WE-VR: INTERACTIVE VIRTUAL REALITY DEVICE FOR CHILDHOOD LEUKOCORIA AND PEDIATRIC CATARACT DETECTION SYSTEM

A Project Study Presented to the Faculty of

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In Partial Fulfillment of the Course Requirements for the Degree of

Bachelor of Science in Electronics Engineering

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APPROVAL SHEET

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ABSTRACT

The Philippines is globally recognized for having one of the highest rates of cataracts, which are responsible for approximately 51% of cases of blindness and affect approximately 2.5 million Filipinos. The early detection, diagnosis, and treatment of pediatric cataracts and cataract-induced childhood leukocoria are essential in ensuring favorable outcomes for affected individuals. This is attributed not solely to the decrease in the likelihood of loss of visual acuity, but also to the subsequent improvement in the patient's quality of life after receiving treatment. To aid with diagnostic gaps, where patients go undiagnosed due to a lack of access to diagnostic tools and healthcare services, a detection device is developed. The device consists of three eye tests: visual acuity test, which uses Virtual Reality (VR) technology of an eye chart to test how well a patient can see from a specific distance; slit-lamp capture test (SLCT), which captures a dilated pupil by burst and macro photography without the use of dilating eye drops; and the red-reflex test (RRT), using flash photography to induce a red-orange (normal) or white reflex (abnormal) observed in the reflection of the retina. The captured images from the SLCT and RRT underwent classification using a Convolutional Neural Network (CNN) model to determine the presence of cataract and leukocoria, respectively. The models used achieved an overall accuracy of 85% in detecting leukocoria and cataracts. WE-VR is readily available and showcases an innovation that simplifies the process in early detection and addressing visual impairment treatment.

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CHAPTER 1

THE PROBLEM AND ITS BACKGROUND

This chapter mainly discusses the study's problem and its background, as well as the introduction, background of the problem, research gap, general and specific objectives, significance, scope and limitations, as well as the definition of terms.

1.1 Introduction

A cataract is a cloudiness of the lens of the eye, which is typically clear. They are the most common cause of blindness [1]. Cloudy patches in the lens can get larger and more frequently, leading the child's vision to deteriorate over time. Cataracts can induce "wobbling eyes" and a squint, in which the eyes point in various directions, in addition to reduced vision. Cataracts in children are usually minor and have little or no impact on their eyesight. However, if the child's vision is affected by cataracts, their normal vision growth may be slower or stopped. Surgical removal of the damaged lens is usually indicated as soon as possible in these circumstances [2].

Advancements in technology have increased in efficiency, making our tasks easier and accomplished better. Technology has a significant role in accomplishing tasks. Before, tasks were done manually, and they consumed a lot of human labor, resources, and time. Now that technology continues to advance, tasks are carried out faster and with less time consumed.

To name one of these technological developments, Virtual Reality is a simulation of an environment, providing the feeling of being totally immersed in the surroundings through realistic images and objects. It provides an immersive entertainment and makes the user experience a digitally-drawn world [3].

Virtual reality combines three-dimensional simulation with wearable goggles. This combination provides an appearance that users can interact with as if the images presented were true. Integrating cataract detection through a life-like world is better than traditional diagnostic examinations. Not only does this let children enjoy a simulated world but also lets them be entertained, causing them to do the tests at their will.

1.2 Background of the Study

Pediatric cataract, as the name suggests, is an eye condition which is an opacification or clouding of the crystalline lens in children [4]. It is an avoidable and treatable leading cause of vision impairments. Untreated cataracts in children under the age of 8 may result in permanent complications such as amblyopia (lazy eyes) and legal blindness due to failure of vision development because deprivation of vision causes significant changes to the structure of the brain [5]. Despite having a successful surgery to remove the cataract — the child's vision may not recover at all or the amblyopia might be irreversible [6]. Although the condition is rare due to cataracts being primarily related to aging, it is still one of the major causes of pediatric blindness with prevalence of 75% occurring in developing or low-income countries like the Philippines. In the Philippines, a 2018 study was conducted by the Philippine Eye Research Institute about the Philippine National Survey of Blindness and Eye Disease Study Project which was led by Dr. Leo Cubillan. The results showed that 18% or 1224 respondents were of ages 0-9 years old and the prevalence of visual impairment among them is at 0.01 or 68 out of the total respondents for the age group. While cataract remains the main cause of visual impairment in the Philippines, no specific number accounting for pediatric cataract was mentioned [7].

For the reason that late realization of pediatric cataract puts the child at risk of developing permanent vision impairments—early detection and management of the condition is crucial in saving the child a great amount of blind-years (time where a person is blind) [8]. Cataracts are primarily diagnosed by an eye care professional who examines for anatomical abnormalities in the lens using a slit-lamp [9]. However, among the noise introduced by eyelashes, white lights, and different amplification factors of the optical device—the non-cooperation of the patient is one of the challenges of using a slit-lamp in capturing images of the anterior (front) segment of the eye [10]. In a study conducted in 2017, pupil dilation and slit-lamp adapted photography were used for the feasibility study of monitoring and morphological classification of pediatric cataract. The study included both cooperative and uncooperative children in which the latter had to be sedated first then, based on the child's age or weight, will be put under either their three (3) assistance techniques and equipment: flying-baby posture, strap technique, and transformable bed which are mostly measures that restrict movements [11].

Studies show that in clinical or hospital settings, children may feel anxious, frightened, and upset especially before and during the medical tests and procedures. These emotions that the children may be experiencing can cause them distress that they become resistant and uncooperative [12]. Since children are impressionable, another alternative approach that is non-pharmaceutical can be guiding the children towards make-believe scenarios which immerse children in a different experience. Giving children choices and options about what will happen rather than making direct predictions about the future will help to maintain trust and foster cooperation [13]. Multiple research studies have reached the consensus that employing VR technology proves advantageous as a means of distraction intervention for children undergoing different medical procedures [14]. Use of interactive VR device in healthcare shows potential, two studies namely VR-Based Visual Acuity Tests with Refractive Error Detection using Wavefront Sensor for Early Detection of Amblyopia and iVRead: Interactive Virtual Reality for Early Detection of Amblyopia for Kindergarten Pupils which utilized VR technology for vision screenings are the inspirations of this study.

1.3 Research Gap

Slit-lamp screening and identification approach for pediatric cataracts were the focus of the recent research studies. It is difficult and clinically demanding to check slit-lamp images and do visual acuity assessments on children. In addition, studies show that the use of Virtual Reality technology helps as a distraction technique for pediatric patients. However, none of these studies have emphasized on developing a child-friendly technology that employs a visual acuity test, slit lamp capture test and red reflex capture test which can be utilized for the detection of pediatric cataracts and leukocoria.

1.4 Research Objectives

This section focuses on the general objectives, as well as the specific objectives needed in this study.

1.4.1 General Objective:

The overall objective of the study was to develop a compact, child-friendly, and cost-effective device for the early detection of pediatric cataracts and cataract-induced childhood leukocoria, addressing diagnostic gaps caused by limited access to healthcare services and diagnostic tools in underserved areas of the country.

1.4.2 Specific Objectives:

The specific objectives of this study are:

1. To construct an adjustable and interactive virtual reality device which employs red reflex capture test, visual acuity test and slit lamp capture test.
2. To develop a machine learning model for the captured image from the red reflex capture test and slit lamp capture test using CNN.
3. To create a 3D app simulation of visual acuity test for the mobile VR, an application for the control panel of the system, and a website to present the results of the mentioned eye tests.
4. To test and evaluate the device's operability and accuracy in accordance with the ISO/IEC 25010 standards.

1.5 Significance of the Study

A number of examinations can be done to detect cataract and leukocoria, but the manner of execution to those may not seem interesting to children . This could make it difficult to detect or diagnose the disease earlier. That said, the proponents introduced a study that benefited the society by assisting doctors in performing tests on their patients.

The earlier the cataract is detected and treated, the lesser there would be a risk for blindness [15].

Virtual Reality provides the user the impression that they are completely immersed in their surroundings through realistic-looking images [16]. In this study, an interactive program was developed to detect the early signs of cataract. Rather than the tests being done in a traditional manner, it was in the form of interactive virtual simulation.

This research covers the Section II of the Harmonized National RD Agenda, which focuses on Health. This area focuses on the design and development of inexpensive, secure, and dependable hospital equipment and biomedical technologies linked to eye health. Moreover, the Sustainable Development Goals addressed in this research include goals which focus on health and well-being, and on industry, innovation, and infrastructure.

This study can be helpful for future researchers who will explore cataract, its detection in children, and may serve as a tool to develop better diagnostic procedures in identifying the disease.

1.6 Scope and Limitations

This study aims to develop a system capable of detecting cataracts and leukocoria in children. It places a primary emphasis on incorporating detection tests into the newly developed interactive environment, such as the ETDRS eye chart. Only children (between the ages of four to ten) were included in the data gathering process.

This study only detects childhood leukocoria and pediatric cataracts, which are types of eye problems that are particularly common among children; however, it did not cover the diagnosis of other types of cataracts and leukocoria. In addition, it only captured the anterior area of the eye; any additional images, such as those of the fundus images, were not included in this research. The treatment of cataracts and leukocoria were not addressed in this research since doing so would go beyond the parameters of the study. This study is not intended to take the place of the professionals in this area; rather, it provided support to those professionals in order to make the job that they perform more efficient.

1.7 Definition of Terms

- **Algorithm -** It is a well-defined sequential computing method that accepts a value or set of values as input and generates the output or outputs required to solve a problem.
- **Amblyopia -** a condition in newborns and young children where one or both eyes do not grow normally during childhood
- **Cataract -** A cataract is an unclear spot in the eye's lens that causes vision to deteriorate. It is an affliction of the eye that results in lens clouding. If a vision condition progresses gradually and is not corrected, vision loss may eventually occur.
- **Early Treatment Diabetic Retinopathy Study (ETDRS) Chart -** is one of the primary tools used to determine a patient's visual acuity (VA). ETDRS charts display a sequence of five letters of similar difficulty on each row, with uniform space between the letters and rows.

- **Lens -** It is a transparent, biconvex layer of the eye that primarily consists of proteins. It enables the eye to focus on various distant things. It is located in front of the vitreous body and behind the iris.
- **Leukocoria -** An abnormally bright white reflection from the retina of the eye is referred to as leukocoria. Several dangerous ophthalmic illnesses frequently present with this symptom first.
- **Ophthalmoscope** - The eye doctor can inspect the interior of the eye using an ophthalmoscope. It features light and numerous tiny lenses the doctor can use to examine.
- **Ophthalmologist** - An expert in eye care is an ophthalmologist. Ophthalmologists are medical doctors (MDs) or osteopathic doctors (DO) who specialize in diagnosing and treating eye and vision disorders.
- **Pediatrics** - is the area of medicine that deals with treating newborns, kids, teenagers, and young adults.
- **logMAR -** also known as the logarithm of the minimum resolution angle. LogMAR 0.00 is comparable to 6/6 (20/20) and LogMAR 1.00 is equivalent to 6/60 (20/200) when describing the letter size in a logMAR chart. From one row to the next, the letter size fluctuates by 0.1 LogMAR. LogMAR charts adhere to the Bailey-love format, which mandates: 2. There should be a logarithmic progression of letter size so that the scaling factor remains constant throughout the chart and does not change when nonstandard viewing distances are used.
- **Red Reflex Test -** detect issues in the cornea, lens, vitreous, and retina; it is especially beneficial for small children who may acquire eye illnesses

- **Slit-lamp -** a common procedure where a doctor flashes a light into the eye to search for damage or infections
- **Testability -** in the context of visual acuity, testability refers to a subject's capacity to finish visual acuity testing in both eyes on the very first attempt
- **Visual Acuity -** an eye examination that determines how well a person can see a certain feature of a letter or symbol from a certain distance
- **Virtual Reality** - By using computer modeling and simulation, virtual reality (VR) enables users to engage with a manufactured three-dimensional (3-D) visual or other sensory world.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter covers the fundamental ideas, theoretical frameworks, and relevant research that may be used to the process of conceiving the project. This covers technical phrases from projects that have been created in the past as well as those that are being developed now.

2.1 Pediatric Cataracts in the Philippines

In the Philippines, cataract is still the leading cause of blindness, despite a decline in the population of people with visual impairment over time. According to the results of the first national blindness research, the total incidence of blindness was 1.02 percent in the middle of the 1980s. However, it started declining in the early 2000s (findings from the third national survey on visual impairment). Cataract remains the leading cause of blindness, accounting for 70% of all blind people surveyed [17].

Cataracts are by far the most prevalent reason for childhood blindness. Children with untreated cataracts face a significant social, economic, and emotional cost to the child, family, and society. Pediatric cataract-related blindness can be treated with early detection and adequate management [8].

Pediatricians usually detect them during vision tests or after an eye injury. The therapy for cataracts is determined on their kind, as well as their severity and whether or not they are present in both eyes. In the majority of cases involving children, restoring their eyesight will need more than just undergoing surgery. Treatment must continue to help heal the eye-brain connections. To focus crisp images on the retina, you must have the necessary refractive correction. Children, unlike adults, require specialized surgical devices and techniques. Cataract surgery is generally safe when performed by a skilled surgeon [18].

2.1.1 Types of Pediatric Cataracts Based on the Age of Onset

Cataract development in children can either be congenital or acquired throughout adolescence. [19]. Infantile cataracts form throughout the first year of life, whereas congenital cataracts are lens opacities that appear at birth or soon after. While acquired pediatric cataracts appear during adolescence.

2.2 Childhood Leukocoria

Leukocoria is an irregular or asymmetrical pupillary reflex in which the appearance of a white or yellow-orange reflex in the pupil may indicate common eye disorders [20]. A light beam focused on the eye through the pupil causes the red ocular reflex, which is characterized by a reddish-orange reaction that is typical of the color of the retina and the choroid. The retina partially absorbs and reflects the light through the pupil. The pediatrician detects leukocoria during the screening for red reflex test by directly examining the eye with an ophthalmoscope. It is also noticeable by direct inspection and by shining a light into the pupil of the affected eye [21].

2.3 Diagnosis

This section will discuss the diagnoses required in order to detect whether a child has a cataract and/or leukocoria. This section includes necessary tests to determine the presence of the eye diseases mentioned, namely red reflex test, visual acuity test, and slit-lamp examination.

2.3.1 Red Reflex Test

Red reflex is caused by the light from an ophthalmoscope that passes through all the normally uncomplicated regions of a person’s eye. Anything that hinders the optical pathway will result in deviation from the red reflex’ normal pattern [22].

The red reflex test is capable of detecting issues related to the anterior portion of the eye. The test is particularly useful in children who might develop eye diseases who are too young to speak and complain about vision concerns. Red reflex detection is more successful in a dark environment. The ophthalmoscope will be positioned close to the doctor's eyes, roughly 50 centimeters from the patient [23].

2.3.2 Visual Acuity Test

An important aspect in screening and examining the eye is an eye chart. The measurement of visual acuity is vital to every ophthalmological examination, that is, done by letter recognition.

Visual acuity refers to the ability of the eyes to perceive and identify objects, shapes, and forms. This capacity is examined through eye charts which an individual is required to read, from the largest to the smallest text, in order to determine the acuity score [24].

2.3.2.1 Early Treatment Diabetic Retinopathy Study Chart

The ETDRS chart is based on letters balanced according to the reading difficulty. An equal number of letters and spacing in rows and in letters are present in the ETDRS chart, expressed in logarithmic values. The letters on the chart are assigned a value of 0.02 Logarithm of the Minimum Angle Resolution (LogMAR), being the number of read letters as the basis and not rows [25].

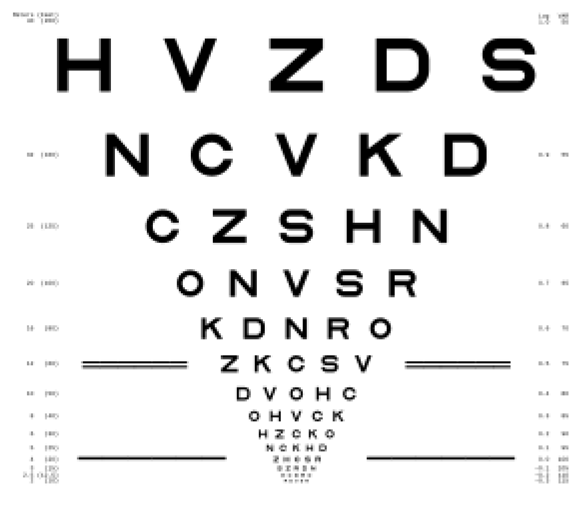


Figure 1 Early Treatment Diabetic Retinopathy Study Chart

2.3.3 Slit-lamp Examination

One method of identifying cataracts is through the use of a Slit-lamp examination, which assesses the condition of the pupils in the eye. The Slit-lamp is a medical device equipped with specialized lighting lamps that allow for visualizing the eye's state. By illuminating the anterior segment (frontal structures) and posterior segments of the eye, including the eyelids, sclera, conjunctiva, iris, lens, and cornea, the Slit-lamp enables thorough examination. Typically, cataract assessment involves initial After conducting a slit-lamp examination, the obtained images are analyzed by the physician. Additionally, the doctor's inspection of the cloudy area within the pupil determines the type of cataracts. [26].

Table 1 Synthesis of the Diagnosis for Leukocoria and Cataract

	[23]	[27]	[26]
Author(s)	Richard Bowman, Foster et al.	Tao Wang et al.	Riyanto Sigit, Kom et al.
Year	2018	2020	2018
Title	Testing the red reflex	A comparison of visual acuity measured by ETDRS chart and Standard Logarithmic Visual Acuity chart among outpatients	Classification of Cataract Slit-Lamp Image Based on Machine Learning
Diagnosis	Red reflex test	ETDRS chart and Standard Logarithmic Visual Acuity Chart	Slit-lamp examination
Relevant Findings and Relationship	Red Reflex Test	Visual Acuity Test	Slit Lamp

2.4 Slit Lamp Imaging using Mobile Phone

Cataract identification based on image processing has been created that can conduct early detection of cataracts in a timely and efficient manner. Several cataract detection studies based on fundus image processing have been developed and established [28].

Smartphones can serve as a portable device which can be used to identify cataracts in patients. There are studies that use a fundus camera that can be attached to a mobile phone. This enables the rear camera of the smartphone to view the retina and capture digital still photographs or clips throughout the test [29]. This involves an external light source to generate a strong slit of light that is projected onto the anterior chamber of the patient's eye in order to examine the anterior segment of the eyes. Patients or doctors with remote access can independently conduct tests utilizing a smartphone slit lamp [30].

2.5 Virtual Reality

The goal of a virtual reality is to display on each eye a different picture at the same time period. This makes it possible for a new type of technology to help people who are visually impaired by sending information to only the parts of the retina that are healthy or less damaged. To make a decent test environment for developing and testing reliable

Table 2 Synthesis for Slit lamp Imaging using Mobile Phone

	[28]	**[29]**	**[30]**
Author(s)	Richard Bina Jadi Simanjuntak et al.	Amy Ruomei Wu et al.	Phuong Truong et al.
Year	2022	2018	2020
Title	Cataract Classification based on Fundus Images using Convolutional Neural Network	Comparison Study of Funduscopic Examination Using a Smartphone-Based Digital Ophthalmoscope and the Direct Ophthalmoscope	A smartphone attachment for remote ophthalmic slit lamp examinations
Classified Disease	Cataract	Cataract	Cataract
Algorithm	Convolutional Neural Network(CNN)		
Relevant Findings and Relationship	Classification of cataracts into four classes: Normal, Immature, Mature and Hypermature	Demonstrating Smart-based Digital Ophthalmoscope effectiveness in funduscopic examination compared to direct ophthalmoscope	Smartphone-based Ophthalmoscope detecting the presence of cataract in the anterior part of the eye.

assistive technology, it is important to know how visual impairments, especially cataracts, affect people. It is also important to compare the benefits of existing treatments to the use of assistive technology and to figure out if VR-based assistive technology would be a good choice [31]. Numerous studies have found that using VR technology as distraction intervention for young patients through a range of medical procedures is an effective strategy [32].

Table 3 Synthesis of Virtual Reality

	[31]	[32]
Author(s)	Besic et al.	Eijlers et al.
Year	2019	2019
Title	Virtual Reality Test setup for Visual Impairment Studies	Systematic Review and Meta-analysis of Virtual Reality in Pediatrics: Effects on Pain and Anxiety
Relevant Findings and Relationship	VR for visually impaired	VR in pain and anxiety

2.6 Machine Learning Models and Algorithms

This section describes the machine learning models and algorithms related to this study. This covers the algorithms such as Circular Hough Transform, the Fuzzy Edge Estimation, and the Convolutional Neural Network.

2.6.1 Circular Hough Transform

Hough Transform is a transformation technique of an image that can be used to select out or acquire certain parts of an image. Since the point of a transformation is to get a more specific feature, the most common way to find curved shapes like lines, circles, ellipses, and parabolas is the Circular Hough Transform (CHT) [26].

CHT returns the coordinates for the center detected, as well as its radius. This algorithm can be used in the detection and elimination of the iris since the pupil is circular in shape [33].

2.6.2 Fuzzy Edge Estimation

In fields such as model recognition and biomedical imaging, edge estimation is utilized as a technique. Edge estimation identifies the image's high-frequency parts. Edge estimation using fuzzy membership function is a nonlinear kind of picture enhancement. To extract accurate edge information, it is essential to establish fuzzy rules effectively. In order to express fuzzy rules, fuzzy membership functions have a vital significance in a fuzzy inference system. Fundamental components of a fuzzy system, specifically membership functions, are employed to define the fuzzy structure of the system [34].

2.6.3 Convolutional Neural Network

Convolutional Neural Networks are typically employed for the recognition of image-based patterns that aid in automatic image categorization. Typically, it consists of layers, including the input layer, output layer, and hidden layers. Typically, a hidden layer in a CNN algorithm comprises convolutional layers, an activation function, pooling layers, fully connected layers, and normalization layers [35].

Table 4 Synthesis of Machine Learning Models and Algorithms

	[33,26]	[34]	[35]
Author(s)	A.B. Jagadale and D.V Jadhav, Sigit et al.	Dixit et al.	Weni et al.
Year	2016, 2018	2018	2021
Title	Early Detection and Categorization of Cataract using Slit-Lamp Images by Hough Circular Transform, Classification of Cataract Slit-lamp Image Based on Machine Learning	An Efficient Fuzzy Based Edge Estimation for Iris Localization and Pupil Detection in Human Eye for Automated Cataract Detection System	Detection of Cataract Based on Image Features Using Convolutional Neural Networks
Classified Disease	Cataract	Cataract	Cataract
Algorithm	Circular Hough Transform (CHT)	Fuzzy Edge Estimation	Convolutional Neural Network (CNN)
Relevant Findings and Relationship	Detection, Classification	Detection	Detection

The overview of the different related literature connected to machine learning models and algorithms is shown in Table 1. It shows the condition or disease that was categorized, the algorithm that was used, as well as the relevant findings that are associated with this study.

CHAPTER 3

METHODOLOGY

This chapter discusses the approaches and processes that were used throughout the planning and execution of the project. Additionally, the algorithmic structure of the programs and the design flow method were included.

3.1 Research Design

Developmental research design was used in the study as it aims to develop and innovate processes, technology that must meet the criteria in detecting the presence of leukocoria or cataract, hence making it more efficient and convenient. The study utilizes developmental research design as the purpose is to develop a device which comprises tests in detecting leukocoria and cataract in children's eyes.

3.1.1 Theoretical Framework

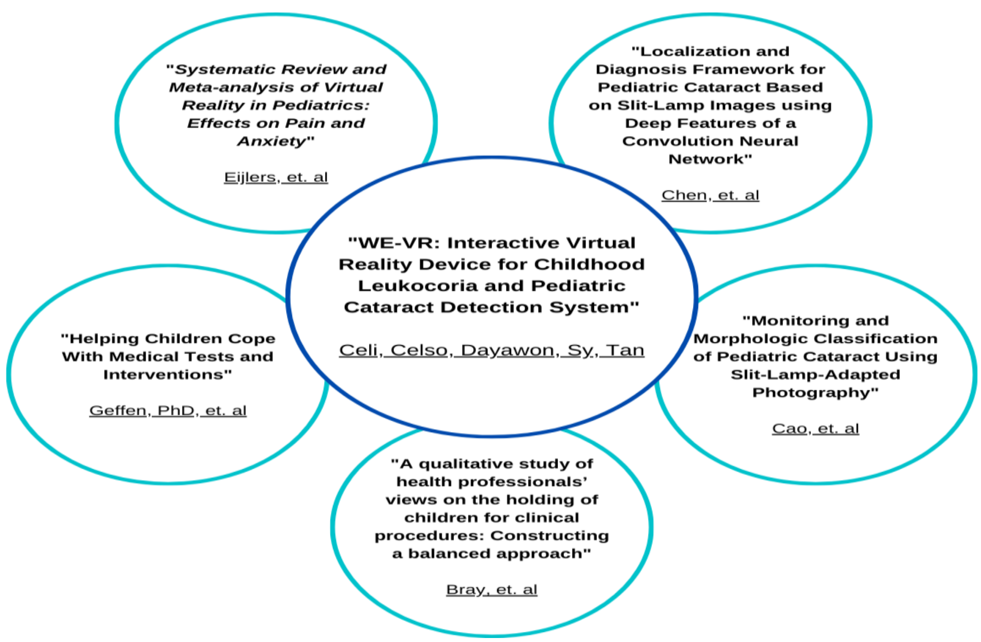


Figure 2 Theoretical Framework of the Study

The figure shown above is the Theoretical Framework of the Research which largely supports the project study. In the Philippines, a 2018 study was conducted by the Philippine Eye Research Institute about the Philippine National Survey of Blindness and Eye Disease Study Project which was led by Dr. Leo Cubillan. The results showed that 18% or 1224 respondents were of ages 0-9 years old and they comprise 68 out of the total responses for the age group, or 0.01 percent, of those with visual impairment. The children's refusal to cooperate makes it challenging to use a slit light to take photographs of the anterior (front) region of the eye., in addition to the noise introduced by eyelashes, white lights, and other amplification factors of the optical instrument [10]. Children who were not cooperative had to be drugged before being placed under one of the three (3) assistance techniques and equipment, which are —the flying-baby posture, the strap technique, or the transformable bed—which are mostly measures that restrict movement [11]. Kids can experience anxiety, fear, and distress in clinical or hospital environments, particularly before and during medical examinations and procedures. The children may become so distressed by these feelings that they become uncooperative and resistant [12]. Leading the kids toward make-believe scenarios that immerse them in varied experiences is another non-pharmaceutical alternative strategy. Instead of providing straight forecasts about the future, giving children options and choices about what will happen will help them to retain trust and promote collaboration [13]. Numerous studies have found that using VR technology as a distraction strategy for young patients undergoing various medical procedures is a useful tool [14].

3.1.2 IPO diagram

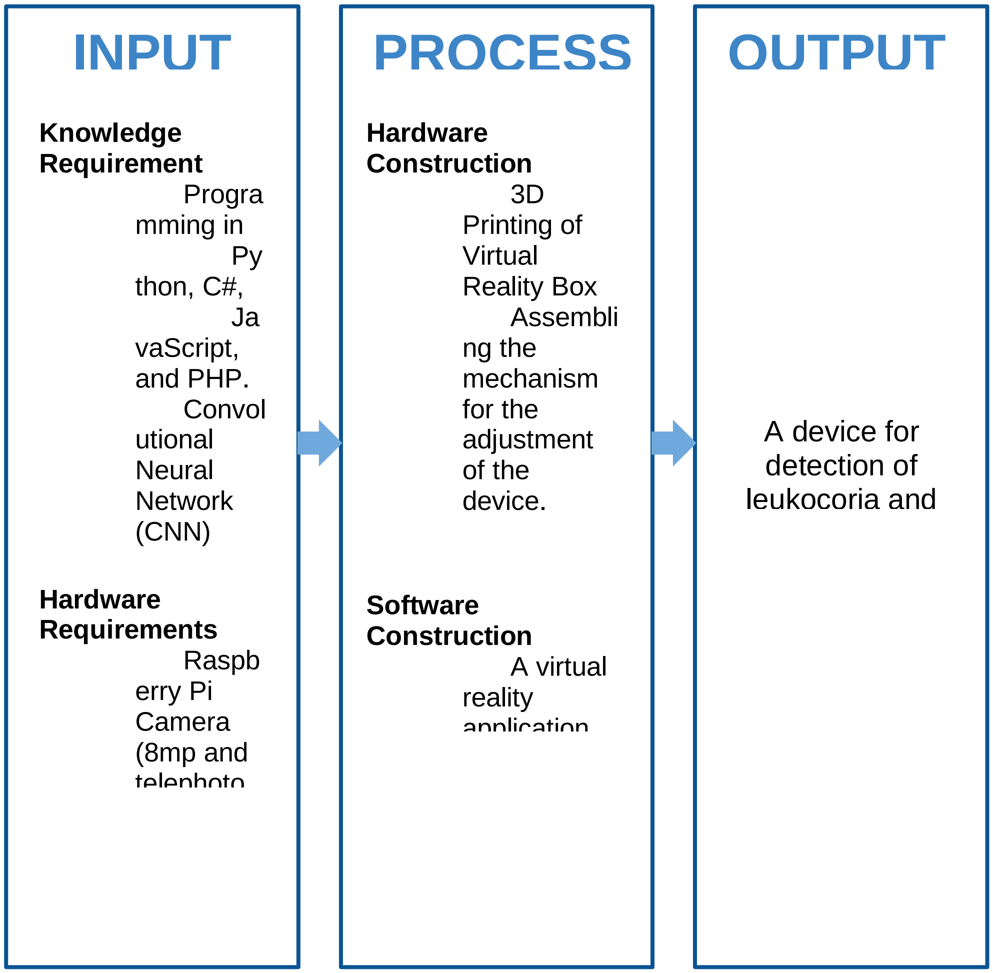


Figure 3 Input-Process-Output Diagram

The designing of this study required several input requirements in the aspects of knowledge, hardware, and software. Android Studio, Google Collab, HTML, CSS, PHP, and Unity 3D were utilized for the development of the mobile application, web application, and the creation of the application which is used for the testing of visual acuity. After the construction of the device's form, a mobile device will serve as the screen for projecting the test, and the two Raspberry Pi cameras to capture the eyes. Furthermore, Raspberry Pi board will be placed inside the modified VR Device.

For software development, a virtual reality application is developed to conduct the visual acuity test. In addition, a web application was created to display the patient's information, including the captured image of the patient's eye and the initial results from the device.

For the interpretation of data, the machine-learning algorithm Convolutional Neural Network was used to determine the presence of leukocoria and/or cataract in the eyes.

Upon the completion of the necessary inputs and processes, a device that detects the presence of cataract and/or leukocoria in the children’s eyes was developed.

3.1.3 System Architecture

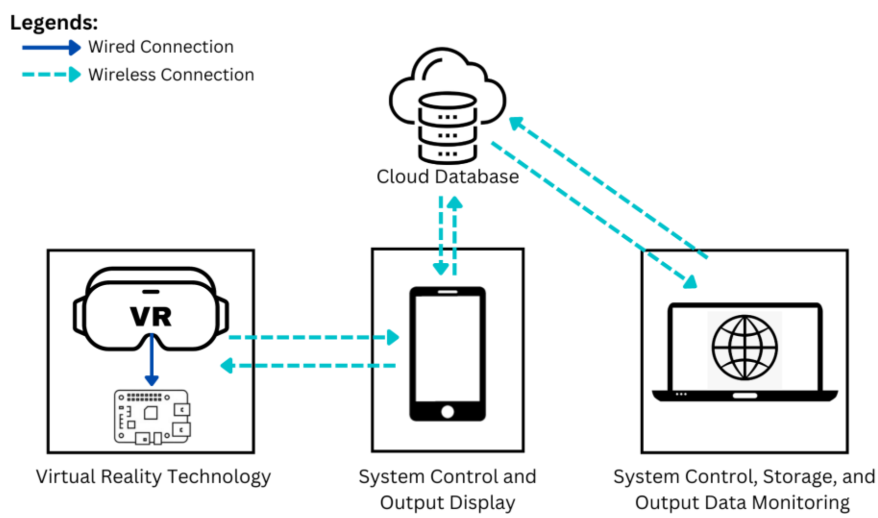


Figure 4 System Architecture

The figure displayed above is the system architecture of the project study. The visual screening tests are combined in a virtual reality environment, which is handled by two Raspberry Pi (4B and 3B) computers and has a display for mobile applications. The mobile application acts as both monitoring and control for the system, allowing it to automatically display data and send it to the database. The Wi-Fi that is already included into the Raspberry Pi enables wireless communication between VR and mobile controllers. When connected to the internet, the mobile application will send the data to a storage facility in the cloud. On a website, authorized employees may see the findings of data analysis. In addition to that, it was constructed so that the physician may provide comments depending on the outcomes of the patients' tests.

3.2 Research Process Flow

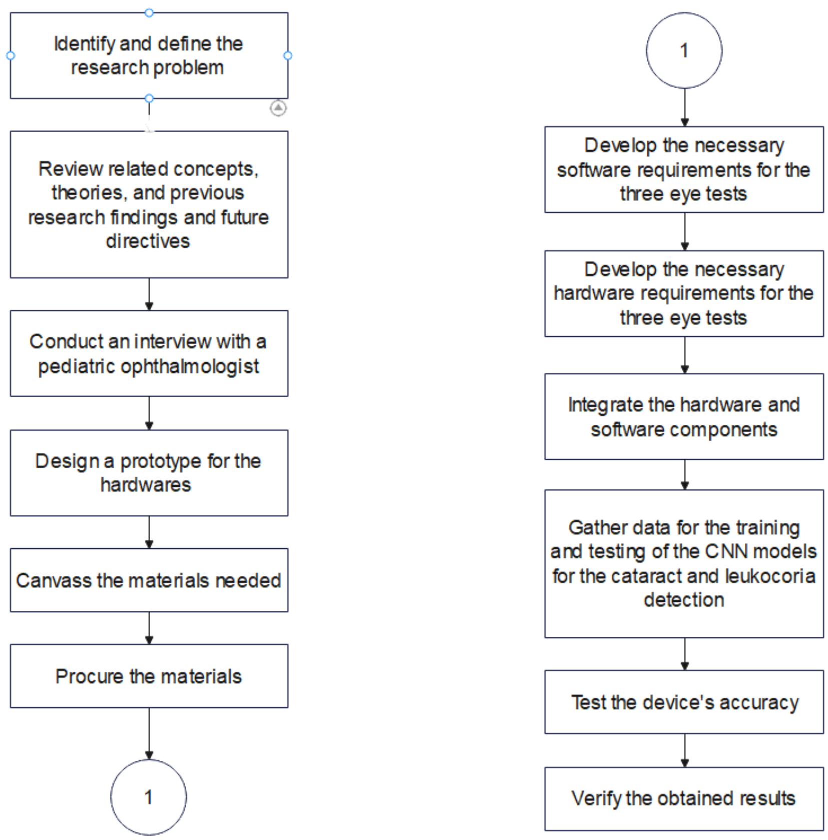


Figure 5 Research Process Flow

The figure above shows the necessary sequential steps in order to accomplish the study. The process has five parts- conceptualization, designing, developmentation, integration, and testing. For the first part the proponents need to identify the research problem, review related literature, and consult with an eye care professional. Then, from the result of the first part, the proponents need to create a design for the prototype which also includes canvassing and purchasing of the materials needed. After this, the proponents need to develop the software and hardware requirements of the system. Then proponents need to integrate the hardware and software components. Then after the prototype is completed, the proponents need to gather data using the device developed for the training and testing of the CNN models for the cataract and leukocoria detection. Then for the final part, the proponents need to test the device's operability and verify the obtained results for its accuracy.

3.3 Development of the Prototype

This section will discuss the necessary steps that must be followed in order to create the hardware device for the study.

3.3.1 Materials and Equipment

Camera Modules - This optical device was used to collect images during the slit lamp capture test. 8 megapixel was used in the camera for high resolution and high quality image of the eye. And the 16mm telephoto lens was used for the red reflex test circuit.

Figure 6 Camera Modules

Raspberry Pi - This device connects into a computer monitor and utilizes a regular keyboard and mouse, which allows individuals to explore computers and learn how to write in languages such as Python. This was used in order to connect the device to a computer.

Figure 7 Raspberry Pi

LED - this was utilized inside the device to illuminate the inside of the device in order to capture a clear image.

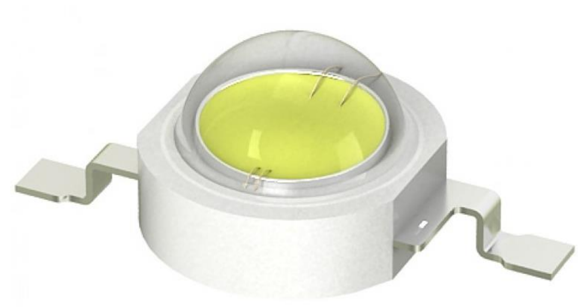


Figure 8 High Power LED

Biconvex Lens -A lens with two surfaces that are bent outward is said to be biconvex. It bends the light entering, bringing the rays together at a focal point on the other side of the lens. It is frequently employed in optical devices and optics to focus light and treat eyesight issues.

Figure 9 Biconvex Lens

3D Filament - a printing filament made up of polymer which melts when heated. This is fed into the 3D printer where it is heated and shaped according to the 3D object file.

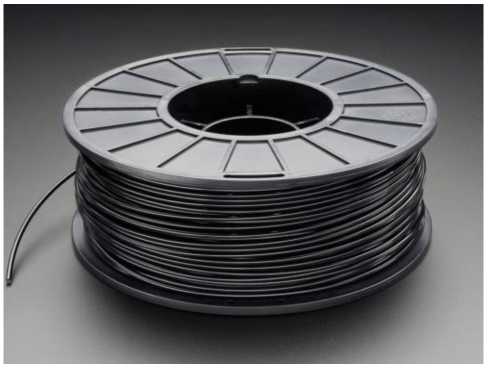


Figure 10 3D Filament

3.3.2 Hardware Construction

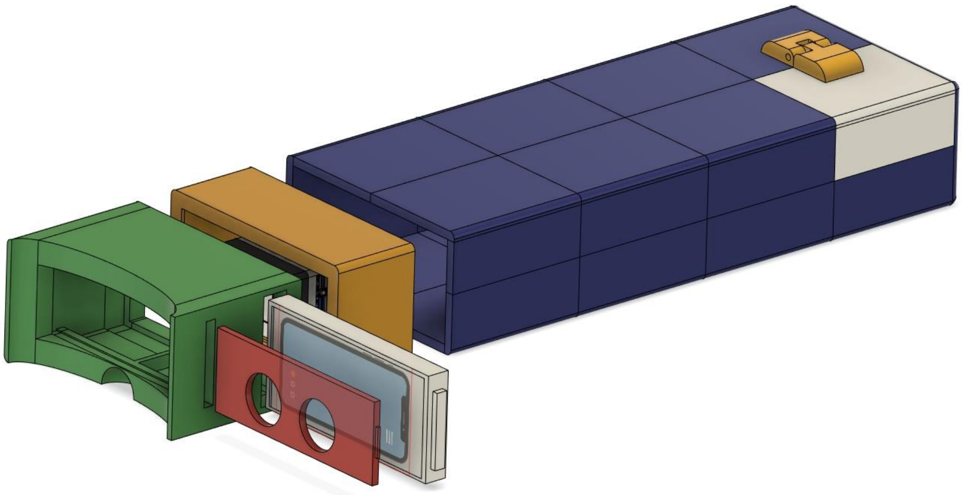


Figure 11 WE-VR Prototype

The device comprises three distinct components: the base, which is located at the front and houses the lens and a smartphone holder; the enclosure for the slit-lamp, and the enclosure for the red-reflex test. The lens holder is equipped with a pair of biconvex lenses, which are utilized during the visual acuity test to create a three-dimensional simulated virtual reality display of the E-ETDRS chart projected from the smartphone. The lens holder is positioned approximately two inches away from the smartphone holder, aligning with the focal length of the lens. To compensate for the device's weight and length, a tripod stand is employed as a support. This stand can be adjusted and retracted to accommodate the patient's sitting position. Underneath the stand, a chin rest is provided to stabilize the patient's head during the testing process.

3.3.2.1 Design of the Device

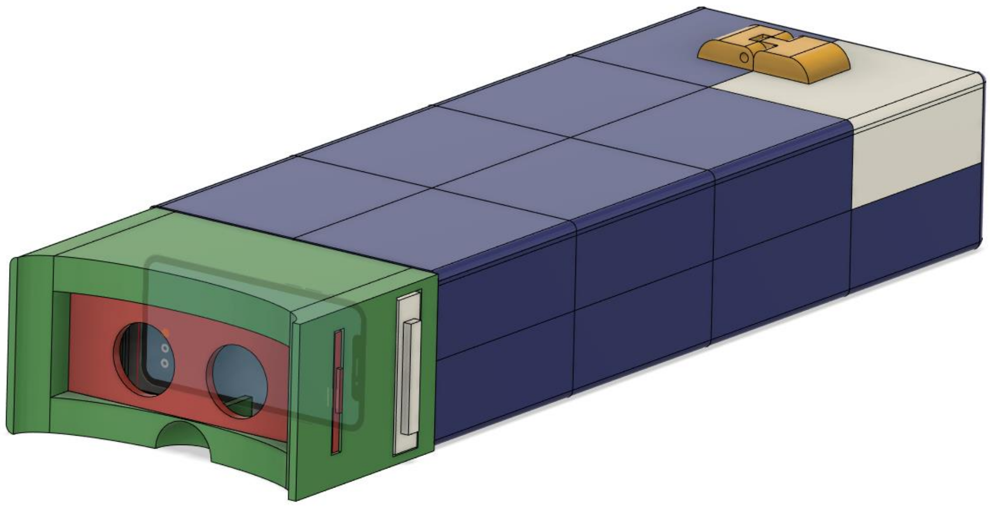


Figure 12 Visual Acuity Test Setup

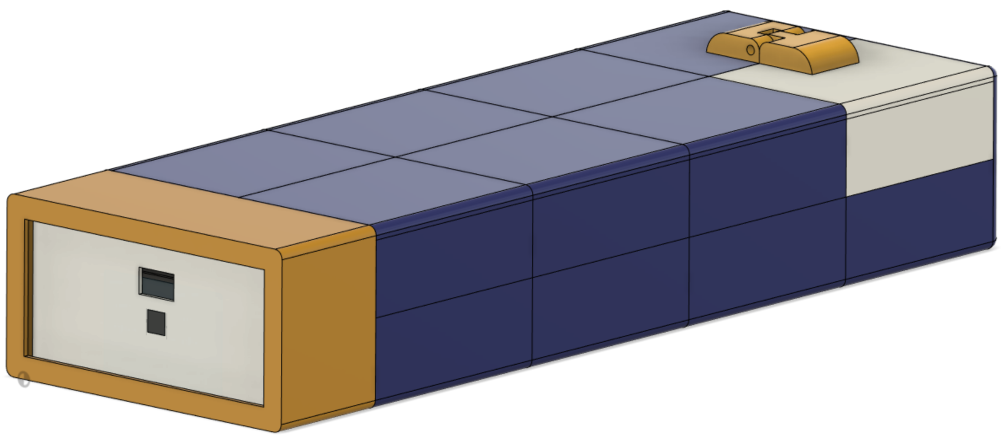


Figure 13 Slit-lamp Capture Test Setup

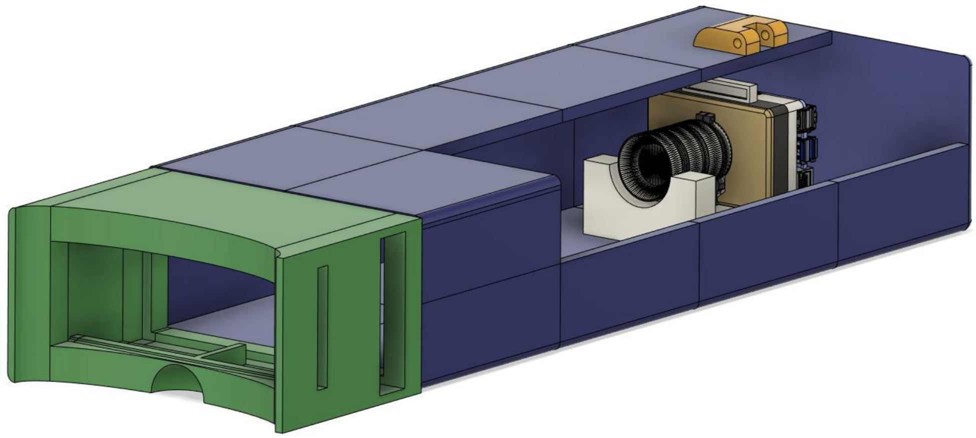


Figure 14 Red Reflex Test Setup

3.3.2.2 Measurement of the Device

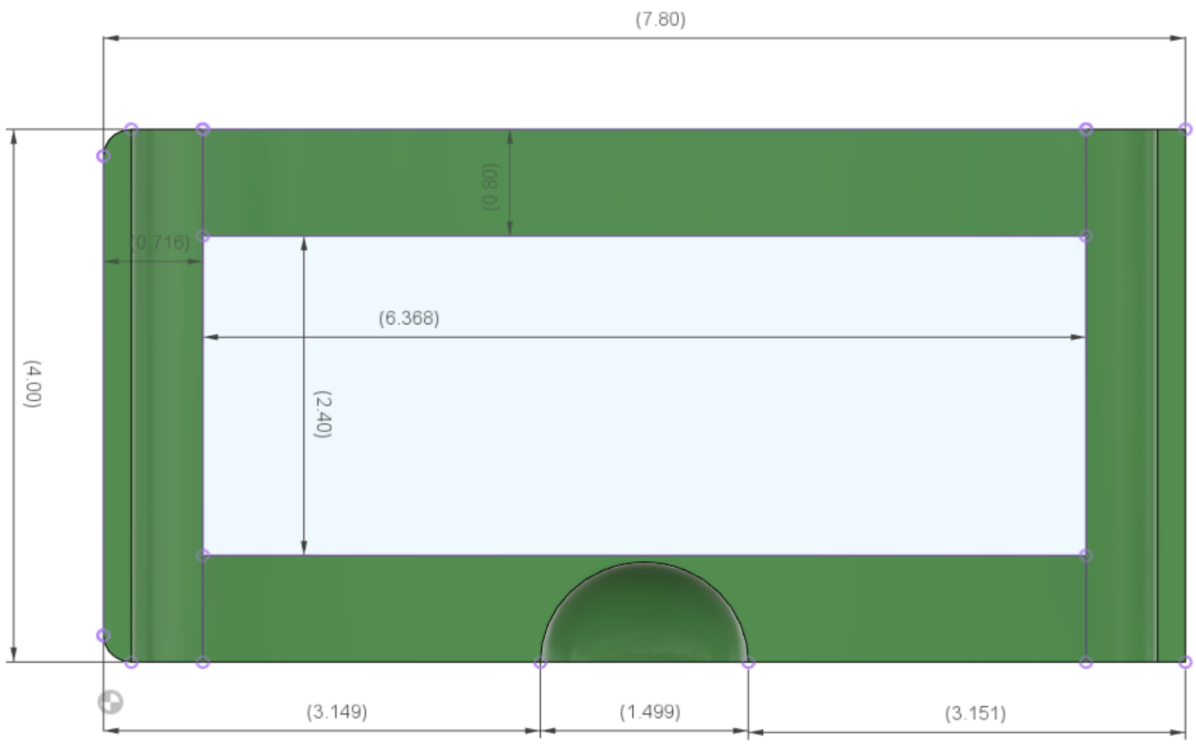


Figure 15.a VR Base (Front)

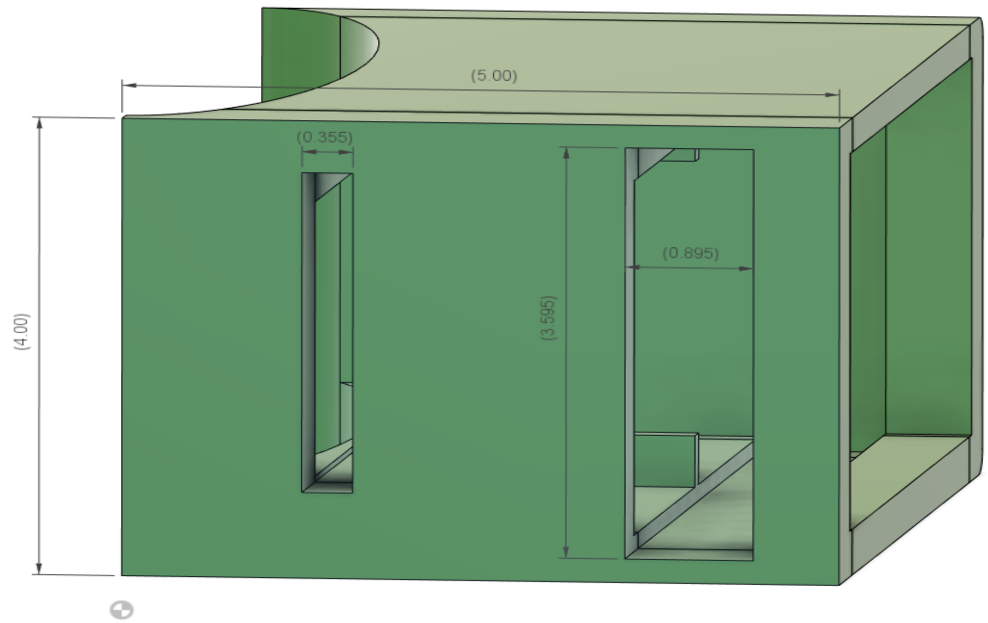


Figure 15.b VR Base (Right Side View)

Figure 15 VR Base Setup

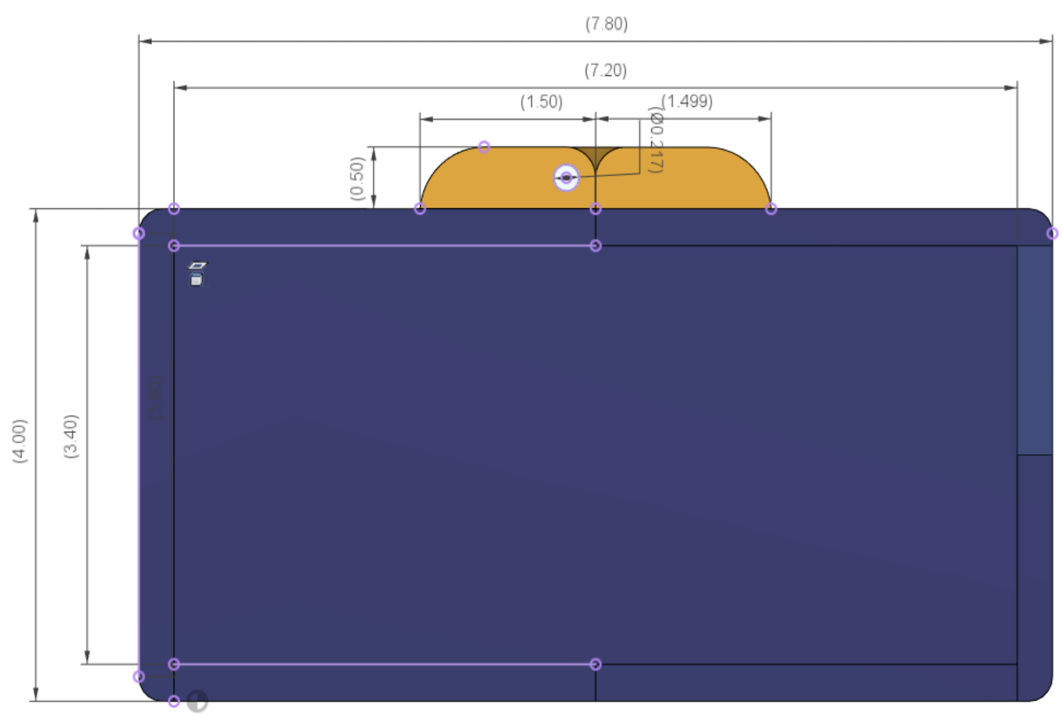


Figure 16 Red-reflex Enclosure (Front View)

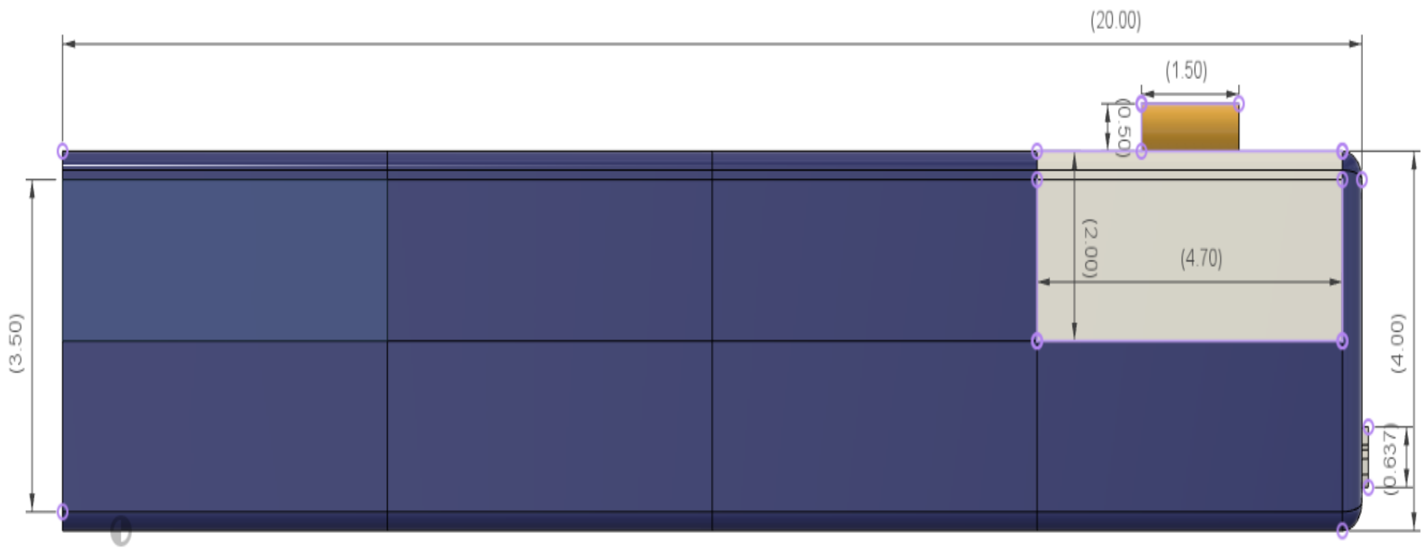


Figure 17 Enclosure (Right Side View)

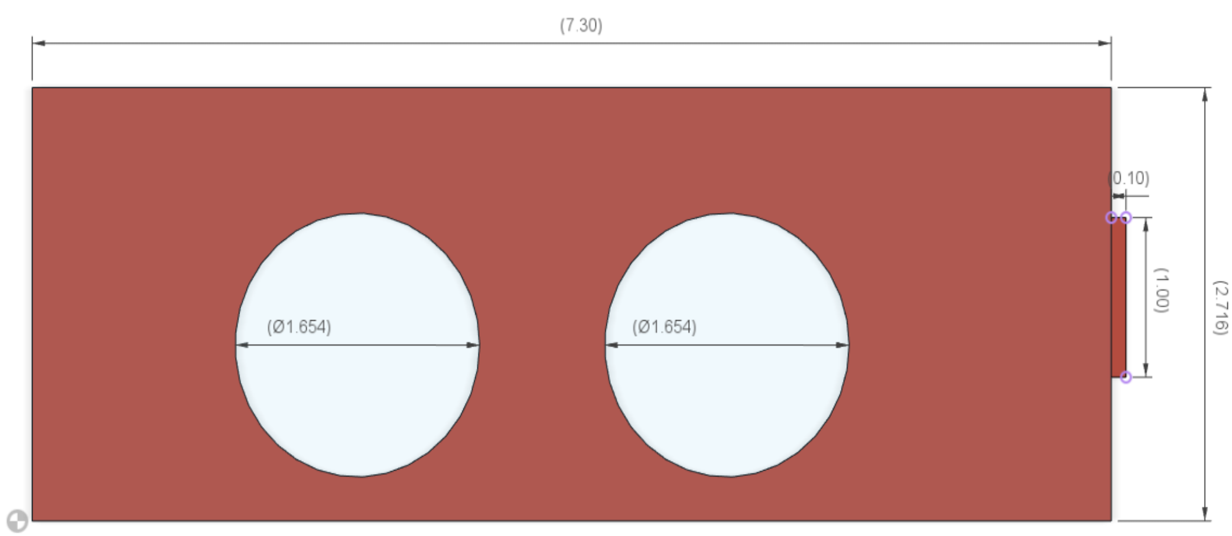


Figure 18 Lens Holder

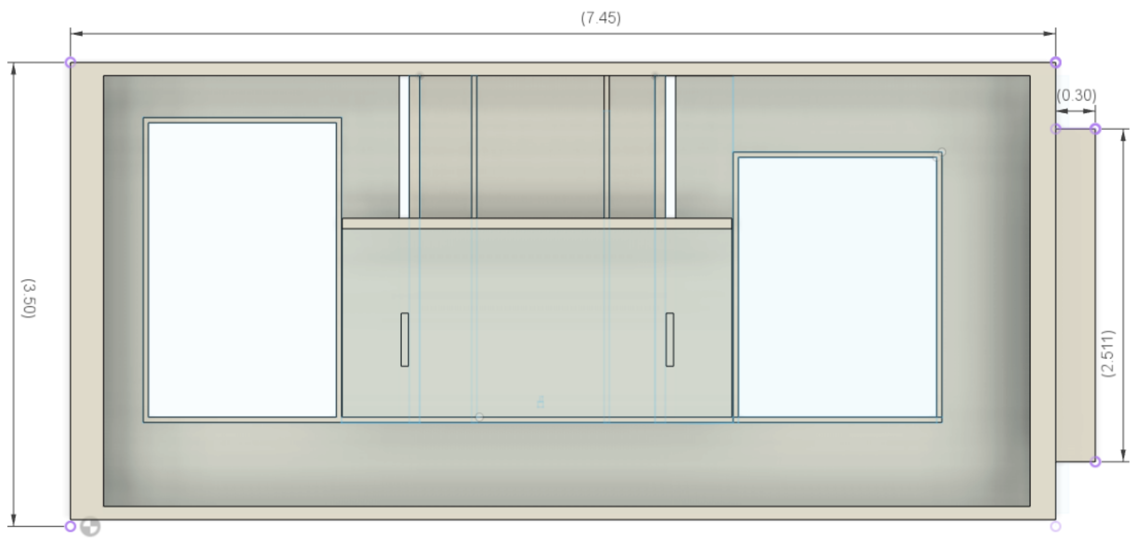


Figure 19 Smartphone Holder

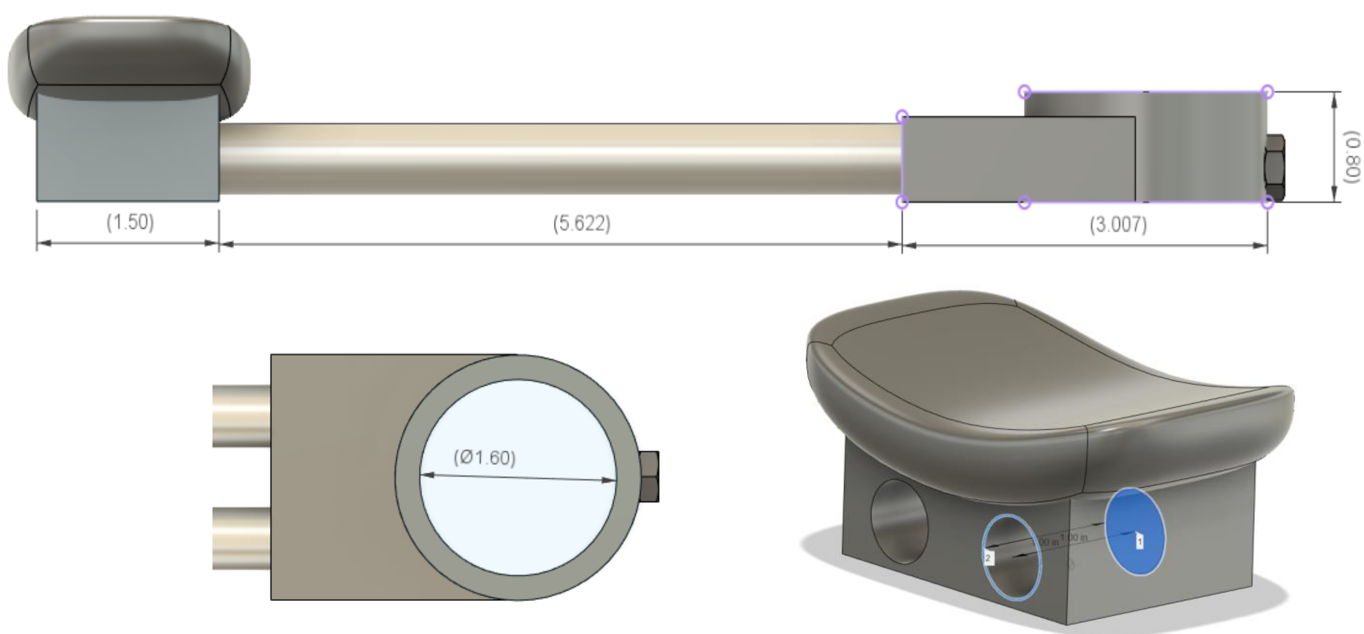


Figure 20 Chin Rest

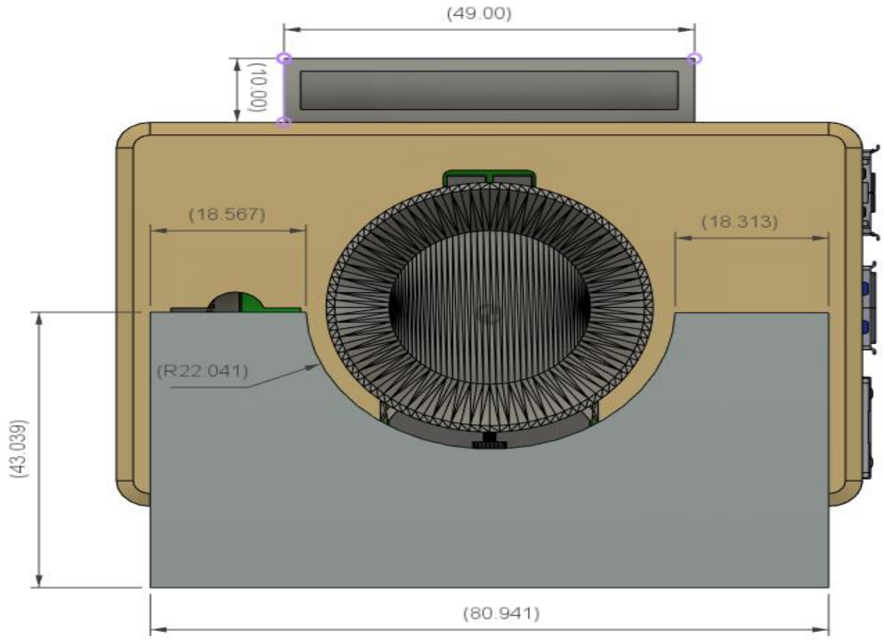


Figure 21 Red-Reflex Camera with Stand (Front Part)

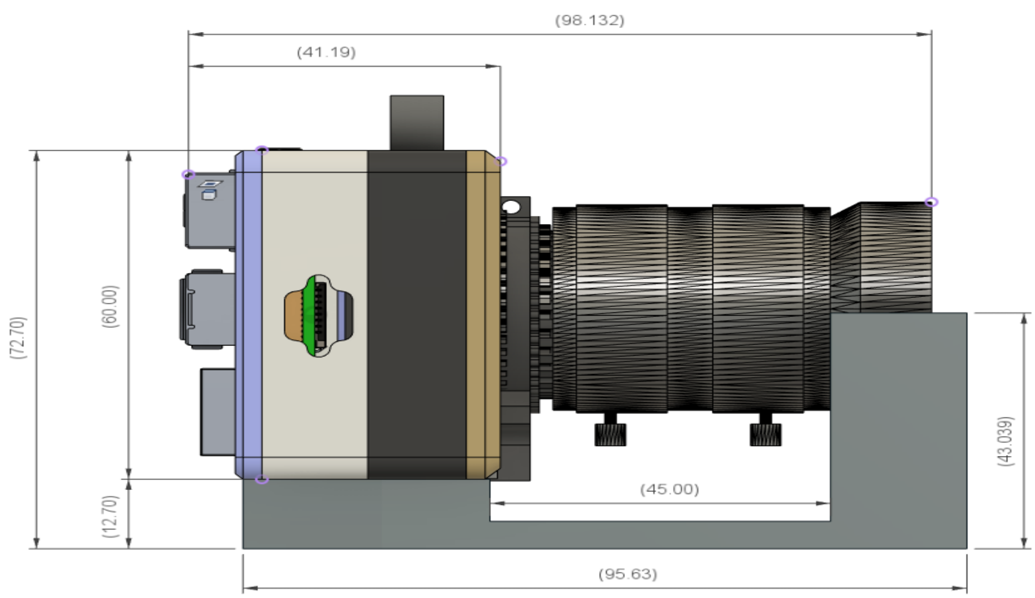


Figure 22 Red-Reflex Camera with Stand (Side Part)

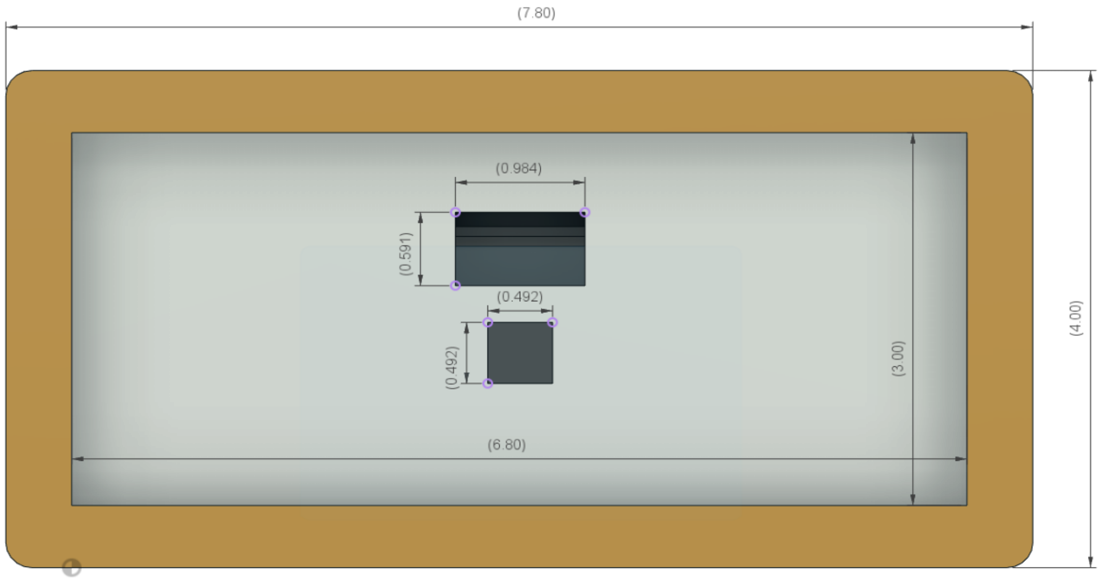


Figure 23 Slit-lamp Enclosure

3.3.3 Circuit Construction

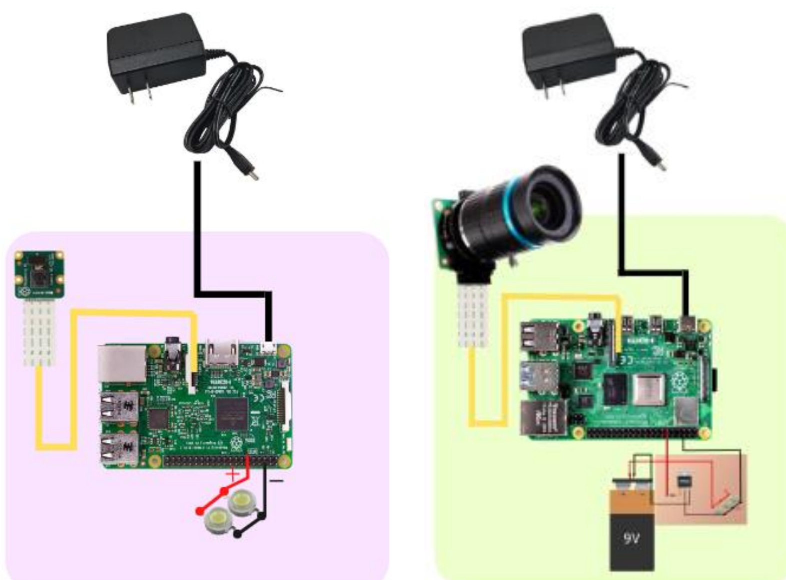


Figure 24 Circuit Design for Slit Lamp Capture Test (Left) and Red Reflex Test (Right)

The figure shown is the schematic diagram for the two tests that were conducted using the device. As shown on the circuit for the SLCT, Raspberry Pi 3 Model B was used as the microcontroller of the device. Connected to it is a Raspberry Pi Camera module and LED beads. The circuit design for the RRT used Raspberry Pi 4 Model B as the microcontroller board. Connected to it is a Raspberry Pi High Quality Camera and telephoto lens. For the level-shift circuit the components IRF540N MOSFET, li-ion battery, and LED beads are configured in a connection to power the LED beads using an external power supply.

3.3.4 Design consideration for the Power Management of the system

A 5V, 10A adaptor was used for the prototype's power supply in the device's power management system. The microprocessor inside the prototype was powered by this voltage. A dedicated smartphone charger was used to manually charge the Android smartphone. This was done to prevent the battery pack from overheating or overcharging while the device is in use.

3.4 Development of Machine Learning Model using CNN

The complex patterns that predict unobserved data are utilized and illustrated using machine learning models. Machine learning's subject of interpretability is rapidly expanding, and several studies have looked at different features of interpretations [36].

In order to categorize the photos into 1000 object categories, The photographs were divided into 1000 object categories by Simonyan and The VGG19, a convolutional neural network of 19 layers, 16 convolutional layers, and 3 fully connected layers, was introduced by Zisserman (2014). The ImageNet database, which has one million photos in 1000 categories, is used to train the VGG19 algorithm. Because each convolutional layer uses numerous 3 x 3 filters, it is a highly popular algorithm for image classification [37].

The development of a machine learning model using Convolutional Neural Network (CNN) is explained in this section. This presents the algorithm for the slit lamp capture test and machine learning architecture for the slit-lamp capture and red reflex tests.

3.4.1 Algorithm Development for the Slit-lamp Capture and Red Reflex Test

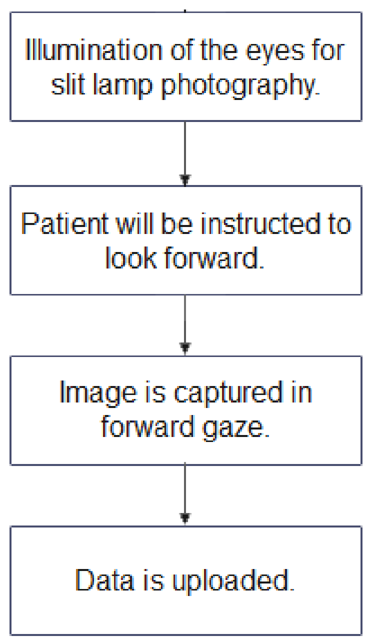


Figure 25 Procedure for Slit Lamp Capture Test

The depicted figure above illustrates the algorithm utilized in the slit lamp capture test. The process starts with the detection and the recognition of the eyes. The illumination will be set by shining or beaming light into the patient's eye, which will assist the slit lamp photography. In order to acquire a clear image of the gaze, the patient will be instructed to look forward. Moreover, the image acquired will be uploaded and stored in the system.

3.4.2 Machine Learning Architecture for the Slit-lamp Test

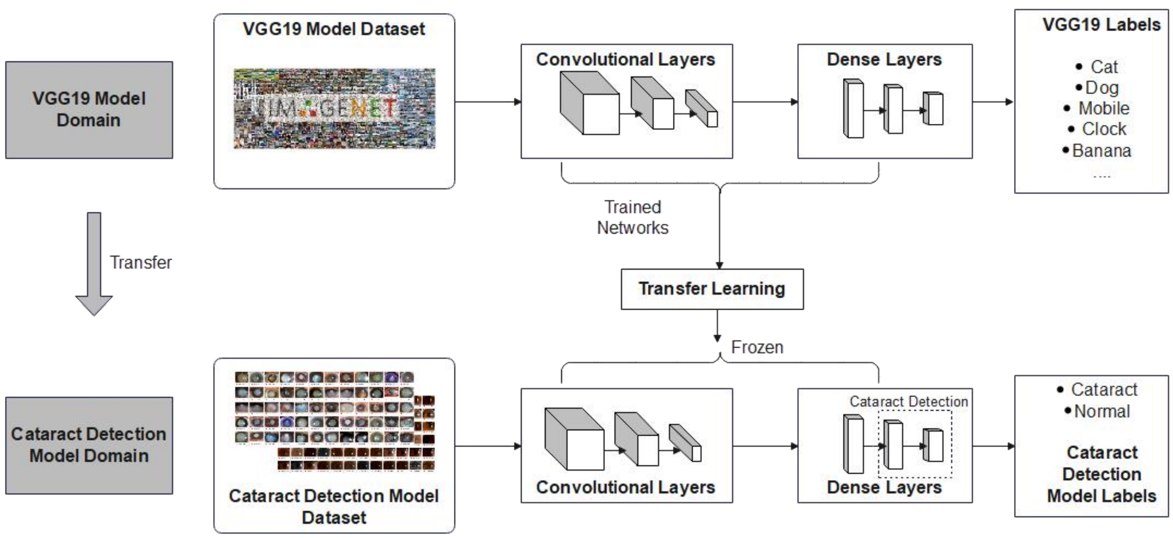


Figure 26 Transfer Learning Architecture of the Cataract Detection Model

Figure 19 displays the transfer learning architecture of the cataract detection model for the slit-lamp test. As seen in the flowchart, VGG19 model was used as the pre-trained CNN model. Pre-trained layers were taken from the VGG19 model for the transfer learning, those layers were then frozen to retain the weights by setting the base layers as untrainable. To train the model with the custom cataract dataset, the top layers of the VGG19 model were employed which makes use of the labeled data it was trained on.

3.4.3 Machine Learning Architecture for the Red Reflex Test

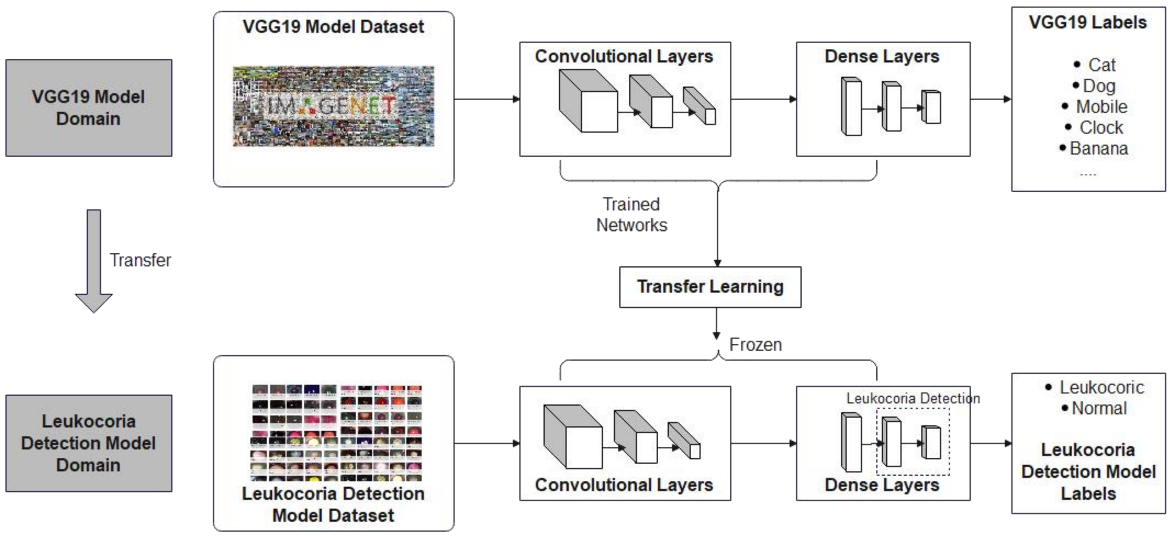


Figure 27 Transfer Learning Architecture of the Leukocoria Detection Model

The figure shown is the transfer learning architecture of the leukocoria detection model for the red reflex test. As indicated in the figure, VGG19 was used as the pretrained CNN model, similar to what was used for the transfer learning of the cataract detection model. To train the model with the custom leukocoria dataset, the top layers of the VGG19 model were employed as well which makes use of the labeled data it was trained on.

3.5 Development of Applications

This section discusses the development of software components needed for the study to achieve one of its objectives. This section comprises the development of the mobile applications and web page development.

3.5.1 Mobile Application Development

Instead of deploying the standard eye chart for the visual acuity test, the proponents created an application that simulates the ETDRS eye chart in 3D for use with mobile VR.

The said application was developed using Unity3D. Unity3D is a cross-platform game development tool engine that enables users to quickly design 3D video effects, 3D video games, real-time 3D animation, structural visualization, and other varieties of games [38].

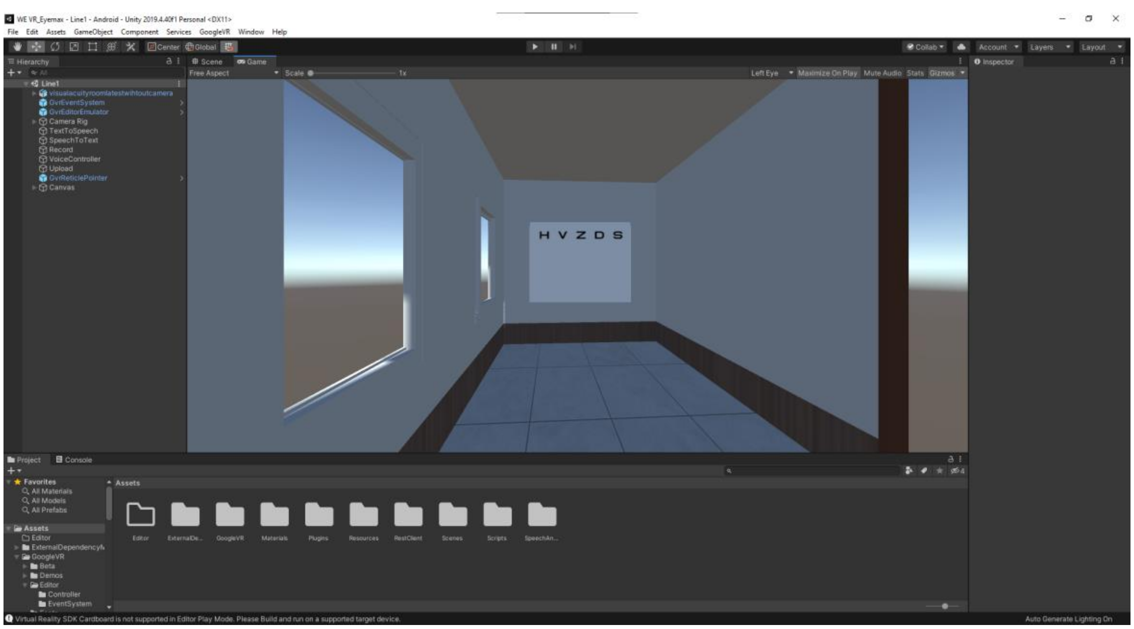


Figure 28 Mobile Application Development using Unity 3D

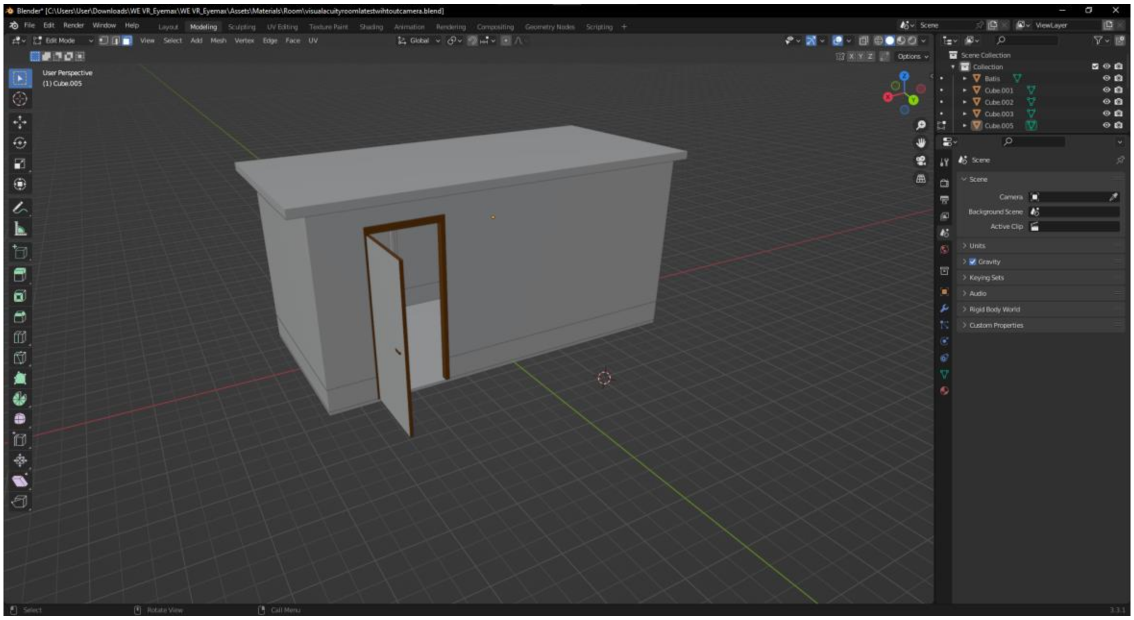


Figure 29 VR Environment Development in Blender

In order to consider the 20 feet distance requirement for visual acuity test, the virtual reality space was created using an application called Blender. It is known as an open-source 3D creation software tool used for modeling and animation. The file is eventually uploaded to Unity to build the mobile application for the visual acuity test and add the 3D text. Moreover, on the farthest wall of the room, the lines of the ETDRS chart was displayed sequentially.

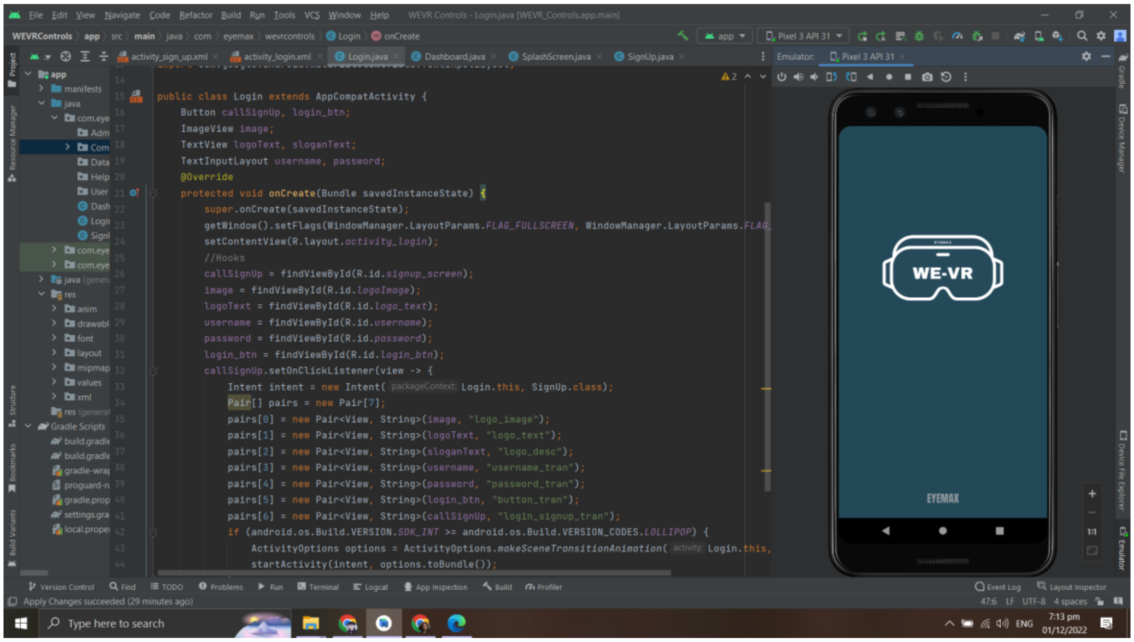


Figure 30 Sample View of the Mobile Application on Android Studio

The figure above depicts the Mobile Application for the User Interface, which was primarily used to save data from the visual acuity test. It includes login and signup, as well as access to a real-time database called 'Google Firebase.' The application also provided basic information about the Team, the Law (National Vision Screening Act), and the disease in concern (Cataract and Leukocoria).

3.5.2 Web Application Development

Hypertext Markup Language (HTML) is among the markup languages that web designers use to build a web page (HTML). The text, pictures, and videos in a document are also included in this. Web browsers like Chrome, Firefox, and Edge are used to read HTML documents in order to display the content in the right format. [39]

phpMyAdmin is a free and open source administration tool used for handling the administration of MySQL database server. The creation of database, user accounts, and running queries can be done using phpMyAdmin.

Javascript is an object-oriented computer programming language used to create interactions in developing web pages. It is said that anything that moves, refreshes, is one of the best examples of this language.

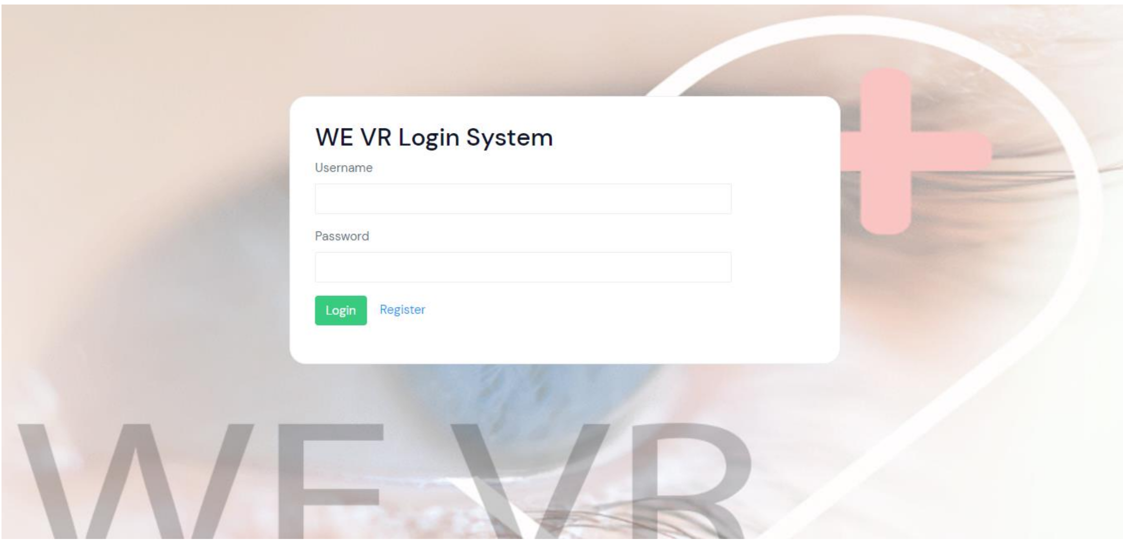


Figure 31 Login Page of the Web Application

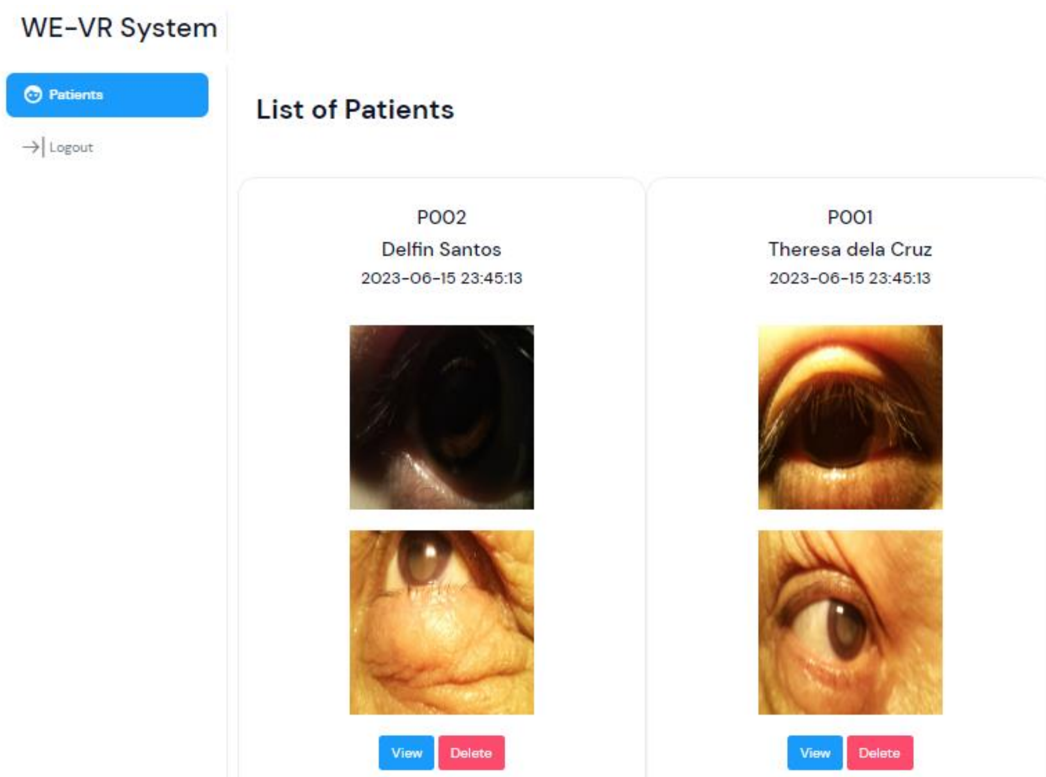


Figure 32 List of Patients Page of the Web Application

3.6 User Acceptance and Testing of the Device

The testing of the device was in accordance with International Organization for Standardization/International Electrotechnical Commission 25010:2011 (ISO/IEC 25010:2011). This involves the quality model of the device quality evaluation system.

The testing of the device must provide all the features. This includes the visual acuity test, and fully-detects the presence of cataract and leukocoria in the patient's eyes. The processing of the captured eyes of the patient must have fast processing-time or almost real-time in order to utilize its performance. In addition, the utilization of datasets in training the device must be implemented. The hardware and software of the device must be compatible and perform its functions on detecting leukocoria and cataracts. And the results from the device must also be connected with the computer for the ophthalmologist's diagnosis. When used by children, the device should make it accessible to them and safeguard them from issues or errors in cataract and leukocoria detection. If it is used to screen the patient's eye, the device must provide accurate information and function well. The acquired image can be utilized as a dataset in training the device because the device includes an eye-capture test. For patient data protection, only approved Ophthalmologists or the hospital should have access to the information. If the equipment malfunctions, the parts utilized in its construction should be replaceable.

This section also covers the evaluation of the device on patients, specifically children. In this part, the proponents must gather written consent of the patient through their guardian. Also, the proponents must notify and get approval from the hospital staff up to the highest position about the test that'll be conducted. The written consent from the patient with signature and non-disclosure agreement from the highest position of the hospital doctor and patient must be duly signed.

When testing the device on patients, the proponents must examine the factors that must be considered. Among these factors are the intensity of light, the distance between the device and the eyes, as well as the ergonomic side (weight and height) of the device.

In addition, since pediatric cataract patients are not that prevalent in the Philippines, the researchers must also test the device on ***non-pediatric patients*** in addition to testing it on pediatric patients.

3.7 Testing Procedure

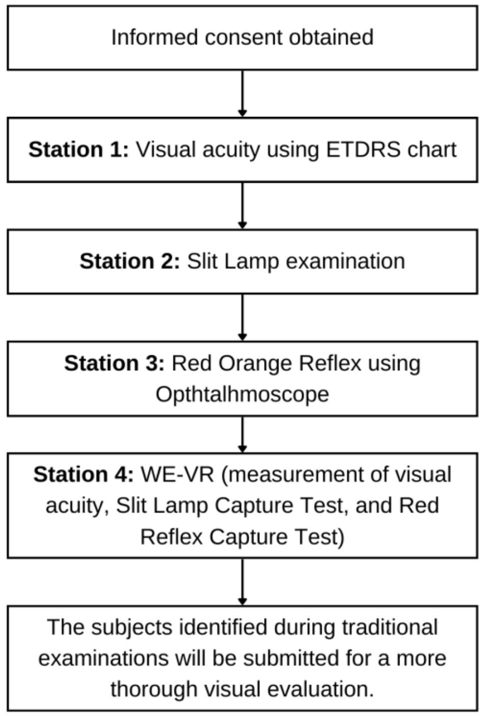


Figure 33 Testing Procedure Flow

3.7.1 Visual Acuity Test using ETDRS chart

A. Testability

The subjects were examined using binocular vision to see whether or not they are able to recognize each letter on the ETDRS chart. After that, the tests proceeded with one eye closed. The patients had his or her left eye covered while attempting to identify one prototype per line. This process continued through increasingly smaller lines until the individual was unable to identify the optotype. The other eye had the exact same procedure performed on it. If a subject can finish the testing in both eyes, then that topic is deemed testable.

B. Measurement of Visual Acuity

The patients began reading increasingly smaller optotypes beginning two lines above the threshold or the last line that failed in the prior test. This process continued until the subjects flunk the test. In order to be considered a failure, a line must have more than two incorrect optotypes. If at least three optotypes were found in a line, then the line is said to have passed. The visual acuity was reported in logMAR units individually for each eye.

C. Retest

A second person (Lay Screener) will take a measurement of the visual acuity after a short break (few minutes). This is done so that test-retest reliability may be determined.

3.7.2 Slit Lamp examination

During the slit lamp examination, the patient's head was supported by a chinrest and forehead rest. During the examination, the ophthalmologist flashed a bright light into and around the patient's eyes. If the ophthalmologist had to dilate the patient's pupils, they would provide eye drops. These often need a few minutes to function. Once the pupils have been dilated, the ophthalmologist would reexamine the patient's eyes.

3.7.3 Red Orange Reflex Test using Ophthalmoscope

Using an ophthalmoscope, a pediatric ophthalmologist performed an ROR (Red Orange Reflex) test on the patient. The ophthalmoscope contains a lens in which the doctor placed his/her eye in order to determine if the patient's eyes had a red or orange reflex. If the doctor observed a white reflex (no trace of red or orange) on the patient's eyes, a thorough eye examination would be recommended.

3.7.4 VR Device

The VR Device was an integration of the three eye tests commonly conducted on patients for cataract and leukocoria detection namely the visual acuity test in which a 3D application simulation of the traditional ETDRS eye chart was used to measure how well a patient can read a series of letters in a standardized setting, the slit-lamp capture test which is combination of high-quality camera module and high-powered LED to examine abnormalities in the anterior part of the eyes, and the red-orange-reflex test which induced a reflection of the retina that can determine if the patient has a condition called leukocoria.

3.8 Statistical Analysis

In order to assess the accuracy level, the proponents examined the findings from the process's data-gathering phase in this part. The Z-Test was applied in this study with an alpha level of 5% in order to compare the means of the two groups, the visual acuity of the WE-VR and the LEA Symbol Chart. The Z-Test will be in use in order to know whether the result follows under the normal distribution of the null hypothesis. Moreover, the utilization of a two-tailed Z-Test will determine the estimated effect and significance of the samples.

$$Z = \frac{\overline{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$$

$\bar{X}$ → sample mean

μ → population mean

σ → population standard deviation

n → number of samples

3.9 Project Work Plan (Gantt Chart)

The table provided below offers an insightful representation of the work plan adopted by the project proponents for the development of the device. The plan is effectively visualized using a Gantt chart. Each month is clearly indicated, and the duration of each task is plotted, showing an in-depth overview of the project's timeline and the sequence of tasks to be accomplished. This structured approach allows for effective project monitoring and ensures efficient allocation of resources and timely completion of the device development.

Table 5 Gantt Chart

Task Description	2022									2023						
	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
Objective No. 1																
3D Modeling																
3D Printing																
Canvassing of Materials for Stand of the Device																
Canvassing of Components Needed for the Circuit																
Circuit Connection and Wiring																
Purchasing of the Components needed																
Development of the Circuit Design (SLCT and RRT)																
Development of the Visual Acuity Test																
Objective No. 2																
Algorithm for slip-lamp capture test																
Algorithm for red reflex test																
Interfacing of Raspberry Pi																
Objective 3																
Development of the Mobile Application																
Development of the Web Application																
Objective 4																
Clinical Trial																

Deployment of the Project															

The table above shows the works done over time and the plans for the following months.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter provides the interpretation of the gathered data as well as the analysis of the results based on the tests that were conducted.

4.1 Project Technical Description

The project study WE-VR: Interactive Virtual Reality for Childhood Leukocoria and Pediatric Cataract Detection System is a device that carries out three eye tests necessary to detect the presence of childhood leukocoria and pediatric cataracts; these tests are namely the visual acuity test, slit-lamp capture test, and red reflex capture test. This project study is intended to develop an accurate, cost-effective, and easy-to-use vision screening device to supplement the vision screening kit given by Philippine Eye Research Institute (PERI) in order to improve the detection of Childhood Leukocoria and Pediatric Cataract and related risk factors among Filipino children.

This project employs virtual reality technologies, voice recognition, web application development, and image processing using a convolutional neural network (CNN).

The VR device is worn when the user is seated on a chair. As soon as the patient is ready, the lay screener may begin the operation. The controls and outcomes of each test are shown in "WEVR controls." The first test is the visual acuity exam, which requires the patient to read the letters shown on the VR screen. Speech recognition was used to identify and record the answer. The lay screener may verify if the system appropriately detected the answer using the Manual method. After completion of the VA test, the visual acuity value (LogMAR) with adjustment is shown.

The next test is the slit lamp capture test. The result is presented in the Web Application, along with the detection of refractive error. The patient is instructed to gaze inside the device, focusing on one eye at a time. Each eye is captured by the Raspberry Pi camera V2, and the image captured undergoes image processing and CNN in order to detect the presence of Cataract.

The Red Reflex test is the last examination. During this examination, a telephoto lens is used so that the subject's eye may be captured in its entirety. The lay screener gives the patient instructions to move in a subtle manner so that they may get the correct angle for the Red/Orange reflex to display. To induce the red or orange reaction in the eye, a high-power LED is employed.

When all three tests have been finished, the web application offers a summary of how each test went along with an overall score. If at least one of the tests came out inconclusive, the device would encourage the patient to speak with an ophthalmologist in order to have further testing done on their eyes. The results are uploaded and stored on a website, but only licensed medical professionals and other approved personnel are able to access it.

4.2 Project Structural Organization

4.2.1 VR Device

The visual representations provided below offer a comprehensive overview of both the internal and external components that comprises the entire device. The internal portion encompasses the three distinct tests integrated within the device, namely the visual acuity test, the slit lamp capture test, and the red reflex test.

Figure 34 Front Part of the Device

Figure 35 Back Part of the Device

Figure 36 Right and Left Sides of the Device

Figure 37 Visual Acuity Test

Figure 38 Slit Lamp Capture Test

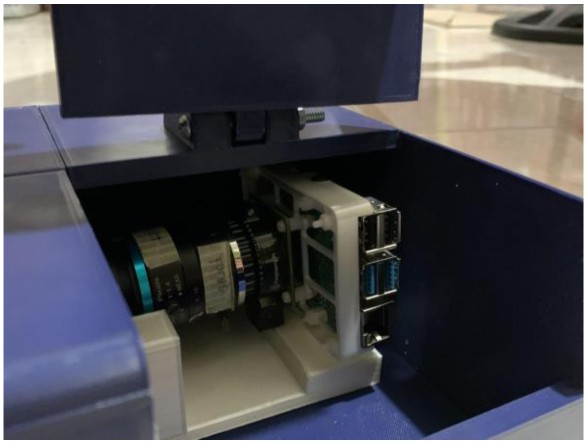


Figure 39 Red Reflex Test

4.2.2 Sample Images from the VR Device

4.2.2.1 Sample Raw Image for the Slit Lamp Capture Test

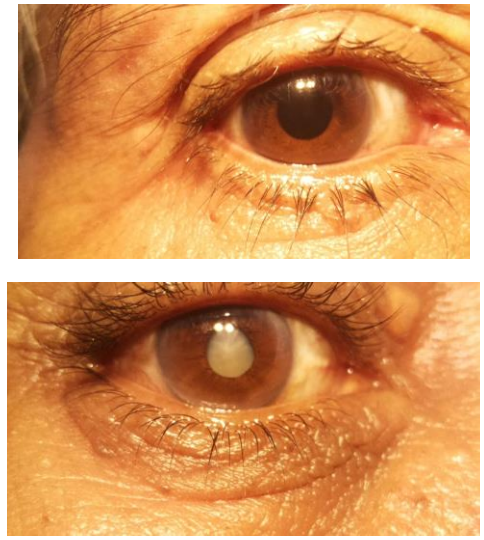


Figure 40 SLCT Raw Images

The figure shown above are the sample raw images taken from the pi camera V2 in Slit Lamp Capture test. This raw image proceeded to image processing and CNN in order to identify and detect whether there is a presence of Cataract.

4.2.2.2 Sample Raw Image for the Red Reflex Capture Test

Figure 41 RRT Raw Image

The figure above is a sample image captured for the Red Reflex Test using the device.

4.2.3 Web Application

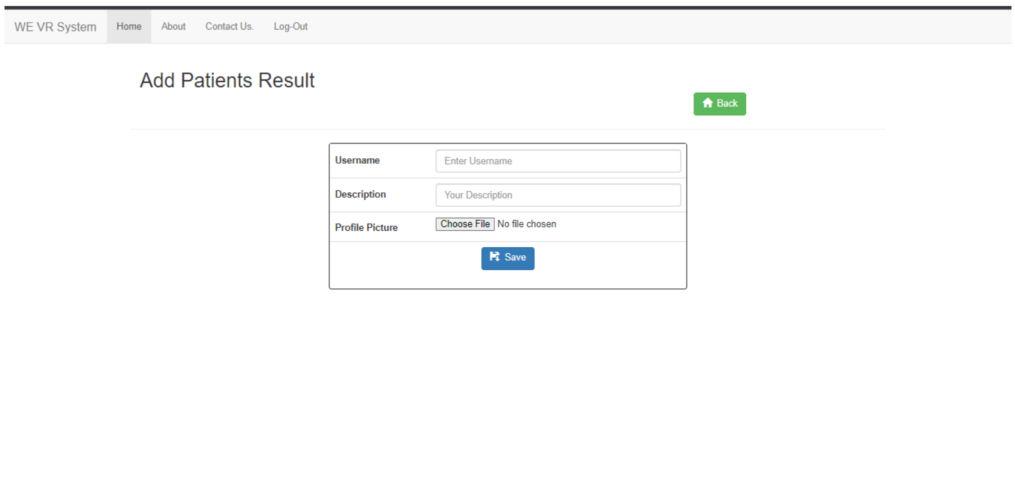


Figure 42 Interface of the Web Application for Inputting Results

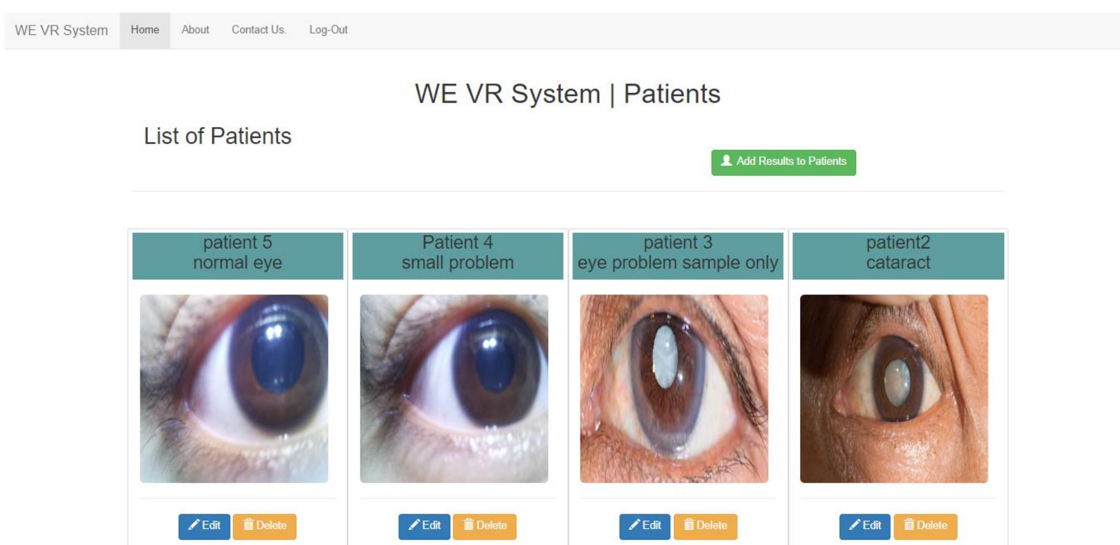


Figure 43 Interface of the Web Application for Displaying Results

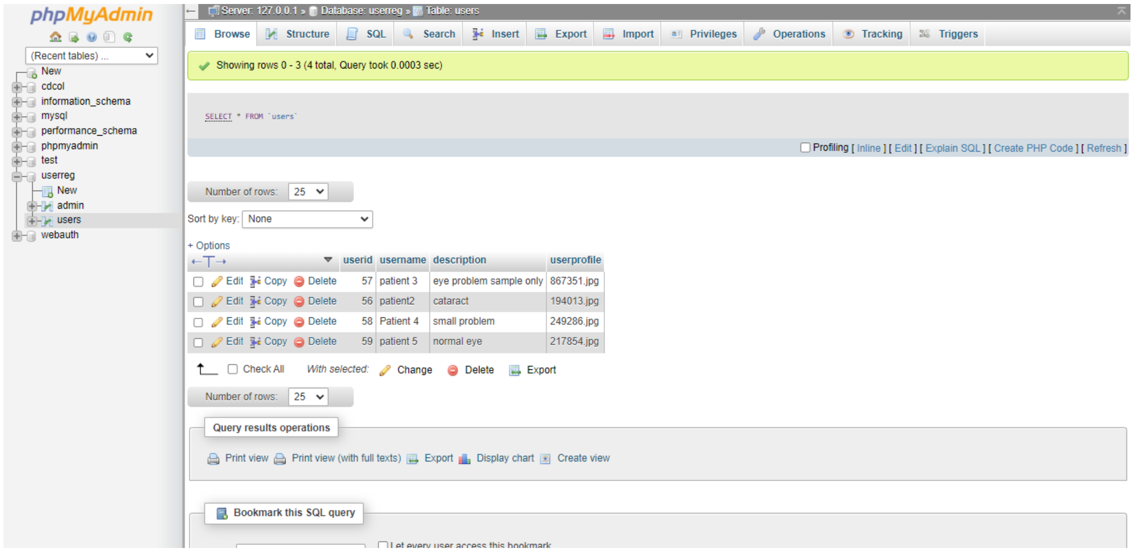


Figure 44 View of the phpMyAdmin Database

The displays above demonstrate the user interface of a web application, specifically the Patients List window. This window allows for various actions to be performed on patient records, including adding, editing, and deleting their results. The data entered by users is stored in the phpMyAdmin database, ensuring secure and organized storage.

4.2.4 Mobile View of the VR

The displayed image demonstrates the binocular perspective of the patient while utilizing the 3D software application for the visual acuity test within the device. It illustrates the initial screen of the application upon startup. Moreover, the display can be manipulated and controlled using the application for controls.

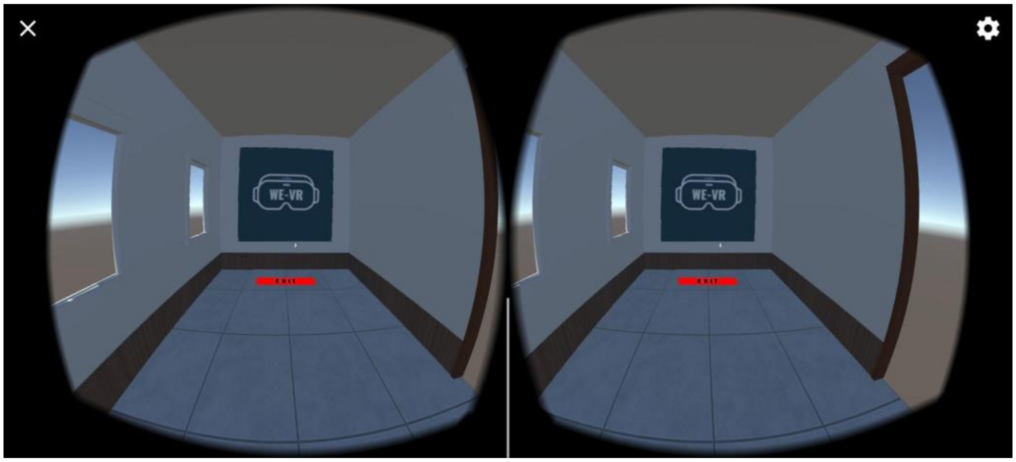


Figure 45 Binocular View of the 3D Software Application

4.2.5 Mobile View of the Controls

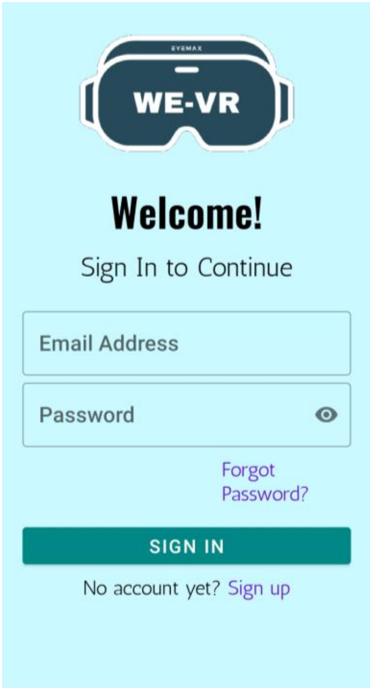


Figure 46.a Main Window

Figure 46.b Login Page

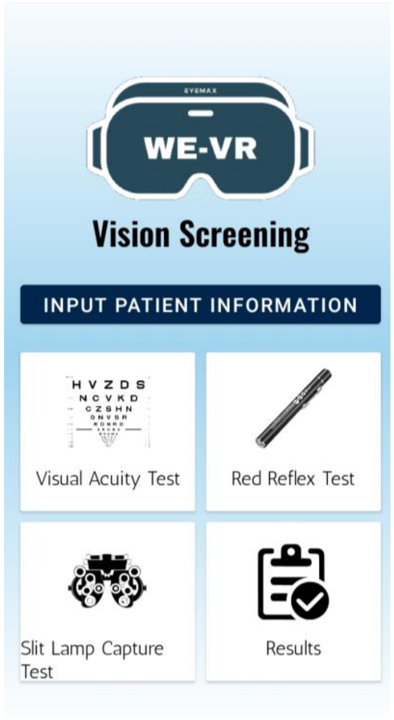


Figure 46.c Main Dashboard

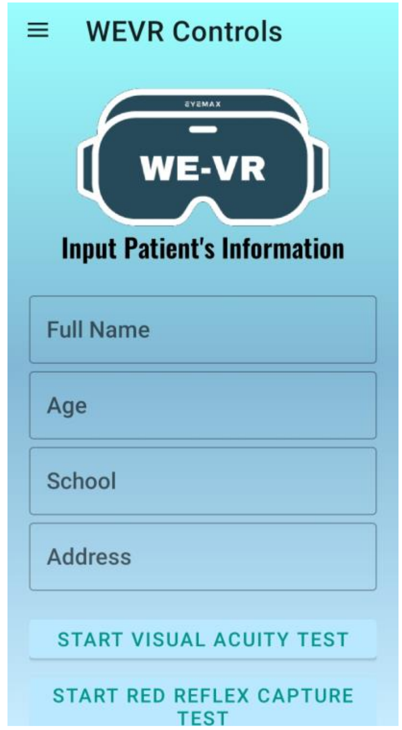


Figure 46.d Patient's Information Page

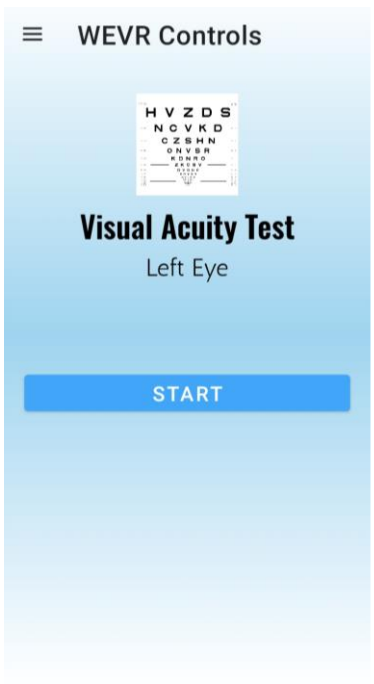


Figure 46.e Visual Acuity Test Start Page

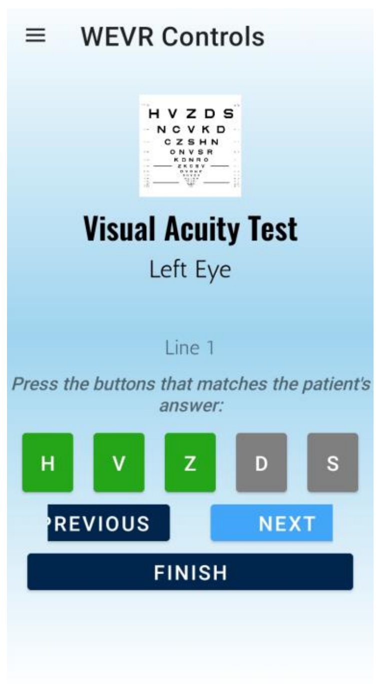


Figure 46.f Visual Acuity Test Lines

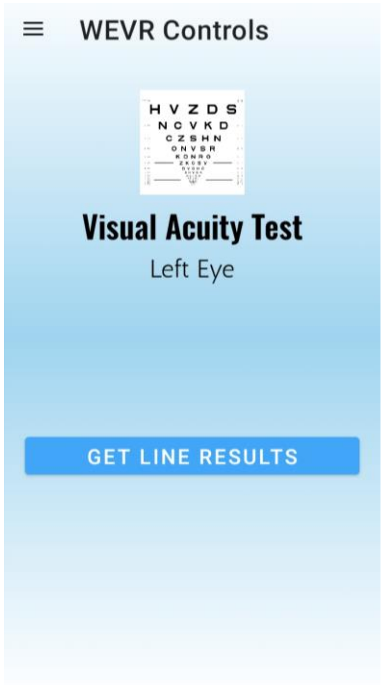


Figure 46.g Visual Acuity Test Get Line Results

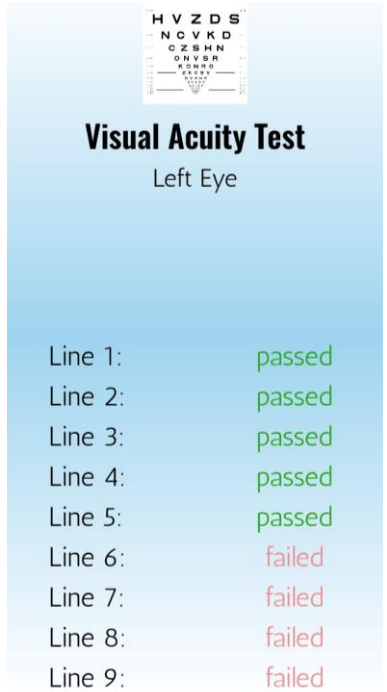


Figure 46.h Visual Acuity Test Response Confirmation

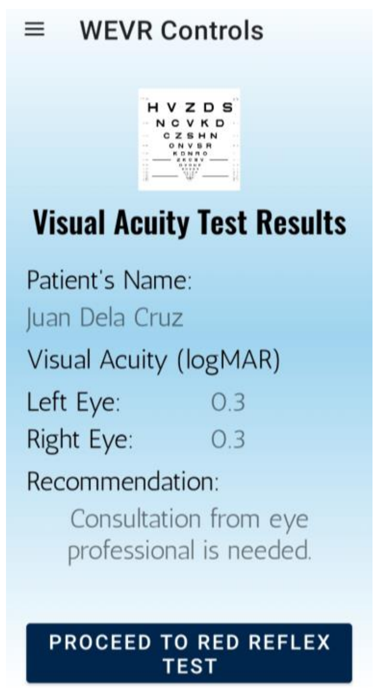


Figure 46.i Visual Acuity Test Results

Figure 46 EyeMax Controls GUI

Figure 46.a depicts the primary interface of the WE-VR app. Access to the app requires login credentials, as shown in Figure 46.b. Users must sign up to create an account, which can also be used to access record lists on the website. The app's main dashboard is displayed in Figure 46.c, while Figure 46.d showcases the input panel for patient information. Once the patient is ready, the examiner can commence the visual acuity test, which is performed monocularly (one eye at a time). Figure 46.f illustrates the controls for displaying the ETDRS chart line by line. The voice processing system automatically recognizes the letters read by the patient. At the end of the test, the examiner can verify the accuracy of the system's identified inputs, as demonstrated in Figure 46.g. Subsequently, the visual acuity test results are presented in Figure 46.i. These results include the patient's name, visual acuity measurements for the left and right eye, and a recommendation regarding normal or corrected visual acuity.

4.3 Project Limitations and Capabilities

The purpose of this study is to create a system that makes use of head-mounted virtual reality technology in order to correctly quantify the existence of cataract, leukocoria, and visual acuity in order to detect cataract and leukocoria and its related risk factors in elementary pupils. Virtual Reality (VR) Technology, Image Processing, and CNN are all used in this work. On both the WE-VR mobile app and the WE-VR web app, the results of each test were shown.

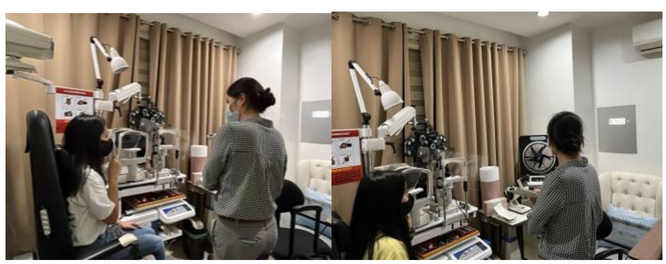
4.4 Experimental Results and Data Analysis

The VR device measurements were compared to traditional eye exams conducted by a pediatric ophthalmologist using an eye chart and a slit lamp tool. The WE-VR device underwent validation and testing at Taguig Pateros District Hospital under the supervision of Dr. Ed Gomez. Dr. Patricia Cabrera, a pediatric ophthalmologist at UP-PGH, served as our clinical study adviser and facilitated the testing process.

Data collection extended to private optical clinics in Taguig and Muntinlupa, encompassing participants aged 9 to 53 years old. Younger individuals were assessed using the VR for Visual Acuity, while the older age group underwent Slit lamp testing for cataract detection.

4.4.1 Results/Finding and Analysis

First face-to-face consultation with Dra. Patricia P. Cabrera from UP-PGH. Screening tests such as Decimal Eye Chart and Lea Symbol Chart were used to be able to understand and gain knowledge about the traditional process of screening the eye of the patients. The screening tests were conducted at Dra. Cabrera’s clinic at De La Salle University Medical Center situated at Dasmarinas, Cavite.



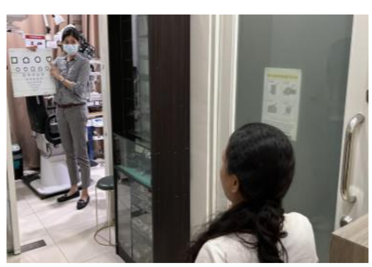


Figure 47 Traditional Screening Tests Conducted at DLSUMC

The second in-person consultation was conducted at another clinic of Dra. Patricia P. Cabrera, which is located at the Asian Hospital and Medical Center in Muntinlupa. During this consultation, four test patients were instructed to use the Lea Symbol Chart. The purpose was to compare the accuracy of the device's results with the results of traditional screening tests.

Figure 48 Traditional Screening Tests Conducted at Asian Hospital and Medical Center

Based on the consultations conducted, the table presented below indicates the specific charts utilized and the individual results obtained for both the left and right eyes of the test subjects. This data was gathered from four test patients, resulting in a total of eight samples.

Table 6 Results from the Traditional Screening Tests in 10 feet distance

Test Patient	Chart Type	Right Eye Result (10ft)	Left Eye Result (10ft)
1	Decimal Eye Chart	20/150	20/150 (-1)
2	Decimal Eye Chart	20/150 (-1)	20/200

Table 7 Results from the Traditional Screening Tests with logMar value

Test Patient	Chart Type	Right Eye Result (logMar)	Left Eye Result (logMar)
3	Lea Symbol Chart	.86	.64
4	Lea Symbol Chart	0.1	0.1
5	Lea Symbol Chart	0.3	0.3
6	Lea Symbol Chart	0.3	0.2
7	Lea Symbol Chart	0.8	0.5
8	Lea Symbol Chart	0.3	0.3

The provided table below shows the results of the visual acuity test for the initial 10 samples. Additionally, it presents a comparison between the results obtained from the device and the clinical test done using the LEA Symbol Chart.

Table 8 Visual Acuity Test Results of the Ten Initial Samples

Visual Acuity (logMAR)		
Sample No.	**WE-VR**	**Clinical**
1	0	0.1
2	0	0.1

3	0.5	0.5
4	0.8	0.8
5	0.3	0.3
6	0.3	0.2
7	0.4	0.8
8	0.5	0.5
9	0.4	0.3
10	0.4	0.3

Sample 1	EyeMax
Sample 2	Clinical

	Sample 1	Sample 2
Sample size	10	10
Lowest value	0.0000	0.1000
Highest value	0.8000	0.8000
Median	0.4000	0.3000
95% CI for the median	0.1425 to 0.5000	0.1475 to 0.6575
Interquartile range	0.3000 to 0.5000	0.2000 to 0.5000

Hodges-Lehmann median difference	0.0000
95% Confidence interval	-0.05000 to 0.1500

Wilcoxon test (paired samples)

Number of positive differences	3
Number of negative differences	3
Test statistic Z	-0.333333
Two-tailed probability	P = 0.7389

Figure 49 Summary of Wilcoxon signed-rank test

To summarize, according to figure 41, the two-tailed probability (P) is 0.7389, which exceeds the significance level of 0.05. Consequently, we must accept the null hypothesis. The median of the paired differences in the population is nearly zero. This indicates that the visual acuity test utilizing WE-VR is accurate, acceptable, and satisfactory.

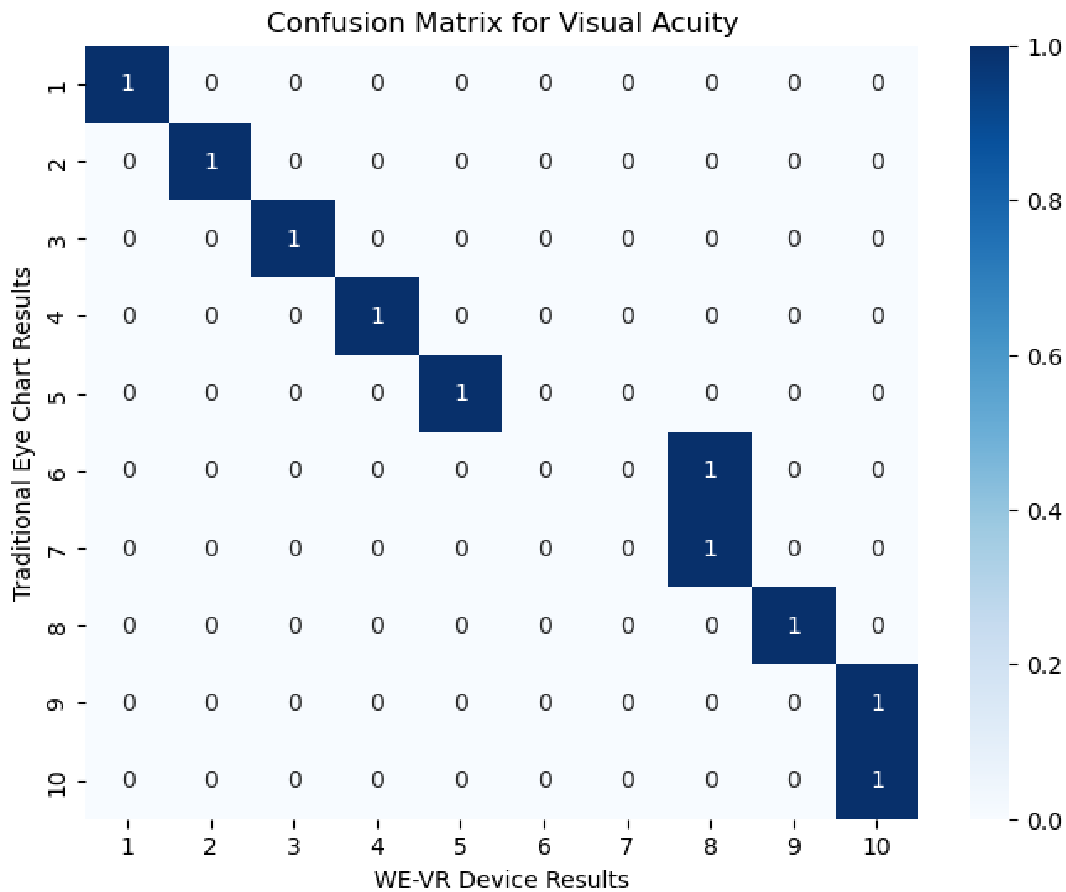
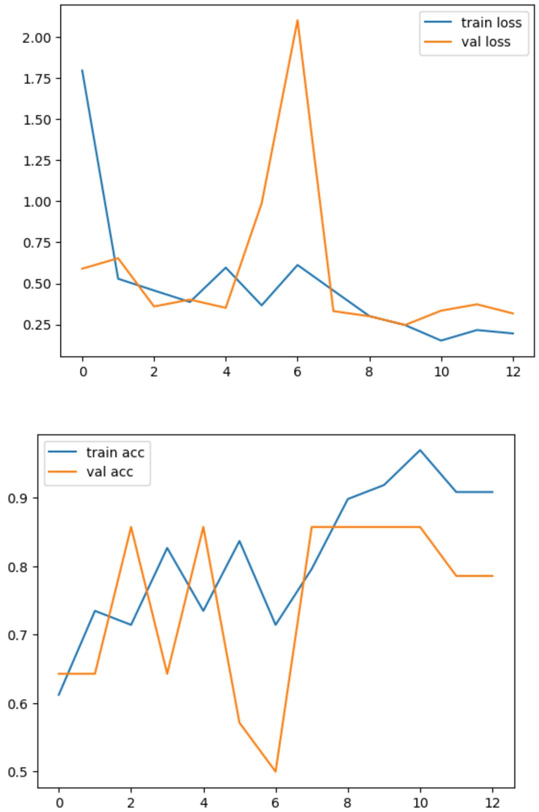


Figure 50 Confusion Matrix of Visual Acuity Test

The confusion matrix of the Visual Acuity test is based on the compared traditional eye chart and tested visual acuity of the device. 8 out of 10 samples have been correctly classified making it 73% accurate based on the model.




```
2/2 [==============================] - 0s 89ms/step
Confusion Matrix
[[4 1]
 [2 5]]
Classification Report
              precision    recall  f1-score   support

    cataract       0.67      0.80      0.73         5
      normal       0.83      0.71      0.77         7

    accuracy                           0.75        12
   macro avg       0.75      0.76      0.75        12
weighted avg       0.76      0.75      0.75        12

1/1 [==============================] - 2s 2s/step - loss: 0.4233 - accuracy: 0.7500
Accuracy:  0.75
Loss:  0.4232929050922394
```

Figure 51 Training History of the Cataract Detection using CNN

More information on each class's precision, recall, and F1-score is provided in the classification report. The "cataract" class has a precision of 0.67, meaning that most predicted "cataract" samples are correct. Recall is 0.80, which indicates that a sizable number of "cataract" samples are being identified by the model.

Precision and recall are both quite high for the "normal" class, with respective values of 0.83 and 0.71. Both classes' F1-scores are also fairly high, demonstrating a reasonable balance between recall and precision.

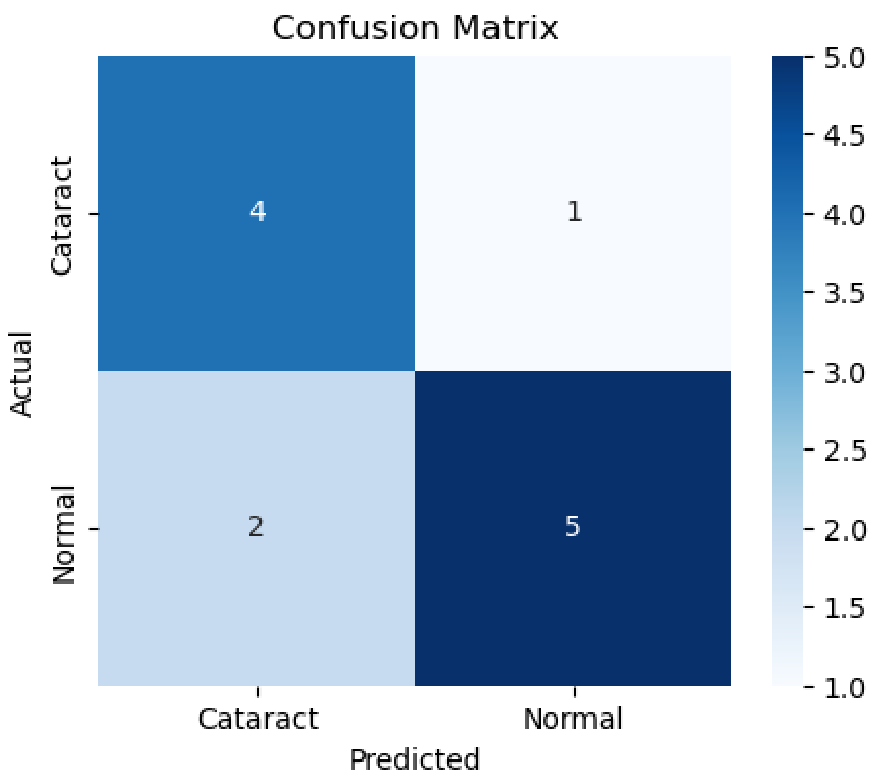
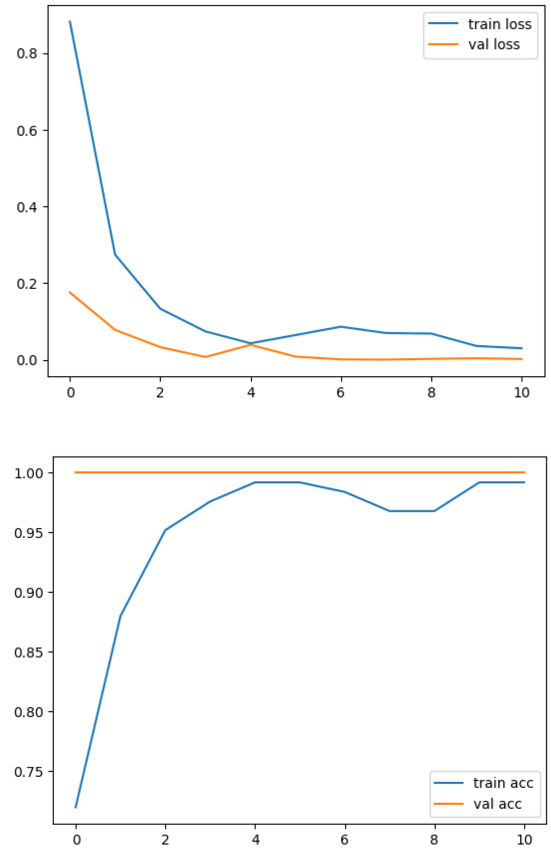


Figure 52 Confusion Matrix of the Cataract Detection using CNN

The confusion matrix indicates that the model accurately predicts both the "normal" and "cataract" classes. In the "cataract" class, it has accurately classified 4 out of 5 samples, while in the "normal" class, it has successfully classified 5 out of 7 samples making the overall accuracy of the model as 75%.




```
2/2 [==============================] - 3s 3s/step
Confusion Matrix
[[11  0]
 [ 0  5]]
Classification Report
              precision    recall  f1-score   support

    cataract       1.00      1.00      1.00        11
      normal       1.00      1.00      1.00         5

    accuracy                           1.00        16
   macro avg       1.00      1.00      1.00        16
weighted avg       1.00      1.00      1.00        16

1/1 [==============================] - 3s 3s/step - loss: 0.0117 - accuracy: 1.0000
Accuracy:  1.0
Loss:  0.011742449365556 24
```

Figure 53 Training History of the Leukocoria Detection using CNN

The classification report provides more evidence of the model's excellent performance, with precision, recall, and an F1-score of 1.00 for both classes. This proves the model correctly predicts every instance of both classes. The model's total accuracy is 1.0, which is the maximum level of accuracy. The model's training performance appears to be excellent with minimal errors, as indicated by the low loss value of 0.0117.

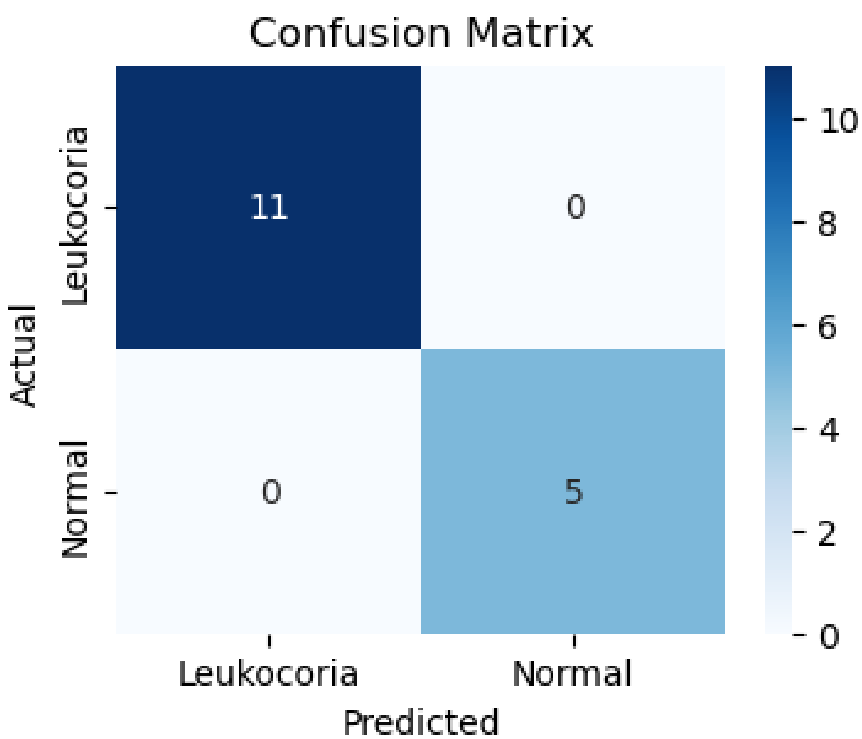


Figure 54 Confusion Matrix of the Leukocoria Detection using CNN

The confusion matrix demonstrates that the model correctly predicts both the "normal" and "cataract" classes. All 11 of the samples for the "cataract" class and all 5 of the samples for the "normal" class have been accurately classified making the overall accuracy of the model as 100%.

4.4.2 Raspberry Pi Cameras

For the two eye tests namely the Slit-lamp Capture and the Red Reflex Test both use Raspberry Pi boards with compatible camera sensors the Raspberry Pi Camera v2.1 and the Raspberry Pi High-quality Camera with telephoto lens.

4.4.2.1 Raspberry Pi Camera V2.1

Figure 55 Initial images captured (not yet calibrated)

The images shown above are some of the captured images for the Slit-lamp Capture Test using the device when it isn't calibrated yet. The figures show unfocused and overexposed captured images.

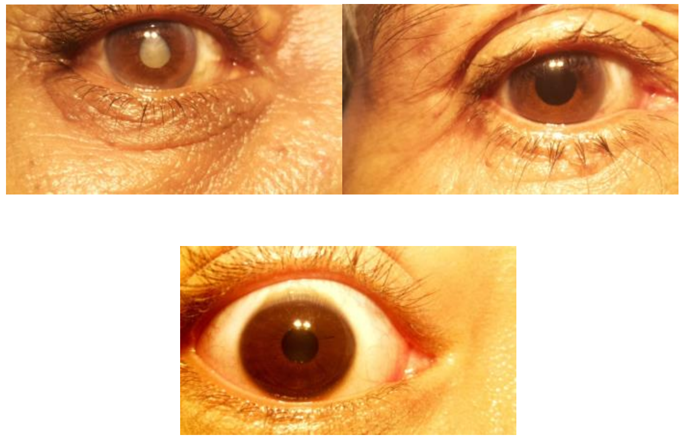


Figure 56 Captured image after calibration (adjustment of the focus)

The above images show high-quality shots captured using the device for the Slit-lamp Capture Test. After calibrating the focus and the flash the captured eye images show dilated pupils. The images are also focused and not overly exposed.

4.4.2.2 Telephoto Lens

Figure 57 Initial images captured (not yet calibrated)

The above figure shows a captured eye image for the Red Reflex Test where the high-quality camera is not calibrated yet. The image shows an unfocused shot.

Figure 58 Captured image after calibration (adjustment of the focus)

The above figure shows a captured eye image for the Red Reflex Test where the high-quality camera is already calibrated. The image shows a focused shot.

4.4.3 Experts and Stakeholders Evaluation

This section encompasses the assessment conducted by expert ophthalmologists who collaborated on the evaluation. It also includes the evaluation by stakeholders, which is based on the ISO/IEC 20510 standard.

4.4.3.1 Experts Evaluation

Two partner Ophthalmologists evaluated the prototype for this project study. The first one is Dr. Patricia Cabrera, MD, a Pediatric Ophthalmologist, and one of the Clinical Advisers for this study. Second is Dr. Ed Gomez of the Taguig Pateros District Hospital.

Figure 59 The team with Dr. Patricia P. Cabrera, MD, Pediatric Ophthalmologist

Figure 60 The team with Dr. Ed Gomez, Ophthalmologist

4.4.3.2 Stakeholders Evaluation

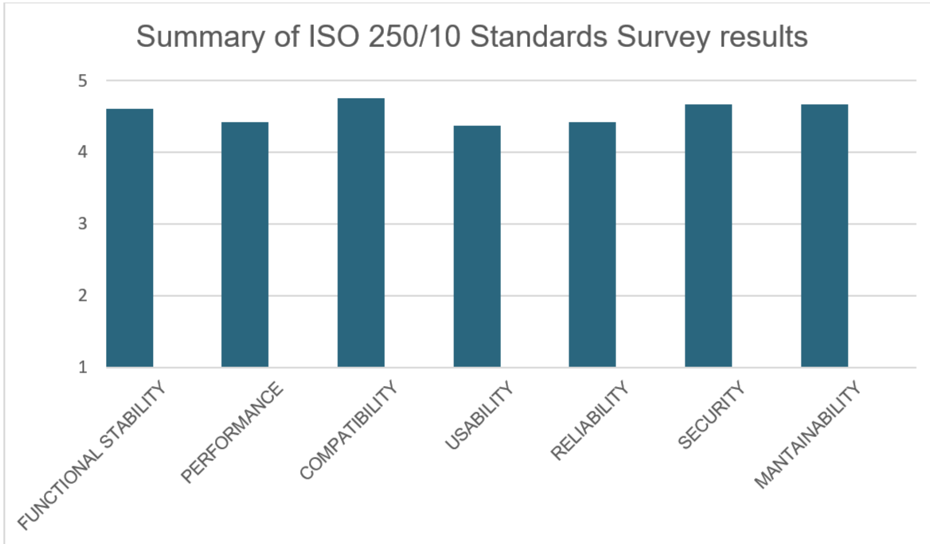


Figure 61 Summary of Survey Results

The study conducted a survey to collect feedback from users and supervising doctors and interns, in accordance with the ISO/IEC 20510 standard. The survey results, displayed in the figure, provide valuable insights. The evaluation of the device's accuracy and performance affirms that the developed WE-VR device demonstrates favorable outcomes. These results highlight its potential as a valuable tool for initial or pre-screening purposes and for telemedicine, aiming to enhance the detection of cataract and leukocoria.

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary of Findings

The WE-VR device has demonstrated its accuracy in measuring visual acuity and detecting the presence of cataract and leukocoria. The results of hypothesis testing indicate that the device is effective, as all null hypotheses were accepted. Moreover, the device achieved an overall accuracy rate of 85% with a misclassification rate of 15%. This means that, on average, the device correctly assessed visual acuity in 13 out of 16 samples, detected cataract in 7 out of 12 cases, and successfully identified leukocoria in all 11 images. Consequently, the prototype exhibits accurate detection of cataract, leukocoria, and even corneal scarring, making it a suitable tool for early vision screening across different age groups, not limited to elementary pupils. Additionally, its application in telemedicine is feasible. It's important to consider certain factors that may impact the testing process, such as underlying eye health conditions, the testing environment, and the age of the patient. These variables can influence the device's performance and should be taken into account during the screening process.

5.2 Conclusions

1. The proponents have successfully designed and constructed a device incorporating Virtual Reality technology, intended for conducting visual acuity tests, slit lamp capture tests, and red reflex tests. During the development process, the team sourced materials from various countries, taking into account factors such as cost and quality of each material and component. The device's casing was meticulously

designed and 3D printed to ensure it met the necessary specifications and dimensions required for accommodating the microcontrollers and other essential components.

2. The researchers have achieved successful development of a Convolutional Neural Network (CNN) model capable of accurately detecting the presence of cataract and/or leukocoria in captured eye images. Additionally, the model includes the capability to identify corneal scarring as an additional feature.
3. The proponents have successfully created a 3D app simulation for visual acuity tests, an Android application for controlling the device's features, and a Web Application as a central platform for collecting and storing the results of three eye tests.
4. The device is a reliable and suitable tool for detecting the presence of cataracts and leukocoria, which includes assessing visual acuity, slit lamp capture, and red-orange reflex. It possesses the advantage of being accessible and user-friendly, making it suitable for use by lay screeners in the community.

This device allows for early detection of cataract and leukocoria, enabling timely intervention. Corrective measures like contact lenses, eyeglasses, or refractive surgeries can be applied promptly to prevent complications. Additionally, the device is portable, affordable, and distinct from other commercially available VR devices and slit lamp tools used for vision screening. It can also be used for telemedicine, specifically, it can help those communities that cannot afford or have limited access to ophthalmology clinics. Its cost-effectiveness and ease of transport make it a valuable tool for practitioners seeking convenient preliminary testing results.

5.3 Recommendations

To further improve the study, the proponents would recommend creating a device that would be much more portable. Specifically, create 3 different devices for 3 individual tests so that if a user wants only a specific part of the eye test, he/she can use it more easily.

As for the Visual Acuity test using VR, the proponents would recommend to consider presbyopia patients (or patients 40 above – who often use reading glasses). With the slit-lamp capture test (SLCT), the proponents recommend using a high quality macro camera module compatible with the Raspberry Pi controller instead of the Raspberry Pi v2 camera that only has 8MP sensor. It is also recommended to have a monitor that would serve as the display for the live feed of the camera for the patients to see as advised by one of our partner ophthalmologists. Lastly for the red reflex test, it is recommended not to configure the flash to be fixed in its position rather to have it be able to move to be able to induce reflex similar to how slit-lamp tool is used to induce red-orange reflex (ROR).

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APPENDIX A

Bill of Materials

MATERIALS	QTY.	PRICE	TOTAL COST
Makerbot Filament	4	Php 899.00	Php 3596.00
Raspberry Pi 3B	1	Php 4,000.00	Php 4,000.00
Raspberry Pi 4B	1	Php 9,200.00	Php 9,200.00
Raspberry Pi 4B Case	1	Php 400.00	Php 400.00
Raspberry Pi Adapter	1	Php 600.00	Php 600.00
Power Adapter	2	Php 495.00	Php 990.00
5MP Camera Module	1	Php 268.00	Php 268.00
8MP Raspberry Pi Camera V2.1	1	Php 1,300.00	Php 1,300.00
16 mm Telephoto Lens	1	Php 3,929.00	Php 3,929.00
CS Mount	1	Php 3,929.00	Php 3,929.00
32GB SD Card	1	Php 550.00	Php 550.00
64GB SD Card	1	Php 325.00	Php 325.00
Foam for VR Base	1	Php 450.00	Php 450.00
Biconvex Lens	2	Php 75.00	Php 150.00
Tripod Stand	1	Php 339.99	Php 339.00
Battery Holder	1	Php 90.00	Php 90.00
Battery Holder	1	Php 30.00	Php 30.00
Li-ion Battery	2	Php 100.00	Pho 100.00
Solid Wire	1	Php 20.00	Php 20.00
5m 18 AWG Stranded Cable	1	Php 100.00	Php 100.00
1m Wire	1	Php 12.00	Php 12.00
5m Wire for Raspberry Pi	1	Php 209.00	Php 209.00
Resistors	2	Php 4.00	Php 8.00

PCB	1	Php 24.00	Php 24.00
Micro USB TP4056	2	Php 30.00	Php 60.00
IRF540N MOSFET	1	Php 35.00	Php 35.00
Shrinkable Tubes	1	Php 20.00	Php 20.00
Lead	1	Php 17.00	Php 17.00
Stove Bolt RHD	1	Php 54.00	Php 54.00
Adhesive	20	Php 40.00	Php 800.00
1W Warm LED beads	2	Php 15.00	Php 30.00
3W White LED beads	2	Php 22.5	Php 45.00
		Total	**Php 31,000**

APPENDIX B

Needs Assessment

The proponents utilize the ISO/IEC 25010 standard to assess the device. This standard consists of 20 questions that evaluate various aspects, including functional suitability, performance efficiency, compatibility, usability, reliability, security, and maintainability. The objective of this survey is to assess the device based on the criteria outlined in the ISO/IEC 25010 standard.

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QUESTIONNAIRE

The students involved prior to this study need to conduct a survey for evaluation of different aspects of the proponent, entitled "WI-VR: Interactive Virtual Reality Device for Childhood Leukocoria and Pediatric Cataract Detection System"

Instruction: Please rate whether you strongly disagree or strongly agree. Check one response of the following statements. Rate 1 – if Strongly Disagree 2 – Disagree 3 – Neither Agree nor Disagree 4 – Agree 5 – Strongly Agree

Name:_____________________________ Occupation:_____________ Date:___________

SURVEY STATEMENTS		Rating				
		5	4	3	2	1
FUNCTIONAL SUITABILITY						
Completeness	1. The device functions properly according to the specifications.					
Correctness	2. The device provides an accurate result.					
Appropriateness	3. The device fulfills its functions.					
PERFORMANCE EFFICIENCY						
Time behavior	1. The vision screening test conducted using the device works faster than the traditional test.					
Resource utilization	2. Tests are done correctly with little time and minimum cost incurred, and without wasting resources.					
COMPATIBILITY						
Coexistence	1. The VR and the control panel work together without problem.					
Interoperability	2. The control panel and the VR functions simultaneously.					
USABILITY						
Appropriateness recognizability	1. The device can be recognized as a tool to detect leukocoria and pediatric cataract.					
Learnability	2. Instructions can be learned easily.					
Operability	3. Controls are easy to operate					
User error protection	4. The device protects users against making errors.					
User interface aesthetics	5. The user interface is pleasing to the eye.					
RELIABILITY						
Maturity	1. The device is stable in conducting vision tests.					
Availability	2. The device can be used anytime.					
Fault tolerance	3. The device works even when some hardware or software faults occur.					
Recoverability	4. The data can be recovered in case of system failure.					
SECURITY						
Confidentiality	1. Data is accessible only to authorized personnel.					
Integrity	2. Device prevents unauthorized access and modification of data.					
Accountability	3. Any alteration in the results is recorded.					
MAINTAINABILITY						
Analyzability	1. The sequence process of the entire program can be easily understood.					
Testability	2. The device is automated which can perform three tests, namely visual acuity, red reflex, and slit lamp capture test.					

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QUESTIONNAIRE

Ang mga mag-aaral na kalahok sa pag-aaral na ito ay kailangang magsagawa ng sarbey para sa pagsusuri ng iba't-ibang aspeto ng proyektong **"WI-VR: Interactive Virtual Reality Device for Childhood Leukocoria and Pediatric Cataract Detection System"**

Panuto: Markahan ang mga kahon sa ibaba kung sumasang-ayon o hind isa mga nabanggit. Pumili ng isa mula **1** – Lubos na hindi sumasang-ayon **2** – Hindi sumasang-ayon **3** – Hindi alinman sa mga nabanggit **4** – Sumasang-ayon **5** - Lubos na sumasang-ayon

Pangalan: [illegible] Trabaho: ophthalmologist Petsa: 6/15/23

MGA PAHAYAG		Iskor 5	4	3	2	1
PAGGANANG ANGKOP						
Pagkakumpleto	1. Ang aparato ay gumagana ayon sa nabanggit na spesipikasyon.		✓			
Kawastuhan	2. Ang aparato ay nagbibigay ng tamang resulta.		✓			
Kaangkupan	3. Nagagawa ng aparato ang tungkulin nito.		✓			
KASANAYAN SA TUNGKULIN NG APARATO						
Oras	1. Mas mabilis ang pagsusuri ng paningin sa aparatong ito kumpara sa tradisyonal na aparato.			✓		
Maayos na paggamit ng resources	2. Ang mga pagsusuri ay nagawa nang tama sa kaunting oras, nang walang sinasayang na resources.	✓				
PAGKAKATUGMA						
Coexistence	1. Ang VR at ang control panel ay gumagana nang walang problema.		✓			
Interoperability	2. Ang VR at ang control panel ay gumagana nang sabay.	✓				
KAKAYAHANG MAGAMIT						
Kakayahang tumuklas	1. Ang aparato ay masasabing instrumento upang makatuklas ng leukocoria at cataract.	✓				
Learnability	2. Madaling maunawaan ang panuto.	✓				
Operability	3. Madaling kontrolin ang aparato.		✓			
User error protection	4. Pinoprotektahan ng aparato ang gumagamit mula sa kamalian.		✓			
Kagandahan ng user interface	5. Ang user interface ay kaaya-aya sa paningin.		✓			
KAKAYAHANG MAASAHAN						
Maturity	1. Kaya ng aparatong magsagawa ng vision screening.		✓			
Kakayahang magamit	2. Maaaring gamitin ang aparato anumang oras.		✓			
Fault tolerance	3. Gumagana ang aparato kahit may software o hardware fault.					
Recoverability	4. Sa oras ng pagpalya, maaaring mabawi ang data sa aparato..					
SEGURIDAD						
Confidentiality	1. Ang data ay maaari lamang makita ng awtorisadong tao.		✓			
Integridad	2. Hindi pinahihintulutan ang hindi awtorisadong pagpasok o pagbago sa data.		✓			
Pananagutan	3. Ang pagbabago sa mga resulta ay nakatala.		✓			
KAKAYAHANG MAPANATILI						
Analyzability	1. Ang pagkakasunod-sunod ng proseso ay madaling maunawaan.		✓			
Testability	2. Ang aparato ay automated at kayang gawin ang tatlong pagsusuri na visual acuity, red reflex, at slit-lamp capture na mga pagsusuri..		✓			

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Panuto: Markahan ang mga kahon sa ibaba kung sumasang-ayon o hind isa mga nabanggit. Pumili ng isa mula **1** – Lubos na hindi sumasang-ayon **2** – Hindi sumasang-ayon **3** – Hindi alinman sa mga nabanggit **4** – Sumasang-ayon **5** - Lubos na sumasang-ayon

Pangalan: Rachel Ebto Trabaho: CAD Daftsman Petsa: 5-21-23

MGA PAHAYAG		Iskor 5	4	3	2	1
PAGGANANG ANGKOP						
Pagkakumpleto	1. Ang aparato ay gumagana ayon sa nabanggit na spesipikasyon.		✓			
Kawastuhan	2. Ang aparato ay nagbibigay ng tamang resulta.	✓				
Kaangkupan	3. Nagagawa ng aparato ang tungkulin nito.	✓				
KASANAYAN SA TUNGKULIN NG APARATO						
Oras	1. Mas mabilis ang pagsusuri ng paningin sa aparatong ito kumpara sa tradisyonal na aparato.	✓				
Maayos na paggamit ng resources	2. Ang mga pagsusuri ay nagawa nang tama sa kaunting oras, nang walang sinasayang na resources.	✓				
PAGKAKATUGMA						
Coexistence	1. Ang VR at ang control panel ay gumagana nang walang problema.	✓				
Interoperability	2. Ang VR at ang control panel ay gumagana nang sabay.	✓				
KAKAYAHANG MAGAMIT						
Kakayahang tumuklas	1. Ang aparato ay masasabing instrumento upang makatuklas ng leukocoria at cataract.	✓				
Learnability	2. Madaling maunawaan ang panuto.	✓				
Operability	3. Madaling kontrolin ang aparato.	✓				
User error protection	4. Pinoprotektahan ng aparato ang gumagamit mula sa kamalian.	✓				
Kagandahan ng user interface	5. Ang user interface ay kaaya-aya sa paningin.	✓				
KAKAYAHANG MAASAHAN						
Maturity	1. Kaya ng aparatong magsagawa ng vision screening.	✓				
Kakayahang magamit	2. Maaaring gamitin ang aparato anumang oras.		✓			
Fault tolerance	3. Gumagana ang aparato kahit may software o hardware fault.		✓			
Recoverability	4. Sa oras ng pagpalya, maaaring mabawi ang data sa aparato..	✓				
SEGURIDAD						
Confidentiality	1. Ang data ay maaari lamang makita ng awtorisadong tao.	✓				
Integridad	2. Hindi pinahihintulutan ang hindi awtorisadong pagpasok o pagbago sa data.	✓				
Pananagutan	3. Ang pagbabago sa mga resulta ay nakatala.	✓				
KAKAYAHANG MAPANATILI						
Analyzability	1. Ang pagkakasunod-sunod ng proseso ay madaling maunawaan.	✓				
Testability	2. Ang aparato ay automated at kayang gawin ang tatlong pagsusuri na visual acuity, red reflex, at slit-lamp capture na mga pagsusuri..	✓				

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Pangalan: LYRIC D. OCTAVIANO Trabaho: Intern Petsa: 6/15

MGA PAHAYAG		Iskor				
		5	4	3	2	1
PAGGANANG ANGKOP						
Pagkakumpleto	1. Ang aparato ay gumagana ayon sa nabanggit na spesipikasyon.	✓				
Kawastuhan	2. Ang aparato ay nagbibigay ng tamang resulta.	✓				
Kaangkupan	3. Nagagawa ng aparato ang tungkulin nito.	✓				
KASANAYAN SA TUNGKULIN NG APARATO						
Oras	1. Mas mabilis ang pagsusuri ng paningin sa aparatong ito kumpara sa tradisyonal na aparato.	✓				
Maayos na paggamit ng resources	2. Ang mga pagsusuri ay nagawa nang tama sa kaunting oras, nang walang sinasayang na resources.	✓				
PAGKAKATUGMA						
Coexistence	1. Ang VR at ang control panel ay gumagana nang walang problema.	✓				
Interoperability	2. Ang VR at ang control panel ay gumagana nang sabay.	✓				
KAKAYAHANG MAGAMIT						
Kakayahang tumuklas	1. Ang aparato ay masasabing instrumento upang makatuklas ng leukocoria at cataract.	✓				
Learnability	2. Madaling maunawaan ang panuto.	✓				
Operability	3. Madaling kontrolin ang aparato.	✓				
User error protection	4. Pinoprotektahan ng aparato ang gumagamit mula sa kamalian.	✓				
Kagandahan ng user interface	5. Ang user interface ay kaaya-aya sa paningin.	✓				
KAKAYAHANG MAASAHAN						
Maturity	1. Kaya ng aparatong magsagawa ng vision screening.	✓				
Kakayahang magamit	2. Maaaring gamitin ang aparato anumang oras.	✓				
Fault tolerance	3. Gumagana ang aparato kahit may software o hardware fault.	✓				
Recoverability	4. Sa oras ng pagpalya, maaaring mabawi ang data sa aparato..	✓				
SEGURIDAD						
Confidentiality	1. Ang data ay maaari lamang makita ng awtorisadong tao.	✓				
Integridad	2. Hindi pinahihintulutan ang hindi awtorisadong pagpasok o pagbago sa data.	✓				
Pananagutan	3. Ang pagbabago sa mga resulta ay nakatala.	✓				
KAKAYAHANG MAPANATILI						
Analyzability	1. Ang pagkakasunod-sunod ng proseso ay madaling maunawaan.	✓				
Testability	2. Ang aparato ay automated at kayang gawin ang tatlong pagsusuri na visual acuity, red reflex, at slit-lamp capture na mga pagsusuri..	✓				

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Pangalan: Chumy T. Santos   Trabaho: School Clinic Teacher   Petsa: May 16, 2023

MGA PAHAYAG		Iskor				
		5	4	3	2	1
PAGGANANG ANGKOP						
Pagkakumpleto	1. Ang aparato ay gumagana ayon sa nabanggit na spesipikasyon.	✓				
Kawastuhan	2. Ang aparato ay nagbibigay ng tamang resulta.	✓				
Kaangkupan	3. Nagagawa ng aparato ang tungkulin nito.	✓				
KASANAYAN SA TUNGKULIN NG APARATO						
Oras	1. Mas mabilis ang pagsusuri ng paningin sa aparatong ito kumpara sa tradisyonal na aparato.	✓				
Maayos na paggamit ng resources	2. Ang mga pagsusuri ay nagawa nang tama sa kaunting oras, nang walang sinasayang na resources.	✓				
PAGKAKATUGMA						
Coexistence	1. Ang VR at ang control panel ay gumagana nang walang problema.	✓				
Interoperability	2. Ang VR at ang control panel ay gumagana nang sabay.	✓				
KAKAYAHANG MAGAMIT						
Kakayahang tumuklas	1. Ang aparato ay masasabing instrumento upang makatuklas ng leukocoria at cataract.	✓				
Learnability	2. Madaling maunawaan ang panuto.	✓				
Operability	3. Madaling kontrolin ang aparato.		✓			
User error protection	4. Pinoprotektahan ng aparato ang gumagamit mula sa kamalian.	✓				
Kagandahan ng user interface	5. Ang user interface ay kaaya-aya sa paningin.	✓				
KAKAYAHANG MAASAHAN						
Maturity	1. Kaya ng aparatong magsagawa ng vision screening.	✓				
Kakayahang magamit	2. Maaaring gamitin ang aparato anumang oras.		✓			
Fault tolerance	3. Gumagana ang aparato kahit may software o hardware fault.	✓				
Recoverability	4. Sa oras ng pagpalya, maaaring mabawi ang data sa aparato.	✓				
SEGURIDAD						
Confidentiality	1. Ang data ay maaari lamang makita ng awtorisadong tao.	✓				
Integridad	2. Hindi pinahihintulutan ang hindi awtorisadong pagpasok o pagbago sa data.	✓				
Pananagutan	3. Ang pagbabago sa mga resulta ay nakatala.					
KAKAYAHANG MAPANATILI						
Analyzability	1. Ang pagkakasunod-sunod ng proseso ay madaling maunawaan.	✓				
Testability	2. Ang aparato ay automated at kayang gawin ang tatlong pagsusuri na visual acuity, red reflex, at slit-lamp capture na mga pagsusuri..	✓				

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QUESTIONNAIRE

Ang mga mag-aaral na kalahok sa pag-aaral na ito ay kailangang magsagawa ng sarbey para sa pagsusuri ng iba't-ibang aspeto ng proyektong **"WI-VR: Interactive Virtual Reality Device for Childhood Leukocoria and Pediatric Cataract Detection System"**

Panuto: Markahan ang mga kahon sa ibaba kung sumasang-ayon o hind isa mga nabanggit. Pumili ng isa mula **1** – Lubos na hindi sumasang-ayon **2** – Hindi sumasang-ayon **3** – Hindi alinman sa mga nabanggit **4** – Sumasang-ayon **5** - Lubos na sumasang-ayon

Pangalan: MARIBEL M. CARANDANG Trabaho: NURSE Petsa: 6/15/23

MGA PAHAYAG		Iskor				
		5	4	3	2	1
PAGGANANG ANGKOP						
Pagkakumpleto	1. Ang aparato ay gumagana ayon sa nabanggit na spesipikasyon.	✓				
Kawastuhan	2. Ang aparato ay nagbibigay ng tamang resulta.	✓				
Kaangkupan	3. Nagagawa ng aparato ang tungkulin nito.	✓				
KASANAYAN SA TUNGKULIN NG APARATO						
Oras	1. Mas mabilis ang pagsusuri ng paningin sa aparatong ito kumpara sa tradisyonal na aparato.	✓				
Maayos na paggamit ng resources	2. Ang mga pagsusuri ay nagawa nang tama sa kaunting oras, nang walang sinasayang na resources.	✓				
PAGKAKATUGMA						
Coexistence	1. Ang VR at ang control panel ay gumagana nang walang problema.	✓				
Interoperability	2. Ang VR at ang control panel ay gumagana nang sabay.	✓				
KAKAYAHANG MAGAMIT						
Kakayahang tumuklas	1. Ang aparato ay masasabing instrumento upang makatuklas ng leukocoria at cataract.	✓				
Learnability	2. Madaling maunawaan ang panuto.	✓				
Operability	3. Madaling kontrolin ang aparato.	✓				
User error protection	4. Pinoprotektahan ng aparato ang gumagamit mula sa kamalian.	✓				
Kagandahan ng user interface	5. Ang user interface ay kaaya-aya sa paningin.	✓				
KAKAYAHANG MAASAHAN						
Maturity	1. Kaya ng aparatong magsagawa ng vision screening.	✓				
Kakayahang magamit	2. Maaaring gamitin ang aparato anumang oras.	✓				
Fault tolerance	3. Gumagana ang aparato kahit may software o hardware fault.	✓				
Recoverability	4. Sa oras ng pagpalya, maaaring mabawi ang data sa aparato..	✓				
SEGURIDAD						
Confidentiality	1. Ang data ay maaari lamang makita ng awtorisadong tao.	✓				
Integridad	2. Hindi pinahihintulutan ang hindi awtorisadong pagpasok o pagbago sa data.	✓				
Pananagutan	3. Ang pagbabago sa mga resulta ay nakatala.	✓				
KAKAYAHANG MAPANATILI						
Analyzability	1. Ang pagkakasunod-sunod ng proseso ay madaling maunawaan.	✓				
Testability	2. Ang aparato ay automated at kayang gawin ang tatlong pagsusuri na visual acuity, red reflex, at slit-lamp capture na mga pagsusuri..	✓				

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES
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QUESTIONNAIRE

Ang mga mag-aaral na kalahok sa pag-aaral na ito ay kailangang magsagawa ng sarbey para sa pagsusuri ng iba't-ibang aspeto ng proyektong **"WI-VR: Interactive Virtual Reality Device for Childhood Leukocoria and Pediatric Cataract Detection System"**

Panuto: Markahan ang mga kahon sa ibaba kung sumasang-ayon o hind isa mga nabanggit. Pumili ng isa mula **1** – Lubos na hindi sumasang-ayon **2** – Hindi sumasang-ayon **3** – Hindi alinman sa mga nabanggit **4** – Sumasang-ayon **5** - Lubos na sumasang-ayon

Pangalan: KYLE OLIVEROS Trabaho: JUNIOR DOCTOR Petsa: 6/15/23

MGA PAHAYAG		Iskor 5	4	3	2	1
PAGGANANG ANGKOP						
Pagkakumpleto	1. Ang aparato ay gumagana ayon sa nabanggit na spesipikasyon.		✓			
Kawastuhan	2. Ang aparato ay nagbibigay ng tamang resulta.		✓			
Kaangkupan	3. Nagagawa ng aparato ang tungkulin nito.		✓			
KASANAYAN SA TUNGKULIN NG APARATO						
Oras	1. Mas mabilis ang pagsusuri ng paningin sa aparatong ito kumpara sa tradisyonal na aparato.		✓			
Maayos na paggamit ng resources	2. Ang mga pagsusuri ay nagawa nang tama sa kaunting oras, nang walang sinasayang na resources.		✓			
PAGKAKATUGMA						
Coexistence	1. Ang VR at ang control panel ay gumagana nang walang problema.		✓			
Interoperability	2. Ang VR at ang control panel ay gumagana nang sabay.		✓			
KAKAYAHANG MAGAMIT						
Kakayahang tumuklas	1. Ang aparato ay masasabing instrumento upang makatuklas ng leukocoria at cataract.		✓			
Learnability	2. Madaling maunawaan ang panuto.		✓			
Operability	3. Madaling kontrolin ang aparato.		✓			
User error protection	4. Pinoprotektahan ng aparato ang gumagamit mula sa kamalian.		✓			
Kagandahan ng user interface	5. Ang user interface ay kaaya-aya sa paningin.		✓			
KAKAYAHANG MAASAHAN						
Maturity	1. Kaya ng aparatong magsagawa ng vision screening.		✓			
Kakayahang magamit	2. Maaaring gamitin ang aparato anumang oras.		✓			
Fault tolerance	3. Gumagana ang aparato kahit may software o hardware fault.		✓			
Recoverability	4. Sa oras ng pagpalya, maaaring mabawi ang data sa aparato..		✓			
SEGURIDAD						
Confidentiality	1. Ang data ay maaari lamang makita ng awtorisadong tao.		✓			
Integridad	2. Hindi pinahihintulutan ang hindi awtorisadong pagpasok o pagbago sa data.		✓			
Pananagutan	3. Ang pagbabago sa mga resulta ay nakatala.		✓			
KAKAYAHANG MAPANATILI						
Analyzability	1. Ang pagkakasunod-sunod ng proseso ay madaling maunawaan.		✓			
Testability	2. Ang aparato ay automated at kayang gawin ang tatlong pagsusuri na visual acuity, red reflex, at slit-lamp capture na mga pagsusuri..		✓			

APPENDIX C

Project Documentation

Deployment in various clinics (Upper Left to Right: Asian Hospital, Medical Center Taguig; Lower Left to Right: Prenza Elementary School, Medical Center Taguig)

Deployment in various clinics (Upper Left to Right: Asian Hospital, Taguig Pateros District Hospital; Lower Left to Right: Medical Center Taguig)

Initial Consultation at De Lasalle, Dasmariñas, Cavite

APPENDIX D

Program Codes

MOBILE APP (WE-VR Controls)

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android">

    <uses-permission android:name="android.permission.ACCESS_NETWORK_STATE"
/>
    <uses-permission android:name="android.permission.INTERNET" />

    <application
        android:allowBackup="true"
        android:icon="@drawable/app_logo"
        android:label="WEVR Controls"
        android:roundIcon="@drawable/app_logo"
        android:supportsRtl="true"
        android:theme="@style/Theme.WEVRControls" >
        <activity
            android:name=".VisualAcuityLeftNew"
            android:exported="true" />
        <activity
            android:name=".ResultREright"
            android:exported="true" />
        <activity
            android:name=".ResultREleft"
```

```
    android:exported="true" />
<activity
    android:name=".HelperMain"
    android:exported="true" >
</activity>
<activity
    android:name=".MainActivity2"
    android:exported="true" />
<activity
    android:name=".SearchPatient"
    android:exported="true" />
<activity
    android:name=".RefractiveErrorRight"
    android:exported="true" />
<activity
    android:name=".VisualAcuityRight"
    android:exported="true" />
<activity
    android:name=".VisualAcuityRightNew"
    android:exported="true" >
</activity>
<activity
    android:name=".ResultRED"
```

```
    android:exported="true" />
<activity
    android:name=".ResultLRT"
    android:exported="true" />
<activity
    android:name=".ResultVAT"
    android:exported="true" />
<activity
    android:name=".OverallResult"
    android:exported="true" />
<activity
    android:name=".AboutTeam"
    android:exported="true" />
<activity
    android:name=".AboutLaw"
    android:exported="true" />
<activity
    android:name=".AboutDevice"
    android:exported="true" />
<activity
    android:name=".UserProfile"
    android:exported="true" />
<activity
```

```
    android:name=".Header"
    android:exported="true" />
<activity
    android:name=".Dashboard"
    android:exported="true" >

</activity>
<activity
    android:name=".PatientProfile"
    android:exported="true" />
<activity
    android:name=".VisualAcuityLeft"
    android:exported="true" />
<activity
    android:name=".LightReflex"
    android:exported="true" />
<activity
    android:name=".RefractiveErrorLeft"
    android:exported="true" />
<activity
    android:name=".ResetPassword"
    android:exported="true" />
<activity
```

```
            android:name=".Login"
            android:exported="true" />
        <activity
            android:name=".SignUp"
            android:exported="true" />
        <activity
            android:name=".Connect"
            android:exported="true" />
        <activity
            android:name=".MainActivity"
            android:exported="true" >
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />

                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
    </application>

</manifest>
```

Visual Acuity Test (VA Application)

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using Proyecto26;
using UnityEngine.SceneManagement;

public class ChangeScene : MonoBehaviour
{
    public static int VAcommand;
  //  public Text vacom;



    void Update()
    {
        RestClient.Get<UserScene>("https://wevr-controls-db815-default-rtdb.asia-
southeast1.firebasedatabase.app/" + "VAscore/" + "Command" + ".json").Then(response
=>
        {
            UserScene user = new UserScene();
            user = response;
```

```
            VAcommand = user.VAcommand;
            //  vacom.text = VAcommand.ToString();
            if (VAcommand == 10)
            {
                Application.Quit();
                Debug.Log("Has quit");
            }
            else if (VAcommand > 0)
            {
                SceneManager.LoadScene("Line" + VAcommand);
            }



        });


    }
    public void setValue()
    {
        VAcommand = 10;
        UserScene user = new UserScene();
        RestClient.Put("https://wevr-controls-db815-default-rtdb.asia-
southeast1.firebasedatabase.app/" + "VAscore/" + "Command" + ".json", user);
    }
```

```
    public void Exit()
    {
        Invoke("setValue", 2);
    }

}
```

For every line (USER),

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using System;


[Serializable]
public class L1User
{
    public string L1score;



    public L1User()
    {
        L1score = L1Score.L1res;
```

```
    }

}
```

For every line (CS),

```
using Proyecto26;
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class L1CS : MonoBehaviour
{
    public static int VAcommand;
    //  public Text vacom;



    void Update()
    {
        RestClient.Get<UserScene>("https://wevr-controls-db815-default-rtdb.asia-
southeast1.firebasedatabase.app/" + "VAscore/" + "Command" + ".json").Then(response
=>
        {
```

```
            UserScene user = new UserScene();
            user = response;
            VAcommand = user.VAcommand;
            //  vacom.text = VAcommand.ToString();
            if (VAcommand == 10)
            {
                Application.Quit();
                Debug.Log("Has quit");
            }
            else if (VAcommand == 1)
            {
                Debug.Log("Retain scene");
            }
            else
            {
                SceneManager.LoadScene("Line" + VAcommand);
            }

        });

    }
}
```

For every line (SCORE),

```
using Proyecto26;
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;
using UnityEngine.UI;


public class L1Score : MonoBehaviour
{
    public GameObject border;
    public Renderer borderRenderer;
    public Text scoreText;
    public static string L1res;
    public static int VAcommand, VArecord;
    // Start is called before the first frame update
    public void scoreL1()
    {
        string result = scoreText.text;
        if (result.Contains("h v z d s") || result.Contains("v h z d s") || result.Contains("z h v
d s") || result.Contains("d h v z s") || result.Contains("s h v z d")
            || result.Contains("h z v d s") || result.Contains("v z h d s") || result.Contains("z v h
d s") || result.Contains("d z h v s") || result.Contains("s z h v d")
```

```
            || result.Contains("h v d z s") || result.Contains("v h d z s") || result.Contains("z h v s d") || result.Contains("d h v s z") || result.Contains("s h v d z")
            || result.Contains("h v s z d") || result.Contains("v h s z d") || result.Contains("z h v s d") || result.Contains("d h v z s") || result.Contains("s h v d z")
            || result.Contains("h z d v s") || result.Contains("v z d h s") || result.Contains("z v d h s") || result.Contains("d v h z s") || result.Contains("s v h z d")
            || result.Contains("h z s v d") || result.Contains("v z s h d") || result.Contains("z v s h d") || result.Contains("d v h s z") || result.Contains("s v h d z")
            || result.Contains("h d v z s") || result.Contains("v d h z s") || result.Contains("z d h v s") || result.Contains("d h v s z") || result.Contains("s h v z d")
            || result.Contains("h d s z v") || result.Contains("v d s h z") || result.Contains("z d s h v") || result.Contains("d v h s z") || result.Contains("s v h d z"))
        {
            L1res = "passed";
        }
        else
        {
            L1res = scoreText.text;
        }
        L1User user = new L1User();
        RestClient.Put("https://wevr-controls-db815-default-rtdb.asia-southeast1.firebasedatabase.app/" + "VAscore/" + "L1" + ".json", user);
        borderRenderer = border.GetComponent<Renderer>();
```

```
        borderRenderer.material.color = Color.blue;
        Debug.Log("Has uploaded result");


    }


    public void Upload()
    {
        Invoke("scoreL1", 2);
        Invoke("PointerExit", 3);
    }
    public void PointerExit()
    {
        borderRenderer = border.GetComponent<Renderer>();
        borderRenderer.material.color = Color.white;
    }



        // Update is called once per frame
    void Update()
    {
        RestClient.Get<UserScene>("https://wevr-controls-db815-default-rtdb.asia-
southeast1.firebasedatabase.app" + "VAscore/" + "Command" + ".json").Then(response
=>
```

```
        {
            UserScene scene = new UserScene();
            scene = response;
            VAcommand = scene.VAcommand;
            if (VAcommand == 10)
            {
                Application.Quit();
                Debug.Log("Has quit");
            }
            else if (VAcommand > 1 | VAcommand < 1)
            {
                SceneManager.LoadScene("Line" + VAcommand);
            }

        });
        RestClient.Get<RecordCommand>("https://wevr-controls-db815-default-rtdb.asia-
southeast1.firebasedatabase.app" + "VAscore/" + "Record" + ".json").Then(response =>
        {
            RecordCommand record = new RecordCommand();
            record = response;
            VArecord = record.VArecord;
            if (VArecord == 2)
            {
```

```
        Upload();

      }

    });
  }
}
```

Raspberry Pi Code (for SLCT CAPTURE)

```
import pymysql
import picamera
import datetime
import time
```

```
import os
os.chdir("/home/pi/Desktop/SLCT (Leukocoria) Images")#Enter the path where the
images needs to be stored
pymysql.install_as_MySQLdb()
import MySQLdb
import RPi.GPIO as GPIO

# Input your phpMyAdmin database credentials
db = MySQLdb.connect(host="", user="", passwd="*", db="")

# prepare a cursor object using cursor() method
cursor = db.cursor()

# prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO SLCT_Leukocoria (id, timestamp, image) VALUES (NULL, %s,
%s)"""
# Set GPIO mode and pin
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
led_pin = 17
GPIO.setup(led_pin, GPIO.OUT)

# Create a Camera object
```

```
camera = picamera.PiCamera()

# Capture 2 images
for i in range(1):
    # Create a timestamp for the image filename
    timestamp = datetime.datetime.now().strftime('%Y-%m-%d %H:%M:%S')

    # Turn on LED
    GPIO.output(led_pin, GPIO.HIGH)



    # Capture image
    camera.capture(timestamp + '.jpg')

    # Turn off LED
    GPIO.output(led_pin, GPIO.LOW)

    # Open image file and read data
    with open(timestamp + '.jpg', 'rb') as f:
        image_data = f.read()

    try:
        # Execute the SQL command
```

```
        cursor.execute(sql, (timestamp, image_data))
        # Commit changes to the database
        db.commit()
        print("Image saved and uploaded to database")
    except:
        # Rollback in case there is any error
        db.rollback()
        print("Error: Unable to upload image to database")

    # Sleep for 5 seconds
    time.sleep(5)

# Clean up the camera and GPIO resources
camera.close()
GPIO.cleanup()

# Close database connection
db.close()
```

Raspberry Pi Code (for RRT CAPTURE)

```
import pymysql
import picamera
import datetime
import time
```

```
import os
os.chdir("/home/pi/Desktop/RRT Images")#Enter the path where the images needs to be
stored
pymysql.install_as_MySQLdb()
import MySQLdb
import RPi.GPIO as GPIO

# Input your phpMyAdmin database credentials
db = MySQLdb.connect(host="", user="", passwd="*", db="")

# prepare a cursor object using cursor() method
cursor = db.cursor()

# prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO RRT (id, timestamp, image) VALUES (NULL, %s, %s)"""

# Set GPIO mode and pin
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
led_pin = 17
GPIO.setup(led_pin, GPIO.OUT)

# Create a Camera object
```

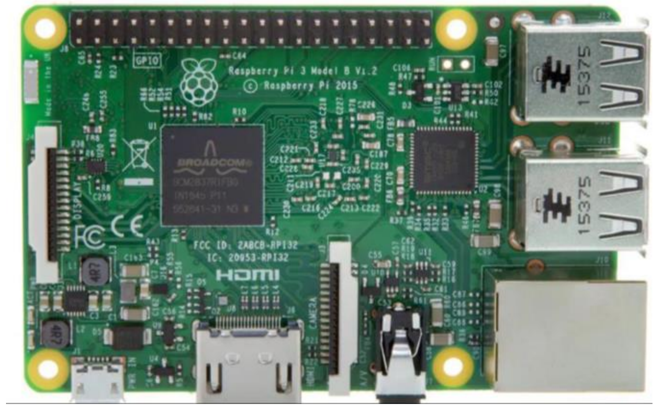
```
camera = picamera.PiCamera()


# Capture 2 images
for i in range(1):
    # Create a timestamp for the image filename
    timestamp = datetime.datetime.now().strftime('%Y-%m-%d %H:%M:%S')


    # Turn on LED
    GPIO.output(led_pin, GPIO.HIGH)


    # Capture image
    camera.capture(timestamp + '.jpg')


    # Turn off LED
    GPIO.output(led_pin, GPIO.LOW)


    # Open image file and read data
    with open(timestamp + '.jpg', 'rb') as f:
        image_data = f.read()
    try:
        # Execute the SQL command
        cursor.execute(sql, (timestamp, image_data))
        # Commit changes to the database
```

```
        db.commit()
        print("Image saved and uploaded to database")
    except:
        # Rollback in case there is any error
        db.rollback()
        print("Error: Unable to upload image to database")

    # Sleep for 5 seconds
    time.sleep(5)

# Clean up the camera and GPIO resources
camera.close()
GPIO.cleanup()

# Close database connection
db.close()
```

APPENDIX E

Data Sheet

Raspberry Pi 3 Model B



Raspberry Pi 3 Model B is the earliest model of the third-generation Raspberry Pi. It replaced Raspberry Pi 2 Model B in February 2016.

Quad Core 1.2GHz Broadcom BCM2837 64bit CPU

1GB RAM

BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board

100 Base Ethernet

40-pin extended GPIO

4 USB 2 ports

4 Pole stereo output and composite video port

Full size HDMI®

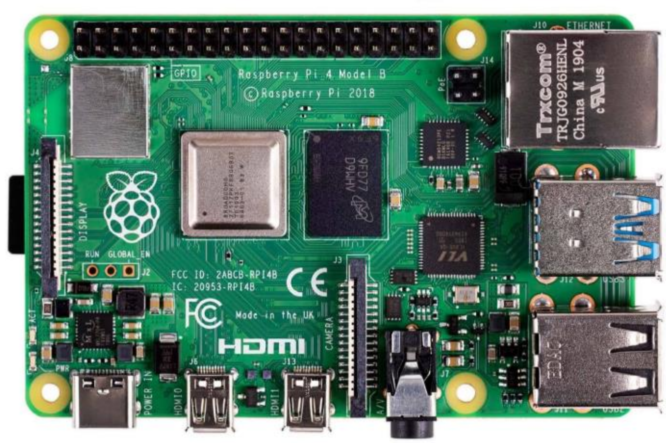
CSI camera port for connecting a Raspberry Pi camera

DSI display port for connecting a Raspberry Pi touchscreen display

Micro SD port for loading your operating system and storing data

Upgraded switched Micro USB power source up to 2.5A

Raspberry Pi 4 Model B



Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.8GHz

1GB, 2GB, 4GB or 8GB LPDDR4-3200 SDRAM (depending on model)

2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE

Gigabit Ethernet

2 USB 3.0 ports; 2 USB 2.0 ports.

Raspberry Pi standard 40 pin GPIO header (fully backwards compatible with previous boards)

2 × micro-HDMI® ports (up to 4kp60 supported)

2-lane MIPI DSI display port

2-lane MIPI CSI camera port

4-pole stereo audio and composite video port

H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)

OpenGL ES 3.1, Vulkan 1.0

Micro-SD card slot for loading operating system and data storage

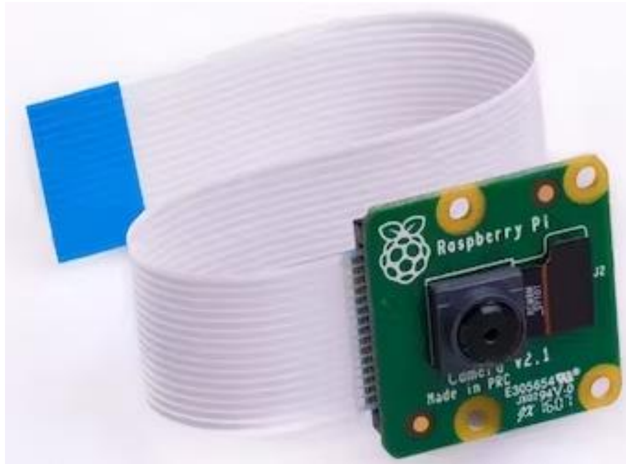
5V DC via USB-C connector (minimum 3A*)

5V DC via GPIO header (minimum 3A*)

Power over Ethernet (PoE) enabled (requires separate PoE HAT)

Operating temperature: 0 – 50 degrees C ambient

Raspberry Pi Camera Module 2



Official Raspberry Pi Camera Board, supports Raspberry Pi, CM3/3+/4,

Jetson Nano, Jetson Xavier NX

IMX219 8-megapixel sensor

Camera specifications

CCD size : 1/4inch

Aperture (F) : 2.0

Focal Length : 3.04mm

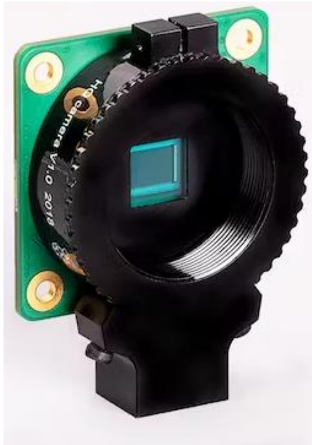
Angle of View (diagonal) : 62.2 degree

3280 × 2464 still picture resolution

Support 1080p30, 720p60 and 640x480p90 video record

Dimension: 25mm × 24mm × 9mm

Raspberry Pi High Quality Camera



Sony IMX477R stacked, back-illuminated sensor, 12.3 megapixels, 7.9 mm sensor diagonal, 1.55 μm × 1.55 μm pixel size

Output: RAW12/10/8

Back focus length of lens: 2.6mm–11.8mm (M12 Mount variant), 12.5mm–22.4mm (CS Mount variant)

Lens sensor format: 1/2.3” (7.9mm) or larger

IR cut filter: Integrated

Ribbon cable length: 200 mm

Tripod mount: 1/4”-20

16mm Telephoto Lens for Raspberry Pi HQ Camera CS

Image format: 1"

Focal length: 16mm

Resolution: 3 MegaPixels

Aperture: F1.4-16

Mount: C

Field Angle:

1": 44.6°× 33.6°

2/3": 30.0°× 23.2°

1/1.8": 24.7°× 18.6°

1/2": 21.8°× 16.4°

Back Focal Length: 17.53mm

Optical Length: 67.53mm

M.O.D.: 0.20m

Dimension: 39×50mm

Weight: 133.7g

Operation: Manual

APPENDIX F

Deployment Data

VISUAL ACUITY TEST DATA

The provided table below shows the results of the visual acuity test for the initial 10 samples. Additionally, it presents a comparison between the results obtained from the device and the clinical test done using the LEA Symbol Chart.

Visual Acuity (logMAR)		
Sample No.	**WE-VR**	**Clinical**

1	0	0.1
2	0	0.1
3	0.5	0.5
4	0.8	0.8
5	0.3	0.3
6	0.3	0.2
7	0.4	0.8
8	0.5	0.5
9	0.4	0.3
10	0.4	0.3

Sample 1	EyeMax
Sample 2	Clinical

	Sample 1	Sample 2
Sample size	10	10
Lowest value	0.0000	0.1000
Highest value	0.8000	0.8000
Median	0.4000	0.3000
95% CI for the median	0.1425 to 0.5000	0.1475 to 0.6575
Interquartile range	0.3000 to 0.5000	0.2000 to 0.5000

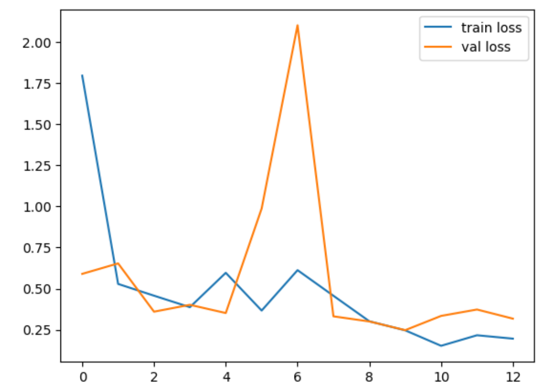
Hodges-Lehmann median difference	0.0000
95% Confidence interval	-0.05000 to 0.1500

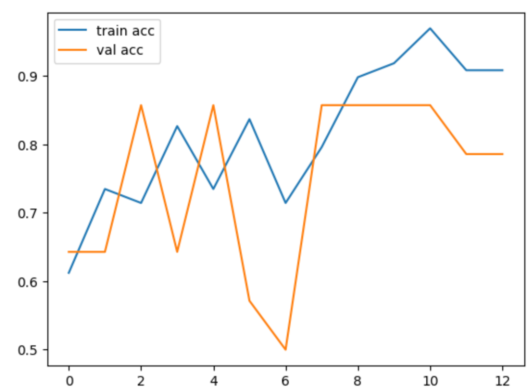
Wilcoxon test (paired samples)

Number of positive differences	3
Number of negative differences	3
Test statistic Z	-0.333333
Two-tailed probability	P = 0.7389

To summarize, according to figure 41, the two-tailed probability (P) is 0.7389, which exceeds the significance level of 0.05. Consequently, we must accept the null hypothesis. The median of the paired differences in the population is nearly zero. This indicates that the visual acuity test utilizing WE-VR is accurate, acceptable, and satisfactory.

SLIT LAMP CAPTURE TEST (SLCT) TEST DATA

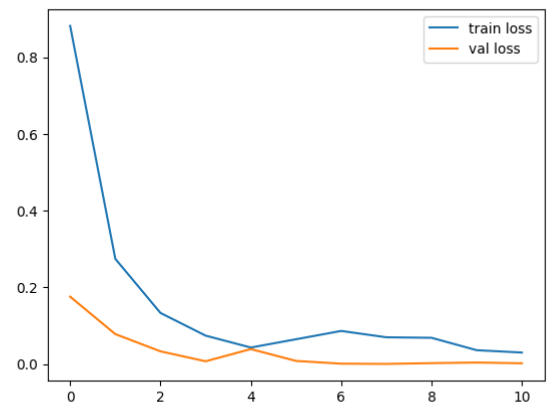


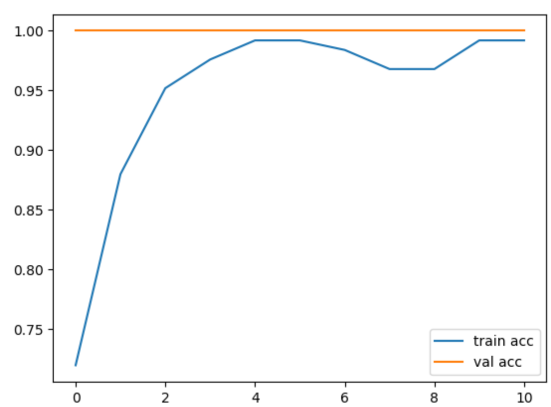



```
2/2 [==============================] - 0s 89ms/step
Confusion Matrix
[[4 1]
 [2 5]]
Classification Report
              precision    recall  f1-score   support

    cataract       0.67      0.80      0.73         5
      normal       0.83      0.71      0.77         7

    accuracy                           0.75        12
   macro avg       0.75      0.76      0.75        12
weighted avg       0.76      0.75      0.75        12

1/1 [==============================] - 2s 2s/step - loss: 0.4233 - accuracy: 0.7500
Accuracy:  0.75
Loss:  0.4232929050922394
```

More information on each class's precision, recall, and F1-score is provided in the classification report. The "cataract" class has a precision of 0.67, meaning that most predicted "cataract" samples are correct. Recall is 0.80, which indicates that a sizable number of "cataract" samples are being identified by the model. Precision and recall are both quite high for the "normal" class, with respective values of 0.83 and 0.71. Both classes' F1-scores are also fairly high, demonstrating a reasonable balance between recall and precision.

RED REFLEX CAPTURE TEST (SLCT) TEST DATA





```
2/2 [==============================] - 3s 3s/step
Confusion Matrix
[[11  0]
 [ 0  5]]
Classification Report
              precision    recall  f1-score   support

    cataract       1.00      1.00      1.00        11
      normal       1.00      1.00      1.00         5

    accuracy                           1.00        16
   macro avg       1.00      1.00      1.00        16
weighted avg       1.00      1.00      1.00        16

1/1 [==============================] - 3s 3s/step - loss: 0.0117 - accuracy: 1.0000
Accuracy:  1.0
Loss:  0.01174244936555624
```

The classification report provides more evidence of the model's excellent performance, with precision, recall, and an F1-score of 1.00 for both classes. This proves the model correctly predicts every instance of both classes. The model's total accuracy is 1.0, which is the maximum level of accuracy. The model's training performance appears to be excellent with minimal errors, as indicated by the low loss value of 0.0117.

APPENDIX G

Informed Consent

To: Anna Richie A. Quilatan, MD, MSHSM
Chief of Hospital
Taguig Pateros District Hospital

Thru: Ronnel S. Matibag, MD
Chairman, Hospital Ethics Committee

Timoteo Neil I. Trinidad, MD
Chairman, Professional Research & Training

Leila C. Bondoc, MD
Chairman, Data Privacy Committee

Leila C. Bondoc, MD
Medico-Legal Officer
Lic. No. 94196

6 · 8 · 23

Introduction

The Philippines is globally recognized for having one of the highest rates of cataracts, which are responsible for approximately 51% of cases of blindness and affect approximately 2.5 million Filipinos. The early detection, diagnosis, and treatment of pediatric cataracts and cataract-induced childhood leukocoria are essential in ensuring favorable outcomes for affected individuals. This is attributed not solely to the decrease in the likelihood of loss of visual acuity, but also to the subsequent improvement in the patient's quality of life after receiving treatment. To aid with diagnostic gaps, where patients go undiagnosed due to a lack of access to diagnostic tools and healthcare services, a detection device is developed. The device consists of three eye tests: visual acuity test, which uses Virtual Reality (VR) technology of an eye chart to test how well a patient can see from a specific distance; slit-lamp capture test (SLCT), which captures a dilated pupil by burst and macro photography without the use of dilating eye drops; and the red-reflex test (RRT), using flash photography to induce a red-orange (normal) or white reflex (abnormal) observed in the reflection of the retina. The captured images from the SLCT and RRT will undergo classification using a Convolutional Neural Network (CNN) model to determine the presence of cataract and leukocoria, respectively.

Statement of the Problem

General Objective:

The objective of the study was to develop a compact, child-friendly, and cost-effective device for the early detection of pediatric cataracts and cataract-induced childhood leukocoria, addressing diagnostic gaps caused by limited access to healthcare services and diagnostic tools in underserved areas of the country.

Specific Objectives:

The specific objectives of this study are:

1. To develop an adjustable and interactive virtual reality device which employs slit lamp capture test, visual acuity test and red reflex capture test.
2. To develop a machine learning model for the captured image from the red reflex capture test and slit lamp capture test using CNN.

Anna Richie A/Quilatan, M.D.
TPDH Chief of Hospital

3. To develop a 3D app simulation of visual acuity test for the mobile VR, an application for the control panel of the system, and a web application to present the results of the mentioned eye tests.
4. To test and evaluate the device's operability and accuracy in accordance with the ISO/IEC 25010 standards.

Questionnaire to be used on data gathering

Attached is a copy of the Evaluation (ISO/IEC 25010) Form

Attached is a copy of the Consent Form

Finances

The amount spent in developing the device–*WE-VR* is approximately Php 65,000.

Others

- **Number of Patients needed:** 10-20 Patients
- **Age range:** The device can be used for all ages
- **Target Date for data gathering:** June 14 - 15

Pahintulot ng pasyente para sa medikal na larawan kuha gamit ang isang "modified camera"

Kami ay sina

Jullienne Mae E. Celso (Project Lead)
Shaina Nicole S. Tan (Software and Hardware Developer)
Sophia Mae B. Sy (Software and Hardware Developer)

Kami ay Engineering students mula sa Technological University of the Philippines, na gumawa ng produkto na may layunin na tuklasin kung ang isang tao ay mayroong puti sa balintataw o "pupil" na maaring dulot ng katarata, bukol sa mata, peklat sa kornea, o iba pang sakit. Ang mga kondisyon na ito ay maaaring magdulot ng pagkalabo ng mata at maaaring hindi agad mapansin kung hindi magpatingin sa doktor. Inaasahan namin na ang produkto na ito ay magagamit para sa pagsuri kung sino ang mga pasyente na may problema sa mata at kailangang pumunta sa doktor.

Nais naming suriin kung ang produkto namin, na isang "modified camera", ay makakatuklas ng "leukocoria" o puti sa balintataw. Kayo ay inaanyayahang makilahok sa pagsusuri na ito dahil kayo ay may puti sa balintataw dahil sa isang medikal na kondisyon.

Ano ang kailangan ninyo gawin? Kailangan lang namin kuhanan ng litrato ang inyong mga mata gamit ang aming "modified camera". Ito ay may ilaw o "flash" na maaaring makasilaw ng pansamantala. Ang ilaw ay gawa sa LED at ito ay may 100 -110 lumens na lakas. Ang ganitong ilaw ay kasing liwanag ng regular na flashlight at hindi higit na maliwanag sa ilaw ng "slit lamp" na siyang ginamit ng doktor upang tignan ang inyong mata. Ang pagkuha ng litrato ay tatagal lamang ng 1 segundo, at maaaring kumuha ng 2 hanggang 3 litrato.

Ang resulta ng pagsusuri na ito ay gagamitin namin upang ayusin at gumawa ng "improvements" sa aming produkto. Maaari din po namin gamitin ang inyong litrato sa presentasyon ng aming thesis o sa publikasyon sa siyentipikong peryodiko o aklat sa hinaharap. Kailanman ay hindi po namin ibibigay ang inyong pangalan or personal na impormasyon sa kahit sino. Wala pong ibang parte ng mukha na kukuhanan ng litrato at ito ay hindi po magagamit upang kayo ay makilala.

Sa pagpirma sa ibaba ng kasulatang ito, ako, si ______________________________, ay nagpapatunay
(Pangalan ng nagbigay ng pahintulot)

na naipaliwanag sa akin ang kasulatan ng pahintulot na ito ni ______________________________, sa mga
(Taong kumukuha ng pahintulot)

kondisyong nauunawaan ko.

Pinahihintulutan ko na makuhanan ng larawang medikal na gagawin sa:

- o akin
- o aking anak
- o aking alaga na ako ang legal na tagapag-alaga

para sa

- pagsusuri sa produkto na ginawa ng mga Engineering students para sa kanilang thesis
- presentasyon ng litrato sa mga siyentipikong pagpupulong
- publikasyon sa siyentipikong peryodiko o aklat sa hinaharap
- iba pang layuning nakasaad dito

Nauunawaan kong hindi ako makakatanggap ng kabayaran mula sa anumang partido.

Ang pagtanggi sa pagbibigay ng pahintulot sa mga larawan ay hindi makakaapekto sa anumang paraan sa medikal na pangangalaga na matatanggap ko, ng aking anak, o alaga.

____

(Pirma sa ibabaw ng insinatiktik na pangalan ng nagbigay ng pahintulot)

____

(Kaugnayan sa pasyente ng nagbigay ng pahintulot)

____

(Pangalan ng doktor o kinatawan na kumukuha ng pahintulot)

Para sa mga pasyenteng ang edad ay sa pagitan ng 7 at 18 taon, ang pirma sa ibaba ay nagpapatunay na ang kasulatan ng pahintulot ay naipaliwanag sa akin sa mga salitang naiintindihan ko, at sumasang-ayon ako na gamitin ang aking larawan gaya ng nabanggit sa itaas

____

(Pirma sa ibabaw ng isinatiktik na Pangalan ng Pasyente)

____

(Pirma sa ibabaw ng isinatiktik na pangalan ng saksi)

____

(Pirma sa ibabaw ng isinatiktik na pangalan ng taong nagpaliwanag pahintulot; ilagay ang opisyal na designasyon)

Pahintulot ng pasyente para sa medikal na larawan kuha gamit ang isang "modified camera"

Kami ay sina Jeyfrel Austin Celi, Jullienne Mae Celso, John Daniel Dayawon, Sophia Mae Sy, at Shaina Nicole Tan.

Kami ay Engineering students mula sa Technological University of the Philippines na gumawa ng produkto na may layunin na tuklasin kung ang isang tao ay mayroong puti sa balintataw o "pupil" na maaring dulot ng katarata, bukol sa mata, peklat sa kornea, o iba pang sakit. Ang mga kondisyon na ito ay maaaring magdulot ng pagkalabo ng mata at maaaring hindi agad mapansin kung hindi magpatingin sa doktor. Inaasahan namin na ang produkto na ito ay magagamit para sa pagsuri kung sino ang mga pasyente na may problema sa mata at kailangang pumunta sa doktor.

Nais naming suriin kung ang produkto namin, na isang "modified camera", ay makakatuklas ng "leukocoria" o puti sa balintataw. Kayo ay inaanyayahang makilahok sa pagsusuri na ito dahil kayo ay may puti sa balintataw dahil sa isang medikal na kondisyon.

Ano ang kailangan ninyo gawin? Kailangan lang namin kuhanan ng litrato ang inyong mga mata gamit ang aming "modified camera". Ito ay may ilaw o "flash" na maaaring makasilaw ng pansamantala. Ang ilaw ay gawa sa LED at ito ay may 100 -110 lumens na lakas. Ang ganitong ilaw ay kasing liwanag ng regular na flashlight at hindi higit na maliwanag sa ilaw ng "slit lamp" na siyang ginamit ng doktor upang tignan ang inyong mata. Ang pagkuha ng litrato ay tatagal lamang ng 1 segundo, at maaaring kumuha ng 2 hanggang 3 litrato.

Bukod dito, ang aming produkto ay mayroon ring "visual acuity chart," na aming nais suriin. Ito ay katulad ng chart na matatagpuan sa klinika ng doktor sa mata. Kukuhanan namin ang inyong "visual acuity" o ang pinakamaliit na liny ana inyong kayang basahin sa pamamagitan ng aming chart. Ito ay tatagal lamang ng lima hangggang sampung minuto.

Ang resulta ng pagsusuri na ito ay gagamitin namin upang ayusin at gumawa ng "improvements" sa aming produkto. Maaari din po namin gamitin ang inyong litrato sa presentasyon ng aming thesis o sa publikasyon sa siyentipikong peryodiko o aklat sa hinaharap. Kailanman ay hindi po namin ibibigay ang inyong pangalan or personal na impormasyon sa kahit sino. Wala pong ibang parte ng mukha na kukuhanan ng litrato at ito ay hindi po magagamit upang kayo ay makilala.

Sa pagpirma sa ibaba ng kasulatang ito, ako, si ______________________________, ay nagpapatunay
(Pangalan ng nagbigay ng pahintulot)

na naipaliwanag sa akin ang kasulatan ng pahintulot na ito ni ______________________________, sa mga
(Taong kumukuha ng pahintulot)

kondisyong nauunawaan ko.

☐ Pinahihintulutan ko na makuhanan ng larawang medikal na gagawin sa:

- akin
- aking anak
- aking alaga na ako ang legal na tagapag-alaga

APPENDIX H

WE-VR User Manual

EYEMAX

USER'S MANUAL

VERSION 1.0

WE-VR

INTERACTIVE VIRTUAL REALITY DEVICE FOR CHILDHOOD LEUKOCORIA ND PEDIATRIC CATARACT DETECTION SYSTEM

AUGUST 2023

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PRODUCT DESCRIPTION

The WE-VR device aims to develop an interactive virtual reality system for detecting childhood leukocoria and pediatric cataracts in Filipino children. The system includes three eye tests: visual acuity, slit-lamp capture, and red reflex capture. The project utilizes technologies such as head-mounted virtual reality, web application development, and image processing with a convolutional neural network (CNN).

Figure 1 WE-VR Device

PURPOSE OF THE DEVICE

The objective of the WE-VR device is to enhance the current vision screening kit offered by the Philippine Eye Research Institute (PERI) by providing a device that is superior in terms of quality, affordability, and user-friendliness. It focuses on helping people in communities without access to healthcare by identifying and addressing vision problems early on. This ensures timely support and intervention for those affected, with efficient

screening and referral processes in place. The goal is to provide necessary eyecare assistance to those who need it.

The installation kit contains a SD card that includes the August 2023 versions of APKs that are needed to be installed to the devices to access the VR application for the Visual Acuity Test:

WE-VR INSTALLATION KIT	
ETDRS Chart	Application (APK)
WE-VR Controls	Application (APK)

Table 1 Applications Included in the SD Card

QR code is also provided below which will redirect to the google drive link that includes the applications. This is to ensure that you can access the latest version of the applications in case there are updates made.

Figure 2 QR codes for the Applications

Installation of APK from the SD Card on Phone:

To install an APK file from an SD card, you can follow these steps:

1. Prepare your SD card: Insert the SD card into your device's SD card slot or use an SD card adapter to connect it to your device.
2. Enable installation from unknown sources: By default, Android devices block the installation of apps from unknown sources for security reasons. To install an APK file from an SD card, you need to enable this option. Open the Settings app on your Android device, then navigate to "Security" or "Privacy" (the exact location may vary depending on your device and Android version). Look for the option called "Unknown sources" or "Install unknown apps." Tap on it and toggle the switch to enable installation from unknown sources.
3. Use a file manager app to locate the APK file on the SD card.
4. Tap the APK file to start the installation process.

5. The installation process will take a few moments. Once the installation is finished, you'll see a confirmation message stating that the app has been successfully installed.
6. Disable installation from unknown sources for security reasons.

Installation of APK from QR Code and Google Drive Link on Phone:

Installing an APK (Android Application Package) file from a QR code linked to a Google Drive file allows you to install apps on your Android phone. Follow the steps below to install an APK from a QR code and Google Drive link:

1. Open the QR code scanner app on your phone. Use the QR code scanner app to scan the QR code associated with the Google Drive link. On the Google Drive page, tap the "Download" button to begin downloading the APK file to your phone.
2. On your Android phone, navigate to "Settings" and select "Security" or "Privacy" (the name may vary depending on your phone).
3. Look for the "Unknown Sources" option and toggle it to enable. This allows installation from sources other than the Play Store.
4. After the download is complete, open the "File Manager" app on your phone. This app allows you to navigate and manage files on your device. Locate the downloaded APK file in the file manager app.
5. Tap on the APK file to initiate the installation process.
6. A prompt will appear, asking for your confirmation to install the app.
7. Tap on the "Install" button to proceed with the installation.
8. The installation process may take a few moments. Once completed, you can now find and launch the installed app on your phone's app drawer or home screen.
9. Grant any necessary permissions that the app may require.

To establish an internet connection, follow the instructions below:

1. Power on your device and select the "Settings" option to access the network settings menu.
2. Within the network settings menu, locate the "Wi-Fi" option. Tap on it to proceed.
3. You should now see a list of available Wi-Fi networks in your vicinity. Select your desired network from the list.
4. After establishing an internet connection, you can proceed to access the three tests: the visual acuity test, slit-lamp capture test, and red reflex test.

Note: For the *visual acuity test* applications to work simultaneously, ensure that both of the phones are connected to the same network.

Visual Acuity Test

Ensure that both of the devices are connected to the internet. Launch the ETDRS Chart and WE-VR Controls applications on both devices.

For ETDRS Chart application:

1. Make sure that the orientation and view of the patient is fixed on the chart.
2. Wait for the other device which contains the controls to settle and connect on the phone where the ETDRS chart is installed.

For WE-VR Controls application:

1. Using the application for controls, click the *sign up* button in order to create an account. If you have an account, enter the credentials and then click sign in.
2. Choose Visual Acuity Test from the options.
3. Enter the information of the patient such as the full name, age, school, and address.
4. Click the “Start Visual Acuity Test” button.

While using both of the applications simultaneously:

1. There will be an instruction that states that the left eye should be tested first. On the device, choose the lens holder that covers the right side of the eye.
2. Click the start button and let the patient read lines of the letters shown in the VR application.
3. On the controls, click on each letter that the patient has said correctly. Don't do anything on the ones that are wrong.
4. Click next after each line and tap finish when the last line is reached.
5. Click the "Get Line Results" to see if the patient passed or failed each line of the test.
6. Do instructions 3-5 for the right side of the side. Make sure to switch the lens holder to the ones that cover the left eye.
7. After testing both of the eyes, the complete test results will be shown. This includes the patient's name, visual acuity using logMAR values for each eye, and the recommendation.

Slit-Lamp Capture Test (SLCT) and Red Reflex Test (RRT)

1. Ensure that both the Raspberry Pi board and the device you plan to use for remote access are connected to the same network, such as a pocket Wi-Fi.
2. Enable the VNC server on the Raspberry Pi board.
3. On the device you want to use for remote access, open the VNC Client application.
4. In the VNC Client application, locate the IP address of the Raspberry Pi board by searching for it.
5. Access the Raspberry Pi board in headless configuration.
6. Open the Thonny IDE on the Raspberry Pi board.
7. Load the Python script specifically designed for SICT/RRT into the Thonny IDE.
8. Run the Python script within the Thonny IDE.
9. The captured eye image will be automatically uploaded to the database.
10. Access the Web Application and download the captured eye image.

11. Upload the captured eye image to the Flask Application where the Convolutional Neural Network (CNN) model is deployed.
12. Wait for the detection result to be generated.
13. Input the result of the detection into the Web Application.

Python Scripts:

```
import pymysql
import picamera
import datetime
import time
import os
os.chdir("/home/pi/Desktop/SLCT (Cataract) Images")#Enter the path where the images needs to be stored
pymysql.install_as_MySQLdb()
import MySQLdb
import RPi.GPIO as GPIO

# Input your phpMyAdmin database credentials
db = MySQLdb.connect(host="", user="", passwd="*", db="")

# prepare a cursor object using cursor() method
cursor = db.cursor()

# prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO SLCT_Cataract (id, timestamp, image) VALUES (NULL, %s, %s)"""

# Set GPIO mode and pin
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
led_pin = 17
GPIO.setup(led_pin, GPIO.OUT)

# Create a Camera object
camera = picamera.PiCamera()

# Capture 2 images
for i in range(1):
    # Create a timestamp for the image filename
```

```
    timestamp = datetime.datetime.now().strftime('%Y-%m-%d %H:%M:%S')

    # Turn on LED
    GPIO.output(led_pin, GPIO.HIGH)

    # Capture image
    camera.capture(timestamp + '.jpg')

    # Turn off LED
    GPIO.output(led_pin, GPIO.LOW)

    # Open image file and read data
    with open(timestamp + '.jpg', 'rb') as f:
        image_data = f.read()

    try:
        # Execute the SQL command
        cursor.execute(sql, (timestamp, image_data))
        # Commit changes to the database
        db.commit()
        print("Image saved and uploaded to database")
    except:
        # Rollback in case there is any error
        db.rollback()
        print("Error: Unable to upload image to database")

    # Sleep for 5 seconds
    time.sleep(5)

# Clean up the camera and GPIO resources
camera.close()
GPIO.cleanup()

# Close database connection
db.close()
```

Figure 3 Python Script for SLCT (Cataract)

```
import pymysql
```

```
import picamera
import datetime
import time
import os
os.chdir("/home/pi/Desktop/SLCT (Leukocoria) Images")#Enter the path where the images needs to be stored
pymysql.install_as_MySQLdb()
import MySQLdb
import RPi.GPIO as GPIO

# Input your phpMyAdmin database credentials
db = MySQLdb.connect(host="", user="", passwd="*", db="")

# prepare a cursor object using cursor() method
cursor = db.cursor()

# prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO SLCT_Leukocoria (id, timestamp, image) VALUES (NULL, %s, %s)"""

# Set GPIO mode and pin
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
led_pin = 17
GPIO.setup(led_pin, GPIO.OUT)

# Create a Camera object
camera = picamera.PiCamera()

# Capture 2 images
for i in range(1):
    # Create a timestamp for the image filename
    timestamp = datetime.datetime.now().strftime('%Y-%m-%d %H:%M:%S')

    # Turn on LED
    GPIO.output(led_pin, GPIO.HIGH)

    # Capture image
    camera.capture(timestamp + '.jpg')
```

```
    # Turn off LED
    GPIO.output(led_pin, GPIO.LOW)

    # Open image file and read data
    with open(timestamp + '.jpg', 'rb') as f:
        image_data = f.read()

    try:
        # Execute the SQL command
        cursor.execute(sql, (timestamp, image_data))
        # Commit changes to the database
        db.commit()
        print("Image saved and uploaded to database")
    except:
        # Rollback in case there is any error
        db.rollback()
        print("Error: Unable to upload image to database")

    # Sleep for 5 seconds
    time.sleep(5)

# Clean up the camera and GPIO resources
camera.close()
GPIO.cleanup()

# Close database connection
db.close()
```

Figure 4 Python Script for RRT (Leukocoria)

Software Updates

- Regularly check for software updates from the QR code provided by the manufacturer. These updates often include bug fixes, performance improvements, and security enhancements.
- Install updates promptly and follow the provided instructions to ensure a smooth update process.

Service and Repairs

- Only authorized service centers or technicians should perform repairs or modifications on the device. Unauthorized repairs may void the warranty or cause further damage.
- If you encounter any issues or abnormalities with the device, please email the team at eyemax.tupm@gmail.com.

APPENDIX I

WE-VR Manual for Duplication

WE-VR:

INTERACTIVE VIRTUAL REALITY DEVICE FOR CHILDHOOD LEUKOCORIA and PEDIATRIC CATARACT DETECTION SYSTEM

Duplication of Prototype Manual

Table of Contents

I. Introduction

This is the "Duplication of Prototype Manual" for the WE-VR system to detect pediatric cataract and childhood leukocoria. This manual intends to provide a thorough guide for replicating the prototype of this innovative medical equipment, which plays a significant role in the detection of cataracts and leukocoria. The design, operation, and assembly procedure of this device can be better understood by those working in the healthcare and medical technology industries in this manual.

The WE-VR prototype may be replicated, providing a unique chance to investigate its intricate workings. Individuals can precisely recreate the prototype by following the comprehensive instructions, safety recommendations, and step-by-step processes described in this manual, enabling a comprehensive understanding of its capabilities and limitations.

It is important to highlight that this document is only meant to be used by the medical and engineering community for research and instructional reasons. Without the necessary permission, the duplicate procedure described above should not be used for commercial production or dissemination. Individuals will have a deeper grasp of the cataract and leukocoria detection system by participating in the duplication process described in this manual, enabling improvements in diagnostic technologies and improving patient care.

II. Overview of the Prototype

Figure 1 WE-VR Prototype

The WE-VR prototype is a comprehensive integration of three essential eye tests utilized for detecting cataracts and leukocoria in patients. The device is divided into the three following parts:

1. **Visual Acuity Test (VAT)**: The prototype incorporates a 3D application simulation of the traditional ETDRS eye chart using Virtual Reality technology. This test measures the patient's ability to read a series of letters in a standardized environment.

Figure 2 Visual Acuity Test

2. **Slit-Lamp Capture Test (SLCT):** The prototype combines a high-quality camera module with a high-powered LED to examine abnormalities in the anterior part of the eyes.

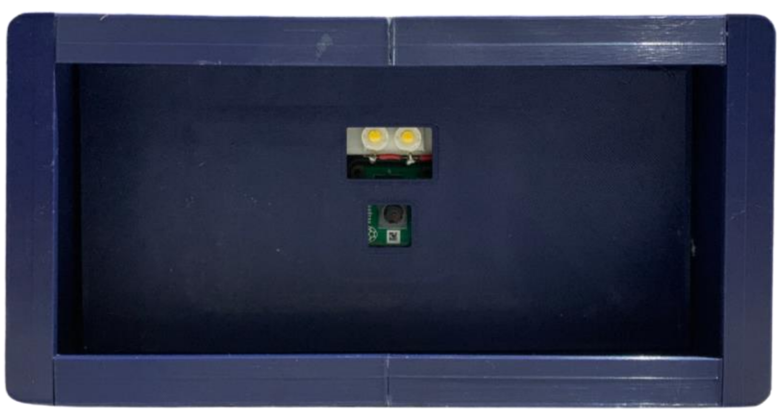

Figure 3 Slit-lamp Capture Test

3. **Red-Orange-Reflex Test (RRT)**: With the use of a high-quality camera, telephoto lens, and a high-powered LED, this test induces a reflection of the retina, allowing for the detection of a condition known as leukocoria.

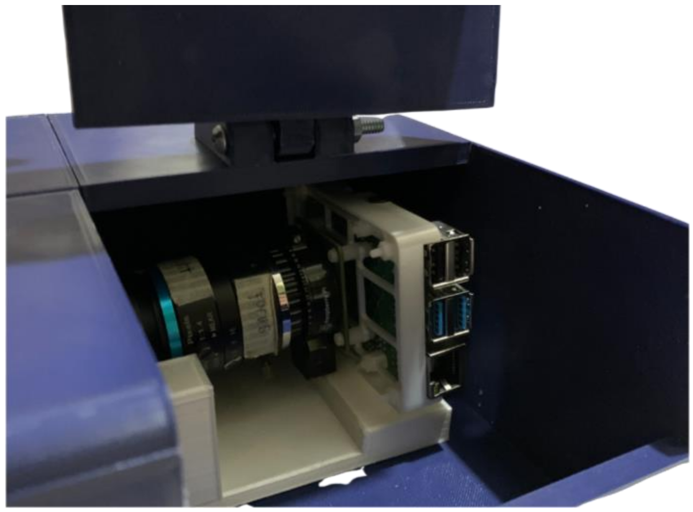

Figure 4 Red-Orange Reflex Test

By carefully following the instructions provided in this manual, you can recreate the WE-VR prototype, enabling the integration of these three important eye tests for cataract and leukocoria detection.

III. Required Tools and Equipment

The following devices and supplies are needed in order to accurately replicate the prototype:

1. Tripod Stand
2. Foam
3. Leather
4. Biconvex Lenses
5. Mobile Phone
6. Raspberry Pi Boards
7. Raspberry Pi Camera v2
8. Raspberry Pi High-Quality Camera 12MP
9. Raspberry Pi 16mm 10MP Telephoto Lens
10. High Power LED Beads
11. Male to Female Jumper Wires
12. Li-on Batteries
13. IRF540n MOSFET
14. 1kΩ Resistor
15. PCB

IV. Step-by-Step Duplication Process

The following steps are the necessary

4.1. Gathering Materials

Apart from the listed materials in the previous section required to build the prototype, gathering the following materials are also essential in the prototype duplication process:

4.1.1. Power Supply Components: In addition to the power supply mentioned earlier, specific power supply components are necessary for the Raspberry Pi, which is a key element of the prototype. Ensure you gather the following materials:

- Micro USB power adapter: A compatible power adapter to provide a stable power source to the Raspberry Pi. Make sure the adapter meets the recommended voltage and current requirements of the Raspberry Pi model you are using.
- Micro USB cable: A cable to connect the power adapter to the Raspberry Pi for power delivery.
- Power bank (optional): If the prototype requires a portable power source where it cannot connect to a direct power source, consider including a power bank that can supply sufficient power to the Raspberry Pi.

4.1.2. Raspberry Pi accessories: In addition to the Raspberry Pi itself, there are specific accessories you need to gather for its proper functioning and connectivity:

- MicroSD card: A suitable microSD card with sufficient storage capacity for installing the operating system and storing data.

4.1.3. Peripherals and Interface Components: The prototype's Raspberry Pi boards are set up in a headless configuration using VNC. To be able to access and control the Raspberry Pi's graphical desktop environment from a computer you need the following:

- Pocket WI-FI: It is a convenient option for accessing your Raspberry Pi from anywhere with an internet connection.
- Desktop

4.1.4. Software Dependencies: The following software prerequisites are necessary for the Raspberry Pi to operate correctly and be accessed remotely:

- Operating System: Install the desired operating system on the microSD card by following the directions provided by the in the operating system's documentation. The prototype used the Raspberry Pi OS (formerly known as Raspbian).
- VNC Client and Server Software: Install the VNC server on the Raspberry Pis and the VNC client on a desktop to enable remote access.
- IDE: To run the programs for the capture tests install the desired development environment. The prototype is using the built-in Thonny IDE in the Raspberry Pi OS.

4.1.5. Miscellaneous materials:

- Cyanoacrylate Adhesive: To put some parts of the 3D printed parts cyanoacrylate adhesive is used. It cures quickly, has strong bond, and provides an almost invisible seam making it the best option for the task.

4.2. Fabricating Components

3D printing technology was used to construct the prototype's structural elements, such as the enclosure and VR base. To fabricate these parts, refer to the figures below designed using Fusion 360.

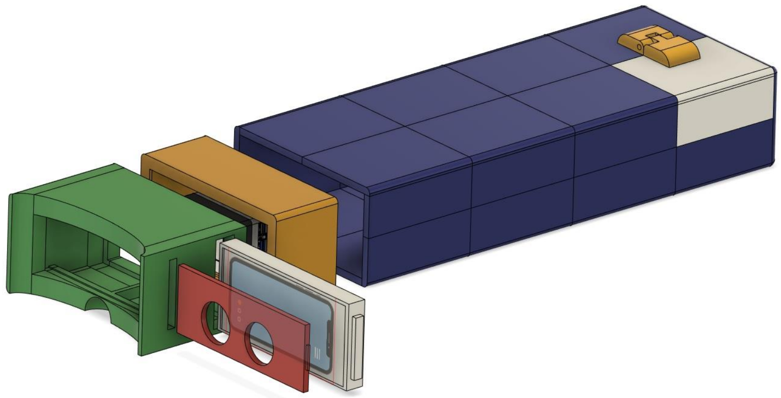

Figure 5 3D Model of the WE-VR Prototype

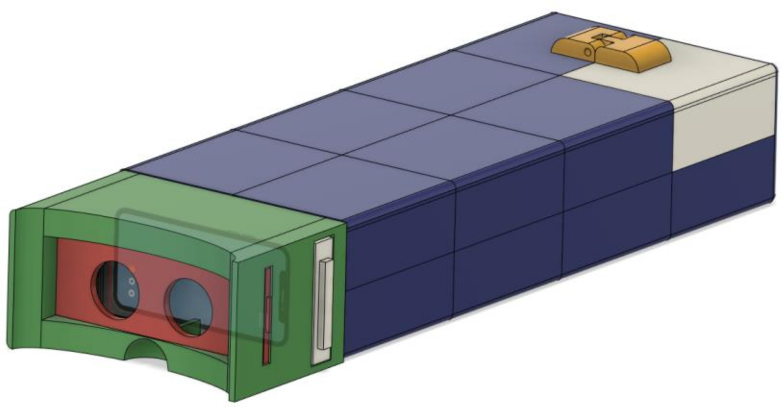

Figure 6 Visual Acuity Section of the WE-VR Prototype

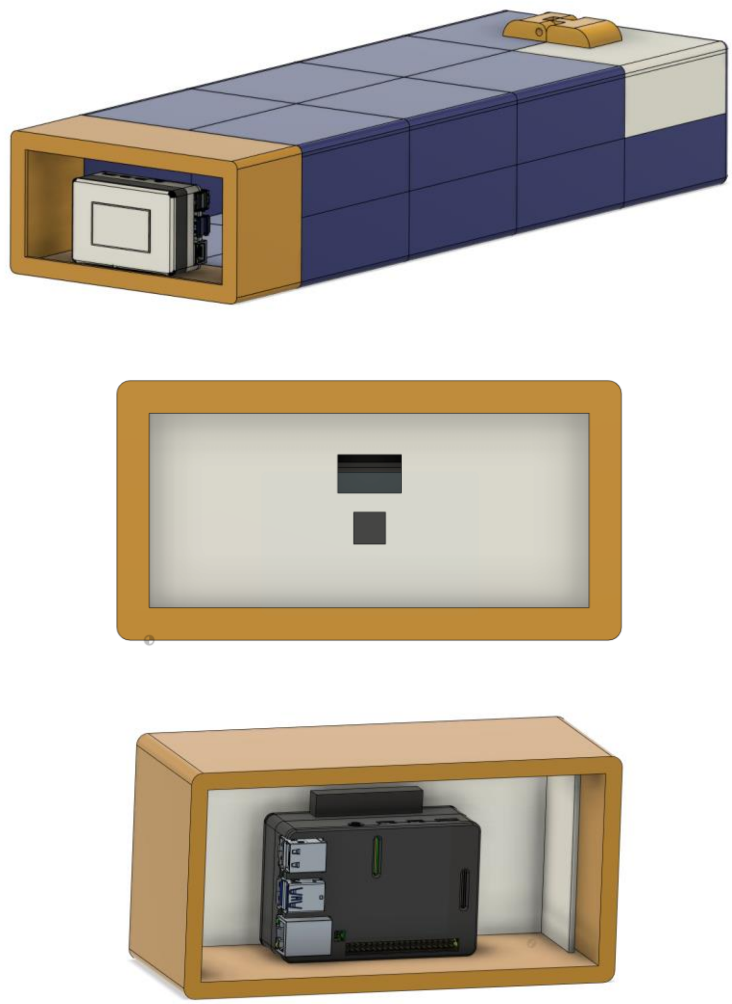

Figure 7 SLCT Section of the WE-VR Prototype

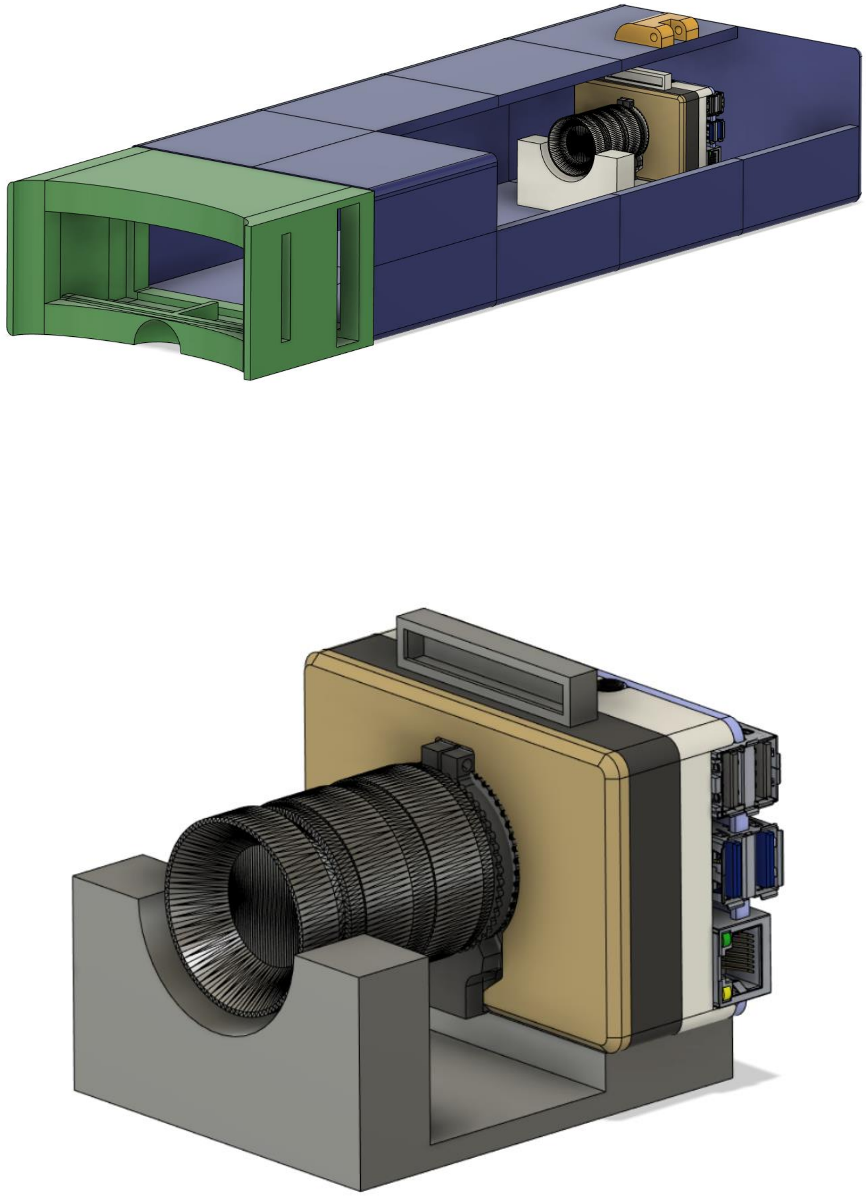

Figure 8 RRT Section of the WE-VR Prototype

The following figures show the dimensions of the 3D model parts above:

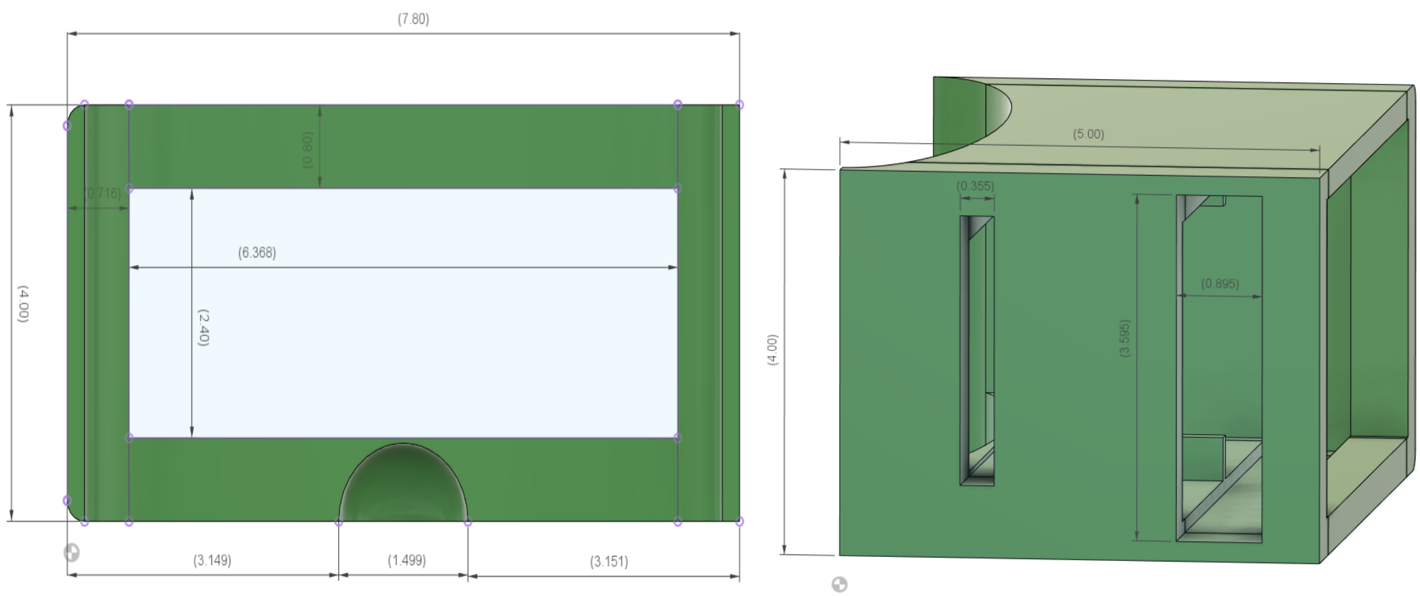

Figure 9 Dimensions of the VR Base

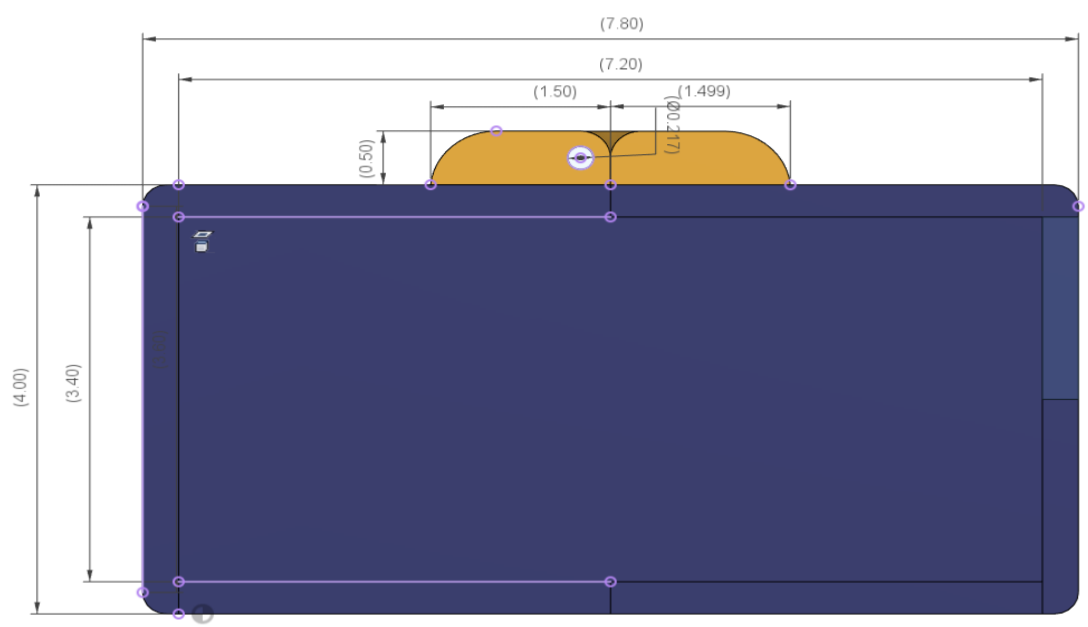

Figure 10 Dimensions Red-reflex Enclosure (Front View)

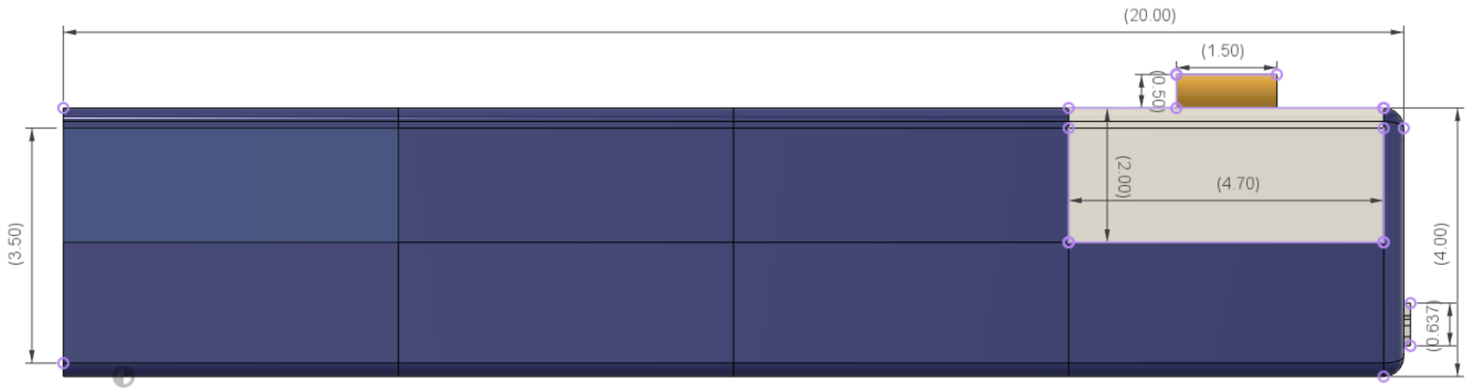

Figure 11 Dimensions of Enclosure (Right Side View)

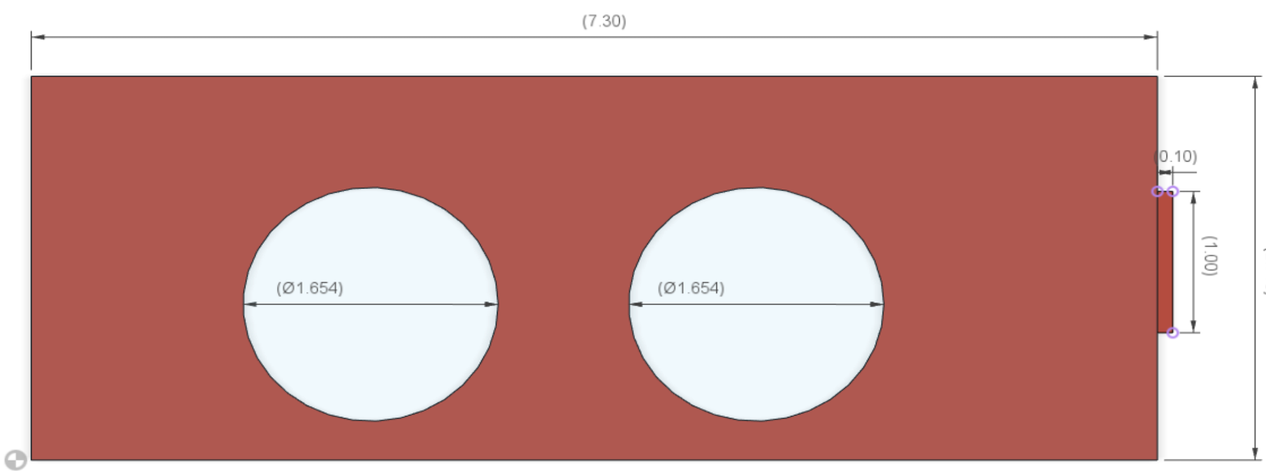

Figure 12 Dimensions of Lens Holder

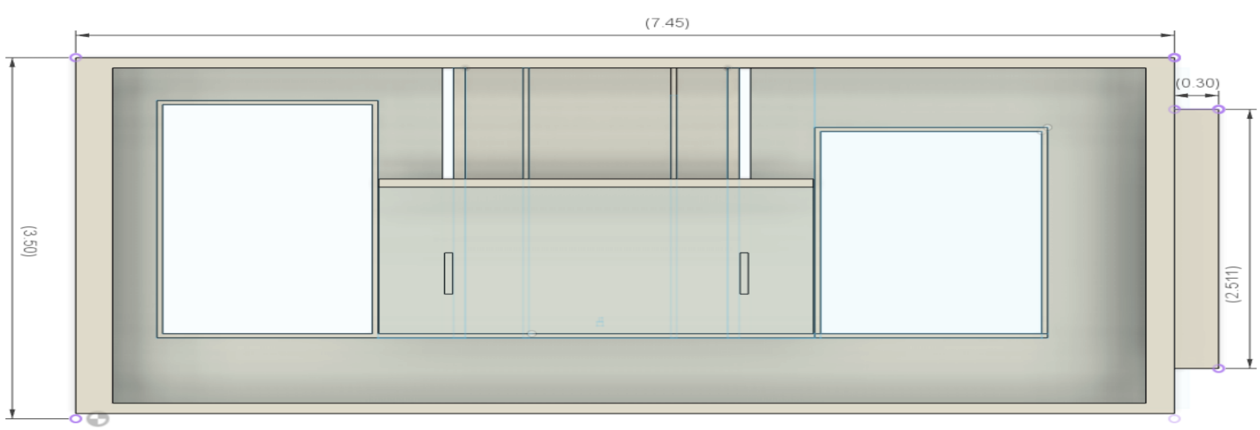

Figure 13 Dimensions of Smartphone Holder

Figure 14 Dimensions of Chin Rest

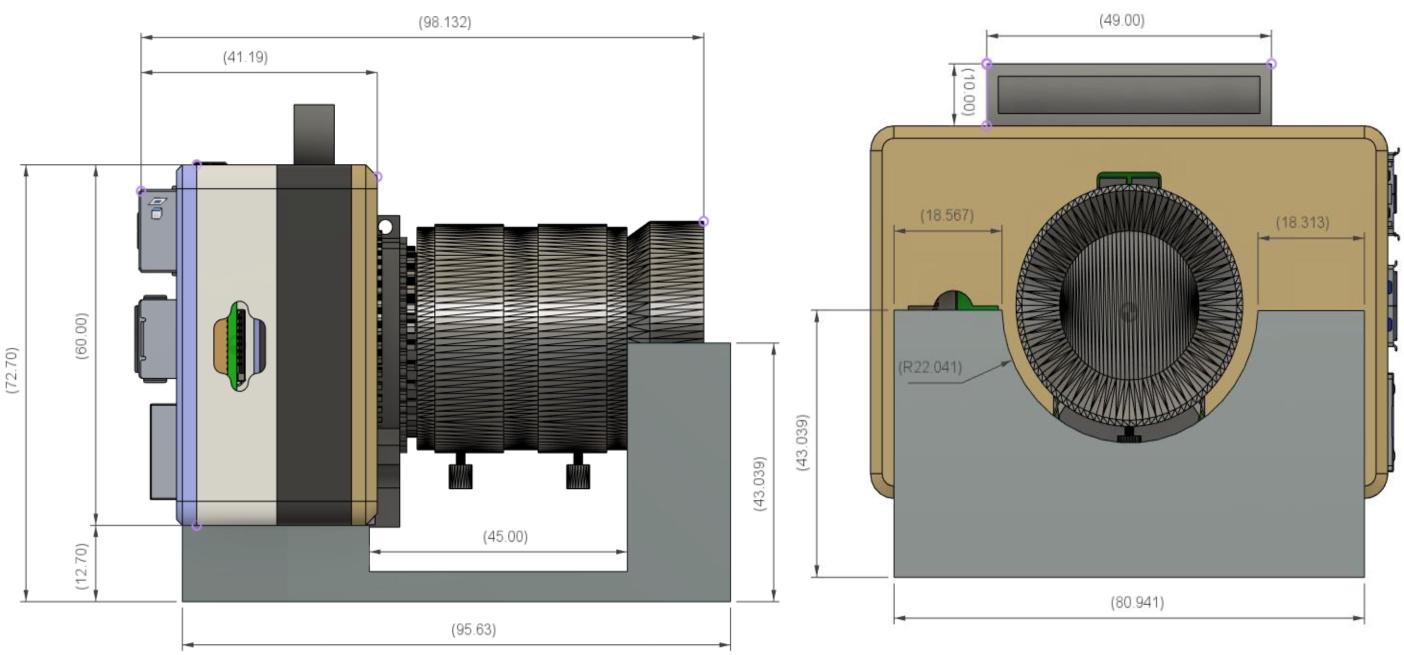

Figure 15 Dimensions of Red-Reflex Camera with Support

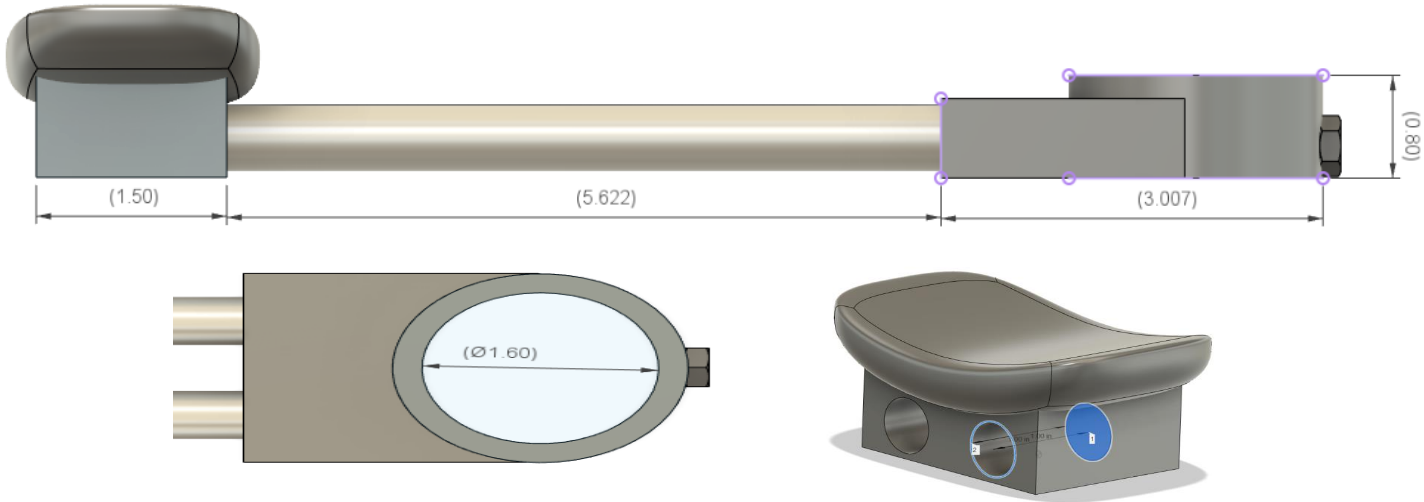

Figure 16 Dimensions of Chin Rest

4.3. Assembly and Integration

4.3.1. Construction of the Visual Acuity Test (VAT)

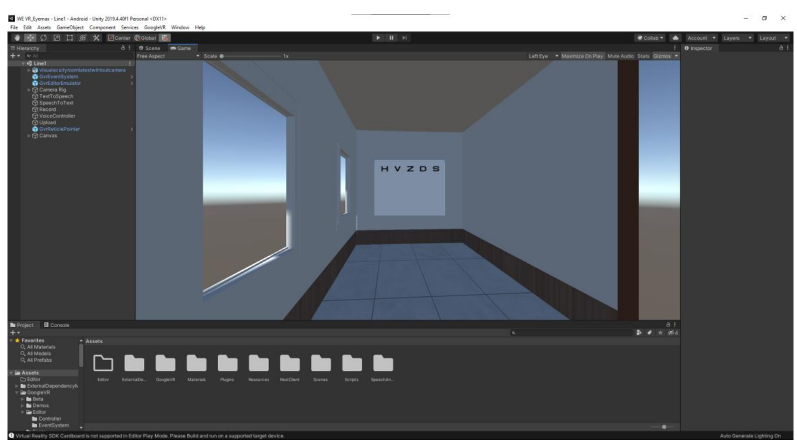

Figure 17 Development of the 3D Simulation App of the ETDRS using Unity 3D

For the development of 3D app simulation of the ETDRS chart Unity 3D and Blender was used. The virtual reality space was developed using the Blender application to provide for the 20-foot distance requirement for the visual acuity test. It is a free and open-source 3D modeling and animation software program. The file is later transferred to Unity for the incorporation of 3D texts and the building of the visual acuity test mobile application.

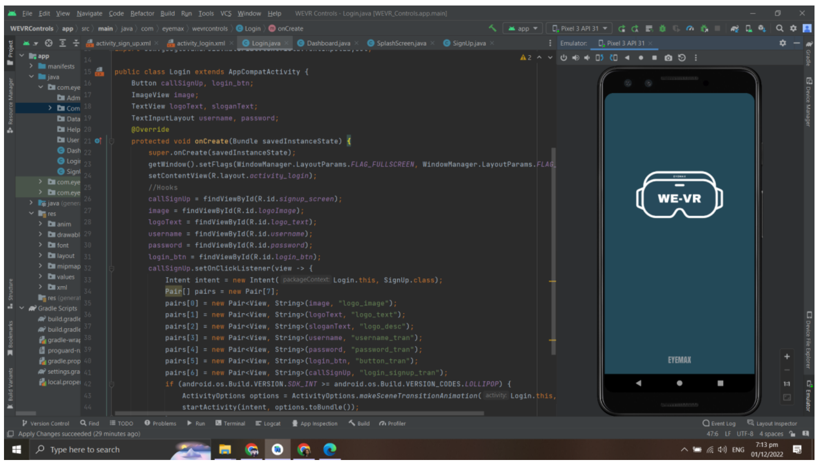

Figure 18 Development of the Mobile Application for the Control of the 3D App Simulation

Android Studio was used to create the mobile application. The mobile app is used to operate the 3D app simulation of the ETDRS chart. It contains login and signup, as well as access to a real-time database known as 'Google Firebase.' The app will also provide basic information about the Team, the Law (National Vision Screening Act), and the ailment under consideration (Cataract and Leukocoria).

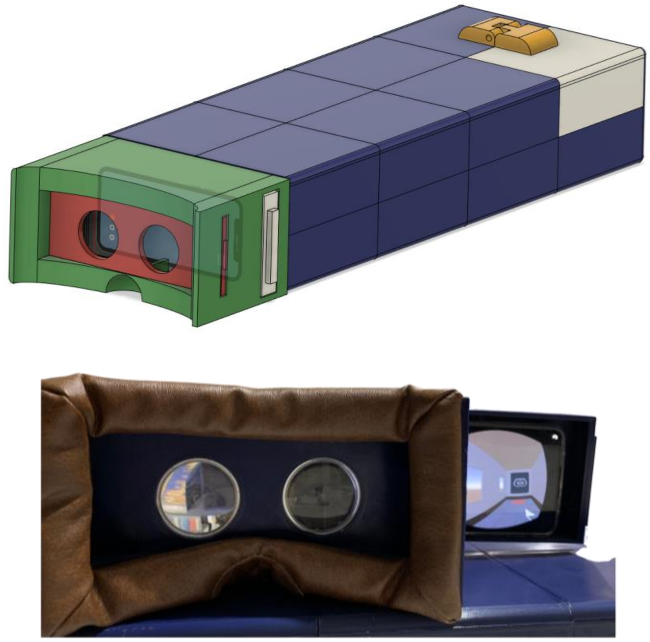

Figure 19 Side-by-Side Comparison of the Actual VAT and its 3D Model

The figure above is a side-by-side comparison of the 3D model and the printed VR base for the Visual Acuity Test. The Visual Acuity Test consists of the VR base, smartphone holder, and lens holder. The VR base holds most of the structural components, the smartphone holder holds the mobile phone that is used for the display of the 3D app simulation of the ETDRS chart, and the lens holder holds the biconvex lenses. The VAT portion is mostly fabricated using 3D printing. To replicate this refer to the previous section Fabricating Components (see 4.2) where the dimensions are shown.

4.3.2. Construction of the Slit-lamp Capture Test (SLCT)

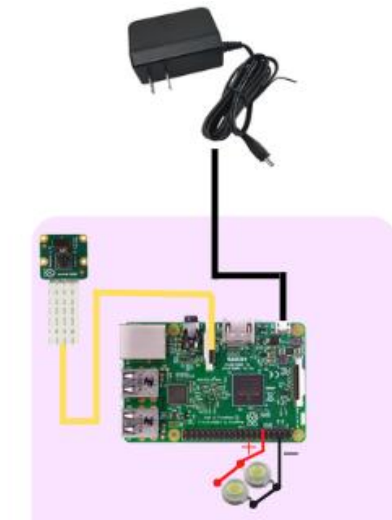

Figure 20 Circuit for the SLCT

To replicate the circuit for the Slit-lamp Capture Test you need the following components: Raspberry Pi 3 Model B, Raspberry Pi power adapter, Raspberry Pi Camera v2.1, and 1W warm high- powered LED beads. Connect the components as shown in the figure above. The Raspberry Pi Camera v2.1 should be connected to the CSI Camera Port, the power adapter to the micro USB Power Input, and the positive terminal of the 2 parallel LED beads to the GPIO 17 pin while the negative terminal is connected to the GND pin.

Figure 21 Side-by-Side Comparison of the Actual SLCT Part and its 3D Model

The structure of the SLCT is mostly fabricated using 3D modeling and printing technology as shown in the image on the right. The dimensions are already provided in the Fabricating Components section (see section 4.2). As for the circuit, the SLCT cover has two holes as can be seen from the image on the left. The upper most is for the parallel LED beads that will serve as the flash for the capture while the lower one is for the camera sensor.

```
import pymysql
import picamera
import datetime
import time
import os
os.chdir("/home/pi/Desktop/SLCT (Cataract) Images")#Enter the path where the images needs to be stored
pymysql.install_as_MySQLdb()
import MySQLdb
import RPi.GPIO as GPIO

# Input your phpMyAdmin database credentials
db = MySQLdb.connect(host="", user="", passwd="*", db="")

# prepare a cursor object using cursor() method
cursor = db.cursor()

# prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO SLCT_Cataract (id, timestamp, image) VALUES (NULL, %s, %s)"""
```

```
# Set GPIO mode and pin
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
led_pin = 17
GPIO.setup(led_pin, GPIO.OUT)

# Create a Camera object
camera = picamera.PiCamera()

# Capture 2 images
for i in range(1):
    # Create a timestamp for the image filename
    timestamp = datetime.datetime.now().strftime('%Y-%m-%d %H:%M:%S')

    # Turn on LED
    GPIO.output(led_pin, GPIO.HIGH)

    # Capture image
    camera.capture(timestamp + '.jpg')

    # Turn off LED
    GPIO.output(led_pin, GPIO.LOW)

    # Open image file and read data
    with open(timestamp + '.jpg', 'rb') as f:
        image_data = f.read()

    try:
        # Execute the SQL command
        cursor.execute(sql, (timestamp, image_data))
        # Commit changes to the database
        db.commit()
        print("Image saved and uploaded to database")
    except:
        # Rollback in case there is any error
        db.rollback()
        print("Error: Unable to upload image to database")

    # Sleep for 5 seconds
```

```
    time.sleep(5)

# Clean up the camera and GPIO resources
camera.close()
GPIO.cleanup()

# Close database connection
db.close()
```

Figure 22 Python Script for the SLCT (Cataract)

Above is the Python script for the Slit-lamp Capture Test for cataract detection. It includes importing the necessary libraries, setting up a phpMyAdmin database for sending the captured images via local hosting, configuring the GPIO pins for the LED beads, initiating the capture process, and formatting the file names while directing the outputs to a specific path. The image can be accessed through our web application so that the image can be fed to the CNN model for cataract detection. The Python script is executed using the built-in Thonny IDE on the Raspberry Pi, which is remotely accessed from a desktop through the VNC application. For instructions on configuring the GPIO pins, enabling VNC on the Raspberry Pi, and creating a phpMyAdmin database, please refer to the available online documentation.

```
import pymysql
import picamera
import datetime
import time
import os
```

```
os.chdir("/home/pi/Desktop/SLCT (Leukocoria) Images")#Enter the path
where the images needs to be stored
pymysql.install_as_MySQLdb()
import MySQLdb
import RPi.GPIO as GPIO

# Input your phpMyAdmin database credentials
db = MySQLdb.connect(host="", user="", passwd="*", db="")

# prepare a cursor object using cursor() method
cursor = db.cursor()

# prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO SLCT_Leukocoria (id, timestamp, image) VALUES
(NULL, %s, %s)"""

# Set GPIO mode and pin
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
led_pin = 17
GPIO.setup(led_pin, GPIO.OUT)

# Create a Camera object
camera = picamera.PiCamera()

# Capture 2 images
for i in range(1):
    # Create a timestamp for the image filename
    timestamp = datetime.datetime.now().strftime('%Y-%m-%d %H:%M:%S')

    # Turn on LED
    GPIO.output(led_pin, GPIO.HIGH)

    # Capture image
    camera.capture(timestamp + '.jpg')

    # Turn off LED
    GPIO.output(led_pin, GPIO.LOW)

    # Open image file and read data
```

```python
    with open(timestamp + '.jpg', 'rb') as f:
        image_data = f.read()

    try:
        # Execute the SQL command
        cursor.execute(sql, (timestamp, image_data))
        # Commit changes to the database
        db.commit()
        print("Image saved and uploaded to database")
    except:
        # Rollback in case there is any error
        db.rollback()
        print("Error: Unable to upload image to database")

    # Sleep for 5 seconds
    time.sleep(5)

# Clean up the camera and GPIO resources
camera.close()
GPIO.cleanup()

# Close database connection
db.close()
```

Figure 23 Python Script for the SLCT (Leukocoria)

Above is the Python script for the Slit-lamp Capture Test for leukocoria detection, specifically the corneal scarring as a leukocoria manifestation. Similar with the previous script for cataract detection includes importing the necessary libraries, setting up a phpMyAdmin database for sending the captured images via local hosting, configuring the GPIO pins for the LED beads, initiating the capture process, and formatting the file names while directing the outputs to a specific path and to the phpMyAdmin database. The image can be accessed through our web application so that the image can be fed to the CNN model for leukocoria detection. The Python script is executed also using the built-in Thonny IDE on the Raspberry Pi, which is remotely accessed from a desktop through the VNC application.

4.3.3. Construction of the Red Reflex Test (RRT)

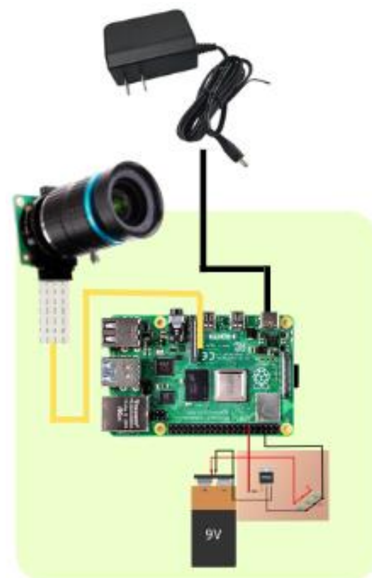

Figure 24 Circuit for the RRT

To replicate the circuit for the Red Reflex Test you need the following components: Raspberry Pi 4 Model B, Raspberry Pi power adapter, Raspberry Pi High-quality Camera (12MP), 16mm telephoto lens, 3W high-powered LED beads, li-ion battery, IRF540N MOSFET, and PCB. Connect the components as shown in the figure above. The 16mm telephoto lens should be connected to the Raspberry Pi High-quality Camera which is then connected to the CSI Camera Port of the Raspberry Pi board and the power adapter to the USB-C Power Input.

Since the supplied 3.3V of the Raspberry Pi board is not sufficient to power the parallel 3W LED beads a level-shift circuit is constructed to power the LED using an additional external power supply. The positive terminal of the 2 parallel LED beads to the GPIO 17 pin while the negative terminal is connected to the GND pin, Connect the gate terminal of the IRF540N to the GPIO 17 pin of the Raspberry Pi board, connect the drain terminal of the IRF540N to the anode terminal of the parallel LED beads, and connect the drain terminal to the ground terminal of the li-ion battery that is connected as well to the GND pin of the Raspberry Pi board. Lastly, connect the positive terminal of the li-ion battery to the cathode terminal of the parallel LED beads.

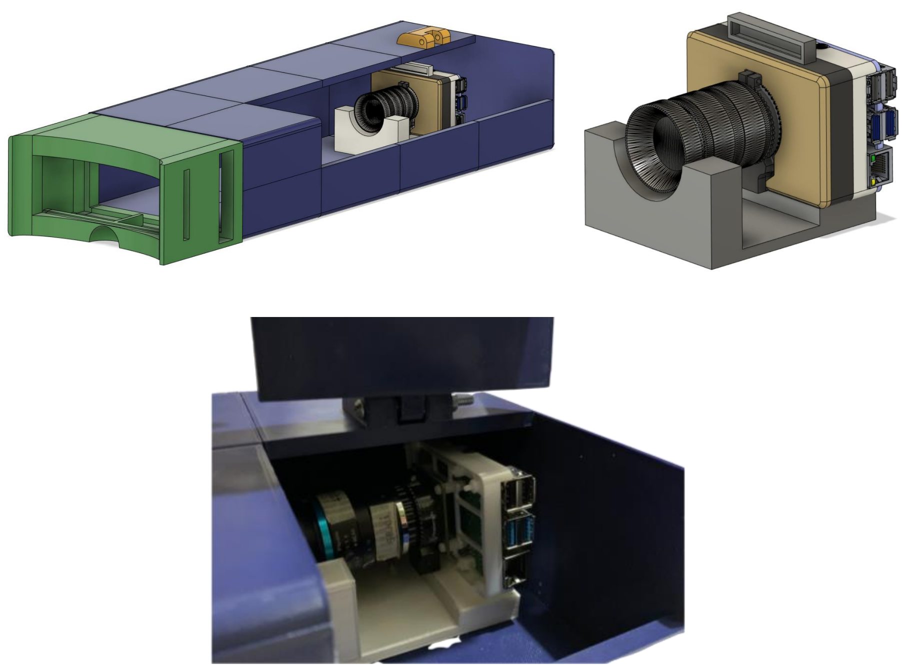

Figure 25 Side-by-Side Comparison of the Actual RRT Part and its 3D Model

Some parts of the Red Reflex Test are fabricated using 3D modeling and printing technology. The dimensions are already provided in the Fabricating Components section (see section 4.2). As for the circuit, the RRT has an elevated support for the Raspberry Pi High-quality Camera and 16mm telephoto lens. This is to make sure that the line of sight of the camera sensor is properly aligned.

```
import pymysql
import picamera
import datetime
import time
import os
os.chdir("/home/pi/Desktop/RRT Images")#Enter the path where the
images needs to be stored
pymysql.install_as_MySQLdb()
import MySQLdb
import RPi.GPIO as GPIO

# Input your phpMyAdmin database credentials
db = MySQLdb.connect(host="", user="", passwd="*", db="")

# prepare a cursor object using cursor() method
cursor = db.cursor()

# prepare SQL query to INSERT a record into the database.
sql = """INSERT INTO RRT (id, timestamp, image) VALUES (NULL, %s,
%s)"""

# Set GPIO mode and pin
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
led_pin = 17
GPIO.setup(led_pin, GPIO.OUT)

# Create a Camera object
camera = picamera.PiCamera()

# Capture 2 images
for i in range(1):
    # Create a timestamp for the image filename
```

```
    timestamp = datetime.datetime.now().strftime('%Y-%m-%d %H:%M:%S')

    # Turn on LED
    GPIO.output(led_pin, GPIO.HIGH)

    # Capture image
    camera.capture(timestamp + '.jpg')

    # Turn off LED
    GPIO.output(led_pin, GPIO.LOW)

    # Open image file and read data
    with open(timestamp + '.jpg', 'rb') as f:
        image_data = f.read()

    try:
        # Execute the SQL command
        cursor.execute(sql, (timestamp, image_data))
        # Commit changes to the database
        db.commit()
        print("Image saved and uploaded to database")
    except:
        # Rollback in case there is any error
        db.rollback()
        print("Error: Unable to upload image to database")

    # Sleep for 5 seconds
    time.sleep(5)

# Clean up the camera and GPIO resources
camera.close()
GPIO.cleanup()

# Close database connection
db.close()
```

Figure 26 Python Script for the RRT

Since both SLCT and RRT use flash photography, the scripts are all similar to one another.

4.3.4. Integration of the Device

Figure 27 WE-VR Prototype

The diagram above displays the whole structure of the WE-VR prototype, which includes the tripod stand, support, VR base, and enclosure. The various components are joined using cyanoacrylate adhesive to attach the 3D printed pieces. To assemble the device, the support is placed on the tripod stand, which serves as a platform for the prototype. The VR base houses the structural pieces required for the Visual Acuity Test, such as the smartphone holder, lens holder, and phone itself for showing the 3D app simulation of the ETDRS chart. The Slit-lamp Capture Test component consists of a portion of the enclosure, the SLCT cover, and the SLCT circuit. Finally, the Red Reflex Test part covers the camera support and the RRT circuit.

In terms of software integration, the capture test scripts include credentials for accessing the phpMyAdmin database. These scripts allow the captured image to be automatically uploaded to the database. The collected image is then accessed via our Web Application and downloaded for use in feeding into the CNN model for cataract and leukocoria detection.

V. Conclusion

In conclusion, the "Duplication of Prototype Manual" includes detailed instructions for replicating the innovative device developed to detect pediatric cataracts and childhood leukocoria. Individuals in the medical and engineering sectors can duplicate the prototype by following the thorough directions, obtaining significant insights into its design, operation, and assembly.

This manual is a significant resource for healthcare and medical technology researchers and experts, letting them to better understand the workings of the developed cataract and leukocoria detection system. Individuals can contribute to the advancement of diagnostic technology and potentially improve patient care in the field by following the duplication process specified in the manual.

It is critical to follow any commercial production or dissemination restrictions or licenses indicated in the handbook. Individuals who use this manual responsibly for research and education purposes can help advance the development of cataract and leukocoria detection devices, ultimately benefiting persons in need of early identification and treatment for these disorder

APPENDIX J

Proponent's Profile

CELSO
JULLIENNE MAE E.

09369953525
jullienne.celso@gmail.com
404 M.A. Felix St., Pasay City

ABOUT ME

An enthusiastic Electronics Engineering student with a strong commitment to professionalism, excellence, and effective leadership. With expertise in software (mobile app, web app, and game development) and hardware (electronic components, microcontrollers, and analog devices), equipped to tackle complex engineering challenges and drive organizational success. Thriving in dynamic environments, I continuously expand my knowledge to stay at the forefront of technology.

EDUCATION

Tertiary Education August 2019 - August 2023
Technological University of the Philippines - Manila
Bachelor of Science in Electronics Engineering

Secondary Education June 2017 - May 2019
Arellano University - Jose Abad Santos Campus
Science, Technology, Engineering, and Mathematics Strand
Senior High School

June 2013 - April 2017
Pasay City West High School
Science, Technology, Engineering Program
Junior High School

Primary Education June 2006 - April 2012
Apelo Cruz Elementary School
Elementary School

WORK EXPERIENCE

Integrated Research and Training Center, TUP - Manila August 2022 - September 2022
Position: Student Intern

Participated in diverse laboratory experiments involving electronic components, Arduino, LAN cable splicing, and fiber optic cable fusion, while documenting procedures, observations, and analysis in comprehensive reports.

SKILLS

- Software development expertise in game, web app, and mobile app development
- Proficiency in 3D printing using MakerBot and Ender printers
- Strong programming skills in Python and JavaScript
- Proficient in circuit design and prototyping techniques
- Specialized software proficiency: NI Multisim, Arduino IDE, MATLAB, Octave, FluidSim, Scilab, LTSpice, Cisco Packet Tracer
- Demonstrates effective leadership qualities

AWARDS/CERTIFICATIONS

May 2023
President's Choice Award (APPRECIATE)

May 2022
Master IP Addressing and Subnetting for CCNA

AFFILIATIONS

Organization of Electronics Engineering Students - Graduating Class Division
August 2022 - July 2023
Position: Feedback & Information Committee

Organization of Electronics Engineering Students (OECES)
August 2019 - July 2023
Position: Member

Institute of Electronics Engineers of the Philippines (IECEP) TUP-Manila Chapter
August 2019 - August 2020
Position: Member

ELECTRONICS ENGINEERING DEPARTMENT

CELI
JEYREL AUSTIN M.

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celijeyfrel@gmail.com
Blk.19 Lot 33 Tierra Del Sueño Heights Brgy. Sto Cristo, SJDM Bulacan

ABOUT ME

An Electronics Engineering student who has a wide range of interests and skills looking for experience in the professional world. I am exploring areas the would help me achieve betterment and development of my interests, skills, and passion. As such , I desire to be somewhere I can learn, develop, and test new things and be able to equip myself with the knowledge and skills acquired through time.

EDUCATION

Tertiary Education August 2019 - August 2023
Technological University of the Philippines - Manila
Bachelor of Science in Electronics Engineering

Secondary Education June 2017-April 2019
Holy Angel School of Caloocan, Inc.
Science, Technology, Engineering, and Mathematics Strand
Senior High School

June 2013 - April 2017
Cielito Zamora Junior High School
Junior High School

Primary Education June 2006 - April 2012
Camarin D Elementary School
Elementary School

WORK EXPERIENCE

Melham Construction Corporation August 2022- Sept. 2022
Position: Intern
Developed a project study entitled "Design and Fabrication of Paper-Based Printed Circuit Board using Water Hyacinth"

SKILLS

- Basic Python Programming
- NI Multisim
- MATLAB Programming
- Cisco Packet Tracer and GNS3
- Microsoft Office
- 3D Modeling (Fusion 360)

AWARDS/CERTIFICATIONS

May 2023
President's Choice Award (Appreciate)
May 2023
Fortinet Training
- **Network Security Associate (NSE 1)**
- **Network Security Associate (NSE 2)**
- **Netwrok Security Associate (NSE 3)**

AFFILIATIONS

Organization of Electronics Engineering Students
2019-2022
Position: Member

Institute of Electronics Engineers of the Philippines (IECEP)
2019-2020
Position: Member

ELECTRONICS ENGINEERING DEPARTMENT

DAYAWON
JOHN DANIEL M.

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johndaniel21dayawon@gmail.com
102 San Miguel St. Brgy. San Gabriel General Mariano Alvarez Cavite

ABOUT ME

I am a recent graduate with a Bachelor's degree in Electronics Engineering. During my academic journey, I have developed a strong foundation in networking and cybersecurity. I am eager to apply my theoretical knowledge and passion for learning in a practical setting. possess excellent communication and problem-solving skills, and I am excited about the opportunity to learn and grow alongside experienced professionals.

EDUCATION

Tertiary Education August 2019 - August 2023
Technological University of the Philippines - Manila
Bachelor of Science in Electronics Engineering

Secondary Education August 2019 - August 2023
University of Perpetual Help System Jonelta - GMA
Science, Technology, Engineering, and Mathematics Strand
Senior High School

June 2013 - April 2017
General Mariano Alvarez Technical High School
Junior High School

Primary Education June 2006 - April 2012
Vox Dei Academy
Elementary School

WORK EXPERIENCE

IPVCYx August 2022 - September 2022
Position: Intern
Performed All-in-one ICT solutions in companies. This includes structured cabling, Firewall configurations, and many more.

Creotec Philippines Inc. January 2017 - February 2017
Position: Intern
I am tasked with checking an printed circuit board to see if the current flows using a multimeter.

SKILLS

- Proficient in Networking simulation tools such as Cisco Packet Tracer and GSN3
- Has basic knowledge in programming languages (Python and HTML)
- Literate in Microsoft Office Applications (Word, Excel, PowerPoint, and etc.)

AWARDS/CERTIFICATIONS

May 2022
NSE Fortinet Network Associate 1 2 and 3

May 2022
Master IP Addressing and Subnetting for CCNA

April 2017
Graduated With Honors

AFFILIATIONS

Organization of Electronics Engineering Students (OECES)
2019 - 2023
Position: Member

Institute of Electronics Engineers of the Philippines (IECEP)
2019 - 2020
Position: Member

ELECTRONICS ENGINEERING DEPARTMENT

SY
SOPHIA MAE B.

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B5 L31/33 Gumamela St., Dolmar Golden Hills Subdivision, Loma de Gato, Marilao, Bulacan

ABOUT ME

A dedicated electronics engineering student with a passion for innovation and problem-solving. Through my academic journey, I have honed my analytical and critical thinking skills to a high degree, complemented by exceptional abilities in collaborative teamwork and effective communication. With a thirst for knowledge, I eagerly embrace new challenges in the ever-evolving field of electronics engineering.

EDUCATION

Tertiary Education August 2019 - August 2023
Technological University of the Philippines - Manila
Bachelor of Science in Electronics Engineering

Secondary Education June 2017 - March 2019
First City Providential College
Science, Technology, Engineering, and Mathematics Strand
Senior High School

June 2013 - April 2017
School of Our Lady of La Salette
Junior High School

Primary Education June 2007 - April 2013
School of Our Lady of La Salette
Elementary

WORK EXPERIENCE

TELUS International July 2022 - Present
Position: Annotator
Precisely annotate data sets to enhance machine learning models, ensuring accurate and reliable AI applications.

Integrated Research and Training Center, TUP Manila August 2022 - September 2022
Position: Intern
Participated in hands-on laboratory experiments involving electronic components and Arduino, while also preparing comprehensive written reports.

SKILLS

- Proficient in Microsoft Office
- Proficient in Google Workspace
- Basic Knowledge in IP Addressing and Subnetting
- Basic Circuit Simulation (Multisim, Cisco Packet Tracer)
- Basic Programming Skill (Python, MATLAB, Octave, C++)
- UX/UI Design (Figma)
- Web Design (HTML, CSS)
- 3D Game Development (Unity, Blender)
- 3D Printing using Ender 3 (Cura)
- Video Editing (Filmora, Vegas Pro)
- Strong Communication Skills

AWARDS/CERTIFICATIONS

May 2023
President's Choice Award (APPRECIATE)

May 2022
Master IP Addressing and Subnetting for CCNA - MNET IT

AFFILIATIONS

Organization of Electronics Engineering Students - TUP Manila
2019 - 2023
Position: Member

Institute of Electronics Engineers of the Philippines - TUP Manila Student Chapter
2019 - 2021
Position: Member

ELECTRONICS ENGINEERING DEPARTMENT

TAN
SHAINA NICOLE S.

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Caloocan City

ABOUT ME

As a motivated student, my passion lies in biomedical engineering. I am dedicated to advancing healthcare through innovative technology and contributing my abilities to create life-saving solutions in the field.

EDUCATION

Tertiary Education August 2019 - September 2023
Technological University of the Philippines - Manila
Bachelor of Science in Electronics Engineering

Secondary Education June 2017 - April 2019
Lagro High School
Science, Technology, Engineering, and Mathematics Strand
Senior High School

June 2013 - April 2017
Camarin High School
Junior High School

Primary Education June 2006 - April 2012
North Fairview Elementary School
Primary School

WORK EXPERIENCE

Integrated Research and Training Center (IRTC) August 2022- September 2022
Position: Research Assistant Intern

- *Researched and evaluated diagnostic and monitoring technologies for Tourette Syndrome.*
- *Conducted ANOVA and Post Hoc analysis for voltage and power data as part of an Energy Forecasting study led by a Faculty Researcher.*

SKILLS

- Web App Development (Front-end)
- Creating and managing databases using myPhpAdmin
- Operate Raspberry Pi and Arduino boards for Projects
- Transfer Learning using pre-trained Deep Learning models
- Python, R, and MATLAB programming

AWARDS/CERTIFICATIONS

May 2023
APPRECIATE 2023 President's Choice Awardee
April 2019
Academic Awardee: With Honors
April 2017
Academic Awardee: With Honors
March 2015
Academic Awardee: With Honors

AFFILIATIONS

Department of Science and Technology-Science Education Institute (DOST-SEI)
2019-2023
Position: Undergraduate Scholar

Organization of Electronics Engineering Students (OECES)
A.Y. 2021- 2022
Position: Documentation and Membership Committee Member

ELECTRONICS ENGINEERING DEPARTMENT