CHAPTER 1 INTRODUCTION TO THE STUDY

Background of the Study and Theoretical Framework

Healthcare is a universal matter that should be given utmost importance and attention. Everyone can be at risk of acquiring any disease and it is no matter that it should be left unchecked. The healthcare industry is one of the most major sectors that has a substantial impact on the entire global population, and it is closely linked to the success of any country. Healthcare is vital to how a country is perceived in terms of keeping economic stability. As a result, healthcare has an important influence on all government initiatives.

Technology plays a vital role in healthcare. Health practitioners can use Information Technology (IT) to save and access data from a patient's health records. It also improves patient information transmission by providing a comprehensible form that anyone may use. As a result, the likelihood of medication errors is decreased. Lastly, it facilitates the retrieval of patient information from a database without the need for fresh health tests. All the healthcare technologies mentioned above have one thing in common: they increase health and patient safety (Bouronikos, 2020).

Technology increases provider capacity and patient access, preventing deaths and increasing people's quality of life. Healthcare enterprises now have greater influence on people's lives as society has moved from leveraging technology to better patient care. Over the last 20 years, technology's involvement in healthcare has grown quickly, and it is predicted to continue to develop in line with society's technological achievements. Having the capacity to store, exchange, and assess health data is closely related to technological advancements (Skinner, 2017).

While the advancements of technology are given, the limitations of these technologies are still open to solutions and improvement. Specifically, to what extent a technological product/service has to offer along with its main function and what other instances it is used for.

These technologies cater to its users' needs primarily only with solutions that are indicated on the product. Technology in the form of devices such as heart rate monitors, oximeters, and digital thermometers that scan body heat temperature are examples of these products. The devices mentioned are used for acquiring vital signs that are basically on-hand results currently present to only one location where remote monitoring is possible to implement, these devices also relate to vital information that refer to baselines in classifying diseases and diagnosing certain maladies that cannot be properly determined unless accompanied by doctors or health experts. Technology in this field can be further improved by integrating the limitations of what these products offer and including more features that answer to the purposes of the gathered data.

Technology within the medical field refers to technological equipment that people can utilize to gather data regarding their personal well-being and physical condition. These gadgets can even transmit an individual's medical information to doctors, nurses, or other healthcare providers in real time. These devices are expected to increase in demand for the coming years as more consumers express an interest in sharing their data with their providers and insurers.

The development and use of medical devices like HealthSense come with important challenges. It is crucial to make sure that the measurements are accurate and reliable for proper diagnosis and monitoring. Integrating with existing healthcare systems is important for sharing data seamlessly. Safety measures must be in place to protect patients. Meeting regulatory requirements and getting approvals are complex and time-consuming processes. Patient privacy and data security are top priorities.

User experience depends on easy-to-use interfaces. Ethical considerations, ongoing maintenance, and support are also significant. Making devices cost-effective is necessary for better access. Overcoming these challenges is essential to create high-quality, safe, and effective medical devices that enhance patient care.

In this subject matter, the researchers have decided to create a healthcare device connected to an embedded system that will monitor vital signs such as heart and pulse rate, oxygen rate, blood pressure and body temperature of the person wearing it, and the device will forecast the possibility of a cardiovascular disease from the result of the analyzation of information coming from the vital signs and data input of the user will then display the susceptibility of acquiring a heart disease. This device will be made useful and efficient for healthcare workers, facilities, and patients to deal with sudden and out of hand situations that will provide convenience.

Currently, there are existing solutions in the market that aim to monitor vital signs and predict heart disease, but they may have limitations and room for improvement. One existing solution is wearable fitness trackers, such as smartwatches, which can monitor heart rate, activity levels, and sleep patterns. These devices, however, may lack the necessary accuracy and specialized algorithms for heart disease prediction. They are primarily designed for general fitness tracking rather than specific medical diagnosis. Another existing solution is remote patient monitoring systems, which allow healthcare professionals to monitor patients' vital signs remotely. These systems often rely on separate devices for measuring vital signs, which can be cumbersome for patients and may not provide real-time monitoring or predictive capabilities.

The integration of embedded sensors, data analysis algorithms, and user-friendly interfaces holds promise for improving healthcare practices and patient outcomes. Challenges include ensuring accurate measurements, developing robust algorithms, usability, privacy, cost effectiveness, and regulatory compliance. The goal is to create a device that provides accurate monitoring, predictive analysis, and convenience for healthcare professionals, facilities, and patients, ultimately enhancing heart disease detection and management.

Theoretical Framework

According to Brown (2021), the capacity of a machine to mimic human intelligence is referred to as machine learning in the field of artificial intelligence. Systems using artificial intelligence (AI) are used to complete difficult jobs in a way that is like how individuals solve problems. The concept of machine learning is based on the idea that machines can learn in a similar way to how humans learn. When humans learn, they do so by observing patterns in data and making connections between those patterns to form an understanding of the world around them. Similarly, on huge datasets, machine learning algorithms can be trained to find patterns and generate predictions based on those patterns.

Systems with artificial intelligence, such as machine learning systems, are utilized to carry out difficult tasks in a way that resembles how people solve issues. A machine learning system, for instance, might be trained on a lot of medical data to find patterns that point to a certain condition. The system can then use that learning to make predictions about whether patients have that disease based on their symptoms and other factors.

Machine learning is based on data, whether it be numerical, visual, or textual. Data examples include time series data from sensors, financial transactions, photographs of people or even particular baked goods, repair records, and sales statistics. Data that have been gathered and prepared for use as training data will be used to train a machine learning model. With more data, the program performs better (Brown, 2021).

Based on Statistics Solutions (2022), when dealing with a dependent variable that has two possible outcomes, logistic regression (binary) is the suitable regression analysis method to employ. Logistic regression, like other regression analyses, is used for prediction purposes. Logistic regression allows to describe data and understand the association between a single dependent binary variable and one or more independent variables of nominal, ordinal, interval, or ratio-level. Logistic regression is categorized as a supervised learning technique.

Logistic regression is utilized to estimate or predict the probability of a binary event, such as a yes/no outcome. An application of logistic regression within machine learning is exemplified by the identification of whether an individual is likely to be infected with the COVID-19 virus or not. This scenario represents binary classification, as it involves only two possible responses: infected or not infected (Chandrasekaran, 2021).

In this study, Logistic regression was used to predict the susceptibility of a person being diagnosed with a heart disease based on Age, Gender, chest pain type (four values), resting electrocardiographic results, maximum heart rate achieved, exercise induced angina, thal: 0 = normal; 1 = fixed defect; 2 = reversible defect, fasting blood sugar > 120 mg/dl. The variables mentioned above would be the factors that will analyze whether you are susceptible to heart disease or not.

An embedded system refers to a computer hardware system that incorporates a microprocessor and specialized software to carry out a designated task, either autonomously or as part of a larger system. While embedded systems are classified as computer systems, user interface (UI) which can vary significantly, ranging from absence of any UI to intricate graphical user interfaces (GUIs) like those found in mobile devices. User interfaces can encompass elements such as buttons, LEDs (light-emitting diodes), touchscreen functionality, and in certain cases, remote interfaces are employed by certain systems as well.

Embedded systems only function inside of a complete device that has all the necessary components, including a processor, power supply, memory, and communication ports.

These communication ports are used to transport data using a communication protocol between the processor and peripheral devices. The processor analyzes and interprets data using basic software that is stored in the memory.

The study intends to develop an embedded system using Arduino to create functionalities for a healthcare device that will serve as a tool for the user to monitor vital signs and keep track of them which will then analyze the accumulated data to later predict the user’s status whether he has the possibility of having a heart disease.

The results will be then displayed on a remote device the user can access anytime. Whenever it does not meet the healthy baseline, it will show a message referring to the user’s likelihood of acquiring a heart disease.

Objectives of the Study

In order to develop and create a healthcare device that will monitor the vital signs of a user in real time and create a Machine learning model that will predict whether the user has a heart disease.

Specifically, it aims to:

1. To create an embedded device using Arduino that will scan and monitor vital signs of the user and display it on a mobile application.

2. To develop an AI/ML system that will analyze and display the results from the provided data of a user that will recommend whether he should see a doctor.

3. To develop and deploy a web app that will host the machine learning algorithm which can be accessed from a mobile phone or personal computer.

4. To evaluate the effectiveness and usability of the healthcare device in monitoring vital signs of a user and the accuracy for the algorithm that was used for predicting a heart disease.

Significance of the Study

This research is beneficial to the following users:

IT students/Developers. The healthcare device will be able to provide insights and guide the students who also want to develop and create a healthcare device. Also, the development of this study will help them improve their technical skills and increase their knowledge relating to the Internet of Things (IoT) and embedded systems.

Healthcare Facilities. The healthcare device will help health facilities, especially hospitals, to respond quickly to any emergency and apply the medical treatment necessary.

Healthcare Professionals. This study will aid health professionals since they are the one to closely monitor patients within their respective health facilities. This technology will aid them throughout their daily medical rounds.

Intended User/Patients. People who are at risk and prone to fever are the main beneficiaries of this study. Healthcare monitoring of these individuals will be further improved and health related mishaps can be effectively averted.

Definition of Terms

For better understanding, the following terms are defined conceptually and operationally:

Algorithm -- a constrained set of clearly defined instructions that are frequently used to solve a certain set of issues or carry out a computation.

The Logistic Regression algorithm, which is used in this study, is used to assess vital sign data and apply machine learning techniques to forecast the likelihood that patients would develop heart disease. The software of the gadget is programmed with a set of pre-established rules and decision-making processes that are incorporated into this algorithm, ensuring reliable and accurate predictions.

Arduino -- a platform that may be used for free to build electronic projects. It consists of two crucial parts: software running on your computer's Integrated Development Environment (IDE) and a programmable circuit board, sometimes known as a microcontroller. The IDE makes it possible for users to create and upload computer code to the actual board, which speeds up the creation of several electronic projects.

In this study, the Arduino board is equipped with software that is specifically designed to interpret the data gathered from the sensors. The software then carries out data processing and analysis using the embedded algorithm incorporated within the Arduino board. The Arduino board provides a flexible and customizable platform for controlling the sensor system and collecting and analyzing vital signs data, which enables the HealthSense device to provide accurate and reliable heart disease predictions.

Embedded systems -- a carefully crafted combination of computer hardware and software that are used to carry out functions. These systems can operate independently or as crucial parts of a bigger system. Embedded systems may have programmable traits that enable flexibility in their functionality or fixed traits that are created to carry out a predefined set of tasks.

In this study, embedded systems referred to the electronic parts of the HealthSense medical device. These include sensors, microcontrollers, and software that are tightly integrated into the architecture of the device. The embedded systems were created with the specific intent of actively monitoring and collecting patient vital sign data in real-time. This covers significant metrics including oxygen saturation levels, blood pressure, and heart rate. The embedded systems are also responsible for processing and analyzing the collected data using the predefined algorithm to provide heart disease predictions. The use of embedded systems in the HealthSense medical device enables accurate and reliable vital signs monitoring and heart disease prediction, while also allowing for a compact and portable design suitable for use in various healthcare settings.

Health Monitoring Device -- a compact electronic device that may be worn on the body or attached to it are known as health monitoring devices. They make it easier to measure different physiological indicators. Temperature, blood pressure, blood oxygen levels, breathing rate, sound, GPS location, elevation, physical movement, changes in direction, and even the electrical activity of vital organs like the heart, muscles, brain, and skin can all be monitored and tracked by these devices.

In this study, health monitoring device referred to the HealthSense medical device itself. The HealthSense medical device itself is intended for the purpose of monitoring and collecting real-time vital signs data from patients. These data include crucial measurements like blood pressure, heart rate, and oxygen saturation levels. The device incorporates an embedded sensor system that is responsible for capturing and measuring the vital signs data accurately. Additionally, the device is equipped with an embedded algorithm, which processes and analyzes the collected data.

Machine Learning -- is the usage and development of computer systems that can learn and adapt without being given explicit instructions, by analyzing data patterns and drawing conclusions using algorithms and statistical models.

In this study, it refers to train the algorithm embedded in the device to accurately predict heart disease based on the vital signs data collected from patients.

Vital Signs -- medical conditions can be detected or monitored by observing vital signs. Vital signs can be evaluated in various settings such as hospitals, homes, emergency medical situations, or any other relevant locations.

In this study, The HealthSense medical device is designed to collect and monitor these vital signs in real-time using an embedded sensor system, which includes sensors for assessing the oxygen saturation levels in the blood, the heart rate, and other pertinent parameters.

Prediction -- making a statement or estimation regarding the occurrence of an event or action in the future, often based on existing knowledge or past experiences.

In this study, prediction referred to the use of the embedded algorithm in the HealthSense medical device to analyze the vital signs data collected from patients and generate a risk assessment for heart disease. Specifically, the algorithm uses Machine Learning techniques to identify patterns in the vital signs data and correlate them with the heart disease's existence or absence. In accordance with this analysis, the algorithm generates a prediction of the patient's risk of getting heart disease. The prediction is based on the patient's vital signs data and other relevant clinical factors.

Heart Disease -- a category of illness that impacts the heart or blood vessels.

In this study, the HealthSense medical device is built to analyze the vital sign data gathered from patients and produce a risk assessment for heart disease using an embedded algorithm and machine learning techniques.

Delimitation of the Study

The study aims to develop and create a health care device that will real-time monitor any user's vital signs. The user’s vital signs will be monitored by the embedded system and the sensors attached to the healthcare device.

The device is limited to three to four sensors specifically pulse rate, temperature, oxygen rate, and blood pressure for monitoring vital signs and inaccuracies encountered will be incapable of predicting input values that are outside of the dataset’s accumulated subject entries.

The sensors also have a margin of error when monitoring user vital signs, issues that occur could not be completely addressed as this would have to be entirely determined by the limitations of the sensor’s integrity.

The application requires the Internet to access the Machine Learning Web-application.

CHAPTER 2 REVIEW OF RELATED STUDIES

Review of Existing and Related Studies

Heart disease prediction using machine learning techniques

Machine Learning (ML), a vital component of Artificial Intelligence, is transforming research in a variety of domains. This research focuses on the use of machine learning to diagnose cardiac disease in humans. Given the global prevalence and lethal implications of cardiovascular diseases (CVDs), precise diagnosis is critical. Machine learning approaches may efficiently predict whether an individual has a cardiovascular illness by evaluating attributes such as chest discomfort, cholesterol level, and age (Garg et al., 2021).

Supervised learning, a type of machine learning method, helps to simplify the detection of cardiovascular illnesses. Algorithms such as K-Nearest Neighbor (KNN) and Random Forest are used to categorize people as having or not having cardiac disease. K-Nearest Neighbor (K-NN) and Random Forest are two supervised machine learning techniques used in this paper. The K-Nearest Neighbor (K-

NN) algorithm predicts with an accuracy of 86.885%, while the Random Forest algorithm predicts with an accuracy of 81.967% (Garg et al., 2021).

IoT based Advanced Wearable Safety Device using Arduino

The Internet has opened several ways to do the needful in this direction to know the common symptoms of a person in danger. If a person fears, his/her heart beat increases, blood pressure becomes high, hands and body shake due to fear, blood flow increases, breathes rapidly, rate of respiration becomes high, sweat comes out, body temperature increases, muscles become active etc. (Tanupriya, Er. et al, 2020).

The extent of fear in a person can be measured by sensing the level of these symptoms. When these symptoms are above a specific threshold, it can be said that a person is in danger. There are specific sensors for measuring the above-described symptoms. Hence, all these sensors to an Arduino board which is programmed according to the needs like saving contacts in order to send an alert and setting a threshold for sensors, above which an alert will be sent to the saved contacts. The Global Positioning System (GPS) must be connected to track the whereabouts of the individual and Global System for Mobile communication (GSM) to send messages to the saved contacts. The device consists of various sensors like temperature sensor, heart rate and respiration sensor ADS1292R ECG/Respiration Breakout Kit, muscle sensor SEN13723 EMG sensor, sweat sensor EDA/Galvanic Skin Response sensor, Vibration sensor SW-420 Module, blood pressure sensor and two manual switches (Tanupriya, Er. et al, 2020).

The study also aims to monitor the person's vital signs using sensors and arduino; to connect all these sensors to an arduino board which is programmed that whenever it does not meet a certain baseline it will send a message to the software application relating to the user's condition.

PhysioDroid: Combining Wearable Health Sensors and Mobile Devices for a Ubiquitous, Continuous, and Personal Monitoring

According to Villalonga et al. (2014), PhysioDroid is a cutting-edge widespread system for remote and constant tracking of an individual's physiological and behavioral condition. The system combines wearable health sensors capable of detecting physical and behavioral traits with mobile devices that collect and process the data.

PhysioDroid's primary purpose is to empower people in everyday situations and raise their awareness and participation in healthcare and well-being by offering a brief overview of their health state. The system also incorporates tracking and alert mechanisms for various circumstances, as well as the ability to initiate emergency measures when necessary.

Furthermore, PhysioDroid wants to harness health data acquired from numerous users, which can contribute to the acceleration of medical and social knowledge. As a result, caregivers are able to provide more efficient medical assessments, treatments, and preventative approaches (Banos et al., 2014).

In line with this concept, the present study aims to develop a system that utilizes a sensor for monitoring a person's health. The collected data is transmitted to a mobile app, which is responsible for collecting and processing the data (Villalonga et al., 2014; Banos et al., 2014).

The application of wearable smart sensors for monitoring the vital signs of patients in epidemics: a systematic literature review

Wearable smart sensors have emerged as a potential technique for monitoring vital indicators on a regular basis while avoiding discomfort and involvement with ordinary daily activities (Mohammadzadeh et al., 2020). This study sought to examine the use of wearable smart sensors in disease prevention and vital signs monitoring during epidemics. To discover relevant articles published till June 2, 2020, the researchers did a thorough search across databases such as Web of Science, Scopus, IEEE Library, PubMed, and Google Scholar.

Among the 277 articles initially found, 11 studies met the inclusion criteria. The majority of papers (36%) were published in 2020, with distribution across 10 different journals, including multiple articles in the Journal of Medical Systems. Body temperature, heart rate, and blood pressure were the most commonly monitored vital signs using wearable sensors. Wearable devices like helmets, watches, and cuffs, as well as body area network sensors, were popular choices for monitoring vital signs during epidemics.

The reviewed studies were primarily conducted in the USA, Malaysia, and India, accounting for 65% of the total papers. The application of appropriate technological solutions, including continuous monitoring of vital signs using sensors, has the potential to enhance epidemic disease control and management. However, further research is needed to investigate the real effects and effectiveness of these sensors (Mohammadzadeh et al., 2020).

In line with this research, the study aims to utilize a health device to monitor vital signs and provide efficient monitoring of user’s status. However, the specific focus of this study is on examining the utilization of wearable smart sensors for disease management and vital signs monitoring during epidemic outbreaks (Mohammadzadeh et al., 2020).

Health Network Wearable: Remote patient monitoring system

According to Thangarajah Raajkumar's project on Hackster.io (2021), a Health Network Wearable system is introduced for remote patient monitoring. The system involves connecting a patient's vital measurement data to a Health Network device, which then syncs with a dedicated mobile application. Medical professionals responsible for the ward can access the app to view the displayed data and receive notifications for critical values.

To establish connectivity with the Electronic Medical Records (EMR) system, Bluetooth mesh technology is utilized. The system incorporates the nRF52840 Dongle to enhance Bluetooth range and device functionality. Power consumption monitoring is facilitated using the Power Profiler Kit II, and a Li-Po battery powers the device. The Arduino Nano R3 development board and a Bluetooth module are employed to establish a Bluetooth mesh connection between each patient's EMR system and the device (Thangarajah Raajkumar, 2021).

The study will also be using arduino on the device that will be developed and data will also be displayed and kept in the app that is connected to the device. In addition, both are sending notifications, to the device technician or health practitioner and the study above directly to the medical personnel in-charge (Hackster.io, 2021).

Power of Android Wearable Technology

Android, a widely recognized open-source mobile device operating system, is extensively used in the electronics industry. It is utilized in embedded products, including contemporary Android Wearable devices that connect with the human body and synchronize with mobile devices. These wearable devices incorporate cutting-edge features such as voice activation, calendar integration, music playback, biometric measurements, and email functionality. They also facilitate interaction with other handheld devices. The paper discussed in this summary presents technical details about Android Wearables, development processes, and debugging techniques using Android Studio. The development system encompasses cross-compilers, libraries, debuggers, prebuilt file system images, and product-specific support libraries.

Specifically designed for Google devices like smartwatches and glasses, Android Wear technology offers a simplified interface along with a range of fitness features. Smartwatches equipped with advanced health tracking applications provide coaching and reminders for workouts, as well as information on speed, distance, and time. Integrated biometric tools and sensors monitor the user's heart rate and regularly update average heart rate information (International Journal of Scientific and Research Publications, 2015).

This study is about android wear technology which is kind of similar to this study. They both make use of sensors to monitor vital signs but with different reasons. Additionally, they are integrating embedded systems to the products they are developing which the proposed study is also trying to accomplish.

Designing Embedded Systems with Arduino Microcontrollers: A Way Forward for Technological Advancement in Nigeria

The Arduino Microcontroller has made it easier for engineers to incorporate embedded systems into their designs without requiring extensive knowledge of complex computer technologies. Engineers can program the Microcontroller directly from their desktop computer or laptop, eliminating the need for additional equipment. The open-source nature of Arduino has fostered the formation of communities and groups on social media and other platforms, where individuals work on various projects using the Microcontroller. This study aims to provide concise information about the device, focusing on topics that beginners would find helpful.

The structure of the Arduino Uno Microcontroller is explained, along with its basic programming syntax and functions. As an illustration, this study describes the design of a simple sequential timing system for an advertisement display. The operational codes were written and compiled using the Arduino Integrated Development Environment (IDE), while the simulation was conducted using UnoArduSim V2.1.

Moreover, this study aims to enhance the understanding of electrical and electronic engineers and enthusiasts, serving as a valuable resource for prototyping electrical and electronic systems and fostering socio-economic benefits (Akinwole & Adeoye, 2020).

This study is alike in incorporating embedded systems with arduino. Thus, this study is similar to the previous study because it both utilizes an arduino to create a system.

The use of vital signs as predictors for serious bacterial infections in children with acute febrile illness in a pediatric emergency setting in Sudan

In primary care and hospital emergency departments, distinguishing children with serious infections from those with milder febrile illnesses poses a daily challenge. It is recommended to assess vital signs as part of this evaluation. To investigate the predictive value of vital signs in identifying children with serious bacterial infections, a study was conducted in a Pediatric emergency department in Sudan. The study included 150 patients aged 1 month to less than 16 years who presented with acute febrile illnesses. The severity of infection was categorized as either serious or non-serious bacterial infection. Vital signs and oxygen saturation were recorded and compared to the outcome of the children. Bivariate and multivariate regression analysis was performed on the data.

The study findings indicate that vital signs played a significant role in predicting serious bacterial infections among children with acute febrile illnesses. Tachycardia (elevated heart rate) and tachypnea (rapid breathing) were found to be the most sensitive and specific signs in predicting serious bacterial infections. High temperature equal to or above 40°C, severe hypoxemia (oxygen saturation below 90%), and hypotension (low blood pressure) were less sensitive but highly specific indicators for serious bacterial infections (Salah et al., 2014).

Both studies used vital signs as predictors of having a malady.

Machine Learning Enabled Vital Sign Monitoring System

The healthcare industry has undergone a significant transformation with the advent of the Internet of Things (IoT), as stated by Vats in 2019. This technological advancement has enabled remote monitoring, utilization of smart sensors, and integration of medical equipment. The IoT has brought numerous benefits to the healthcare sector, including improved patient health and safety, enhanced physician care delivery, and better doctor-patient engagement.

In countries such as the USA, UK, Germany, Canada, and Australia, smart healthcare is primarily associated with providing healthcare facilities for ambient assisted living. It also plays a crucial role in educating individuals about available healthcare facilities, enabling them to self-manage emergencies. However, smart healthcare also presents certain disadvantages, including concerns regarding security and privacy, integration challenges, and technology adoption.

Machine Learning (ML) has evolved from pattern recognition, enabling computers to learn without explicit programming for specific tasks. ML has found numerous applications in healthcare, including disease identification, drug discovery, medical image diagnosis, and robotic surgical tools. However, diagnostic errors remain a significant issue in healthcare. The Institute of Medicine at the National Academies of Science, Engineering, and Medicine reports that diagnostic errors contribute to approximately 10% to 17% of hospital complications and account for around 10% of patient deaths (Vats, 2019).

This related study and this study both utilize machine learning that is implemented through vital signs monitoring and other smart functions in healthcare.

Vital Signs Prediction and Early Warning Score Calculation Based on Continuous Monitoring of Hospitalized Patients Using Wearable Technology

According to Ali Amer et al. in 2020, the study focused on using wearable technology to continuously monitor the vital signs of hospitalized patients for real-time early warning scores (EWS) estimation and vital signs time-series prediction. The vital signs monitored included heart rate, blood pressure, respiration rate, and oxygen saturation of patients in cardiology, postsurgical, and dialysis wards. The study explored two aspects: high-rate estimation of vital signs components for one-minute segments, contrary to the conventional practice of 2 to 3 times per day, and the use of a hybrid machine learning algorithm (kNN-LS-SVM) to predict future values of vital signs.

The study demonstrated the feasibility of implementing real-time EWS in clinical practice and showcased the promising prediction performance of vital signs compared to state-of-the-art approaches like LSTM. For cardiology patients, the mean absolute percentage errors in predicting one-hour averaged heart rate were 4.1%, 4.5%, and 5% for the upcoming one, two, and three hours, respectively.

The findings indicate the potential of wearable technology in continuously monitoring hospitalized patients' vital signs, enabling real-time EWS estimation and reliable prediction of future vital sign values. These approaches offer cost-utility, mobility, portability, streaming analytics, and early warning for vital signs deterioration. Thus, this involves the development of a real-time vital signs monitoring system that provides efficient cost-utility, mobility, and portability, similar to previous research.

Machine learning based classification model for screening of infected patients using vital signs

According to Han et al. in 2021, reliably distinguishing healthy from infected persons and detecting illness origins are critical for disease prevention and treatment. Because of environmental and subjective elements, traditional quarantine approaches depending on remote body thermometers and questionnaires have drawbacks. Using Machine Learning techniques for this purpose could provide a more objective and effective solution.

The research presents a non-contact measurement method that collects data using medical radar. The radar data is then filtered to remove interference and retrieve vital characteristics such as heart rate and breathing rate. Following that, five Machine Learning algorithms are used to determine if an individual is healthy or contaminated. The acquired dataset is used to train and test the categorization models.

The performance of the classification algorithms is evaluated based on the f1-score parameter, with an accuracy threshold set at over 80%. Notably, the Deep Learning algorithm achieves the highest result, with an accuracy of 98%.

This study successfully implements patient classification algorithms that demonstrate good performance. This has potential benefits for swiftly screening infected patients in public health centers located in underdeveloped areas where access to healthcare is limited.

Hence, both studies utilize machine learning algorithms in the field of healthcare to analyze accumulated data and detect the likelihood of a person having a disease.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

Description of the Study

The study aims to develop and create a healthcare device that monitors the vital signs of the user in real-time and predict the probability of the user from acquiring a heart disease based on the provided data.

The mobile application is developed using Google Blockly as the programming language and MIT App Inventor as the integrated development environment (IDE). On the other hand, the embedded system is created using C++ as the programming language and Arduino as the IDE. The researchers also utilized Firebase to create and manage the real-time database.

Sources of Information

Documentary research data. This study encompasses resources that provide valuable information for the advancement of the research. The researchers collected data from online articles and studies that offer source codes, diverse methodologies, datasets, and academic articles relevant to the study.

Medical Device. A purpose-built device specifically designed for medical applications, focusing on retrieving and monitoring the vital signs of a user. Its primary objective is to provide valuable and real-time information about an individual's health status. This innovative device incorporates a range of specialized sensors that are capable of capturing and analyzing data.

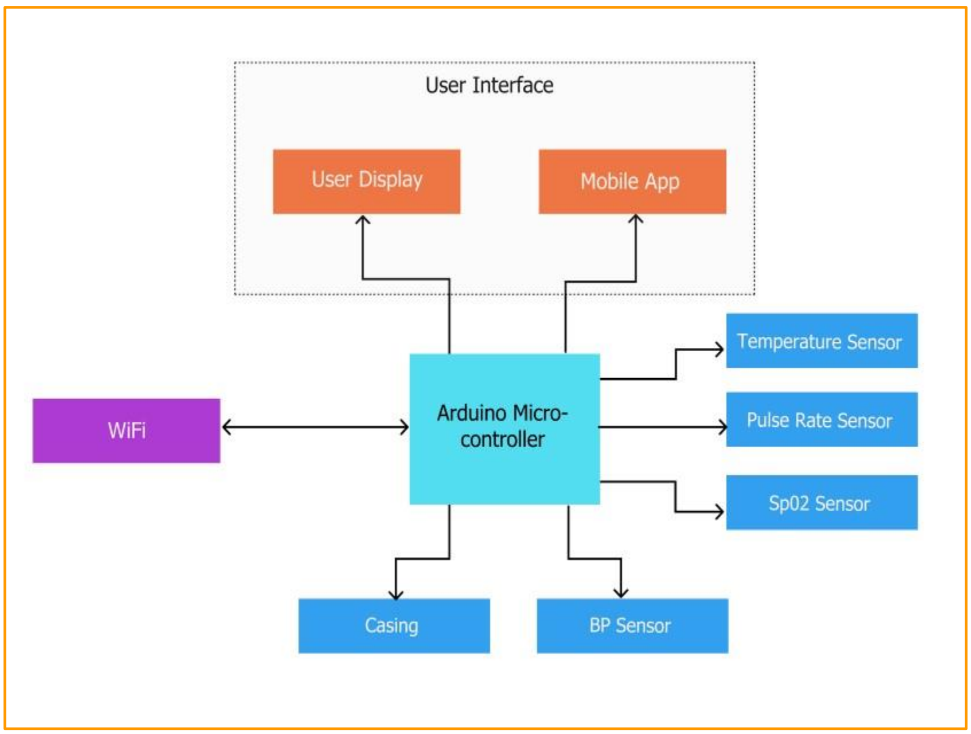

Figure 1. Block Diagram

Heart Disease Prediction System. A machine learning system that follows an algorithm to determine the results of gathered data which was tested with 76% accuracy to classify whether a user has heart disease or not.

Accuracy Test. A validation test that was conducted to assess the accuracy of the heart disease prediction. The researchers gathered 1025 samples from a diverse group of individuals to ensure the reliability of the prediction.

Software Evaluation Form. The system's qualities were assessed using a standardized evaluation form that focused on usability and effectiveness. This evaluation form incorporated ISO-standard Usability Evaluation Tools to gauge the system's performance

Components and Design

System Architecture

As indicated in Figure 2, the user utilized a device to gather data from sensors integrated into the system. It is then directly recorded in the database. After being saved in the database, the data were presented in the mobile app. Following that, the user must provide the remaining information required to determine the likelihood of developing heart disease.

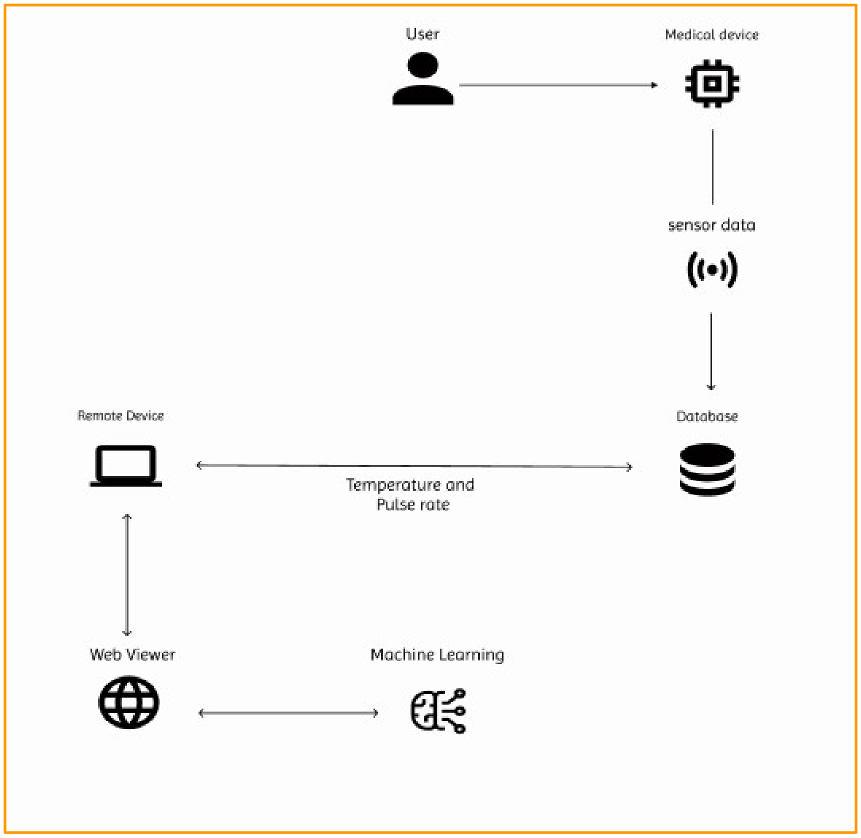

Figure 2. System Architecture of the System

Procedural Design

Shown in Figure 3 is the procedural design that specifies the steps that must be followed. First, the user performs the necessary steps in setting up the device. Then the vital signs of the user — e.g., pulse/heart rate and temperature – will be checked. Device starts to analyze the data that is received from the user. Should the user decide to get themselves checked, they will be redirected to the web application. Then the machine learning algorithm will predict the susceptibility of the user to heart diseases based on the gathered data.

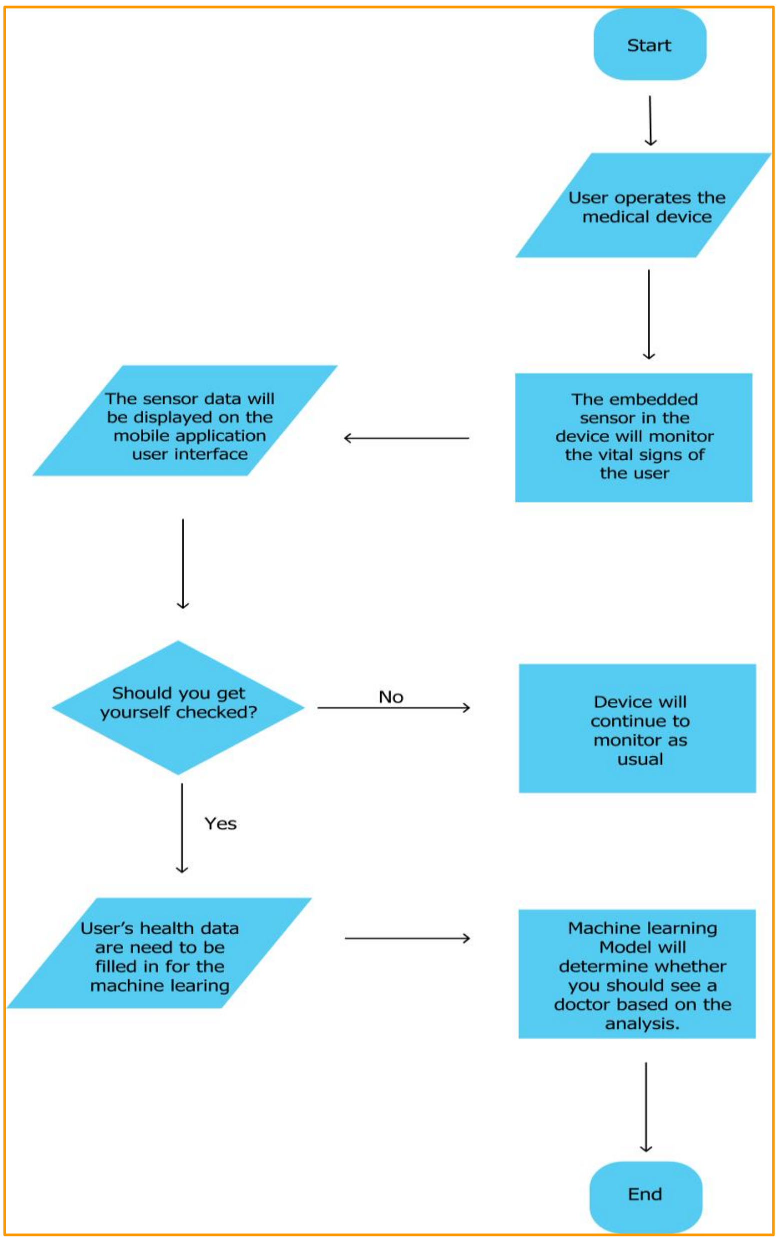

Figure 3. Procedural Flow of the System

Activity Diagram

Figure 4 shows the embedded sensor system collects data from sensors and user inputs. It processes the data and transmits it to the monitoring system. Vital signs monitoring displays real-time data. Heart disease prediction analyzes collected data from the user and gives feedback to them if they are at risk of heart disease.

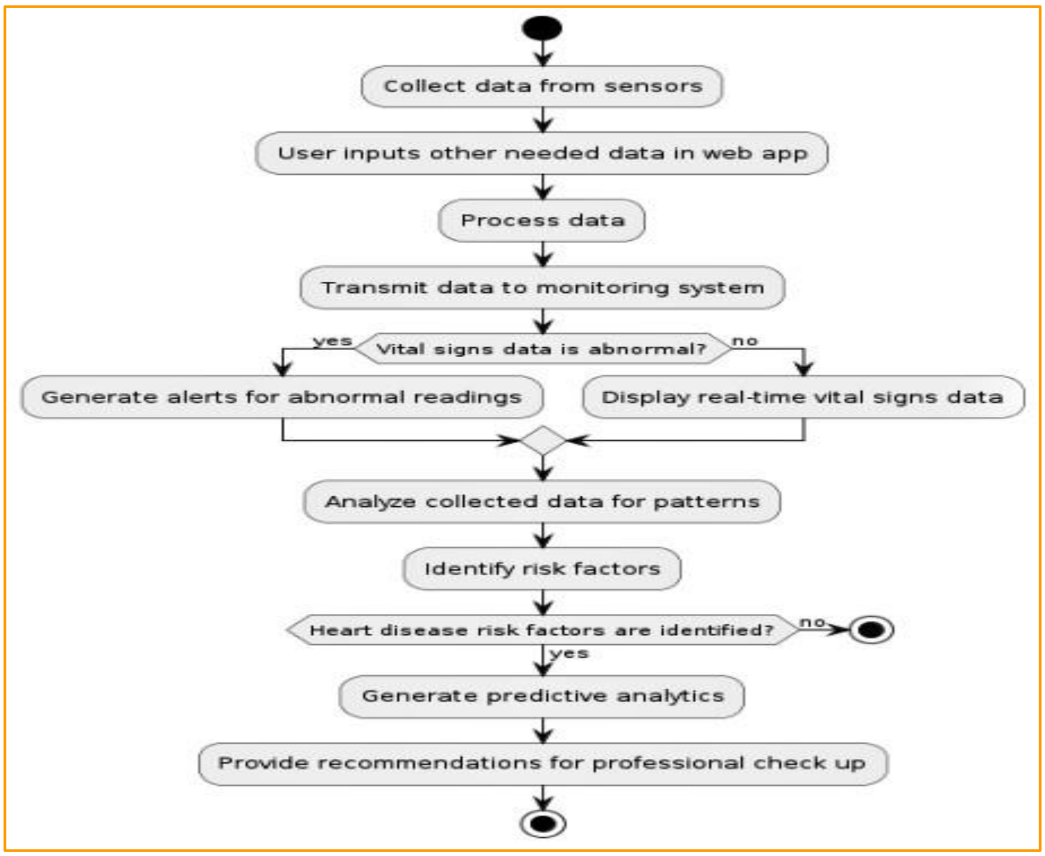

Figure 4. Activity Diagram of the System

Data Flow Diagram

As depicted in Figure 6, the user first operates the medical device then the sensors embedded within the device will monitor vital signs. Then, the sensors and microcontroller process the data and transmit it to the real time database. From the database, the recorded vital signs are displayed on the mobile application. Next is if the user wants to know if they are susceptible to heart disease, there is a button in the mobile app where it will redirect them to the web app of the machine learning. The machine learning model analyzes collected data and predicts susceptibility to heart disease.

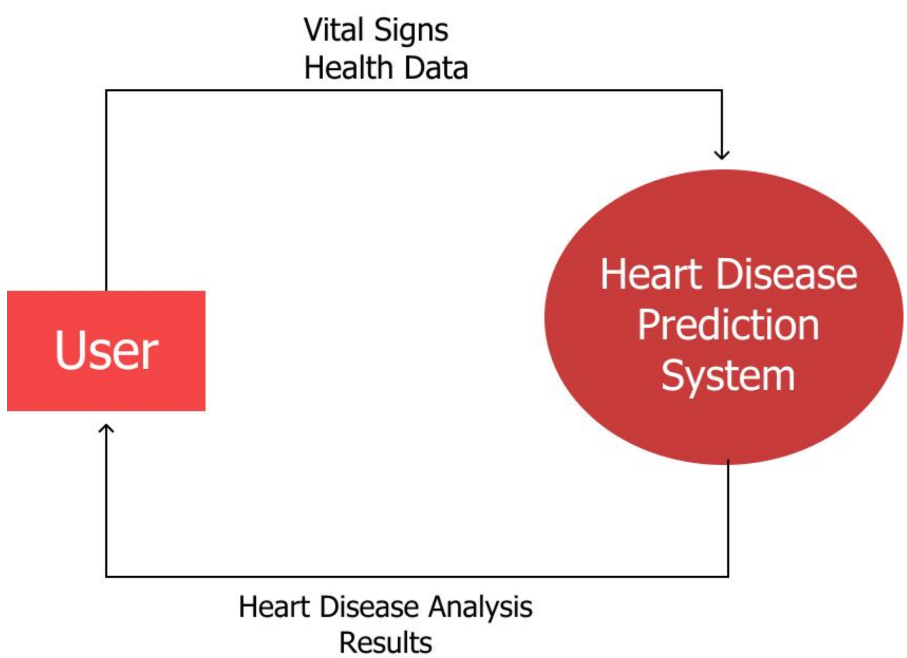

Figure 5. Context Diagram

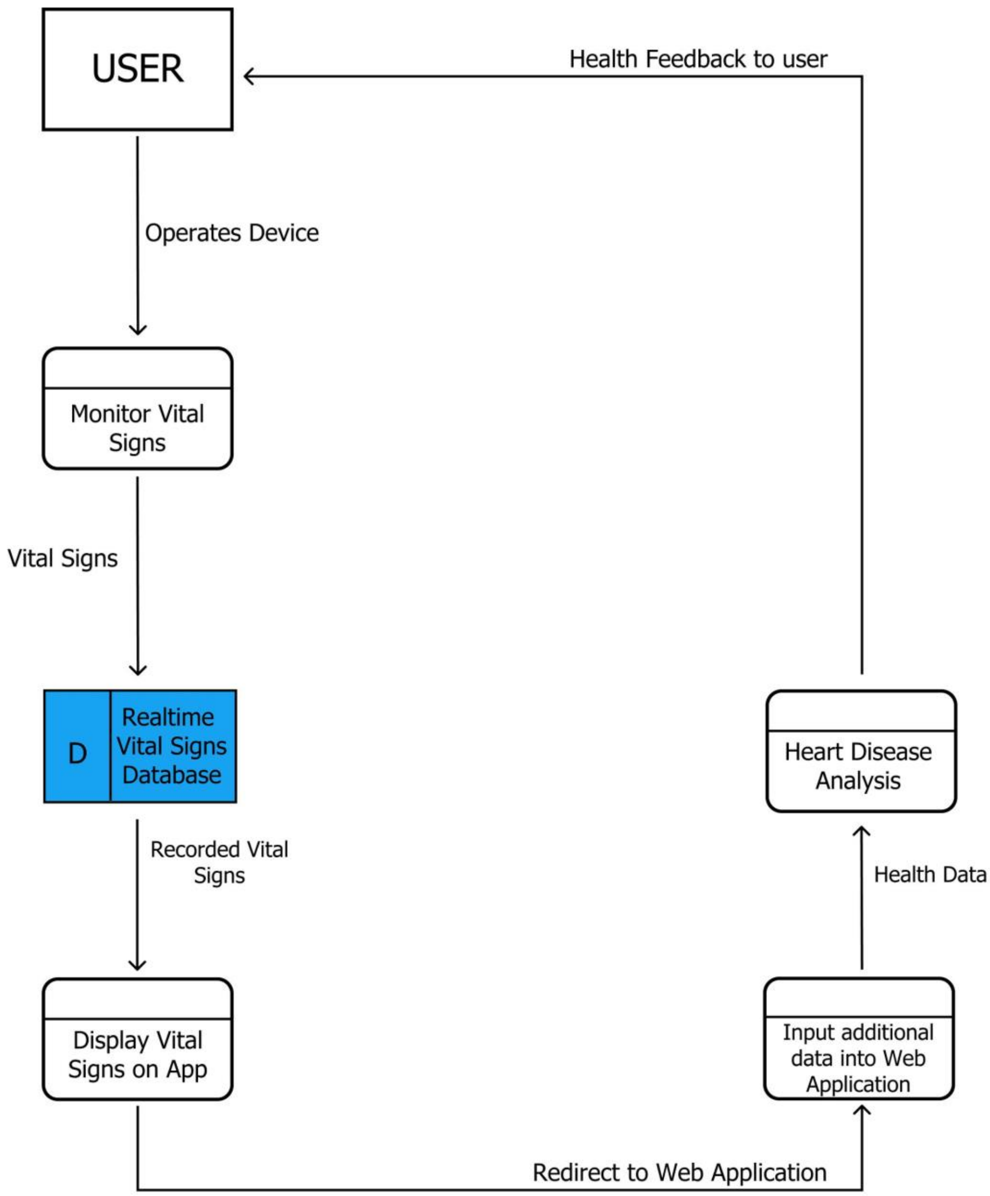

Figure 6. Data Flow Diagram of the System

Figure 7 displays the system consists of several main classes: Device, Embedded Sensor System, Vital Signs, Heart Disease Prediction, User, and Monitoring

System. Each class has specific attributes and methods associated with it. For example, Device has attributes like ID and manufacturer, as well as methods like getStatus() and updateStatus(). The relationships between classes are also defined, such as the Device being connected to the Embedded Sensor System and the Embedded Sensor System providing data to measure Vital Signs. The User is associated with a Device for monitoring, and the Monitoring System interacts with the Device.

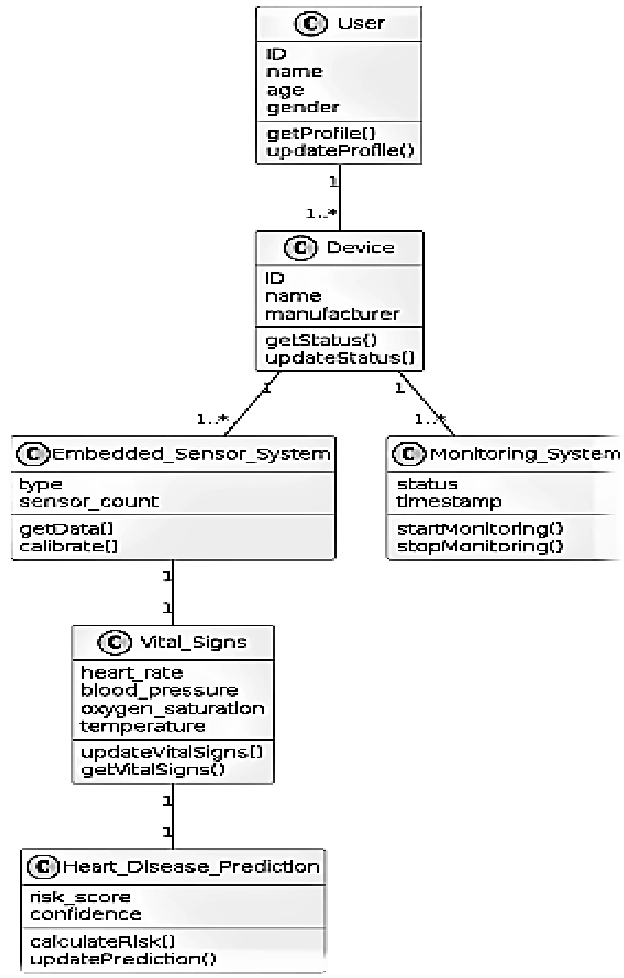

Figure 7. Class Diagram

System Development Life Cycle

This research used an Agile Development Process Model. The SDLC is a systematic and organized sequence of phases that enables developers to consistently deliver software of high quality. Through rigorous examination and timely deployment, the SDLC process ensures that the system meets user expectations effectively. The agile methodology seeks to outperform heavyweight processes in terms of productivity. It requires less planning and divides a task into small sub-tasks or increments through teamwork. The researchers opted for the Agile Model as it is the most fitting approach for developing the proposed system. This model allows for a more efficient workflow as the work is divided into iterations, and concurrent development is possible. With the Agile Model, researchers can swiftly implement changes or enhancements to the system. Before releasing this system, the researchers underwent a series of cycles or iterations to identify any errors, adapt to change promptly, and continuously develop the system. The team followed the stages of the software development life cycle, which included gathering requirements, analyzing, designing, coding, testing, and maintenance.

Requirements collection - During this stage, the researchers collected information and requirements for the system. The project objectives are defined by the researchers in order to determine the course of action for the development of the suggested system.

Analysis – The researchers analyzed the potential requirements and costs of the possible necessities in creating the proposed study.

Designing – This is where the researchers designed and develop the system software using Google Blockly for the mobile application and Streamlit for the web application.

Coding – In this stage, this is where the researchers make use of package distribution applications for the machine learning environment, Google Blockly for developing a simple mobile application with basic functionalities and Arduino IDE for all the sensors of the device.

Testing - During this stage, multiple tests are created and carried out to detect and correct faults, inaccuracies, and other concerns before the system is released for user deployment. The researchers assessed the completed system to identify any issue that may be present. The Accuracy test is employed in this stage to confirm the efficiency of the health monitoring system.

Maintenance - During the maintenance stage, the researchers performed monthly system maintenance. This include a thorough examination of the system to identify any bug or error. Additionally, a session may be scheduled during this stage to discuss any issue or potential enhancement to the system.

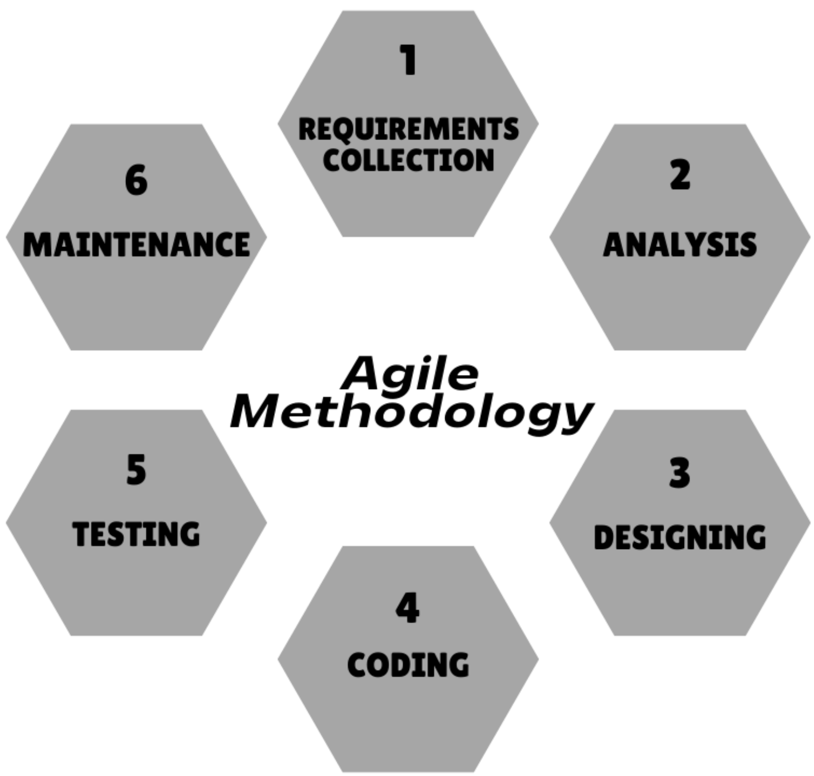

Figure 8. System Development Life Cycle Agile Model

CHAPTER 4 RESULTS AND DISCUSSIONS

Implementation

This chapter contains the required steps that are needed to fulfill the objectives that are set in this study. This section contains the presentation and discussion of data analysis from the results of the study.

Hardware specifications (recommended requirements):

- Single- or dual-core processor (not necessarily newest generation; at least 1 GHz)
- Med-res display with impressive display technology (ex. Super AMOLED, not HD)
- ~4-inch display
- 720p HD video capture
- 4G capable
- 1GB of RAM or less
- Android 2.3

The device with the provided sensors was developed to be efficient and beneficial for anyone, particularly for those who need to have their health closely monitored in case of emergencies. Its main function is to monitor the body's vital signs, including the pulse/heart rate, oxygen saturation, temperature, and blood pressure.

The sensor used was Max30102 from MaxTech Inc. that has been developed specifically for precise monitoring of heart rate and blood oxygen levels. Because of its small size and low power consumption, it is suited for use in wearable devices and medical applications. In order to enhance power economy, the sensor includes an adjustable LED current. It ensures accurate and dependable readings by using ambient light cancellation and high-resolution data processing. The MAX30102 sensor provides dependable and safe monitoring capabilities in a tiny and simple form factor with smooth integration via the I2C interface.

MAX30102 Sensor Data Sheet

General Information:

- Product Name: MAX30102 Sensor
- Manufacturer: MaxTech Inc.
- Model Number: MAX30102
- Sensor Type: Optical sensor
- Technology: Photoplethysmography (PPG)

Electrical Specifications:

- Supply Voltage: 1.8V to 2.0V
- Supply Current: 600µA (typical)
- Output Data Rate: Programmable from 50Hz to 1kHz
- Operating Temperature Range: -40°C to 85°C
- Communication Interface: I2C Mechanical

Specifications:

- Package Type: Surface Mount Device (SMD)
- Dimensions: 5mm x 4mm x 1.2mm
- Weight: 0.1 gram
- Pin Count: 14
- Pin Pitch: 0.5mm Features:
- Integrated optical sensor for heart-rate and blood oxygen level monitoring
- Low power consumption
- Adjustable LED current for optimized power usage
- Ambient light cancellation for accurate measurements
- High-resolution 18-bit ADC for precise data conversion
- Integrated temperature sensor for compensation

- Small form factor for wearable applications
- RoHS compliant Applications:
- Wearable fitness trackers
- Smartwatches
- Medical devices
- Health monitoring systems
- Sports and performance analysis
- Non-invasive health monitoring

The front-end development application was built on Google Blockly, which was required for the mobile application, Google colaboratory for testing and training the ML algorithm, Streamlit for web hosting the machine learning algorithm, and Arduino for the embedded system. Firebase is the tool for monitoring the real-time database.

Figure 9 shows the home page interface. In this section, the vital signs of the user, namely, Blood pressure, Oxygen Level, Temperature and Pulse rate are on display and are updated real-time from the database. The button below with the text, "Feeling anything?" redirects the user to the machine learning web app.

Figure 9. HealthSense App User Interface

Figure 10.1, 10.2, 10.3 shows the web application's interface. In this section, users must enter the relevant information into the input boxes to precisely predict and analyze their risk of heart disease. The user must follow the instructions above of each input box to ensure error free experience. The "See Results" button will show the user if they are in need to go to a doctor or are in good condition.

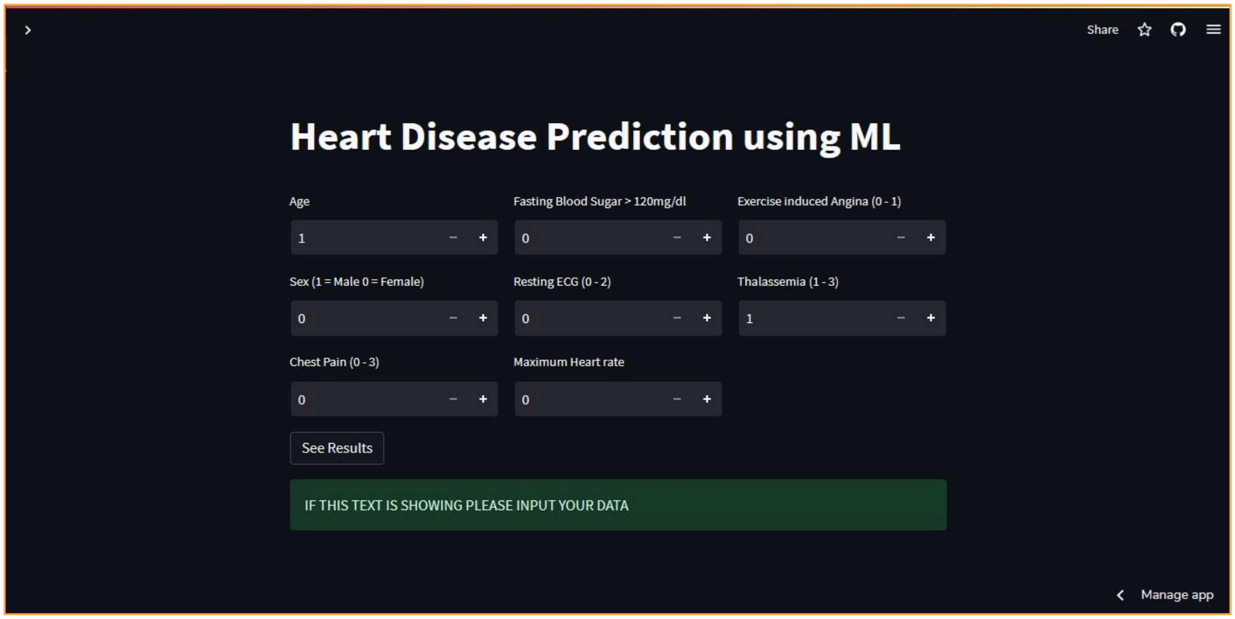

Figure 10.1. User Interface of Machine Learning Web app Input

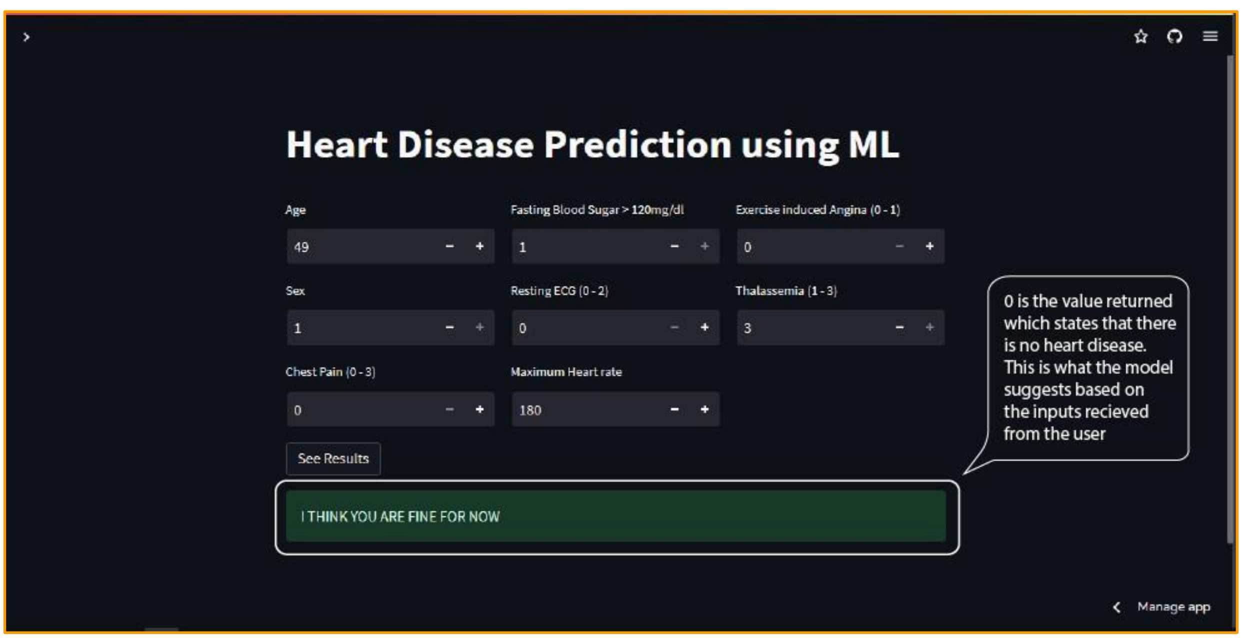

Figure 10.2. User Interface of Machine Learning Web app Output for 0 Value

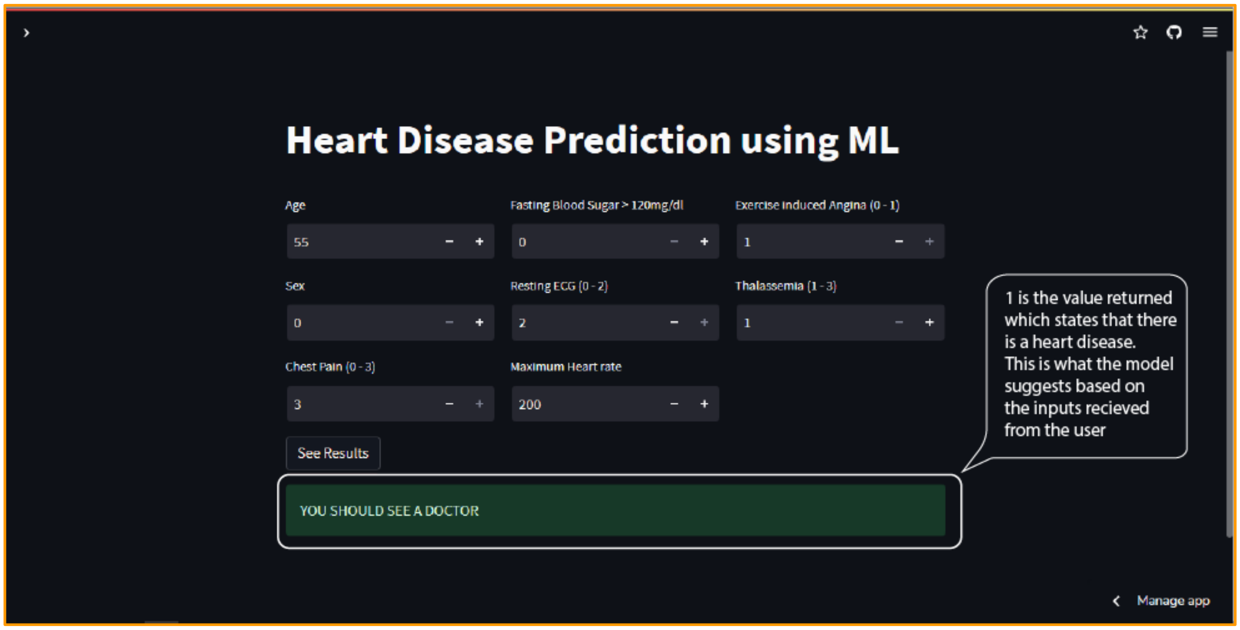

Figure 10.3. User Interface of Machine Learning Web app Output for 1 Value

Results Interpretation and Analysis

Performance of Algorithms on Training data:

The system underwent training using the medical records of 1025 patients obtained from the dataset, which included information about their vulnerability to heart diseases.

The following attributes were used within the dataset to predict if the user is prone to heart disease or not:

1. Age

2. Sex
3. Chest pain type (four values)
4. Resting electrocardiographic results
5. Maximum heart rate achieved
6. Exercise induced angina
7. Thal: 0 = normal; 1 = fixed defect; 2 = reversible defect
8. Fasting blood sugar > 120 mg/dl
9. Target

According to Lapp (2019), the data collection, established in 1988, encompasses four databases, Cleveland, Hungary, Switzerland, and Long Beach V comprise 76 attributes, including the target attribute, although published experiments typically utilized only a subset of nine attributes. The "target" field signifies the presence of cardiac disease in the patient, with a value of 0 indicating no disease and a value of 1 indicating the presence of disease.

Given these attributes retrieved from the data set, the accuracy of the training data is 0.766407 while the test data is 0.74222.

Table 1. Training Accuracy and Testing Accuracy Result

Algorithm used	Training Accuracy	Testing Accuracy
Logistic Regression	0.76	0.74

Table 2. Confusion Matrix

	Confusion Matrix	
	Positive (1)	Negative (0)
Positive (1)	76	34
Negative (0)	24	91

System Evaluation Results

The system evaluation was conducted to 1 RHU Barangay Health Center health workers located in Poblacion, Nueva Valencia, Guimaras, selected IT students, and elders.

The researchers used ISO/IEC 25010 to assess how well the system meets the specified and implied requirements.

Functional Suitability, Performance Efficiency, Compatibility, Usability, Security, and Portability were among the evaluation criteria. A five-point Likert scale was employed to assess the scores, which is often used to measure changes in behavior, attitudes, knowledge, perceptions, and values. A Likert-type scale asks respondents to score their replies to evaluative questions using a series of statements. It consists of 25 questions designed to assess the system's quality on a five-point scale: 5 for outstanding (pass), 4 for very satisfactory (pass), 3 for satisfactory (pass), 2 for fair (fail), and 1 for poor (fail).

The respondents are composed of twenty health workers and ten general users mostly made up of students from West Visayas State University (see Appendix I for reference).

The instruments used in this study were surveys. The surveys included interview questionnaires that ask the participants about their experience with the device. Comments and feedback as well as the overall rating for the healthcare device were listed. Convenience sampling is used to select the respondents who are included from the list of participants. The survey questionnaires were a mixture of both closed and open-ended questions about the experiences and preferability of the proposed device (iso/iec 25010 standards). A Likert Scale was utilized to acquire additional feedback from the respondents. Participants in this study included few selected users determined by the researchers. Some users were chosen in this study based on their underlying conditions through convenience sampling.

The evaluation form included five criteria: functional suitability, performance efficiency, usability, reliability, and security. Each criterion was to be evaluated as "outstanding," "very satisfactory," "satisfactory," "fair," or "poor." To calculate the corresponding degree of rating, a scale was created. The following numerical weights were assigned for statistical purposes:

Weight	**Description**
5	Outstanding
4	Very Satisfactory
3	Satisfactory
2	Fair
1	Poor

Legend:

Table 3.1. Scale used in Evaluation of the System

Scale	**Description**
1-1.80	Poor
1.81-2.60	Fair
2.61-3.40	Satisfactory
3.41-4.20	Very Satisfactory
4.21-5	Excellent

Table 3.2 shows the health workers' evaluation results of the system. Results showed that the functional

stability (M=4.26), performance efficiency (M=4.23), compatibility (M=4.25), usability (M=4.5), reliability (M=4.45), security (M=4.22), portability (M=4.2), and the grand mean of 4.3, it resulted that the system shows excellent in terms of descriptive results.

Table 3.2. Health Workers Evaluation Results of the System

Criteria	**Mean**	**Description**	**Rank**
Functional Suitability	4.26	Excellent	3
Performance Efficiency	4.23	Excellent	5
Compatibility	4.25	Excellent	4
Usability	4.5	Excellent	1
Reliability	4.45	Excellent	2
Security	4.22	Excellent	6
Portability	4.2	Very Satisfactory	7
Grand Mean	4.3	Excellent	

Table 3.3 shows the general users' evaluation results of the system. Results showed that the functional stability (M=3.76), performance efficiency (M=3.83), compatibility (M=3.78), usability (M=3.78), reliability (M=3.85), security (M=3.84), portability (M=3.75), and

the grand mean of 3.79. Based on descriptive results, the grand mean interpreted the system as very satisfactory.

Table 3.3. General User Evaluation Results of the System

Criteria	**Mean**	**Description**	**Rank**
Functional Suitability	3.76	Very Satisfactory	6
Performance Efficiency	3.83	Very Satisfactory	3
Compatibility	3.78	Very Satisfactory	4.5
Usability	3.78	Very Satisfactory	4.5
Reliability	3.85	Very Satisfactory	1
Security	3.84	Very Satisfactory	2
Portability	3.75	Very Satisfactory	7
Grand Mean	3.79	Very Satisfactory	

Table 3.4 shows the Overall Evaluation result of health workers and general users. The results showed that the functional stability (M=3.93), performance efficiency (M=3.97), compatibility (M=3.94), usability (M=4.04), reliability (M=4.05), security (M=3. 97), portability (M=3. 90), and the grand mean of 3. 97. The Grand Mean interpreted the system as very satisfactory based on descriptive results.

Table 3.4. Health workers and General User Evaluation Results of the System

Criteria	Mean	Description	Rank
Functional Suitability	3.93	Very Satisfactory	6
Performance Efficiency	3.97	Very Satisfactory	3.5
Compatibility	3.94	Very Satisfactory	5
Usability	4.04	Very Satisfactory	2
Reliability	4.05	Very Satisfactory	1
Security	3.97	Very Satisfactory	3.5
Portability	3.90	Very Satisfactory	7
Grand Mean	3.97	Very Satisfactory	

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Research Study Design and Implementation

The researchers conducted a study to develop a healthcare device that monitors vital signs and predicts the possibility of heart disease. The device was intended to provide convenience for healthcare workers, facilities, and patients in dealing with sudden situations, particularly for those who need close health monitoring in emergencies. The study utilized convenience sampling, collecting 1025 samples to ensure the accuracy of heart disease prediction. The system's qualities were evaluated using a software evaluation form based on ISO-standard Usability Evaluation Tools, which included five criteria and a corresponding degree of rating. The front-end development involved a block-based programming language built on Google Blockly, Google colaboratory for testing and training the Machine Learning algorithm, Streamlit for web hosting the ML, and Arduino for the embedded system. Firebase was utilized for monitoring and organizing the real-time database. This research can potentially contribute to the development of healthcare devices that are efficient, accurate, and accessible to healthcare workers, facilities, and patients in monitoring vital signs and predicting the possibility of heart disease.

Summary of Findings

The intent of this research was to assess the efficiency and performance of the device with an embedded system that monitors vital signs and forecasts the likelihood of heart disease. The researchers conducted a system evaluation of two RHU Barangay Health Centers located in Poblacion, Nueva Valencia, Guimaras, and Dumalag, Capiz, using ISO/IEC 25010 to assess how well the system meets the specified and implied requirements. The evaluation criteria included Functional Suitability, Performance Efficiency, Compatibility, Usability, Security, and Portability, with scores interpreted using a five-point Likert scale.

The 8 main attributes derived from the dataset have different levels of probability which increased the chances of predicting the accurate result. 0.76% refers to the training accuracy and 0.74% to the testing accuracy. Previous versions of the model scored higher accuracy scores as these models included all thirteen attributes contained within the dataset. However, these attributes had no significant relation to the main component of the study as unattainable results for the device such as the number of major vessels colored by fluoroscopy were required to be filled-out by the user.

Inaccurate results encountered when operating the device were the results of the dataset from having a limited coverage for the age attribute specifically ages from 22-77. The respondents, composed of twenty health workers and ten general users, mostly students from West Visayas State University, were asked to rate their responses to evaluative questions. Results showed that the system demonstrated excellent quality with a grand mean of 4.3 out of 5. Specifically, the functional stability, performance efficiency, compatibility, usability, reliability, security, and portability all received high ratings from the respondents.

Conclusions

After implementation and testing, the application yielded the following results and met its objectives which are the following:

1. The heart disease prediction system with an embedded sensor system using Arduino performed admirably. It has successfully met the criteria and goals of scanning and monitoring the vital signs of the users, with the ability to display them on a mobile application.

2. The accuracy test revealed that training and testing accuracy had results of 0.76 and 0.74, respectively, out of 1025 training data. As a result, it indicated that it had high accuracy and fulfilled its objective.

3. According to the evaluation results based on ISO 25010, the application received a highly satisfactory rating overall, with an average score of 3.97. This indicated that the application is well-suited to fulfill the users' requirements and expectations.

In summary, the study affirms that the healthcare device linked to an embedded system is a dependable and effective means of monitoring vital signs and forecasting the likelihood of heart disease. These findings provide a foundation for future research aimed at advancing and refining similar healthcare devices and embedded systems, ultimately improving healthcare provision and patient outcomes.

Recommendations

Based on the given conclusions, here are some recommendations:

1. Continuous Model Improvement: Although the accuracy results are already quite good, ongoing efforts should be made to improve the predictive model. This could involve collecting more data, refining the algorithms, and exploring additional features or parameters that may enhance the accuracy of the predictions. Continuous improvement will lead to better performance and a more reliable system.

2. Privacy and Security Considerations: As the application deals with personal health data, it is crucial to prioritize privacy and security measures. Implement robust encryption protocols, user authentication mechanisms, and secure data storage

practices to protect users' sensitive information. Regular security audits and updates should also be conducted to address any potential vulnerabilities.

3. Persistent Follow-up and Monitoring: Perform continual tracking and subsequent investigations to assess how effective the system is and efficiency over long periods of time. This will help determine the system's durability, reliability, and effectiveness in real-life scenarios, ensuring its continued usefulness and positive impact on patient outcomes.

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Appendices

Appendix A

Letter to the Adviser

CYRENEO S. DOFITAS JR.
Associate Professor I
West Visayas State University Luna
St. Lapaz, Iloilo City

Dear Prof. Cyreneo S. Dofitas Jr.,

The undersigned are BS Information Technology Research 1/Thesis 1 students of CICT, this university. Our thesis/capstone project title is "HealthSense: A Medical Device with an Embedded Sensor System for Vital Signs Monitoring and Heart Disease Prediction".

Knowing of your expertise in research and on the subject matter, we would like to request you to be our **Thesis Adviser**.

We are positively hoping for your acceptance. Kindly check the corresponding box and affix your signature in the space provided. Thank you very much.

Respectfully yours,

1. Ana Patricia F. Felasol
2. Thrys J. Formoso
3. Patricia Anne A. Gaquit
4. John Kate E. Marbebe
5. Luke Ian B. Undar PS:

Advisers are tasked to work with the students in providing direction assistance as needed in their thesis/capstone project. They shall meet with the students weekly or as needed to provide direction, check on progress and assist in resolving problems until such a time that the students pass their defenses and submit their final requirements, as well as, preparing their evaluations and grades.

Action Taken:	
☑ I Accept.	
○ Sorry. I don't accept.	Signature over printed name of the Adviser

cc:
CICT Dean Research
Coordinator
Group
**To be accomplished in 4 copies*

Appendix B

Letter to the Technical Editor

	ADVISER'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F10
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **Technical Editor**, the attached manuscript of the thesis entitled:

HealthSense: A Medical Device with an Embedded Sensor System for Vital Signs Monitoring and Heart Disease Prediction

Said manuscript has been presented to me for preliminary evaluation and guidance, and after a series of corrections/directions given which was implemented by the proponents whose names are listed hereunder and their thorough research, we have come to its completion.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the Technical Editor for **TECHNICAL EDITING**.

for:
CYRENEO DOFITAS JR
Adviser's Name & Signature

Date: June 2, 2022

Group Members:
1. Ana Patricia F. Felasol
2. Thrys J. Formoso
3. Patricia Anne A. Gaquit
4. John Kate E. Marbebe
5. Luke Ian B. Undar

Note: *This form should be accomplished and signed if the corrections and changes made by the adviser have been implemented and a new copy of the document have been printed for checking and submission to the next editor*

Appendix C

Letter to the Grammarian

	ADVISER'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F10
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **English Editor**, the attached manuscript of the thesis entitled:

HealthSense: A Medical Device with an Embedded Sensor System for Vital Signs Monitoring and Heart Disease Prediction

Said manuscript was presented to me and was reviewed and edited in terms of technical specifications, correctness of diagrams and other technical matters. The corrections and suggestions was carried and implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the English Editor/Grammarian for **English Grammar Editing.**

REGIN CABACAS
Technical Editor's Name & Signature

Date: 6-5-23

Group Members:
1. Ana Patricia F. Felasol
2. Thrys J. Formoso
3. Patricia Anne A. Gaquit
4. John Kate E. Marbebe
5. Luke Ian B. Undar

Note: *This form should be accomplished and signed if the corrections and changes made by the adviser have been implemented and a new copy of the document have been printed for checking and submission to the next editor*

Appendix D

Letter to the Format Editor

WEST VISAYAS STATE UNIVERSITY ILOILO CITY 1902	ENGLISH EDITOR/GRAMMARIAN'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	**WVSU-ICT-SOI-03-F12**
		Issue No.	**1**
		Revision No.	**0**
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	**April 27, 2018**
		Issued by:	**CICT**
		Page No.	**Page 1 of 1**

Respectfully endorsed to the **Thesis Format Editor**, the attached manuscript of the thesis entitled:

HealthSense: A Medical Device with an Embedded Sensor System for Vital Signs Monitoring and Heart Disease Prediction

Said manuscript was presented to me for English grammar editing, corrections has been made and the proponents whose names are listed hereunder implemented said corrections and changes in the revised manuscript.

Now therefore, I hereby **ENDORSE** the said thesis manuscript for **Thesis Format Editing**.

MA. ELFLEDA R. ECUBE, Ph.D.
English Editor/Grammarian's Name and Signature

Date: June 15, 2023

Group Members:
1. Ana Patricia F. Felasol
2. Thrys J. Formoso
3. Patricia Anne A. Gaquit
4. John Kate E. Marbebe
5. Luke Ian B. Undar

Note: *This form should be accomplished and signed if the corrections and changes made by the English Editor have been implemented and a new copy of the document have been printed for checking and submission to the next editor.*

Appendix E

Letter to the Thesis Coordinator

	THESIS FORMAT EDITOR'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F13
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **Thesis Coordinator**, the attached manuscript of the thesis entitled:

HealthSense: A Medical Device with an Embedded Sensor System for Vital Signs Monitoring and Heart Disease Prediction

Said manuscript was presented to me and has checked the preliminaries, thesis document convention and end matters, made some corrections which was implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** said manuscript to the Thesis Coordinator for appropriate action.

RÉGIN A. CABACAS
Thesis Format Editor's Name and Signature

Date: Jun 30, 2022

Group Members:
1. Ana Patricia F. Felasol
2. Thrys J. Formoso
3. Patricia Anne A. Gaquit
4. John Kate E. Marbebe
5. Luke Ian B. Undar

Note: *This form should be accomplished and signed if the corrections and changes made by the Thesis Format Editor have been implemented and the four (4) new copies have been printed ready for bookbinding.*

Appendix F

Certificate for Bookbinding

	CERTIFICATION FOR BOOKBINDING (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F14
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

This certifies that the attached manuscript of the thesis entitled:

HealthSense: A Medical Device with an Embedded Sensor System for Vital Signs Monitoring and Heart Disease Prediction

Is now ready for bookbinding. Said manuscript was presented to me and has checked the preliminaries, thesis document convention and end matters, made some corrections which was implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** said manuscript for **BOOKBINDING**.

REGIN A. CABACAS
Thesis Coordinator's Name and Signature

Date: July 4, 2023

Group Members:
1. Ana Patricia F. Felasol
2. Thrys J. Formoso
3. Patricia Anne A. Gaquit
4. John Kate E. Marbebe
5. Luke Ian B. Undar

Note: *This form should be accomplished and signed if the corrections and changes made by the Thesis Format Editor have been implemented and the four (4) new copies have been printed ready for bookbinding.*

Appendix G

Gantt Chart

	DURATION														
	2022												2023		
	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March
CHAPTER 1	■	■	■	■											
Background of the Study	■	■													
Theoritical Framework	■	■													
Objectives of the Study	■	■	■	■											
Significance of the Study	■														
Definition of Terms	■		■	■											
Delimitations of the Study	■		■												
CHAPTER 2			■	■	■	■									
Review of Existing and Related Studies			■	■	■	■									
CHAPTER 3					■	■	■	■	■	■					
Description of the Proposed Study					■										
Methods and Proposed Enhancements						■	■								
Components and Design					■			■	■	■					
CHAPTER 4										■	■	■	■		
Implementation										■	■				
Results Interpretation and Analysis											■	■			
System Evaluation and Results												■	■		
CHAPTER 5												■	■	■	■
Summary of the Proposed Study Design and Implementation												■	■	■	
Summary of Findings												■	■	■	
Conclusions												■		■	■

Appendix H

Sample Codes

```
#include <Wire.h>

#include "MAX30105.h"

#include "heartRate.h"

#include "spo2_algorithm.h"



#include <Arduino.h>

#if defined(ESP32)

  #include <WiFi.h>

#elif defined(ESP8266)

  #include <ESP8266WiFi.h>

#endif

#include <Firebase_ESP_Client.h>
```

```
MAX30105 particleSensor;



/* 1. Define the WiFi credentials */

#define WIFI_SSID "tests"

#define WIFI_PASSWORD "12345test"



// Insert Firebase project API Key #define API_KEY

"AIzaSyBXdVIjqyhHqSb3Nt3pQNSZGqBQKQ5D7sk"



// Insert RTDB URLefine the RTDB URL */ #define

DATABASE_URL "iotdb-24e1a-

defaultrtdb.firebaseio.com"




/* 3. Define the Firebase Data object */

FirebaseData fbdo;
```

```
 /* 4, Define the FirebaseAuth data for
authentication data */
FirebaseAuth auth;



/* Define the FirebaseConfig data for config data */

FirebaseConfig config;

 unsigned long dataMillis =
0; int count = 0;
//===========================
============= Millis variable
to send/store data to
firebase database. unsigned
long sendDataPrevMillis = 0;
const long
sendDataIntervalMillis =
10000; //-->
Sends/stores data to firebase database every 10 seconds.

//========================================
```

```
// Boolean variable for sign in status. bool
signupOK = false;
 float
store_random_Float_Val; int
store_random_Int_Val;
 const int aaa = 4; const int pump = A3; const
int speg = A0; int pum;  // variable to store
the value read int tester; int spegmo;  //
variable to store the value read   int systol;
int diastol; void setup()
{

  Serial.begin(115200);

  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
Serial.print("Connecting to Wi-Fi");
while (WiFi.status() != WL_CONNECTED){
Serial.print(".");     delay(300);
  }

  Serial.println();

  Serial.print("Connected with IP: ");

  Serial.println(WiFi.localIP());
```

```
  Serial.println();



  /* Assign the api key (required) */
config.api_key = API_KEY;


  /* Assign the RTDB URL (required) */
config.database_url = DATABASE_URL;


  /* Sign up */   if (Firebase.signUp(&config,
&auth, "", "")){
    Serial.println("ok");
    signupOK = true;

  }
else{
    Serial.printf("%s\n",
config.signer.signupError.message.c_str());
  }   pum =
analogRead(pump);   tester =
digitalRead(aaa);   spegmo =
```

```
analogRead(speg);

if(tester == 0){

//    Serial.println("Off");

//    delay(1000);

  }   else if(tester ==

1){      if(pum >= 60){

pum = pum/3;

diastol = pum; //

delay(1000);

    }     if(spegmo >=

2300){       systol =

(spegmo/27);

    }

  }

  String bpressure =String(systol)+"-"+String(diastol);

//   Serial.println(bpressure); if (Firebase.ready() &&

signupOK && (millis() - sendDataPrevMillis > 5000 ||

sendDataPrevMillis == 0)){        sendDataPrevMillis =

millis();     // Write an Int number on the database path

test/int     if (Firebase.RTDB.setInt(&fbdo,
```

```
"Database/temperature", temperature)){

      Serial.println("PASSED");

"Database/bloodpressure", bpressure)){

      Serial.println("PASSED");

      Serial.println("PATH: " + fbdo.dataPath());
Serial.println("TYPE: " + fbdo.dataType());
    }
else {
      Serial.println("FAILED");

      Serial.println("REASON: " + fbdo.errorReason());

    }     if
(Firebase.RTDB.setInt(&fbdo,
"/Database/pulserate", bpmInt)){
Serial.println("PASSED");

          Serial.println("PATH: " + fbdo.dataPath());
       Serial.println("TYPE: " + fbdo.dataType());
    }
else {
      Serial.println("FAILED");
```

```
      Serial.println("REASON: " + fbdo.errorReason());

    }     if
(Firebase.RTDB.setInt(&fbdo,
"/Database/oxygenlevel", SPO2)){
      Serial.println("PASSED");

          Serial.println("PATH: " + fbdo.dataPath());
       Serial.println("TYPE: " + fbdo.dataType());
    }
else {
      Serial.println("FAILED");

      Serial.println("REASON: " + fbdo.errorReason());

    }

    }

}
```

Appendix I

Data Dictionary

Variable Name	Description	Data Type	Format	Range
Patient ID	Unique identifier for each patient	Integer	4-digit number	1000-9999
Age	Patient's age	Integer	Whole number	18-100
Gender	Patient's gender	String	"Male" or "Female"	
Weight	Weight of the patient in kilograms	Float	Decimal to one decimal place	20.0-200.0
Height	Height of the patient in centimeters	Float	Decimal to one decimal place	100.0-250.0
Blood pressure	Systolic and diastolic blood pressure of the patient in mmHg	String	"systolic/diastolic"	"60/40" to "200/120"
Heart rate	Heart rate of the patient in beats per minute (BPM)	Integer	Whole number	30-200
Respiratory rate	Respiratory rate of the patient in breaths per minute (BPM)	Integer	Whole number	5-50
temperature	Body temperature of the patient in Celsius	Float	Decimal to one decimal place	34.0-42.0
Heart disease	Presence or absence of heart disease in the patient	Boolean	True or False	
Predicted heart disease	Predicted probability of heart disease in the patient based on sensor data	Float	Decimal to three decimal places	0.000-1.000

Appendix J

ISO Questionnaire

Check the box if you are a Health worker, proceed if not.

☐ I am a Health worker

Functional Suitability *

	Outstanding (5)	Very Satisfactory (4)	Satisfactory (3)	Fair (2)	Poor (1)
Completeness - healthsense covers all the specified tasks and user objectives	○	○	○	○	○
Correctness - healthsense provides the correct results with the needed degree of precision	○	○	○	○	○
Appropriateness - healthsense facilitate the accomplishment of specified tasks and objectives	○	○	○	○	○

Performance Efficiency *

	Outstanding (5)	Very Satisfactory (4)	Satisfactory (3)	Fair (2)	Poor (1)
Time behaviour - the response and processing times and throughput rates of a product or system, when performing its functions, meet requirements	○	○	○	○	○
Resource utilization - the amounts and types of resources used by a product or system, when performing its functions, meet requirements	○	○	○	○	○
Capacity - the maximum limits of a product or system parameter meet requirements	○	○	○	○	○

Compatibility *

	Outstanding (5)	Very Satisfactory (4)	Satisfactory (3)	Fair (2)	Poor (1)
Co-existence - healthsense can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product					
Interoperability - two or more systems, healthsense exchange information and use the information that has been exchanged					

Usability *

	Outstanding (5)	Very Satisfactory (4)	Satisfactory (3)	Fair (2)	Poor (1)
Appropriateness recognizability - users can recognize whether a product or system is appropriate for their needs	○	○	○	○	○
Learnability - healthsense can be used by specified users to achieve specified goals of learning to use the product or system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use	○	○	○	○	○
Operability - healthsense has attributes that make it easy to operate and control	○	○	○	○	○

User error protection - healthsense protects users against making errors.	○	○	○	○	○
User interface aesthetics - the user interface enables pleasing and satisfying interaction for the user	○	○	○	○	○
Accessibility - healthsense can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use	○	○	○	○	○

Reliability *

	Outstanding (5)	Very Satisfactory (4)	Satisfactory (3)	Fair (2)	Poor (1)
Maturity - healthsense meets needs for reliability under normal operation	○	○	○	○	○
Availability - healthsense is operational and accessible when required for use	○	○	○	○	○
Fault tolerance - healthsense operates as intended despite the presence of hardware or software fault	○	○	○	○	○
Recoverability - healthsense in the event of an interruption or a failure, a product or system can recover the data directly affected and re-establish the desired state of the system	○	○	○	○	○

Security *

	Outstanding (5)	Very Satisfactory (4)	Satisfactory (3)	Fair (2)	Poor (1)
Confidentiality - healthsense ensures that data are accessible only to those authorized to have access					
Integrity - healthsense prevents unauthorized access to, or modification of, computer programs or data.					
Non-repudiation - actions or events can be proven to have taken place so that the events or actions cannot be repudiated later					
Accountability - the actions of an entity can be traced uniquely to the entity					
Authenticity - the identity of a subject or resource can be proved to be the one claimed					

Portability *

	Outstanding (5)	Very Satisfactory (4)	Satisfactory (3)	Fair (2)	Poor (1)
Installability - effectiveness and efficiency with which a product or system can be successfully installed and/or uninstalled in a specified environment	○	○	○	○	○
Replaceability - can replace another specified software product for the same purpose in the same environment.	○	○	○	○	○

Appendix K

Documentation

Appendix L

Disclaimer

This software project and its corresponding documentation entitled “HealthSense: A medical device with an embedded sensor system for vital signs monitoring and Heart Disease prediction” is submitted to the College of Information and Communications Technology, West Visayas State University, in partial fulfillment of the requirements for the degree, Bachelor of Science in Information Technology. It is the product of our own work, except where indicated text.

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