UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electronics & Computer Technology and Engineering

DEVELOPMENT OF REAL -TIME HEALTH MONITORING SYSTEM FOR THE ELDERLY USING INTERNET OF THINGS

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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DEVELOPMENT OF REAL -TIME HEALTH MONITORING SYSTEM FOR THE ELDERLY USING INTERNET OF THINGS

MUHAMMAD HAKIM BIN ABU BAKAR

A project report submitted
in partial fulfillment of the requirements for the degree of
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DEDICATION

This thesis is lovingly dedicated to my beloved parents,

Abu Bakar bin Maidin

Sa'diah binti Arshad

who have been the guiding light in my life and have selflessly supported me,
my significant other and supportive friends
who have been a constant source of encouragement and inspiration throughout my academic journey.

ABSTRACT

This project introduces a real-time health monitoring system for the elderly, leveraging Internet of Things (IoT) technology. Central to the system are the MAX30100 sensor, for monitoring heart rate and SpO2, and the MPU6050 accelerometer, for accurate fall detection. These components are linked to an ESP32 microcontroller, which interfaces with the Blynk IoT platform to ensure seamless monitoring and immediate alerts. Effectiveness of the system was validated through experiments with simulated falls and Activities of Daily Living (ADLs), involving three diverse participants. The system recorded all types of falls without fail, differentiating them from normal activities. Notably, heart rate and SpO2 levels remained stable throughout, indicating the system's reliability in avoiding false alarms. Graphical data analysis showed clear distinctions between falls and normal activities, with no significant fluctuations in vital signs during falls. A 24-hour test with various activities and an 8-fall scenario further demonstrated the system's consistency and real-life applicability. The project's success lies in its meticulous data analysis, showing high accuracy in fall detection and stable vital sign monitoring. This precision, coupled with a low rate of false positives, highlights the potential for timely medical interventions, crucial in geriatric care. Future developments include integrating machine learning algorithms for enhanced precision in fall detection and expanding the range of monitored vital signs (blood pressure, body temperature, ECG). Additionally, direct communication with emergency services could significantly improve response times in emergencies. This IoT-based health monitoring system marks a significant advancement in elderly care, offering a more integrated, responsive, and user-friendly healthcare solution. Its success paves the way for further innovations in healthcare technology, emphasizing the safety and well-being of the aging population. community.

ABSTRAK

Projek ini memperkenalkan sistem pemantauan kesihatan secara masa nyata untuk warga emas, dengan menggunakan teknologi Internet of Things (IoT). Komponen utama sistem ini adalah sensor MAX30100, untuk memantau kadar denyutan jantung dan SpO2, serta sensor pecutan MPU6050, untuk pengesanan kejatuhan yang tepat. Komponen-komponen ini disambungkan kepada mikropengawal ESP32, yang berinteraksi dengan platform IoT Blynk untuk memastikan pemantauan yang lancar dan amaran segera. Keberkesanan sistem ini telah disahkan melalui eksperimen dengan simulasi kejatuhan dan Aktiviti Harian Hidup (ADLs), yang melibatkan tiga peserta yang berbeza. Sistem ini mencatat semua jenis kejatuhan tanpa gagal, membezakannya daripada aktiviti normal. Secara menarik, kadar denyutan jantung dan tahap SpO2 kekal stabil sepanjang masa, menunjukkan kebolehpercayaan sistem dalam mengelakkan amaran palsu. Analisis data grafik menunjukkan perbezaan yang jelas antara kejatuhan dan aktiviti normal, tanpa sebarang perubahan signifikan dalam tanda-tanda vital semasa kejatuhan. Ujian 24 jam dengan pelbagai aktiviti dan skenario 8 kejatuhan lebih lanjut menunjukkan konsistensi sistem dan kebolehgunaannya dalam keadaan sebenar. Kejayaan projek ini terletak pada analisis data yang teliti, menunjukkan ketepatan yang tinggi dalam pengesanan kejatuhan dan pemantauan tanda-tanda vital yang stabil. Ketepatan ini, bersama dengan kadar positif palsu yang rendah, menonjolkan potensi untuk intervensi perubatan yang tepat pada masanya, yang sangat penting dalam penjagaan geriatrik. Pembangunan masa depan termasuk mengintegrasikan algoritma pembelajaran mesin untuk ketepatan yang lebih tinggi dalam pengesanan kejatuhan dan memperluaskan rangkaian tanda-tanda vital yang dipantau (tekanan darah, suhu badan, EKG). Selain itu, komunikasi langsung dengan perkhidmatan kecemasan boleh secara signifikan memperbaiki masa tindak balas dalam kecemasan. Sistem pemantauan kesihatan berasaskan IoT ini menandakan kemajuan penting dalam penjagaan warga emas, menawarkan penyelesaian penjagaan kesihatan yang lebih terintegrasi, responsif, dan mesra pengguna. Kejayaannya membuka jalan untuk inovasi lanjut dalam teknologi penjagaan kesihatan, menekankan keselamatan dan kesejahteraan populasi warga emas.

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TABLE OF CONTENTS

		PAGE
APPROVAL		
ABSTRACT		**i**
ABSTRAK		**ii**
ACKNOWLEDGEMENTS		**iii**
TABLE OF CONTENTS		**iv**
LIST OF TABLES		**vii**
LIST OF FIGURES		**viii**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Background	1
1.2	Problem Statement	2
1.3	Project Objective	3
1.4	Scope of Project	4
CHAPTER 2	**LITERATURE REVIEW**	**5**
2.1	Population Ageing	5
2.2	Internet of Things (IoT)	7
2.3	Blynk	8
2.4	Real-Time Health Monitoring	11
	2.4.1 Real-Time Monitoring Application	13
	2.4.1.1 Heart Rate	14
	2.4.1.2 Blood Pressure	14
	2.4.1.3 Oxygen Saturation (SpO2)	15
	2.4.1.4 Body Temperature	16
	2.4.1.5 Sleep Pattern	16
	2.4.1.6 Fall Detection	17
	2.4.1.7 Environmental Factor	18
2.5	Previous Research	19
	2.5.1 IoT Enabled Health Monitoring Kit Using Non-Invasive Health Parameters	19
	2.5.2 Mobile IoT Cloud-based Health Monitoring Dashboard Application for The Elderly	20
	2.5.3 IoT-based Infant Body Temperature Monitoring device	21
	2.5.4 Prototype Development of an IoT Health Monitoring Device for Elderly Patient	23
	2.5.5 IoT Health Monitoring Device of Oxygen Saturation (SpO2) and Heart Rate Level	24
	2.5.6 Fall Detection System Using Wearable Sensors with Automated Notification	25

2.6 Summary of Previous Research 28
2.7 Summary of Past Related Paper 33

CHAPTER 3 METHODOLOGY 34
3.1 Introduction 34
3.2 Methodology 34
3.2.1 Illustration of the project 35
3.3 Hardware Requirements 35
3.3.1 ESP32 Module 36
3.3.2 MPU 6050 Gyroscope Accelerometer Sensor 39
3.3.3 MAX30102 Oximeter and Heart Rate Sensor 40
3.3.4 LM2596 DC-DC Buck Converter Step Down Module Power Supply 42
3.3.5 Litium-ion Battery 44
3.3.6 Donut Board 45
3.3.7 Designing a Custom Project Casing 46
3.4 Software Requirements 49
3.4.1 Blynk Application V2.0 49
3.4.2 Arduino IDE 51
3.4.2.1 Explaination On Fall Detection Coding Using MPU6050 Sensor 54
3.4.2.2 Explaination On Heart Rate & Oxygen Level (Sp02) Coding Using MAX30100 Sensor 56
3.4.2.3 Explaination Blynk Platform Integrate With Codings 57
3.4.3 TinkerCad 3D 58
3.5 The Working Flow of The System 59
3.6 Summary 60

CHAPTER 4 RESULTS AND DISCUSSIONS 61
4.1 Introduction 61
4.2 Results and Analysis 62
4.2.1 Experiment Setup for Data Collection 62
4.2.2 Accuracy Of Detecting Fall Event 62
4.2.2.1 Fall Event Detection Mechanism 64
4.2.3 Accuracy Of Measuring Heart Rate and Oxygen Level 65
4.2.4 Blynk Application Alert Fall Detection, Heart Rate and Oxygen Level Sp02 68
4.2.5 Flow Of Blynk App Trigger Notifications. 70
4.2.6 Detailed Analysis of Fall Detection, Heart Rate, and Oxygen Saturation Levels Across Three Participants 72
4.2.7 Analysis Participant 1 73
4.2.8 Analysis Participant 2 78
4.2.9 Analysis Participant 3 82
4.3 Summary 85

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS 87
5.1 Conclusion 87
5.2 Future Work Recommendations 88

REFERENCES 90

APPENDICES **95**

LIST OF TABLES

TABLE	TITLE	PAGE
Table 1.1	Share of population aged over 65 years and 80 years in 2021 [6].	6
Table 2.2	Summarization of Previous Research	28
Table 2.3	Summarization of Past Related Paper	33
Table 3.1	Pinout use in ESP32[43]	38
Table 3.2	MPU6050 Pinout Specifications[44]	40
Table 3.3	Technical specifications of MAX30102[45]	41
Table 3.4	Technical specifications LM2596 DC-DC Buck Converter[46]	43
Table 3.5	Battery Specifications [47]	45
Table 3.6	Donut Board Specifications [48]	46
Table 3.7	Explanation for each case part	47
Table 3.8	Creating account on Blynk	50
Table 3.9	IDE Libraries [50]	52
Table 3.10	MPU6050 coding explaination	54
Table 3.11	MAX30100 Coding Explaination	56
Table 3.12	Blynk Coding Integration	57
Table 4.1	Explaination on Fall Event and non Fall Event alert	63
Table 4.2	Accuracy measuring & positioning	67
Table 4.3	Coding usage for measuring heart rate (BPM) and SpO2	67
Table 4.4	Investigation Phase	73
Table 4.5	Participant Information	73

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	ECG output signal on Blynkk application [12]	9
Figure 2.2	Appliances controlled on Blynkk application [13]	10
Figure 2.3	User Interface system Home Security[14]	11
Figure 2.4:	System structure of health monitoring system.[18]	13
Figure 2.5	Prototype of Health Parameters [37]	20
Figure 2.6	Diagram showing how the system work. [38]	21
Figure 2.7	Prototype of the device [39]	22
Figure 2.8	Prototype of the device [40]	24
Figure 2.9	Block diagram of the system [41]	25
Figure 2.10	Prototype of the Design [42]	26
Figure 3.1	Illustration of the project system	35
Figure 3.2	Block diagram for the hardware development	35
Figure 3.3	The circuit design of the project using Fritzing	36
Figure 3.4	Schematic design of ESP32 Module[43]	38
Figure 3.5	MPU6050 Pinout[44]	39
Figure 3.6	MAX30102 pinout[45]	41
Figure 3.7	LM2596 DC-DC[46]	43
Figure 3.8	LM2596 DC-DC Buck Converter pinout[46]	43
Figure 3.9	INR185650 2000mAh 3.7 7.4Wh Battery[47]	44
Figure 3.10	Donut Board 10x24cm[48]	46
Figure 3.11	3D Casing for ESP32 and battery compartment	48
Figure 3.12	3D Pulse Oximeter Clip to use with MAX30100 Board Sensor	49
Figure 3.13	3D Accelerometer Case to use for MPU6050 Board Sensor	49

Figure 3.14 Developer Zone to create template and edit widget in Dashboard 51

Figure 3.15 Blynk Dashboard Cloud Console showing real- time data recorded in Blynk cloud [49] 51

Figure 3.16 Arduino IDE Dashboard[50] 52

Figure 3.17 Autodesk Tinkercad logo 58

Figure 3.18 Flowchart of the system 59

Figure 4.1 Web Dashboard show value sync to mobile app. 68

Figure 4.2 Timeline Dashboard show warning sent to the users. 69

Figure 4.3 Blynk Appication in smartphone user inrterface shows value and graphical graph. 70

Figure 4.4 Blynk Application notification notify user when fall detection, heart rate and oxygen level meets threshold. 72

Figure 4.5 Amplitudes spike showing Fall Event tested in 30 minutes duration times. 74

Figure 4.6 Percentage Amplitudes spike showing Fall Event tested in 30 minutes duration times. 74

Figure 4.7 Spo2 & Heart Rate data graph when Fall Event 76

Figure 4.8 Falls and ADLs scenarios. 78

Figure 4.9 Amplitudes spike showing Fall Event randomly total in 6 Fall event 79

Figure 4.10 Percentage Amplitudes spike showing random with total of 6 Fall Event 79

Figure 4.11 Heart Rate & Oxygen Level Spo2 data graph when Fall Event 1 until 6 81

Figure 4.12 Fall Event spike in amplitudes on all day 83

Figure 4.13 Fall Event on 1 hour period of time 83

Figure 4.14 Heart Rate & Oxygen Level Spo2 During testing Fall Event in 1 hours 83

Figure 4.15 Fall Event spike in amplitudes during sleep time. 84

Figure 4.16 Heart Rate During testing Fall Event in sleeping time 84

Figure 4.17 Oxygen Level Spo2 During testing Fall Event in sleeping time 85

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendix A	Gant Chart Project Activities	95
Appendix B	Coding ESP32 Microcontroller to Blynk app	97

CHAPTER 1

INTRODUCTION

1.1 Background

Real-time health monitoring systems help elderly to maintain their health and independence while providing peace of mind to caregivers and family members. These systems use sensors and data analysis algorithms to continuously monitor vital signs and other health parameters, providing early warning signs of potential health issues and personalized treatment plans for chronic conditions. By leveraging the power of technology, real-time health monitoring systems offer a valuable tool for healthcare providers and caregivers to monitor and manage the health of elderly individuals.

The Development of a Real-Time Health Monitoring System for the elderly not only benefits the elderly but also eases the work for their caregivers. Caregiving can be a physically and emotionally demanding task, and caregivers often experience stress, burnout, and health problems themselves. Real-time health monitoring systems can help alleviate some of these issues by providing continuous monitoring and early intervention, allowing caregivers to catch potential health issues before they become serious.

By providing personalized treatment plans for chronic conditions and enabling elderly individuals to live independently, real-time health monitoring systems reduce the burden on caregivers and provide peace of mind that their loved ones are receiving the care they need. With remote monitoring and alerts, caregivers can also rest assured that they will be notified of any issues that may arise, allowing them to take appropriate action.
Moreover, real-time health monitoring systems can also provide valuable data insights to healthcare providers, allowing for more informed decision-making and better coordination

of care. This can lead to improved health outcomes for both elderly individuals and their caregivers.

The development of a Real-Time Health Monitoring System for the elderly can help their caregivers to monitor their health condition by providing continuous monitoring and early intervention. Hence, these systems can help to alleviate the physical and emotional burden of caregiving, while also improving health outcomes and providing peace of mind to all involved.

1.2 Problem Statement

As the elderly population continues to grow, there is a rising demand for effective and efficient healthcare solutions. One of the significant challenges facing the healthcare system is the need for continuous health monitoring, which can help to prevent potential health issues and enable early intervention. Traditional healthcare systems often rely on periodic check-ups, which can miss critical health changes that occur between visits. This approach may be particularly inappropriate for the elderly population, who frequently confront chronic diseases and age-related health risks that necessitate constant monitoring and prompt interventions. Significant changes in health condition might have already occurred by the time a planned check-up occurs, resulting in delayed diagnosis, disease progression, or an emergency. Patients underwent manual monitoring within clinical and hospital settings for substantial durations, concurrently maintaining precise reports and records to facilitate potential future utilization by healthcare professionals, including doctors and other clinicians up until now [1]. Moreover, these visits can be burdensome for the elderly, involving travel, waiting times, and limited face-to-face consultation time.

In addition, healthcare providers and caregivers frequently have hectic schedules and limited opportunities for extra training on monitoring elderly patients. The difficulty is to create training programs that are brief, focused, and efficiently convey the necessary knowledge and skills within the time limits. For instance, in Korea, healthcare providers and caregivers were unacquainted with the intensive care unit (ICU) and disbelieved the medical staff as they spent limited time together [2]. The current approach of periodic check-ups often leads to delayed diagnoses and limited interaction between patients and healthcare providers. Therefore, by further study and building the device and leveraging IoT technology, the device collects and analyzes vital health data, enabling early interventions and reducing the burden on both elderly patients and healthcare providers can aid in overcoming the limitations. The device aims to enhance the accuracy, reliability, and usability of health monitoring for the elderly, ultimately improving their overall well-being.

1.3 Project Objective

The main aim of this project is to propose a reliable and accurate real-time health monitoring system for the elderly using IoT to monitor vital signs such as heart rate, blood oxygen level, and body temperature, as well as fall detection.

a) To develop an IoT-based Real-Time Health Monitoring System to monitor the elderly.

b) To develop a data-logging and alerting system using the Blynk application.

c) To evaluate the developed system in terms of its reliability and accuracy.

1.4 Scope of Project

The scopes of this project are as follows:

a) The developed monitoring device will collects and transmits real-time data of heart rate, blood oxygen levels and fall detection every 1 second

b) Several scenarios related to the level of temperature, heart rate, and oxygen and the fall detection will be conducted to see the effectiveness of the triggering and notification of develop system.

CHAPTER 2

LITERATURE REVIEW

2.1 Population Ageing

Population ageing refers to the increase in the proportion of older people in a population over time. It is commonly measured by the percentage of individuals aged 65 and over in a given population [3]. Population ageing is associated with changes in the health and well-being of older adults. As people age, they are more likely to experience chronic health conditions, such as cardiovascular diseases, cancer, neurodegenerative diseases, and other age-related conditions. Gerontologists study the physical, cognitive, and psychological aspects of ageing, including risk factors for diseases, interventions for healthy ageing, and strategies to promote well-being in older adults [4].

The escalating percentage of elderly humans in the population has profound consequences for healthcare and social systems, as it may affect healthcare demand, delivery, and expenses, plus systems for social support. Chronic medical conditions associated with ageing, including cardiovascular disease, cancer, neurodegenerative diseases, as well as other age-related conditions, make the elderly more probable to necessitate healthcare services. It can lead to an increase in the demand for healthcare services such as hospitalizations, long-term care, and palliative care

The pressures of demographic changes due to population ageing will be determined by people's health status as they grow older, emphasizing that the health and well-being of elderly people have become strongly connected to conditions throughout their entire lifespan. As the population of the elderly grows, there is bound to be a higher need for healthcare care which fits the requirements of the elderly in the Countries within upcoming years. The share of the population aged 65 years and 80 years and over is increasing and will be estimated to rise in the year 2050 [5].

Table 1.1 Share of population aged over 65 years and 80 years in 2021 [6].

Country	Age (%)	
	65 +	80 +
Myanmar	6.3	0.9
Indonesia	6.8	1.0
Malaysia	7.3	1.1
Vietnam	8.8	1.6
Singapore	14.1	2.3
Thailand	14.5	3.3

The ageing population has led to a surge in the number of elderly individuals who need medical assistance and care due to chronic conditions, disabilities, or any other health conditions. Caring for elderly parents at home whilst still juggling work commitments can be a challenging task for adult children. Numerous adult children take on the role of caregiver for their elderly parents, providing physical, emotional, and financial support. Caregiving can be difficult when the caregiver lives far away from the elderly parents [7]. One of the difficulties that adult children who care for their elderly parents while working face is a lack of technological equipment to monitor their elderly parents at home.

Technology may have a significant part in facilitating remote monitoring and communication, which could assist caregivers stay in contact with their elderly parents and ensure their well-being. Remote monitoring devices, sensors, and communication tools, for instance, would provide real-time information about an elderly parent's health, activity level, and home safety. These technologies could assist caregivers in remotely monitoring their parents' health and providing timely assistance when required. Wearable devices or smart home sensors, for example, can monitor vital signs, detect falls, and send alerts in the event of an emergency, giving caregivers peace of mind and the ability to respond quickly [8].

2.2 Internet of Things (IoT)

The Internet of Things (IoT) is a network of interconnected devices and objects that communicate and exchange data with one another, commonly over the internet, to enable real-time monitoring, data collection, and automation of various tasks, resulting in increased efficiency, convenience, and functionality in a variety of domains [9]. These devices can be included in everyday objects such as smartphones, smart appliances, wearables, vehicles, and other embedded systems that are equipped with sensors, software, and connectivity to collect and share data. The concept of IoT has gained significant attention in recent years due to its potential to transform various industries, including healthcare, transportation, smart homes, agriculture, and more. IoT technology allows for real-time monitoring, data analysis, and automation, enabling improved efficiency, convenience, and decision-making.

One of the advantages of IoT is enhanced health monitoring and care. Real-time monitoring through IoT devices collects and transmits health data in real-time, healthcare providers could remotely monitor patients' health parameters including heart rate, blood pressure, glucose levels, and activity levels. This real-time monitoring allows for the early detection of health issues and prompt interventions, ultimately leading to better patient outcomes. This enables early detection of health issues and timely interventions, reducing the need for frequent hospital visits and improving patient outcomes. It is also able to collect and analyse large amounts of health data, which can be used to provide personalized healthcare services. This can include personalized diet plans, exercise routines, medication reminders, and other health interventions tailored to an individual's unique health needs, promoting proactive health management and disease prevention [10].

Devices connected to the internet of things can assist in remote patient management by granting healthcare practitioners the ability to remotely monitor and manage patients. This reduces the need for patients to make frequent trips to the hospital and makes it easier for patients to receive treatment in the comfort of their own homes. This is especially beneficial for patients who suffer from chronic diseases, those who are old, or those who struggle with mobility challenges. In addition, Internet of Things devices enables patients to actively participate in their healthcare by giving them access to their health data and promoting self-monitoring and self-management on their behalf. This may lead to more patient participation, greater adherence to treatment programs, and overall patient satisfaction.[11].

2.3 Blynk

The authors in [12], concentrate on the development of an ECG monitoring healthcare system based on the Internet of Things Blynk application. They intend to develop a cost-effective, simple-to-use, and remotely accessible device for clinicians to monitor the cardiac status of their patients who have difficulties with heart activity. Blynk is an IoT application that allows for remote monitoring of ECG data. Blynk is a technology that allows physicians to remotely access and monitor their patients' cardiac conditions. The Blynk app enables the construction of interfaces for various projects by utilising the many widgets available.

Figure 2.1 ECG output signal on Blynkk application [12]

The patient's ECG sensor collects data on cardiac activity, which is subsequently analysed by the use of the Arduino Uno microcontroller. The processed data is then wirelessly delivered to the Blynk application for the Internet of Things through a Wi-Fi module. The Blynk app provides a real-time interface for clinicians to see and monitor patient data. The software graphically shows ECG data, allowing clinicians to see fluctuations in their patients' ECG signals. This function allows clinicians to quickly detect any anomalies or changes in cardiac activity.

The suggested IoT monitoring system in [13]is intended to monitor and control electrical equipment remotely. The system employs a sensor-based monitoring station located near the electrical device to transmit the application system's status to the user. Users may remotely manage and monitor their connected devices using the Blynk app. The linked hardware pins' state is continually relayed to the Blynk server, allowing users to view stored data from the IoT server. They may also operate their gadgets remotely over a wireless connection using Blynk technology.

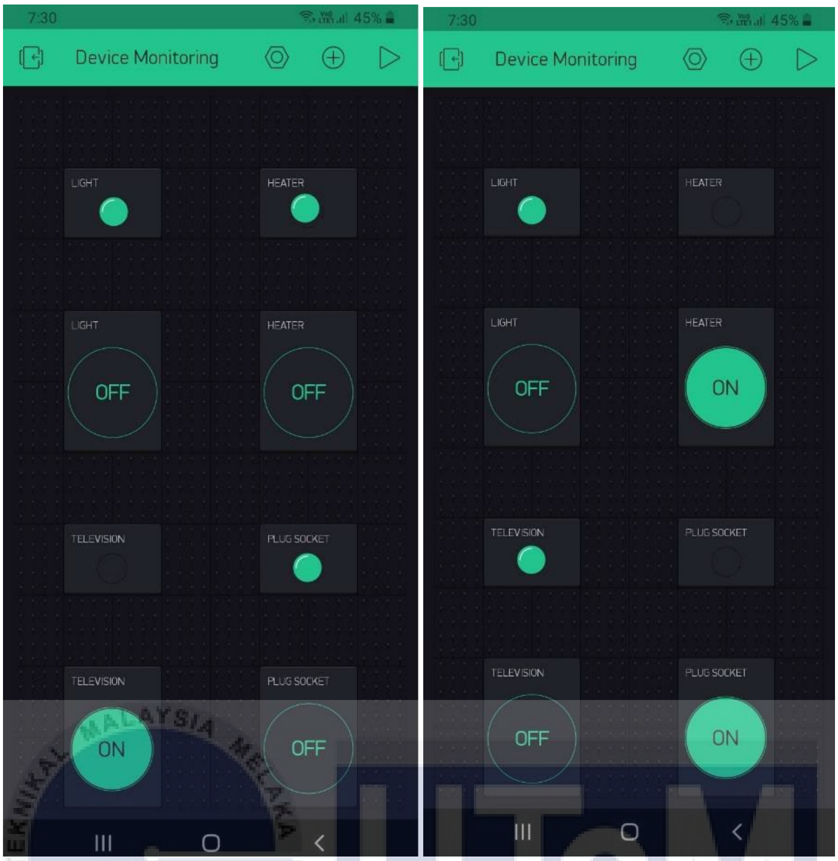


Figure 2.2 Appliances controlled on Blynkk application [13]

The project's hardware unit is linked to a light unit, heating, television, and a plug outlet. The relay devices linked between the microcontroller and the appliances are used to check the state of the appliances. Figure 2.2 (left) shows that, except for the television, all other appliances are turned on. As a result, the television's switch displays 'ON' to activate the television circuit from the remote side. Several switching procedures are used to verify the state of the appliances, and a few are depicted in Figure 2.2(right) with amended status from Figure 2.2(left). Based on the confirmed circuit, the Blynk framework could potentially be used for a variety of control applications without delay.

The author in [14] describes the system combines multiple sensors, controls, and actuators to give increased security and monitoring capabilities for houses. the system's hardware components, which include Arduino-nano and NodeMCU ESP8266 controllers, an RFID reader, a numerical code to open the door, a PIR sensor to detect intruders, a

DHT-22 sensor to detect room temperature and humidity, a rain sensor to detect rain, a fire sensor to detect a stove fire, LDR sensors to monitor light conditions, light bulbs and solenoid valves used as actuators.

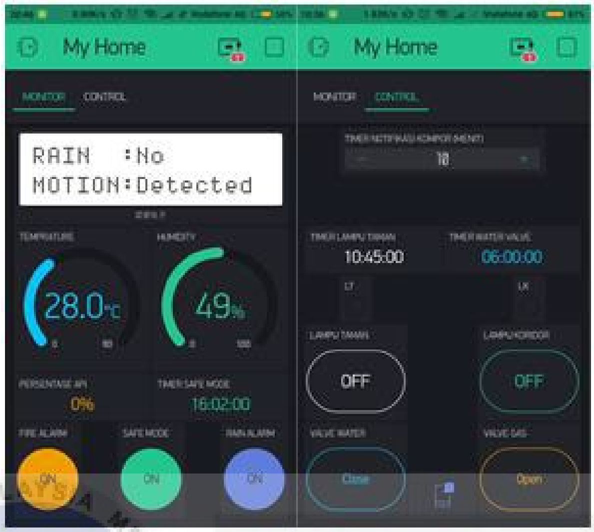


Figure 2.3 User Interface system Home Security[14]

The Blynk programme is downloaded and used to pick and assemble widgets for controlling system and monitoring. The sensor data is transferred to the Blynk server and shown on the smartphone screen. The keypad number is read if the RFID tag has been recognized; otherwise, the process loops back to the beginning. If the correct password is entered, the door will unlock; otherwise, a buzzer will sound and an email will be sent. Therefore, Blynk is essential in developing the interface for the IoT-enabled home security and monitoring system.

2.4 Real-Time Health Monitoring

Real-time health monitoring encompasses the continuous and immediate surveillance of an individual's health parameters, data, and vital signs, delivering instantaneous feedback and alerts. This method makes use of technology, such as sensors and monitoring devices, to collect data on various health indicators ranging as heart rate, blood pressure, temperature, respiration rate, and activity levels. The collected data is transferred in real time to a monitoring system or healthcare specialists, allowing for immediate analysis and interpretation. Real-time health monitoring facilitates the timely detection of abnormalities, changes, or potential health risks, thereby facilitating prompt interventions and the provision of appropriate medical care.

A study was carried out in [15] that developed a framework that is based on the Internet of Things for real-time health monitoring. To make the continuous monitoring of vital signs possible, it was designed using both wearable technology and cloud computing as part of its framework. The approach that was used allowed the medical staff to acquire information that was accurate as well as up-to-date, and the data that was obtained was then securely uploaded to the cloud.

The authors in [16]explain the usage of wearable devices that were a component of their system. These devices were all furnished with sensors that were able to assess a range of crucial indicators, such as a person's temperature, blood pressure, and heart rate. The usage of Bluetooth and Wi-Fi, along with other wireless communication protocols, was employed to establish a connection between these various electronic devices and the cloud computing infrastructure. According to [16], after the information had been received by the sensors, it was instantly uploaded to the cloud so that it could be processed and analyzed.

The increasing dependence in the healthcare business on the Internet of Things (IoT) to improve accessibility and quality while simultaneously cutting costs. The author explores how the Internet of Things (IoT) is becoming increasingly important in the healthcare industry to enhance access, quality, and affordability. According to [17] the dependency of the healthcare industry on the Internet of Things is growing every day to enhance access to healthcare, increase the quality of treatment, and eventually lower the costs of health care.

According to [18], the technology provided healthcare practitioners with access to a centralized platform from which they were able to monitor and analyze the data that had been gathered through the use of cloud computing capabilities. The experts were able to provide improved treatment to the patients. This made it possible for medical personnel to more effectively treat patients by enabling them to track the progression of changes in vital signs over time and recognize any anomalies or trends that may have been present.

The Internet of Things-based system for real-time health monitoring that was built demonstrated that in general, the potential for wearable devices and cloud computing to be coupled in the context of the healthcare industry. According to [18], the capacity for medical staff to provide patients with treatment that is both more effective and delivered in a more timely manner was made feasible by the continuous monitoring of vital signs and the availability of data in real-time.

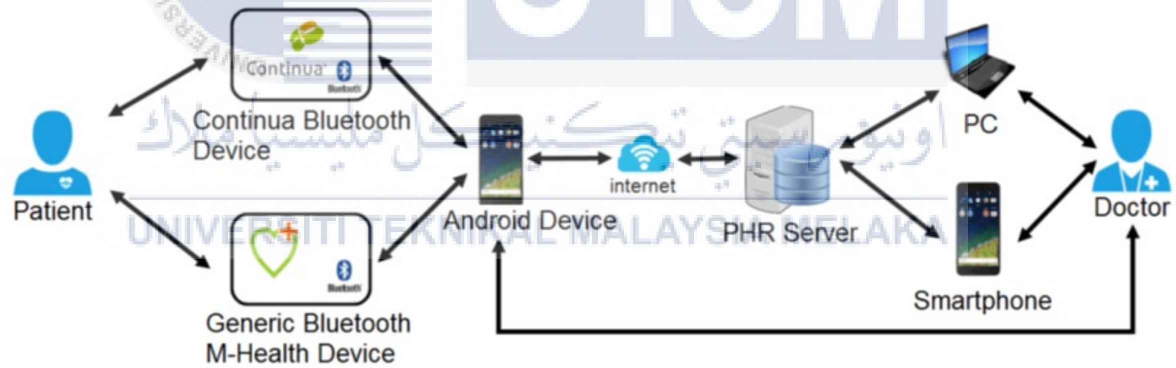


Figure 2.4:System structure of health monitoring system.[18]

2.4.1 Real-Time Monitoring Application

Real-time health monitoring systems allow for the collection of in-depth information regarding an individual by keeping track of a wide variety of factors simultaneously. These parameters offer extremely helpful insights into numerous facets of a person's health, including physiological and behavioural elements. The following parameters are frequently observed and documented:

2.4.1.1 Heart Rate

Generally, heart rate measurement in hospitals was done manually using methods such as auscultation, palpation, or electrocardiography (ECG). These methods involved healthcare professionals using stethoscopes to listen to the heart sounds, feeling the pulse at certain locations, or using ECG machines to record the electrical activity of the heart [19]. Monitoring a patient's heart rate involves counting the number of times their heart beats in one minute. It can recognise irregular cardiac rhythms (also known as arrhythmias) and aberrant heart rates, both of which are important pieces of information regarding cardiovascular health. These approaches required direct interaction with patients and often involved specialized equipment and trained personnel. Real-time monitoring of the heart rate permits quick intervention i an abnormality is detected, hence allowing medical professionals to handle any cardiac disorders on time. Medical professionals to handle any potential cardiac difficulties on time [20].

2.4.1.2 Blood Pressure

The blood pressure reading gives crucial information about the health and functioning of the cardiovascular system. A normal blood pressure level is around 120/80 mmHg. Higher levels, on the other hand, may suggest hypertension (high blood pressure), which is a substantial risk factor for many cardiovascular disorders such as heart attacks and strokes. It is critical to frequently measure blood pressure since it can assist identify potential health risks and advise suitable interventions. Maintaining a nutritious diet, engaging in regular physical activity, controlling stress, and, in certain situations, medication may be prescribed to control blood pressure [21].

Maintaining control of hypertension and avoiding complications arising from it, such as heart attacks, strokes, or renal difficulties, requires diligently keeping track of one's blood pressure continuously. Measurements of blood pressure include two values: systolic pressure, which refers to the force that is applied to the artery walls when the heart contracts, and diastolic pressure, which refers to the pressure that is present while the heart is at rest. Monitoring blood pressure in real-time enables early detection of aberrant variations, which in turn enables appropriate adjustments to be made to treatment plans, whether such plans involve medication or changes in lifestyle [22].

2.4.1.3 Oxygen Saturation (SpO2)

The monitoring of oxygen saturation calculates the proportion of oxygen in the blood that is bound to the haemoglobin. It is of utmost significance for patients undergoing medical operations as well as those who suffer from illnesses that affect the respiratory system. The early detection of oxygen deprivation or hypoxemia, which can be an indicator of lung disorders, breathing difficulties, or other health issues, is made possible by SpO2 monitoring in real-time [23]. This measurement gives critical information about the blood's oxygen-carrying capacity and the efficiency of oxygen transport to tissues and organs throughout the body [24].

Pulse oximetry is a non-invasive monitoring technique that is frequently used in medical settings to measure the oxygen saturation levels in a patient's blood. It entails the use of a pulse oximeter, a device that emits light at specific wavelengths and transmits it through tissue, most commonly the fingernail bed. The pulse oximeter measures the quantity of light absorbed in the blood by both oxygenated and deoxygenated haemoglobin. Pulse oximetry is regarded as a standard monitoring tool for anaesthetic situations. This device is also utilized in emergency rooms, hospital wards, and ambulances to test the oxygenation status of patients with respiratory difficulties or to monitor the respiratory effects of pain drugs. The widespread utilization of pulse oximeters in hospitals has considerably reduced the occurrence of unrecognized drops in oxygen levels, assuring quicker treatments and increased patient safety. [25].

2.4.1.4 Body Temperature

Body temperature is the measurement of the heat created and maintained by the human body. It is an essential physiological measure that gives essential information concerning the body's metabolic activity and overall well-being. The average human body temperature is approximately 37 degrees Celsius, but this number can shift slightly depending on age, time of day, and individuality. Many conditions, such as the flu or low-temperature hypothermia, can result in a noticeable rise or fall in core body temperature. Almost every ailment has fever as one of its symptoms. [26].

Keeping a constant watch on the temperature of the body is an effective way to detect fever or variations in temperature that are not normal. An elevated body temperature is frequently an indication that an infection or inflammation is present beneath the surface. The ability to monitor vital signs in real-time enables early detection of fever, which in turn enables quick medical intervention and the provision of suitable therapy [27].

2.4.1.5 Sleep Pattern

The regularity and structure of an individual's sleep-wake cycle are referred to as sleep patterns. It includes the amount, time, and quality of sleep obtained in 24 hours. Biological cycles, lifestyle decisions, and environmental influences all have an impact on sleep patterns. Studying sleep patterns is critical for evaluating sleep health and detecting possible sleep disorders. The number of hours of sleep required varies by age group. Infants and early children necessitate sleep than adults, despite older adults may have alterations to their sleep architecture and need less overall sleep duration. Differences among individuals exist likewise, with some people being "short sleepers" who function well on fewer hours of sleep and others being "long sleepers" who need more sleep [28].

Real-time monitoring of sleep patterns requires keeping track of characteristics such as total sleep time, different stages of sleep, and any disturbances to sleep. It is useful for determining the quality of one's sleep as well as diagnosing sleep problems such as insomnia, sleep apnea, and restless leg syndrome. Real-time sleep monitoring provides significant insights into an individual's sleep habits, allowing for personalised treatments to enhance sleep hygiene and overall well-being. This is made possible by the fact that the monitoring is done in real time[29].

2.4.1.6 Fall Detection

Almost all human beings has been encountered an undesired fall, whether as a toddler learning to walk or as an adult. People are thus familiar with the fall process. To deal with the fall, athletes developed corrective and preventive mechanisms; they can even control "high energy" falls. Nonetheless, it is difficult to characterize the phenomena precisely, and even more difficult to devise a method for detecting it. A person's fall can be defined as the fast transition from a sitting position to a reclining or nearly laying position. It is not a deliberate movement, such as lying down [30].

Fall Detection Algorithms and sensors can detect sudden changes in body position or acceleration when used for fall detection. Real-time fall detection is particularly important for the older population, which may be more susceptible to injuries sustained as a result of falling. Early identification of falls provides prompt response and aid, potentially lessening the impact of injuries as well as their severity so that they are receiving the correct treatment and decreasing the likelihood of medication errors [31].

2.4.1.7 Environmental Factor

The impact of one's environment on their health and happiness can be better understood by keeping tabs on things like temperature, humidity, air quality, and noise levels. The causes of asthma, allergies, and other health problems can be better understood with the aid of real-time environmental monitoring. It can teach people what they can do to improve the quality of their living space for themselves and their families [32].

Real-time temperature monitoring is vital for studying how extreme temperatures effect health. High temperatures can cause heat-related disorders, whereas low temperatures raise the risk of hypothermia. Real-time temperature monitoring enables people to undertake the necessary steps to avoid heat-related illnesses, starting with consuming sufficient water and seeking shade. It additionally enables people to maintain appropriate indoor temperatures while making properly informed choices about clothing and heating to decrease the risk of hypothermia. People can establish a safe and comfortable atmosphere which encourages their well-being by being aware of temperature variations and adopting proactive precautions [33].

According to [34], high indoor humidity levels were linked to an increased risk of respiratory problems. As a result, real-time monitoring of humidity levels enables users to manage excessive humidity circumstances quickly and prevent potential negative impacts on respiratory health.

Real-time air quality monitoring systems serve a vital role in assisting people in protecting their respiratory health. Poor air quality, which is characterized by pollutants and allergens, may result in a major impact on respiratory function and precipitate respiratory disorders. People can stay updated about pollutant levels and allergen prevalence in their area by regularly monitoring air quality measures in real-time. This understanding allows people to implement the required safeguards and make sensible choices to protect their respiratory health. To alleviate the negative impacts of poor air quality on respiratory health, measures such as reducing exposure, employing air filters, and ensuring sufficient ventilation can be implemented immediately [35].

Monitoring noise levels has significance as high levels of noise may give a negative impact on health and well-being. Persistent exposure to loud noise may result in stress, sleep disorders, cognitive deficits, and cardiovascular concerns. People may discover and reduce potential noise-related dangers by using real-time monitoring. Those who are cognizant of noise levels may implement proactive measures which include utilizing ear protection, soundproofing living rooms, or finding quieter regions to foster a healthier and more serene environment [36].

2.5 Previous Research

2.5.1 IoT Enabled Health Monitoring Kit Using Non-Invasive Health Parameters

The development of an IoT Enabled Health Monitoring Kit Using Non-Invasive Health Parameters proposed in [37] can keep track of several aspects of an individual's health, including their blood oxygen level, movements, heart rate, electrocardiogram (ECG), and alterations in the electrical characteristics of their skin. Raspberry pi and a cloud IoT platform, the latter of which is based on the Thingspeak server, have been combined in this system to create its foundation. The system that has been proposed is not only effective but also very easy to use. The reliability and efficiency of the suggested system in comparison to the existing models have been demonstrated through experimental experiments.

The suggested system for detecting various health parameters makes use of the following sensors as its hardware components: LM35 temperature sensor, Pulse sensor, AD8232 ECG sensor, GSR sensor, MAX30100 sensor, and ADXSL345 sensor. These sensors are utilised to monitor the user's health status in real-time. To measure the temperature of the user's body [37], the LM35 temperature sensor is inserted into the user's finger.

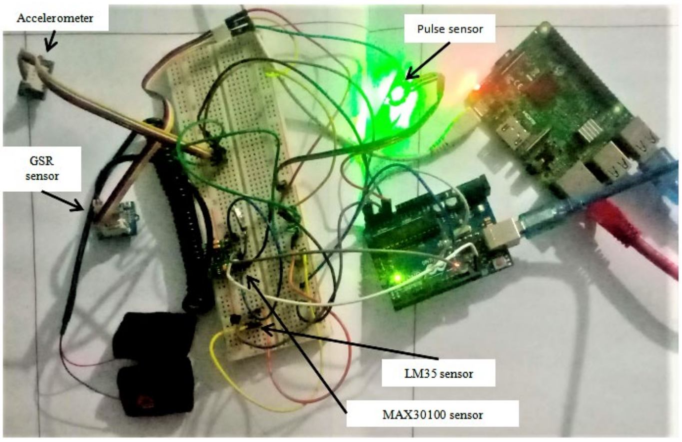


Figure 2.5 Prototype of Health Parameters [37]

The results of the empirical research indicate that the suggested system is trustworthy and successful in its monitoring of health conditions making use of metrics that do not involve intrusive procedures[37]. The findings indicate that the suggested system is capable of precisely measuring a variety of physiological variables, including but not limited to an individual's blood oxygen level, heart rate, electrocardiogram (ECG), changes in the electrical properties of their skin, and motions.

2.5.2 Mobile IoT Cloud-based Health Monitoring Dashboard Application for The Elderly

The development of the device [38] was created to keep an eye on the health of older people. The app was made with the Flutter framework, which lets you see info on mobile devices. The system has four main screens, including a dashboard for data sensors P1(body temperature) and P3(heart rate and SpO2), a personal page, and a page for notifications.

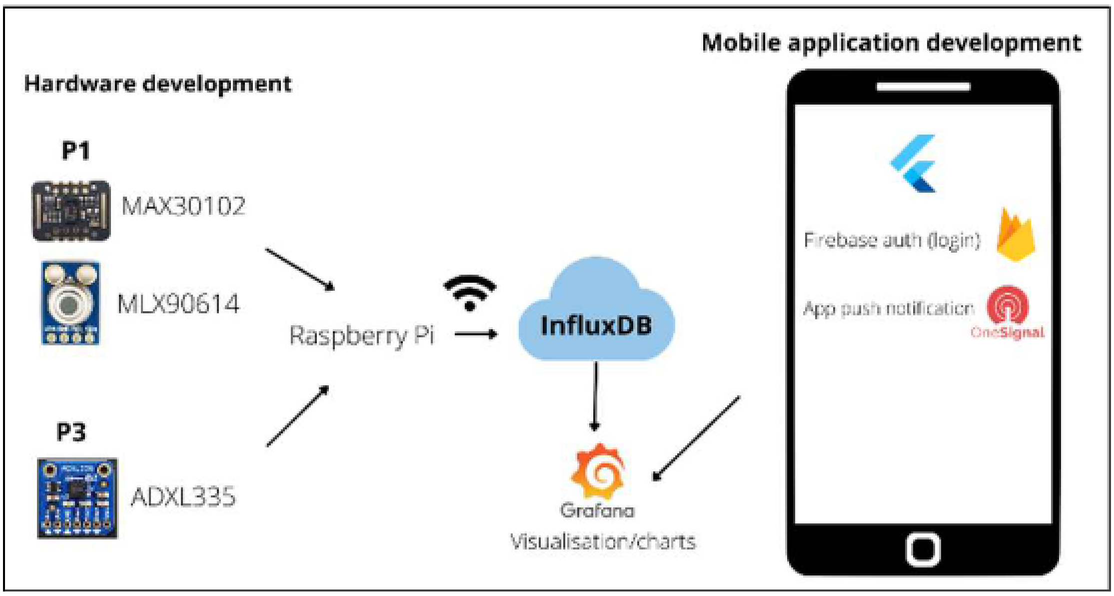


Figure 2.6 Diagram showing how the system work. [38]

The login function of the app uses Google sign-in authentication to protect the privacy and security of its users. When there has been a fall, the OneSignal platform sends alerts and messages to the mobile app. This function makes sure that if there is an emergency, carers or family members are notified right away. The screen shows information about the body temperature, heart rate, SpO2, and falls of the people being watched. This information is important for keeping an eye on the health of older people, who may have health problems that need to be watched constantly.

The author [38] also said that it can also keep track of where the elderly are at all times by using RFID or Bluetooth tags to find their exact location in case of emergencies. Also, suggestions for the future of the system include measuring its real-time response to see how well it works and using a safe encryption system to protect database information.

2.5.3 IoT-based Infant Body Temperature Monitoring device

The development of an IoT-based Infant Body Temperature Monitoring device discussed in the journal provides valuable insights into the potential of IoT in healthcare.

While the focus is on monitoring infant vital signs, the need for health monitoring devices that cater to the needs of different age groups, including the elderly, is briefly mentioned [39].

Expanding on this, These devices consider factors such as ease of use, affordability, and non-intrusiveness to ensure maximum acceptance and adoption. This device uses a wireless network to transfer data from the wearable sensor to a mobile phone for remote monitoring. The device is designed to be controlled by a single microcontroller, the ESPresso Lite V2.0 based on ESP8266, and is powered by a lithium-ion polymer battery. The exact method of data transmission is not mentioned

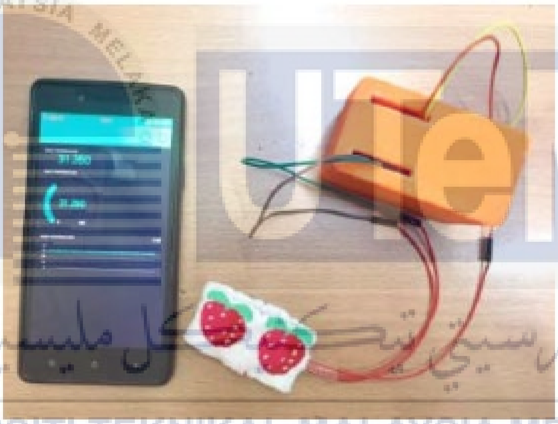


Figure 2.7 Prototype of the device [39]

The prototype monitoring device solely monitors an infant's temperature. Although the system is primarily designed to monitor temperature, it may be expanded or improved to monitor other important metrics such as heart rate, oxygen saturation, respiration rate, and any other parameter [39]. Vital indicators such as heart rate, blood pressure, respiratory rate, and oxygen saturation levels can be monitored by an IoT-based health monitoring gadget for the elderly. The device can capture real-time data from older people using sensors and wearable technology.

2.5.4 Prototype Development of an IoT Health Monitoring Device for Elderly Patient

The author discusses the development of a prototype of an IoT health monitoring device for older people. The author said about the problems health care workers face when keeping an eye on older people and how technology can help them solve these problems [40]. The device is built on a donut-shaped board that is the right size, and it is made up of a microprocessor, sensors, a Wi-Fi module, and a power supply, among other electronic modules.

A microprocessor called an ESP8266 NodeMCU board is used in the device. This board connects the device to Wi-Fi. A MAX30102 pulse oximeter sensor is used in the device. This sensor records the patient's heart rate and blood oxygen saturation (SpO2) level. A DHT11 temperature and humidity monitor is also used to measure the temperature and humidity around the patient.

The Wi-Fi module in the device is an ESP8266 Wi-Fi module, which makes it possible for the device and the smartphones of healthcare workers to talk to each other wirelessly. All of the electrical parts of the device get their power from a 3.7V Li-ion battery, which is the device's power source.

Through the internet, the proposed method sends a signal to the Blynk server to connect the user's device to the hardware. The Blynk app sends a ping signal to make sure the link is made and then waits for the server to confirm that the connection is made. Once they are linked, doctors and nurses can use the Blynk app on their phones to get health information about their patients.

Figure 2.8 Prototype of the device [40]

With this developed prototype, health workers can access information about a patient's health parameters and location, which is stored in a cloud database. This lets doctors and nurses check on the health of their patients from anywhere at any time using their smartphones.

The author also talks about some of the possible benefits of using this device in hospitals and care centers for older people, such as reducing the amount of work for healthcare workers, improving patient outcomes, and lowering the cost of healthcare. It also talks about some things that could be done to make progress better for society [40].

2.5.5 IoT Health Monitoring Device of Oxygen Saturation (SpO2) and Heart Rate Level

The present paper discusses an IoT health monitoring device that has been [41] developed to offer a dependable and effective means of monitoring the health of elderly individuals. The MAX30100 Pulse Oximeter and Heart-Rate Biosensor are utilized to measure heart rate and SpO2 levels, which are crucial parameters for assessing an individual's general well-being. The information obtained by these constituents is recorded in a Firebase-generated database, which facilitates convenient retrieval and examination of the data.

The system is dependent on the wireless transfer of data through the use of a Wi-Fi module, which has the potential to be unreliable in locations with poor network coverage or interference. Because of this, there is a possibility that data could be lost or that transmission will be delayed, both of which have the potential to compromise the system's precision and dependability.

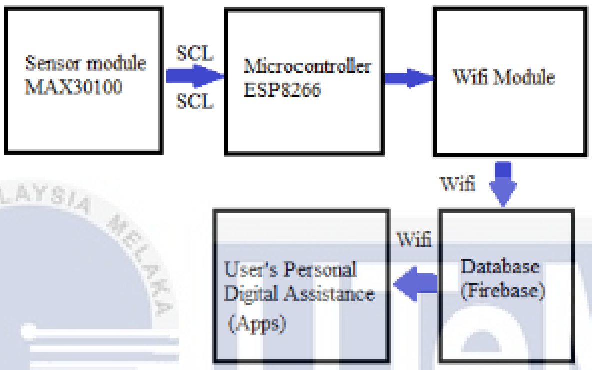


Figure 2.9 Block diagram of the system [41]

The system comprises a microcontroller, specifically the NodeMCU ESP8266, as well as a Wi-Fi module in the form of the ESP8266. Additionally, a database has been established utilizing Firebase. The MAX30100 Pulse Oximeter and Heart-Rate Biosensor are controlled and data is processed by the microcontroller, whereas the Wi-Fi module is utilized to wirelessly transmit data to the Firebase database. The measured data is stored in a database, which can be accessed via a web-based interface developed using the HTML 5 language with the Visual Code Studio IDE [41].

2.5.6 Fall Detection System Using Wearable Sensors with Automated Notification

The author starts by talking about the development of wearable healthcare gadgets. Its origins may be traced back to the 16th century, when doctors employed pulse watches to measure the heart rates of their patients. The first wearable gadget, portable

ECG equipment that could be worn on a belt, was created in 1975. Sensors, wireless connection, and data analytics improvements have brought wearable healthcare technology a long way since then.

[42] monitors older individuals and alerts them in the event of an accident such as falling or sliding. The system's microcontroller is an Arduino NodeMCU, which is in charge of gathering and processing data from the input sensors. The input sensors utilised are a gyroscope and an accelerometer (MPU6050), which are mounted to the geriatric wearable gadget. Changes in motion and direction are detected by these sensors, suggesting a fall or other unusual behaviour.

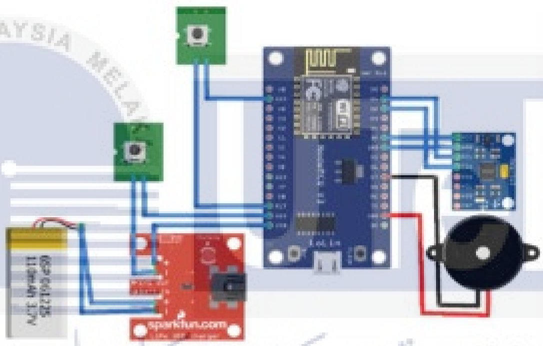


Figure 2.10 Prototype of the Design [42]

In this setup, the output device is an ESP8266 Wi-Fi module, which delivers the data gathered by the microcontroller to the cloud application. Blynk is the cloud application utilised, and it gets data from the wearable gadget over Wi-Fi and sends an email notice when a fall scenario is recognised. This system's power source is a rechargeable battery, which powers all components of the wearable device. This battery guarantees that the gadget may be worn continually without needing to be recharged.

It detects falls by combining gyroscope and accelerometer sensors. These sensors are fitted to the older person's wearable gadget and may detect changes in motion and direction. The gyroscope sensor determines the rotation rate around each axis, while the accelerometer sensor determines acceleration along each axis. The device can identify changes in motion and direction that vary from typical activities like walking or sitting by merging data from both sensors. The components operate in tandem to produce an effective fall detection system that employs wearable sensors and automated alerts. This technology may help avoid additional health concerns and enhance the quality of life of elderly persons by detecting falls early and informing them quickly.

2.6 Summary of Previous Research

Table 2.2 Summarization of Previous Research

Titles	Advantages	Disadvantages	Area of Improvement	Summary
1. IoT Enabled Health Monitoring Kit Using Non-Invasive Health Parameters	• Non-invasive monitoring: The system lets you keep an eye on different health factors without having to do anything that would harm you. • Real-time monitoring: The monitors let health conditions be checked in real time. • Comprehensive measurements: The system measure physiological factors, such as blood oxygen level, heart rate, ECG, electrical qualities of the skin, and movement. • Easy to use: The method is made to be simple and easy for anyone to use.	• Limited scope: The system may not cover all conceivable health metrics, and there may be other parameters that could be monitored. • Sensor accuracy: The accuracy of the sensors used in the system may vary, affecting the precision of the measurements. • Potential technical issues: There may be technical challenges or limitations related with the Raspberry Pi or cloud IoT platform.	• Improved sensor accuracy: Improving the quality of the system's sensors would result in more precise measurements. • Increased parameter coverage: Consider adding more sensors or modules to monitor a broader range of health metrics. • Improved user interface: Improving the user interface and giving more intuitive controls may improve the overall user experience. • Addressing any technical constraints or issues associated with the Raspberry Pi or cloud IoT platform would improve system performance and reliability.	Non-invasively monitors vital signs. The Raspberry Pi and cloud-based IoT platform automate the system. Sensors measure blood oxygen, heart rate, ECG, and skin characteristics in real time. Empirical and experimental study demonstrate the system's reliability and efficacy. It provides accurate non-invasive health monitoring [37]. Raspberry Pi-based IoT smart healthcare monitoring is affordable and efficient [43]. Wearables and wireless channels remotely monitor patients' health, improving diagnosis and healthcare. Health records improve disease detection. Hospitals, ambulances, and emergency care receive data alerts. Remote monitoring, good diagnosis, and fast emergency responses

				revolutionise healthcare with this technology.
2. Mobile IoT Cloud-based Health Monitoring Dashboard Application for The Elderly	• Accessibility of mobile apps: The Flutter framework-built app provides easy access to health information on mobile devices. • Privacy and security: The Google sign-in authentication protects the privacy and security of user data. • Immediate notifications: In the event of an emergency, the OneSignal platform delivers alerts and messages to notify carers or family members.	• Fall detection reliability: The accuracy and reliability of fall detection utilising the system may vary, necessitating further validation and improvement. • Technical constraints or limits related with the usage of RFID or Bluetooth tags for location tracking may have an impact on system performance. • Not Wearable. Too big Strap on body.	• Fall detection algorithm enhancement: Improve the fall detection algorithm to improve accuracy and reduce false alarms. • Evaluating the system's real-time reaction: Assess the system's real-time response to determine its effectiveness and pinpoint areas for improvement.	Flutter-based software makes real-time health data easier to access. It displays sensor data, personal information, notifications, and Google-authenticated login. The app tracks heart rate, SpO2, body temperature, and falls. OneSignal alerts carers of falls instantly. The programme also tracks position using RFID or Bluetooth tags for crisis identification [38].
3. IoT-based Infant Body Temperature Monitoring device	• Ease of use: The gadget is meant to be user-friendly and simple to use, ensuring maximum acceptance and adoption. • Affordability: Considering affordability in the device design makes it accessible to a broader variety of users. • Potential for expansion: The gadget can be updated to measure vital factors other than temperature, such as heart rate, oxygen saturation, and respiration	• The gadget prototype just monitors temperature, potentially missing out on other critical vital signals. • Limited age group coverage: The device is primarily intended for monitoring newborn vital signs, whereas the need for health monitoring devices that cater to various age groups, including the elderly, is mentioned but not elaborated upon.	• Enhance the gadget to monitor a broader range of key metrics beyond temperature, catering to the demands of different age groups. • Power optimisation involves looking into power-saving measures and effective battery management in order to extend the device's battery life and reduce the need for frequent recharge.	Usability, affordability, and non-intrusion are the device's goals. It wirelessly delivers data to a mobile phone for real-time monitoring and fast action if abnormalities are found. The authors developed the gadget prototype using the ESP8266-based ESPresso Lite V2.0 microcontroller and a wearable sensor[39].Wearable health monitoring systems for babies require sensors that properly and reliably record vital signs including heart rate, body temperature, and respiration

	rate.			rate. These sensors should collect data without irritating the baby's skin. A communication method that can send wearable device data to a hospital or caregiver's smartphone is another issue. This requires a fast, dependable wifi connection.[44]
4. Prototype Development of an IoT Health Monitoring Device for Elderly Patient	• Simplified connection: The device uses Wi-Fi connectivity, allowing wireless communication between the device and healthcare personnel' smartphones, facilitating efficient data transmission. • Comprehensive health parameters: The gadget includes sensors such as a pulse oximeter (heart rate and SpO2) and a temperature and humidity monitor, which provide essential information for monitoring patients' vital signs and environmental circumstances.	• Not Wearable • Battery life and power supply: The use of a 3.7V Li-ion battery as the power source may pose issues in terms of battery life and the necessity for regular recharging or battery replacement. • Scalability and compatibility: The device's scalability to accommodate a larger number of patients, as well as its interoperability with existing healthcare systems or electronic medical records, are not mentioned.	• Can make it Wearable • Battery optimisation: Improve the device's power management system to extend battery life and eliminate the need for frequent recharging. • Scalability and integration: Ensure that the device is scalable and compatible with existing healthcare systems, electronic medical records, and other infrastructure to allow for smooth integration into healthcare settings.	A CPU, sensors, Wi-Fi module, and power supply are on a donut-shaped board. An ESP8266 NodeMCU board provides Wi-Fi connectivity, and sensors such the MAX30102 pulse oximeter and DHT11 temperature and humidity monitor measure vital indicators. With internet connectivity and a Blynk server, the device sends real-time health data to healthcare providers' smartphones. The device stores data in a cloud database, allowing remote monitoring of patients' health parameters and location. [40]

5. IoT Health Monitoring Device of Oxygen Saturation (SpO2) and Heart Rate Level	• Integration of the NodeMCU ESP8266 microcontroller and the ESP8266 Wi-Fi module: The system includes the NodeMCU ESP8266 microcontroller and the ESP8266 Wi-Fi module, allowing wireless data transmission to the Firebase database. • Web-based interface: The HTML 5-based web-based interface provides a user-friendly platform for obtaining and visualising the observed health data.	• Wireless data transfer reliability: The Wi-Fi module transfers data wirelessly, which may fail in areas with low network coverage or interference. Data loss or delayed transmission could compromise system correctness and reliability. • The device only measures heart rate and SpO2, ignoring other vital signs and health indicators that may provide a more complete health assessment.	• Network connectivity optimisation: Improve wireless connectivity to ensure data flow in demanding network situations. • Expanded sensor capabilities: Add sensors to monitor more vital signs and health factors for a more complete health evaluation. • Real-time data monitoring: Create features to monitor recorded data in real time to assess senior patients' health.	A MAX30100 Pulse Oximeter and Heart-Rate Biosensor measure elderly people's SpO2 and heart rate in the IoT health monitoring gadget. Data is saved, analysed, and authorised by authorised personnel for medical analysis. This real-time vital sign monitoring can detect health concerns or emergencies. This technology can help elderly people discover and avoid health issues by monitoring their health [41].
6. Fall Detection System Using Wearable Sensors with Automated Notification	• Early fall detection: The wearable device's gyroscope and accelerometer sensors detect motion and orientation to detect falls or aberrant behaviour in older people. • Wireless data transmission: The ESP8266 Wi-Fi module allows real-time monitoring and rapid notifications from the wearable device to the cloud application. • Cloud application integration: When a fall is detected, the Blynk cloud	• Wi-Fi dependence: The system requires a stable Wi-Fi connection. Data transmission and real-time notifications may be affected by network outages. Cellular networks are reliable alternatives to WiFi. • Lack of two-way communication: Currently, the wearable device only detects falls and warns carers. Voice communication and	• Integration of additional sensors: Add heart rate or blood pressure monitors to gather more health data and provide a holistic perspective of the wearer's well-being. • Two-way communication: Enable two-way contact between the wearer and carers for emergency support.	The described system monitors seniors and alerts them of falls. It uses a wearable device (MPU6050) with sensors like a gyroscope and accelerometer to detect falls or strange behaviour. Arduino NodeMCU microcontrollers analyse data. Using an ESP8266 Wi-Fi module, it sends data to Blynk. A fall scenario triggers an email notification from the cloud

	application sends carers or healthcare professionals email notifications.	emergency buttons may improve the device's emergency usability.		application. The wearable's rechargeable battery ensures uninterrupted operation. The technology detects unusual motion and direction by combining gyroscope and accelerometer data.[42]

2.7 Summary of Past Related Paper

A wide range of technologies for developing methods of real-time monitoring for the elderly are being examined, according to the numerous papers being researched. This literature study demonstrates that each technique has different accuracies, usefulness, and limits. Table 2.3 already includes a comparison of publications based on authors used in technological developments.

Table 2.3 Summarization of Past Related Paper

References	Board Used		Sensors				Connection		Clouds				Portability	
	Rasberry Pie	Arduino Uno(ESP Devkit & Microcontroller	AD8232	MPU6050	MAX30102	LM35/D HT11	Bluetooth	Wifi	PC	Blynk	Thing speak	Web	Yes	No
[12]		/	/					/		/				/
[13]		/				/		/		/				/
[14]		/				/		/						/
[15]	/		/		/			/				/	/	
[16]		/	/		/	/		/	/					/
[18]			/		/		/		/			/		
[30]		/		/				/				/	/	
[31]		/		/				/				/		/
[37]	/		/	/	/	/		/			/			/
[38]	/				/		/					/		
[39]		/				/		/						/
[40]		/			/	/		/		/				/
[41]		/			/			/						/
[42]		/		/				/		/			/	
This Work		/		/	/	/		/		/			/	

CHAPTER 3

METHODOLOGY

3.1 Introduction

The approaches used to create the suggested Development Of Real-Time Health Monitoring System For the Elderly Using the Internet Of Things are presented in this chapter. This comprises an explanation of the system development process flow, hardware and software choices, and the proposed system's functioning flow.

3.2 Methodology

The real-time health monitoring system for the elderly will be developed using an ESP-32 board, a 3.7V LiPo battery, and sensors such as the MAX30102 Pulse Oximeter, and MPU6050. Software development will involve creating a Blynk IoT application and coding with the Arduino IDE. IoT platform Blynk allows for remote operation, data presentation, storage, and visualization of data. Users are required to develop Blynk applications, which can then be downloaded from the Google Play Store, in order for them to be able to get alerts. This technique gives customers the ability to remotely monitor and view their health data, while also guaranteeing that the Blynk app provides easy access.

3.2.1 Illustration of the project

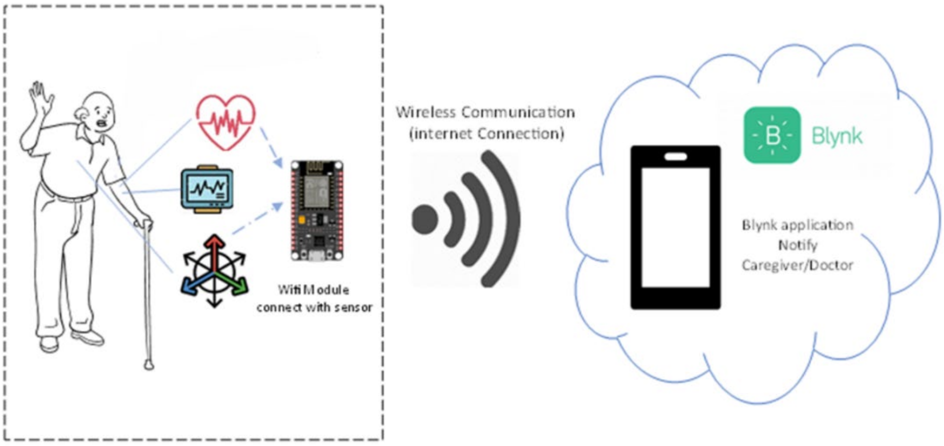


Figure 3.1 Illustration of the project system

3.3 Hardware Requirements

The study's success heavily depends on the significance of the hardware utilized. The inquiry process involves the utilization of specific hardware components, each with a designated function. Figure 3.1 displays the hardware utilized in the development of this project.

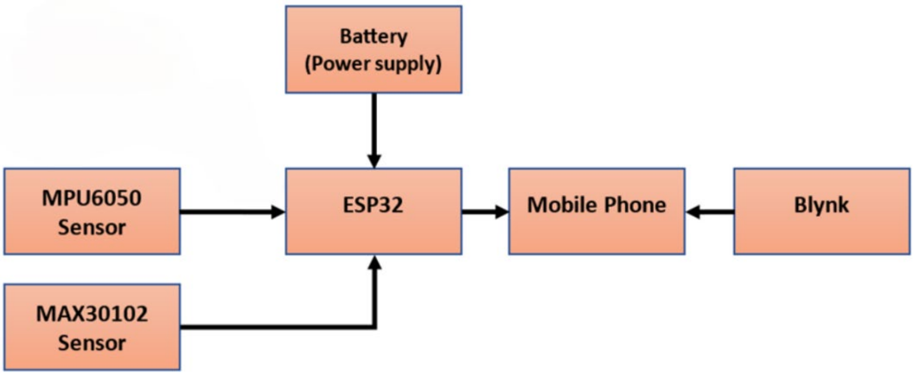


Figure 3.2 Block diagram for the hardware development

This project uses the ESP-32, an open-source microcontroller, to meet the specifications laid out in Figure 3.2. Next, ESP-32 provides a language-based IDE (internal development environment). The language can communicate with other C and C++ applications.

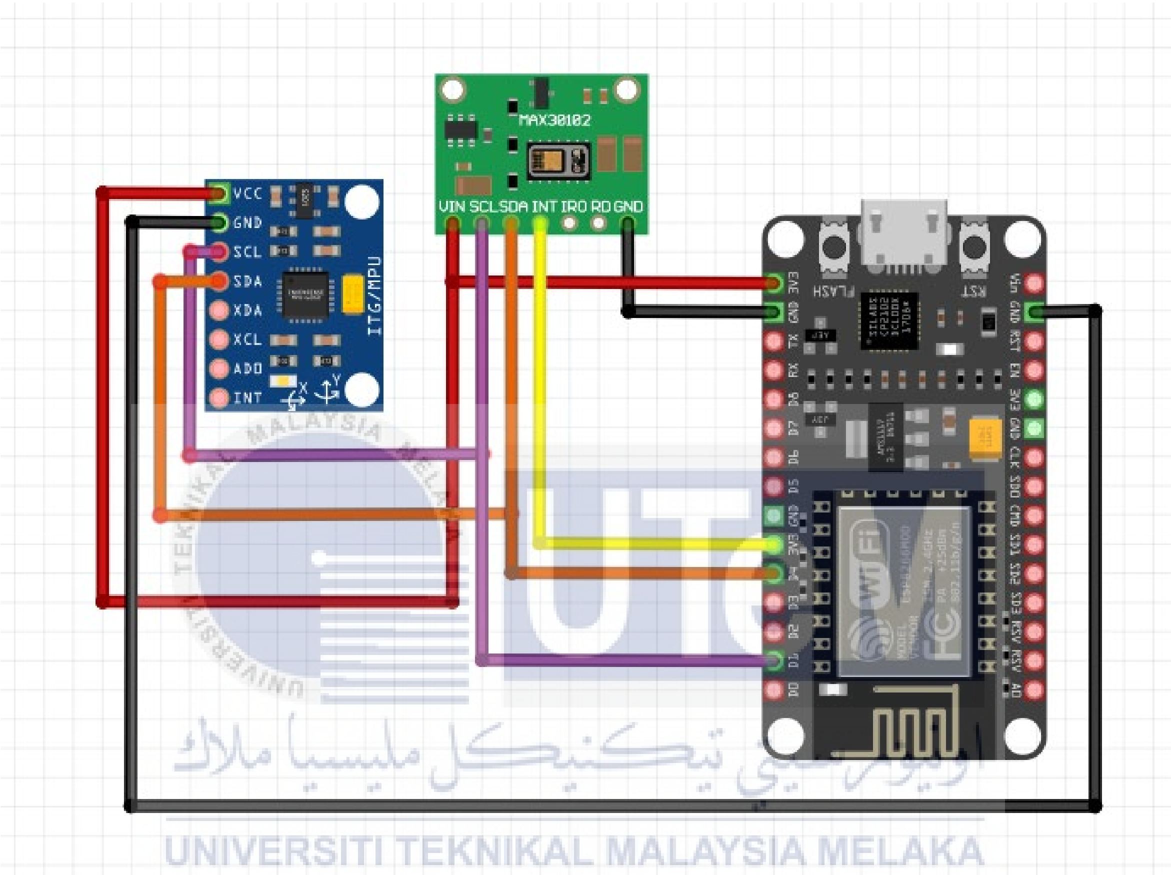


Figure 3.3 The circuit design of the project using Fritzing

Figure 3.3 show the connection of the hardware that will use. The main system is microcontroller which is ESP32 module. Other components uses such as MPU 6050 senosr, LM35 sensor, 4.7 kohm resistor, and MAX 30102 sensor.

3.3.1 ESP32 Module

For good reason, the ESP32 platform has garnered substantial appeal among electronics novices and aficionados. It provides a flexible and open-source method for generating numerous electrical creations. The ESP32 is built around a hardware programmable circuit board known as a microcontroller. This microcontroller has a strong CPU, plenty of memory, and several input/output pins, allowing it to do complicated tasks and interface with diverse sensors, actuators, and other components.

In addition to the hardware, the ESP32 platform includes a software component known as an Integrated Development Environment (IDE). This IDE is a programming environment for developing and uploading code to the ESP32 board that runs on your PC. It provides a user-friendly interface, code editor, and debugging tools, making it easier for users to construct projects and bring their ideas to life.

One of the primary advantages of the ESP32 over predecessors like as the Arduino is its simplified programming procedure. Unlike many other programmable circuit boards, the ESP32 does not require a separate piece of hardware known as a programmer to load fresh code into the board. Instead, a simple USB cable is required to connect the ESP32 to the PC, allowing immediate code uploading and debugging.

The ESP32 also has built-in RF components. The ESP32, like its predecessor, the ESP8266, includes essential radio frequency (RF) components such as a power amplifier, low-noise reception amplifier, antenna switch, filters, and an RF balun. This integration removes the need for extra external RF components, simplifying the hardware design process. It also allows wireless communication capabilities, allowing the ESP32 to connect to Wi-Fi networks, Bluetooth devices, and other wireless protocols.

The ESP32's simplicity and adaptability make it appealing to both new and seasoned developers. The ESP32 provides a great basis for many applications, including home automation systems, IoT devices, robotics, sensor networks, and much more, thanks to its simple programming environment, plentiful hardware resources, and built-in wireless capabilities. The ESP32's expanding community also provides comprehensive documentation, tutorials, and support, further strengthening its attractiveness as a platform for electrical innovations.

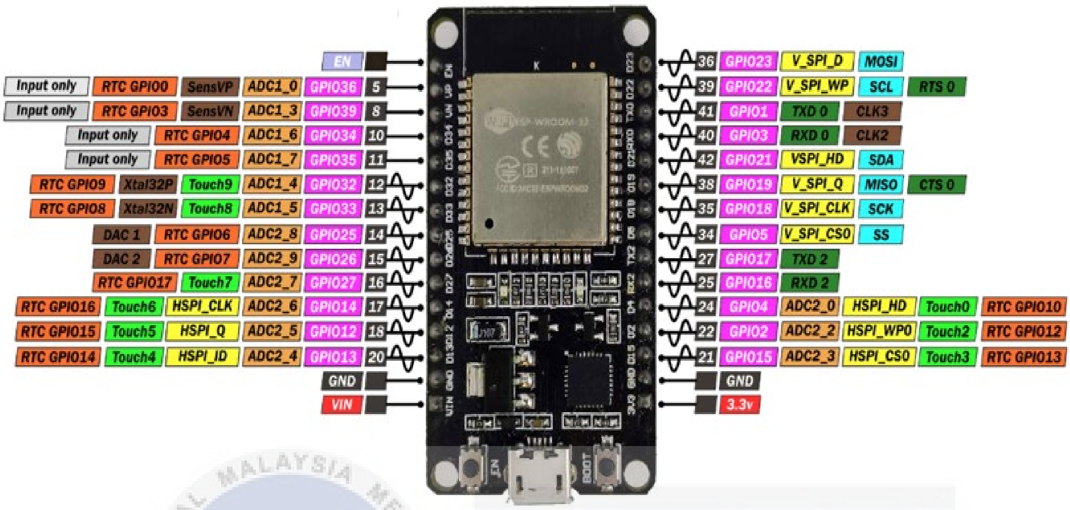


Figure 3.4 Schematic design of ESP32 Module[43]

Table 3.1 Pinout use in ESP32[43]

MPU6050 Pins	ESP332 Pins
SDA	GPIO21
SCL	GPIO22
Vcc	3.3V
GND	GND
MAX30102 Pins	**ESP32 Pins**
INT	GPIO19
SCL	GPIO22
SDA	GPIO21
Vcc	3.3V
GND	GND
LM35	**ESP32 PIns**
Vcc	3.3V
Signal	GPIO5
GND	GND

3.3.2 MPU 6050 Gyroscope Accelerometer Sensor

The MPU-6050 is a module that has both an accelerometer and gyroscope on all six of its axes. The gyroscope provides a reading in radians per second for the rotational speed. This term is used to describe the gradual shift that occurs in the angular position along the X, Y, and Z axes (sometimes called roll, pitch, and yaw) over a period of time. A broad range of motion-related metrics, including as acceleration, velocity, direction, and displacement, may be measured in this way. The Digital Motion Processor (DMP) included in this component may do complex computations, freeing the Microcontroller to focus on other tasks.

The module also has two auxiliary pins for communicating with external IIC modules, such as a magnetometer; however, this capability may be disabled if desired. Because the module's IIC address may be altered, the AD0 pin can be used to link more than one MPU6050 sensor to a single microcontroller. Because this module also includes easily accessible, well-documented, and up-to-date libraries, it is rather straightforward to use with well-known platforms such as Arduino.

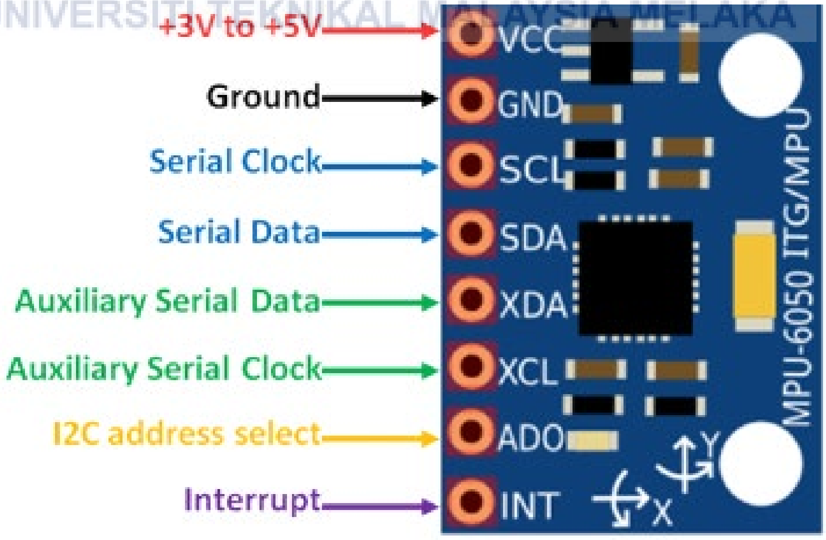


Figure 3.5 MPU6050 Pinout[44]

Table 3.2 MPU6050 Pinout Specifications[44]

Pin Number	Pin Name	Description
1	Vcc	Power for the module, ranging from +3V to +5V. Normally, +5V is frequently utilised.
2	Ground	Ground
3	Serial Clock (SCL)	Used to generate a clock pulse for I2C communication.
4	Serial Data (SDA)	Used for data transmission through I2C connection.
5	Auxiliary Serial Data (XDA)	Can be used to connect other I2C modules to MPU6050. Optional.
6	Auxiliary Serial Clock (XCL)	Can be used to interface other I2C modules with MPU6050. Optional
7	AD0	If many MPU6050s are utilised in a single MCU, this pin can be used to change the address.
8	Interrupt (INT)	Interrupt pin to signify that data is ready for the MCU to read.

3.3.3 MAX30102 Oximeter and Heart Rate Sensor

The MAX30102 Oximeter and Heart Rate Sensor is a compact module widely used for measuring oxygen saturation (SpO2) levels and heart rate in various applications. It utilizes advanced algorithms, infrared (IR), and red LED lights to provide non-invasive and continuous monitoring of SpO2 levels. In addition to SpO2 measurement, the MAX30102 sensor can accurately detect and calculate heart rate using optical techniques. The module features integrated red and IR LEDs that emit light onto the skin, while photodetectors capture the reflected light for analysis. Ambient light cancellation technology ensures reliable and accurate readings even in varying lighting conditions.

The MAX30102 operates with low power consumption, making it suitable for portable and battery-powered applications. It communicates with microcontrollers or other devices using the I2C protocol, offering easy integration. The sensor's small form factor enables it to be seamlessly integrated into wearable devices, medical equipment, and fitness trackers. With adjustable sample rates, resolutions, and interrupt functionality, the MAX30102 sensor provides flexibility and customization options based on specific application requirements. The MAX30102 Oximeter and Heart Rate Sensor offer reliable and accurate measurements, making it a versatile choice for various health and wellness applications.

Table 3.3 Technical specifications of MAX30102[45]

Power supply	3.3V to 5.5V
Current draw	~600µA (during measurements)
	~0.7µA (during standby mode)
Red LED Wavelength	660nm
IR LED Wavelength	880nm
Temperature Range	-40˚C to +85˚C
Temperature Accuracy	±1˚C

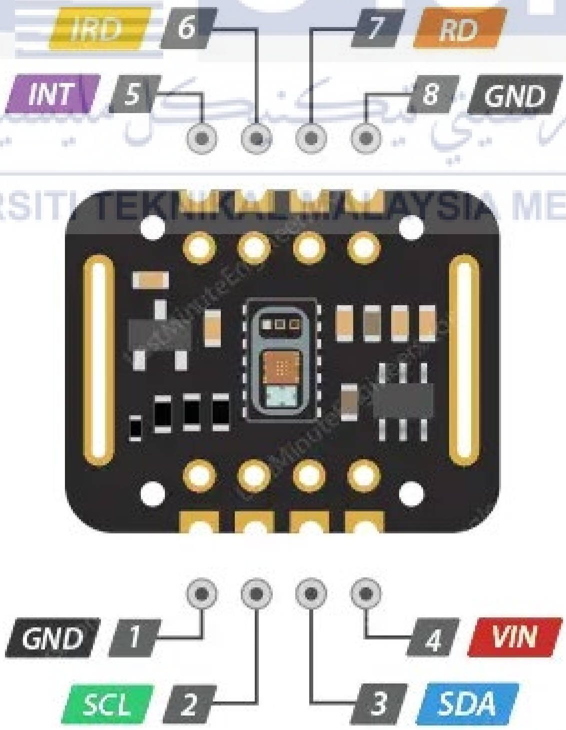


Figure 3.6 MAX30102 pinout[45]

3.3.4 LM2596 DC-DC Buck Converter Step Down Module Power Supply

The LM2596 DC-DC Buck Converter is a specialized electronic component designed for voltage regulation, particularly for stepping down voltage in various electrical applications. This device is commonly known as a DC-to-DC power converter or a buck converter. Its primary function is to lower a higher input voltage to a more manageable and lower output voltage, which is crucial in many electronic circuits where the supplied voltage needs to be adapted to the requirements of specific components.

The LM2596 converter operates by taking an input voltage, which can range from 4.5V to 40V, depending on the specific model, and then providing a regulated output voltage that is lower than the input. The output voltage of this module is adjustable within the range of 1.5V to 35V DC. This adjustability is facilitated by a high-precision potentiometer included in the module, allowing for fine-tuning of the output voltage to meet the specific needs of the application.[46]

A notable feature of the LM2596 is its capacity to handle a maximum output current of up to 3A, making it suitable for driving loads under this threshold. During the voltage step-down process, the current increases, which is a typical characteristic of buck converters. This feature is essential in applications where a specific current level is necessary for the operation of downstream components or systems. Additionally, the module is designed with efficiency in mind, ensuring that power is used effectively during the conversion process.[46]

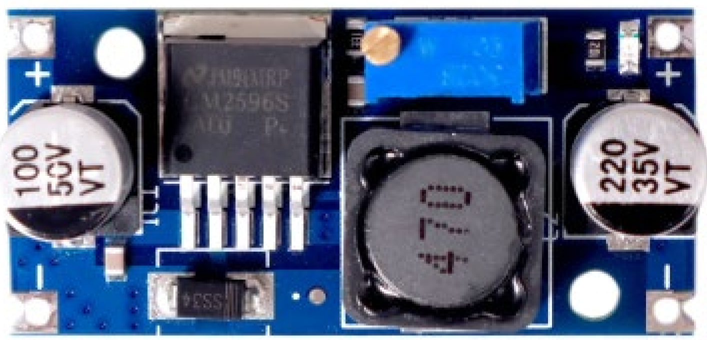


Figure 3.7 LM2596 DC-DC[46]

Table 3.4 Technical specifications LM2596 DC-DC Buck Converter[46]

Specification	Details
Type	Step-Down Voltage Regulator Module
Model	LM2596
Maximum Output Current	3A
Input Voltage Range	4.5V to 40V DC
Output Voltage Range	1.5V to 35V DC (Adjustable)
Output Power	15W maximum
Adjustable Output	Yes

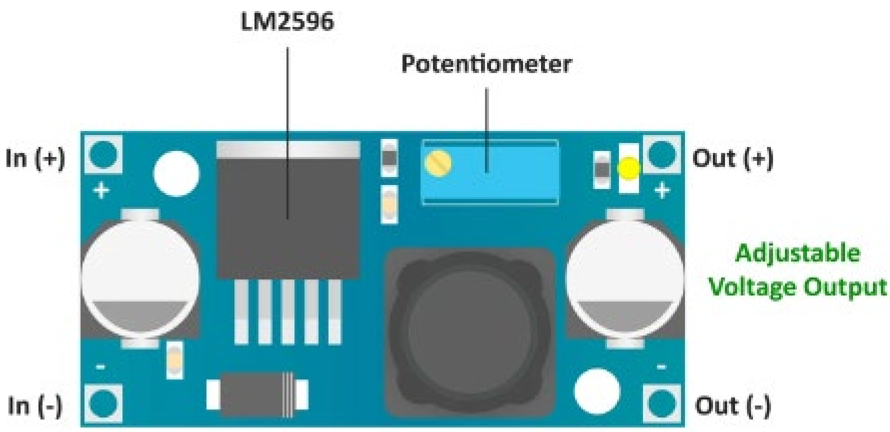


Figure 3.8 LM2596 DC-DC Buck Converter pinout[46]

3.3.5 Litium-ion Battery

The "INR" in its name stands for Lithium Nickel Manganese Cobalt, which describes the chemistry of the battery. This type of battery chemistry is known for providing a good balance of power density, safety, and longevity, making it a popular choice for many applications. The "185650" part of the name indicates the physical dimensions of the battery: 18mm in diameter and 65mm in length. The "0" at the end signifies that the battery is cylindrical in shape.[47]

A capacity of "2000mAh" (milliampere-hours) refers to the amount of charge the battery can hold. This capacity suggests how long the battery can run before needing to be recharged, depending on the power consumption of the device it's used in. The nominal voltage of "3.7V" is a standard value for lithium-ion batteries, indicating the average voltage the battery provides during discharge. "7.4Wh" (watt-hours) is a measure of the energy capacity of the battery. It's calculated by multiplying the voltage (in volts) by the capacity (in ampere-hours). This value gives an indication of how much energy the battery can store and deliver over time.[47]

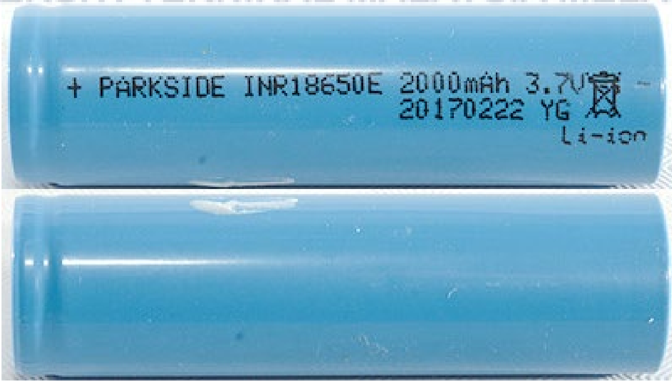


Figure 3.9 INR185650 2000mAh 3.7 7.4Wh Battery[47]

Table 3.5 Battery Specifications [47]

Specification	Detail
Battery Type	INR (Lithium Nickel Manganese Cobalt)
Model	185650
Capacity	2000mAh
Nominal Voltage	3.7V
Energy	7.4Wh
Form Factor	Cylindrical
Dimensions	18mm diameter x 65mm length

3.3.6 Donut Board

The Donut Board, a specialized type of prototyping board used in electronics, is particularly valuable when transitioning from early-stage designs on a solderless breadboard to more permanent circuit construction. Named for the donut-like shape of the soldering holes or pads on its surface, this board features individual copper rings around each hole, ensuring isolated and customizable connections for electronic components. Typically, these boards are made from Paper Phenolic, a material known for its durability, and the holes are spaced 100mil or 2.54mm apart, aligning with the standard pitch for many electronic components.

A large Donut Board might contain around 96 columns and 35 rows, totaling 3360 holes, providing ample space for assembling complex circuits. This density of holes, all plated through, is ideal for through-hole components, which are a mainstay in various electronic projects. Unlike stripboards that have continuous copper strips to connect components, the Donut Board's design necessitates manual creation of connections using copper wire. This requirement affords the user greater flexibility in circuit layout, allowing for custom wire routing in complex or non-linear designs, a feature that can be particularly beneficial in advanced or experimental projects.

Figure 3.10 Donut Board 10x24cm[48]

Table 3.6 Donut Board Specifications [48]

Specification	Detail
Type	Donut Board (Prototyping Board)
Material	Paper Phenolic
Hole Spacing	100mil or 2.54mm
Number of Holes	96 columns x 35 rows (3360 Holes)
Hole Characteristics	Individual copper per hole, plated through
Dimensions	10cm x 24cm
Connection Method	Requires copper wire for connections
Circuit Customization	High flexibility for circuit layout

3.3.7 Designing a Custom Project Casing

Designing a custom project casing for a health monitoring device using Tinkercad 3D involves several thoughtful steps to ensure functionality and ease of use. First, understanding the dimensions of the MPU6050 and MAX30100 sensors, as well as any additional components, is crucial for a snug fit. Tinkercad, being user-friendly and accessible, is ideal for modeling the casing. The design process starts with sketching the base, ensuring enough room for both sensors and considering their optimal orientation. It's important to incorporate specific slots for the sensors and pathways for wiring, along with cutouts for any user interface elements like buttons or displays.

Special attention should be given to the MAX30100 sensor to ensure its skin-contacting part remains exposed, and overall design should facilitate ventilation to prevent overheating. The casing should also be designed for easy assembly and maintenance, possibly using snap-fit parts or screw holes. After completing the design in Tinkercad, the files can be exported for 3D printing. Testing the prototype with the actual components is crucial, as it may require iterations to perfect the design, considering fit, accessibility, and sensor functionality.

Table 3.7 Explanation for each case part

Part (Figure)	Explanation
3D Casing for ESP32 and Battery Compartment	A custom-designed 3D printed casing specifically made to house an ESP32 module along with a compartment for its power source, which is typically a battery. The design ensures that the ESP32, a popular Wi-Fi and Bluetooth microcontroller, is protected and can be easily integrated into various projects, especially those requiring mobility or wireless connectivity.
3D Pulse Oximeter Clip for MAX30100 Board Sensor	A 3D printed clip designed to hold the MAX30100 sensor, which is used for measuring blood oxygen saturation (SpO2) and heart rate. The clip is probably designed to be attached to a finger or earlobe, enabling the sensor to detect blood flow changes for monitoring

	vital signs. This setup is commonly used in health monitoring and medical applications.
3D Accelerometer Case for MPU6050 Board Sensor	A 3D printed case meant to enclose the MPU6050 sensor board, a popular accelerometer and gyroscope module. The case is designed to protect the sensor and possibly to facilitate its attachment or positioning in various applications, such as motion tracking, gesture recognition, or stabilization.

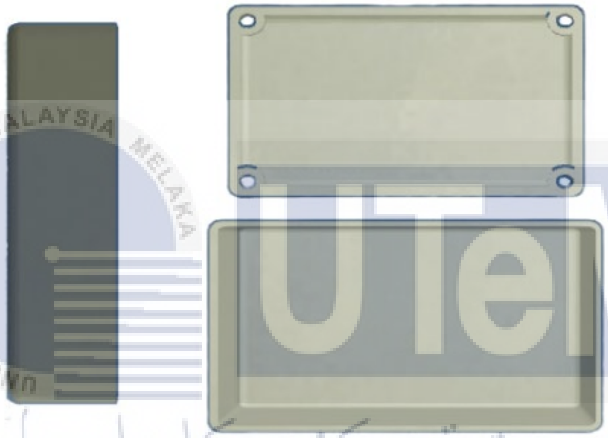


Figure 3.11 3D Casing for ESP32 and battery compartment

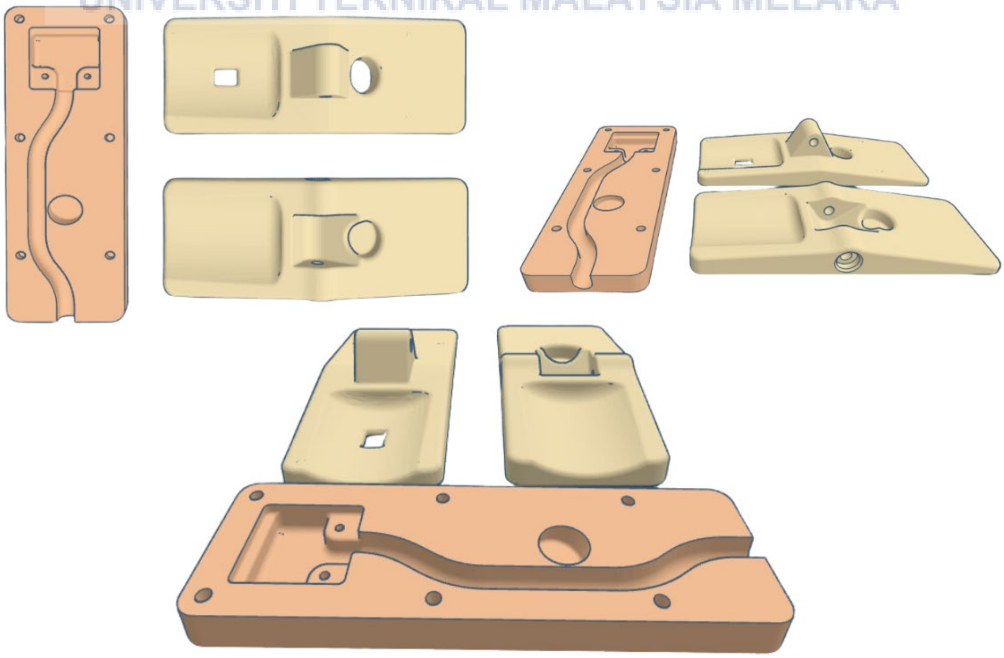


Figure 3.12 3D Pulse Oximeter Clip to use with MAX30100 Board Sensor

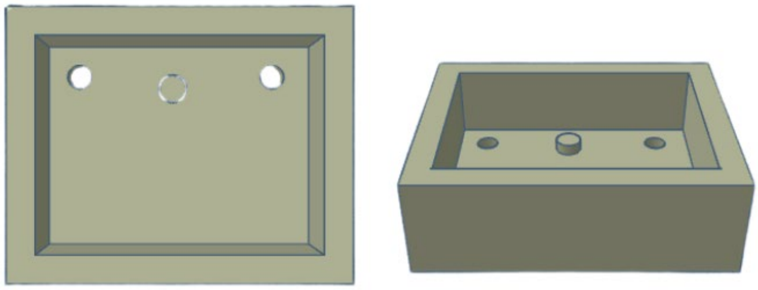


Figure 3.13 3D Accelerometer Case to use for MPU6050 Board Sensor

3.4 Software Requirements

When it comes to developing this project, there are numerous options for selecting the most appropriate software; which is because software selection is dependent on the specific needs of the project.

3.4.1 Blynk Application V2.0

This application is designed for the Internet of Things and is one of the IoT platforms. The critical components of this platform are the Blynk app, the Blynk server, and the Blynk library. Using several widgets from the Blynk library, users may design visually appealing interfaces for displaying real-time monitoring and alert notifications. The Blynk server is responsible for communication between the smartphone and the Hardware. At the same time, the Blynk library is responsible for communication with the server and all input/output instructions for the system. The relevance of Blynk in this strategy is that Caregiver or Doctor can monitor and may get alerts on data from the Hardware.

Table 3.8 Creating account on Blynk

Assign	**Description**
Visit the Blynk Website	Go to https://blynk.io/ in your web browser.
Find the Sign-Up Option	Look for a button or link that says "Sign Up" or "Get Started" on the Blynk homepage.
Enter Your Details	Fill in your details such as email, password, and possibly your name or company.
Agree to Terms and Conditions	Read and agree to the terms and conditions and the privacy policy by checking the corresponding box.
Verification	Check your email for a verification message from Blynk and click the link to activate your account.
Download the App (Optional)	If using a smartphone, download the Blynk app from the Google Play Store or Apple App Store.
Log In and Start Using Blynk	Log in to your new Blynk account with your email and password to begin exploring its features.

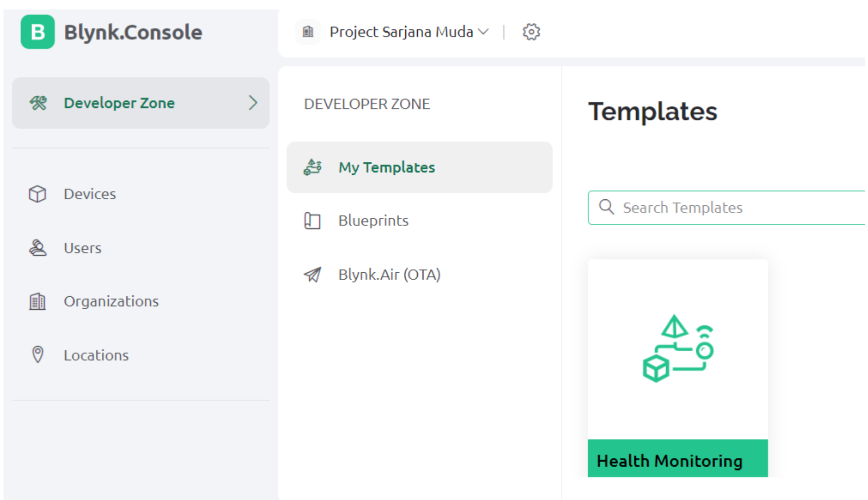


Figure 3.14 Developer Zone to create template and edit widget in Dashboard

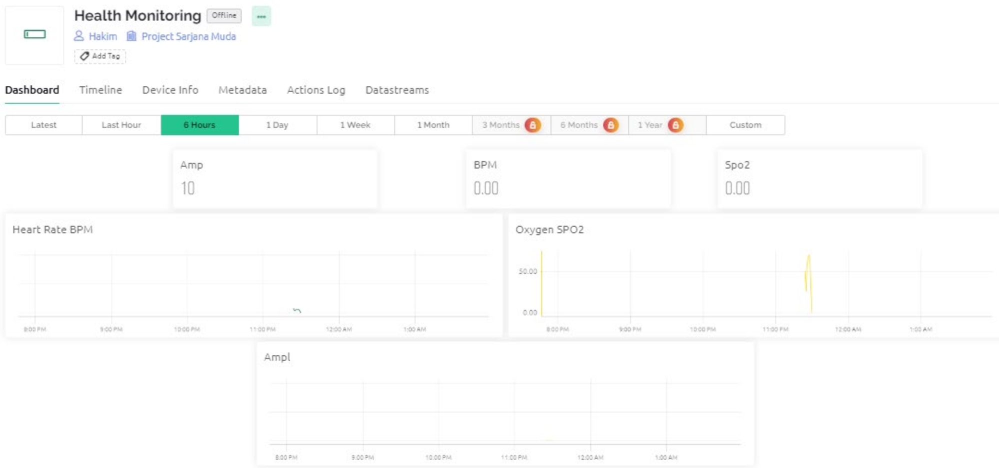


Figure 3.15 Blynk Dashboard Cloud Console showing real- time data recorded in Blynk cloud [49]

3.4.2 Arduino IDE

The integrated development environment (IDE) of Arduino is a Java programme that has several levels. The IDE is used to process the programming language and connections. It includes a code editor with text copying and pasting, text finding and replacement, automatic indentation, code navigation aid, and syntax highlighting. It also features a one-click feature for uploading code to an Arduino board. As the project progresses, the sketch programmes are saved as text files on the development machine. The Arduino IDE employs unique code organisation techniques and supports programming languages such

as C and C++.

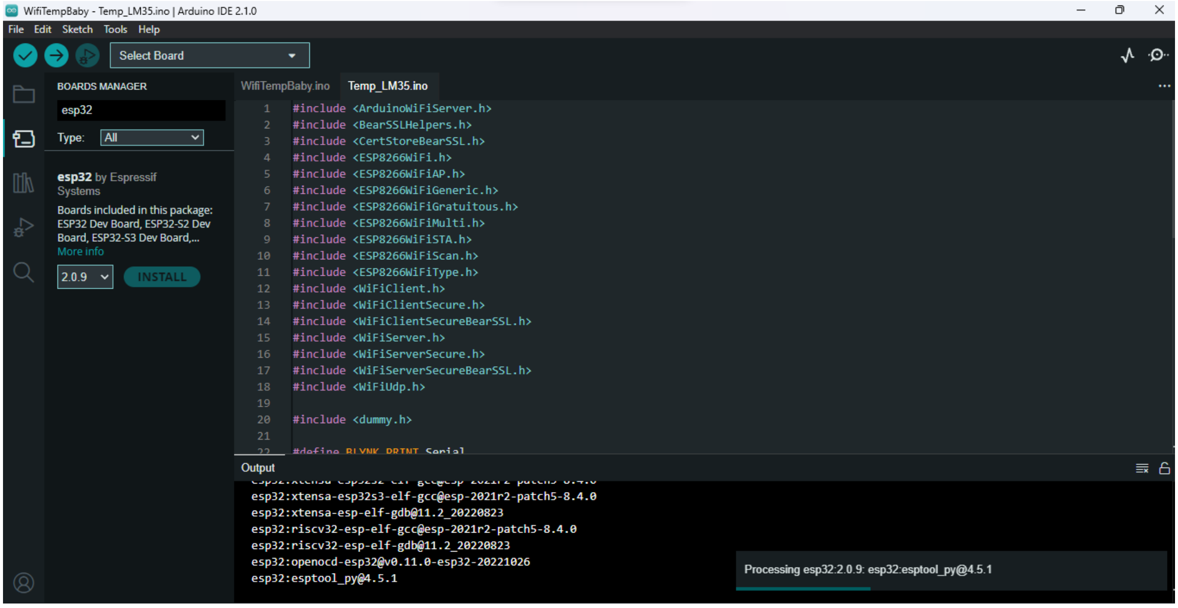


Figure 3.16 Arduino IDE Dashboard[50]

Table 3.9 IDE Libraries [50]

Fall Detection		
Sensors	Library	Purpose
MPU 6050	Adafruit_MPU6050	Designed for interfacing with the MPU6050 sensor module, a popular and versatile motion-tracking device. This library is typically used in projects involving microcontrollers, like those from the Arduino or Adafruit families The MPU6050 combines a 3-axis gyroscope and a 3-axis accelerometer. The library provides a simplified way to interact with these sensors, handling the complex communication protocols and data processing needed to use the MPU6050.
Heart Rate & Blood Oxygen Saturation Level		
MAX30100	Arduino-	The library provides a set of functions and methods to

	MAX30100-master	easily interface with the MAX30100 sensor. This includes initializing the sensor, setting parameters, and reading sensor data The primary function of the library is to enable the Arduino to read data from the MAX30100 sensor. This includes heart rate (beats per minute) and SpO2 (blood oxygen saturation levels)
	I2C Protocol	
	Adafruit_BusIO	The Adafruit_BusIO library provides a unified interface for different communication protocols like I2C (Inter-Integrated Circuit), SPI (Serial Peripheral Interface), and potentially others. This standardization simplifies the process of writing code to interact with various sensors and devices
	Blynk	
	BlynkNcpDriver	The BlynkNcpDriver library is a low-level driver for Arduino boards, providing a shared interface to the services offered by Blynk.NCP. It's compatible with all Arduino architectures and is used for facilitating communication with the Blynk platform, commonly employed in IoT applications

3.4.2.1 Explaination On Fall Detection Coding Using MPU6050 Sensor

This code snippet is designed to detect falls using an MPU6050 accelerometer with an Arduino(ESP-32). This code effectively uses a multi-stage approach to detect a fall, involving threshold-based detection and orientation change analysis.

Table 3.10 MPU6050 coding explaination

Variable/Function	Detailed Description
MPU_addr	The I2C address for the MPU-6050 sensor, allowing communication between the sensor and the microcontroller.
AcX, AcY, AcZ, Tmp, GyX, GyY, GyZ	Raw data variables for the accelerometer (AcX, AcY, AcZ) and gyroscope (GyX, GyY, GyZ), plus a temperature reading (Tmp).
ax, ay, az, gx, gy, gz	Processed acceleration and gyroscope data. Calibration offsets are applied to raw data to obtain these values.
fall, trigger1, trigger2, trigger3	Boolean flags used to track the fall detection process: fall indicates a fall event, trigger1-trigger3 are stages in detecting the fall.
trigger1count, trigger2count, trigger3count	Counters to track the duration for which each trigger has been active, helping in determining the progression of a potential fall event.
angleChange ‘if (angleChange >= 30 && angleChange <= 400)’	Stores the magnitude of angular change based on gyroscope data, used in determining the orientation change during a fall.
send_mpu() Function	Main function to process the data from the MPU6050

	sensor and run the fall detection algorithm. It performs data reading, processing, and implements the logic of the fall detection mechanism.
Fall Detection Logic	A multi-stage logic using sensor data. Trigger 1 checks for a sudden decrease in amplitude (potential fall initiation), Trigger 2 checks for a subsequent increase (indicative of impact), and Trigger 3 assesses the change in orientation (concluding a fall event).
Trigger Activation/Deactivation 'trigger2 = true;' 'if (trigger2 == true)'	Triggers are activated based on specific sensor data thresholds. They are deactivated if the subsequent conditions aren't met within a specified duration, indicated by their respective counters.
Blynk Integration 'Blynk.logEvent("fall_event");'	Code segments (commented out) for integrating with the Blynk platform, indicating the intent to send notifications or log events on a connected app when a fall is detected.
Resetting Triggers 'triggerXcount' 'if (trigger2count >= 6)'	Logic to reset the trigger conditions if a complete fall sequence is not detected, ensuring the system is ready to detect subsequent fall events.

3.4.2.2 Explaination On Heart Rate & Oxygen Level (Sp02) Coding Using MAX30100 Sensor

This code is designed to measure heart rate and blood oxygen levels (SpO2) using the MAX30100 sensor with an Arduino, integrated with the Blynk platform for IoT applications

Table 3.11 MAX30100 Coding Explaination

Component/Function	Explanation
PulseOximeter pox	Object for interfacing with the MAX30100 sensor.
float BPM, SpO2	Variables to store Heart Rate (BPM) and SpO2 (oxygen saturation) levels.
uint32_t tsLastReport	Timestamp variable for tracking last data report time.
BlynkTimer timer	Timer object for scheduling regular tasks.
onBeatDetected()	Callback function that triggers when a heartbeat is detected. Prints a message to the serial monitor.
setup()	Initializes serial communication, Blynk, and MAX30100 sensor settings. Also sets up the I2C communication for MPU6050 (if used) and configures a timer for send_mpu function.
loop()	Main loop running Blynk functions, updating sensor readings, and reporting heart rate and SpO2 data to Blynk and Serial Monitor.
pox.update()	Updates the MAX30100 sensor readings.
Blynk.virtualWrite(V3, BPM); Blynk.virtualWrite(V4,	Sends the BPM and SpO2 data to the Blynk server for remote monitoring.

SpO2);	
Serial.print Statements	Prints heart rate and SpO2 readings to the Serial Monitor for debugging.
delay(10)	Short delay to stabilize the loop execution.

3.4.2.3 Explaination Blynk Platform Integrate With Codings

The provided code integrates with the Blynk platform, by utilizing a Blynk authentication token to establish a secure connection with the Blynk server.

Table 3.12 Blynk Coding Integration

Code Component	Integration with Blynk
BLYNK_AUTH_TOKEN	Authentication token for connecting to the Blynk server.
Blynk.virtualWrite(V3, BPM)	Sends heart rate data to Blynk's virtual pin V3.
Blynk.virtualWrite(V4, SpO2)	Sends oxygen saturation data to Blynk's virtual pin V4.
Blynk.virtualWrite(V0, Amp)	Sends amplitude data from accelerometer to Blynk's virtual pin V0.
Blynk.logEvent("fall_event")	Logs fall events in the Blynk app for monitoring/alerts.
BlynkTimer	Manages scheduling of tasks like sending data to Blynk.
Blynk.run() and timer.run()	Maintains connection with Blynk and executes scheduled tasks.
Commented Out Blynk	Suggests potential for sending alerts/emails

Notifications	through Blynk.

3.4.3 TinkerCad 3D

TinkerCAD, a popular online 3D modeling program, serves as a highly accessible platform for users ranging from beginners to those with moderate experience in 3D design. The primary function of TinkerCAD lies in its user-friendly interface, making it an ideal tool for educational purposes and amateur design projects. Unlike more complex 3D modeling software, TinkerCAD simplifies the design process, allowing users to create models using basic shapes and straightforward tools. A key aspect of TinkerCAD is its accessibility.

Figure 3.17 Autodesk Tinkercad logo

Being a web-based application, it eliminates the need for powerful computing resources, thus making 3D modeling more accessible to a wider audience. This feature is particularly beneficial in educational settings, where resources might be limited. Students can easily learn the basics of 3D design without the steep learning curve often associated with more advanced software. Another significant function of TinkerCAD is its integration with 3D printing technology. Users can design objects in TinkerCAD and then export them in a format suitable for 3D printing. This seamless integration encourages hands-on learning and experimentation, as users can bring their digital designs into the physical world.

3.5 The Working Flow of The System

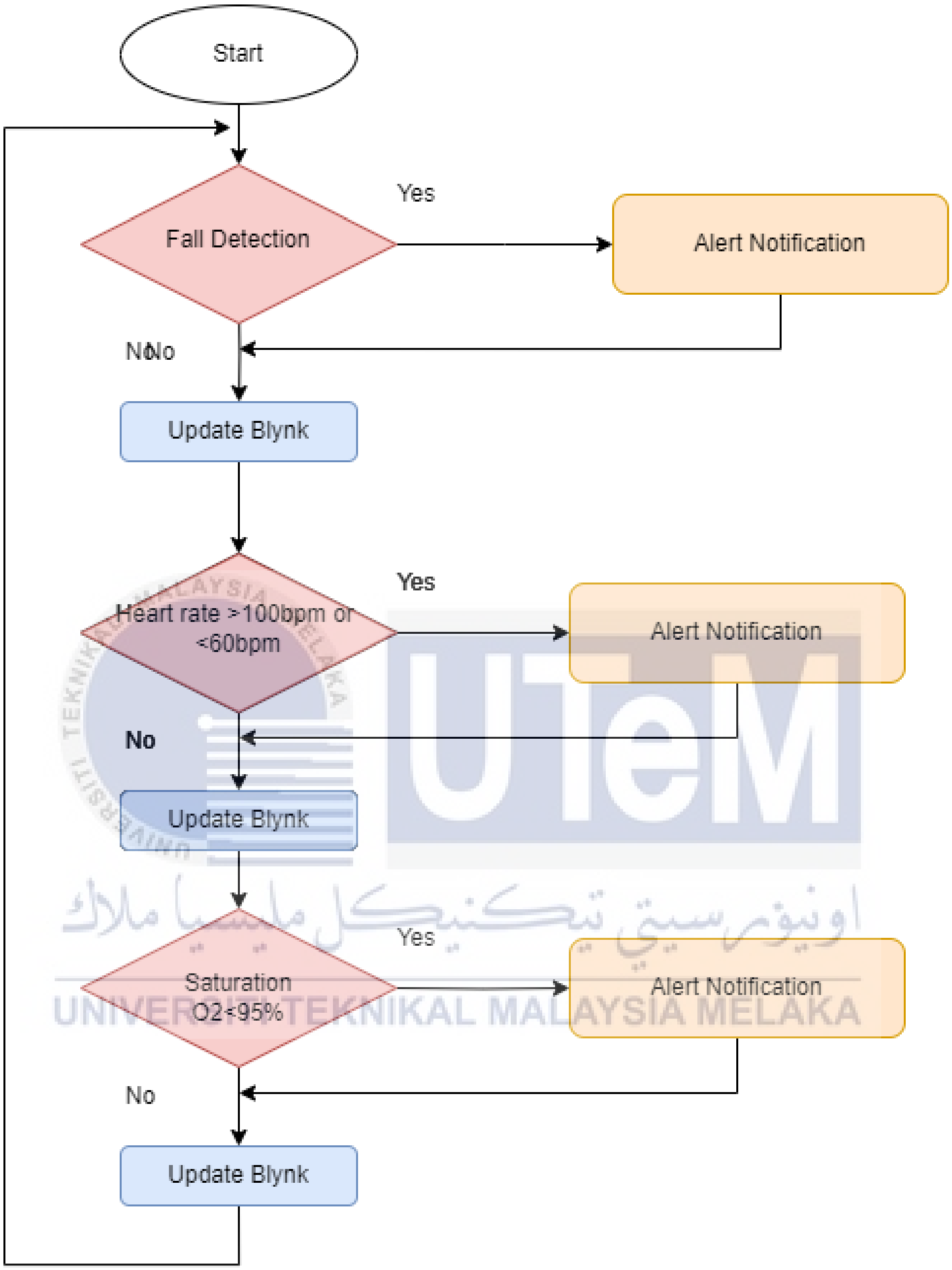


Figure 3.18 Flowchart of the system

Figure 3.9 shows the flowchart related to the purpose of an IoT- based real-time health monitoring for the elderly. First, the system will begin to initialize the ESP32 wifi and all sensors used. All sensors will detect the parameter they design for. For fall detection, whenever a fall is detected, the system will display it in the Blynk app and alert the caregiver by sending out notification. For heart rate and Spo2 detection. The sensor will detect the finger and calculate the saturation of oxygen and heart rate. The system will alert if the certain value exceed the thereshold value. The system will continuously monitor each real-time data and save the data in blynk cloud.

3.6 Summary

This chapter presents the methods used to achieve this work's goals. The project's workflow is presented in a flowchart to give a clear view of the process. The software and hardware involved in this work are also presented. The expected result of monitoring the fall detection, heart rate and oxygen saturation in blood through BLYNK can be display in the application and related data are disscused in this chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter delves into the pivotal findings of our project, "Development of a Real-Time Health Monitoring System for the Elderly Using IoT." The project's cornerstone is the integration of two advanced sensors: the MPU6050 for detecting falls, and the MAX30100 for monitoring heart rate and oxygen levels. This system aims to enhance elderly care by providing continuous, real-time health monitoring using Blynk App, thereby ensuring timely medical interventions when necessary. Here, we meticulously analyze the data gathered from these sensors, evaluate the system's performance, and discuss its implications in the broader context of elderly healthcare. By scrutinizing our system's functionality, reliability, and overall effectiveness, we endeavor to highlight its potential as a transformative tool in the realm of geriatric care, offering insights into its real-world applicability and future prospects.

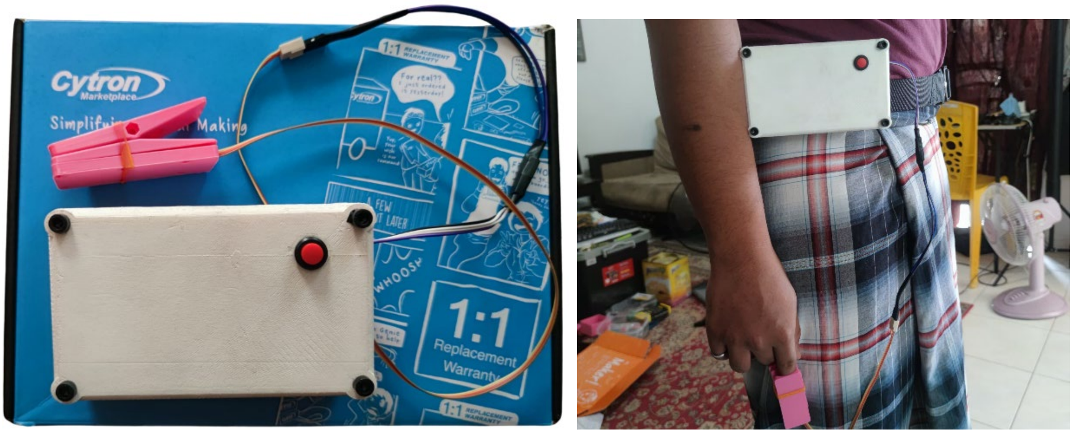


Figure 4.1 The Device Position in waist harness with belt and point finger for measuring heart rate and oxcygen level.

4.2 Results and Analysis

4.2.1 Experiment Setup for Data Collection

This results study employed a dual-experimental approach to refine and validate our algorithm: one focusing on simulated falls and the other on Activities of Daily Living (ADLs). We engaged 3 participants (2 males, 1 females), ranging in age from 23 to 60 years and weighing between 52 to 106 kg. The monitoring system was strategically placed on the right side of each subject's waist for optimal data acquisition not only recorded movement data but also continuously monitored heart rate and oxygen levels to provide a comprehensive health profile during each scenario. For the fall simulation, we designed a comprehensive set of scenarios encompassing various fall types—forward, backward, and sideward (right and left),. To ensure robust data, each participant enacted each fall type cumulating in a total of 5-7 simulated falls per subject.

4.2.2 Accuracy Of Detecting Fall Event

In parallel, the Activities of Daily Living (ADL)'s component encompassed four common activities: walking, lying down, sitting, and resting. This was to ensure the system's efficacy in distinguishing between normal daily movements and fall-like motions. The data collection was get from Blynk cloud and IDE Serial Monitor. The criteria were analyzed and determined using a subset of data gathered from 3 participants. For the purpose of assessing the algorithm's sensitivity and specificity, the remaining data are being utilized for validation. The experiments provided the basis for data collection.

Fall Detection Logic:

- **Lower Threshold (Trigger 1)**: If the amplitude is below a certain threshold (5 in this case), it's considered as the first trigger of a potential fall.
- **Upper Threshold (Trigger 2)**: Following Trigger 1, if the amplitude exceeds another threshold (6 or higher), it indicates a sudden change in motion, like a fall.
- **Orientation Change (Trigger 3)**: The code then checks for a significant change in orientation, which is inferred from the gyroscope data. If the orientation change is within a certain range (between 10 and 360 degrees), it triggers the third and final indicator of a fall.
- **Fall Confirmation**: A fall is confirmed if, after the third trigger, the orientation remains relatively stable (between 0 and 10 degrees change).

Table 4.1 Explaination on Fall Event and non Fall Event alert

Experiments	Scenarios	Fall Alerts
Falls Event	Forward Fall	21
	Backward Fall	30
	Leftward Fall	19
	Rightward Fall	22
Activities of Daily Living (ADL). Non Fall Event	Walking	9
	Lying down	10
	Sitting	7
	Resting	9

4.2.2.1 Fall Event Detection Mechanism

Amplitude Calculation from Accelerometer Data:

- The MPU6050 sensor continuously calculated motion along three axes: x (ax), y (ay), and z (az), to get the value of the amplitude.
- The system calculates the amplitude of motion by combining these three axis readings. The formula used is the square root of the sum of the squares of ax, ay, and az. This amplitude represents the intensity of the motion at any given moment.

Fall Event Trigger Criteria:

- A fall event is detected based on specific criteria set in the code. This involves a sudden increase in the calculated calculated amplitude was based on calculation on ax ay and az axis point , indicating a rapid and unusual movement, akin to a fall.
- Upon creating new value from calculatedThe code specifies threshold values for amplitude changes. When these thresholds are surpassed, it signals a potential fall. For instance, a sudden increase in amplitude to a value significantly higher than the regular motion readings is an indicator of a fall.

Recording and Notification of Fall Events:

- Upon detecting a fall, the system immediately records the event. This recording includes the time of the fall and the amplitude readings at that moment.
- Simultaneously, the ESP32, which is the central processing unit of the system, sends a Blynk.logEvent to the Blynk application. This function it triggers a real-time notification to the user's mobile device through the Blynk app.
- The accuracy of the fall detection system is primarily contingent on the sensitivity and precision of the MPU6050 accelerometer. By carefully calibrating the threshold levels for amplitude changes, the system achieves a high degree of

accuracy in distinguishing falls from normal daily activities. The reliability of the system is further enhanced by the algorithm's ability to analyze the pattern of motion. It's not just the intensity of the motion (amplitude) but also the nature of the motion change that is considered,

Table 4.2 Fall Event Trigger from axis accelerometer to amplitude value

Function	Role in code

Reading data from Accelerometer sensor	`ax = (AcX - 2050) / 16384.00;`
	`ay = (AcY - 77) / 16384.00;`
	`az = (AcZ - 1947) / 16384.00;`
	`gx = (GyX + 270) / 131.07;`
	`gy = (GyY - 351) / 131.07;`
	`gz = (GyZ + 136) / 131.07;`

Calculating Amplitude vector for 3 axis	`float Raw_Amp = pow(pow(ax, 2) + pow(ay, 2) + pow(az, 2), 0.5);` `int Amp = Raw_Amp * 10`
Amp value calculated and sent to the Blynk virtual pinout(V0,Amp)	`Serial.println(Amp);` `Blynk.virtualWrite(V0, Amp);`

4.2.3 Accuracy Of Measuring Heart Rate and Oxygen Level

The code provided implements a health monitoring system that measures heart rate (BPM) and blood oxygen levels (SpO2) using the MAX30100 Pulse Oximeter sensor. This sensor is a reliable and accurate tool for non-invasive cardiovascular and respiratory monitoring. It uses IR and red LEDs to detect changes in blood color, which correlate with heartbeats and oxygen saturation. The accuracy of the MAX30100 in measuring heart rate and SpO2 is quite high under steady-state conditions. However, its precision can be influenced by several factors including movement, ambient light, and the positioning of the sensor on the body. The actual calculations are typically embedded within the sensor's firmware and the accompanying library

Heart Rate (BPM) Measurement:

1. **Photoplethysmography (PPG) Signal**: The MAX30100 uses a method called photoplethysmography to detect blood volume changes in the microvascular bed of tissue. It emits light from LEDs (one infrared and one red) and measures how much light is absorbed by the blood.
2. **Detecting Pulse**: The sensor detects the pulse by observing the changes in light absorption. Each heartbeat increases blood flow to the finger, wrist, or earlobe (common measurement points), which leads to a slight increase in light absorption.
3. **Calculating Beats Per Minute**: The time interval between successive heartbeats is measured. The heart rate in beats per minute is then calculated by counting the number of beats over a specific time period (usually a minute) or converting the time interval between beats into a rate per minute.

SpO2 (Blood Oxygen Saturation) Measurement:

1. **Red and Infrared Light Absorption**: SpO2 measurement is based on the different absorption rates of red and infrared light in oxygen-rich vs. oxygen-poor blood. Oxygenated hemoglobin absorbs more infrared light and allows more red light to pass through, while deoxygenated hemoglobin absorbs more red light and allows more infrared light to pass through.
2. **Ratio Calculation**: The sensor measures the absorption of both wavelengths of light, and the microcontroller or a processing algorithm calculates the ratio of these absorptions.
3. **Deriving SpO2**: The calculated ratio is then converted into an SpO2 percentage using an empirical formula derived from calibration with known SpO2 levels. This

formula is based on the varying absorption characteristics of oxygenated and deoxygenated blood.

Table 4.3 Accuracy measuring & positioning

Position of MAX30100 Sensor	Accuracy
Point finger	96.77%

Table 4.4 Coding usage for measuring heart rate (BPM) and SpO2

Function / Component	Role in Code
MAX30100 Pulse Oximeter Library	Facilitates communication between the microcontroller and the MAX30100 sensor.
‘pox.begin()’	Initializes the sensor (pox.begin()) and sets up necessary configurations at the start (setup()) of the program.
‘pox.update()’	Continuously refreshes and updates the heart rate and SpO2 data from the sensor in the main loop (pox.update() in loop()).
‘pox.getHeartRate()’	Retrieves the latest heart rate measurement (BPM = pox.getHeartRate()) from the sensor after each update.
‘pox.getSpO2()’	Retrieves the latest SpO2 measurement (SpO2 = pox.getSpO2()) from the sensor after each update.
‘pox.setOnBeatDetectedCallback ()’	Sets a callback function (pox.setOnBeatDetectedCallback(onBeatDetected)) to log when a heartbeat is detected, used

	in setup().

4.2.4 Blynk Application Alert Fall Detection, Heart Rate and Oxygen Level Sp02

The ESP32, serving as the project's nerve center, was programmed to communicate with both the MAX30100 and MPU6050 sensors. These sensors shared the SDA and SCL pinouts, leveraging the I2C communication protocol. This setup allowed each sensor to operate on its unique address, ensuring that the data from the heart rate monitor and the accelerometer could be accurately captured and transmitted without interference. Through Blynk, the data collected by the ESP32 is presented in an accessible, easy-to-understand format.

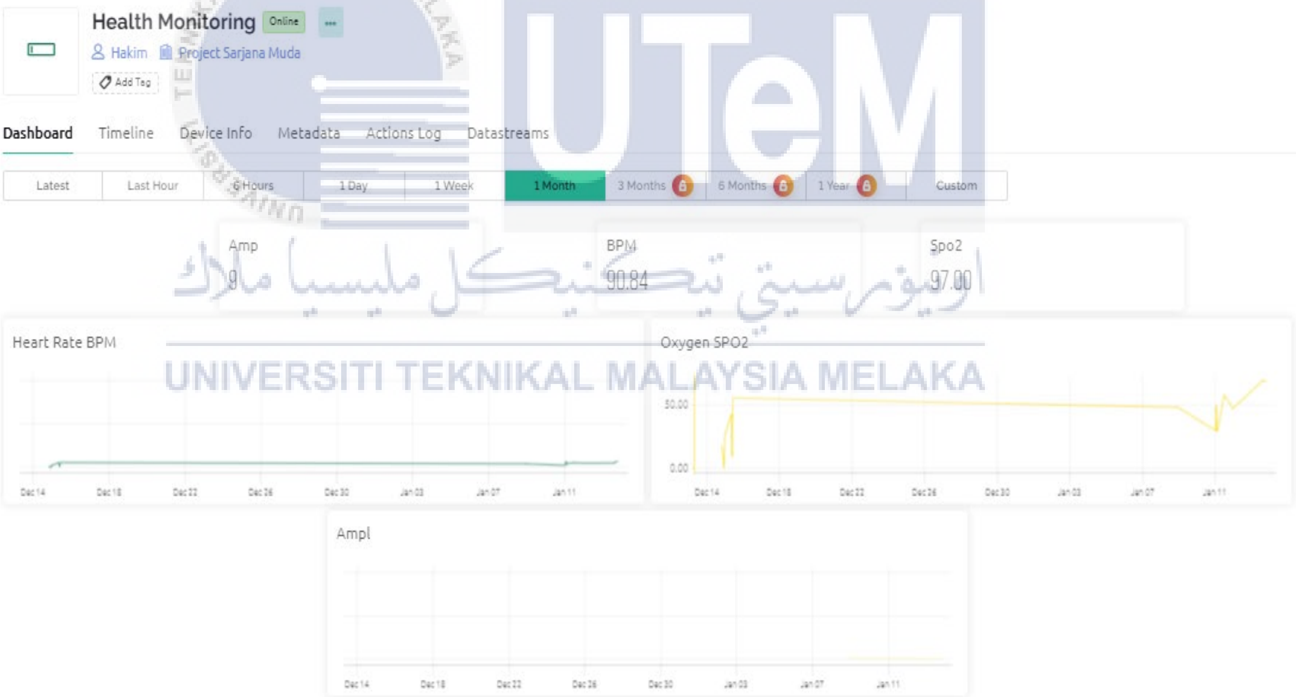


Figure 4.2 Web Dashboard value sync to mobile app.

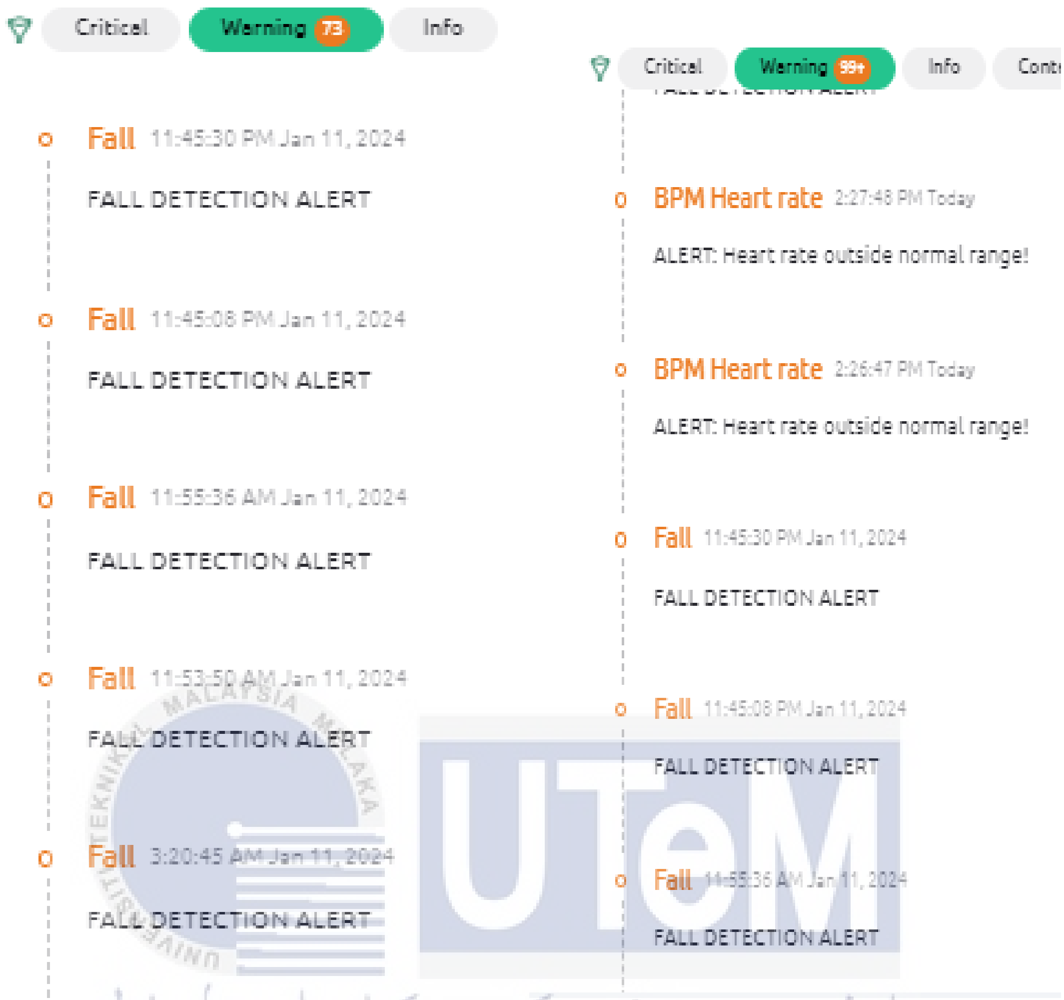


Figure 4.3 Timeline Dashboard show warning sent to the users.

- **Fall Detection Alert**: A prominent alert section at the top, highlighted the value when a AMP value is high (fall detected).
- **Heart Rate Graph**: Below the alert section, a dynamic line graph shows the heart rate over time.
- **Oxygen Saturation (SpO2) Graph**: Adjacent to the heart rate graph, another line graph displays the SpO2 levels

4.2.5 Flow Of Blynk App Trigger Notifications.

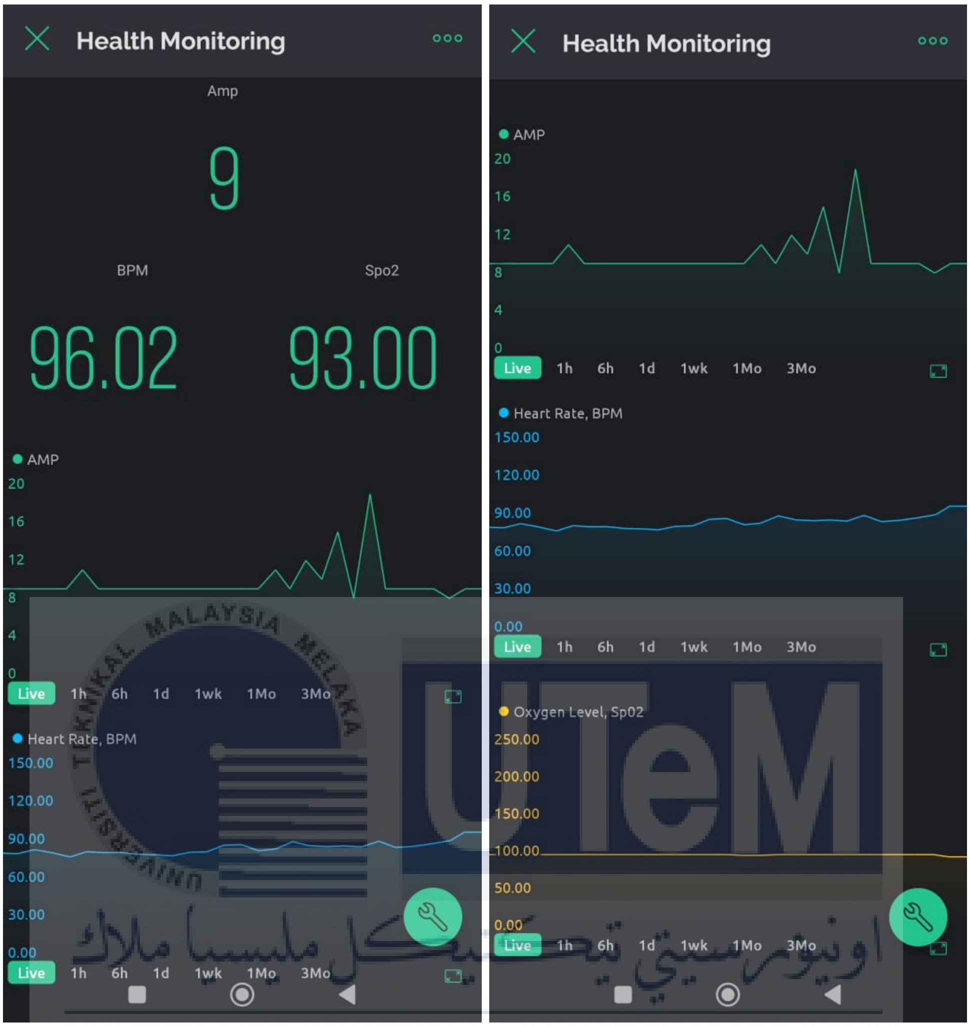
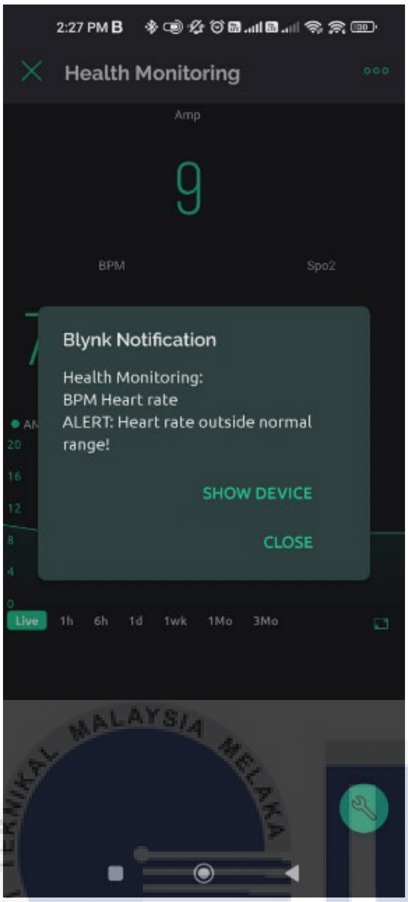
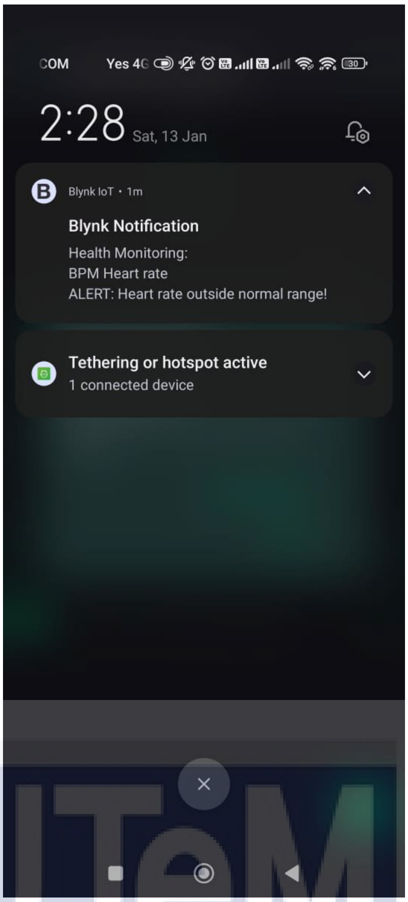
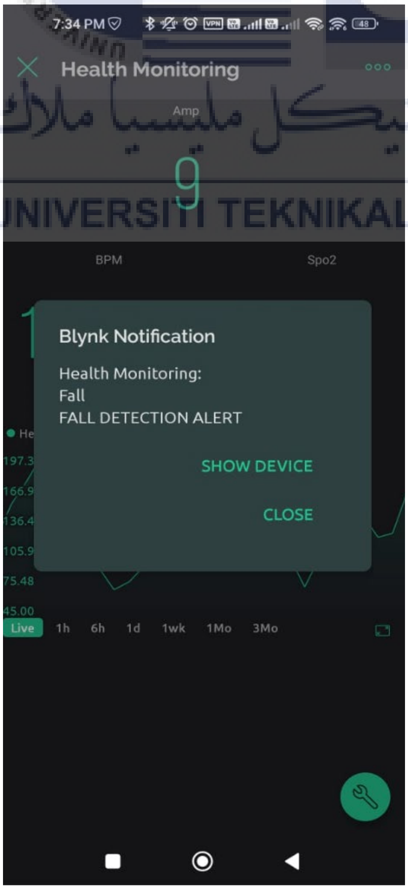
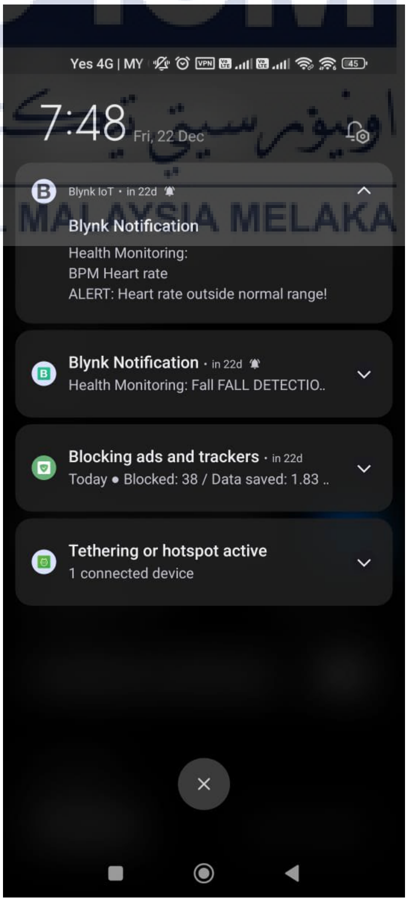


Figure 4.4 Blynk Appication in smartphone user inrterface shows value and graphical graph.


Health Monitoring
Amp
9
BPM
Spo2
Blynk Notification
Health Monitoring:
BPM Heart rate
ALERT: Heart rate outside normal range!
SHOW DEVICE
CLOSE
Live
1h
6h
1d
1wk
1Mo
3Mo


2:28 Sat, 13 Jan
Blynk IoT • 1m
Blynk Notification
Health Monitoring:
BPM Heart rate
ALERT: Heart rate outside normal range!
Tethering or hotspot active
1 connected device


7:34 PM
Health Monitoring
Amp
9
BPM
Spo2
Blynk Notification
Health Monitoring:
Fall
FALL DETECTION ALERT
SHOW DEVICE
CLOSE
Live
1h
6h
1d
1wk
1Mo
3Mo


Yes 4G | MY
7:48 Fri, 22 Dec
Blynk IoT • in 22d
Blynk Notification
Health Monitoring:
BPM Heart rate
ALERT: Heart rate outside normal range!
Blynk Notification • in 22d
Health Monitoring: Fall FALL DETECTIO..
Blocking ads and trackers • in 22d
Today • Blocked: 38 / Data saved: 1.83 ..
Tethering or hotspot active
1 connected device

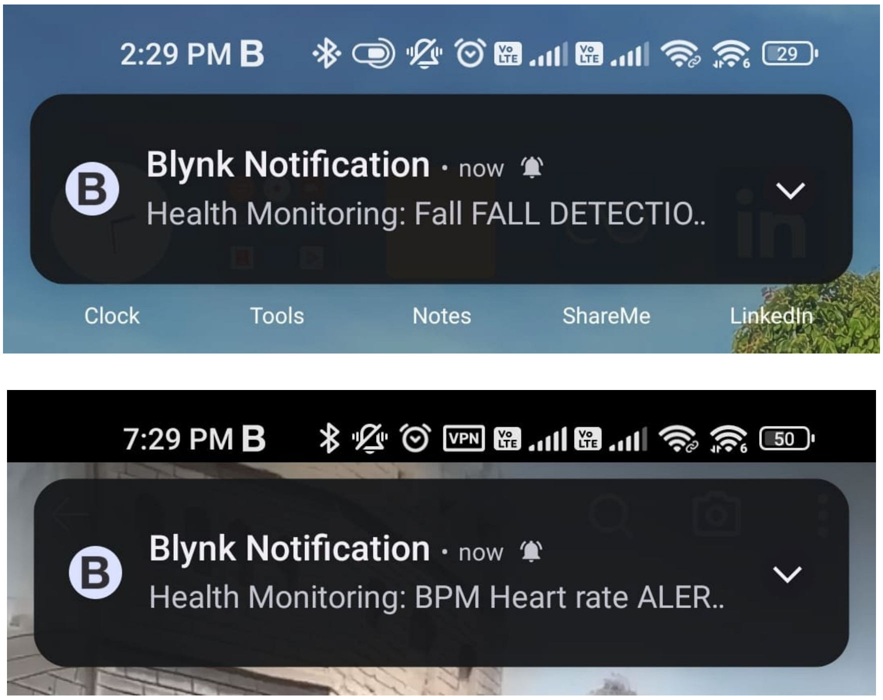


Figure 4.5 Blynk Application notification notify user when fall detection, heart rate and oxygen level meets threshold.

- **Shared I2C Connection**: Both the MAX30100 and MPU6050 sensors are connected to the ESP32 via a shared I2C bus. Sharing the same SDA (Serial Data) and SCL (Serial Clock) pins, these sensors operate due to distinct I2C addresses, allowing the ESP32 to communicate with each sensor individually.
- **Data Acquisition and Timing**: The ESP32, retrieves data from both sensors at different clock speeds. This ensures timely data reading and writing, in accordance with the programmed code.

4.2.6 Detailed Analysis of Fall Detection, Heart Rate, and Oxygen Saturation Levels Across Three Participants

This section provides an in-depth analysis of three key health metrics - fall detection, heart rate, and oxygen saturation levels - as monitored and recorded from eight individuals participating in the study. The focus is on examining the effectiveness of the fall detection mechanism and the accuracy of heart rate and oxygen saturation readings. This comprehensive evaluation aims to validate the reliability and efficiency of the health monitoring system in real-world scenarios, encompassing a diverse range of participants.

Table 4.5 Investigation Phase

Time of Data Collection	Duration of Research	Commencement Date	Conclusion Date
24 Hours	4 Days	29/12/2023	1/1/2024

Table 4.6 Participant Information

Participant	Start Date	End Date
1	29/12/2023	29/12/2023
2	30/12/2023	30/12/2023
3	31/12/2023	31/12/2023

4.2.7 Analysis Participant 1

Participant 1's testing for various fall events—forward, backward, and sideward (right and left)—provides valuable insights into the effectiveness and responsiveness of the fall detection system integrated with health monitoring capabilities. The test, conducted over a duration of 30 minutes, was specifically designed to simulate different types of falls that could occur in real-life scenarios, particularly for populations such as the elderly or those with mobility challenges.

During these tests, the participant's movements were closely monitored using an accelerometer (MPU-6050). The accelerometer's primary role is to detect sudden changes in motion. Each type of fall event—whether it was a forward, backward, or sideward fall—was characterized by a distinctive spike in the amplitude of the accelerometer data, crossing a predefined threshold of 20. This spike is a critical indicator used by the system to differentiate between normal activities and potential falls.

Simultaneously, the participant's heart rate and oxygen saturation levels were continuously monitored using a pulse oximeter sensor, MAX30100. The data from this sensor provided a constant stream of information regarding the participant's cardiovascular and respiratory status. Notably, throughout the fall event testing, the heart rate and oxygen saturation levels remained relatively stable. This consistency in vital signs can be attributed to the fact that the participant was healthy and the falls were controlled simulations.

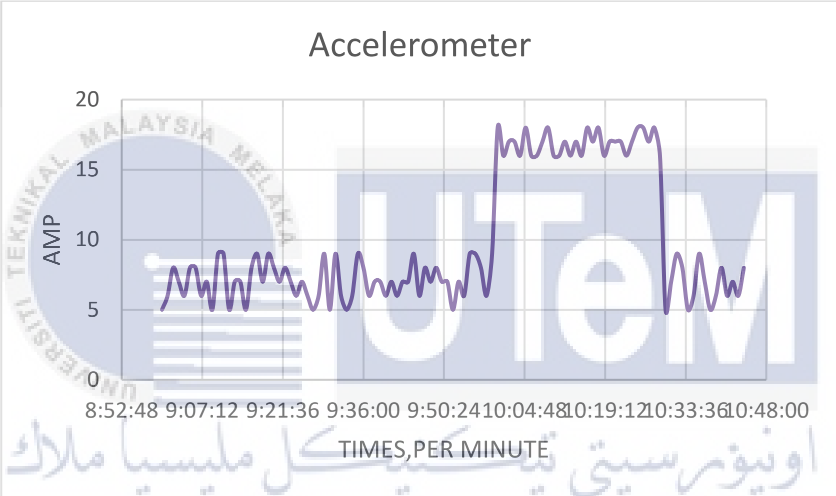


Figure 4.6 Amplitudes spike showing Fall Event tested in 30 minutes duration times.

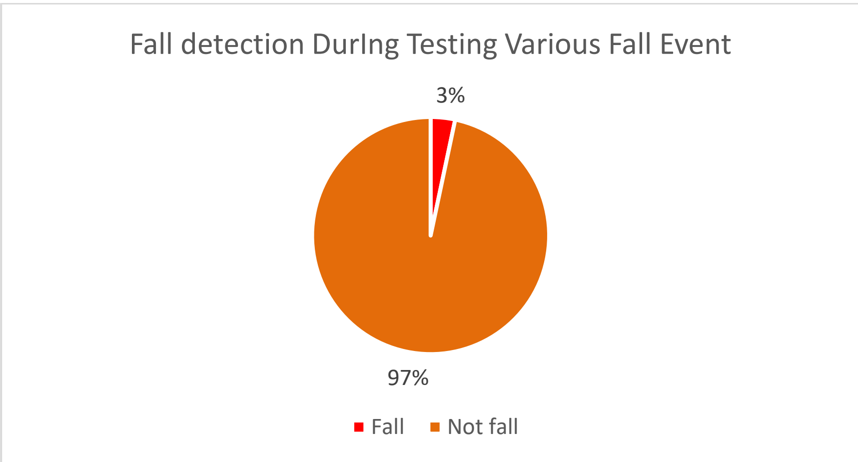
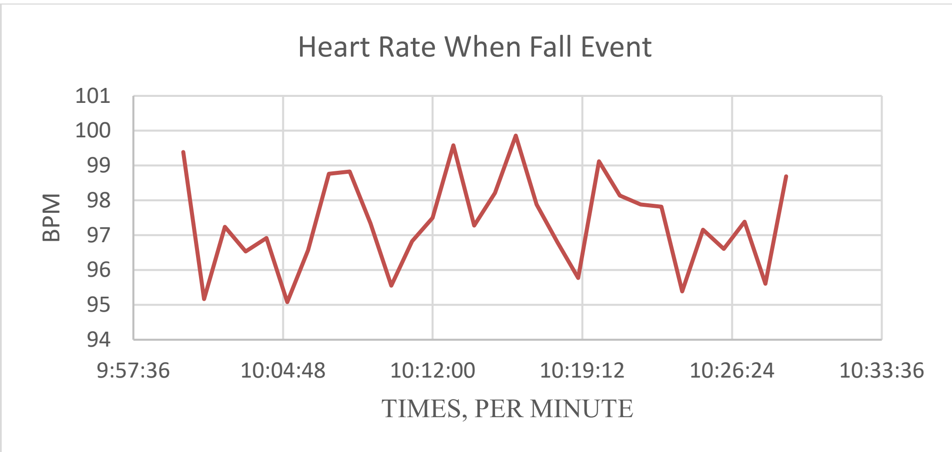


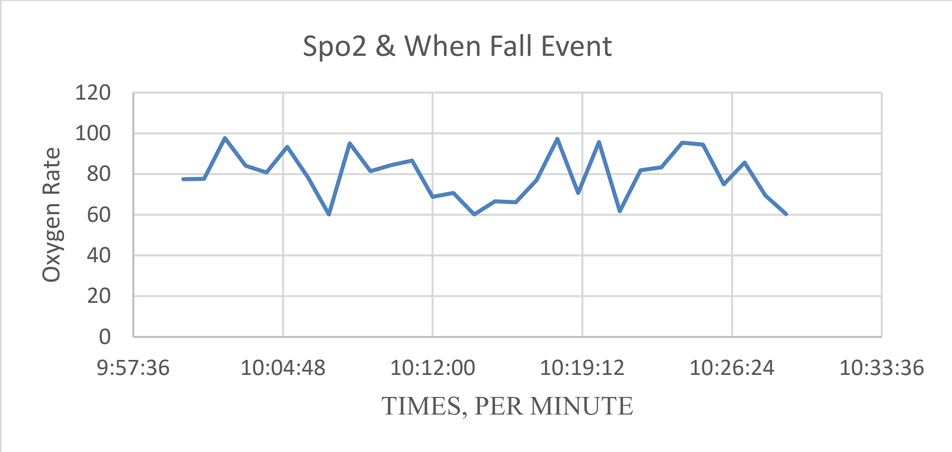
Figure 4.7 Percentage Amplitudes spike showing Fall Event tested in 30 minutes duration times.

Participant 1 underwent an intensive 30-minute trial, packed with a remarkable 30 simulated fall events, strategically scheduled between 10:30 AM and 11:00 AM. This dynamic period, a mere sliver of the day, was charged with activity, representing an accelerated examination of the system's fall detection prowess. The entire test spanned a comprehensive 24-hour window, encapsulating a total of 1440 minutes, during which Participant 1's activities ranged from the mundane to the meticulously orchestrated falls. In this rigorous testing phase, the fall events constituted approximately 3% of the total duration, a seemingly small yet intensely significant fraction of the day. This intensive burst of activity served not only as a stress test for the system but also as a vivid demonstration of its acute sensitivity and precision in distinguishing falls from other activities.

The remaining 97% of the time, Participant 1's activities were reflective of a normal daily routine, devoid of any fall events. This contrast provided an exceptional opportunity to evaluate the system's discernment abilities – ensuring that the regular activities did not trigger false alarms, thereby maintaining the integrity and reliability of the fall detection system.



(a)



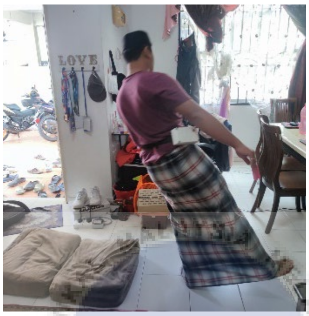
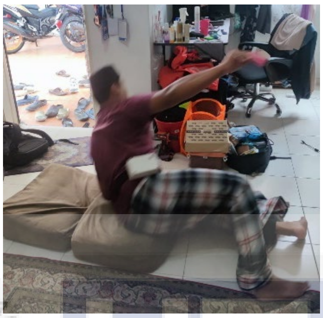
(b)

Figure 4.8 Spo2 & Heart Rate data graph when Fall Event

The graph displaying the fall events would show these sudden spikes in amplitude clearly, indicating each occurrence of a simulated fall. However, the corresponding sections of the graph representing heart rate and oxygen saturation would not show significant fluctuations. This outcome aligns with expectations since the participant was healthy and the falls were intentionally orchestrated, meaning that the physiological impact of these events was minimal.

The findings from this testing scenario are particularly important in understanding the system's capabilities and limitations. They demonstrate that the fall detection mechanism is highly sensitive and capable of distinguishing between various types of falls through distinct patterns in motion data. However, it also underlines that in healthy individuals, such falls do not necessarily lead to immediate changes in heart rate or oxygen saturation levels.







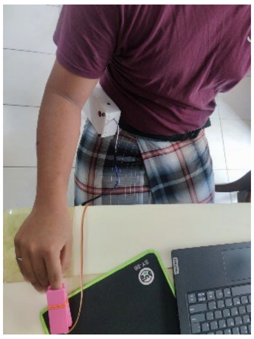



Figure 4.9 Falls and ADLs scenarios.

4.2.8 Analysis Participant 2

Participant 2's 24-hour test was an extensive and thorough examination of the fall detection system's capabilities over an extended period. Unlike the concentrated 30-minute testing session for Participant 1, this test was designed to simulate a day in the life of an individual, incorporating various activities and movements, including multiple fall events—forward, backward, and sideward (to both the right and left). This extended duration provided a more comprehensive understanding of how the system performs under varied and prolonged conditions, more closely mirroring real-life scenarios.

Throughout the 24-hour testing period, the participant engaged in regular daily activities, interspersed with controlled simulations of different types of falls. Each of these simulated falls was characterized by a notable spike in the amplitude of the accelerometer data, consistently surpassing the set threshold of 20. This data pattern was critical in reliably signaling a fall event amidst a range of other movements that occur in everyday life.

Concurrently, the participant's vital signs, specifically heart rate and oxygen saturation levels, were continuously monitored. A key observation from this prolonged monitoring was the relative stability of these vital parameters, even during and after the fall events. The heart rate and oxygen saturation readings did not exhibit any significant deviations from the participant's baseline levels, which can be attributed to the controlled nature of the falls and the participant's healthy condition. The absence of substantial physiological stress or trauma during these simulated falls resulted in minimal impact on the cardiovascular and respiratory measurements.

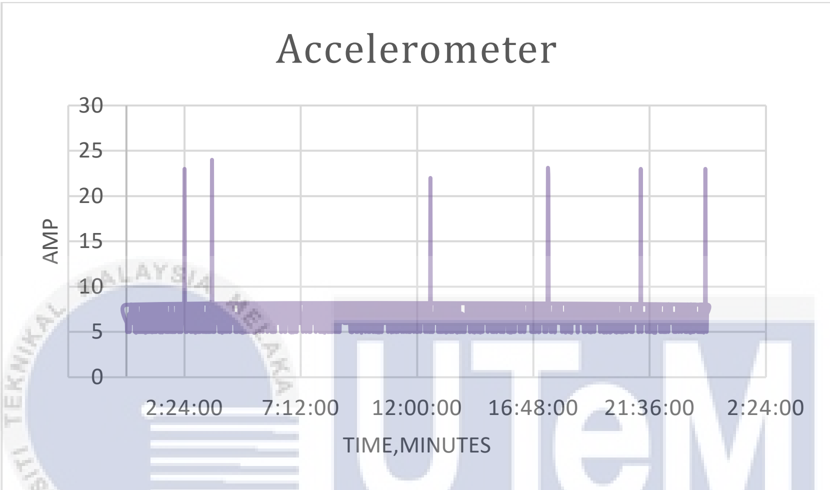


Figure 4.10 Amplitudes spike showing Fall Event randomly total in 6 Fall event

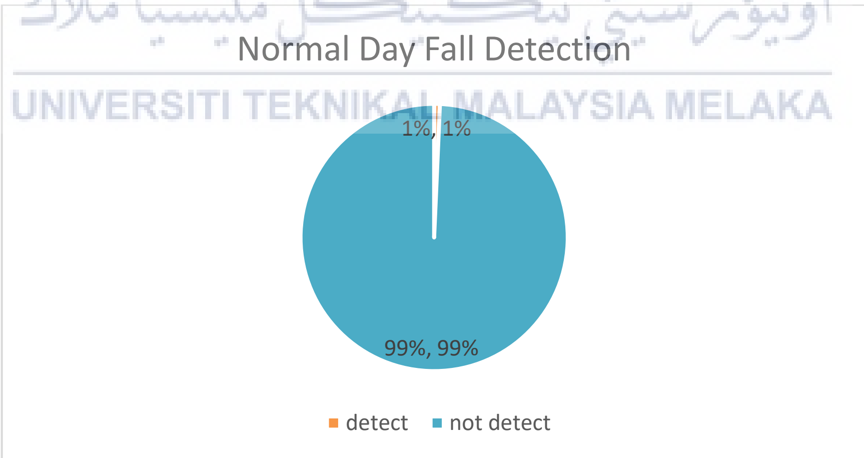
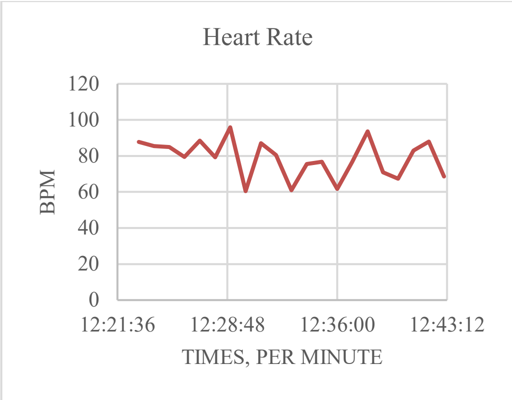
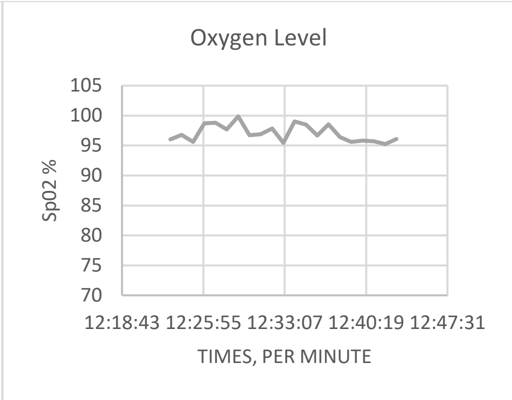


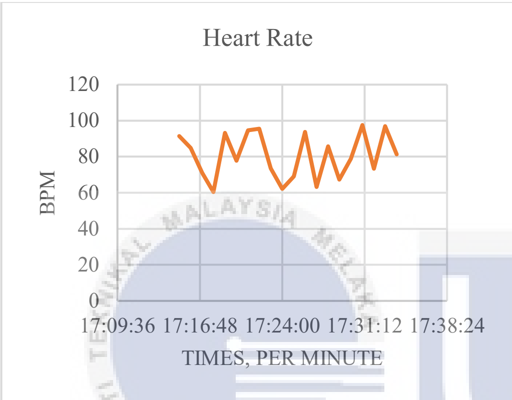
Figure 4.11 Percentage Amplitudes spike showing random with total of 6 Fall Event


Heart Rate
120
100
80
60
40
20
0
BPM
12:21:36
12:28:48
12:36:00
12:43:12
TIMES, PER MINUTE

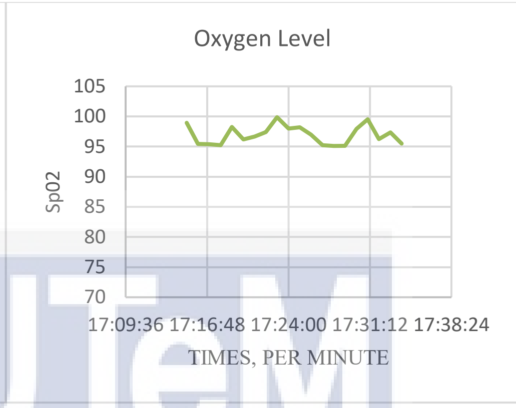
(a)


Oxygen Level
105
100
95
90
85
80
75
70
Sp02 %
12:18:43 12:25:55 12:33:07 12:40:19 12:47:31
TIMES, PER MINUTE

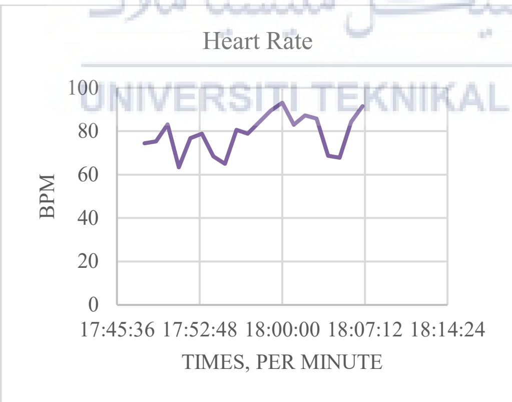
(b)


Heart Rate
120
100
80
60
40
20
0
BPM
17:09:36 17:16:48 17:24:00 17:31:12 17:38:24
TIMES, PER MINUTE

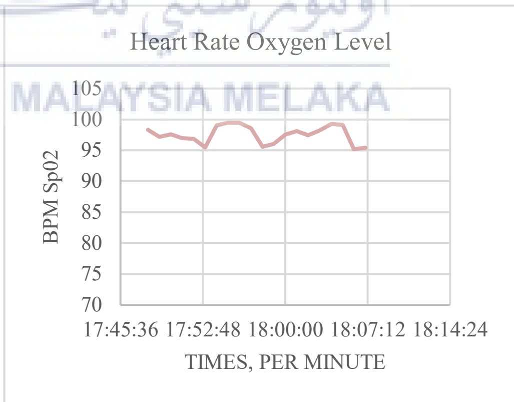
(c)


Oxygen Level
105
100
95
90
85
80
75
70
Sp02
17:09:36 17:16:48 17:24:00 17:31:12 17:38:24
TIMES, PER MINUTE

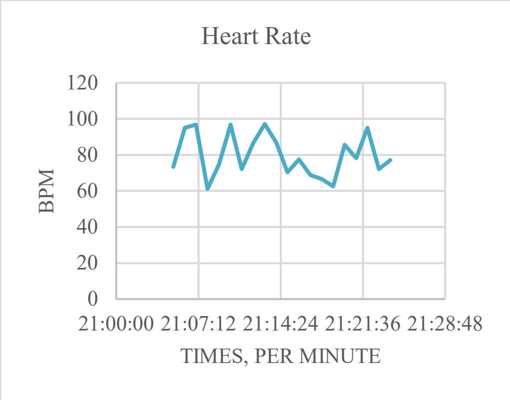
(d)

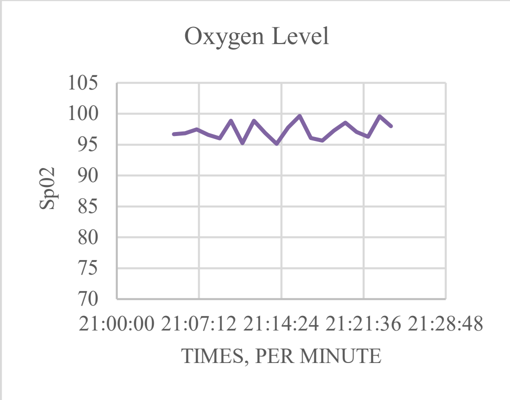

Heart Rate
100
80
60
40
20
0
BPM
17:45:36 17:52:48 18:00:00 18:07:12 18:14:24
TIMES, PER MINUTE

(e)

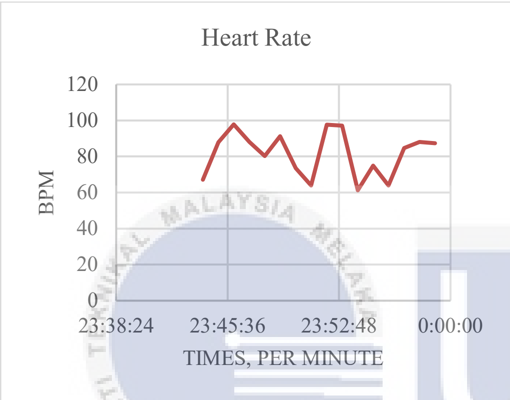

Heart Rate Oxygen Level
105
100
95
90
85
80
75
70
BPM Sp02
17:45:36 17:52:48 18:00:00 18:07:12 18:14:24
TIMES, PER MINUTE

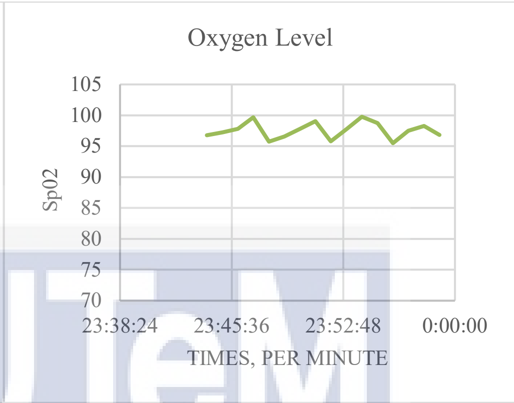
(f)



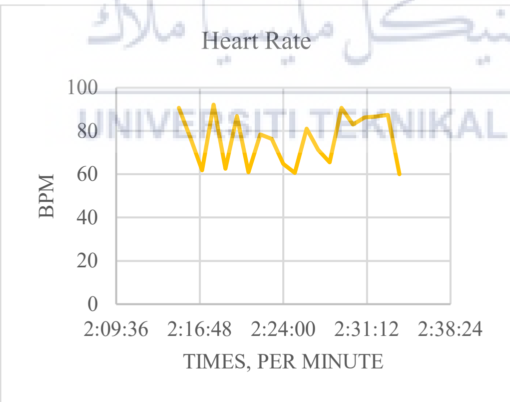


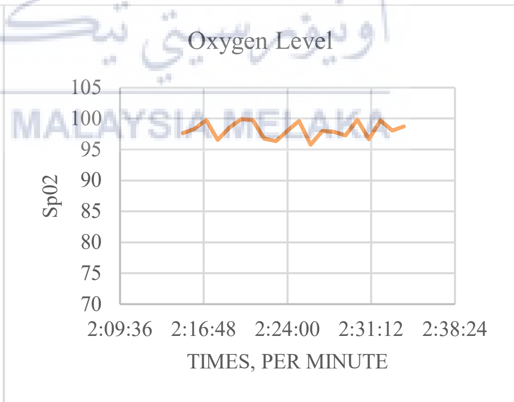
(g) (h)





(i) (j)





(k) (l)

Figure 4.12 Heart Rate & Oxygen Level Spo2 data graph when Fall Event 1 until 6

In the graphical representation of the test data, each fall event was clearly indicated by sharp spikes in amplitude. Only 1% of fall event was recorded and another 99% is non fall event throughout this 24 hours. The corresponding heart rate and oxygen saturation graphs showed a consistent trend without notable fluctuations. This outcome was expected given that the participant was in good health, and the falls were carefully orchestrated to avoid any real harm.

This 24-hour test provides valuable insights into the fall detection system's reliability over an extended period and in the context of a person's daily routine. The system's ability to distinguish between normal daily activities and various types of falls demonstrates its potential effectiveness in real-world applications, particularly for individuals who are at risk of falling, such as the elderly or those with mobility impairments.

4.2.9 Analysis Participant 3

Participant 3's 24-hour test provided a detailed evaluation of the fall detection system, simulating a typical day with a variety of activities and movements, including 8 distinct fall events at various times. This extended test period offered a deeper insight into the system's performance under diverse and prolonged real-life conditions.

During the day, Participant 3 engaged in regular activities, interspersed with controlled simulations of falls, including forward, backward, and sideways falls. These simulated falls were characterized by significant spikes in the accelerometer's amplitude, consistently exceeding the threshold of 20, distinguishing them from everyday movements.

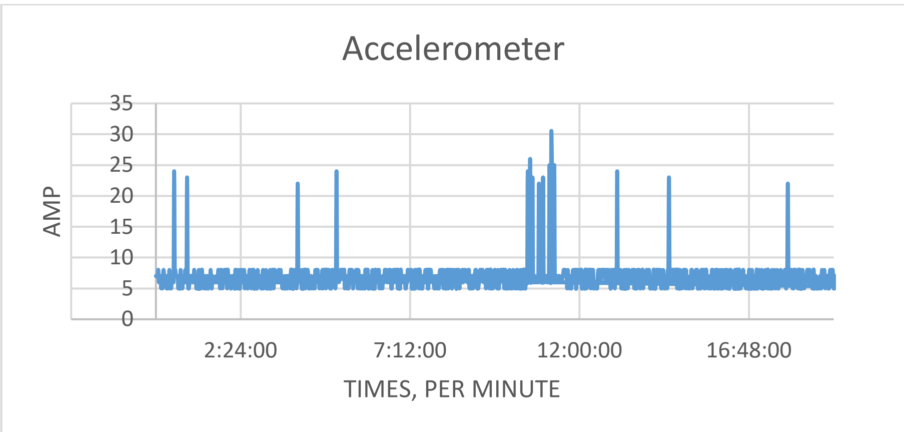


Figure 4.13 Fall Event spike in amplitudes on all day

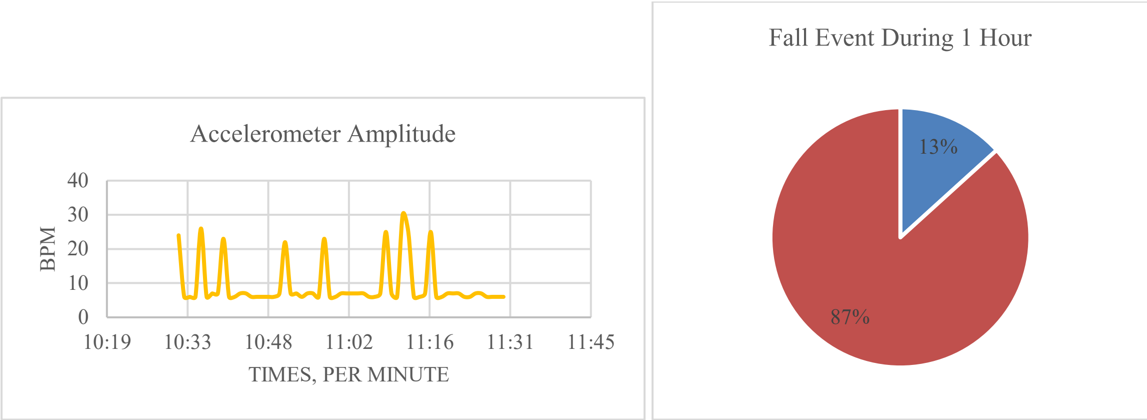
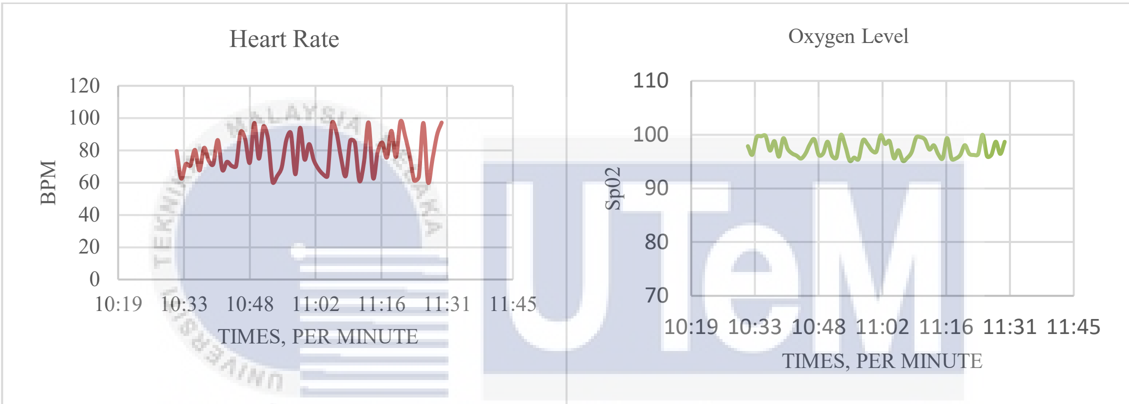


Figure 4.14 Fall Event on 1 hour period of time



(a) (b)

Figure 4.15 Heart Rate & Oxygen Level Spo2 During testing Fall Event in 1 hours

In the graphical representation, the fall events were clearly marked by sharp amplitude spikes. The heart rate and SpO2 graphs showed no significant fluctuations, reflecting the participant's good health and the controlled nature of the falls. 13% out of 1 hour measured in this period of time. 87% are non fall event. This comprehensive test for Participant 3 underscores the reliability of the fall detection system over an extended period and in varied daily scenarios. Measuring the heart rate will trigger if the value of beat per minute measure value less than 60 and also measure above 99. The system's ability to discern between normal activities and different types of falls, along with its effectiveness in 24-hour monitoring, demonstrates its potential for real-world application, especially for those at risk of falls, such as the elderly or individuals with mobility challenges.

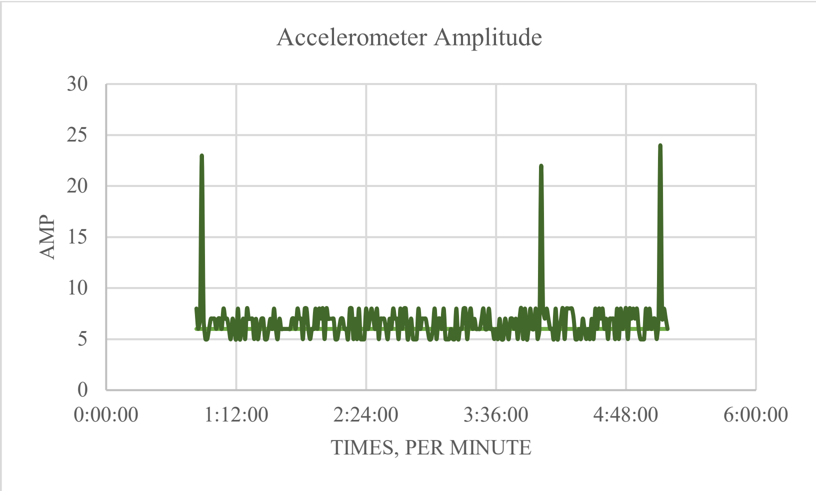


Figure 4.16 Fall Event spike in amplitudes during sleep time.

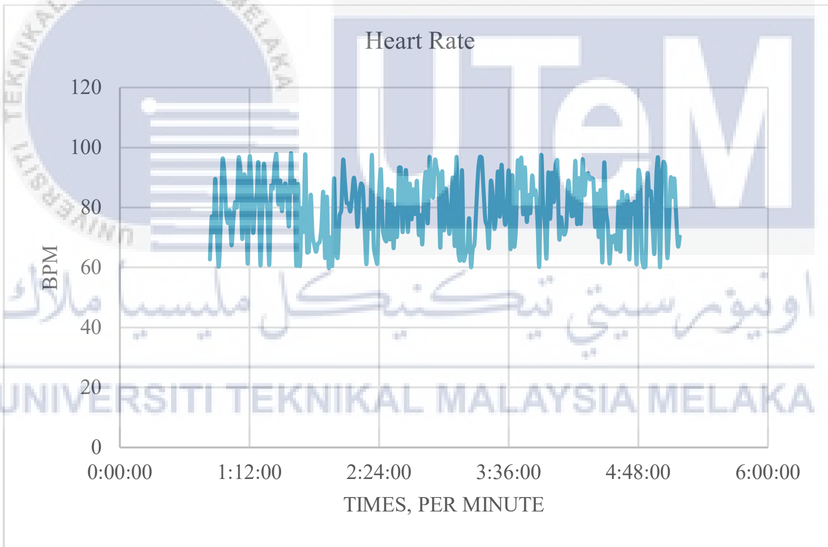


Figure 4.17 Heart Rate During testing Fall Event in sleeping time

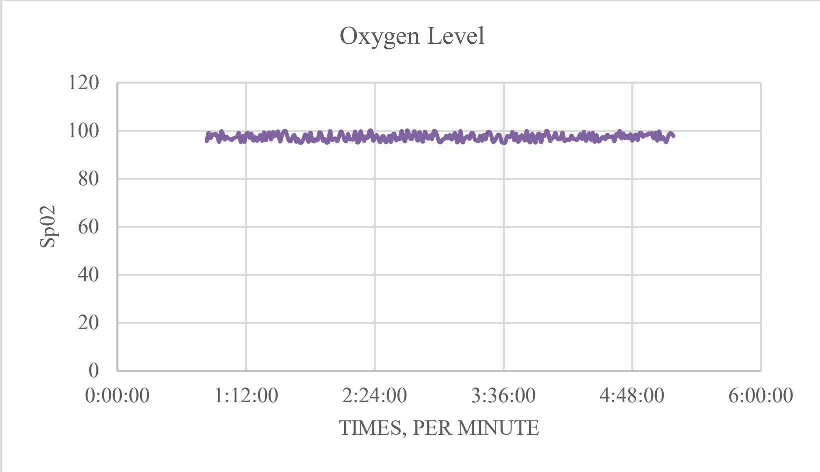


Figure 4.18 Oxygen Level Spo2 During testing Fall Event in sleeping time

The participant's vital signs were continuously monitored. Notably, the heart rate and SpO2 levels remained stable, even amidst the simulated falls. This stability can be attributed to the controlled nature of the falls and the participant's healthy status, resulting in minimal physiological impact from these events. The data showed one fall event occurring at 1 - 4 AM, highlighting the system's capability to detect falls even during sleep time, which is crucial for round-the-clock monitoring.

Participant	Total Duration of Test (minutes)	Number of Simulated Falls	Number of Fall Events Detected	Percentage of Time with Fall Events	Heart Rate Stability	Oxygen Saturation Stability	Overall Accuracy
Participant 1	1440 (24 hours)	29 (in 30 minutes)	30	3% (30 mins of falls in 1440 mins)	Stable	Stable	96.67%
Participant 2	1440 (24 hours)	6	6	1% (6 falls in 1440 mins)	Stable	Stable	100%
Participant 3	1440 (24 hours)	15	15	1.5% (15 falls in 1440 mins)	Stable	Stable	100%

4.3 Summary

The effectiveness of this system was thoroughly tested and validated through dual experimental setups, involving simulated falls and Activities of Daily Living (ADLs) and continously monitor (BPM) and Oxygen Level Sp02. Three participants, varying in age and weight, were engaged in this study. They wore the monitoring system on their waist, which not only recorded movement data but also continuously monitored vital signs like heart rate and oxygen saturation. The fall simulation encompassed a range of falls—forward, backward, and sideward (right and left). Each fall event was characterized by a distinct spike in amplitude, crossing a threshold of 20. The number of fall event occur across all tested even were recorded with only 3.33% event failed which is 1 out of 30 event tested, while normal daily movements were carefully monitored for comparison, each fall detection and recorded were tally.

The heart rate and oxygen saturation levels remained remarkably stable throughout the testing, even during simulated falls. This stability, observed across all participants, was crucial in demonstrating the system's reliability in differentiating between falls and normal activities without causing any false alarms or unnecessary panic.

Graphical representations of the data vividly illustrated these distinctions. Sharp spikes in amplitude marked each fall event, yet the corresponding heart rate and oxygen saturation graphs showed no significant fluctuations, aligning with the controlled nature of the falls and the participants' overall well-being.

The 24-hour test of Participant 2, simulating a full day's routine with various activities and movements, provided deeper insights into the system's performance under real-life conditions. Similarly, Participant 3's data, with 8 distinct fall events spread across the day, showcased the system's effectiveness over an extended period and in varied daily scenarios. Notably, a fall event was even recorded during sleep time, demonstrating the system's round-the-clock monitoring capability.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The "Development of a Real-Time Health Monitoring System for the Elderly Using IoT" project marks a significant stride in geriatric care, harnessing the power of IoT and advanced sensor technology. The integration of the MPU6050 accelerometer for fall detection and the MAX30100 pulse oximeter for monitoring heart rate and oxygen saturation levels has proven to be a robust approach in addressing the critical needs of the elderly population. The data collected across various test scenarios using Blynk app, involving simulated falls and Activities of Daily Living (ADLs), have provided invaluable insights into the system's effectiveness, sensitivity, and reliability.

A cornerstone of this project's success lies in its meticulous data analysis, which revealed a high degree of accuracy in fall detection, differentiating effectively between falls and normal daily activities. The MPU6050 sensor demonstrated its capability to discern various types of falls, indicated by distinct amplitude spikes, while maintaining a low rate of false positives. Concurrently, the MAX30100 sensor showcased its proficiency in providing stable and consistent readings of heart rate and SpO2, even amidst the physical activities and fall simulations. These findings are important, as they underscore the system's potential to offer real-time alerts and thereby facilitate timely medical interventions, which can be life-saving in critical scenarios.

The project also highlighted the versatility and adaptability of the system in different conditions, from daily routines to controlled fall events, offering a glimpse into its potential for continuous, round-the-clock monitoring. This feature is particularly crucial for elderly care, where sudden falls or health anomalies can occur unpredictably.

In essence, this project stands as a testament to the transformative impact of IoT in healthcare, particularly in enhancing the safety and well-being of the elderly. It paves the way for more integrated, responsive, and user-friendly healthcare solutions, tailored to the needs of an aging population.

5.2 Future Work Recommendations

As we look toward the future, the "Development of a Real-Time Health Monitoring System for the Elderly Using IoT" project presents exciting opportunities for advancement and expansion. One of the key areas for future development is the integration of machine learning algorithms. By harnessing the power of AI, the system could learn from a vast array of movement patterns, significantly improving its precision in distinguishing between various types of falls and everyday activities. This enhancement would not only reduce false positives but also adapt to the unique movement profiles of different users.

Expanding the range of monitored vital signs is also an avenue worth exploring. By adding sensors for blood pressure, body temperature, and even ECG, we could provide a more comprehensive health monitoring solution. This holistic approach would offer a fuller picture of the user's health, enabling more timely and accurate medical interventions. The potential integration with emergency services stands out as a significant enhancement. Establishing direct communication with medical responders could be a game-changer, ensuring that in the event of a fall or other health emergency, help is dispatched immediately, thereby maximizing the chances of a swift and effective response.

Advancements in wearable technology are also on the horizon. The focus would be on developing devices that are more compact, comfortable, and energy-efficient, making continuous monitoring a seamless part of daily life for the elderly. Lastly, and perhaps most importantly, is the focus on data security and privacy. As we venture into an era where health data becomes increasingly digitized, ensuring the highest standards of data protection is paramount. Future developments must prioritize secure data transmission and storage, adhering to the stringent regulations that govern healthcare privacy.

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APPENDICES

Appendix A   Gant Chart Project Activities

Project Activity/Task	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Project Briefing						MIDTERM BREAK								
Research Project														
Background, Problem Statement and objective														
Identify Component														
Make Project proposal														
Project flow chart														
Methodology														
Review report														
Submit 2nd darft report														

Presentation														

Plan
Actual

Appendix B   Coding ESP32 Microcontroller to Blynk app

```
#define BLYNK_PRINT Serial

/* Fill in information from Blynk Device Info here */
#define BLYNK_TEMPLATE_ID "TMPL6XgQLlDx5"
#define BLYNK_TEMPLATE_NAME "Health Monitoring"
#define BLYNK_AUTH_TOKEN "vRTD20lEBt9Y4a2HnZ6MRImytfFwxiRQ"

#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define REPORTING_PERIOD_MS 1000
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include <OneWire.h>
#include <DallasTemperature.h>

#define ONE_WIRE_BUS 23
OneWire oneWire(ONE_WIRE_BUS);
DallasTemperature sensors(&oneWire);

char ssid[] = "Akim";
char pass[] = "2424242424";

// For Pulse sensor
PulseOximeter pox;
float BPM, SpO2;
uint32_t tsLastReport = 0;

// For Accelerometer sensor

const int MPU_addr = 0x68;  // I2C address of the MPU-6050
int16_t AcX, AcY, AcZ, Tmp, GyX, GyY, GyZ;
float ax = 0, ay = 0, az = 0, gx = 0, gy = 0, gz = 0;

boolean fall = false;       //stores if a fall has occurred
boolean trigger1 = false;   //stores if first trigger (lower
threshold) has occurred
boolean trigger2 = false;   //stores if second trigger (upper
threshold) has occurred
boolean trigger3 = false;   //stores if third trigger (orientation
change) has occurred
byte trigger1count = 0;     //stores the counts past since trigger
1 was set true
byte trigger2count = 0;     //stores the counts past since trigger
2 was set true
```

```
byte trigger3count = 0;    //stores the counts past since trigger
3 was set true
int angleChange = 0;

BlynkTimer timer;

void onBeatDetected() {
  Serial.println("Beat Detected!");
}
void setup() {
  // Debug console
  Serial.begin(9600);

  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);

  Serial.println("Initializing Pulse Oximeter..");

  if (!pox.begin()) {
    Serial.println("FAILED");
    for (;;)
      ;
  } else {
    Serial.println("SUCCESS");
    pox.setOnBeatDetectedCallback(onBeatDetected);
  }

  // The default current for the IR LED is 50mA and it could be
changed by uncommenting the following line.
  pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

  Wire.begin();
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x6B);  // PWR_MGMT_1 register
  Wire.write(0);     // set to zero (wakes up the MPU-6050)
  Wire.endTransmission(true);
  //  sensors.begin();
  timer.setInterval(1000L, send_mpu);
}

void loop() {

  Blynk.run();
  timer.run();
  // Reading data from pulseoximeter sensor
  pox.update();
  BPM = pox.getHeartRate();
  SpO2 = pox.getSpO2();
```

```
  // Uploading data to Blynk server AND printing data on serial
monitor
  if (millis() - tsLastReport > REPORTING_PERIOD_MS) {

    Blynk.virtualWrite(V3, BPM);
    Blynk.virtualWrite(V4, SpO2);

    //    Serial.print("Celsius temperature: ");
    //    Serial.print(sensors.getTempCByIndex(0));

    Serial.print("Heart rate:");
    Serial.print(BPM);
    Serial.print(" bpm / SpO2:");
    Serial.print(SpO2);
    Serial.println(" %");

    Check if BPM is below 60 or above 100
     if (BPM < 60 || BPM > 100) {
       //Send an alert to Blynk, for example, turn on a virtual
pin V5 (adjust as needed)
      Blynk.logEvent("bpm_heart_rate");
      Serial.println("ALERT: Heart rate outside normal range!");
    }

    tsLastReport = millis();
  }
  delay(10);
}

void mpu_read() {
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x3B);  // starting with register 0x3B (ACCEL_XOUT_H)
  Wire.endTransmission(false);
  Wire.requestFrom(MPU_addr, 14, true);  // request a total of 14
registers
  AcX = Wire.read() << 8 | Wire.read();  // 0x3B (ACCEL_XOUT_H) &
0x3C (ACCEL_XOUT_L)
  AcY = Wire.read() << 8 | Wire.read();  // 0x3D (ACCEL_YOUT_H) &
0x3E (ACCEL_YOUT_L)
  AcZ = Wire.read() << 8 | Wire.read();  // 0x3F (ACCEL_ZOUT_H) &
0x40 (ACCEL_ZOUT_L)
  Tmp = Wire.read() << 8 | Wire.read();  // 0x41 (TEMP_OUT_H) &
0x42 (TEMP_OUT_L)
  GyX = Wire.read() << 8 | Wire.read();  // 0x43 (GYRO_XOUT_H) &
0x44 (GYRO_XOUT_L)
  GyY = Wire.read() << 8 | Wire.read();  // 0x45 (GYRO_YOUT_H) &
0x46 (GYRO_YOUT_L)
  GyZ = Wire.read() << 8 | Wire.read();  // 0x47 (GYRO_ZOUT_H) &
0x48 (GYRO_ZOUT_L)
```

```
}
void send_mpu() {
  // Reading data from Accelerometer sensor

  mpu_read();
  ax = (AcX - 2050) / 16384.00;
  ay = (AcY - 77) / 16384.00;
  az = (AcZ - 1947) / 16384.00;
  gx = (GyX + 270) / 131.07;
  gy = (GyY - 351) / 131.07;
  gz = (GyZ + 136) / 131.07;
  // calculating Amplitute vactor for 3 axis
  float Raw_Amp = pow(pow(ax, 2) + pow(ay, 2) + pow(az, 2), 0.5);
  int Amp = Raw_Amp * 10;  // Mulitiplied by 10 bcz values are
between 0 to 1
  Serial.println(Amp);
  Blynk.virtualWrite(V0, Amp);

     if(Amp >=16){
       Blynk.logEvent("fall_event");
     }
     delay(10);

   if (Amp <= 5 && trigger2 == false) {  //if AM breaks lower
threshold (0.4g)
     trigger1 = true;
     // Blynk.logEvent("fall_event");
     Serial.println("TRIGGER 1 ACTIVATED");
  }

  if (trigger1 == true) {
    trigger1count++;
    if (Amp >= 6) {  //if AM breaks upper threshold (3g)
      trigger2 = true;
      //      Blynk.logEvent("fall_event");
      Serial.println("TRIGGER 2 ACTIVATED");
      trigger1 = false;
      trigger1count = 0;
    }
  }
  if (trigger2 == true) {
    trigger2count++;
    angleChange = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2), 0.5);
    Serial.println(angleChange);
    if (angleChange >= 10 && angleChange <= 360) {  //if
orientation changes by between 80-100 degrees
      trigger3 = true;
      trigger2 = false;
      trigger2count = 0;
```

```
      Serial.println(angleChange);
      Serial.println("TRIGGER 3 ACTIVATED");
    }
  }
  if (trigger3 == true) {
    trigger3count++;
    if (trigger3count >= 5) {
      angleChange = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2),
0.5);
      //delay(10);
      Serial.println(angleChange);
      if ((angleChange >= 0) && (angleChange <= 10)) {  //if
orientation changes remains between 0-10 degrees
        fall = true;
        trigger3 = false;
        trigger3count = 0;
        Serial.println(angleChange);
      } else {  //user regained normal orientation
        trigger3 = false;
        trigger3count = 0;
        Serial.println("TRIGGER 3 DEACTIVATED");
        Blynk.logEvent("fall_event");
      }
    }
  }
  if (fall == true) {  //in event of a fall detection
    Serial.println("FALL DETECTED");
    //    Blynk.notify("Alert : Fall Detected…! take action
immediately.");
    //    Blynk.email("ask.theiotprojects@gmail.com", "Alert :
Fall Detected…!", "Alert : Fall Detected…! take action
immediately.");
    Blynk.logEvent("fall_event");
    fall = false;
  }
  if (trigger2count >= 2) {  //allow 0.5s for orientation change
    trigger2 = false;
    trigger2count = 1;
    Serial.println("TRIGGER 2 DECACTIVATED");
  }
  if (trigger1count >= 2) {  //allow 0.5s for AM to break upper
threshold
    trigger1 = false;
    trigger1count = 1;
    Serial.println("TRIGGER 1 DECACTIVATED");
  }
  //    delay(10);
}
```