient's doctor as an emergency alert with full medication information.

In paper [5], Johan Bhurney et al. used the photoplethysmography method via the PPG sensor to detect the variations in blood volume and blood flow in the body.

2.2 Electrocardiography

In paper [6] the authors have proposed a health monitoring and measurement system by inexpensive wearable sensors. The sensor will collect some physiological parameters and will transmit the data to a gateway server via Bluetooth. The physiological bio markers that are taken into consideration is ECG, Respiratory rate, Skin temperature and EMG muscle movement.

Paper [7] mainly focuses on electrocardiogram of a patient through IoT enabled sensors. Despite conventional clinical ECG equipment has 12-lead system, this proposed system implements 3-lead placement in a triangular fashion around the heart. The data is processed through a MCU and sent to the cloud with wireless access points.

In work [8] the researchers mainly worked on developing a software infrastructure that supports ECG signal analysis for feature extraction and classification for diagnosing the heart condition. The features space extracted for the ECG signal, led to an accuracy of 98.7%. They also made it clear that ECG analysis and classification can be done in real time.

Paper [9] describes the way of measuring physiological ECG data using single board computer with the help of e-health sensor platform. The ECG data is processed to get the Heart Rate(HR) and Heart Rate Variability (HRV) which later on will be used to diagnose vital diseases.

2.3 Glucose and Cholesterol

In the work by Meghana chandrashekar et al. a Near-infrared sensor is used to measure the glucose level of a person which can measure the glucose level without the blood samples from the human body. Another used sensor is BMI sensor which can measure cholesterol level of a person. In this process, a signal is passed through the human body and the sensor waits for the receiving time of the signal on the other side and then the cholesterol level is calculated based on that time. There are two parts - software and hardware. The software application will monitor a persons health by measuring the blood glucose level and cholesterol level of the human body. The hardware kit is made of Infrared sensor and BMI sensor which helps to measure glucose and cholesterol level to monitor a persons health.

In the work of Mr. Li et al.[10] consider some parameters as the vital element of heart condition prediction e.g. (Blood pressure, ECG, SpO2, Heart rate, Pulse Rate, Blood glucose, Blood fat). For intermediate communication Bluetooth and long distance communication Cellular network, Wireless network is used.

In the paper of Mr. Gomez et al.[11] described the statistics of the mortality of patients suffering from different chronic disease. It appears to be that, most of the patients dying from heart failure have been suffering from Overweight 2.6M, Elevated Cholesterol 4.4M, Blood Pressure 7.1M. Therefore, detecting these vital of the patients on a regular basis and sending them for monitoring to a specialist was their main objective. But they described that due to technological limitations these devices are not smaller quite yet. Although some devices e.g. Glucometer, Wrist blood pressure cuff, HRM including electrocardiogram is available today.

Chapter 3

Proposed Method

3.1 Parameters

As we are mainly focusing on cardiac issues, our main purpose is to collect data-set related to cardiac disease of patients. From previous study and test result, we have seen that 12 parameters mentioned below would be sufficient enough to provide us with an accurate prediction of a patient's cardiac condition. The parameters below given are associated with their respected available sensors.

3.1.1 Age

According to this paper, at age 40 the lifetime risk of developing heart disease is one out of two for men and for women it is one out of three. If we consider age as 70 the statistics suggest that it is one out of three for men and for women it is one out of four [12].

3.1.2 Gender

Heart disease is more seen among the middle aged people specially it is two to five times more common in men than it is in women [13].

3.1.3 Chest pain type

Chest pains are the most common symptoms indicating different Cardiovascular disorders. So that's why it is chosen as one of the parameters.

3.1.4 Resting blood pressure

From the paper of J.Gomez [11] and C. Li et al. [10], we get the numbers form which it appears that most of the patients dying from heart failure have been suffering from Overweight 2.6M 4.4M, Blood Pressure 7.1M. Which leads us choosing RBP (Resting Blood Pressure) as one of the parameters.

3.1.5 Cholesterol

Elevated cholesterol is one of the major cause of death among people having heart condition said by J. Gomez et al. in [11].

3.1.6 Fasting blood pressure

Fasting leads to loss of weight and and reduction of blood pressure. Which is why it was chosen as a parameter for generating the cardiac prediction of the patient.

3.1.7 Resting ECG

ECG stands for Electrocardiograms. ECG is used for detection cardiac arrhythmia [8]. Which is essential because we need to observe the condition of heart of a patient and detect different anomalies. ECG helps us to do that. Besides we can calculate the hear BPM with ECG.

3.1.8 Max heart rate

Maximum heart rate is almost equivalent to heart rate although it would help us to observe the heart condition throughout the day.

3.1.9 Exercise included angina

Angina is a type of chest pain that causes due to the lack of oxygen flow to the heart. It is a symptom of Coronary heart disease.

3.1.10 Old peak

3.1.11 Slope

3.1.12 CA

3.2 Prototype

3.2.1 Heart Rate Sensor Module

As we are about to develop a system where IoT devices will be used to get the dataset of 12 parameters, so we basically started working on patient heart rate first, from where we will be able to get the maximum result of heart rate.

Figure 3.1: Heart Rate Sensor Module (LM358)

3.2.2 ECG Module

We have worked on patient Resting ECG where we used ECG sensor module - AD8232 to get ECG graph and corresponding data. We implemented the module with the existing Arduino UNO microcontroller as it has available pins which are required to implement that module.

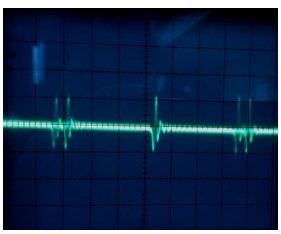

Figure 3.2: Output of ECG module (AD8232)

3.2.3 Combined Prototype: Heart Rate and ECG

The H/W implementation we did so far is the combination of Heart Rate Sensor module and AD8232 ECG module where both modules work with a single Arduino UNO microcontroller using 9V DC battery. The required componentes are given below:

- Arduino UNO x 1
- 16 x 2 LCD Display x 1
- 10K Potentiometer
- 330 Resistor (Optional for LCD backlight)
- Push Button
- Heartbeat Sensor Module with Probe (finger based)
- Mini Breadboard
- Connecting Wires
- AD8232 ECG module
- 9V DC battery

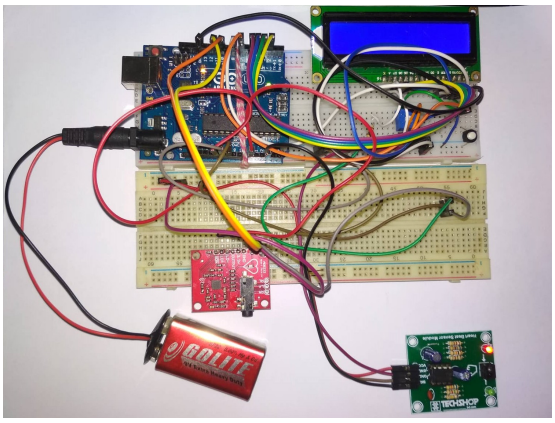

Figure 3.3: Combined prototype of Heartbeat sensor module and ECG module

Chapter 4

Compliance with Standards

4.1 Wireless Connectivity

- IEEE 802.15.6 Wireless Body Area Network (e.g. Bluetooth low energy): It is an Independent System used for Monitoring daily Activity of an individual. Wireless Body Area Network rely broadcast short Range Airborne Electromagnetic Waves with relatively low Frequency [11].
- IEEE 802.11 Wireless Networking(WLAN) - WiFi: It is Specifies over the air interface between two wireless clients. It provides 1 or 1 Mbps Transmission in the 2.4 GHz band using either frequency hopping spread Spectrum (FHSS) or Direct Sequence Spread Spectrum (DSSS) [10].

4.2 Cable Connectors

- USB 2.0 Cable Type A/B: It is used to transfer data from computer to Arduino and Arduino to Computer. The maximum data signaling rate (DSR) of USB 2.0 cable is 480 Mbps. The maximum data signaling rate (DSR) is limited 280 Mbps or 35 MBps due to Bus access Constraints.
- Mini Jack (3.5 mm): It is Used For Analog Audio Signal for Portable Devices.
- Pin: It just electronic wired pin for Connect various hardware Component.

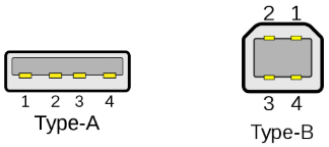

Figure 4.1: USB 2.0 Cables

4.3 Interface

- HTML
- DOM
- CSS

4.4 Data Format

- JSON-LD
- ASCII

4.5 Programming Languages

- Javascript 1.8.5
- Python 3.6
- Java 1.8.0

Chapter 5

Impacts and Constraints

5.1 Economical Impact

The initial investment in the project will be high as all the devices are being implemented individually. Modern sensor and technologies are being used which are costly but the cost will be decreased if components can be combined together. A combined and minimized prototype for health monitoring will be affordable to people and people will be highly benefited to learn about their present heart condition and take necessary preventive steps. Health-related data will be easily accessible by authorized personnel. Job opportunity can be provided to manage the data set of patient.

5.2 Ethical Impact

The main objective of this work is to benefit the cardiac patients of our country where no ethical questionable decisions would have to be made. The disadvantaged people will be highly benefited as they will get to know about their current cardiac situation and will be able to take precautionary steps at the right time.

There is no chance of attempting any kind of unfair means as the output will be generated by the machine learning algorithm itself and will be displayed to the patient in the real time. All the users health data and information will be stored in the database with the users consent. In long-term patients will be benefited because they will be able to observe their health status.

5.3 Environmental Impact

We have used Arduino UNO using 5V, Heart Rate Sensor Module (LM358) using 3.5V and ECG Module (AD8232) using 3.5V. We used overall 5V DC power supply in the prototype. Using these devices with minor power causes no harm or effect on human body. This devices are also safe to use and causes no threat or effect to the ecosystem and the environment.

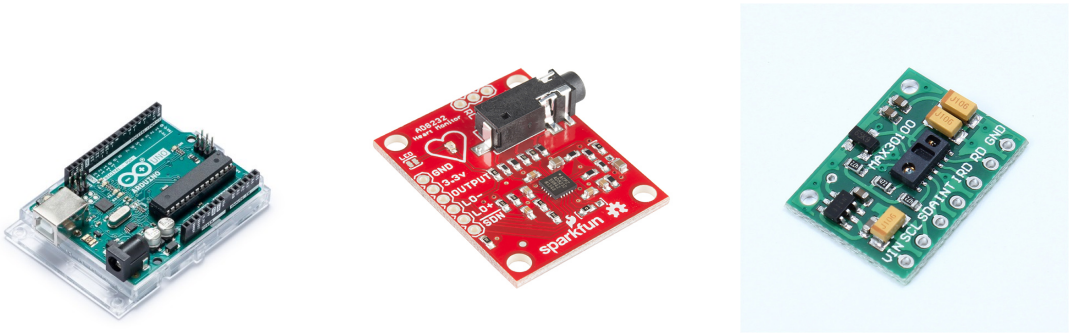

Figure 5.1: Arduino UNO, Heart Rate Sensor Module, ECG Module

5.4 Health and Safety Impact

To priotirize human health and safety, we have used 5V DC power supply. Due to the use of DC operated modules, there is no adverse impact on health. To ensure privacy and safety of users personal information and health data, user authentication and data encryption will be applied to control the data manipulation.

In order to generate the ECG signal from human body, new electrodes will be used for every other user. As AC power brick connection is dangerous while the ECG electrodes are connected to the human skin, we have used DC power supply and refrained from any kind of AC power brick connection.

5.5 Social Impact

Our IoT based cardiac disease prediction device will highly benefit the society as people will be much more health conscious by getting early health prediction. It will create a long-term impact because currently, the people living in the society are not so aware of

their health. They seldom go to the hospital for a health checkup. So this type of hardware would help them to be conscious of possible danger and change the conventional conservative mindset that is mostly seen in our society.

This project would be acceptable in our society because there are no such things that would hamper the social rules and regulations.

5.6 Political Impact

There are no issues that would possibly break any laws. Government support will help to make the device more affordable among general people. Government approval is required to use in Hospitals or to be used as a health monitoring device. Because there are some regulations imposed by the government for such medical devices to be used openly on patients in hospitals.

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