Vein Locator Sugar Level and Blood Pressure Detector

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Project Supervisor: Engr Waqas Ali

Submitted By

[Eesha Durrani]
[Fazal Muhammad Sani]
[Muhammad Umar Athar]
[Atif Anees Khan]

Department of Electrical Engineering

HITEC University Taxila Cantt, Pakistan

Declaration

We, hereby declare that this project neither as a whole nor as a part there of has been copied out from any source. It is further declared that we have developed this project and the accompanied report entirely on the basis of our personal efforts made under the sincere guidance of our supervisor. No portion of the work presented in this report has been submitted in the support of any other degree or qualification of this or any other University or Institute of learning, if found we shall stand responsible.

Signature: _______________

Name: Eesha Durrani

Signature: _______________

Name: Fazal Muhammad Sani

Signature: _______________

Name: Muhammad Umar Athar

Signature: _______________

Name: Atif Anees Khan

HITEC University Taxila Cantt, Pakistan

Spring 2023

Certification

This is to certify that Eesha Durrani 19-EE(P)-015, Fazal Muhammad Sani 19-EE(P)-073, Muhammad Umar Athar 19-EE(P)-108, Atif Anees Khan 19-EE(P)-124have successfully completed the final project **Vein Locator Sugar Level and Blood Pressure Detector,** at the HITEC University Taxila Cantt, Pakistan, to fulfill the partial requirement of the degree **B.S. Electrical Engineering.**

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Engr. Waqas Ali

Lecturer, Project Advisor

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Dr. Muhammad Ali Mughal

Chairperson-EED

HITEC University Taxila

Sustainable Development Goals

SDG No	Description of SDG	SDG No	Description of SDG
SDG 1	No Poverty	**SDG 9**	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger	SDG 10	Reduced Inequalities
SDG 3	Good Health and Well Being	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals

Range of Complex Problem Solving			
	Attribute	**Complex Problem**	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	
7	Consequences	Have significant consequences in a range of contexts.	
8	Interdependence	Are high level problems including many component parts or sub-problems	
Range of Complex Problem Activities			
	Attribute	**Complex Activities**	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).	
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	

Abstract

There have been many concerns in the healthcare field about the difficulties in precisely identifying veins for medical procedures, particularly in cases involving toddlers, older people, people with dark or hairy skin, hypovolemia, or swollen skin. It's important to pinpoint the vein because doing so can speed up medical treatment considerably. A suggested instrument system uses a camera and infrared light to take photos of veins that are then processed by a computer to address this issue. The real-time projection of the processed images onto the patient's skin or on any screen uses improved contrast to make it easier to see veins. A non-invasive blood pressure monitoring module is also included in the device to quickly gauge blood flow rates, especially in emergency scenarios. The blood sugar level detection module in this system, it should be noted, calls for invasive techniques. Healthcare workers can gain from improved vein location, sped-up treatments, and effective blood flow evaluation by combining these technologies.

Undertaking

I certify that the project **Vein Locator Sugar Level and Blood Pressure Detector** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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List of Acronyms

IR	Infrared
mmHg	Millimeters of Mercury
Mg/dL	Milligrams per Deciliter
Mmol/L	Milli-moles per Liter
IDE	Integrated Development Environment
OS	Operating System
IC	Integrated Circuit
ADC	Analog-to-Digital Converter
OpenCV	Open Source Computer Vision
SDG	Sustainable Development Goals
PKR	Pakistani Rupee
FIR	Finite Impulse Response
PPG	Photoplethysmography
PTT	Pulse Transit Time
NIRS	Near-Infrared Spectroscopy
IoT	Internet of Things
GPIO	General Purpose Input/output
CSI	Camera Serial Interface
Op Amps	Operational Amplifiers
FPS	Frames per Second
CLAHE	Contrast Limited Adaptive Histogram Equalization
BPM	Beats per Minute
EMR	Electronic Medical Records
HIS	Hospital Information System
AR	Augmented Reality

Chapter One

1 INTRODUCTION

The entire project's initial phase is covered in this chapter, along with a brief introduction, the problem that was solved, the key goals, document convention, intended audience, reading suggestions, assumption and dependencies, broader impact, and a feasibility analysis.

1.1. Document Convention

This section deals with the complex terms involved in writing this document and put definitions to ease the reader's mind.

1.1.1. Definitions

Here are some definitions that are required for this document:

Vein Locator: A device or system that utilizes infrared technology and image processing algorithms to enhance the visibility of veins, aiding in the accurate localization of veins for medical procedures. Infrared (IR)

Camera: A type of camera that detects infrared radiation, allowing it to capture images of veins that are otherwise not visible to the naked eye.

Image Processing Algorithms: Algorithms or mathematical techniques used to analyze and manipulate digital images, such as enhancing contrast, detecting edges, or extracting specific features.

Blood Pressure: The force exerted by the blood against the walls of the arteries, typically measured in millimeters of mercury (mmHg), indicating the pressure during both the contraction (systolic) and relaxation (diastolic) phases of the heart.

Blood Pulse Rate: The number of times the heart beats per minute, indicating the heart rate and providing information about the rhythm and regularity of the heartbeat.

Blood Glucose Level: The concentration of glucose (sugar) in the bloodstream, measured in milligrams per deciliter (mg/dL) or millimoles per liter (Mmol/L), serving as an indicator of blood sugar levels.

Non-Invasive: Referring to medical procedures or techniques that do not require the insertion of instruments or devices into the body, minimizing discomfort and reducing the risk of complications.

Invasive: Referring to medical procedures or techniques that involve the insertion of instruments or devices into the body, typically through incisions or punctures.

Hypovolemia: A condition characterized by a decrease in the volume of blood circulating in the body, leading to low blood pressure and reduced blood flow to organs and tissues.

Prototype: A working model or initial version of a system or device, used for testing and evaluation purposes before full-scale production or implementation.

Arduino: An open-source electronics platform based on easy-to-use hardware and software, designed for creating interactive projects and prototypes.

Arduino IDE (Integrated Development Environment): A software application used for writing, compiling, and uploading code to Arduino boards, providing a user-friendly interface for programming Arduino microcontrollers.

Raspberry Pi: A credit-card-sized single-board computer that can be used for various applications, offering a low-cost and versatile platform for electronics projects.

Operating System (OS): Software that manages computer hardware and software resources, providing an interface for users and applications to interact with the computer system.

Linux OS: An open-source operating system specifically designed for Raspberry Pi, providing a Linux-based environment optimized for the Raspberry Pi hardware.

Arduino Programming Libraries: Collections of pre-written code that extend the functionality of Arduino, providing ready-to-use functions and modules for various tasks and components.

Python Libraries: Modules or packages in the Python programming language that provide additional functionality for specific tasks or components, allowing for easier development and integration with other systems.

Microcontroller: A small computer on a single integrated circuit (IC) that contains a processor, memory, and input/output peripherals, often used for embedded systems and control applications.

Analog-to-Digital Converter (ADC): A device or circuit that converts analog signals, such as voltage or current, into digital data that can be processed by a digital system, such as a microcontroller.

Sensor: A device that detects and responds to physical or environmental changes, converting them into measurable signals or data, commonly used in applications such as temperature sensing, motion detection, or light sensing.

CSI Port: The Camera Serial Interface port is a dedicated interface on the Raspberry Pi for connecting camera modules.

Thonny: Thonny is a Python Integrated Development Environment (IDE) that provides a user-friendly interface for writing and executing Python code.

OpenCV: OpenCV (Open-Source Computer Vision Library) is a popular open-source computer vision and machine learning software library used for image and video processing.

Time: The time module in Python provides functions for working with time-related operations, such as sleep and timing measurements.

NumPy: NumPy is a Python library that stands for 'Numerical Python'. It provides support for large, multi-dimensional arrays and matrices, along with a collection of mathematical functions to operate on these arrays.

Pi Camera: This is a module is a Python library that allows easy access to the Raspberry Pi camera module, enabling capturing images and videos.

cv2: 'cv2 is the alias commonly used to refer to the OpenCV library when importing it in Python.

Gaussian Blur: Gaussian blur is a filtering operation used to reduce image noise by averaging the pixel values in the neighborhood using a Gaussian kernel.

Sharpen Filter: A sharpen filter is a kernel or matrix applied to an image to enhance the edges and details, increasing their visual prominence.

Canny Edge Detection: Canny edge detection is an image processing algorithm used to identify the edges in an image based on changes in intensity. It is widely used for feature extraction and image segmentation.

CLAHE: CLAHE stands for Contrast Limited Adaptive Histogram Equalization. It is an image enhancement technique that improves the contrast of an image by redistributing the pixel intensities based on the local histogram.

Negative Image: A negative image, also known as an inverted image, is an image where the colors or intensities are inverted. It is obtained by subtracting the pixel values from the maximum value (e.g., 255 for an 8-bit image).

BGR: BGR is an acronym for Blue, Green, and Red, which are the primary colors used in many color image representations. In OpenCV, the default color order for reading and manipulating images is BGR.

Frame Truncation: Frame truncation refers to the process of discarding the current frame data from the camera's buffer, allowing it to capture a fresh frame for further processing.

Keyboard Interrupt: A keyboard interrupt occurs when a user presses a specific key or combination of keys on the keyboard, resulting in the termination of the program or a specific action.

Break Statement: The break statement is used in loops to exit the loop prematurely. In this project’s python program, it is used to break out of the continuous capture loop when the user presses the 'q' key.

FPS: FPS stands for Frames per Second. It refers to the number of individual frames or images displayed or captured per second in a video or animation. Higher FPS values result in smoother motion and more fluid visuals.

Resolution: Resolution refers to the number of pixels or dots that make up an image or display. It is typically represented by the width and height of the image or screen in pixels. Higher resolutions result in sharper and more detailed images.

Sleep Time: Sleep time refers to the duration of a pause or delay introduced in a program. It is commonly used to control the timing or synchronization of different processes. In the given context, the sleep time is used to introduce a small delay of 0.1 seconds before starting the image processing loop.

Contrast: Contrast refers to the difference in brightness between different parts of an image or display. It is a measure of the range of intensity values present in an image. Increasing contrast enhances the distinction between light and dark areas, making the image appear more vivid and detailed.

1.2 Intended Audience and Reading Suggestions

This content is intended for diverse audience involved in the field of healthcare and medical research and technology development. Enlisted are the groups of audience which can follow this document for their research purposes:

a. Healthcare Professionals

All doctors, nurses and other medical personnel fall into this category who are responsible for the care and monitoring of their patients daily. They will find this text helpful in determining the potential impact and capabilities of this system.

b. Researchers and Academics

Individuals who are involved in healthcare research facilities and academia will this document helpful in advancing and continue highlighting key research areas.

c. Biomedical Engineers and Technologists

Professionals who are entitled to design, develop and implement medical devices that benefit patients and the professionals

d. Electrical, Electronics and Computer Engineers

Engineers from relevant field can take this research as a starting point for more sophisticated and state of the art modifications as future works for implementing more complex researches.

e. Decision Makers and Administrators

All hospital administrators, policy makers and leaders of healthcare organizations will find this document valuable for understanding the benefit of an integrated patient monitoring system.

1.3. Assumption and Dependencies

1.3.1. Assumptions

- Following are the assumption to be made while implementing this project:
- In the hospital setting for which we are creating this system, it is expected that all facilities, necessary infrastructure, including power supply, and physical space, are present.
- For the next five years, it is assumed that the system is compatible with the majority of the current gadgets, sensors, and communication protocols.
- All required patient data is presumed to be protected.
- It is expected that the system complies with all applicable laws, rules, and regulations governing healthcare information privacy, security, and data exchange. To safeguard patient privacy and data security, the necessary measures will be taken.

1.3.2. Dependencies

Successful implementation of the integrated patient monitoring system depends on the enlisted factors:

- The project depends on cooperation and coordination between a variety of stakeholders, such as healthcare professionals, administrators, IT staff, and system developers.
- The availability of hardware elements, including as sensors, monitors, microcontrollers, and communication devices, is a prerequisite for the system's deployment. Additionally, it is reliant on the accessibility of software elements including firmware, and user interfaces.
- The technical proficiency of the development team is essential for the system's successful implementation. Their expertise and understanding in fields

including sensor integration, software development, data processing, and network configuration are essential.

- The effectiveness and performance of the system are dependent on meticulous testing and validation methods.

1.4. Briefing

It has been a convention that when doctor or nurses needs to inject in the body using syringe, they first have to stop the blood flow in the arm in order to get visibility of veins. Normally in patients this technique is very easily done however accessing the vein in case of elderly people whose blood vessels and veins are squeezed due to age, infants whose veins are very small, dark skin toned people, people with conditions of hypovolemia, people in critical situations with swelled skin.

For these people the medical professionals get into trouble finding the veins for injecting the medicine. Here the conventional method fails for utilization. We need to develop a device in order to foresee the veins inside the such situational skins and ease the process for the professionals. In a similar way in critical situations, it takes much time for measuring the blood pressure and blood glucose levels. So, we are going to add these small systems are well in order to make this device multipurpose.

1.5. Problem Statement

The existing methods for vein localization, blood pressure monitoring, and blood glucose level detection in medical procedures present several challenges, particularly when dealing with elderly individuals, infants, individuals with dark skin tones, hypovolemia, and critical situations with swelled skin. The conventional techniques are often time-consuming, costly, and may lack user-friendly interfaces for both healthcare professionals and laymen.

Therefore, there is a need to develop a low-cost, effective, multipurpose, and user-friendly international system that addresses these challenges. This system should incorporate a vein locator for precise vein visualization, a blood pressure monitoring module for quick and reliable measurements, and a blood glucose level detection module for non-invasive monitoring. By developing such a system, we aim to enhance medical procedures, improve patient care, and provide an accessible solution that can be utilized by healthcare professionals and non-professionals alike.

1.6. Introduction and Background

Before providing injections, medical practitioners have traditionally depended on the procedure of momentarily stopping blood flow in the arm to identify veins. While most patients respond well to this technique, there are some patients who present difficulties, including the elderly with narrowed blood vessels, infants with small veins, people with dark skin tones, those with hypovolemia, and people in critical conditions with swollen skin. These circumstances make it challenging for medical practitioners to precisely pinpoint veins for administering medication, making the traditional approach ineffective.

It is urgently necessary to create a specialized equipment that can see veins within these particular skin problems in order to get around these restrictions and make injection procedures easier for medical experts. The difficulties are further exacerbated in emergency scenarios by the time-consuming methods for checking blood pressure and blood glucose levels. We intend to address this by developing a flexible system that includes these extra features, making it a complete solution.

Our technology will function as a versatile tool for medical experts by integrating vein visualization capabilities with blood pressure monitoring and blood glucose level measurement. This cutting-edge method will increase vein location efficiency and accuracy, hasten vital sign assessment, and eventually enhance patients' overall healthcare experiences.

In many foreign hospitals and medical institutions, the use of cutting-edge medical equipment has become standard practice in the field of healthcare. However, in Pakistan's largest healthcare facilities, conventional techniques continue to be used. High pricing, import taxes, frequent changes in the duty rate, and the high cost of insurance for expensive package deliveries from abroad are some of the reasons why modern products are not widely available in the nation.

This project intends to develop a novel medical gadget that addresses a particular issue in order to increase its affordability and accessibility to a larger population. The vein locator in question enables medical practitioners to quickly find veins for a number of procedures, such as blood sample and intravenous cannula insertion.

In order to improve vein visibility, hospitals typically tighten the arm using a belt or strap. However, this procedure takes a long time, especially in emergency situations. It is also inappropriate for patients with certain conditions.

There is a need for a quick and effective procedure utilizing engineering knowledge to address these restrictions. Vein locating devices are already available, but because they are mainly imported into Pakistan, they are expensive and less widely available. AccuVein AV500 (650,000 - 833,000 PKR), AimVein Pro (490,000 - 572,000 PKR), Hellovein Max (1,041,088 - 1,041,609 PKR), and Veineye (500,000 PKR) are some noteworthy imported vein locator brands and their associated costs in Pakistani Rupees (PKR).

Figure 1.6.1: Expensive Vein locator devices

By creating a locally produced vein locator system, we hope to overcome the current drawbacks and provide a practical remedy that can be used in a range of healthcare facilities, such as clinics, hospitals, and even as a component of home first aid kits. In order to alter and optimize the gadget and make it available to healthcare professionals and people from all walks of life in Pakistan, this project will make use of engineering expertise and market analysis.

1.7. Broad Based Objectives

The goals of this research are to improve accessibility and affordability while addressing the difficulties that currently exist in vein-localization and medical monitoring. The precise goals consist of:

- Create a vein locator system that can accurately and effectively visualize veins, especially in difficult cases such those involving people with dark skin tones, elderly patients, babies, people with hypovolemia, or those with swollen skin.
- Add non-invasive blood sugar level monitoring to the gadget to improve its overall usefulness and adaptability. This will allow for quick and convenient glucose level checks without the need for invasive treatments.
- Include a thorough system for measuring blood pressure and pulse rate, enabling medical personnel to get rapid, precise vital sign readings in urgent situations.
- Make sure the product is accessible to a larger range of healthcare facilities, including hospitals, clinics, and even situations where healthcare is provided at home.
- Compete with products sold on foreign markets by supplying a competitive and cutting-edge equipment that satisfies global performance, reliability, and usability criteria.
- Design a user-friendly interface that is easy to use and produces accurate results for both healthcare experts and people without a medical background.
- By attaining these goals, we hope to transform medical practices, enhance patient care, and advance healthcare technology in our area and beyond.

1.8. Brief Feasibility Analysis

A brief feasibility analysis is written in order to shed light on the points through which we can map the product worth with respect to some factors. In our case we are categorizing the product with three factors, its economic factor, operation and technical factor and they are elaborated below:

1.9.1. Economic Feasibility

The part on economic viability assesses the project's financial components, such as cost analysis, return on investment, and pricing strategy. The project's financial viability and potential profitability are thoroughly examined.

Cost Analysis:

To determine whether the project is financially feasible, a detailed cost study must be performed. This includes calculating the costs related to manufacturing, marketing, distribution, and component acquisition, manufacture, and research and development.

Any additional costs associated with getting the required certifications and adhering to regulatory standards should be taken into account in the cost analysis. A reasonable assessment of the project's total cost can be made by taking into account the prices of parts like the IR camera, Raspberry Pi, Arduino Uno, Max 30100 sensor, and glucose test strips.

Return on investment:

For the purpose of determining the project's financial sustainability, it is essential to forecast the time it will take to see a return on investment. Analyzing the predicted market demand of international devices as mentioned above, the price we approach shall be very low compared to them(1 lac). An estimation of the time needed to return the initial investment can be made by analyzing the market potential and competitive environment which shall be done when the system is introduced in the market.

Pricing Strategy:

To ensure profitability and competition, a proper pricing strategy must be developed. The cost of manufacturing, market demand, rivalry, and the product's perceived value should all be considered when determining the price strategy. A pricing strategy that strikes a balance between affordability for prospective customers and guaranteeing a sufficient profit margin for the business can be developed by performing market research and examining the pricing strategies of comparable devices. To meet varied market demands, it may also be considered to offer several pricing tiers or bundles for specific client categories.

1.9.2 Technical Feasibility

The suggested vein finder system with integrated medical features is evaluated for its capabilities, dependability, and prospective relevance in the technical feasibility section. It assesses the system's technical components to determine whether it can be successfully developed and implemented.

The software algorithms of the system perform real-time picture analysis and projection, enabling medical practitioners to swiftly and accurately find veins. The system's capabilities are further enhanced by the functions for measuring blood pressure and detecting blood glucose levels, which enable thorough patient monitoring.

The healthcare sector has a lot of potential for the proposed system. The device can significantly increase the precision and speed of medical procedures by giving healthcare practitioners a dependable, non-invasive, and effective tool for vein localization. This is especially helpful when working with patients who have difficult vein access, in emergencies, and in urgent situations.

1.9.3. Operational Feasibility

The section on operational viability looks at the usefulness and practicability of the suggested vein locator system with built-in medical features. It focuses on making sure that the system is both affordable and easy to use for both medical professionals and non-medical people.

The system is made to be simple to use and intuitive, making it suitable for both those with and without medical backgrounds. With basic, uncomplicated instructions and visual cues to lead users through the vein location procedure, blood pressure measurement, and blood glucose level monitoring, the user interface will be easy to use.

Comprehensive instructional programs and support materials will be created to promote the system's acceptance and use. Medical experts will attend training sessions to become familiar with the features and functionality of the system. Users will also have access to user manuals and online tools to help them utilize and troubleshoot the system.

Chapter Two

2 LITERATURE SURVEY

The literature review of this project provides a comprehensive analysis of existing research, studies, and publications related to vein detection, vital sign monitoring, and wearable medical devices. It aims to identify the current state of the art, research gaps, and potential opportunities for innovation, ultimately informing the development and advancement of the proposed vein locator system.

2.1 Motivation of Work

The motivation behind this project is to address the limitations of existing vein identification methods by creating a cost-efficient, faster, and user-friendly solution. The goal is to streamline the process of vein identification, making it multi-purpose and suitable for various healthcare settings. By leveraging advanced technologies and automation, the project aims to improve efficiency, reduce costs, and enhance patient care in the field of vein identification.

In recent times, there has been significant research conducted by various organizations and companies exploring the field of vein pattern biometric technology. This research has primarily focused on analyzing vein patterns in different parts of the body, including the face and hand. The idea behind the vein pattern analysis came from the Infrared Imaging (FIR) and the thermal imaging. More detail is in the later section.

2.2 System Analysis

2.2.1. Technique for Data Gathering

The first step in tackling any problem statement is to acquire the pertinent data from a variety of sources. This entails conducting interviews with professionals in the healthcare industry, examining present practices (reviewing existing technologies), conducting online surveys, studying online research papers, journals and online systems.

After extensive investigation, we arrived at the conclusions through *web research* and *interviews with hospital professionals* regarding the current system in Pakistan, which has been in use. This chapter will continue with a detailed explanation of why a sophisticated system we have discussed before are so expensive and how the system will be made cost efficient.

2.2.2 Analysis of Existing Technologies

Every other body that contains heat inside it radiates certain wavelength of infrared. Same goes for the human body and the blood vessels and vein which contain heat inside it and thus radiate certain (very negligible amount) wavelength of infrared. Which radiate out and attenuate according to the infrared transmittance spectrum of atmosphere. This was first analyzed using a thermal camera that records the temperature information of face and hence often referred to as a face thermogram [1].

Human veins on the surface are warmer than the tissues around them, according to scientific investigations. In order to identify users, MacGregor and Welford developed a device that performed a hand vein scan while the hand was clenched [2]. The British Technology Group and Cambridge Consultants Ltd then worked together to investigate hand vein patterns, leading to the creation of Veincheck, a commercial technology displayed at a symposium in September 1993 [3].

Despite the product's modest commercial success, the idea attracted a lot of scientific attention. Active infrared imaging was used by the Australian Institute of Security and Applied Technology [4] and a Korean research team [5] to record vein patterns on the back of the hand. Fujitsu Laboratories also investigated vein patterns on the hand's palm side [6].

Due to the lack of a study of the elements impacting the quality of the vein pattern images in these earlier studies, it took ten years of research and testing to improve the IR imaging system using technologies like ultrasound [6] and near infrared [7]. The imaging method has now been refined with near-infrared imaging, in which the subject is illuminated with NIR and reflected light is measured [8][9]. A portable hand vein finder system using non-invasive infrared technology is demonstrated in their works.

The epidermis is able to absorb NIR radiation, whereas deoxyhemoglobin-venous blood cannot. As a result, the image created by reflected and scattered light exhibits dazzling skin surface and dark lines (veins).

Monitoring blood pressure and sugar levels is essential for maintaining people's health, especially for those who have chronic diseases like diabetes and hypertension. A lot of research has been done on non-invasive blood pressure measurement methods with the goal of creating reliable and practical tools for everyday monitoring. Numerous strategies, such as Oscillometric [10], photoplethysmography (PPG) [11], and pulse transit time (PTT) methodologies [12], have been investigated.

These methods determine blood pressure characteristics including systolic and diastolic pressure using various sensors and algorithms. The development of portable blood pressure monitors that are simple to wear on the wrist or upper arm has also been facilitated by improvements in wearable technology, offering convenience and accessibility for routine monitoring.

Similar to this, it is crucial for people with diabetes to recognize and monitor their blood sugar levels. Invasive techniques, including finger pricking for blood glucose assessment [13], are used in conventional approaches. Non-invasive methods, on the other hand, that provide painless and continuous monitoring are gaining popularity.

Numerous strategies have been investigated, including electrochemical sensing [14], impedance spectroscopy [15], and optical methods based on near-infrared spectroscopy (NIRS) [16]. These techniques try to measure certain physiological alterations or characteristics linked to the body's concentration of glucose, such as light absorption or electrical impedance, in order to determine glucose levels.

So here considering the cost minimizing factor and faster results we need to stick to such methods which provide instant results. Glucose/sugar level detection will be done invasively.

2.2.3. Drawbacks of Existing Models

Followings are the drawbacks in the existing techniques:

- Limited accuracy in vein identification due to manual interpretation.
- Difficulty in visualizing deep or small veins.

- Inability to adapt to variations in patient anatomy and skin tones and condition.
- Lack of consistency in vein visibility under different lighting conditions.
- Limited usability or complexity in operation such as critical condition of body.
- Lack of real-time feedback for precise cannulation guidance.

2.3 Analysis from the Current System

- Vein pattern recognition technology is gaining attention for biometric systems.
- Different imaging techniques like active infrared imaging and thermal imaging are utilized to capture vein patterns.
- Vein pattern recognition has applications in access control, identity verification, and medical diagnostics.
- Ongoing research and development efforts are focused on image processing algorithms, hardware optimization, and usability improvements.
- Vein pattern recognition systems can be integrated with other technologies and devices.
- Continued advancements can lead to improved accuracy and wider adoption of vein recognition systems.
- PPG method and the system or sensor using PPG for analyzing the heart rate which in turn can help us monitor blood pressure.
- Invasive method for blood glucose level is the only way for fast measurement of sugar levels in blood.

2.4 The Outcome of the Literature Survey

Followings are the outcomes we consider from the literature survey:

- Vein detection technologies are being developed for cannulation with the goal of increasing accuracy, usability, and patient comfort. Vein visualization has been investigated using a variety of methods, including ultrasound, near-infrared spectroscopy, and infrared imaging.
- Methods for non-invasively measuring blood pressure, such as cuff less and continuous monitoring systems, have grown in popularity. These techniques have the potential to provide more practical, in-the-moment blood pressure readings, increasing patient compliance and overall monitoring precision.

- The development of non-invasive glucose monitoring tools has advanced; however, the cost issue still remains. So according to our use case we have to consider the finger stick method.
- Mobile health technology and wearables have showed a lot of promise for remote monitoring and individualized healthcare. These tools make it possible to continuously monitor vital signs and glucose levels, giving users the ability to better control their health.
- The accuracy and interpretation of medical data may be improved by combining normal data with image processing. However, for the future works machine learning and artificial intelligence would allow for the early identification of problems and the development of tailored treatment plans.

Chapter Three

3 PROPOSED SYSTEM

In the sphere of medical care, the suggested system provides a ground-breaking solution for vein location, blood pressure monitoring, and blood glucose level detection. This multifunctional system promises to improve efficiency, accuracy, and accessibility in healthcare settings by fusing cutting-edge technologies and user-friendly design.

3.1 Objectives

The objectives of the proposed system are as follows:

1. Create a vein locator system that can rapidly and accurately locate veins in patients, especially in difficult circumstances like elderly patients, newborns, people with dark skin tones, and patients who have hypovolemia or swollen skin.
2. To enable effective and prompt monitoring of patients' cardiovascular health, particularly in urgent situations, integrate a blood pressure measurement module.
3. Include a blood glucose level detection module for non-invasive blood sugar level monitoring, which will give patients with diabetes or other metabolic diseases critical information.
4. Make the system affordable so that healthcare facilities with tight budgets and resource restrictions can use it.
5. Knowing the level of technological expertise, medical professionals should have no trouble using the system because to its user-friendly interface and simple operation.
6. Develop trust and confidence in the system's performance by ensuring its dependability and accuracy in giving real-time measurements of blood pressure, blood glucose levels, and vein placements.
7. Improve patient comfort and speed up medical operations by helping patients find their veins quickly, requiring fewer needle insertions overall.

8. Enable easy interface with current medical equipment and healthcare systems, enabling thorough patient monitoring and data sharing.
9. Enable telemedicine and remote monitoring applications, allowing medical personnel to evaluate patients' conditions remotely and deliver prompt interventions.
10. Create a modular and adaptable system architecture to lay the groundwork for future additions and changes. This will enable the introduction of more features and functionalities in upcoming iterations.

3.2 System Proposal

This section outlines the key components and technologies utilized, along with their integration, to create a reliable and versatile healthcare solution.

I. Vein Locator

- Utilize an IR camera and Raspberry Pi to develop a vein locator system
- Emit infrared light to highlight veins on the skin surface
- Employ image processing algorithms to enhance visibility and accurately identify vein locations

II. Blood Pressure/Heart Rate Detector

- Incorporate a heart rate sensor 30100 and Arduino UNO for blood pressure and heart rate measurement
- Enable real-time monitoring of patients' cardiovascular health
- Provide accurate and timely readings of blood pressure and pulse rate.

III. Sugar Level Detection

- Integrate test strips and a preprocessing circuit with Arduino Uno for sugar level detection
- Utilize specialized chemical coatings on test strips to convert glucose into measurable signals
- Offer non-invasive measurement of blood glucose levels for effective diabetes management

Note: Each system is further elaborated with additional information and details in the upcoming section of this thesis.

3.3 Main System Diagram

The main system diagram provides a visual representation of the interconnected components and their functionality within the proposed system. This diagram illustrates the integration of the required modules, showcasing how they work together to enhance medical procedures and streamline patient care.

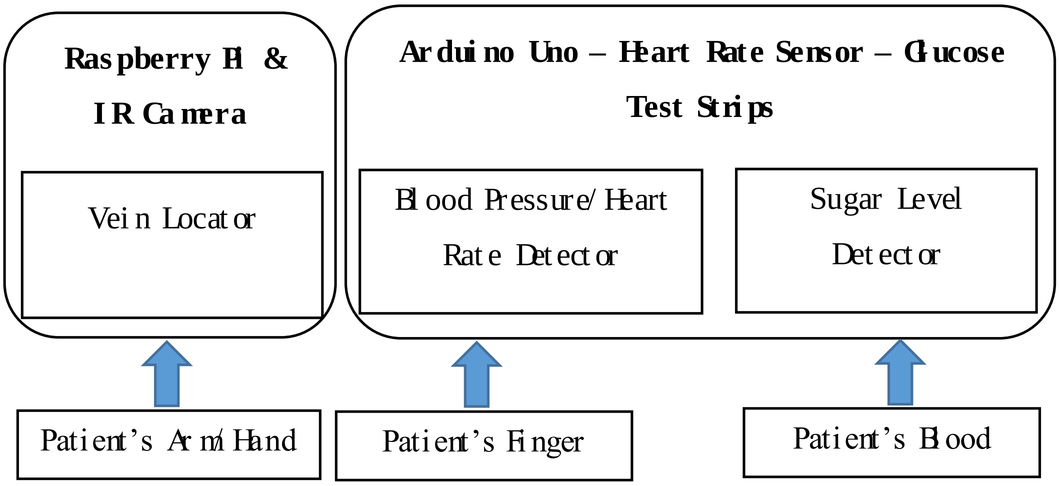

Figure 3.3.1: Main System Diagram

3.4 Benefits

3.4.1 Real Time Monitoring and Display

With this system we get to have a system which can actually show a real time display of the veins underneath the skin of any kind of person with any kind of condition. Moreover, it can be very helpful for the new medical professional who are practicing and don't want to do errors with patients.

3.4.2 Improved Vein Visibility

The vein locator system improves vein visibility, making it easier for medical professionals to locate and access veins for procedures like injections and blood sampling, especially in tricky situations with elderly patients, infants, people with dark skin, people who have swollen skin, and patients who have hypovolemia or swollen skin.

3.4.3 Enhanced Efficiency

The method makes it possible to locate veins more quickly and effectively, cutting down on the time needed for medical treatments and enhancing patient flow in healthcare facilities. This may result in increased output and shorter wait times for patients.

3.4.4 Increased Accuracy

The device increases vein identification accuracy by utilizing cutting-edge imaging technology and algorithms, reducing the possibility of mistakes or difficulties during medical procedures.

3.4.5 Multipurpose Functionality

The system includes modules for measuring blood pressure, heart rate, and blood glucose level detection in addition to vein location. With this multifunctional functionality, a single gadget offers complete health monitoring capabilities.

3.4.6 Cost Efficient

The proposed method provides a reasonable substitute for pricey imported technologies, enhancing accessibility for healthcare professionals and facilities with limited resources to vein location and health monitoring.

3.4.7 User-Friendly

The system's user-friendly interface makes it simple to use for both people with medical backgrounds and those without them. Reduced training requirements and efficient operation are made possible by clear instructions and easy controls.

3.4.8 Portable and Versatile

The system is lightweight and portable, making it simple to move between various healthcare facilities. Because of its adaptability, it can be used in healthcare settings such as hospitals, clinics, and even at home, offering ease and continuity of care.

3.4.9 Home Nursing Kit

Moreover, due to being a user-friendly device it can be used by non-medical professionals as well who want to take care of their families at home.

3.4.10 Potential for Future Development

The proposed system lays the groundwork for future technological gains in healthcare, opening the door to developments in non-invasive diagnostics and patient monitoring.

3.5 Constraints and Limitations

This section outlines the shortcomings in this system; however, these can be considered later for the future recommendations and advancements for the new researchers. Enlisted are:

3.5.1 Dependency on Environmental Factors

The effectiveness of the vein locator system may be influenced by external factors such as ambient lighting conditions and patient-specific characteristics like skin tone, hairiness, or swelling. These variables may affect vein visibility and clarity, which may impair vein localization accuracy.

3.5.2 False Positive/Negative Results

Although the system employs advanced algorithms for vein identification, there is still a possibility of false positive or false negative results. Factors such as movement artifacts, occlusions, or variations in vein visibility can affect the accuracy of vein detection.

3.5.3 Limited Depth of Vein Detection

The system may have limitations in detecting deeper veins or veins located in areas where the infrared light penetration is inadequate. This may require additional techniques or devices for successful vein location in such cases.

3.5.4 Individual Variations

The system's performance may vary among individuals due to anatomical differences, skin characteristics, or underlying medical conditions. Factors such as skin thickness, pigmentation, and vein depth can affect the system's ability to accurately locate veins.

3.5.5 Calibration and Maintenance

The system may require periodic calibration to ensure optimal performance. Regular maintenance and updates to the software, hardware, and algorithms may be necessary to address any issues or improve system functionality.

3.5.6 Invasive Blood Glucose

While the vein locator and blood pressure modules are non-invasive, the blood glucose level detection component requires the use of invasive test strips. This may limit the comfort and convenience for individuals who prefer non-invasive methods for glucose monitoring.

3.5.7 Absence of IoT

The system does not incorporate Internet of Things (IoT) capabilities, limiting its potential for remote monitoring, data connectivity, and real-time analytics.

3.5.8 Absence of multi-sensors

The system lacks the integration of multisensory, limiting its ability to capture additional physiological parameters or provide a more comprehensive health assessment.

Chapter Four

4 METHODOLOGY

The procedure utilized for prototype analysis can be compared to the methods stated in this paper. We construct a functioning prototype for this investigation. The methods used by these attachments are described in some of the subheadings.

4.1 Design Methodology

This project's design is composed of hardware and software implementation. In this chapter, we provide an overview of the components, project functionality, and present a generalized block diagram and flowchart diagram to illustrate the system's operation. Hence here are the list for all the hardware components we will be using and the soft wares we will be using for completing our project:

Hardware:

i. Raspberry Pi 3B+
ii. Arduino Uno
iii. Arducam IR Camera
iv. Max 30100 Heart Rate Sensor
v. Glucose Test Strips
vi. 5v Adapter
vii. LCD 16x2
viii. LM358 and LF356
ix. Projector Cable
x. Plastic Box

Software:

i. Raspberry Pi OS
ii. Thonny – Python IDE
iii. Arduino IDE

4.2 Project Deliverables

4.2.1 Complete Prototype

- A fully functional prototype that demonstrates the capabilities of the vein locator, blood pressure detector, and sugar level detector.
- Project in the form of an accessible kit for people from all walk of life.
- Integration of sensors to ensure smooth data collection and communication

4.2.2 Complete System Documentation

- A detailed documentation covering each perspective of this project
- A detailed literature review to spectate the data gathering, objectives, methodology, outcomes, results and conclusions.
- A complete design of the system inside the document for research purpose, suggestions and recommendations for enhancing this system functionality and potential developments.

4.2.3 Source Code

- Complete functional program
- Source code must be inside the document and other platforms demanded by the institute.
- Complete description of each programming library used.

4.3 Project Working

The project working involves the seamless integration and synchronization of the microcontrollers and sensors to measure the vital signs, and provide real-time feedback.

4.1.1 Phase I – System Initialization & Setup

- Turn on the Raspberry Pi and related Arduino device to start the vein location system.
- Make sure the projector is calibrated and configured correctly before connecting it to the system.

- To turn on the Arduino-connected system and make the necessary connections, turn on the heart-rate sensor.

4.1.2 Phase II – Vein Location processes & Vital Signs Measuring

- To ensure appropriate alignment for precise vein detection, place the arm or hand under the IR camera's field of view
- Set the IR camera to "on" so that it will shine infrared light onto the subject's skin and take pictures.
- Utilize the algorithm built inside the Raspberry Pi to process the collected image.
- Place your finger on the heart rate sensor to start the reading process and wait for synchronization at the same time.
- The heart rate sensor detects the blood vessel pulsations and calculates the heart rate after being synchronized.
- A small amount of blood should be drawn from the fingertip and placed on the sugar strip to determine the blood sugar level.
- The preprocessing circuit and the Arduino-associated system analyses the chemical reaction on the strip and measure the sugar level.

4.1.3 Phase III – Results Display and Presentation

- Project the image onto a suitable surface or the projector screen to display the vein location results.
- Display the sugar level and heart rate reading on an LCD or other visual display for simple interpretation.
- Create a user-friendly interface to clearly and completely show the results.
- Make sure the results are simple to read and comprehend for both individuals with medical backgrounds and those without.
- Include the proper visual alerts or indicators to draw attention to unusual readings or potential problems.

4.4 Block Diagram

The proposed system's overall design and parts are depicted in the block diagram. It offers a high-level illustration of the connections between various modules and subsystems necessary to deliver the desired functionality. The block diagram highlights each component's function and relationship within the system by helping to visualize the flow of data and signals between different parts.

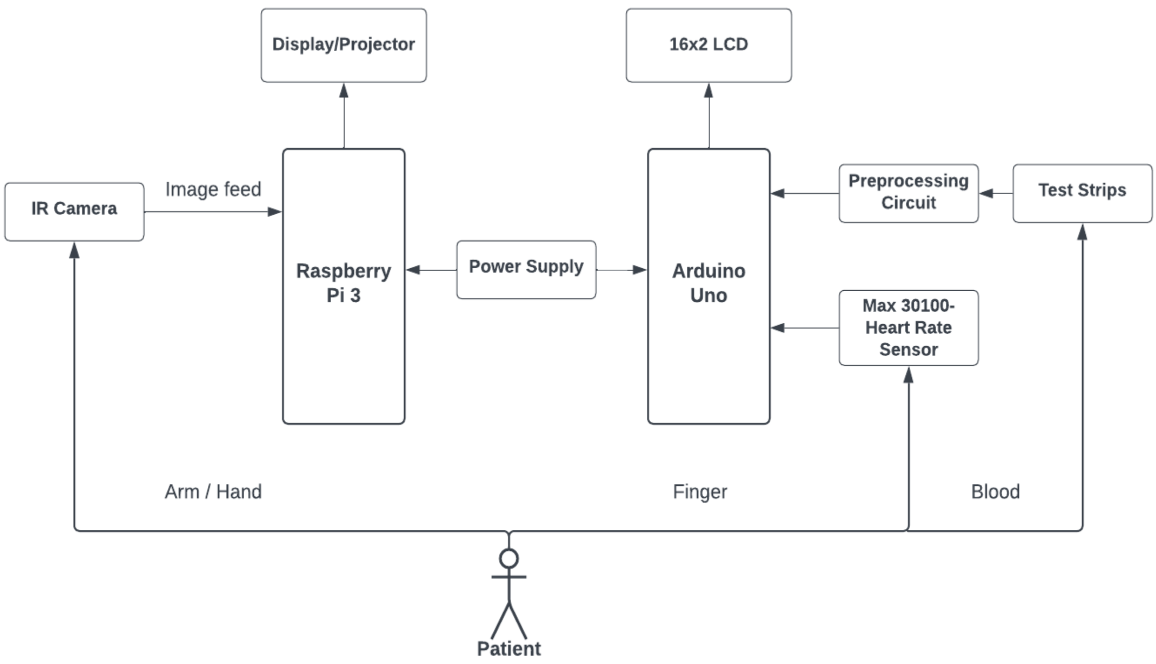

Figure 4.4.1: Block Diagram

4.5 System Flowchart

The flowchart illustrates how actions and decisions move through the system in a sequential manner. The system's logical sequence of activities, procedures, or algorithms is represented visually. The flowchart acts as a road map, laying out the order of procedures and prerequisites to be met when the system is being used. It helps to comprehend the behavior of the system, pinpoint control routes, and guarantee proper synchronization and coordination between various modules and components.

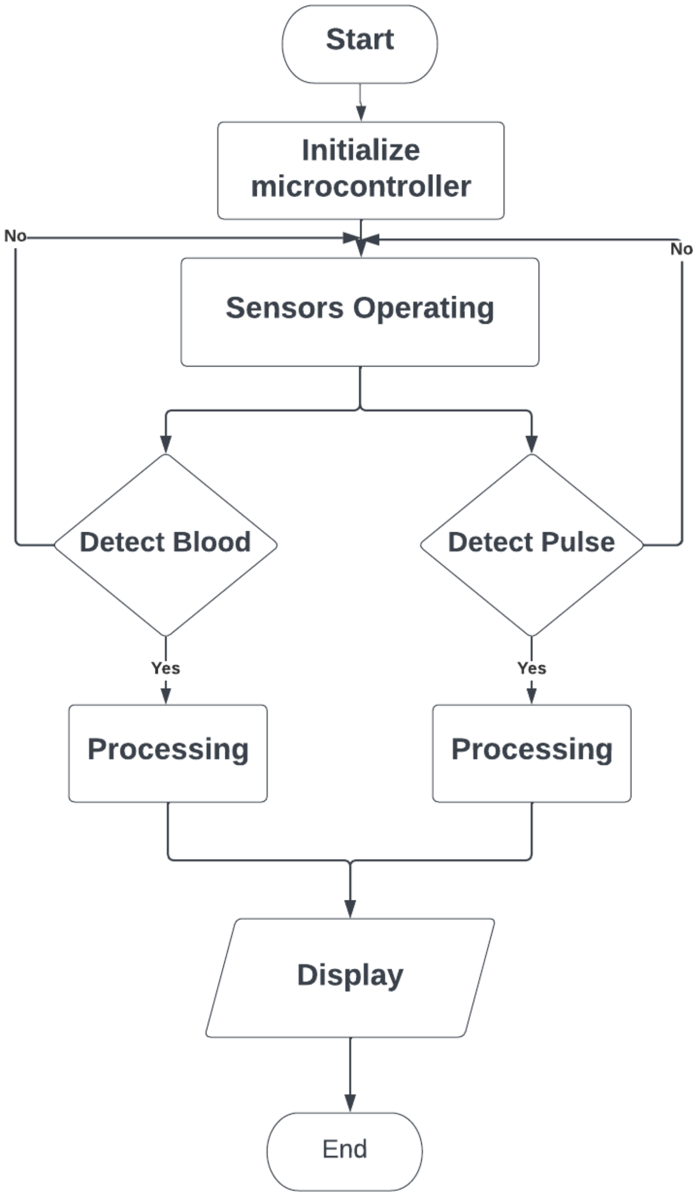

Figure 4.5.1: System Flowchart – Blood Pressure & Sugar Level Detector

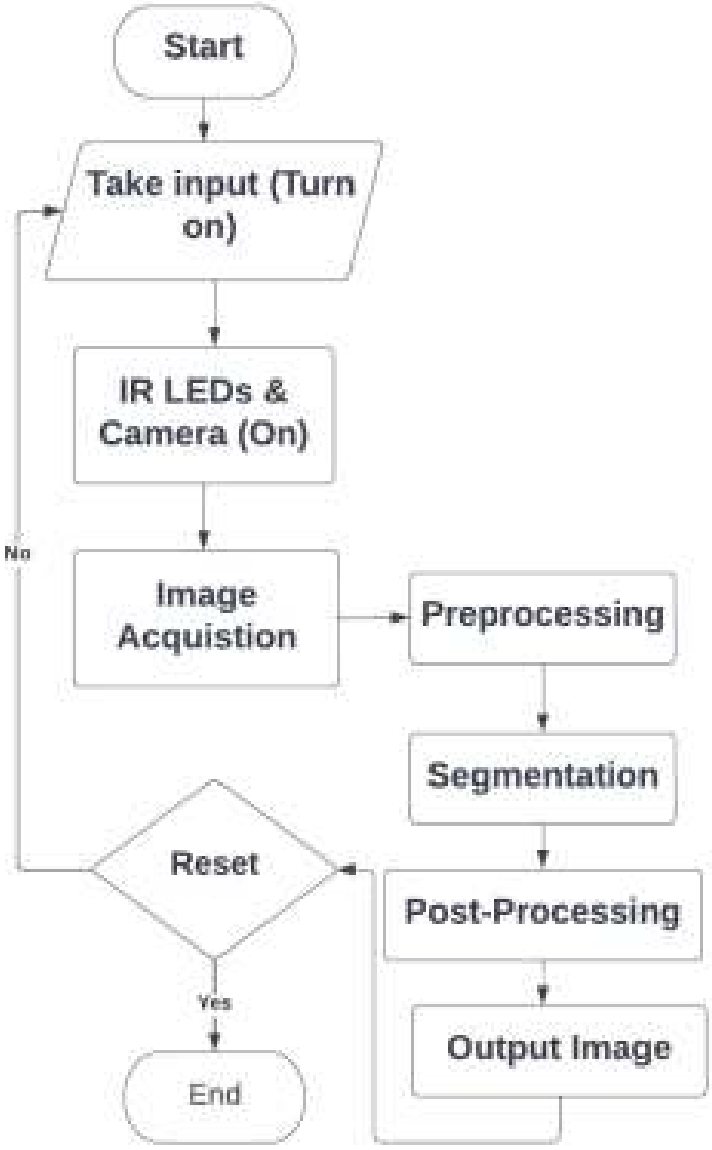

Figure 4.5.2: System Flowchart – Vein Locator

Chapter Five

5 HARDWARE COMPONENTS

This chapter provides an in-depth analysis of the essential elements used in the wireless power transfer system, highlighting each element's unique functions and contributions to the system's overall performance.

5.1 Raspberry Pi Model 3B+

The Vein finder system's primary image processing processor is a single-board computer the size of a credit card called the Raspberry Pi 3B+. It offers a practical and affordable solution for a range of uses, including image processing.

The Raspberry Pi 3B+ is utilized in this project to process the visual data obtained from the IR camera using certain algorithms for vein detection. A Broadcom BCM2837B0 processor, 1GB RAM, and a number of connectivity choices are included in its architecture.

Running on the Raspberry Pi 3B+ is the Raspberry Pi OS, a Linux-based operating system created especially for Raspberry Pi gadgets. It has a user-friendly interface and supports a variety of development packages and frameworks.

Figure 5.1.1: Raspberry Pi 3B+

Running on the Raspberry Pi 3B+ is the Raspberry Pi OS, a Linux-based operating system created especially for Raspberry Pi gadgets. It has a user-friendly interface and supports a variety of development packages and frameworks.

Using its GPIO (General Purpose Input/Output) pins, the Raspberry Pi 3B+ can be connected to sensors and actuators. These pins provide interaction with the physical world by allowing for the interface with various components including sensors, LEDs, motors, etc.

Python is a programming language that is extensively supported on the Raspberry Pi platform and may be used to program the Raspberry Pi 3B+. You can create and run Python code directly on the Raspberry Pi thanks to the Python interpreter that is pre-installed on the Raspberry Pi OS.

You must make sure that an IR camera is compatible with the Raspberry Pi and complies with the necessary interface standards before you can connect it to the Raspberry Pi 3B+. Typically, a ribbon cable is used to connect the camera to the Raspberry Pi's CSI (Camera Serial Interface) port.

Using the Thonny Python compiler, you would create Python code that made use of the camera module and pertinent libraries to do image processing with an IR camera. The code would take pictures with the IR camera, process them with Python libraries like OpenCV or PIL, and carry out tasks like vein recognition. On the Raspberry Pi, Thonny's integrated development environment (IDE) makes it simple to write, run, and debug Python code.

5.2 Arduino Uno

In this project, the sugar level and heart rate detectors are controlled by a microcontroller board called the Arduino Uno. Due to its simplicity and usability, it is a preferred option for embedded system development and prototyping.

The Arduino Uno is used in this project to communicate with the sensors and actuators needed to detect the blood sugar level and heart rate. It collects information from the sensors, makes the appropriate computations, and then adjusts the output devices.

The Atmega328P microcontroller, which powers the Arduino Uno architecture, has 14 digital input/output pins, 6 analogue input pins, a 16 MHz quartz crystal oscillator, and a number of communication ports.

You create code in the Arduino programming language to control the Arduino Uno. Setup and loop procedures in the code are used to initialize the necessary pins, set up the sensors, read data, run calculations, and manage the actuators.

One of the digital or analogue pins of the Arduino Uno should be connected to the output pin of a heart rate sensor, such as the Heart rate sensor 30100. Typically, the heart rate sensor uses optical sensors to detect the pulse on a finger. The sensor's output may be read by the Arduino code, which can then process it to determine the heart rate.

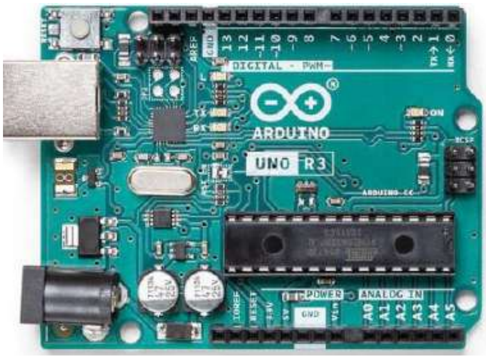

Figure 5.2.1: Arduino Uno

You would require extra parts for the glucose test strip, like a preprocessing circuit to handle the electrical signals from the test strip. The Arduino Uno may be used to connect the circuit, and code can be written to process the analogue readings from the circuit and determine the blood sugar level using pre-established methods.

In order to provide heart rate and blood sugar level detecting functionalities, the Arduino Uno serves as a central controller, collecting data from the sensors, carrying out computations, and regulating the output devices.

5.3 ArducamIR Camera

A small camera module called the ArducamIR Camera was created specifically to take infrared (IR) pictures. For the vein locator capability in this project, it uses infrared technology to visualize the veins on a patient's arm or hand.

In this project, the patient's arm or hand is photographed using an infrared camera, and the resulting images are processed to identify and locate veins. The Raspberry Pi receives the collected photos and processes them for further research.

Arducam IR Camera's architecture is made up of an image sensor, lens, IR filter, and control electronics. It is made to take pictures in the infrared range, making it possible to see veins under the skin more clearly.

There is no proprietary operating system or firmware for the Arducam IR Camera. It is essentially a piece of hardware that interfaces with the Raspberry Pi to take and process pictures.

Figure 5.3.1: IR Camera

Using the camera interface on the Raspberry Pi board, you may connect the Arducam IR Camera to the computer. The camera module attaches to the Raspberry Pi's specific CSI (Camera Serial Interface) connector, ensuring a dependable and quick data flow between the camera and the computer.

Python is one of the many programming languages that can be used to create program for the Arducam IR Camera. Arducam or Raspberry Pi libraries and APIs are used in this project to access and control the camera using Python programming. Setting up the camera, taking pictures, and sending them to the Raspberry Pi for processing all can be done with Python code.

In general, the Arducam IR Camera is a crucial part of getting infrared pictures of the patient's veins. The Raspberry Pi is linked to it, and the project's image processing techniques are used to analyze and locate veins in the acquired photos.

5.4 Max 30102 Heart Rate Sensor

The MAX30102 is a small sensor module for measuring heart rate and blood pressure. It incorporates a photodetector, LEDs, and signal processing tools. The MAX30102 is attached to the Arduino Uno in this project and placed on the patient's finger. It emits light, detects variations in light absorption brought on by pulsatile blood flow, and computes the heart and pulse rates.

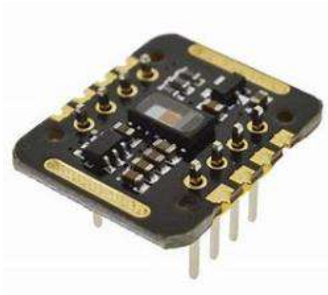

Figure 5.4.1: Max 30102 Heart Rate Sensor

Its architecture consists of photodetectors, light sources, and digital signal processing. The I2C protocol is used for communication with the Arduino Uno. To configure the sensor, read raw data, and extract pulse rate and heart rate information, it is programmed using Arduino libraries. The sensor is initialized by the Arduino code, which also reads data and displays or transmits the estimated heart rate.

5.5 Glucose Test Strips

Diabetes sufferers can measure their blood glucose levels with glucose test strips, which are single-use strips. These strips have enzymes that interact with the blood sample's glucose to generate an electrical signal. The Arduino Uno is used in this project to detect and quantify the blood sugar level using glucose test strips. On the Arduino board, the test strip is placed into the appropriate slot or connector.

The blood sample and the enzymes on the strip interact chemically in the architecture of glucose test strips. Due to this response, an electrical signal that reflects the blood glucose level is produced. Based on the hardware layout of the Arduino board, particular pins or connections are utilized to connect the glucose test strip to the Arduino Uno.

Figure 5.5.1: Glucose Test Strips

Utilizing libraries and code that connect with the glucose test strip is part of programming the Arduino Uno. The test strip interaction, electrical signal reading, and computations necessary to ascertain the blood sugar level are all directed by the Arduino code to the board.

5.6 Power Supply

The Raspberry Pi 3B+ and Arduino Uno microcontrollers are both powered by the 5V adaptor, which is a power source. It guarantees a steady and dependable power supply, enabling the appropriate operation of the microcontrollers and the components linked to them. However, for energizing the whole system you can even attach a multi-port power bank with the project which can power the system separately and make it portable.

Figure 5.6.1: Power Supply

5.7 LCD 16x2

In this project, the measured heart rate and blood sugar levels are shown on the LCD 16x2 module. It offers consumers a simple and legible interface via which they can monitor the findings in real time. Using the GPIO pins, the LCD 16x2 module is connected to the Arduino. It needs a power source, a ground connection, and data connections so that commands can be sent and data can be shown. Digital pins are used by the Arduino to read/write data and control the LCD using a parallel interface.

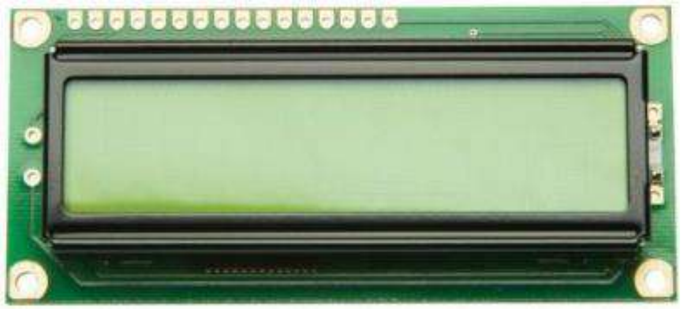

Figure 5.7.1: LCD 16x2

5.8 Projector Cable

The Raspberry Pi is connected to the projector system using a projector cable. It acts as a conduit for the projector to receive and display the processed vein image created by the Raspberry Pi. The projector receives the video signal from the Raspberry Pi through the cable, which enables visualization of the vein image on a surface.

Figure 5.8.1: Projector Cable

5.9 Plastic Box

All of the system's components are housed in a protective casing made of black plastic. It gives the microcontrollers, sensors, and other electronic components a safe and well-organized place to be mounted. To provide proper exposure and contact with the patient's arm or hand and to enable reliable readings and measurements, the sensors are situated outside the body. The body's dark color aids in reducing interference from outside light and upholding ideal conditions for sensor performance.

Figure 5.9.1: Plastic Box

5.10 LM358 and LF356 Operational Amplifiers

Operational amplifiers (op-amps) like the LM358 and LF356 are frequently utilized in electrical circuits and signal processing applications. A dual op-amp with low-power and low-voltage operation is the LM358. It has a wide input voltage range, a high gain, and is intended for general-purpose applications. The LM358 is frequently utilized as a comparator in many electronic systems as well as in audio applications and voltage amplification circuits.

Figure 5.10.1: LM358 and LF356

Chapter Six

6 HARDWARE & SOFTWARE IMPLEMENTATION

In this the whole implementation process is discussed along with the program containing the python script design, libraries and algorithm used, image processing, designing the heart rate sensor Arduino program and also the sugar level detector program.

6.1 Setup of Raspberry PI

Initially we need to install the OS for the raspberry pi. For that you need to have a SD card with minimum of 64 GB memory. You can use memory of 32 & 16 GB as well. Next you need to install Balena software on your windows device and then download the Raspbian OS from their official website.

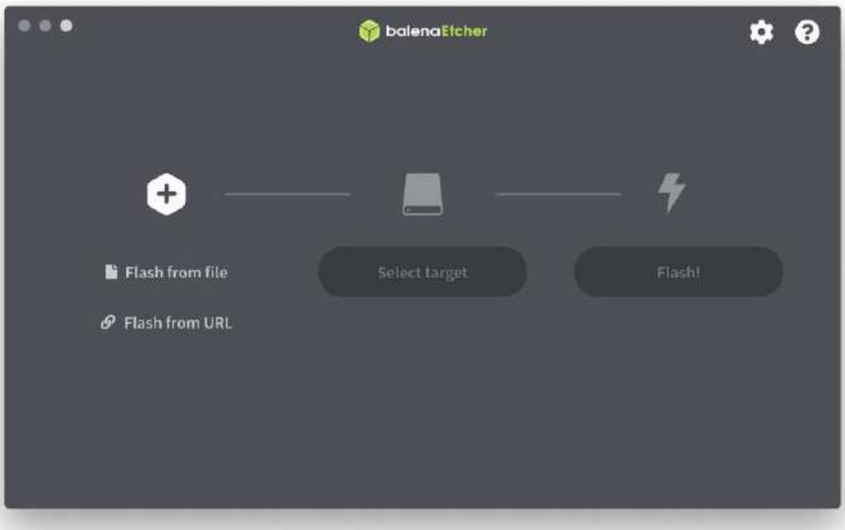

Figure 6.1.1: Linux OS Installation

After the installation file, you need to install the OS by inserting the SD card into the SD card reader and then attach it to the windows device and by using Balena, install the Linux for raspberry pi on the SD card. Remember that you have to wait for complete installation of the OS with no errors at the end as well. Other wise, your Linux will run but will not perform desirably when you are using it for compiling.

After complete installation of the Linux on your SD, now you need to insert the SD card into the Pi and also connect the Pi to any power source. It will start to boot for the first time. You need to complete the process by settling the optimum configurations. Once done the main desktop will be loaded in front of you as shown in the figure below

Figure 6.1.2: Raspberry Pi Desktop

6.2 Post Installation Necessary Commands

After installation of the OS we know we have to use python in the project so first we have to update the terminal, python package, OpenCV, time and NumPy. The commands are listed below step by step with description.

Download package information from all configured sources
sudo apt update
Check current version of Python installed
python --version
Updating pip
python3 -m pip install –upgrade pip

Updating python

Python -m pip install –upgrade python

Installing OpenCV

sudo apt install python3-opencv

Updating OpenCV

sudo apt upgrade python3-opencv

Installing Time and NumPy

pip3 install time numpy

6.3 Setting up IR camera

You may use a Raspberry Pi and the following instructions to set up an IR camera:

- Connect the IR camera to the Raspberry Pi's CSI port. Verify the security of the connections.
- The Raspberry Pi's terminal window should be opened.
- Run the commands listed below to update the Raspberry Pi's firmware:

```
sudo apt update
sudo apt upgrade
sudo rpi-update
```

- Enable the camera interface by running the command:

```
sudo raspi-config
```

- Select "interfacing Options" and then "Camera".
- Choose "Yes" to enable the camera interface.
- Select "Finsih" and reboot the Raspberry Pi.
- Test camera by capturing an image. Run the following command:

```
raspistill -o test_image.jpg
```

- This command captures an image and saves it as "test_image.jpg" in the current directory.
- Check the captures image to verify it the IR camera is working correctly.

6.4 Python Scripts

Now we only need to write the whole python script for the image processing to make the vein locator part of the project. We have attached a complete source code in the end of the thesis as well. However, the script needs to be explained a little with a visual step by step understanding.

```
from picamera import PiCamera
from picamera.array import PiRGBArray
import cv2
import time
import numpy as np
```

These lines import the libraries required to operate with the camera module for the Raspberry Pi, OpenCV, time, and NumPy.

```
camera = PiCamera()
camera.resolution = (848, 480)
camera.framerate = 24
rawCapture = PiRGBArray(camera, size=(848, 480))
cv2.namedWindow('PrecisVeine', cv2.WINDOW_AUTOSIZE)
time.sleep(0.1)
```

The **PiCamera** object is initialized together with its resolution (848, 480) and framerate (24 frame per second (fps)) in these lines. To collect camera frames, use the **rawCapture** object. The processed image is displayed in a window called **"PrecisVeine"** that is created by the **cv2.namedWindow()** function. To ensure correct camera initialization, the **time.sleep** (for 0.1 second) function inserts a small delay.

```
for frame in camera.capture_continuous(rawCapture, format="bgr",
use_video_port=True):
image = frame.array
```

```
b, g, r = cv2.split(image)
image = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
```

This starts a **for loop** that will continuously take pictures with the camera. Each frame is recorded by the **camera.capture_continuous() function**, which stores it in the image variable. The image is divided into its individual colour channels **(B, G, and R)** using the **cv2.split()** function. Using the **cv2.COLOR_BGR2GRAY flag**, the **cv2.cvtColor()** function turns the image to grayscale.

Note: BGR in the above code represents Blue Green Red. **CV2** means computer vision II. However, these are mentioned in abbreviations and the definition portions.

```
blurred = cv2.GaussianBlur(image, (3, 3), 1)
sharpen_filter = np.array([[-1, -1, -1], [-1, 9, -1], [-1, -1, -1]])
sharp_image = cv2.filter2D(blurred, -1, sharpen_filter)
```

These lines carry out procedures for **image processing**. The **cv2.GaussianBlur()** function blurs the image with a **Gaussian filter** to decrease noise. **cv2.filter2D()** applies the **sharpen_filter**, a kernel for sharpening the picture, on the blurry image to get a **sharp_image**.

```
clahe = cv2.createCLAHE(clipLimit=30, tileGridSize=(4, 4))
cl1 = clahe.apply(sharp_image)
```

The **cv2.createCLAHE()** function is used in this section to create a contrast-limited adaptive histogram equalisation (CLAHE) object. The **sharp_image** improved contrast as a result of applying **CLAHE** is stored in the **cl1** variable.

```
cv2.imshow("PrecisVeine", cl1)
rawCapture.truncate(0)
key = cv2.waitKey(1) &0xFF
if key == ord("q"):
    break
```

These lines employ **cv2.imshow()** to display the edited image in the **"Precis Veine" window**. To make room for the following frame, the **rawCapture.truncate(0)** function deletes the currently captured one. If the key pressed is "q," the **cv2.waitKey()** function stops its loop and causes the program to terminate.

6.5 Image Process of Veins

For the overall image conversion pattern is shown below along with a bullet form step by step conversion of the original image into the final form.

- Convert the captured frame to grayscale.
- Apply Gaussian blur to reduce noise.
- Apply a Median filter (sharpening filter) to enhance image details.
- Create a Contrast-Limited Adaptive Histogram Equalization (CLAHE) object.
- Apply CLAHE to enhance image contrast.
- Display the processed image in real-time.

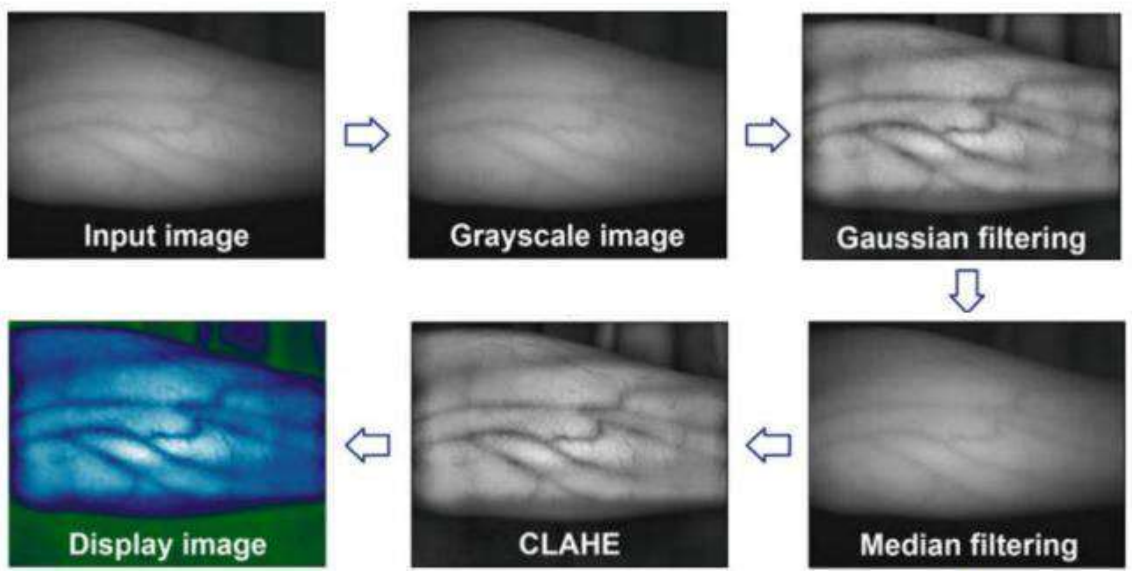

Figure 6.5.1: Image Processing Steps

6.6 Setup Arduino Environment and Importing libraries

Arduino environment is termed with integrated development environment (IDE) that Arduino offers for creating, compiling, and uploading code to Arduino boards. It makes it simple to program and communicate with Arduino microcontrollers because it comes with a code editor, compiler, and uploader. This IDE is quite simple to install and setup by just downloading and install. However, after this you first need to import certain libraries for helping the program run in an optimum way. Following are the list of the libraries we need:

- **Wire.h**

  This library's "Wire.h" file contains the I2C communication-related functions. It enables I2C protocol communication between the Arduino and many peripherals, including sensors, LCD screens, and other devices.

- **LiquidCrystal_i2c.h**

  The I2C interface-based LCD screens are managed by this library. It offers options for cursor positioning, printing text, controlling the lighting, and initializing the display. The library makes it easier for the Arduino and LCD display to communicate.

- **Max30105.h**

  For the MAX30102 sensor module, this library was created specifically. It offers ways to communicate with the sensor, including the ability to initialize it, set the pulse amplitude, read the IR value, and enable temperature measurement. The library abstracts the nitty gritty of interacting with the sensor, making projects easier to use.

- **heartRate.h**

  This library is utilized to determine the heart rate using information from pulse sensors or other comparable devices. It has features for detecting heartbeats, figuring out beats per minute (BPM), and giving the average BPM. Developers may now concentrate on more challenging challenges for their projects because the library makes the process of gathering and analyzing heart rate data simpler.

6.7 Arduino Program Design

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
```

```
#include <Wire.h>

#include "MAX30105.h"

#include "heartRate.h"
```

The necessary libraries for I2C communication, LCD display, MAX30105 sensor, and heart rate calculation are included in this section.

```
MAX30105 particleSensor;
const byte RATE_SIZE = 4;
byte rates[RATE_SIZE];
byte rateSpot = 0;
long lastBeat = 0;
float beatsPerMinute;
int beatAvg;
float temperature;
float vref = 3.3;
float resolution = vref / 1023;
int ccc = 1;
```

The MAX30105 sensor object, variables for calculating heart rate, temperature, voltage reference, and resolution are among the objects and variables declared in these lines.

```
void setup() {
  Serial.begin(9600);
 lcd.begin();
 lcd.backlight();
 lcd.setCursor(0, 0);
 lcd.print("HEALTH MONITORING");
 lcd.setCursor(0, 1);
 lcd.print("SYSTEM......");
 if (!particleSensor.begin(Wire, I2C_SPEED_FAST)) {
   Serial.println("Heart Beat sensor not found");
   while (1);
  }
Serial.println("Place your index finger on the sensor.");
  particleSensor.setup();
particleSensor.setPulseAmplitudeRed(0x0A);
  particleSensor.setPulseAmplitudeGreen(0);
  delay(2000);
}
```

At the beginning, the setup() function is only called once. It also sets the pulse amplitude and initializes the LCD display, MAX30102 sensor, and serial communication. Additionally, it checks that the heart rate sensor is properly connected and shows a notification on the LCD.

```
void loop() {
  for (int i = 0; i < 500; i++)
    Heart_Beat();
  Serial.print("BPM=");
  if (beatsPerMinute > 20 && beatsPerMinute <= 70) {
    beatsPerMinute = 70;
  }
  if (beatsPerMinute > 120) {
    beatsPerMinute = 120;
  }
  lcd.clear();
  Serial.print(beatsPerMinute);
  Serial.print(", Avg BPM=");
  Serial.print(beatAvg);
  Serial.println();
  lcd.setCursor(0, 0);
  lcd.print("BPM=");
  lcd.print(beatAvg);
  particleSensor.setup(0);
  particleSensor.enableDIETEMPRDY();
  int temperature = particleSensor.readTemperature();
  Serial.print("temperatureC=");
  int t =temperature;
  lcd.setCursor(0, 1);
  lcd.print("T=");
  lcd.print(t);
  Serial.println(t);
  if (t > 39) {
    Serial.println("Temp is high");
  }
  else {
  }
}
```

The loop() function is used numerous times. To determine heart rate, 500 calls are made to the Heart_Beat() function. The heart rate value is then checked and modified. The LCD is cleared, and the heart rate is printed and shown on the LCD. Additionally, it determines whether the temperature is high by reading the temperature from the sensor, displaying it on the LCD.

```
void Heart_Beat() {
  particleSensor.setup();
  particleSensor.setPulseAmplitudeRed(0x0A);
```

```
particleSensor.setPulseAmplitudeGreen(0);
long irValue = particleSensor.getIR();
if (checkForBeat(irValue)
```

This above code is the function **Heart_Beat** and it calls the function **particleSensor** to object to configure the sensor, sets the pulse amplitude of the red green LEDs of **particleSensor.setPulseAmplitudeRed** & **particleSensor.setPulseAmplitudeRed**. Later the infrared reads value using getIR function and assigns to the value **irValue**. Lastly this value is passed as an argument to the if statement as a check with the function **checkForbeat.**

6.8 Implementation of Sugar Level Detection

The implementation of the glucose Level Detection is a little simpler. We need to have certain components we have mentioned earlier through them we need to create a circuit of operational amplifiers which could enhance the current generated by the test strip and deliver it to the circuit. Later after enhanced value, that needs to be taken input by the analog pin of Arduino and upon certain calculation and range estimation display on LCD

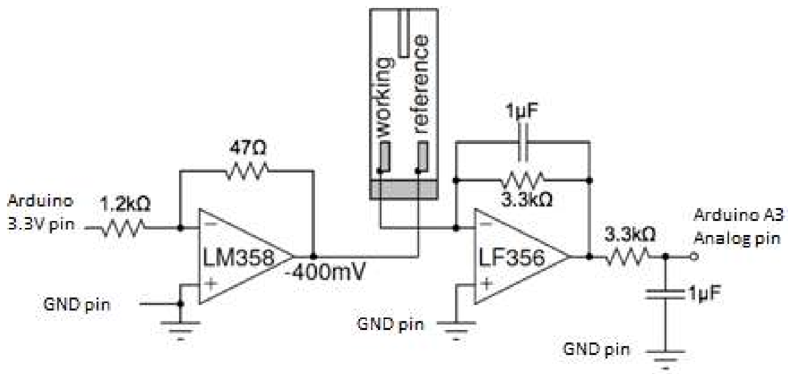

Figure 6.8.1: Sugar level detection circuit

6.9 Prototype Development

The overall system hardware implementation is shown in the below figure, this shows a diagram for the connections of the raspberry pi with the IR camera and secondly the Arduino with LCD 16x2 and Max 30102 sensor.

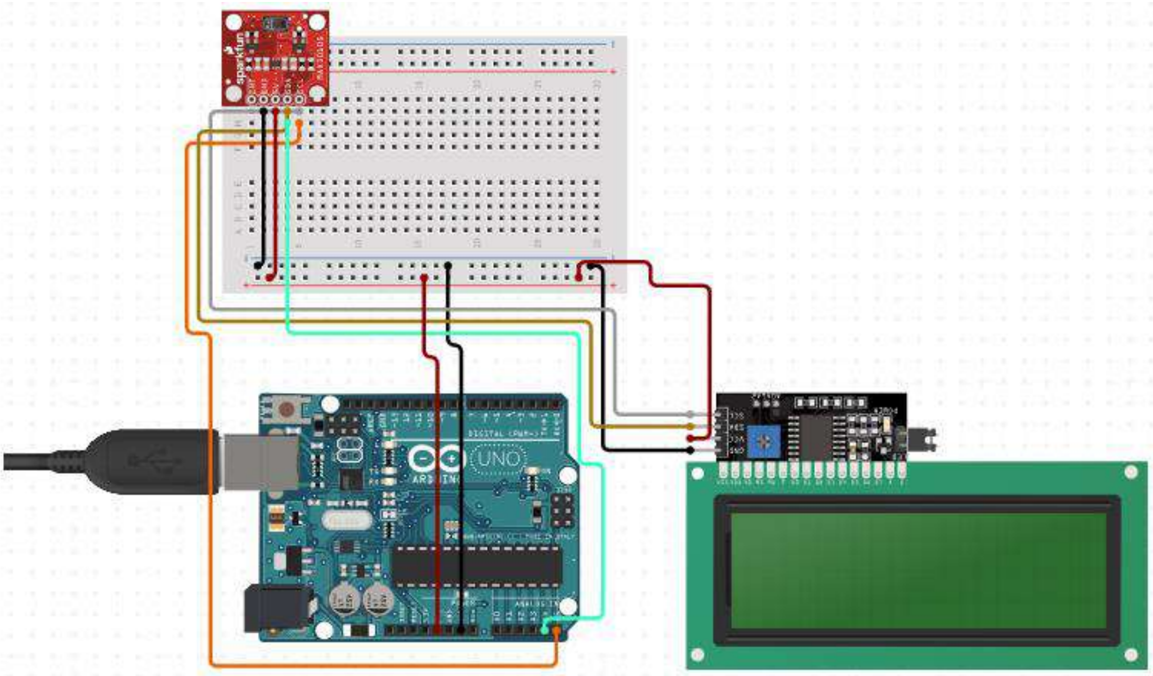

Figure 6.9.1: Arduino Connections

Black Plastic Box: A black plastic box contains the system's parts, including the Raspberry Pi and Arduino. The box helps organize the setup and offers a protected enclosure for the components.

Figure 6.9.2: Black Plastic Box

Arduino and Raspberry Pi: The placement of Arduino and Raspberry Pi is the main factor in adjusting all other sensors and components. These have to rightly adjust in order to manage the space inside the box.

Figure 6.9.3: Embedded Devices Placement

Power Connection: The Raspberry Pi and Arduino have specified cutouts or connectors in the box for power connections. These cutouts provide the system with a safe and convenient power supply.

Figure 6.9.4: Power Connection

LCD Display & Max 30102: A 16x2 LCD display is positioned in the center of the box, outdoors and right beside it the max 30102 sensor is attached.

Figure 6.9.5: LCD and Sensor Adjustment

Test Strip Connector:

The test strip connector has its own spot in the prototype. The system may communicate with specialized test strips through this port to perform extra medical measurements.

Figure 6.9.6: Test Strip placement

IR camera

The Raspberry Pi is connected to the IR camera wire that is fastened inside the box. The wire is then removed from the box to make the camera handheld so that doctors can use their left hand easily. By using this setup, doctors may operate the system and inject a syringe with their right hand at the same time, resulting in minimal patient movement.

Figure 6.9.7: Camera

Final Look

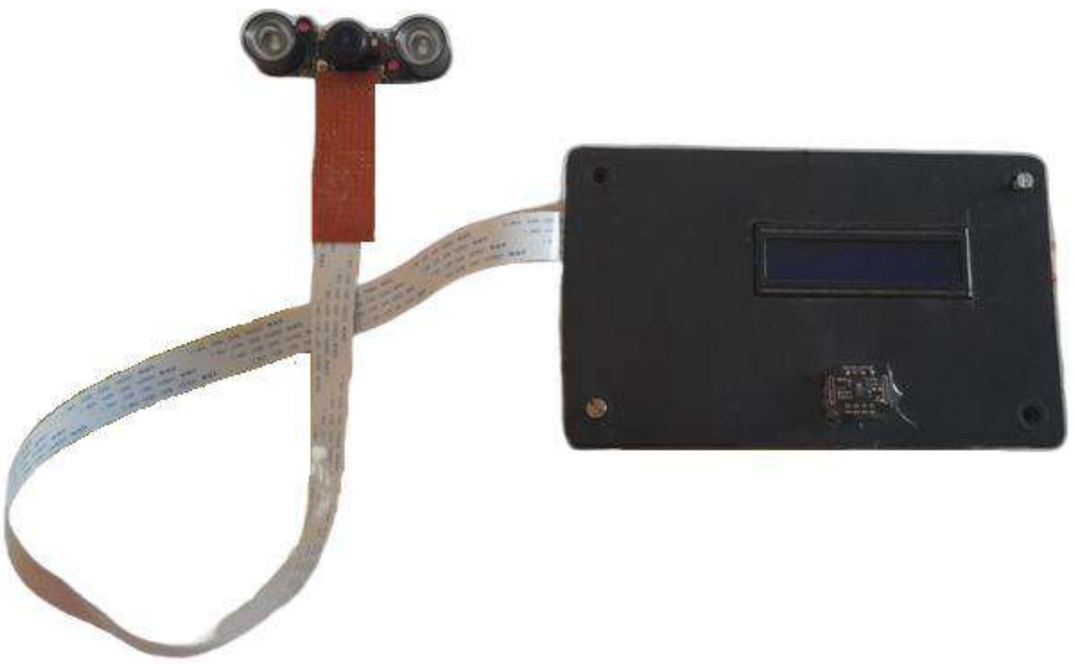

Figure 6.9.8: Overall System

Chapter Seven

7 SYSTEM TESTING & ANALYSIS

For a system to be reliable and functioning, testing and analysis are essential. They aid with finding and fixing any problems or flaws before to the system's deployment. We may make sure that the system satisfies the criteria and performs as intended by thoroughly testing and evaluating its performance. This approach enables us to improve the system's performance, create a dependable product that satisfies user needs, and optimize it.

7.1 System Testing & Strategies

The system testing methods employed in this project are essential for spotting potential issues, verifying the needed system behavior in a variety of scenarios, and ensuring the system's dependability and correctness in real-world healthcare settings.

7.1.1. Module Testing

The hardware modules are assessed individually to confirm integration and functionality. This involves conducting extensive repetitive testing on each module to identify any specific issues, validate inputs and outputs, and ensure effective inter-module communication. The objective is to ensure the modules function properly and seamlessly interact with one another.

7.1.2. Functional Testing

Functional testing is conducted to validate the efficiency of both hardware and application modules in the comatose patient monitoring system. It involves assessing the microcontroller's data gathering, processing, notification generation, and real-time monitoring capabilities. The hardware component is tested through input/output evaluation, sensor calibration, and experimentation with representative values.

7.1.3. Usability Testing

Usability testing aims to identify and enhance any usability issues in the user interface. However, the system is designed to be user-friendly and straightforward. With minimal setup requirements and clear pictorial instructions for attaching certain sensors to patients, the system ensures ease of use. Even individuals without a technical background can achieve the desired usage outcome by following the provided instructions.

7.1.4. Overall System Testing

The overall system testing strategy aims to validate the system's performance, reliability, and compatibility. This includes scenario-based testing and system integration testing to ensure optimal functionality. Once all stages of system testing and debugging are completed successfully, the project should exhibit optimal results, indicating the system's efficiency and effectiveness.

7.2 Testing IR Camera on Difference Body Parts

A lot may be learned about the IR camera's capability to precisely detect and visualize veins in various skin tones, textures, and depths by testing it on various body parts, such as the arm and hand. This project's IR camera has a fixed focus. Therefore, it is vital to hold the camera against the subject at a certain distance in order to achieve the best vein visibility.

By maintaining the proper distance, it is possible to project an adequate number of IR rays onto the subject's skin and see their veins clearly. Poor image quality could result from inadequate IR light reaching the subject if the camera is held too close to it. On the other hand, holding the camera too closely can produce an excessive quantity of IR light, blurring the image that is being presented.

7.3 Testing on Natural Low and High Light

In high natural light conditions, the visibility of veins with the IR camera may be reduced due to interference from strong light sources. In contrast, low natural light conditions can enhance the visibility of veins as there is less interference from ambient light. It is important to consider lighting conditions during testing and use to ensure optimal performance of the vein locator with the IR camera.

7.4 Frame per Second

An IR camera used in vein locator applications typically has a maximum **frame rate per second (fps) that falls between 15 and 30 fps**. Depending on the amount of natural light, the fps can change. The fps may drop due to the necessity for longer exposure periods in low natural light situations where the camera depends more on its own infrared lighting. The longer exposure time enables the camera to capture an image with enough light.

The fps, on the other hand, may increase under high natural light circumstances where there is a lot of ambient light because the camera can use the available light for faster image acquisition. However, it's crucial to establish the appropriate balance because too much natural light can lead to overexposure, which can impair vein visibility and negatively affect image quality. It is crucial to change camera settings, including exposure duration and gain, and to provide proper illumination without leading to overexposure in order to produce the best vein visibility.

However, as a general rule of thumb, **100 to 300 lux of ambient light** might be thought of as ideal for getting the best outcomes. It is crucial to remember that this is only an approximate estimate, and fine-tuning can be necessary depending on the sensitivity of the particular camera and the desired vein visibility.

7.5 Appropriate Range of View

An IR camera used as a vein locator often has a range of view that is measured in centimeters or inches rather than feet. This is due to the fact that in order to get clear pictures of the veins, the camera needs to be placed close to the subject's skin's surface.

The ideal distance from the subject's skin can range from a few centimeters to a few decimeters (a few inches to a few feet), although it is normally within these parameters. A vein locator's recommended field of view is normally between 2 and 30 centimeters (5 and 12 inches) from the subject's skin.

7.6 Heart Rate Sensors on Multiple Units

Due to the abundance of blood arteries close to the skin's surface where the sensor is put on the finger, readings are often reliable and accurate.

The sensor may still deliver reasonably accurate readings when placed on the wrist, but it may be hampered by motion artefacts and a weaker signal than when placed on the finger. As fewer blood vessels are located near to the skin's surface on the wrist, signal quality may be a little worse and readings may be less precise.

In comparison to the finger or wrist, the sensor may provide less precise readings when placed on the earlobe. Less blood vessels and a thinner skin layer in the earlobe may affect the sensor's capacity to record a potent and reliable signal.

7.7 Performance Issues Overviews

Factors	**Outcomes**	**Description of the Issue**	**Optimum Performance Suggestion**
Frame Rate	Maximum 15-30 fps	The frame rate at which the IR camera captures and displays images.	Ensure the camera supports the desired frame rate for real-time monitoring.
Low Natural Light Impact	Poor output of the video – Decreased visibility of veins	Reduced performance in low natural light conditions due to decreased fps.	Increase ambient light or adjust camera settings for optimal visibility & working.
High Natural Light Impact	Poor output of the video - Potential overexposure	Excessive natural light causing overexposed images resulting in veins invisibility	Control light intensity to avoid overexposure and ensure clear images.
Optimum Natural Light	Recommended: 300-500 lux	The ideal light intensity for balanced performance.	Maintain light levels within the recommended range for optimal visibility.

Heart Rate Sensor Performance	Finger: Highly accurate Wrist: Reasonably accurate Earlobe: Slightly less accurate	The heart rate sensor's performance on different body parts.	For accurate readings, use the sensor on the finger or wrist.

Table 7.8: Performance Overview

7.8 Results

For the result we need to show the outputs we are getting from our system. The optimum results conclude this project and gives a successful closure. In the figures 8.1.1 & 8.1.2 below see that Vein Locator is showing veins in the wrist and the knuckles of the hand. Similarly for the blood pressure part we have displayed the results for the Blood pulse measurement and the average blood pulse per minute (figure 8.1.3). Along with this is shown the body temperature as well. Lastly, we can see the results for the glucose level in the blood in the figure 8.1.4

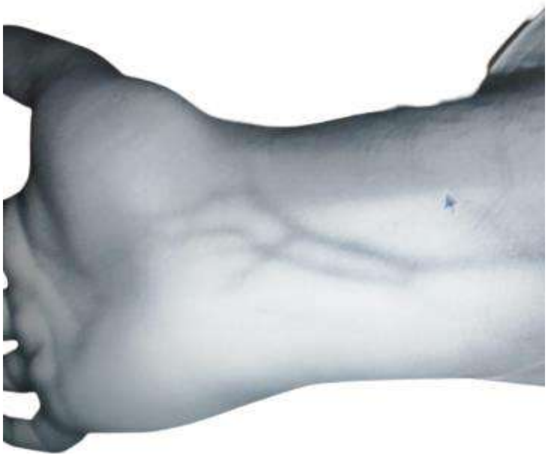

Figure 7.8.1: Wist side veins

Figure 7.8.2: Knuckles side veins

Figure 7.8.3: Blood pulse measurement

Figure 7.8.4: Glucose Level

Chapter Eight

8 ENVIRONMENTAL IMPACT

We're dedicated to putting sustainability first and reducing our project's ecological imprint. We want to save the environment for coming generations by implementing eco-friendly techniques.

8.1 Sustainable Development Goals

Promoting easily available healthcare services, measures for disease prevention, and mental well-being programs are all part of our commitment to good health and wellbeing. In order to promote eco-friendly practices, we encourage innovation in industry and infrastructure.

We oppose inequality and fight to ensure that everyone has access to equal possibilities through social services and economic development. In order to promote a safe and equitable society, we also place a high priority on peace, justice, and strong institutions. We work together with stakeholders through Partnerships for Goals to achieve collective sustainable development and open the door to a more prosperous and just world.

8.2 Broader Impact of SDGs

This project has potential to contribute to several goals of the United Nations Sustainable Development Goals [1] (SGDs). Following are the targeted sustainable development goals and their potential mapping in the next two parts.

8.2.1. Targeted SDGs

This integrated comatose patient monitoring system comes under the domain of healthcare to enhance the quality of treatment of patients and their well-being. Listed are the SGGs this project targets:

- SGD 3 (Good Health and Well-being)
- SGD 9 (Industry, Innovation and infrastructure)

- SGD 10 (Reduced inequalities)
- SGD 16 (Peace, Justice and Strong Institutions)
- SGD 17 (Partnerships for Goals)

8.2.2 Potential Mapping

In order to assess the impact of the project on the targeted SGDs, a checklist is developed for each SGD below:

a SGD 3 – Good Health and Well-being

- Enhancing health outcomes for patients care
- Reducing healthcare related complications and risk
- Fast &Timely monitoring of critical conditions

b SGD 9 – Industry, Innovations and infrastructure

- Innovative technologies for creating low-cost devices
- Hardware and software integration for smooth operations
- Sustainable development infrastructure for healthcare systems

c SGD 10 – Reduced inequalities

- Access to advance monitoring system for all kinds of patients
- Improved system for underserved population and areas.

d SGD 16 – Peace, Justice and Strong Institutions

- Promoting care for patient and minimizing room for error
- Safeguarding lives of people

e SGD 17 – Partnerships for Goals

- Collaboratively developed with healthcare providers and technology experts.
- Knowledge sharing initiatives
- Establishing partnerships to leverage resources and expertise for sustainable solutions

Chapter Nine

9 CONCLUSION & FUTURE RECOMMENDATIONS

The main conclusions from the vein finder system's examination and testing are briefly summarized in this section. This detailed review of the findings and revelations made during the study illustrates the device's functionality, usefulness, and recommended advancements needed to enhance the system.

9.1 Conclusion

Conclusion Remarks: The vein locator system demonstrates promising results in accurately identifying and visualizing veins for medical procedures. It offers improved vein detection, real-time monitoring, and user-friendly operation. However, certain performance limitations in low natural light conditions and variations in vein visibility across different body parts should be considered.

Future enhancements, such as wireless and portable capabilities, integration with machine learning, and collaboration with other healthcare systems, can further enhance the system's functionality and expand its potential applications. Overall, the vein locator system shows great potential to improve venipuncture procedures and enhance patient care.

9.2 Future Works

This section examines options for improving mobility, combining cutting-edge imaging technology, utilizing machine learning methods, and enhancing user experience in vein locator devices.

9.2.1. Integration with other Advanced Systems

To streamline data exchange, improve mobility, enable remote consultations, enhance image processing capabilities, and maximize workflow effectiveness, the vein locator system can be integrated with Electronic Medical Records (EMR), Hospital Information Systems (HIS), telemedicine platforms, mobile applications, image analysis software, and workflow management systems.

9.2.2. Machine Learning Integration

Improve vein recognition and automated vein tracking capabilities by using machine learning and artificial intelligence techniques. Possible work can be to train accurately recognize and segment veins, deploying ML models [17] on the vein locator device to enhance visibility, reduce noise and improve overall quality, introducing ML algorithms that can match capture vein patterns with existing vein databases for identification and lastly forcing the models to perform adaptive algorithms that can change the conditions such as lightening controls and other factors disturbing the visibility.

9.2.3. Wireless and Portable Design

Create wireless, portable, tiny vein locator devices for improved portability in a range of healthcare environments. It can be introduced with using rechargeable batteries for cordless operation and longer usage time, incorporating Bluetooth Wi-Fi for seamless connectivity with smartphones, tablets or laptops for wireless data transfer and other for any other reason and ensuring a reliable and extended wireless range.

9.2.4. Multi – Modal Imaging

To provide a more thorough understanding of veins and increase accuracy, combine infrared imaging with other imaging modalities like ultrasound or near-infrared spectroscopy [18].

9.2.5. Vein Mapping and Database

Create a digital vein database for each patient using integrated vein mapping technology [19] to make it easier to quickly and precisely identify veins during subsequent treatments.

9.2.6. Augmented Reality (AR) Visualization

Investigate the application of augmented reality technology [20] to real-time vein targeting by overlaying vein images onto the patient's skin. Similarly, to develop intelligent glasses or AR googles through which professional can see through the skin directly through glasses.

9.2.7. Vein Health Assessment

Create features to measure vein health, such as blood flow velocity analysis, vein abnormality identification, or vein diameter measurement, to help in the diagnosis and monitoring of vascular disorders [21].

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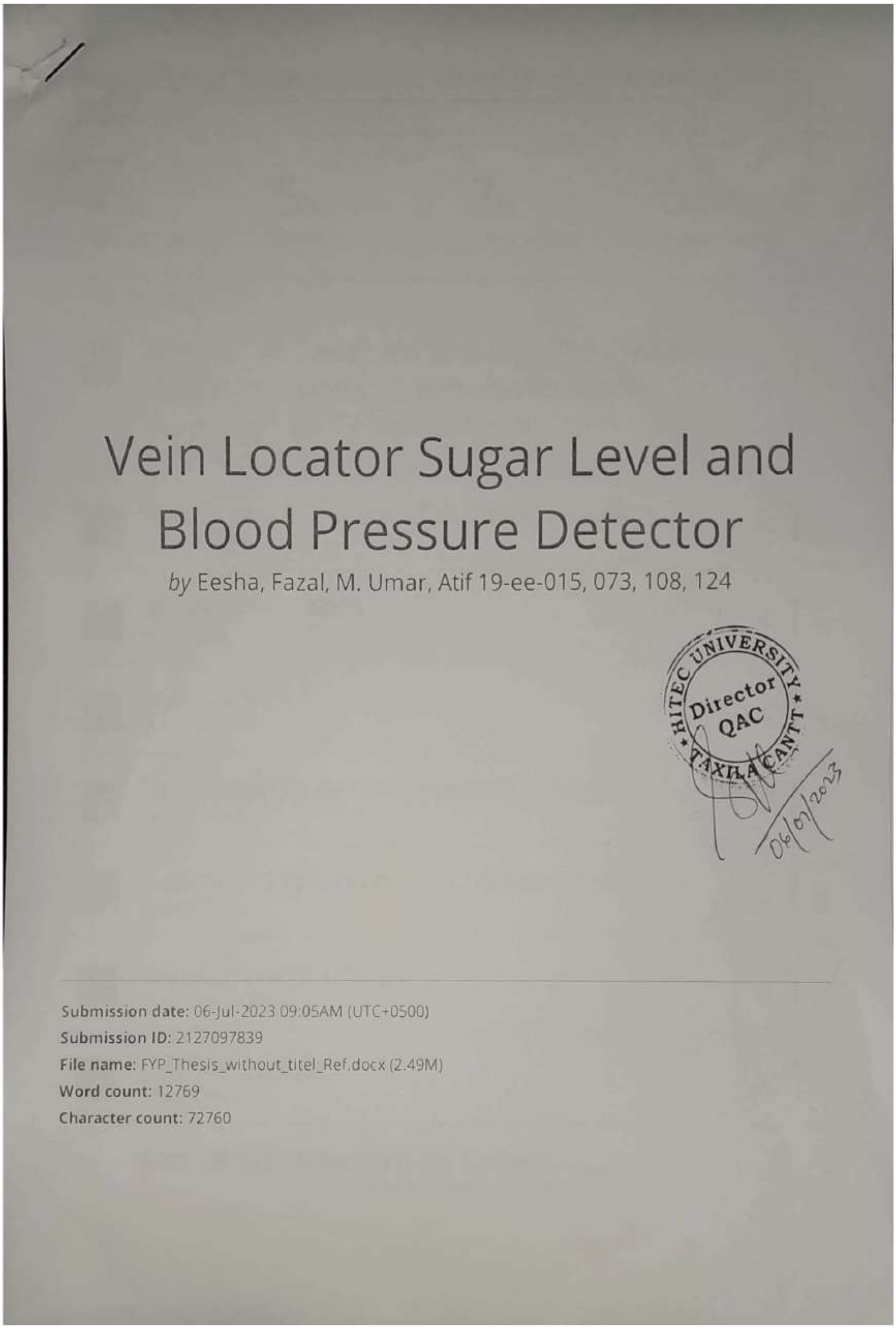

Vein Locator Sugar Level and Blood Pressure Detector

by Eesha, Fazal, M. Umar, Atif 19-ee-015, 073, 108, 124

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