José Rizal University

WEB-BASED PATIENT IDENTIFICATION SYSTEM USING IRIS RECOGNITION

A Thesis Submitted to the Faculty of the College of Computer Studies and Engineering

In Partial Fulfillment
Of the Requirements for the Degree
Bachelor of Science in Computer Engineering

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December 2023

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Chapter 1

Introduction

Patient misidentification is a common problem encountered by nurses and doctors in the medical field. It can cause serious harm to patients, even death by giving incorrect medications and treatments. The main causes are incorrect identification at the point of registration, time pressure when treating patients, and lack of employee training and awareness. Patient misidentification can also lead to duplicate medical records and insurance fraud. For example, in the United Kingdom, there were 236 reported incidents of missing or incorrect wristbands that were used to determine a patient's identity inside the hospital between November 2003 and July 2005. In the United States, there were more than 100 similar cases that happened in the UK that caused improper treatments to patients that was reported from January 2000 to March 2003 (World Health Organization, 2019).

On a study conducted by researchers from University of the Philippines regarding human epidermal growth factor receptor-2 (HER2) which is a test used to detect breast cancer they emphasized to clinicians and surgeons of breast cancer the importance of properly labelling and putting patient identification to breast tissue samples that will be used on laboratories to test the current state of the patient's cancer. Out of 72 medical staffs that's involve in this study, 36% stated that they disagree to the use of HER2 to test breast cancer to patients due to the shortfall of proper patient identification, specimen mislabeling and incompetent testing facility (Orolfo-Real, et.al., 2015)

Today, patient identification errors are the result of outdated methods and systems used by hospitals and the lack of widely used and accepted standards and technological integration. Inaccurate patient identification in hospitals can lead to duplicate testing procedures, higher expenses, and big effects on patient treatments, outcomes, privacy and clinical decision making. The priority of putting the patient's care and safety will be at risk when a patient's record is incorrectly matched to another patient's record. It's because inaccurate data was possible to spread to different systems, records, and databases. Such as, radiology, laboratory and health information networks. This could result in errors on conducting medication, injury imaging and laboratory errors especially in critical surgeries performed to the wrong patient. If a patient has several records, physicians may overlook important information of the patient since there could be duplicate records having different information (Gibson, 2022).

1.1 Background of the Study

Patient identification is crucial for health care; medication treatments, medicine intakes, errors on testing and transfusion, and procedures done to the wrong person were all possible if the hospital failed to identify the patients correctly. Once done incorrectly it would result in more complications to the current status of the patient.

A journal by (Alder, 2023), discussed the benefits of a national patient identifier system such as improving patient safety, reducing healthcare costs, and easier patient tracking. The absence of a universal identifier for patients can cause confusions and medication errors or diagnosis, it would be a struggle for nurses and doctors to monitor the status of their patients. The Patient ID Now Coalition is trying to raise awareness on the issue of patient misidentification. Their aim was to build support in the creation of a national patient identifier system around the world. The researchers believe that this system would help to ensure that patients are accurately identified and accessed. And their medical records are properly matched, that would help to prevent errors and improve patient safety at all cost. The Patient ID Now Coalition is an advocacy group that believes that a national patient identifier is one of the most important patient safety issues to address. The researchers provided an example of the devastating consequences of mismatched patient records. A woman visited her doctor for a mammogram, but she never received the results. She assumed that nothing bad was found, but the reality was that the mammogram results had been mismatched with another patient who had the same name. The error was only discovered one year later by the doctors when the woman mentioned the previous mammogram session during an annual checkup. By that time, the cancer had already progressed to the point where it was terminal and her chances of survival were too low for her to live.

According to a recent study of computerized provider order entry (CPOE) conducted in the United States found that 37.6% of the time, physicians were not verifying the information of patient's identification when the researchers are doing orders in a simulated setting (Kim, 2020). Based on the study conducted by (Alkhaqani, 2023), a group of 140 healthcare workers participated. The study utilized a questionnaire and participatory observation to gather insights to the participants. The findings revealed that majority of healthcare workers (82.1%) did not inquire about the patients' names and dates of birth. Additionally, it was observed that a portion of clinic doctors (37.1%) failed to complete the entire identification process.

The concept for the idea came from the researchers who noticed the lack of a new system to address the issue of patient misidentification. It seems to be an issue that's not giving enough attention to be studied even if it could result in bigger problems to the patient's health and condition, hospital and patient records, medication cost, etc. Errors on patient identification had existed for a long time since the days where medical records were still on stack of papers. When Electronic Health Records (EHRs) were introduced to the health care system, people thought it would offer a lot of benefits, especially in searching patient records faster, easier to share information, elimination of spaces for stack of paper medical records, the risk of losing medical records and accurate identification of patients. It was mainly the human errors who's at fault for these identification errors. That's why health care needs a system to help them fill up the information of patients and as well match their identity to its corresponding profiles using iris biometrics.

This study will investigate the efficiency of using biometric technology to identify patients in a hospital setting. Biometric technology is a trending technology used in different fields. In hospitals when implemented correctly it can be used to accurately identify patients, even in time-sensitive situations or when the patient is unable to provide their own identification for instances that they are unconscious. There are companies that offers system that uses biometrics as authentication and one of these is IRIENCE which is a Korean company that offers different human biometrics systems and devices that can save and compare iris information by converting the iris pattern into frequency values by using the wavelet conversion technology. IRIENCE technology first pixelates the glint part of the original iris image, calculates the average value of the pupil area and finally restores it into a unique iris image. To prevent forge or falsification the company was running a security solution to detect fake iris complying with the ISO standard, they applied forge and falsification prevention technology on iris images, videos and artificial eyes. A big concern with iris technology was the accuracy when a person was wearing eye accessories. But with the use of high-end camera lenses it was guaranteed that users could conduct iris authentication without any problem even wearing contact lenses, glasses, or a goggle. Capable of authenticating every iris regardless of ethnicity or pupil color. They possess an iris algorithm which underwent tests on various pupils over the world and passed all of those tests (Irience, 2023). Another example was the study by Dr. Ebrahimpour N. (2023) who developed MobileNet, a lightweight convolutional neural network (CNN) architecture for image classification and mobile vision. MobileNet requires much less computing power than traditional CNNs, making it ideal for mobile devices, embedded systems, and computers without a GPU. This paper proposes a new iris recognition method that uses MobileNet to extract features from iris images. The extracted feature vectors are then compared to a database of saved feature vectors. If the distance between the two feature vectors is less than a threshold, the person's identity is confirmed; otherwise, it is rejected. Simulations show that the proposed method is accurate enough for identification and authentication.

The study proposes a system based on iris recognition technology that can be used to identify patients in a hospital setting. The system will be evaluated against a dataset of real patient iris images and was collected to be accurate in identifying patients with a high degree of accuracy. The study aims to give important knowledge and recommendations that will help in the successful implementation of Ambisyon 2040's "Panatag." The "Panatag" aims to create a strong and innovative community by promoting economic growth, social equity, and a sustainable environment (AmBisyon Natin 2040, 2016). This study also aims to provide knowledge and recommendations that can help achieve Sustainable Development Goals (SDG) Goal 9 which is the "Industry, Innovation, and Infrastructure." By combining this study with the global sustainability goal, it is believed that it can contribute to the development of a more equitable, innovative future in both current and future generations (United Nations Development Programme, 2023).

1.2 Objectives of the Study

1.2.1 General Objective:

The main objective of this study is to design and develop a patient identification system for data management of patient information and medical records that will use iris recognition technology as primary patient identifier to access each patient profile.

1.2.2 Specific Objectives:

Specifically, this study will pursue the following specific objectives:

- To develop a web-based application that will be used to display patient information and to create profiles for new patients.
- To utilize an iris scanning device to capture the patient's iris which will be processed by the system as the patient identifier.

- To apply Convolutional Neural Network Model to extract iris feature points for recognition and identification of the patients.
- To assess the performance and efficiency of iris biometrics as a patient identifier.

1.3 Conceptual Framework

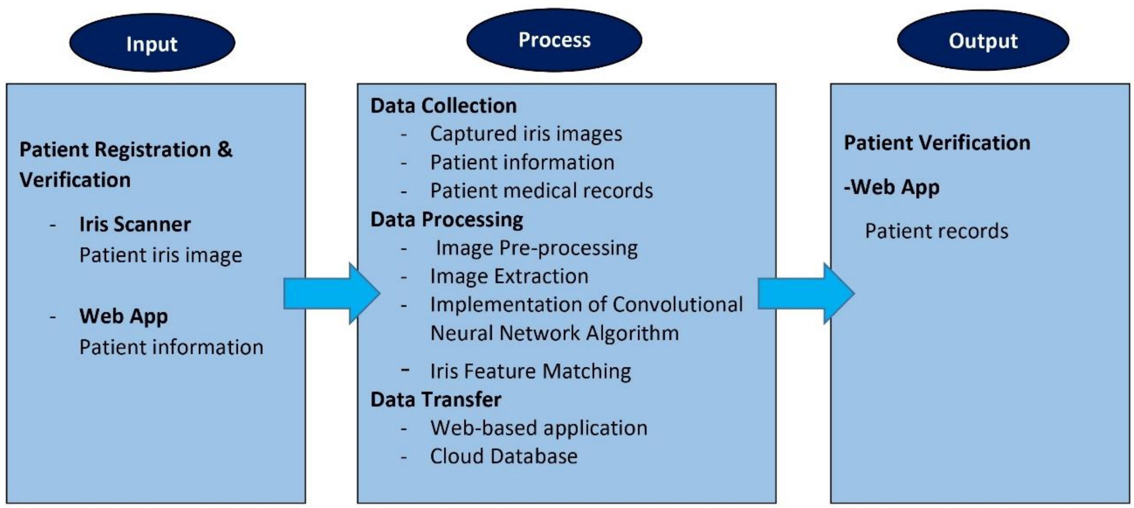

Figure 1 - Conceptual Framework of the System

As shown in the figure above, Figure 1 illustrates and defines the three stages of the process of a system which are input, process, and output. The first stage includes the pre-registration and verification of the patient on the system. Using an iris scanner to capture the iris of the user. The system would use a touchscreen LCD to navigate the web application to register a new patient and verify an existing patient.

The second stage of the conceptual framework of the system includes data processing and data transfer. Using the gathered data from the patient registration, the system will collect the captured data then the data will be transferred to the cloud database and record the captured data (e.g., patient no., illness, address, name, date). As for the captured iris image, the system will extract the data. The system will have image processing for extraction and use the CNN algorithm to verify the captured image. Lastly, the system will display the current information of the user on the LCD display of the prototype from the database such as patient ID number, name, address, and illness. Once the patient identity was verified the user can now use the web application on the secondary device (e.g., computer or laptop) to look and manage patient medical records.

1.4 Significance of the Study

This study will focus on the development of a patient identification system using iris biometrics. The study would benefit to the following:

Patients

The study will provide patients a system especially to patients who's in critical condition to feel at ease that correct information will be recorded to their profile that will serve as their identity for the hospital records. This will eliminate the instance of patient misidentification that could result in duplicate testing procedures, higher expenses, and big effects on patient treatments, outcomes, privacy and clinical decision making.

Hospital

This study would greatly benefit hospitals to ensure the identity of patients that they're dealing with. This would decrease the chances of giving improper medication treatments, medicine intakes, errors on testing and transfusion, and procedures to be done to the wrong patients that would result in bigger problems and complications.

Future researchers

This study will be useful for future researchers that intend to further study iris biometrics and will give an idea to develop a more efficient system to utilize it. This will also give future researchers new knowledge about this study.

1.5. Scope and Limitation

This section concentrated on the extent, limitations, and restrictions of the proposed study.

This study included the following features:

- The system will scan an iris and display the corresponding personal information (e.g., name, patient ID number, age, address, mobile number, and email address) of the patient that will match to it.
- The web application can be accessed through the users' own device (e.g. computer or laptop) but patient's access is limited to pre-registration of his/her basic information.
- Develop a front-end web interface dedicated to patient's access to update his/her authenticated profile information and view his/her diagnostic results.
- The patients who pre-registered will be given a week to go to the hospital to authenticate their profile and register their iris or else the system will delete their profile.
- The system will require authorized personnel (e.g., admins, doctors, nurses, and medical staff) to input email and passwords for user authorization.
- The iris scanning process for patient verification will be done contactless, an authorized personnel (e.g., admins, doctors, nurses, and medical staff) will assist the patients and will be the one who'll use the iris scanning device to capture iris image.

- The doctors are the only authorized personnel who can access and update the medical charts of patients in the web application.
- It will be an AC powered device having an LCD touchscreen and a connected wired iris scanner that can be pulled.
- The researchers will gather 100 patient profiles from students studying in Jose Rizal University.
- The system will use a total of 40 iris images for each patient, 20 each iris images of the left and right eye that will be used for the verification dataset of the iris recognition model.

However, this study was limited to:

- The device will only be designed on scanning biometrics using iris.
- The device can’t scan the iris of patients wearing contact lenses or eye accessories.
- The device will not cover patients having eye disease that will change the appearance of the eye (e.g., cataracts, glaucoma, etc.)
- The device needed to be connected to the internet to have access on the cloud and web application.

1.6. Operational Definition of Terms

Iris Biometrics – It is a form of biometric technology that gives identification to a person using the unique patterns of iris. The system will use a patient’s iris as his/her primary identification on retrieving information and medical records.

Patient Identification System – It is the system that the study will use to apply the process of matching a patient to the appropriate information and medical records, this is to ensure the accurate and reliable output of data.

Convolutional Neural Networks – It is the machine learning algorithm that will be used on the algorithm of iris recognition of the system, which is suitable for image processing and identifying patterns that directly learns data.

Cloud Database – It is the service platform that will be integrated on the system to store the patient's information and medical records that can be accessed anywhere and anytime. Using this the researchers would be able to organize, manage and store data without the need of a server.

Authenticated Patient – It pertains to patients that have their pre-registered profile verified, as well succeeded to register his/her iris images. That the system can use to retrieve the profile and its information.

Unauthenticated Patient – It pertains to patients that haven't verified their pre-registered profile, and didn't register his/her iris images. That the system will not be able to retrieve the profile and its information.

Pre-registered patient – It pertains to patients that fill-up the patient pre-registration with his/her basic personal information, but still haven't registered his/her iris images.

Medical Complaints – It pertains to the illness and symptoms that the patient is feeling.

Iris Registration – It pertains to the process of authenticating the pre-registered patient by registering the patient's iris and validating the patient's personal information. After the process, the patient profile will be categorized as authenticated.

Chapter 2

REVIEW OF RELATED LITERATURE AND RELATED STUDIES

This chapter provides an extensive collection of relevant research studies and literature that includes scientific papers that are relevant to the present study in terms of objective, methodology, and, most crucially, the results. This section presents the viewpoint and concepts given by other existing patient identification systems that are feasible by image processing approach.

2.1 Foreign & Local Literatures

2.1.1 Patient Identification System

(Patel et al., 2021) provide an IoT-based health monitoring system that uses Face Recognition for identifying patients. This method reduces human effort while producing accurate, quick outcomes. The technology uses recognition of faces to develop and register new patient cases, and the Healthboard prototype keeps the database in the cloud. The GUI allows the creation and registration of new cases, as well as the recording and updating of standard data such as heart rate and blood pressure. The ESP-32 IoT module is used to connect to the sensor, and OpenCV is utilized for the facial recognition method. Cloud storage is provided via Amazon DynamoDB, and machine learning may be utilized to train the cloud database. To identify and recognize patients' faces, the system uses Haar Cascaded and LBP methods. It could still be trained using Machine Learning and Deep Learning algorithms as part of a larger project.

While in study of (L. P. Etter et al., 2019) a Health App for subject identification based on ear morphology (Project SEARCH (Scanning EARS for Child Health)). A study conducted an experiment with 194 participants discovered that standardizing the lighting, angle, and spatial location of the ear, known as the 'Donut,' can improve identification rates. The researchers achieved near perfect identification rates on a cohort of participants, proving the feasibility and effectiveness of using the ear as a biometric identifier. The researchers developed the 'Donut' device to improve image processing and gathered near-perfect recognition rates. The SEARCH method was used to generate the top one and top ten most likely matches, with the Donut obtaining 99.5 and 99.5% identification rates, respectively. The crop approach during image pre-processing had an important impact on identification rates as well, although this helped by the Donut as well. Despite the fact that this study did not include a medical intervention or assess a medical outcome, it did not meet FDAAA's criteria of a human subjects study.

(Ueda & Morishita, 2023) studies the use of biological fingerprints collected from clinical images for patient identification, especially in identifying misfiled images in picture archives and systems for communication. To address the challenging classification needs for patient validation and identification, the suggested method uses deep metric learning, which is based on a deep convolutional neural network (DCNN). The PadChest dataset, which includes both posteroanterior (PA) and anteroposterior (AP) view positions, produced a top-1 accuracy of 0.839 with the method's train on the NIH chest X-ray dataset (ChestX-ray8). These were achieved via a 1280-dimensional feature extractor that was pre trained for 300 epochs. This study offers details about how automatic patient identification is being developed, reducing the possibility of medical malpractice caused by human mistake and providing a critical solution for clinical chest X-ray examinations.

2.1.2 Iris Biometrics

Face, fingerprint, iris, gait, retina, voice, hand geometry, and other biometrics specific to humans are commonly used. Some of these, the iris is a protected, externally visible organ with a different epigenetic pattern that remains throughout a person's whole life. These features make it especially attractive for use as a biometric for identifying individuals, state (Matin et al., 2016). The study studies the accuracy and dependability of iris recognition as a biometric for identification of individuals. It focused on segmentation, normalization, feature encoding, and matching in four main phases. This study used the four-level phase quantization based 1D Log-Gabor filters for encoding different features, the circular Hough transform method for automated segmentation, the Daugman's rubber sheet model for normalization, and the Hamming distance algorithm for match affinities.

The CASIA-iris-v4 database shows improved recognition as a result of the tests. The experiment on iris identification, conducted with the CASIA-iris-version 4.0 database, proved the accuracy and reliability of human iris-based verification methods. It highlighted the significance of the human iris in person identification and the value of accurate segmentation in iris image capture and segmentation. For determining overall performance, future studies should take into account more dynamic datasets (Matin et al., 2016).

(Ammour et al., 2020) statement that a multimodal biometric system's robustness depends on its capacity to extract relevant information from individual biometric features. This study introduces a novel face-iris trait-based feature extraction method for a multimodal biometric system. An effective multi-resolution 2D Log-Gabor filter is used to extract iris information, while wavelet transform and singular spectrum analysis (SSA) are utilized to determine face features. At a hybrid level, the appropriate elements from both modalities have been combined through the hybrid fusion process. The assessment procedure is performed done using a hybrid database that combines the Olivetti Research Laboratory's (ORL) face recognition technology (FERET) for the evaluation of faces, and the Chinese Academy of Science Institute of Automation's (CASIA) v3.0 iris image database (CASIA V3) interval for the evaluation of irises.

The successful result of the method to improve the recognition rate has been demonstrated by results from experiments. The performance of unimodal biometrics based on the face or iris is enhanced by the suggested method, based on experiments on the CASIA-ORL and CASIA-FERET databases. The best recognition rates, 99.16% and 99.33%, are obtained using max-min normalization and max rule fusion, respectively. Future studies on feature computation will explore deep learning with conventional machine learning (Ammour et al., 2020).

A person's distinctive gesture is now automatically recognized in order to improve verification in recognition systems. The most accurate biometric identification process is iris and face recognition. CCTV surveillance is one of the important technologies for human identification. Through the biometric system in conjunction with CCTV output, whether there is a person or not, it can analyze the data (Jayavadivel & Prabaharan, 2021).

In the study of (Jayavadivel & Prabaharan, 2021), the step to recognize people from low resolution photos using iris and facial biometrics is shown here. To solve the problem of individual recognition, they combined Gabor and Legendre filters. It is possible and more effective to detect iris and face patterns in multi-spectral images when the hybrid log-Gabor-Legendre filter is used. After log-Gabor-Legendre filtration, two new processes are employed to improve pattern recognition. Thus, a system that uses score level fusion to compare feature and similarity recognition using the log-Gabor-Legendre filter is proposed. Through several stages, the recognition performances of the suggested solution were successfully improved. Compared to conventional linear techniques, experiments prove the validity of facial and iris recognition patterns from CCTV cameras for automated human identification and verification.

2.1.3 Iris Recognition

Based on (Nguyen et al., 2017), iris recognition uses the diversity of intricately textured annular regions of the human eye to be used as human biometrics to identify different people. Near-infrared (NIR) technology is frequently used by systems who use iris identification to take an image of the iris at a distance of less than one meter. In national ID programs, access management, border control, etc., iris recognition is frequently employed. To increase the output, many people have tried to develop or construct long-distance iris recognition devices that can work up to 60 meters away. This study presents a design for iris-recognition-at-a-distance systems, or IAAD.

In biometrics, distant iris recognition is crucial. Distance increased to 10 meters; numerous moving subjects were captured; and the acquisition volume was increased from a few cm3 to m3. These are some of the enhancements that the IAAD systems have made since the initial attempts (Nguyen et al., 2017).

Only a few people use iris recognition by machine learning in research. By the study of (De Marsico et al., 2016), the researchers ignored feature extraction issues and detection and concentrated on recognition. Even though their size can be optimized, feature vectors for iris patterns must be rather complicated since complexity influences learning. In order to compare feature complexity and learning effectiveness, it is necessary to create an objective common benchmark in the context of other learning algorithms.

It is still important to remember that machine learning algorithms have not been explored well. The complex input structure and the large number of classifications to distinguish between both hints at a possible explanation (De Marsico et al., 2016).

These days that terrorist attacks are prominent in different parts of the world; technology somehow developed some clever ways to identify and effectively deal with these scenarios. Biometrics is one of the most efficient solutions developed to resolve this issue, and iris recognition is the best tool to explore among all the biometrics. Despite the fact that several approaches in these areas have been published all throughout the web, there are still a lot of issues with its algorithm.

2.1.4 Convolutional Neural Networks

A type of neural network also called a convolutional neural network, or CNN, has been especially effective at processing data using a grid-like topology, similarly to an image. Visual data is represented in binary form by an image in digital form. The design is made up of a grid-like layout of pixels, each one of that has a pixel value that indicates how bright it is and of what color it should be (Mishra, M., 2020).

(Cornelisse D., 2018) states that the term "convolution" describes the mathematical combination of two different functions to create a third function. This combines two pieces of data. A CNN performs convolution on the input data using the filter or the kernel to create a feature map.

All of the features of a neural network are included in convolutional neural networks. CNN, on the other hand, is a system that was developed specifically for processing images. In addition, their architecture consists of two main blocks. The first block of a neural network is unique as it functions as a feature extractor, performing template matching through convolution filtering operations. The image is filtered many times, generating sized and normalized feature maps. The vector generated by the final feature maps. This vector describes the input and output of the first block. In all classification neural networks, the second block in a CNN comes last. A new vector with elements showing class probabilities will be generated by transforming the values of the input vector. Using logistic or softmax functions, the final layer computes these probabilities. Gradient back propagation is used to identify the parameters, focusing on imagine features during training. However, in the case of CNN, those factors specifically connect to the picture features (Smeda K., 2019).

Convolutional, pooling, and fully-connected (FC) layers are the three different types of layers that compose a CNN (Mishra, M., 2020). The Convolution Layer is responsible for almost all of the network's computational load. The goal is to find a particular set of characteristics in the images provided as input. Convolution filtering is the method used to do this; the basic idea is to just "drag" the window reflecting the feature over the images to calculate the convolution result between the feature and every layer of the scanned image (Smeda K., 2019).

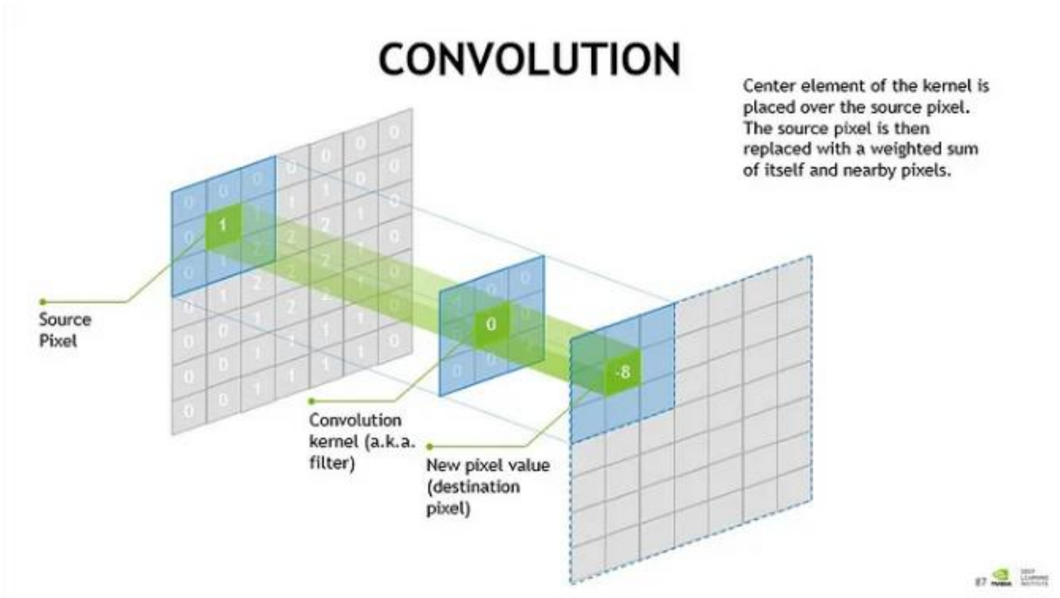

Figure 2. Convolution Layer

$$W_{out} = \frac{W - F + 2P}{S} + 1 \qquad (1)$$

Equation.1 Formula for Convolution Layer

The pooling layer alternatives the network's results by creating a summary statistic of near-by outputs, minimizing the representation's location. Its scope, and reducing computation and weights. For each of the slices of the representation, the operation is performed separately. The average of the neighborhood, the L2 norm, and a weighted average are only a few examples of pooling algorithms. The maximum output from the neighborhood is calculated by the most well-liked method, max pooling. The formula, an activation map, a pooling kernel, and stride may all be used for calculating the size of the output volume (Mishra M., 2020).

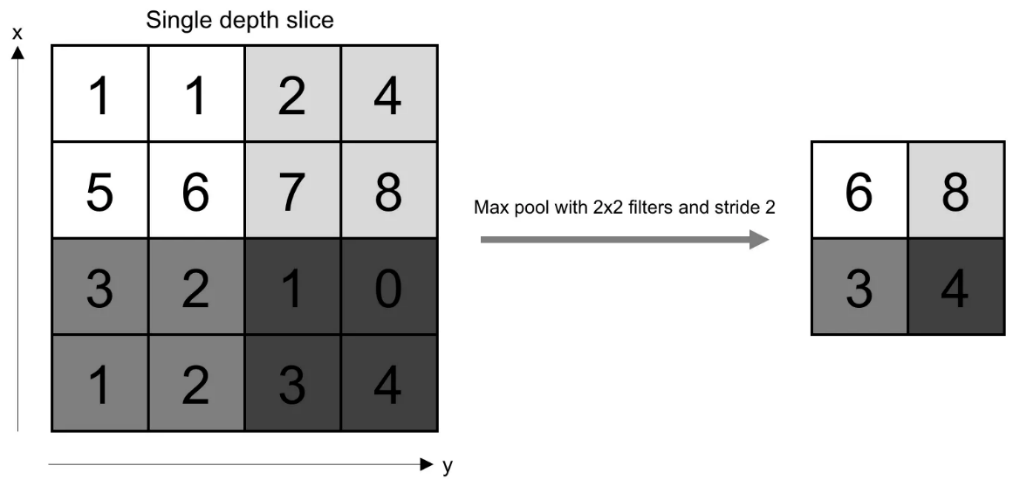

Figure 3. Pooling Operation

$$W_{out} = \frac{W - F}{S} + 1 \qquad (2)$$

Equation 2. Formula for Padding Layer

The fully-connected layer is the last layer of a neural network it is not the characteristic of a CNN. It uses a linear combination along with possibly an activation function to produce an output vector from an input vector. The fully-connected layer categorizes the image as an input and computes probabilities by multiplying each data element by weight, adding them all together, and then using an activation function to determine the probabilities. During the training phase, the convolutional neural network learns weight values by the back propagation of the gradient. The highest values show the feature's position in the image, and the fully-connected layer creates the connection between feature position and class (Smeda K., 2019).

A comprehensive overview of recent advances in CNNs, including new ways to design layers, choose activation functions, and calculate loss functions are discussed in the study by (Gu et al., 2018). The researchers also discussed the applications that make use of CNNs in computer vision, speech recognition, and natural language processing. Deep learning has helped computers get better at a variety of tasks, like recognizing objects in images, understanding speech, and processing natural language. Convolutional neural networks (CNNs) have been especially well-studied because of the rapid growth of annotated data and the increasing power of graphics processing units (GPUs).

A comprehensive review of Convolutional Neural Network (CNN), a deep learning technique used to tackle complicated issues, is also given in the research of (Indolia et al., 2018). It covers methods for learning, three typical designs, and the understanding of concepts. The objective is to help researchers in understanding CNN properly to motivate them to continue their study in this topic. This study is a helpful resource and an instant reference for those who have an interest in the topic, making it a valuable resource. It also analyzes CNN, a method of deep learning that improves traditional methods like shallow networks in learning contextual aspects in high-dimensional data. For the processing of high-resolution data, traffic sign recognition, audio scene segmentation, and MR brain image segmentation, CNN is often used.

2.1.5 Cloud Database

Healthcare security is facing serious risks due to the growing use of electronic medical records. To address this issue, it is important to develop a cloud-based healthcare management system that can efficiently manage patient health data. However, it can raise concerns such as medical fraud and identity theft that must be carefully considered and addressed accordingly. According to (Shakil et al., 2020), biometric-based authentication is the perfect solution for important medical records. The researchers suggested a cloud-based authentication solution called BAMHealthCloud that makes use of behavioral biometric signatures.

In order to increase the security of the system, BAMHealthCloud has implemented a priority-based system that processes vital records. BAMHealthCloud may be used in a variety of sectors, including banking, education, business, and the military, and it is appropriate for large data processing and suitable for applications of all sizes. It also provides for horizontal resource scaling (Shakil et al., 2020).

It is a huge difficulty to move enterprise software systems' databases to the cloud. Cost and migration time estimations are required when selecting a cloud provider and service option, such as a database-as-a-service or a manually created collection of virtual machines. This data is used by numerous organizations for planning and budgeting.

Relational database migration costs, migration timelines, and cloud operating costs were determined using a two-stage methodology described by (Ellison et al., 2018). The database schema and database logs are used in the first stage to determine the structure models and workload of the database that will be moved. The predicted duration and costs are calculated in the second stage using a discrete-event simulation. The researchers set up software tools to automate both stages of their process. Their forecasts are thoroughly compared against the results of actual cloud database migrations.

Building cloud-native databases that separate storage and processing for elasticity is growing in popularity. In order to provide high speed and elastic storage service without disclosing sophisticated storage specifications, cloud-native databases usually use cloud storage as the foundation for their storage engine. This reduces maintenance expenses and expedites the creation of database kernels. Based on (Zongzhi et al., 2022), discovered that there are significant differences between local and cloud storage that invalidate a number of designs when existing databases are moved to cloud storage.

The researchers analyzed the advantages and drawbacks of employing cloud storage for both B+-tree and LSM-tree-based storage engines, and offered a framework for database developers. The researchers use a B+-tree-based

InnoDB as a demonstration vehicle, where the researchers have constructed a suite of optimizations using the suggested framework, and then extend such efforts to the LSM-tree-based RocksDB. Their analyses on both engines demonstrate significant performance advantages on cloud storage (Zongzhi et al., 2022).

Cloud databases are increasingly commonly used as a result of database suppliers shifting their attention to databases as a service (DBaaS), or cloud data services. The current generation of cloud databases, also known as cloud-native databases, are less expensive and seek for greater elasticity by developing new techniques than prior cloud-hosted databases. In order to better utilize the capacity of cloud databases, it is essential to investigate and compare the advantages and disadvantages of different cloud database primary approaches.

The researchers provide a thorough overview of cloud-native databases in the (Li et al., 2022) tutorial. And presented a taxonomy based on several system architectures for the most sophisticated OLTP databases and OLAP databases that are native to the cloud. The researchers then dug extensively into their fundamental techniques to handle transactions, handle analytics, manage storage, replicate data, use serverless computing, recover databases, and maintain security. Finally, discussed the promise and difficulties of the research.

2.1.6 Image Acquisition

One of the important steps to be done in the process of iris recognition is image acquisition. In the study of (Aparna D.K, et.al, 2023) the research noted that in order to make a good image acquisition it is important to capture a high-quality image of the iris. The researchers tried it using a variety of methods such as dedicated iris scanners, webcams, and smartphones. When the researchers choose the proper image acquisition method for the iris recognition based voting system that they are developing it's important to consider the speed, accuracy and security of the system. It was said that it should still be able to capture good quality images even in low light conditions. Capture images quickly to avoid long lines and polling stations in the process that would affect the accuracy. One way that was suggested to increase the security of the image acquisition process is to use a technique called active iris recognition wherein it uses a projecting light pattern onto the iris and then captures the reflected image.

Functional MRI (fMRI) uses rapidly changing magnetic field gradients and radiofrequency (RF) pulses to create images of the brain. When fMRI is performed simultaneously with EEG recording, the EEG signal is contaminated by artifacts from the image acquisition process. These artifacts are caused by electromagnetic induction in the circuit formed by the EEG electrodes, leads, patient, and amplifier. Image acquisition artifacts in EEG-fMRI are particularly challenging because of the preprogrammed nature of the RF and gradient switching sequence. This means that the artifacts are deterministic and can be predicted. However, it also means that the artifacts can be difficult to remove from the EEG signal. There are different methods that can be used to reduce image acquisition artifacts in EEG-fMRI. One common approach is to use a template subtraction method. This involves creating a template of the artifacts from a separate scan and then subtracting this template from the EEG signal. Image acquisition artifacts in EEG-fMRI are a major challenge, but there are different methods that can be used to reduce them. These methods are still under development, but they have the potential to improve the quality of EEG-fMRI data significantly (Ritter P., et.al, 2023).

2.2 Foreign & Local Studies

Patient Health Records have patient identification as an important component alongside biometrics that will have a significant role for technological advancement in the field of healthcare. Patients' identification will become more secure because of biometrics technologies that are available nowadays such as palm vein readers, facial recognition software, eyeball's iris scanner, especially fingerprint scanner that the researchers will utilize for this study. By applying these technologies hospitals would be able to verify that the patients are actually the people they claim to be and the only right person to have access to said data (Saini, 2020).

Biometric technologies were not utilized in the current state of healthcare. Although there are clinics and hospitals that have made progress in using this kind of technology, it's still not enough to be widely used by the healthcare field. With the development of Personal Health Records (PHR), patients, doctors, and healthcare officials now have easier access to the patient's personal health records using a body part to serve as his/her biometrics. Concerns about patient's privacy, security and confidentiality of records in hospitals comes from the issue of PHR being accessible for a lot of people. The requirement of a strong and reliable type of authentication will address the said issue. Activities of suspected fraud, and handling duplicate records can all be prevented to improve patient safety by using fingerprint biometrics as the main patient identification method to be used.

Biometrics were frequently used to detect and identify patients for only one second because biometrics respond quickly to scanners. This identification method was unique for each patient at the same time it cannot be forgotten or copied by anyone. Hence, it's effective to help track the patient (Sheikh et al., 2020). A fingerprint biometric based system that will be used as authentication for a patient's identity will be a fundamental component for this study, it would also need hardware like the tablet and the sensor; the web app that would be used to input the patient information. It has to be compatible with one another. A group of researchers emphasized that the sensor should be able to accept all the fingerprints without error (Mason et al., 2020).

A study was conducted that investigated a number of Telemedicine, E-Health and Wellness (TEW) systems, the researchers found out that there's a concerning number of records of patients that's misinterpreted and stored properly, then analyzed their technologies and security measures. And all of this resulted in wrong prescriptions for patients. To address the problem the team of researchers developed a Health Information Management System (HIMS) called CareMed, this system has a two-factor authentication process that it utilizes using a password or

PIN with the fingerprint biometrics. With this, the researchers were able to incorporate security to the system (Azeta et al., 2019).

(Devi et al., 2021) found that websites are the most popular and convenient way for people to contact hospitals and other healthcare organizations. With the abundance of patients whose ill, Healthcare organizations most likely needed large database management systems to store and manage large amounts of data of patients, doctors, and treatment procedures. To address this need in healthcare, a database management system was developed for hospitals that allows patients, doctors, and administrators to access all of the data efficiently using only a website. This system has allowed patients to book appointments online and view their medical records whenever needed. It also allows doctors to see their appointments and provide online prescriptions, taking into account the patients' medical histories. Administrators can use the system to manage all medical data and allow the laboratory section to upload reports online. This provides contactless medical reports and sends email reminders about upcoming appointments. An anonymous researcher published a study of his web application, in which it stated that the storage and effective use of data are the main challenges in health management systems. The security of health data and its proper use are critical. Doctors can upload patient data to the system and retrieve it when needed (Mishra, 2022).

Around the world, there are various biometrics that were used by researchers as a person’s identity. (Etter L., et al., 2020) developed a mobile app in Zambia that uses people's ears as a biometric tool. The ear biometric system has used a combination of both hardware and software to identify a person using an image of their ear. The software used a pattern recognition algorithm to transform an image of the ear into a unique identifier within the biometrics’ algorithm. The researchers created three cross-sectional datasets of ear images, each increasing in complexity. The final dataset represented their target population of Zambian infants (N=224, aged 6 days-6 months). Using these datasets, the researchers conducted a series of validation experiments, which informed iterative improvements to the system. The results of the improved system, which yielded high recognition rates across the three datasets, demonstrate the feasibility of an Android ear biometric tool as a solution to the persisting patient identification challenge. Different methods can also be used like the well-used fingerprint biometrics. (Salunkhe et al., 2023) described the image preprocessing steps involved in fingerprint and iris scanning. For fingerprint scanning, the colored image is converted to a grayscale image. This is followed by pre-processing steps such as filtering, subsampling, quality control, normalization, and histogram methods. After pre-processing, image transformation methods are used. Image interpolation methods are used after transformation. In the processed image, around 20 to 30 points are evaluated and features are extracted based on texture, curves, lines, patterns, and so on. These features are then stored and converted into a unique code that represents the fingerprint's uniqueness. The same image pre-processing steps system was applied to the iris scanning. The ciliary region, upper eyelid, eyelashes, pupil, iris, lower eyelid, pupil area, and ocular sclera are the features that were extracted from the processed images of eyes. Everything was stored and converted into a unique code that represents the uniqueness of the iris scan of each person. This code was matched to the database to verify the identification of the person to whom it belongs.

The current accuracy of different biometrics technique was tricky to determine, but in a 2023 study, the proposed Faster R-CNN model attain the accuracy range 99.3% for facial recognition that is better than the existing system like Deep CNN, SVM, LBPH, and OMT CNN respectively (Rajeshkumar et al., 2023). (Sahy et al., 2023) developed a model that can accurately classify fingerprints with an overall accuracy rate of 93%. This is significantly higher than the accuracy rate of traditional fingerprint recognition techniques, which is typically around 85%. The model was also able to correctly identify individual children's fingerprints with an accuracy rate of 89%. This means that the model can distinguish between different sets of fingerprints belonging to different children. A recent study about iris recognition was conducted by (Ghosh et al., 2023) wherein the researchers created a model for iris recognition and segmentation that achieved accuracy of 99.50% in training and 99.46% in validation which is significantly high.

Hospitals prioritize the satisfaction and comfort of their patients. This is because patient satisfaction can result in positive outcomes in the hospital, patients can experience shorter hospital stays, fewer medical complications, and higher rates of patient compliance to the treatment and medication. (Dayrit, et.al, 2018) emphasized that the amendment of Republic Act No. 7875 under the Republic Act No. 10606 ensures that all Filipino citizen have access to health insurances. This specific law mandates the following agencies including the Philippine Health Insurance Corporation (PhilHealth), the Department of Health (DOH), local government units and non-government organizations to make sure that every Filipino can have access all health services and facilities that is provided by the government. Under this law it requires PhilHealth to enroll every beneficiary to their care and issue them health insurance ID cards and ID numbers for the main purpose to serve as their identification when searching their records on the system. On a study by (Mendoza et.al, 2019) the research somehow concluded that traditional appointment systems in hospitals are inefficient because it can cause to a long queue of waiting patients. So, the researchers proposed a web-based appointment scheduling system that was called InstaSked to address the issue of long queue lines. It was designed to be used by patients and medical personnel that used Six Sigma methodology, DMADV and BPM. The Six Sigma was a framework used for quality improvement in order to improve system efficiency and reduce errors. DMADV was used to design new products and services and BPM was used for managing the processes to be done by the business. The system efficiently was able to provide a platform for patients to book their appointments online, in lined with this is the result of having fewer queue of appointment call and patient lines. The researchers were able to reduce the patient waiting time by 20%.

For this study the researchers looked for local studies and one of it was a study that have developed an iris recognition system that used multi-level Otsu thresholding in order to improve the system's quality of iris images. Similar to the proposed system the researchers have used a Raspberry Pi camera module to capture the iris images then save it all to the database. The system will then compare the new captured images of iris to the initially stored iris images to know if there will be a match on the records. The results of this study concluded that the accuracy of the system was higher for iris images where Otsu's thresholding was applied with 96.60% compared to the raw iris images having the accuracy of 94.23% (Virtusio et.al, 2022). Another local study was conducted and the researchers have developed iris recognition technology and applied it into detecting drunk drivers. The researchers made use of Hough transform for the system that was used as well in MatLab to extract the features in the iris image. If the input image matches a stored iris image in the database, a signal is sent to the circuit that starts the car's engine. The system also has a bypass system that can be used in emergency situations for the driver like accidents. The study found that the system can identify the driver and detect drunkenness in approximately 11-15 seconds. The study used four images, and the results showed that the time of identification and detection varied depending on the image quality and the level of drunkenness (Villareal et al., 2022).

2.3 Relevance of the current study

The gathered literature and studies will give the researchers ideas on how to build the project. It would be a lot easier to start since the related literature and studies gave us a head start on understanding how this would work. Iris recognition, biometrics, IoT, cloud database, and CNN algorithm are all topics covered in the associated literature and research mentioned in this chapter. These studies illustrate the developments and difficulties in these fields, and they serve as the basis for the creation of the suggested patient identification system using iris recognition. There have been studies of several iris recognition methods in different literature, including pattern matching and feature extraction. These methods can be used in the suggested device to extract biometrics from iris to serve as patient identifiers.

Techniques for image processing are necessary for digital picture analysis and manipulation. These may be used to do picture preprocessing before iris recognition, improving the system's accuracy and performance. Convolutional neural networks (CNNs), a type of deep learning technique, have demonstrated outstanding performance in a variety of image recognition tasks, including iris recognition. A deep understanding of the technologies and procedures pertinent to the creation of the patient identification system is given by the linked literature and studies. It all explained how iris recognition, biometrics, IoT, CNN algorithm, image processing, and accessibility may all help to accurately determine a patient’s identity to give the proper information and treatment. These developments may be built upon by the suggested system to produce a workable and effective method for helping hospitals have a device to determine their patient’s identity using their iris.

Chapter 3

METHODOLOGY

This chapter discusses the methods used, as well as the data gathering and analysis that were important to the study. The methodology covers subjects including the research design, block diagram, hardware specification, algorithms, and software design.

3.1 Research Design

This section will explain the research design that the researchers will use to perform the study. Methods of research are the techniques, processes, or strategies employed to gather data to and develop an analysis and support the acquisition of new knowledge and have a deeper understanding of the topic. There are multiple different research methodologies, and all of them use a particular type of tools to collect data. The research design provides what the study needs.

This study will use an Experimental Research Method. Experimental research method as a first step toward a more effective approach and with the goal of providing empirical evidence on its effectiveness. By utilizing this research design and developing a patient identification system, this research aims to provide a platform for medical institutions and personnel to efficiently verify the patient’s identity. The primary aim of this study is to assess the device's benefits on hospitals by examining its scanning accuracy and scanning time.

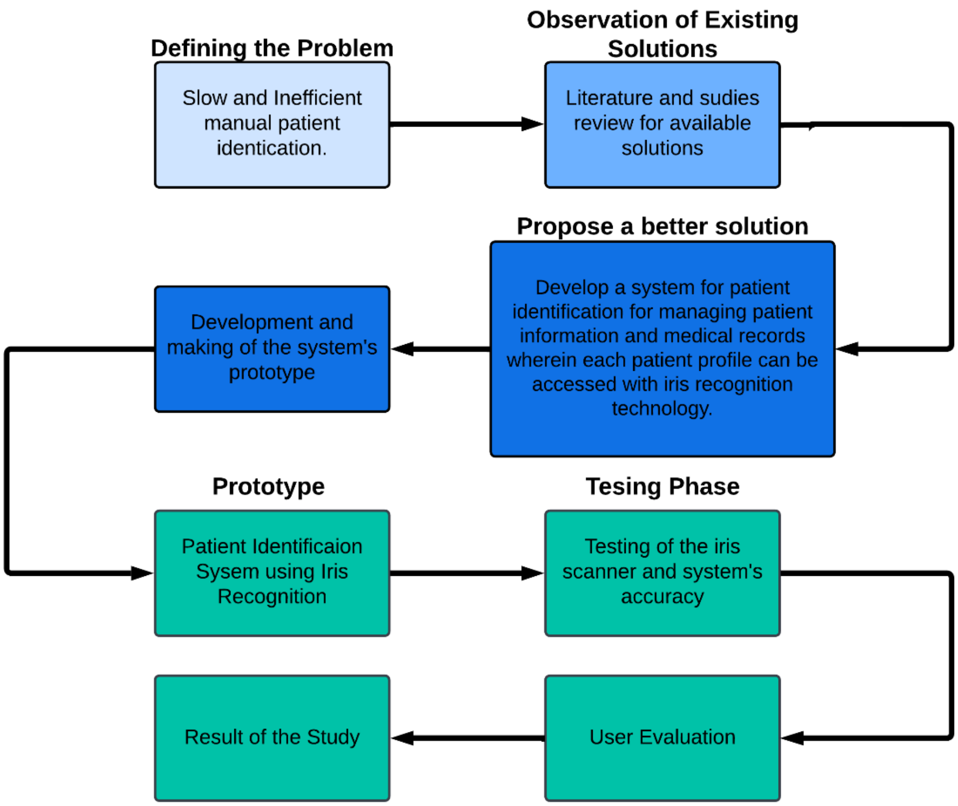

Figure 4. Process Flow Diagram of the Study

Figure 4 shows the diagram of the process flow. The first is that the researchers define the problem for the study. Then after finding the problem, the researchers will gather information about the problem and the previous solutions by using related literature and studies. Designing the solution by making the patient identification system. After proposing the solution, testing is next since the system is for prototype use, the study should be tested whether the system fails or succeeds. After that to show that the study has a contribution by having the results of the system. Lastly, the study will be evaluated by the results of the study.

3.2 Design Methodology

This section discusses the series of steps the proponents will undertake to find and develop solutions to the problem investigated. This includes hardware and software design development diagrams such as the block diagram, feature specification, design approach and system architecture.

3.2.1 Block Diagram

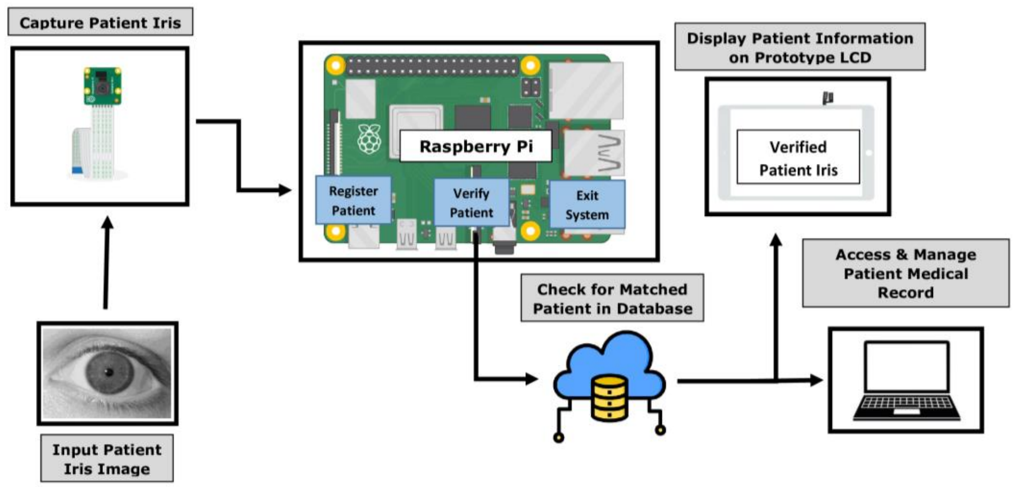

Figure 5. Block Diagram of the system

The block diagram provides a visual representation of the system's components and modules. It starts by using the RPI camera to capture an image of the patient's iris. These images are then preprocessed and utilized as the primary dataset for training the developed model. This training process is carried out on a laptop or computer. The trained model will then be sent back into the main RPI unit. The registered patients can now be verified by the system by capturing a new image of his/her iris. This will be matched from the stored iris images. If verified, the generated scanning access of the user from the RPI will be sent to the database and later on can be viewed via the prototype display. When the patient identity was then verified by the system the user can use the web application using a secondary device (e.g., computer or laptop) to access and manage the patient's medical records.

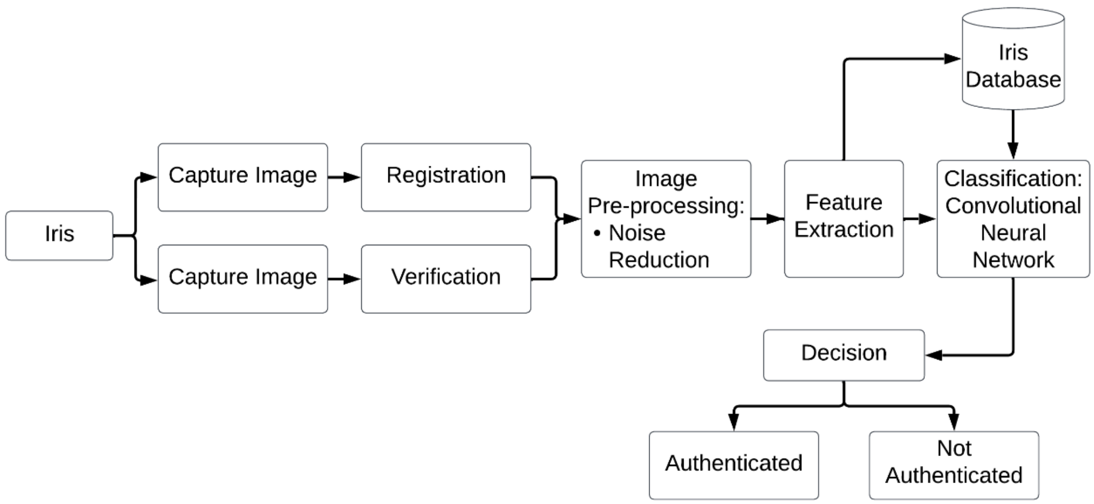

Figure 6. Iris Recognition System

The flow of Figure 6 starts by capturing the iris image. Depending on the situation whether the user will choose between registration and verification, it will be captured via a RPi camera. Then, the captured image will undergo image preprocessing using image noise reduction for enhancing the image. After the image has been preprocessed, it will use feature extraction to determine the features of each image provided by the user. It will be sent either to the database or to the CNN Model for training the dataset. Then if the user chooses for the verification, they will be sent to the decision using the CNN model if they are in the database to be authenticated or not.

3.2.2. Feature Specifications & Design Approach

This section represents the feature specifications and design approach of the system that the researchers will use to conduct the study. This includes the marketing requirements and engineering requirements.

3.2.2.1. Marketing Requirements

This section discusses the user needs to be satisfied by the system as criteria for success for effective use of the product/system. This includes both hardware and software user interface needed for operating the product.

Table 1. Marketing Requirements of the system

User Requirement	Specific Functions	Design Approach	Standard
Authorized Personnel Login and Registration	Only authorized personnel (e.g., admins, doctors, nurses, medical staff) can use the system, the users must be able to create an account and fill-out personal information especially username and password that will be needed to enter the homepage of the system.	The login and registration page will be developed using Html, CSS, Php.	ISO/IEC 25010:2011 Systems and software programs should pass the quality, requirements and evaluations.
Patient Profile Registration	The patient must have a profile in the system with fill-out personal information and medical information associated with iris registration.	The patient profile registration page will be developed using Html, CSS, Php.	ISO/IEC 25010:2011 Systems and software programs should pass the quality, requirements and evaluations.

Patient Iris Scanning	The system should be able to detect a patient iris in order verify the identity of the patient.	Match the iris image captured by the scanning device to the iris templates stored in the database.	ISO/IEC 2382-37:2017 ensures a systematic use of biometrics to use for recognition of human beings and comply with biometric standards.
Touchscreen LCD to display results	All processes must be displayed in the LCD.	A touchscreen LCD will be attached adjacent to the scanning device.	ISO/IEC JTC 1/SC 6 standardization for telecommunications and information exchange between open systems.
Power button to start/stop the device	The system should power on and off each time the button is pressed.	A button that will start and stop the interface of the system.	ISO/IEC JTC 1/SC 6. Telecommunications and information exchange between systems

3.2.2.2. Engineering Requirements

This section discusses technical aspects and performance requirements of the proposed system as criteria for success for effective use of the system. This includes both hardware and software user interface needed for operating the product.

Table 2. Engineering Requirements of the system

Engineering Requirement	Specific Functions	Design Approach	Standard
Capture image of iris	The device must capture images of iris at least 20 angles	Utilize a RPi camera mounted on the device. The camera mush have ultra-high definition of 4056 x 3040 pixels.	ISO/IEC TS 27000 provides general guidance on various aspects of user interface that scan visual information used directly by humans.
Wired Iris scanner	The device should still be useful in	Make the iris scanner	ISO/IEC 11801-1 standard that ensure

	scenarios where the patient was bedridden and unable to stand or sit properly.	unmountable with long cable to anticipate different scenarios.	efficient cabling system that can be used for a wide variety of applications.
Cloud Based Database	Patient information should reflect real time on the touchscreen LCD	Database information should be accessible via Cloud.	ISO 802.11g covers wireless communication standards
User Authentication	System should determine whether the user was authorized or unauthorized to use the system	The system would require the user to enter his/her username and password to verify if the user is an authorized personnel.	IISO/IEC 11770-4 standard for managing passwords and using them to authenticate users.
Patient Authentication	The system should determine whether the patient was registered or unregistered on the system's database upon scanning the iris.	The system would require the patient to have his/her iris scanned to verify if the patient is a registered patient on the system.	ISO/IEC 2382-37:2017 ensures a systematic use of biometrics to use for recognition of human beings and comply with biometric standards.

3.2.2.3 Prototype Design and System Interface

The design of the project has been planned out so that all of the hardware components and software will successfully create the patient identification system. The hardware selected will be utilized for image processing, internet connectivity, and AC power. The hardware together with the software will be used to create the programs and algorithms for image processing, cloud database connection, and web app creation will all work in unison to create the patient identification system using iris recognition.

3.2.2.3.1 Prototype Design

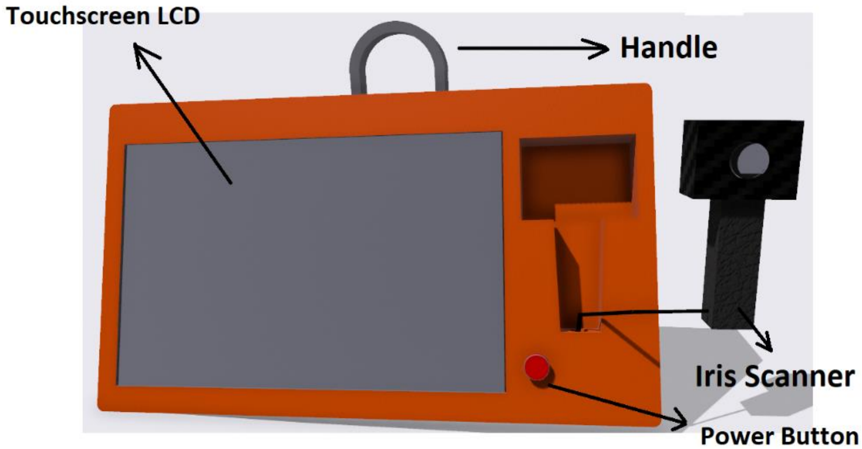

Figure 7. Front View of the Prototype

Figure 7 shows the front view of the prototype, the prototype will have a touchscreen LCD that will display the web application, a wired iris scanning device with a dedicated compartment that can be remove on the device, power button to turn on and off the device and a handle so the device can be carried easily.

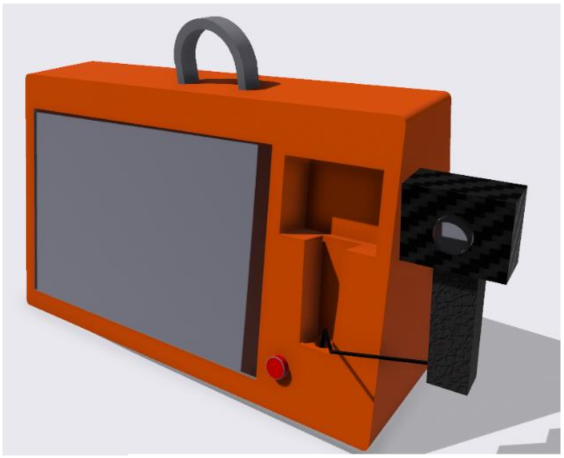

Figure 8. Side View of the Prototype

Figure 8 shows the side view of the prototype, as shown the front of the prototype was tilted to make a touchscreen navigation much easier for the user. With a dedicated slot for the iris scanning device.

3.2.2.3.2 System Interface

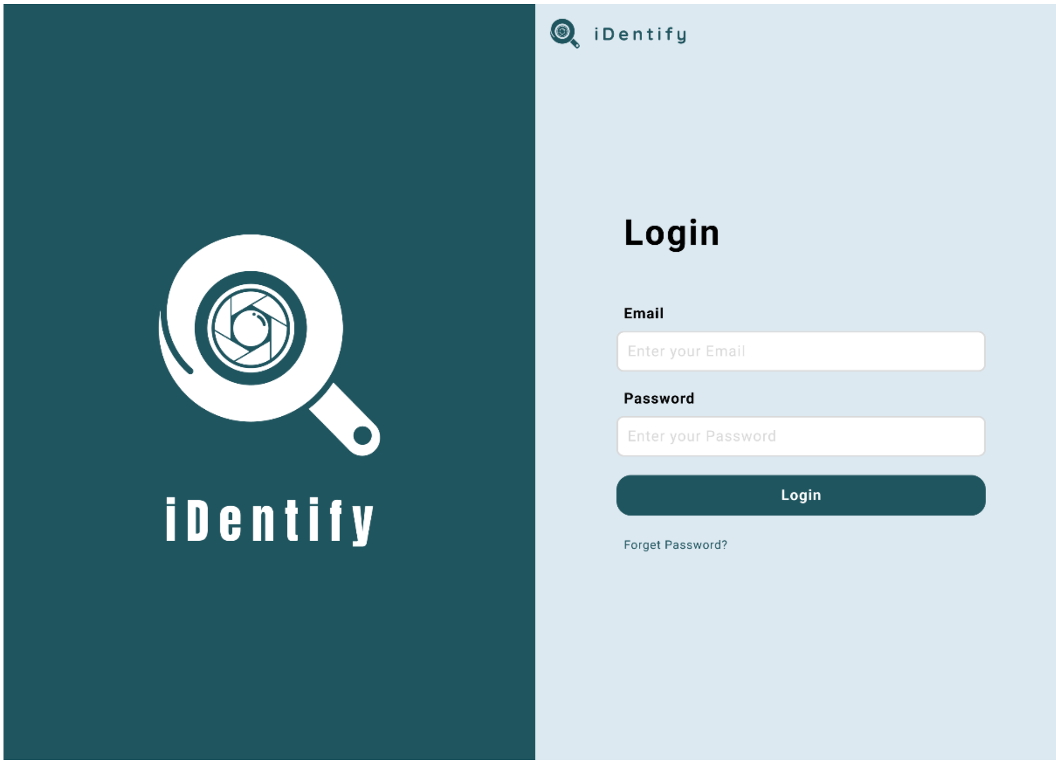

Figure 9. Login Interface of the System

Figure 9 above shows the sample layout of the login interface. Depending on the email and password that will enter by the user he/she will be redirected to the corresponding interface depending on the authority of the profile (e.g. patient, admin, and doctor).

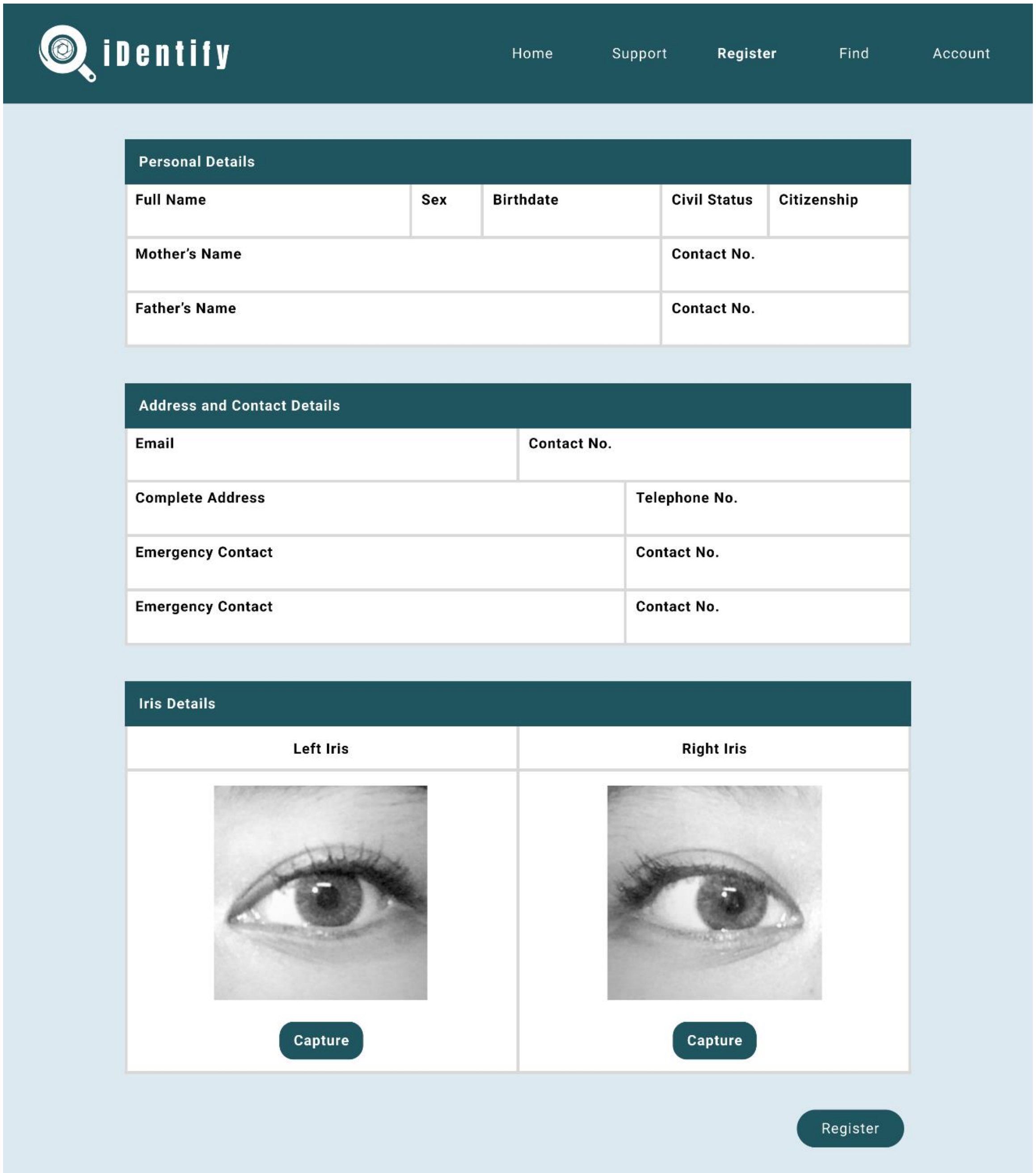

Figure 10. Admin's New Patient Registration Interface

Figure 10 above shows the sample layout of the new patient registration in the admin's interface. Here the admin can enter the patient's information as well as capturing the patient's iris to save in the iris template database.

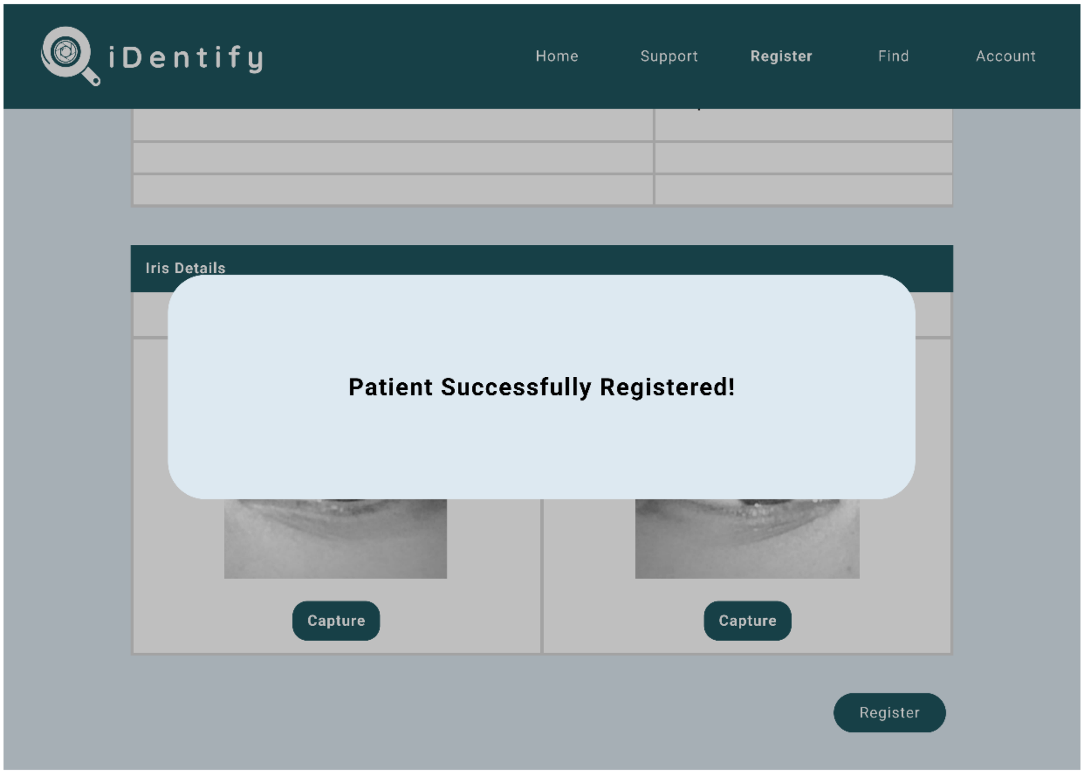

Figure 11. Patient Successfully Registered Interface

Figure 11 above shows the sample layout of the system upon a successful patient registration. A floating window will pop up to indicate that the patient information and iris images have been successfully registered and saved in the database.

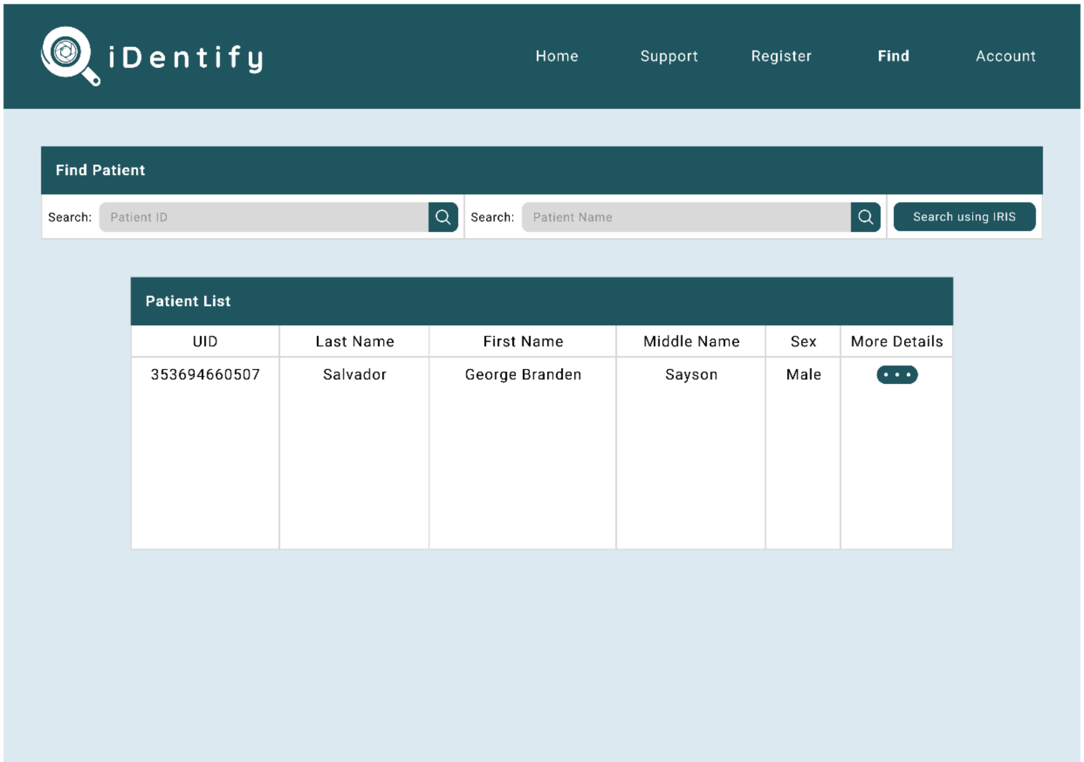

Figure 12. Finding Patient Interface

Figure 12 above shows the sample layout of the system on finding a patient. The admin have 3 options to search for a patient profile it could be using Patient ID, Patient Name, and using Iris. When a user matched to the chosen search method it will be listed on the Patient List.

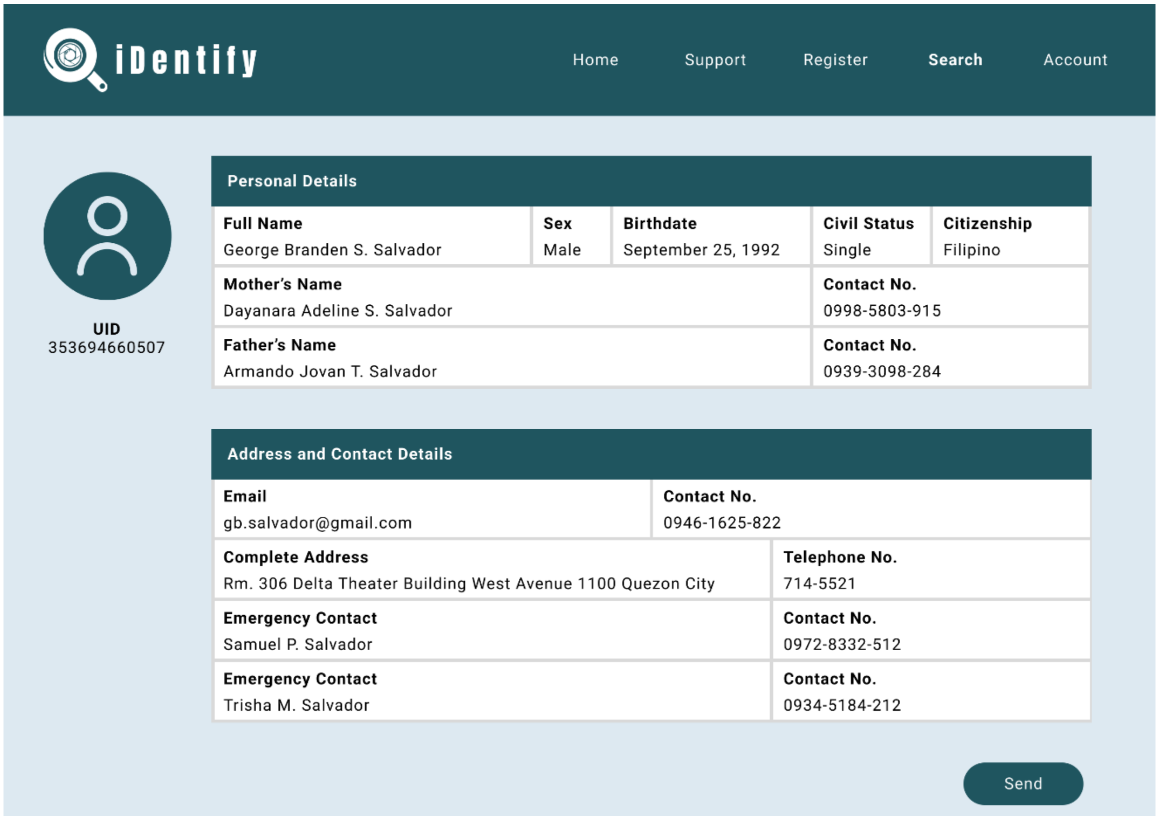

Figure 13. Patient Profile Interface

Figure 13 above shows the sample layout of the system in displaying the patient profile. This will display the latest information of the patient as well as the medical complaint he/she have. The admin have the option to send the profile to a doctor in the hospital that he/she knows that was needed to be seen by the patient.

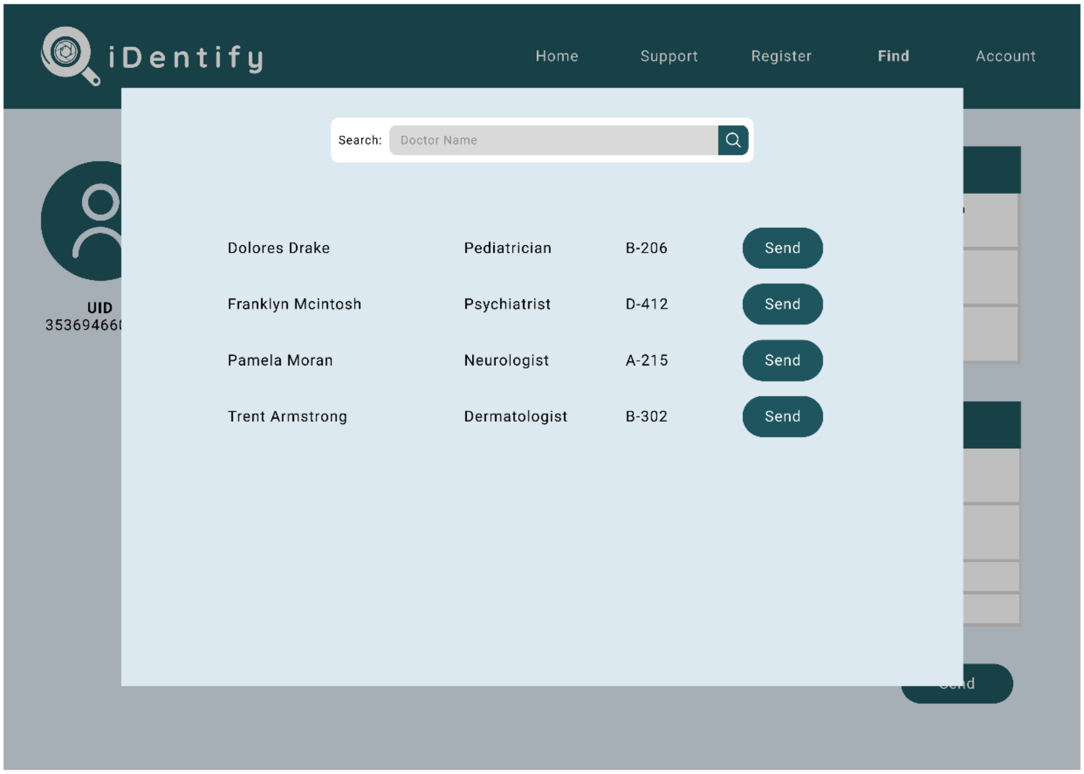

Figure 14. Sending Patient Profile Interface

Figure 14 above shows the sample layout of the system when the admin choose to send the patient profile to a doctor. A list of doctors in the hospital will be displayed showing the doctor’s name, specialization, and doctor’s office. Upon clicking send to the corresponding doctor of choose the patient’s profile will be send to the doctor’s dashboard to prepare for patient diagnosis.

3.2.3. System Architecture

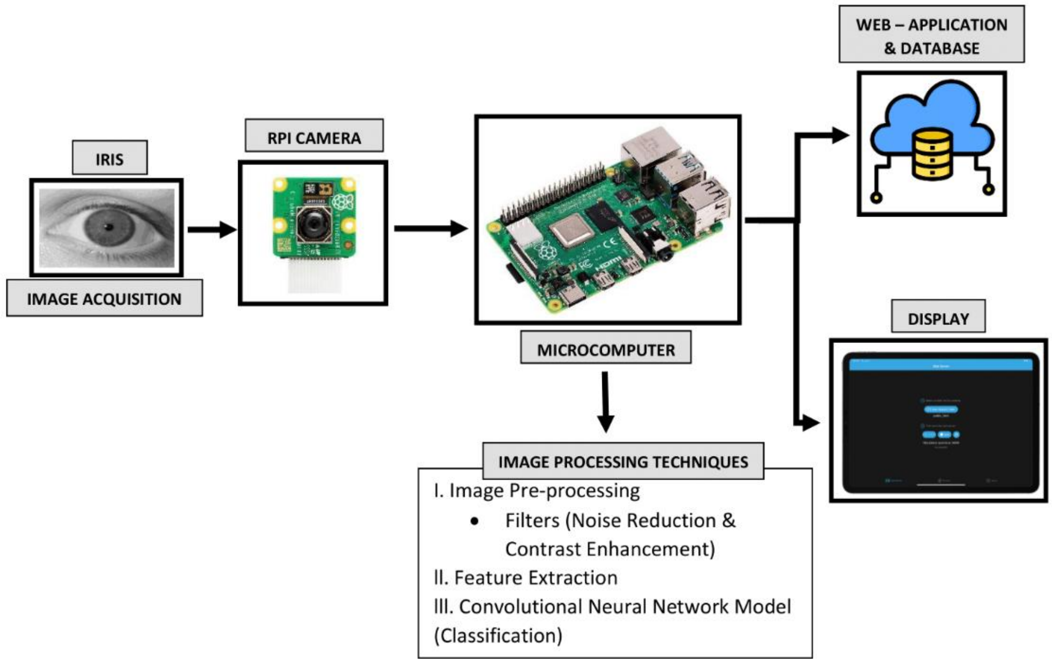

Figure 15. System Architecture

Figure 15 above shows the architectural system design of the initial prototype from its input to the output phase. The parts or functions are represented as blocks that are connected with arrows showing the flow of the diagram. Image Acquisition is the beginning or first stage of the system's registration and verification process. The patient will place either the left or right eye in front of the scanning device and will be captured via the designed camera. Next, the installed sensors are designed to capture the required inputs upon using the scanning device. The device made use of a Raspberry Pi Camera that effectively captures high-resolution iris images of patients. After scanning the required inputs, the microcomputer will gather the data from the inputs, extract the images and verify the registered patient from the database. The microcomputer will be set to verify the image for patient classification and will also display the necessary information (e.g., patient no., address, illness, and medical records). Lastly, the processed and verified patient data from the microcomputer will then be transferred to the system's database. The web-based application is able to display the stored data that are accumulated by the system.

3.2.3.1. System Flowchart

This section illustrates the flow of the entire system upon deployment, along with the procedures that will be applied in the development of the project. It discusses the main stages that the system will undergo. Beginning with the process of registering a new patient profile by collecting their information from the iris scanning device, followed by the authentication up in the verification process stage.

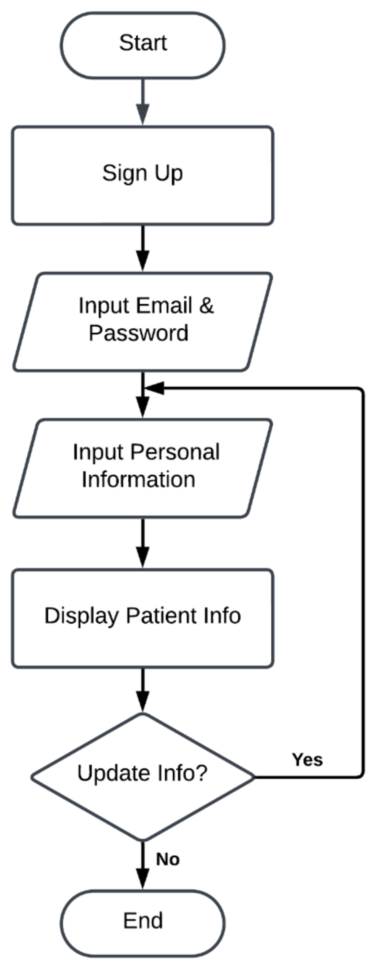

Figure 16. Patient Pre- Registration Flowchart

Figure 16 shows a short illustration of the process of pre-registration of new patient profile. First the patient needs to sign up by inputting an email and password that he/she will use to view and edit the information on his profile whenever needed. Then, the patient will proceed to fill up all the basic personal information needed by the system. After finishing pre-registration, the patient will be given a week to authenticate the profile and register his/her iris.

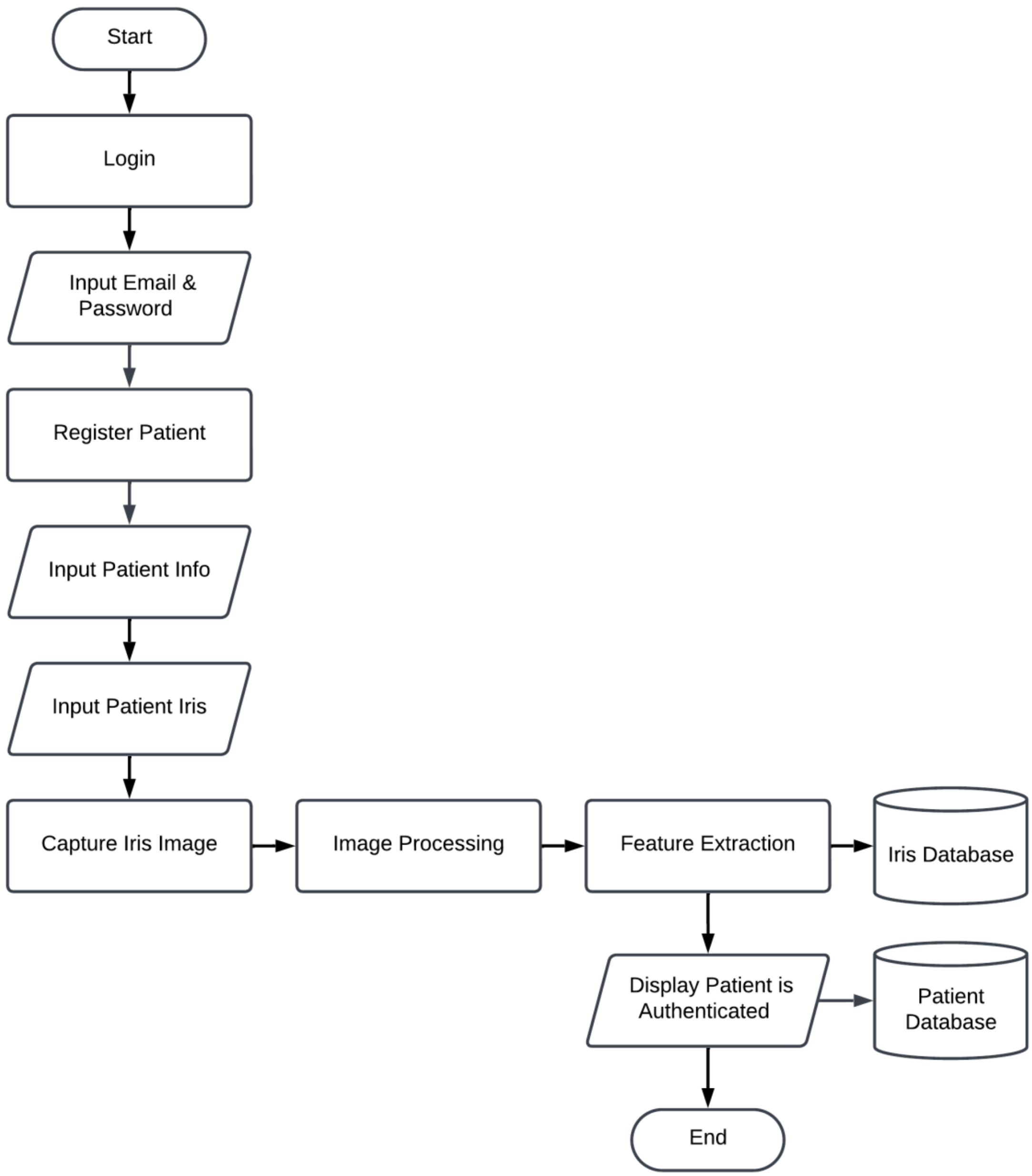

Figure 17. Patient Iris Registration Flowchart

Figure 17 shows an illustration of the process of authenticating a new patient profile by registering the patient’s iris. After the pre-registration of the patient, within the week given to the patient he/she will need to have register 20 images of each of his/her iris then this will be sent to the database. There, the captured iris Image will undergo several image processing techniques and extract its features based on the designed model. This preprocessed image will be saved and serve as a unique template for every registered patient. Thus, the patient is now officially registered and recognized by the system.

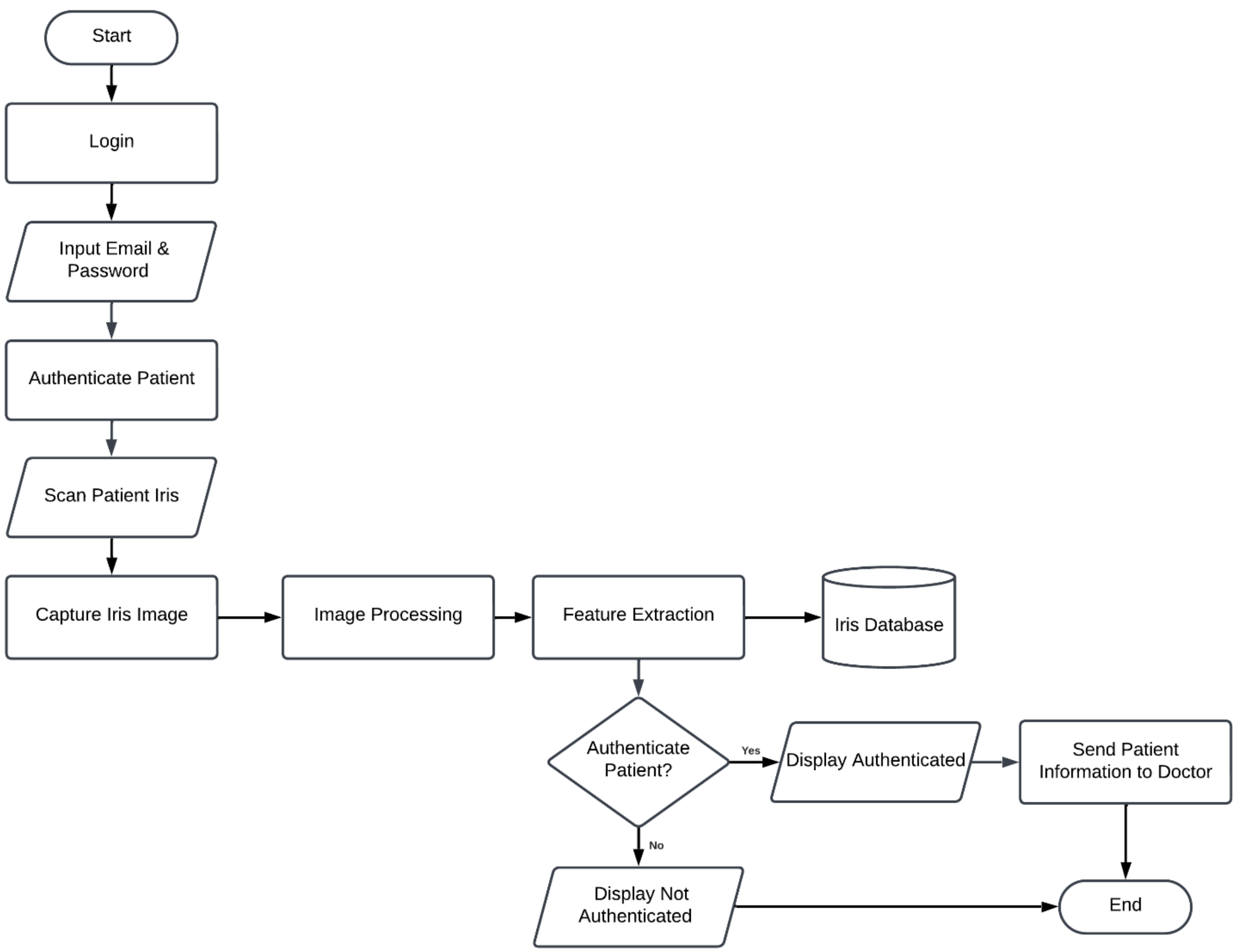

Figure 18. Patient Authentication Flowchart

Figure 18 presents the patient authentication procedures in which any registered or unregistered individual tries to access the scanning device. Similarly, with the iris registration process, each patient is required to have one captured raw image of his/her iris by the scanning device. It will again undergo image enhancement and preprocessing steps in order to clearly distinguish its unique patterns. Afterward, this preprocessed image will be checked first by the system to verify if it has a matched template or existing data in the database; if not, this user will be denied and no longer be able to proceed to the next step. Meanwhile, patients with matching data are considered verified, thus their transaction within the scanning device will be saved. Then the admin was now able to transfer the patient to the corresponding doctor that the patient needed to see.

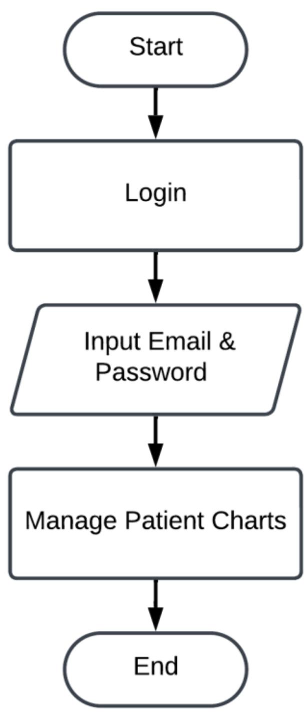

Figure 19. Doctors' Patient Chart Management Flowchart

Figure 19 shows a short illustration of the process of patient chart management that only doctors have access. To get directed to the specific web interface for managing patient charts the doctor needs to enter the given StaffID and password by the management. From there, the doctor now was able to retrieve patient charts and medical records whenever needed.

3.2.4. Architecture of the Ai Model

This CNN model detects the relevant elements without the need for human intervention. It can learn the features taken from the preprocessed image for each class by itself from the images on the iris.

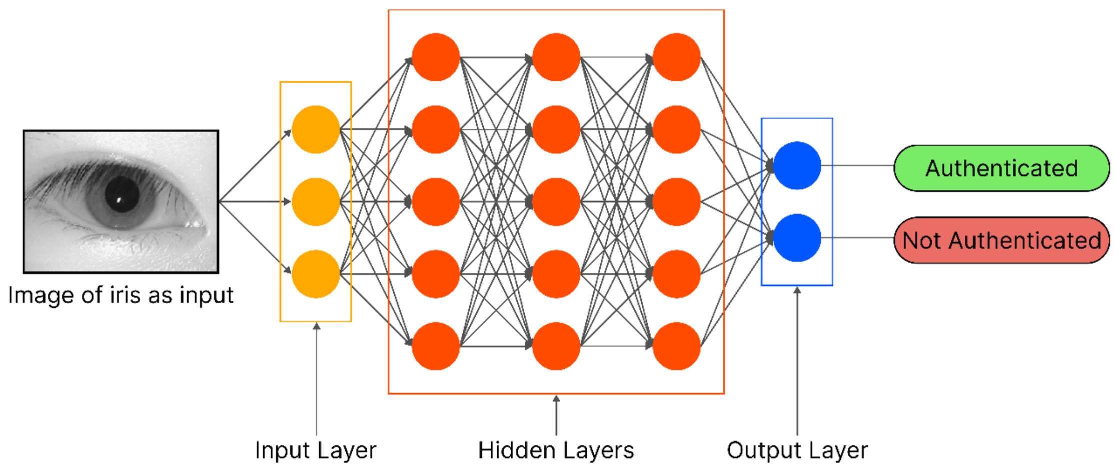

Figure 20. Architecture of Convolutional Neural Network

Figure 20 shows the CNN model starts by inputting the preprocessed image of the iris. The Convolution layer's goal is to reduce the size of the image with the use of filters. Hidden Layers will be useful for extracting rotational and positional invariant dominant features, which helps to keep the model training process running smoothly. Then the model will determine if the processed iris image is an authenticated or not authenticated patient.

3.3. Design Constraints

This section will discuss the different constraints that can be faced by the researchers in designing and conducting the study. It is important to be transparent about these constraints, as they may have influenced the results of the study.

3.3.1. Costs

Hospitals and medical personnel can benefit from the system to automate the process of patient identification that would lead to reduction in hospital's labor cost. It can greatly improve the efficiency of patient care by reducing the amount of time needed to look for medical records of patients in tons of stocked papers. To maximize the cost, the device should be designed to be durable and low-maintenance in order to reduce the overall maintenance cost. For the cloud database, the cost of storing and processing patient information and data in the cloud should be reasonable to what the researchers needed. And the cloud database platform should guarantee a secure and reliable service.

3.3.2. Health & Safety

The device should be designed to be safe for medical personnel (e.g., admins, doctors, nurses, and medical staff) and patients to use. The iris capturing camera should just emit a low level of radiation, and should be comfortable for users to use. The device should be easy to clean and disinfectant since it will be used inside the hospital. And the system should be accurate and reliable in order to minimize the risk of patient misidentification.

3.3.3. Ethical & Legal

A fundamental issue for the system is the data privacy of the patients since the researchers will use patient's information and medical records. But for this study, the researcher would use patient profiles with fake medical information. The system will comply to Republic Act 10173 - Data Privacy Act of 2012 wherein patient information should be secure and confidential when stored and processed by the system (National Privacy Commission, 2012). It should comply with all applicable data privacy laws and regulations. Once the system will be deployed, patients should be informed on how their data will be used for the system and would have the right to prohibit the use of his/her information. The device should as well be used in a consistent way with medical ethics.

3.3.4. Sustainability

In order to attain sustainability in the study, the proposed device should be designed to be durable and long-lasting using good quality components. The researchers need to choose hardware components that are designed to consume less power. For example, a low-power camera. The device's casing should be made from sustainable materials. And it should be easy to recycle or easy to repair at the end of its life cycle.

3.4. Experimentation Procedures

3.4.1. Component Testing

Table 3. Camera Capturing Distance

Trial	Distance of camera from the eye			
	Closed Gap (0 cm)	1 cm	3 cm	5 cm
1				
2				
3				
4				
5				

LEGEND: ✓ = Capture Successful **X =** Capture Unsuccessful

In this table the researchers will test the image capturing success rate of the camera within different distances. The '**✓**' symbol represents that the image capturing was successful, while the '**X**' symbol represents that the image capturing was unsuccessful. The researchers will count the number of successful image captures for every distance of each trial. The formula to get the success detection rate is shown in Equation (3):

$$Success\ Capture\ Rate = \frac{Number\ of\ Success\ Capture}{Total\ \#\ of\ Trials} \quad (3)$$

Table 4. Usability of Iris Image on CNN Model

Number of Patients = 5		**Iris Template** (Tn = Template Number)									
		Left Iris					**Right Iris**				
		T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**T5**
Inputted Patient Iris Image (U1-U5)	**U1**										
	U2										
	U3										
	U4										
	U5										

LEGEND: ✓ = Used by Model **X =** Not Used by Model

In this table the researchers will test the image capturing success rate of the camera within different distances. The '✓' symbol represents that the image capturing was successful, while the '**X**' symbol represents that the image capturing was unsuccessful. The researchers will count the number of successful image captures for every distance of each trial. The formula to get the success detection rate is shown in Equation (4):

$$Iris\ Usability\ Rate = \frac{Number\ of\ Used\ Iris}{Total\ \#\ of\ Trials} \qquad (4)$$

Table 5. Web Application Response Time and Success Transmission Rate

Image	Response Time	Transmission Successful
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Average Response Time		

LEGEND: ✓ = Transmission Successful **X =** Transmission Unsuccessful

In this table the researchers will be testing the Web Application's Response Time and Success Transmission Rate. For the Response time, the researchers will test how long does it take for the web application to respond to the captured image sent by the Raspberry Pi. The formula for the Average Response Time is shown in Equation (5).

$$Average\ Response\ Time = \frac{Response\ Time\ of\ Trial\ 1 + Trial\ 2 + Trial\ n}{Total\ \#\ of\ Trials} \qquad (5)$$

In this data table the researchers will also test the success transmission rate of the mobile application. The '✓' symbol represents that the transmission was successful, while the '**X**' symbol represents that the transmission was unsuccessful. Equation (6) presents the calculation of success transmission rate.

$$Success\ Transmission\ Rate = \frac{Number\ of\ Successful\ Transmission}{Total\ \#\ of\ Trials} \qquad (6)$$

3.4.2. Functional Testing

Table 6. Patient Trial Attempts

Number of Patient = 2	**Trial Attempts** (Tn = Trial number)									
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**
Authenticated Patient in Dataset										
Unauthenticated Patient in Dataset										

LEGEND: TP = True Positive **TN =** True Negative

FP = False Positive **FN =** False Negative

Table 6 shows the number of trials for the authenticated patient in the dataset and an unauthenticated patient in the dataset if it will be authenticated or not. The legend used is similar to the metrics of confusion matrix.

True Positive (TP) is an outcome where the system correctly matches the input image from an existing authenticated patient.

True Negative (TN) is an outcome where the system correctly classified the input image to a non- existing patient.

False Positive (FP) is an outcome where the system misclassified the unauthenticated input image to an existing authenticated patient.

False Negative (FN) is an outcome where the system failed to authenticate the unauthenticated patient.

Table 7. Patient Trial Attempts - Confusion Matrix

<table>
<tr><th colspan="2" rowspan="2">Total Trials on Table 5 = 20</th><th colspan="2">Predicted</th></tr>
<tr><th>Authenticated Patient</th><th>Unauthenticated Patient</th></tr>
<tr><td rowspan="2">Actual</td><td>Authenticated Patient</td><td></td><td></td></tr>
<tr><td>Unauthenticated Patient</td><td></td><td></td></tr>
</table>

This table is the confusion matrix for table 6. From 10 trials each for an authenticated patient and an unauthenticated patient. The researchers will count how many were authenticated as the patient themselves and how many are those who have not been authenticated. As for the user that is unauthenticated on the dataset with 10 trial attempts. The researchers will as well count how many have been predicted as not authenticated and how many have been authenticated to someone from the dataset.

3.4.3. Integration Testing

Table 8. Testing Table for Iris Authentication

Number of Patients = 10		**Iris Template** (Tn = Template Number)									
		T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**
Inputted Patient Iris Image (U1-U10)	**U1**										
	U2										
	U3										
	U4										
	U5										
	U6										
	U7										
	U8										
	U9										
	U10										

LEGEND: ✓ = User Authenticated matches X = Mismatched / No Result

Table 8 will depict the authentication results that will be generated on the alpha testing of the Palm-Vein Scanning device. 10 registered individuals were involved to test the verification accuracy of the system. The '✓' symbol represents that the system has found existing iris data from the database, thus authenticating the patient's identity. Conversely, the '**X**' symbol represents nonexistent data or an unregistered patient. Equation (7) presents the calculation of success authentication rate.

$$Success\ Authentication\ Rate\ = \frac{Number\ of\ Successful\ Authentication}{Total\ \#\ of\ Trials} \tag{7}$$

Table 9. CNN Model Testing Table

Trial	Number of Epochs	Learning Rate	Train-test split	Activation Function	K-Fold Validation	Accuracy (%)	Precision	Recall	F1 Score
1									
2									
3									
4									
5									
6									

Table 9 will show the set of testing tables for hyper parameters. It includes the learning rate, batch size, train-test split, activation function, epoch, fully connected layer, accuracy, and loss. The learning rate determines how much the model changes in response to the estimated mistake, as well as the rate at which the model learns. The data that will be utilized to train the model is known as training data. The validation data is a different collection of information from the training data. During the creation of the model, the training and validation data will be separated when the model is being trained. The Activation function is the next parameter, which determines the output of the neural network given a set of inputs. The accuracy of the model is determined by comparing the predicted data to the actual data. The trial will use the same hyper parameters starting from a batch size of 30, the activation function of softmax, and the learning rate of 0.00005. On the trial 1-3 using 5 epochs, the researchers will run the same CNN model architecture but different training and testing sizes.

To compute the accuracy, precision, recall, and F1 score of the model loaded into the system, the following equations will be used:

$$Accuracy = \left(\frac{TP+TN}{TP+TN+FP+FN}\right)100 \tag{8}$$

Eq. 8 is used to calculate the ratio of the correct predictions made by the model to the total number of the testing data.

$$Precision = \frac{TP}{TP+FP} \tag{9}$$

Eq. 9 is used to calculate Precision. In this research, a false positive means that a user that is non-authenticated (actual negative) has been identified as authenticated (predicted).

$$Recall = \frac{TP}{TP+FN} \tag{10}$$

Eq. 10 refers to how many of the system's true values were predicted correctly. This can be also useful if the false negatives are higher than the false positives.

$$F1\ Score = 2 * \frac{Precision*Recall}{Precision+Recall} \tag{11}$$

Eq. 11 is used for an unequal class distribution. The F1 Score is employed to find a balance between Precision and Recall.

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