ELDERLY PATIENT MONITORING SYSTEM

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Mr. Yashas Mallawarachchi

TABLE OF CONTENTS

Contents

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Background context (Literature Survey)

Heart rate and SpO2 (percentage of the oxygen amount in the blood) are two main parameters to check the health level of the patients who are suffering from respiratory issues important due to frequent changes in heart rate and the SpO2 level.

Setting up suitable sensors according to the physical parameter such as heart rate and spo2 is required. Captured incoming inputs should be sent to the computer via micro controller. Analysis of the heart rate is necessary to monitor the arrhythmia and further analysis on derivation of the SpO2 is required. Finally a construction of a classification model will be done to classify the data in order to interpret.

If any arrhythmia of the heart beat or an abnormal deviation of the oxygen percentage in blood is (SpO2) detected by the system it will alert the caregiver to be equipped for the event.

The main goal of the project is to invent system that can monitor patient's medical condition and current physical state of them in a mobile environment and intelligently take necessary actions based on monitoring results. As a result it'll help to caregiver spending lot of time for keeping their eye on patient and provide the opportunity to identify abnormalities of health condition of patient.

There are several parties who are benefited as a result of this research project. Fundamentally patients who wears the system is high secured from any severe damages happened to themselves and any critical changes of their health condition before it gets worse. Then caregiver are benefited by having some relief to their minds. Moreover caregiver can minimize the expenses spent on some more caregivers and hospitals.

Litreture Survey

Rekha Chandra R, Safeer K P and Srividya P has done a research on "design and development of miniaturized pulse oximeter for continuous SpO2 and HR monitoring with wireless technology". The Saturation of blood (SpO2) and Pulse Rate are the two important parameters for monitoring patient's health condition. They use photo-plethysmo-graphy(PPG) to measure pulse rate. Their System consist of fingertip sensor, Analog device, 8 bit Atmel Microcontroller circuit and display unit (PC).The (SPO2) calculate by measuring intensities of red and infrared lights operating at different wavelengths of 660nm and 940nm. The pulse rate calculated by measuring the peaks of

IR signal between the elapsed time. Then they are measured all these parameters and transferred to PC via Bluetooth for displaying the results [1].

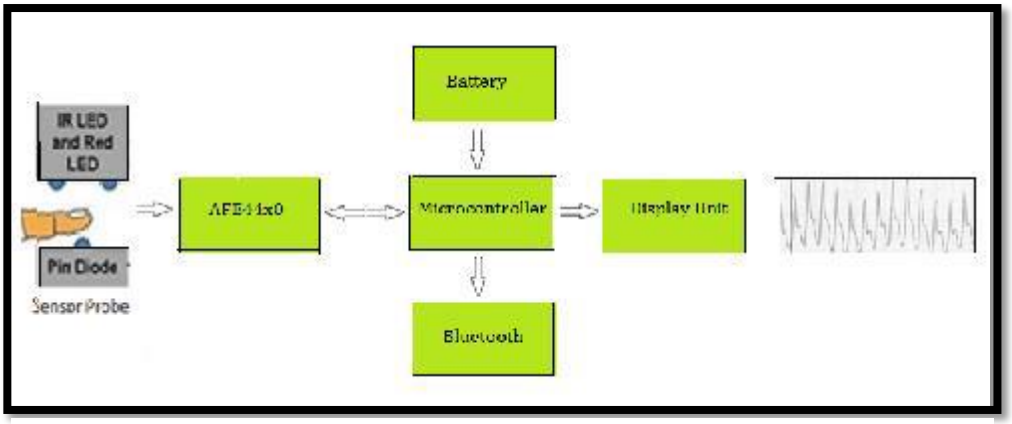

Figure 1.1 Block diagram of SpO2 and Pulse rate measurement

Source: [1]

There is a research done by PG Scholar and 2Assistant Professor, Department of Electronics and Communication Engineering, AVS college of Technology. They proposed an "Advanced Mobile Health Care Monitoring System Using Temperature sensor and Heart beat Rate sensor Method". They use wireless body sensors and smart phones to monitor the well-being of the elderly. When an emergency detection is the smart phone alarm automatically pre people who could be family and friends, the elderly, and to call the ambulance to the emergency call center. It also acts as the personal health information system and he medical advice that provides a platform for communication and the medical knowledge base, so that the family and friends of people served with doctors can work together by him / her to take care. It also acts as the personal health information system and he medical advice that provides a platform for communication and the medical knowledge base, so that the family and friends of people served with doctors can work together by him / her to take care [2].

Their system design describes about the a new approach advanced health monitoring using Arduino Uno is divided into two parts

- Hardware implementation
- Software implementation

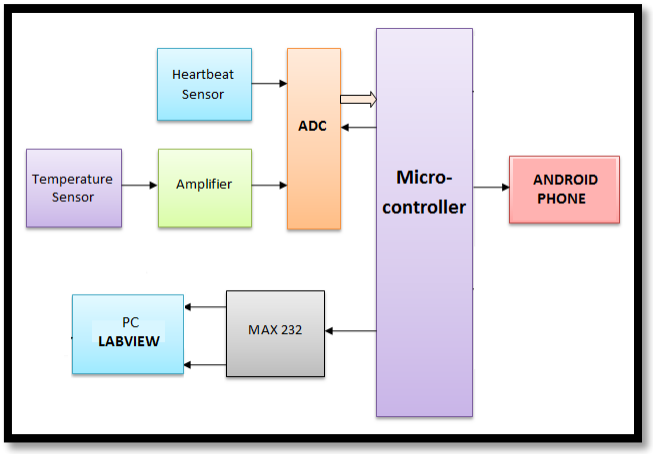

Figure 1.2 System Block Diagram

Source: [2]

There is a research done by Graduate school of Dongseo Univercity, Department of Ubiquitous IT and Division of Computer and Engineering. They design and implement a healthcare monitoring application for ubiquitous sensor network. The pulse sensor uses the arduino board to send the data to the web server via RN-XV wireless module base on 802.11 protocols. The data collected from the patient can be remotely viewed and analyzed by a physician or nurse [3].

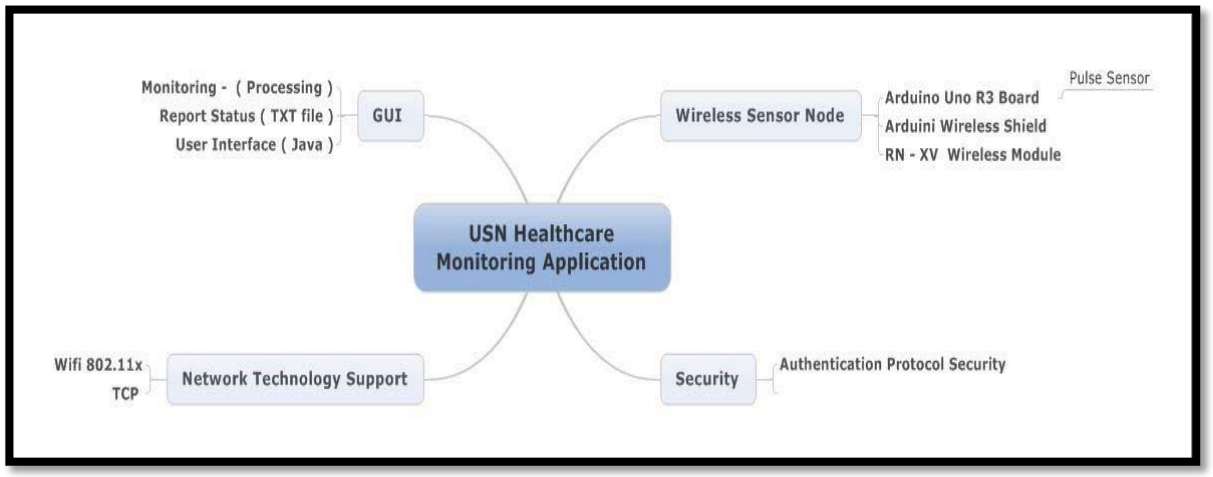

Figure 1.3 Overview of the USN Healthcare Monitoring Application

Source: [3]

N.Watthanawisthu and his crew design and developed “Wireless Wearable Pulse Oximeter for Health Monitoring using ZigBee Wireless Sensor Network”. They developed a portable real-time wireless health monitoring system. This system developed for monitoring of patients’ heart rate and oxygen saturation in blood. This system was designed and implemented using ZigBee wireless technologies and demonstration of pulse oximetry data (heart rate and SpO2) monitoring on three patients in the home. From their experimental results, the system was successfully install for testing in patient’s home for health care monitoring [4].
In this system diagram shows the component and the technologies that they use for their system.

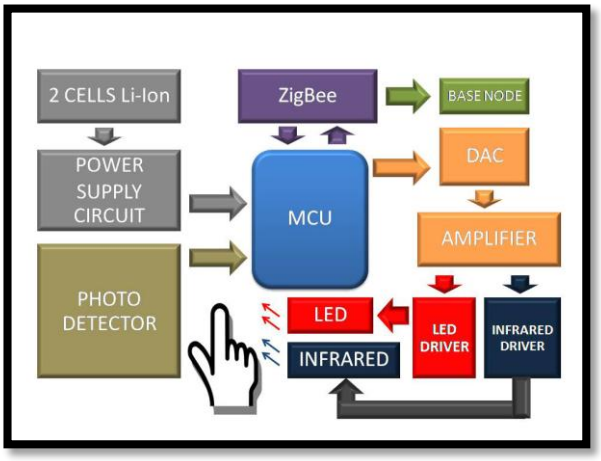

Figure 1.4 Block diagram showed system architecture

Source: [4]

Alan Sands, Phoenix, AZ (US) has proposed “mobile patient monitoring system with automatic data alert”. This system to increase compliance with patient monitoring protocols for patients with chronic disease. They used wireless telecommunication device as the hub of the system. The hub is configured to increase patient compliance with a monitoring protocol by being integrate with a mobile device. The hub receives physiological data about the patient from a medical sensor then collates the sensed data with certain data input by the patient. The reading is transmitted to a server that uses a software application to automatically examine and interpret the data. Alerts send to the care giver via the network when the reading is outside specified parameters [5].

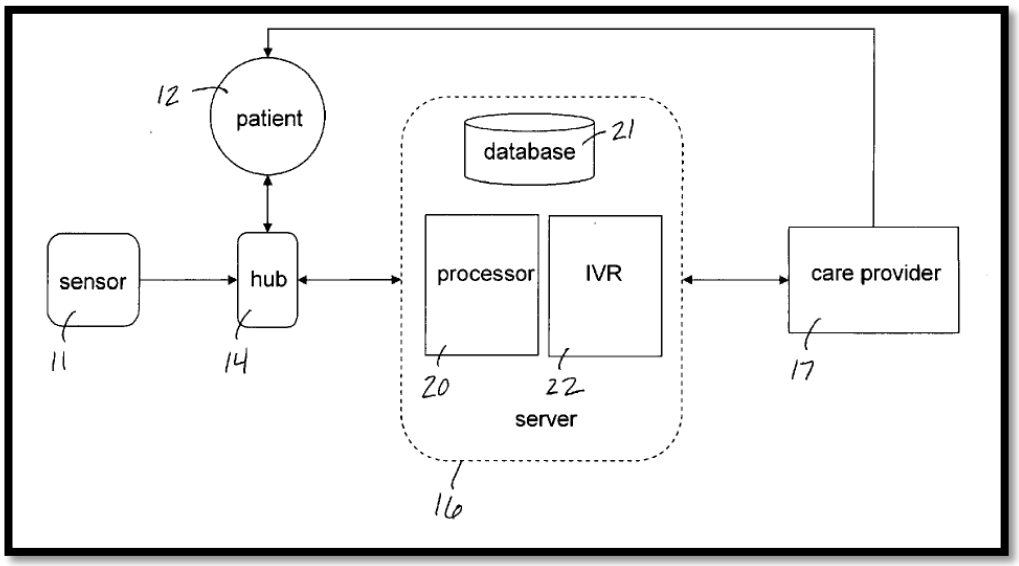

Figure 1.5 System architecture diagram

Source: [5]

P. A. Pawar has proposed “Heart Rate Monitoring System using IRbase Sensor & Arduino Uno”. This system is used to monitor physical parameter like heart beat and send the measured data directly to a doctor through SMS. They used an IR base heart beat sensor, Arduino Uno & GSM module in this system. This device will be able to measure heart beat from an infant to elder person. In their system the heart beat sensor will provide digital signal to Arduino Uno. This internally does the calculation as per programming & display heart rate on LCD along with the information. Further Arduino will communicate with GSM module & will send SMS to doctor cell phone, which is predefined in the program [6].

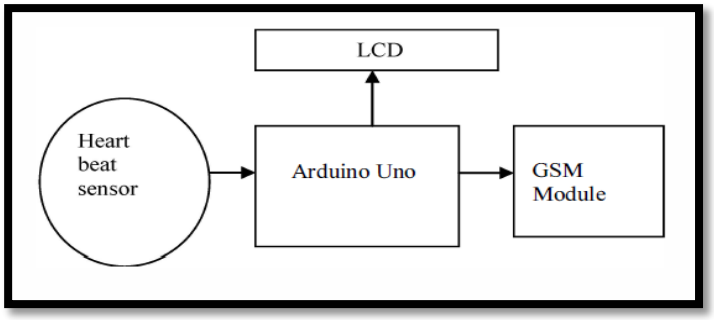

Figure 1.6 Architecture diagram of the system

Source: [6]

Proposed System mainly focus on bedridden patients in this research. All those mentioned above researches are focused on normal patients and those mainly focused on heart rate or some other features using sensors. Here the proposed system will be focused on drag and analysis arrhythmia of heart rate (HR) and deviation of peripheral capillary oxygen saturation (SpO2).

1.2 Research Problem

The caring an elderly patient at home, hospital is a very difficult task for relevant parties who are parents and care takers. Because of the mischievousness and the inability to communicate properly. Due to various illnesses, deceases and physical damages, the lives of infants are at risk. Therefor so many elderly patients are expected to have a close watch.

1.3 Research Objectives

The Elderly Patient Monitoring System is a project focused on several objectives. With the completion of the project we are supposed to fulfill these research objectives. The main objectives of the research project are mentioned as follows.

- Introduce a wrist band to the industry which is capable of continuously monitoring some of the most important medical factors which determines elderly patient's medical condition.
- Provide an opportunity to caregiver not to spend more money for doctors and hospitals for continuously checkups of baby's health conditions by giving secure logins of web application for doctors.
- It gives very comfortable feeling for the patient unlike the devices which are used to track those health parameters.
- Gain knowledge on electronic hardware development, communication between hardware and software devices and modern mobile and web development techniques.

2. METHODOLOGY

2.1 Methodology

Arrhythmia of the heart rate (HR) and deviation of peripheral capillary oxygen saturation (SpO2) are monitored using sensor inputs transmitted through pulse rate and SpO2 sensors. Max30100 pulse oximeter sensor is being used to capture Pulse Rate and SpO2 for further analysis.

Figure 2.1 Max30100 Pulse Oximeter Sensor

As a preprocessing technique, noises of the acquired data will be filtered removing DC (Direct Current) signal and allowing only the AC (Alternative Current) to read heart rate and SpO2 value properly.

Mean median filtration method is used to get the differential of signal to further improve the ability of detecting pulses and to highlight the sudden changes of the signal with a large value. Butterworth filtration method is used to remove higher level harmonies in low pass filter configuration.

Max30100 sensor gives relatively clean signal to calculate the heart rate. Difference between two timestamps will be measured by calculating the delay between two beats. Same concept being applied to calculated BPM (Beats per Minute). Millis function in Arduino gives the timestamp in milliseconds which can be used to get the BPM value.

$$BPM = \frac{60000}{current\ beat\ timestamp - previous\ beat\ timestamp} \qquad (1)$$

SpO2 level can be calculated using following equation.

$$SpO_2 = \frac{HbO_2}{Tot\ Hb} \quad (2)$$

Once DC levels of the signal match, SpO2 level will be calculated by dividing the logs of the RMS (Root of Mean Square) values.

$$R = \frac{AC_{RMS\ RED}/DC_{RED}}{AC_{RMS\ IR}/DC_{IR}} \quad (3)$$

Heart rate of a normal person is between 60% - 100% while SpO_2 is between 94% - 99%. But SpO2 value of patients having respiratory problems can be reduced up to 90%. If it reduced more than that, then it will be detected as an abnormality. When those parameters are measured, all of them are transferred to a personal computer (PC) via Bluetooth to display the results with a user friendly manner. Output will be stored in a 10 seconds data buffer and check for abnormal situations. If an arrhythmia of the heart rate (HR) or deviation of the SpO_2 is detected, system will identify it as an anomaly and caregiver will be alerted.

2.2 Testing & Implementation

During this phase Smart wrist band is developed and in a process to miniature to wearable wrist band. Also Android application developed with smart prediction system.
The first stage of the device development used arduino uno development board with related sensors.

For the purpose of miniature the wristband arduino supported pro mini board is used and its micro controller is programmed using default arduino boot loader with USB to TLL able. Language used during the microcontroller programming is “C”.

Mobile application is implemented using Android platform and Android API is used for the creating Bluetooth connectivity and UI design, “JAVA” used during this application development.

Implementing smart prediction is done by using data mining approach. Sample data set which collected randomly and validate by specialist pediatrician.

Ex-

Table 2.1 Sample Data Set

Heart Rate (BPM)	Oxygen Saturation (%)	Is Critical
80	94	NO
65	78	YES
132	97	YES

2.3 Research findings

When managed to set up the MAX30100 for HR mode and read the raw IR data it should look something like in figure 3, once plotted

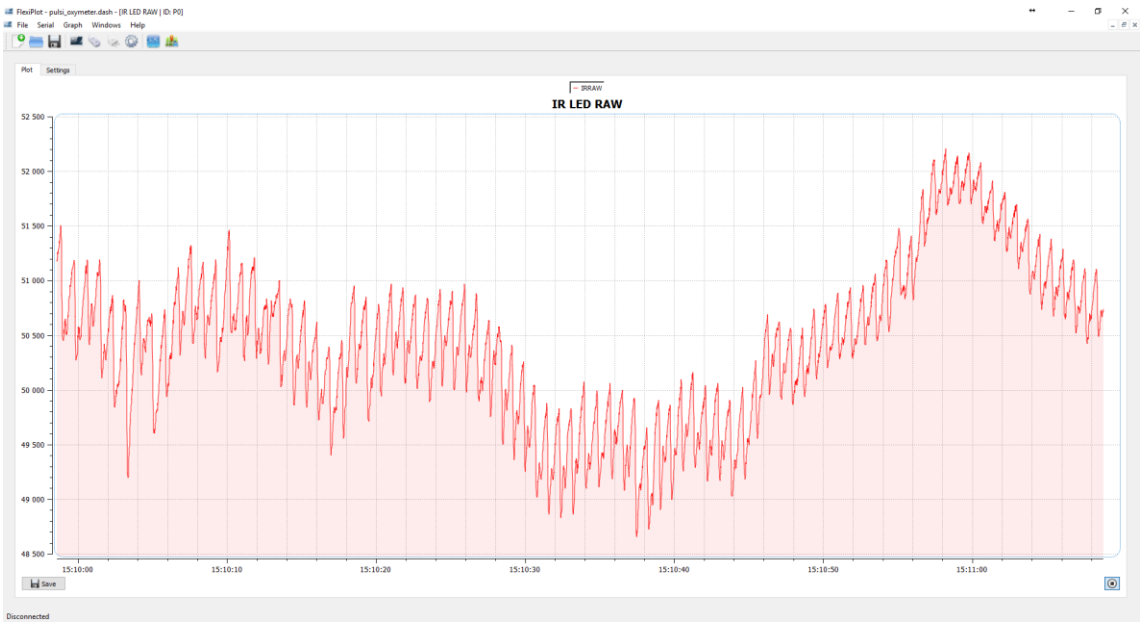

Figure 2.2 RAW IR data, with visible oscillations

As a preprocessing technique, noises of the acquired data will be filtered removing DC (Direct Current) signal and allowing only the AC (Alternative Current) to read heart rate and SpO2 value properly.

Mean median filtration method is used to get the differential of signal to further improve the ability of detecting pulses and to highlight the sudden changes of the signal with a large value. Butterworth filtration method is used to remove higher level harmonies in low pass filter configuration.

3. RESULTS & DISCUSSION

3.1 Results

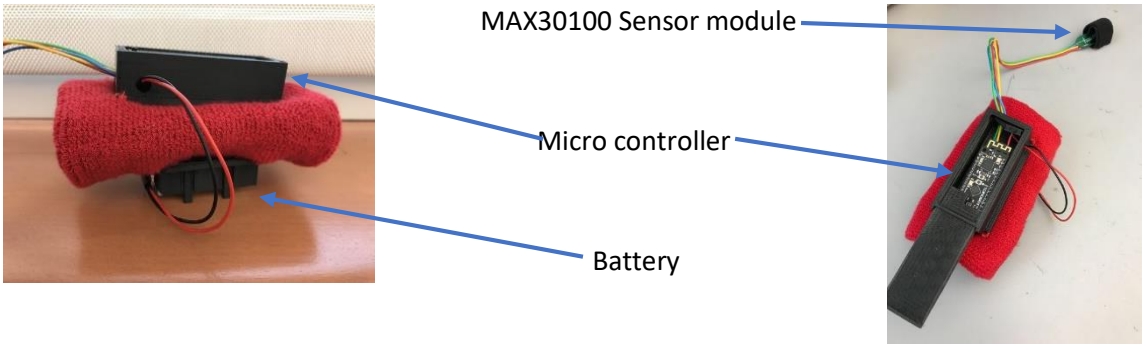

Figure 3.1 Max30100 Band Structure

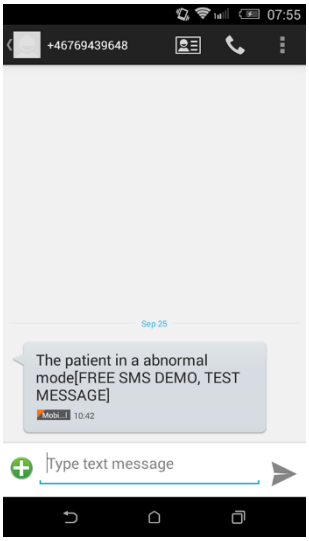

Figure 3.2 Message

3.1.1 Test Cases

Table 3.1 Test cases 1

ID	Description	Action	Test Input	Expected Output
T1	Connecting to the device	Wrist band must be in the range and in working condition.	Click the band name in list view.	Notifications popped up and say whether it connected or not
T2	Displaying values	Home menu is visible	Touch the screen	Progress wheel will be run around the health icons and displays the values
T3	Displaying Notification	When health is critical	Touch the screen	Message displayed saying –Patient in an abnormal mode.

4. CONCLUSION

4.1 Problems Encountered and Lessons Learnt

It was a challenging task to complete this kind of system with a limited amount of time, by studying all the patient monitoring systems in the market. Analyzing the requirements, collecting the data, studying existing technologies to implement this system, gathering ideas from resourceful authorities and conducting literature reviews were done in order to achieve the objectives of the system. Those are good experiences that could be very valuable to us in future. Therefore confidence was built on completing any tough task within a given period. By conducting literature reviews different methodologies that were used for the same problem were discussed.

Therefore self-learning was improved with this study and as a group learnt how to face challenges and overcome them.

4.2 Solutions

Most of the patient Monitoring Systems functionalities that analyze during the literature review are more common and general solutions.

All most all of them are concern only basic functionalities. These systems don't include any self-intelligence; they show some health values. Because of this someone have to monitor this system continuously, only benefit of these systems is providing remote monitoring. Also these systems are costly comparing with what they deliver. But our developed research system have overcome all of those obstacles and have implemented as smart, self-intelligence embedded , interactive, less costly and efficient.

4.3 Future Work

Elderly patient monitoring system has developed mainly for android users. In our next stage we hope to move for IOS and windows phones using cross platform development. Furthermore accuracy level can be increased using newly coming technologies and we will be adapting to those technologies and system will be modified according to needs. If care givers are requesting for another features we will be developed them too.

5. REFERENCES

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6. APPENDICES

7.1 Use case Diagrams

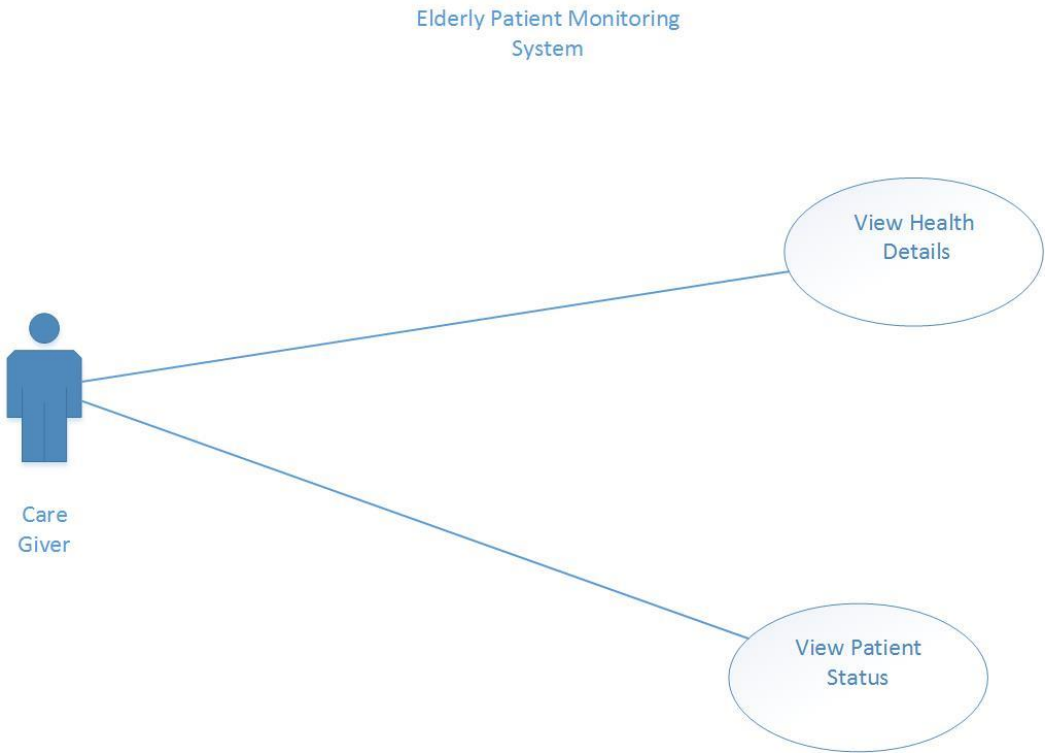

Figure 7.1 : Elderly patient monitoring system Use Case

6.2 Use case scenarios

Use Case	View patient health details
Precondition	Login to the system
Success End Condition	Display the patient health details on the screen.
Primary Actor	Care giver
Description	1. Go to application main menu 2. Tap on View patient status. 3. Tap on the icon that is wanted to see the health details.

Table 7.1 : Use case Scenario-View Patient health details

Use Case	View child status
Precondition	Login to the system
Success End Condition	View child status
Primary Actor	Parent
Description	1. Go to main menu 2. Tap on View child status

Table 7.2 : Use case Scenario-View Patient state

6.3 Sequence Diagram

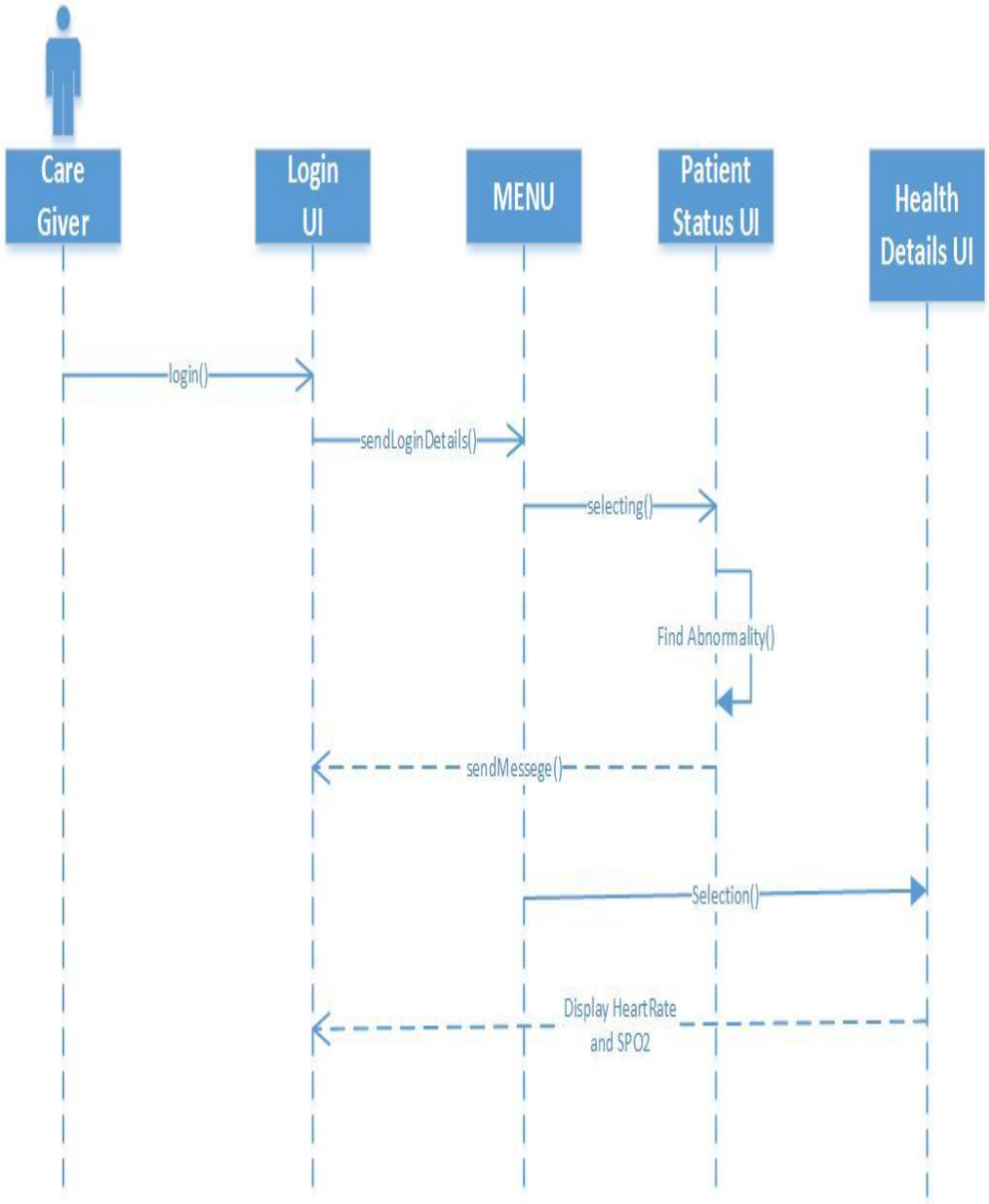

Figure 7.2 : Elderly patient monitoring system Sequence diagram

6.4 Activity diagram

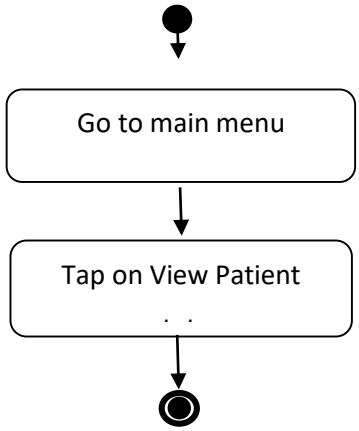

Figure 7.3 : Activity Diagram- View state

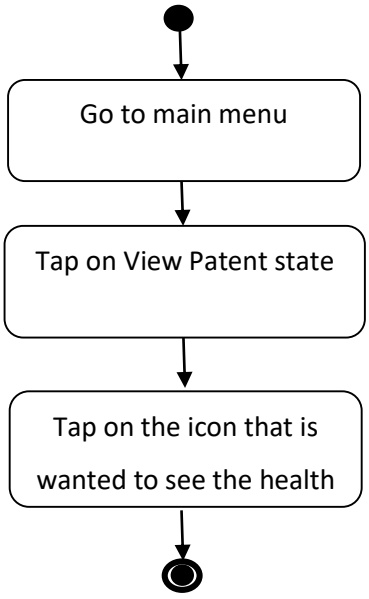

Figure 7.4 : Activity Diagram- View Patient health details