Near - Infrared Based Navigation for Visually Impaired

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ABSTRACT

Nowadays it is quite difficult for people who are blind or visually impaired to navigate and avoid obstacles. There are a lot of visually impaired persons in the world more than 1.1 billion people. Regardless of the cause of their vision impairment congenital or accidental these people struggle with day-to-day tasks. While assistive technology does exist, the majority of it consists of simple items like canes. While canes can be useful in identifying impediments directly in front of the user, they are not able to identify items that are higher than the waist or that are farther away than the cane's reach. This restriction makes it difficult for people with vision impairments to lead completely autonomous lives.

Our idea involves using a camera with different display modes and time-of-flight sensors to identify impediments. The sensor can determine the distance of an object accurately, with a maximum frame rate of 90 frames per second and a range of 0.1 to 10 meters, allowing for real-time object tracking and distance identification.

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CHAPTER 1
INTRODUCTION

Navigation and obstacle avoidance are extremely challenging for visually impaired individuals. Currently, there is a significant number of visually impaired people worldwide, totaling over 1.1 billion individuals. Whether visual impairment is congenital or acquired through accidents, these individuals face difficulties in daily living. Although there are assistive tools available, most of them are limited to basic devices like canes. Although canes can help detect obstacles immediately in front of the user, they cannot detect objects above waist level or objects at a distance beyond the reach of the cane. This limitation hinders visually impaired individuals from fully living independent lives. To address this, researchers have been developing devices using sound-based sensors, which are more suitable than vibration-based systems. These sensors have significantly advanced, enabling the detection of distance and depth accurately [1].

Our idea was to use a camera that could display images in many modes, like regular and grayscale, to develop a device that can identify impediments. The device also includes time-of-flight sensors, which calculate the duration of infrared signals' passage to and from objects. The sensor can determine the object's distance with accuracy using this data, operating at a maximum frame rate of 90 frames per second with a range of 0.1 to 10 meters. Nearly real time object tracking, and distance identification are made possible by the high frame rate.

1.1 Background and significance of the study

Due to the risk of potential dangers for both them and others in their daily life, visually impaired individuals often require assistance from others or the use of assistive tools. Currently, the most popular tool for visually impaired individuals is the white cane. However, using a white cane still poses risks as it has limitations in identifying obstacles and requires a high level of expertise to use effectively. Therefore, our project aims to develop a device that enables visually impaired individuals to lead independent lives confidently. We have come up with the idea of creating a camera capable of accurately identifying obstacles in front of the user and at a greater distance than the white cane. The device is also wider vertically than the white cane, providing better coverage. The project focuses on utilizing the technology from the Intel RealSense D435 camera, which includes time-of-flight sensors for measuring distances accurately. Additionally, the device incorporates a vibration system located at the user's back to indicate the position of obstacles. With this device, visually impaired individuals can navigate their surroundings more safely and independently, overcoming the limitations of traditional white canes.

1.2 Objectives

The device is designed to detect obstacles in front by measuring the distance of objects and utilizing a camera that can display images in RGB and grayscale, as well as infrared imaging through camera detection. Additionally, the device includes a chest strap that delivers vibrational feedback patterns on the user's back and another one is to create the device to detect obstacles without the user having to use their hands or feet to physically search for obstacles.

1.3 Scope of the study

This project focuses on designing a device that detects obstacles and sends signals to visually impaired individuals, indicating the position of the obstacles. The design includes both hardware and software components for an infrared camera capable of detecting the heat emitted by various objects. The detected information is then transmitted to a circuit board equipped with vibration motors, which will provide warning signals to the visually impaired users, informing them about the presence of obstacles.

CHAPTER 2
THEORY

2.1 Medical Related Theories

2.1.1 Partial Blindness:

When people lose vision in certain areas of their visual field, it is referred to as partial blindness. This indicates that while they have restrictions or loss of vision in some regions, they are still able to view parts of images or adjacent objects. A problem of loss vision in a particular area of the visual field or an abnormality such as a lesion or anomaly within the eye can cause visual impairment [2]. It can also happen as a result of things that could harm their vision, like accidents, operations, illnesses of the eyes, or things in the surroundings that could make it more susceptible to vision problems. Depending on the context, the word "partial blindness" might signify many things. The definition of "partial blindness" might change according to the person and the comorbidities. When diagnosing and treating situations involving accidents, factors contributing to visual impairment and the degree of loss are frequently taken into account. While injuries may cause moderate visual loss with no effect on day-to-day activities in certain cases, more serious impairments may necessitate extensive care, advance planning, and lifestyle adaptations.

2.1.2 Complete Blindness:

A person who completely loses their eyesight that means they can't see any surrounding objects or images. There are several conditions that can lead to total visual impairment, such as diseases that induce visual loss, abnormalities within the eyes, loss of vision in both eyes, injuries to brain areas linked with vision, and environmental factors. When someone loses all of their vision, they can need assistance and care to adjust to their new lifestyle. Complete vision loss usually has a major impact on day-to-day functioning, requiring learning and effective adjustment to a world with limited or no vision.

Complete vision loss typically has a effect on a person's everyday activities. This could entail figuring out how to navigate a visually demanding environment and succeeding at it. It may be necessary to use supportive measures like visual augmentation devices, mobility aids, and audio support. Nevertheless, those who are completely blind or visually impaired can nevertheless have happy lives in society and accomplish their objectives. In order to adjust and deal with the emotional difficulties that come with adjusting to complete visual loss, support from family, the community, and medical experts is essential. Those who are close to an individual with complete vision impairment can benefit significantly from an understanding and awareness of the circumstances surrounding this condition, which will help them manage the problems that come with it. Through comprehension and backing from the community, nearsighted people cannot succeed in leading fulfilling lives unless the community, national institutions, and the nation's social infrastructure fully realize this and support them.

2.1.3 Congenital Blindness:

Is the loss of eyesight that starts at birth or in early childhood. This indicates that a person has been blind from birth or from a very young age. Genetics, developmental anomalies, or inherited factors that can impede the normal development of the eyes and visual system during infancy can all contribute to vision loss. Visual abnormalities in infancy can sometimes be caused by traumas sustained shortly after birth or environmental risk factors. Born blind or visually impaired individuals may experience total blindness from birth and need the necessary care to function in the environment of total blindness.

Even after losing their sight, people with congenital visual impairment are able to perceive and experience things through touch and hearing. They can also pick up a range of practical life skills that help them in their daily activities. For those who are born blind, family, society, and medical experts must all work together to support their growth and help them live happy, full lives. It's crucial to comprehend and offer support to a friend or family member who has recently revealed that they are congenitally blind.

2.1.4 Legal Blindness:

A person with legal blindness has restricted substantial visual capacities for everyday activities and critical vision. According to the law, this status serves as a factor for determining benefits and rights related to visual impairment. It has been observed that critical vision is present in legally blind individuals at a level below normal. Typically, depending on the legal requirements of each nation, this is specified by visual acuity or restricted visual fields.

The term "legal blindness" might mean different things in different countries. However, those who are categorized as legally blind typically have limited vision fields at certain points in the visual field, either above or below the line of sight on communication media or have visual acuity of less than 20/200 in the eye. Additional standards for legal blindness take into account visual ability in a range of comprehensive contexts.

Legal blindness may affect one's ability to receive certain rights and advantages, including social entitlements, work prospects, healthcare and financial support, and driving privileges. Nonetheless, being legally blind does not mean that a person cannot succeed or have a happy life. Legally blind people frequently have additional skills and benefit society in ways that those with normal eyesight do not.

2.1.5 Nutritional Blindness:

The majority of cases of nutritional blindness are seen in undernourished populations, frequently affecting young children who go through extended episodes of malnourishment. This insufficiency may be brought on by sociocultural issues that restrict food accessibility or by a lack of access to nutrient-rich foods appropriate for children.

In order to prevent and treat long-term vision loss caused by nutritional deficiencies, managing nutritional blindness entails improving nutrition by giving the eyes and visual system the nutrients they need, treating with vitamin A supplements, and putting in place appropriate nutritional management.

2.2 Assisting Devices for Visually Impaired Individuals:

2.2.1 Reading Assistance Devices: These devices include digital book readers that can be accessed externally via computers and mobile phones. Additionally, there are book-scanning cameras capable of reading even small-sized text.

2.2.2 Vision Enhancement Glasses: These glasses feature magnifying lenses that enlarge images, light-filtering lenses to adjust to varying light conditions, and lenses that enhance contrast to improve visual perception.

2.2.3 Sound Technology: This includes responsive sound systems, vibration systems, and auditory announcement systems.

2.2.4 Navigation Technology: Such as angle detection systems, GPS systems, and automatic mapping.

2.2.5 Mobility Assistance Devices: Examples include electric canes that aid visually impaired individuals in walking smoothly and powered wheelchairs that provide greater mobility.

2.2.6 Organ Tracking Technology: Devices for tracking sounds, such as tapping or singing, and devices that track light and colors.

2.2.7 Educational Assistance Devices: Programs that enable visually impaired individuals to read and write, along with devices that aid in learning and accessing educational materials.

2.3 Example of Devices for Visual Impaired:

2.3.1 Smart Cane for Visually Impaired Individuals

Figure 2.3.1: Example of a Smart Cane for Visually Impaired Individuals [3]

The concept of a smart cane for visually impaired individuals involves incorporating electronics technology to develop assistive devices in accordance with current policies for individuals with disabilities [4]. Visually impaired individuals have great potential to become selfreliant, pursue careers, and lead lives in society similar to those without disabilities. This smart cane, for instance, is designed with an antenna installed at the cane tip to send and receive signals with an RFID card. These signals are then transmitted to the handle of the cane through concealed internal wiring. The handle contains connection points leading to a control box. The auditory signals generated by the control box are transmitted to headphones worn by the user. The user receives auditory descriptions of various paths.

The information about different paths is stored in a Memory Card, which users can replace when needed. Changing paths is made possible by drawing energy from a battery within the control box. The system details and communication between components are established. A drawback of this system is that it lacks convenience in terms of travel, which could potentially lead to accidents. Traveling using this system may take longer than anticipated, and expenses for transportation could increase since using public transportation might not be as feasible.

2.3.2 Orcam Glasses: Talking Glasses

Figure 2.3.2: Example of Orcam Glasses: Talking Glasses [5]

Orcam is a wearable device that can be attached to eyeglasses, designed for individuals with visual impairments or those facing vision-related challenges. It serves as an "eye" for the wearer through a small-sized smart camera [6]. The latest version, MyEye 2.0, is capable of audibly reading books to the user. Moreover, it incorporates features like Face Recognition for identifying people in conversation, Money Notes Detection to determine the value of banknotes held, Product Identification that goes beyond reading product labels to also scan barcodes on packaging and provide information about ingredients or nutritional content as specified by the manufacturer, Color Detection for identifying colors, and even providing information about the current date and time.

A drawback is that individuals with visual impairments often rely heavily on their sense of touch for auditory cues. The need to divide this sensory input further could increase the risk for users.

2.3.3 Smart Glasses for people who are blind and Partially Sighted

Figure 2.3.3: Example of Smart Glasses for people who are blind and Partially Sighted [7]

Ajman University has developed smart glasses designed to assist individuals with visual impairments. These glasses are particularly helpful for blind individuals or those with partial sight. They utilize a technology called "vision equivalence," employing imaging and sunlight to enable users to perceive their surroundings, even at a distance [7]. The glasses can also assist in reading text and other printed materials. Equipped with sensors and cameras, these smart glasses capture data from light and objects, displaying the information on a small screen within the glasses. Users can control the display through voice commands, allowing them to engage in various activities and tasks independently. A limitation is that these glasses may not be suitable for individuals with complete blindness.

Based on the discussed assistive devices for individuals with visual impairments, such as smart glasses, talking glasses, and even the Orcam Glasses, it is evident that the current technology has not entirely resolved all challenges faced by visually impaired individuals. There are still various factors to consider, including the potential disturbance caused by auditory input for those who heavily rely on their sense of hearing, as well as the device's ability to detect obstacles above waist level for effective usage. Additionally, current devices may not address the needs of individuals with complete blindness. Consequently, our device employs a camera that utilizes Time-of-Flight technology to measure object depth. After obtaining data from the camera, we process it using MATLAB on the UP Board Atom x7-E3950, functioning as a compact computer, to divide the image into segments according to a 3x3 grid. This segmentation aligns with the vibration motor positions on the user's back. The vibration motor alerts the user by vibrating in response to the converted data, triggering an alert on the user's back. An Arduino Uno is used to control this system. This device represents a viable option for individuals with complete blindness or other types of visual impairments, providing more choices for their accessibility needs.

2.4 Smartphone GPS Navigation for People with Visual Impairments

If they're a person with low vision, they have probably received or will get mobility training to assist them in becoming familiar with using a cane to travel around their town or city. If individuals with visual impairments want to resume living separately, they will need to acquire these abilities. They might need to take transport to work if they still have a job. Meeting spaces, elevators, and other workplace amenities are still necessary, even if they use paratransit services for their commute [8].

Mobility training will be quite beneficial if the visually impaired are retired. Maybe they want to go see a buddy, spend an hour or two at their preferred coffee shop or cafe, or make a fast trip to the neighborhood grocery. Although treadmills are useful, they just cannot match the benefits of air quality and a change of landscape that come with going for a walk. Walking is one of the finest ways to exercise.

Mobility training can teach a lot about freely traveling, using transport vehicles, getting through doorways, and crossing dangerous intersections. With a mobility teacher's help, they can practice getting to and from their place of work, home, local supermarket, and other often visited places. But at some point, they're going to want to visit a new location— somewhere they've never gone. Perhaps they should get their significant other a surprise gift. Perhaps they're curious about the sounds of people having a good time outside a wide entryway they see while heading home from their job and wondering if it's a fresh eatery. Or perhaps they just need to grab some cash from the closest ATM.

These and other queries can be addressed by a GPS gadget that is usable by those who are blind or visually impaired. When they walk or take the bus, using one will allow them to be aware of the neighboring businesses, transit stations, and junctions. In addition to providing them with turn-by-turn instructions to the nearest hamburger place or coffee shop, a GPS may boost their self-assurance and independence when they're out and about.

It's likely that they've seen, or perhaps used, the onboard GPS system that many automobiles come equipped with, or they may have used a stand-alone GPS unit from a manufacturer like TomTom also another. Even if someone probably hear this gadget give spoken instructions like "Make a left turn" or "drive 10 miles straight ahead," the majority of standalone GPS navigation systems are not really usable by those who are blind or visually impaired. Often, they are unable to hear the names of the nearby companies, hospitals, also other sites of desire, preview their route, or enter a destination into the gadget in an accessible manner.

There is one stand-alone GPS navigator available that is especially made for blind users: HumanWare's Trekker Breeze Handheld Talking GPS. Numerous notetakers that are accessible also have the option of GPS navigation. If the person currently owns a smartphone running, one of these choices might be a suitable fit for them; otherwise, they might not need to buy a separate navigational device. Unbelievably, a standalone GPS device is not as capable of guiding them or providing an accurate description of their surroundings as their smartphone. This is the reason.

A network of satellites is used by the Global Positioning Satellite (GPS) network to determine a specific place. A time-stamped signal is received by the GPS device's sensor from multiple satellites; it is then triangulated using the differences in the times to determine position. GPS is typically the only method used by a standalone device to determine their position. To increase accuracy, a receiver can also make use constantly updated maps of Wi-Fi radio hotspots and the known locations of phone towers.

Points of interest (POI) data and maps are typically preloaded onto stand-alone GPS devices. Updates to this data may need complicated downloads and file transfers, and they may occur seldom at most. While shuttered or renamed businesses may not appear at all in new streets, they may persist in the device's memory for a considerable amount of time. POI and GPS map data on smartphones are updated far more often and typically with little input from the user.

Both Navigon and TomTom have mobile applications with functionality comparable to their standalone portable devices. Both are available, as it will be discovered later in the lesson, if they are going to spend money on satellite navigation software, they might select one of the "blindness-aware" programs that will be talked about. Additionally, the majority of their capabilities are now available for free on any smartphone running Apple iOS or Google Android.

The following section, which assumes that using Google Talkback or Apple VoiceOver as a touch screen reader to use a smartphone in an accessible manner is to be familared, goes over these mobile GPS platforms. If not, it is strongly recommended to read the Guide for Users with Visual Impairments Tech.

The market of GPS devices intended for the blind will keep expanding as new technologies become accessible. Subscribe to AFB AccessWorld so they can stay up to date on the latest developments in both indoor and outdoor navigation.

2.5 Depth sensing camera

If necessary to measure the distance between two items or the distance between a device and an object it's the only definition of depth-sensing. For this, a 3D depth-sensing camera is employed, which automatically recognizes the existence of any object in the vicinity and calculates the distance to it while in motion. This allows the equipment or gadget that has been integrated with the depth-sensing camera to move independently by making wise decisions in real-time [9].

Three of the most well-liked and frequently applied depth technologies now on the market are:

First, sterio vision—the basis upon which the human eye functions—is the same premise upon which a stereo camera operates. The depth of an item is determined by what is known as stereo disparity in human binocular vision. Stereo disparity is the process of calculating an object's distance by comparing its apparent positions as observed by two separate cameras or sensors (or, in the case of a human, their eyes). The below image illustrates this concept very well:

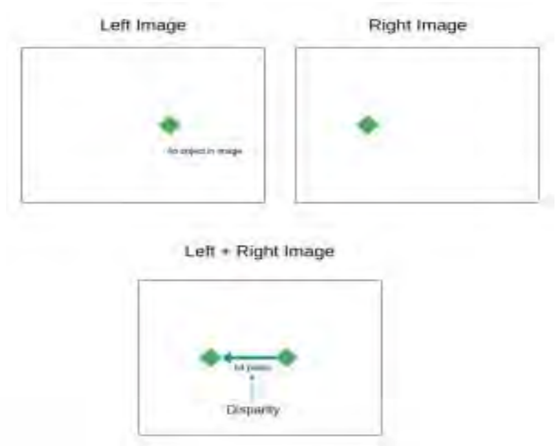


Figure 2.5.1: stereo disparity [9]

The depth of a stereo camera is determined by an algorithm that is often executed on the host platform. However, the two photos must have enough texture and detail for the camera to work properly. Stereo cameras are therefore advised for outdoor applications with a wide field of vision.

The term "time of flight" (ToF) describes how long it takes light to traverse a specific distance. The theory behind how time-of-flight cameras operate is this: the distance to an object is calculated by measuring how long it takes for light produced to return to the sensor after reflecting off its surface. A time of flight camera has three major components such as ToF sensor and sensor module, Light source, Depth sensor

The architecture of a time-of-flight camera is given below:

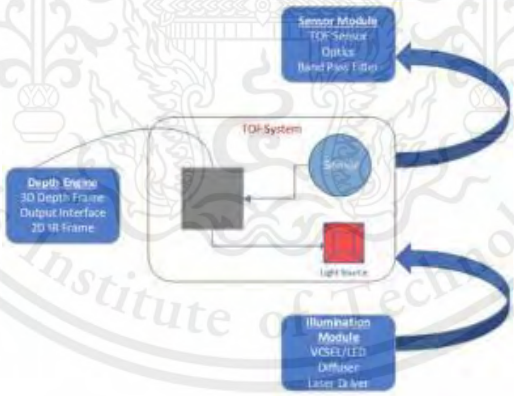


Figure 2.5.2: architecture of a time-of-flight camera [9]

The light data reflected from the target object is gathered by the sensor and sensor module. The gathered light is transformed into raw pixel data by the sensor. Either a VCSEL or an LED that emits light in the NIR (Near InfraRed) spectrum is employed as the light source. The raw pixel data from the sensor is transformed into depth information by the depth processor. Furthermore, it facilitates noise reduction and generates two-dimensional infrared images for further end-user applications.

Structured light camera

A laser or LED light source is used by a structured light-based depth sensing camera to project light patterns—mostly stripes—onto the target object. It is possible to calculate the object's distance based on the obtained distortions. Rebuilding an object's 3D model is frequently accomplished with the help of a structured light 3D scanner.

A comparison of the three methods used for depth sensing.

Each of the three 3D depth mapping cameras that we previously covered has advantages and disadvantages of its own. The specifications of the final application will determine which camera is used. It is usually advised to seek the assistance of an image specialist, such as e-con Systems, to help with the camera integration and evaluation procedure.

Ten distinct parameters can be used to analyze the three technologies. A thorough comparison is provided in the table below:

Table 2.5: Compare version of camera

	STEREO VISION	STRUCTURED LIGHT	TIME-OF-FLIGHT
Principle	Compares disparities of stereo images from two 2D sensors	Detects distortions of illuminated patterns by 3D surface	Measures the transit time of reflected light from the target object
Software Complexity	High	Medium	Low
Material Cost	Low	High	Medium
Depth("z") Accuracy	cm	um~cm	mm~cm
Depth Range	Limited	Scalable	Scalable
Low light	Weak	Good	Good
Outdoor	Good	Weak	Fair
Response Time	Medium	Slow	Fast
Compactness	Low	High	Low
Power Consumption	Low	Medium	Scalable

2.6 Theory of time of flight

The time-of-flight principle is based on measuring the time it takes for a wave to travel from a source (a time-of-flight sensor) to an object and back. Based on that data – as well as some knowledge of math and physics (such as wave propagation) – they can establish the distance of that object from the source. Depending on the technology, different types of waves may be used with different results, though mostly light signal is used, either laser or LED[10].

The time it takes for a wave to travel from a source—a time-of-flight sensor—to an object and back is the basis of the time-of-flight principle. With the help of such information and a basic understanding of physics and arithmetic, including wave propagation, they might determine how far away that object is from the source. Different wave types may be utilized with varying outcomes depending on the technology; however, light signals, such as laser or LED signals, are typically used.

Among the several techniques for creating 3D images are time-of-flight, structured light imaging, and stereoscopic cameras—which use two distinct lenses to replicate depth (where an object is projected onto a structured image, such a grid, and the object's form and distance are determined by measuring how the object distorts the grid) perception and mimic human.

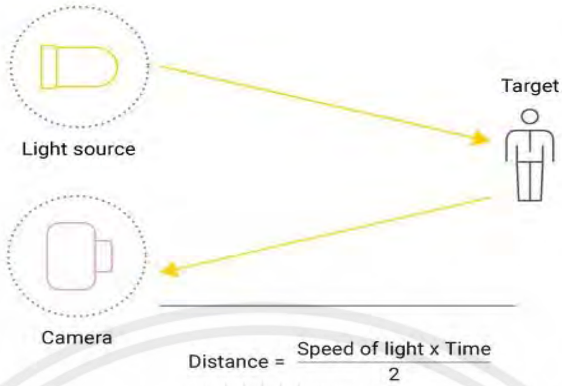


Figure 2.6.1: Explain the solution of time of flight. [10]

Like anything else, ToF has advantages and disadvantages when compared to other imaging methods. Here are a few things to think about.

Working circumstances

It's common knowledge that time-of-flight technology has the benefit of operating in low- to no light. It is accurate to say that ToF is regarded as a "active" imaging method, meaning it depends on projecting its own light. As a result, unlike passive imaging methods (such stereo cameras), it can scan its surroundings without the assistance of an external light source.

But there's more to that coin than meets the eye. Time-of-flight technologies may not function well in natural environments (such as sunlight) since they depend on generating and receiving back reflections of their own light. This is due to interference between the light from the gadget and waves released by other light sources.

Similar to this, there are additional elements that hinder the effective operation of ToF sensors, like corners or "shiny" surfaces that reflect light in various directions, among other things.

Processing speed

Instead of requiring complicated calibration and processing to produce an image, like stereoscopic cameras do, the time-of-flight approach relies on rather simple arithmetic and algorithms. For this reason, ToF-based devices operate more quickly on smaller CPUs and have reduced system needs. This element is particularly relevant in applications where processing rates are critical, such production lines, autonomous vehicles, and factory robots.

The fact that time-of-flight technology operates over a range of half a meter to five meters is one of its most notable advantages. A few ToF sensors can even detect objects up to ten meters away! Though alternative technologies, such structured light imaging, may only be able to detect objects up to two or three meters away, it is important to keep in mind that they are also typically far more precise. Therefore, even while ToF might be effective at short ranges, it might not be the ideal option in use situations where accuracy—rather than range—is the most important factor.

Precision

In other words, how precise is time-of-flight? Since their precision is typically approximated at 1% of the object's distance, it is mostly dependent on that distance (for example, a ToF camera can reach an accuracy of approximately 5 cm if the object is 5 meters away). This puts them in the middle of structured light sensors, which are the most accurate technology and can have an accuracy of as tiny as 1 mm, and stereo cameras, which have a precision of roughly 5–10% of the distance.

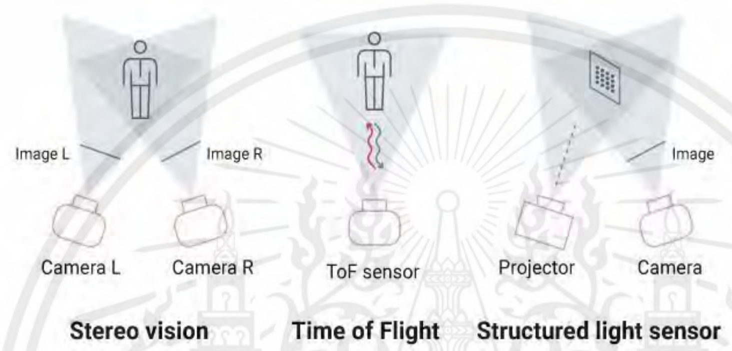


Figure 2.6.2: Compare the range of Stereo vision, Time of flight and Structured light sensor. [10]

Time-of-Flight (ToF) Technology: This technique uses the length of time it takes for light to travel to determine distances. Sending light signals from a source to an object and timing how long it takes for the signals to reach it and return to the sensor or camera is the basis of ToF technology. There are various ways to calculate in ToF technology, however the following is an explanation of the fundamental formula for calculating distance:

Send Light Signals: Lasers and infrared light energy are examples of sources that emit light signals. These light signals interact with surrounding objects and scatter in different directions.

Receive Signals: The light signals reflected back from the object are detected by the camera or sensor that is intended to sense depth. It keeps track of how long it takes for light signals to leave the device and return.

Determine Travel Time: We can determine the total amount of time the light signals took for the round trip by using the time it took for the signals to travel to and from the object as well as the known speed of light (measured or constant value).

Calculate Distance: The following formula can be used to determine the distance to the object:

$$\text{Distance} = (\text{Speed of Light} \times \text{Travel Time}) / 2$$

This calculation uses the measured transit time and the known speed of light, which is roughly 299,792,458 meters per second. This computation will yield a result in meters (or other specified units).

Time-of-flight technology is used in many different applications, such as robotics, gesture recognition systems, depth-sensing cameras, and distance-measuring devices. By utilizing the time it takes for light to reach an object and return to the sensor or camera, it makes precise distance measurements possible [11].

2.7 Object detection by MATLAB

2.7.1 Using Apps to Automatically Label Training Images

In MATLAB, there are interactive tools for convolutional neural network customization and training data preparation. Labeling test images for object detectors is a difficult task, and it can take a while to collect enough training data to generate a usable object detector. This may automatically label the ground-truth data and interactively name objects within a group of photos using the built-in algorithms in the Image Labeler app. While the Video Labeler app is intended for operations involving video processing, the Ground Truth Labeler app is intended for automated driving applications [12].

2.7.2 Develop Object Detection Algorithms Interactively and Sync Across Frameworks

Whether creating a CNN from scratch or adapting an existing one, architectural problems can occur and waste valuable training time. Deep Network Designer allows them to create, modify, and visualize deep learning networks in an interactive manner. Additionally, it has an analysis tool that allows them to search for architectural issues prior to network training.

2.8 Vibration motor

A vibrator motor: what is it?

Definition: The mechanical devices that produce vibrations are called vibrator motors. An electric motor with an uneven mass on its driveshaft is what has caused the vibration to be generated. The user can perceive sound through vibrations produced by this tiny DC motor. Its magnet coreless DC motor, which is permanent and has magnetic qualities (behaving like a magnet only when electric current is passed through the device), is the most important feature that needs to be noticed [13].

Vibration motors are typically made of two types:

• Flat-sized or coin-sized vibrating motor

• Vibrating motor, the size of a cylinder or bar

Vibration Motor Working

Coin or Flat-Sized

A ring magnet, power-supplied brushes attached to the ring magnet, weight, and a rotor with coils connected to the back and commutation points connected to the front are the components that make up a coin-sized or flat-sized motor. The brush's end and the commutation points are linked. The electrical coils of the rotor will be strengthened by this construction. This will produce a magnetic field, which is required in order for the ring magnet to interact with it and cause rotation. A magnetic field causes the production of a force. The weight can be transmitted thanks to this force. The constant shifting of weight produces a force that varies and is perceived as a vibration. The polarity pairs are changed through the use of the commutation points; hence, the coils are constantly changing the polarity while the rotor revolves.

Cylinder or Bar Sized

This vibrating motor is not balanced appropriately. It denotes that a weight off-center is attached to the shaft in order to create centrifugal force during rotation. Vibration is produced by the motor's high-level speed displacement brought on by the force that isn't balanced properly. The motor vibrates in the X and Z axes due to the centrifugal force that is generated within it.

It is possible to compute the vibration's frequency as

$$F_{\text{vibration}} = (\text{Motor RPM})/60$$

and Force is calculated as

$$F_{\text{vibration}} = \text{m} \times \text{r} \times w_2$$

where the eccentric weight's mass, denoted by "m," "r"

stands for the mass offset distance.

The motor's speed is represented by "w" = 2πf.

Both motors share the same internal design and construction, and their components are as follows:

Stator

It is the portion of the rotating electric motor that is stationary. It functions similarly to a magnetic field, creating motion upon contact with the armature. It even serves as an armature that the motor coils use to apply force.

Commutator

It is a revolving electrical switch that is used to periodically store the current flow between the rotor and the external circuit in some types of motors or generators. Since it's a switch, its lifespan is prolonged by counting the circuits that form and break during regular operation.

Windings

The coil turns are as follows. When electricity is sent through any of the coils, it is coupled in a way that creates a magnetic field.

Armature

It is made up of two thin metal plates with copper wires coiled around all three of the armature's poles. Transforming magnetic energy into kinetic energy is how it works.

Brushes

These brushes create current in the shaft between the stator and coils. The motor's life will terminate when the brushes wear out. Therefore, brushless motors, also known as BLDC motors, are used to improve motor life based on this factor.

Weight

Because of its mass, the shaft vibrates in relation to a weighing device. This makes it simple to adjust and control the pressure and magnitude.

Vibrator Motor Specifications/Datasheet

Numerous factors, including size, weight, and operating conditions, affect vibrator motor parameters. Let's look into a few vibrations motor types' specifications. The following details apply to a 10mm shaftless motor with a 3.4mm button type.

Table 2.8.1 The specifications of a vibration motor the specifications.

Specification	Value	Measured in
Operating Voltage	3	V
Frame Diameter	10	mm
Body Length	3.4	mm
Voltage Range	2.5 – 3.8	V
Start Voltage	2.3	V
Weight	1.2	g
Rated Current	75	mA
Rated Speed	12000	rpm
Start Current	85	mA
Vibration Amplitude	0.8	G
Terminal Resistance	75	Ohm

Table 2.8.2 The specifications of a mini vibration motor the specifications.

Specification	Value	Measured in
Operating Voltage	2.2 – 3.6 DC	V
Rated Voltage	3.0 DC	V
Rotation	Clockwise	–
Motor Position	Operates in all positions	–
Operating Conditions	30 – 70^{0}C	Ordinary Humidity
Shaft end play	0.05 – 0.2 (Maximum)	mm
Mass	1.23	Grams
Holding strength of vibration weight	49N	–
Storage Conditions	40 – 80^{0}C	Ordinary Humidity
Rated Load	Counterweight	–

2.8.1 Vibrator Motor Arduino

The Arduino UNO board can be used to control a vibration motor using Arduino. Prior to delving into this topic, it is imperative to acknowledge that the DC vibration motors are in operation. As a result, the initial currents must be restricted, as their value is higher than that of the microcontroller pins.

The transistor is the element that must be positioned between the motor and the microcontroller. The motor can be turned on and off using these transistors as a "Switch." By connecting to a source of high current or low current, they can be readily controlled. At the rated voltages, transistors aid in the motor's safe operation.

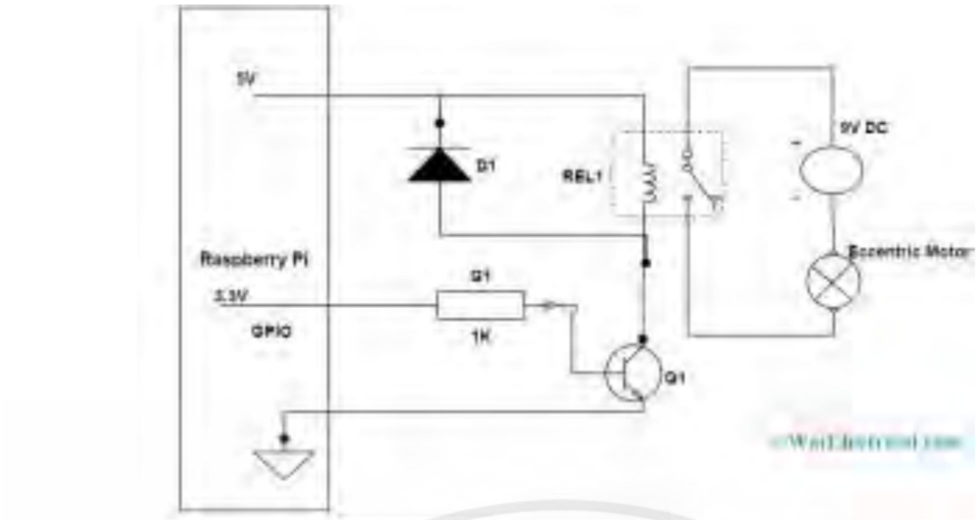


Figure 2.8.1: vibrator-motor-Arduino [13]

Four fundamental components can be used to make the motor, and they are as follows:

• A power supply

• Transistor: MOSFETs, which might be of the P or N type, are typically used for brief vibrations.

• Microcontroller; • Vibration motor

Similar to a switch, the transistor switches the motor on and off. It's crucial to keep in mind that an N-Type transistor can only function in the ON state when the gate's applied voltage is greater than its threshold. Other parts that can be added to improve the stability of the vibration rotor using Arduino are as follows: Schottky Diode

• Resistor Pull-Up

• The pull-down resistor.

• A capacitor for EMI suppression

• Applications for Vibrator Motors

The vibrator motor finds its use in the following industries: food management, petrochemical, and cement manufacturing processes.

• A variety of material handling equipment, including feeders, conveyors, and vibrating screens, use vibration motors.

• Used in the fields of mining and electricity production.

• Widely utilized in pagers, handsets, and cell phones

• Applicable to shakeouts in foundries.

2.9 Smartphone GPS Navigation for People with Visual Impairments

They have probably received, or are going to get, mobility training as a person with a visual impairment to help learn how to navigate their neighborhood or city with a cane or guide dog. If they want to resume their independent lifestyle, they will need to acquire and hone these abilities. They might have to use the bus or train to get to work if they're still employed. They still need to find elevators, conference rooms, and other facilities in the office even if they utilize paratransit services for commuting [14].

Mobility training will be quite beneficial to the visually impaired if they are retired. Maybe they should pay a visit to a buddy, spend an hour or two at their preferred coffee shop or cafe, or make a fast trip to the neighborhood store. While treadmills have their place, they just cannot match the benefits of fresh air and a change of scenery that come with going for a walk. Walking is one of the finest ways to exercise.

They can learn a lot about autonomous travel, bus transportation, safe crossing of busy junctions, and doorway navigation through mobility training. They can practice traveling to and from their place of employment, place of religion, neighborhood grocery shop, and other frequented locations with the assistance of a mobility teacher. But eventually, the visual impaired person is going to want to travel to a new place, somewhere they 've never been. Maybe they would like to get their partner a surprise gift. Perhaps they 're curious about the sounds of people having a good time outside an open doorway they pass on their way home from work and wonder if it's a new restaurant. Or perhaps they just need to grab some cash from the closest ATM.

These and other queries can be addressed by a GPS gadget that is usable by those who are blind or visually impaired. When they walk or take the bus, using one will allow them to be aware of the neighboring businesses, transit stations, and junctions. In addition to giving them turn-by-turn directions to the closest burger joint, shoe store, or coffee shop, a GPS may boost their self-assurance and independence when they're out and about.

It's likely that they've seen, or perhaps used, the onboard GPS system that many automobiles come equipped with, or they may have used a stand-alone GPS unit from a manufacturer. Even if they've probably heard these gadgets give spoken instructions like "Make a left turn" or "drive 10 miles straight ahead," the majority of standalone GPS navigation systems are not really usable by those who are blind or visually impaired. Often, they can't hear the names of surrounding businesses, hospitals, or other sites of interest preview their route, or enter a destination into the gadget in an accessible manner.

There is one stand-alone GPS navigator available that is especially made for blind users: HumanWare's Trekker Breeze Handheld Talking GPS. Numerous notetakers that are accessible, such the HIMS Braille Sense and Voice Sense, also have the option of GPS navigation. If they already have an Android or iOS smartphone, one of these choices might be a suitable fit for them; otherwise, they might not need to buy a separate navigational device. Unbelievably, a standalone GPS device is not as capable of guiding them or providing an accurate description of their surroundings as their smartphone.

A network of satellites is used by the Global Positioning Satellite (GPS) network to determine a specific position. Their GPS device's sensor receives a time-stamped signal from several satellites to determine their position. It then triangulates their position based on the difference in these times. GPS is typically the only method used by a standalone device to determine their position. To increase accuracy, a smartphone GPS receiver can also make use of constantly updated maps of Wi-Fi radio hotspots and the known locations of phone towers.

Points of interest (POI) and map data are typically preloaded onto standalone GPS devices. Updates to this data may need complicated downloads and file transfers, and they may occur seldom at most. While shuttered or renamed businesses may not appear at all in new streets, they may persist in the device's memory for a considerable amount of time. POI and GPS map data on smartphones are updated far more often and typically with little input from the user.

2.10 Comparison between MATLAB object detection and python object detection

1.Community and Libraries:

Many open-source object detection libraries have been developed as a result of Python's larger and more active community. TensorFlow's Object Detection API is the most widely used library for object detection in Python. Other prominent libraries include Faster R-CNN and YOLO (You Only Look Once) [15].

MATLAB's Computer Vision Toolbox provides object detection functionality as well. In comparison to Python, it might have less pre-trained models and resources, even though it offers a wider number of functions and tools for computer vision tasks.

2.Ease of Use:

Python is renowned for being straightforward and user-friendly. A lot of Python object identification packages, such PyTorch and TensorFlow, feature comprehensive documentation and intuitive APIs. Although MATLAB offers an intuitive platform for creating computer vision applications, users who are unfamiliar with MATLAB's ecosystem and syntax may find the learning curve more challenging.

3.Flexibility:

Python is a versatile programming language, making it easier to integrate object detection into larger applications. Numerous Python packages are available for use in the preparation, display, and post-processing of discovered objects' data.

With its own toolboxes for signal and image processing, MATLAB provides good integration. For researchers and engineers who are already familiar with MATLAB, it is a great fit.

4.Performance:

High-performance object identification can be accomplished using both Python and MATLAB, while the exact performance may vary depending on the hardware and implementation. GPU acceleration can be used by Python packages.

5.Cost:

Since Python is an open-source language, a wide range of object identification tools and packages are accessible without charge. On the other hand, there can be additional expenses for specific hardware or cloud-based services. Since MATLAB is a commercial program, a license might be needed to use the Computer Vision Toolbox. Depending on their usage and organization, the price may change.

7.Deployment:

MATLAB and Python offer possibilities for deploying object detection models in many contexts, such as cloud services, mobile applications, and embedded devices[16].

8.OpenCV

The main components of real-time operation, which is crucial in nowadays systems, is OpenCV, a massive open-source library for computer vision, machine learning, and image processing. It may be used to process photos and videos in order to recognize persons, objects, and even handwritten text written by humans. When Python is connected with other libraries, such NumPy, it may process the OpenCV array structure for analysis. To find visual patterns and their different features, we take advantage of vector space and perform mathematical operations on these features.

OpenCV's first version became available. OpenCV is licensed under a BSD license, which makes it free for both industrial and scholarly use. It offers interfaces in C++, C, Python, and Java and supports Windows, Linux, Mac OS X, iOS, and Android. The primary goal of OpenCV's creation was real-time computational efficiency applications. Optimal C/C++ is used in everything to take advantage of multi-core processing.

CHAPTER 3
METHODOLOGY

3.1 Introduction

In Chapter 2 we identified that what theory we use to know in this project and now

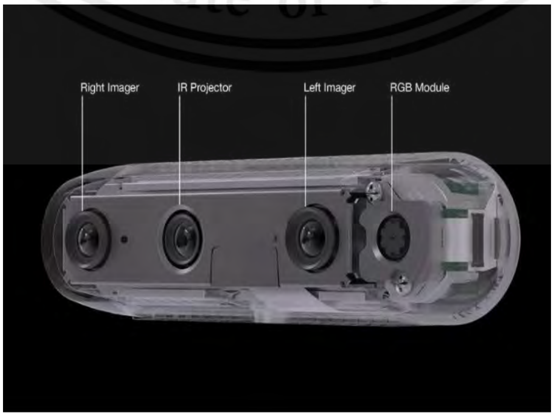
This chapter will describe the design of our project infrared based navigation for visually impaired, a material that we use in this project. First, the chapter describes the project's material methodology and system (section 3.2), our design (section 3.3). And a proposed solution and result (section 3.4).

3.2 Material

3.2.1 The Intel RealSense D435 depth camera

Is a camera with efficient depth sensing capabilities. It utilizes a combination of stereo and infrared technology to perform depth measurements. With its wide-ranging vision capability, it can effectively perceive objects at distances of up to 10 meters. This versatile camera can be applied to a variety of tasks and applications [17].

a.



b.

Figure 3.2.1.1: a. An external camera, and b. Internal camera of the Intel RealSense D435 depth camera

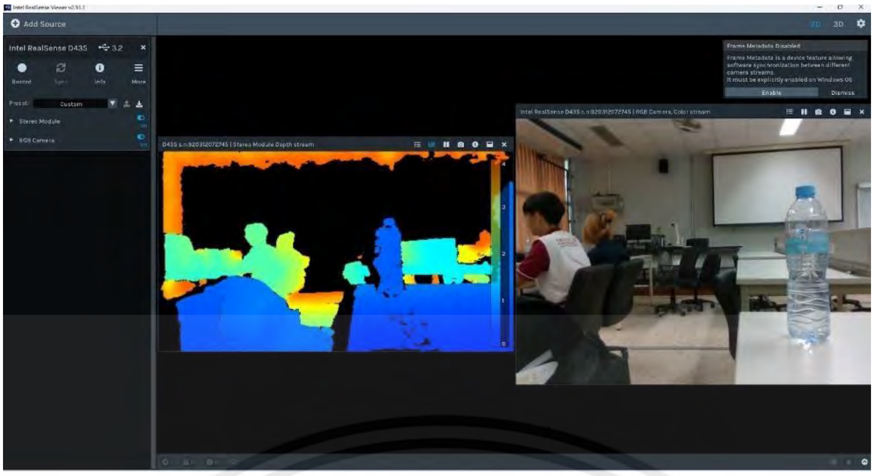


Figure 3.2.1.2: Example of RGB and Infrared Images from the Intel RealSense D435 Depth Camera

"Active stereo depth sensing" is the technique used by the Intel RealSense D435's primary camera to produce depth information about the photos it takes [18]. In order to measure an object's distance from the camera, active stereo depth sensing uses stereoscopic vision in conjunction with the emission of infrared (IR) light onto the scene. The two infrared cameras on the D435 camera are spaced about the same as our eyes apart. It employs triangulation to determine the distance between each pixel in the image after capturing pictures with both cameras [19].

The D435 contains two IR cameras in addition to an RGB camera for color picture capturing. Three-dimensional images are produced by combining color data with depth information. Even under challenging lighting situations, a number of technologies, including global shutter, structured light, and active infrared stereo, combine to improve the precision and dependability of depth acquisition [20].

All things considered, the D435's active stereo depth sensing technique is a flexible instrument appropriate for a range of uses, including 3D scanning, augmented reality, and robotics.

Using depth sensing technology, the Intel RealSense D435 depth camera generates three-dimensional images and enhances environmental perception. The camera's internal processing is a sophisticated on-chip operation that needs software to get exact and reliable depth readings. The following is the basic function:

1.Distance Sensing: The Time-of-Flight (ToF) technology of the RealSense D435 camera is used to measure distances. With ToF technology, objects are exposed to infrared (IR) light, and the duration of time it takes for the light to reach the item and return to the camera is measured. The distance is then determined using the timing and variations in the light signal.

2.Depth Image Generation: The camera uses the depth map, which displays the depth values of each pixel in the image, to create a depth image. Computers can better identify the form and structure of things in an image with the aid of this depth map [21].

3. The following essential ideas serve as the foundation for the ToF technology employed in the RealSense D435:

3.1 Sending Light Signals: A light source, like a laser or infrared emitter, can produce light signals. These light signals interact with surrounding objects and are projected in different directions.

3.2 Receiving Signals: Light signals from objects are detected by cameras or sensors made for depth perception, which also record the amount of time it takes for the light to travel to and from the object.

3.3 Calculating Travel Time: The camera may determine an object's distance by measuring the time it takes for light signals to go back and forth and by knowing the speed of light, which is a constant value.

3.4 Determining Depth: The speed of light and the amount of time it takes for light signals to travel can be used to determine an object's depth. Depth may be calculated using the following formula:

Depth = (Speed of Light × Time of Flight) / 2.

The time it takes for a light signal to travel back and forth is known as the Time of Flight in this formula, and the speed of light is a known constant, or around 299,792,458 meters per second. Meters (or other designated units) are used to display the outcome.

Furthermore, scientists have discovered that the Intel RealSense D435 depth camera is capable of capturing and analyzing both normal and black-and-white images. Moreover, it is capable of taking pictures that identify infrared (IR) light. These features enable a wide range of applications, including 3D scanning, augmented reality, and robotics.

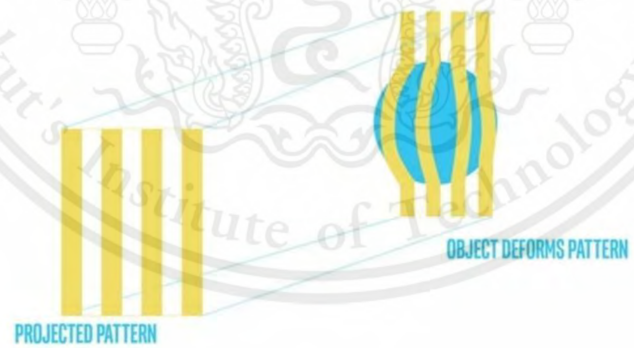


Figure 3.2.1.3: Time-of-Flight Method [17]

3.2.2 Vibration Motor

When it gets a signal, the vibration motor—a tiny electric motor running on direct current—vibrates to alert people. It is frequently found in pagers, game controllers, cell phones, and many other gadgets. It makes no sound. This study makes use of a small vibration motor.

An eccentric weight, also known as an imbalanced weight, is fixed to the motor shaft of the small vibration motor in order for it to function. The desired vibrations are produced when the motor is turned on because of the uneven weight causing the motor shaft to gently vibrate.

Even though the weight on the motor shaft is not balanced, the theory underlying the operation of this little vibration motor centers on the concept of force. A force that is out of balance with respect to the motor's axis is created by the unbalanced weight, and this causes mild vibrations. The following formula can be used to determine this force, which is also referred to as the eccentric force:

Where:

$$F = m * r * \omega^2$$

- F is the force that is eccentric.
- The mass of the unbalanced weight is denoted by m.
- The distance r measures how far the center of mass is from the center of rotation.
- The rotational angular velocity is denoted by ω.

The eccentric force produced by the motor, which is a polynomial function of the motor's angular velocity, determines the vibrations' frequency and speed. Consequently, a motor's angular velocity can be increased to increase the frequency and speed of vibration.

In this research, a vibration motor is used to alert users to the surrounding dangers related to the device under study.

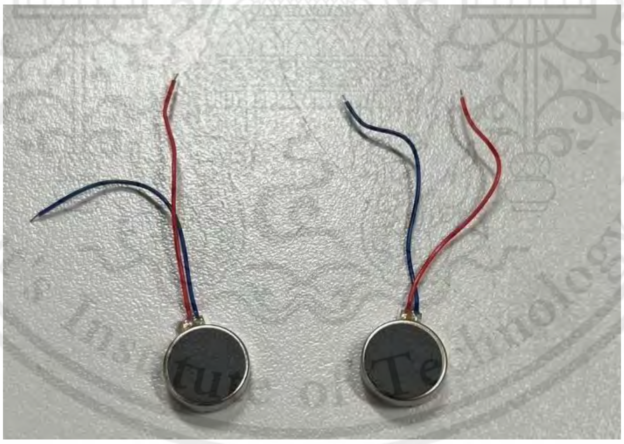


Figure 3.2.2: Example of Vibration motor

3.2.3 Arduino

Arduino is a free platform for developing hardware and software that makes it possible to design and manage a wide range of electronic devices. It is frequently used to construct and program electrical projects and provides development flexibility. An essential component of this platform is the Arduino boards, which are renowned for their robustness and openness and facilitate program writing by users without the need for deep coding knowledge.

An active community of Arduino users exists in Thailand, and Arduino-related events are highly sought-after. Arduino may be used to easily integrate vibration motors for a variety of purposes. An illustration of connecting a vibration motor to an Arduino board is provided below:

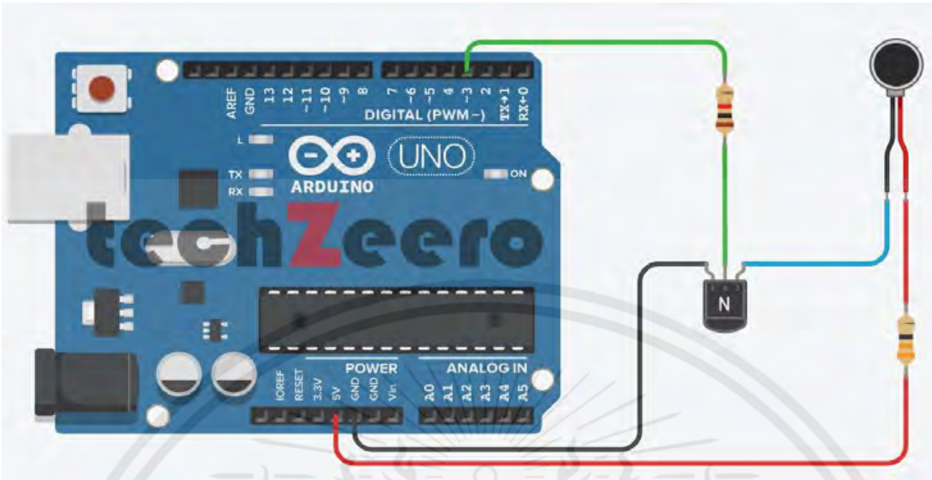


Figure 3.2.3: Example connecting a Vibration Motor to an Arduino:

3.2.4 UP-Board Atom x7-E3950

Figure 3.2.4: Example of UP Board Atom x7-E3950

Compact and multipurpose, the UP-Board Atom x7-E3950 is a computer board. It is equipped with a quad-core Intel Atom x7-E3950 processor, which has a maximum clock speed of 2.0 GHz. In addition to providing a variety of connectivity choices like USB 3.0, SATA, GPIO, HDMI, and more, it is an environmentally safe power source. This board is appropriate for Internet of Things (IoT) and industrial applications where energy efficiency and flexibility are needed.

The UP-Board Atom x7-E3950 is capable of a multitude of functions, including industrial testing apparatus control, manufacturing system control, and portable computer use. It functions similarly to a standard computer, letting them install different software programs and operating systems. Nonetheless, the UP-Board Atom x7-E3950 is more appropriate for applications with constrained space and adaptable system needs because of its lower size and variety of peripheral connectivity options.

The UP-Board Atom x7-E3950 can be used similarly to a standard computer, and it can be configured to install applications and operating systems in the same way as other computers. It is compatible with a wide range of accessories and devices [22].

This kind of computer board was selected for projects that need continuous software processing from an open camera, including detecting impediments ahead, because it has a processor chip that can function consistently over long periods of time.

3.2.5 Python

Python is a popular programming language used for creating software and websites, task automation, and data analysis. Python is a general-purpose language, which means it isn't tailored for any particular issue and may be used to develop a wide range of programs. Its adaptability and ease of use for beginners have made it one of the most popular programming languages available today.

Python is the fourth most popular programming language, according to Stack Overflow's 2022 Developer Survey, with respondents stating that they use it for development work over 50% of the time. Additionally, according to survey results, the most-wanted technologies are Python and Rust, with 18% of developers who do not currently use it stating that they would like to learn Python.

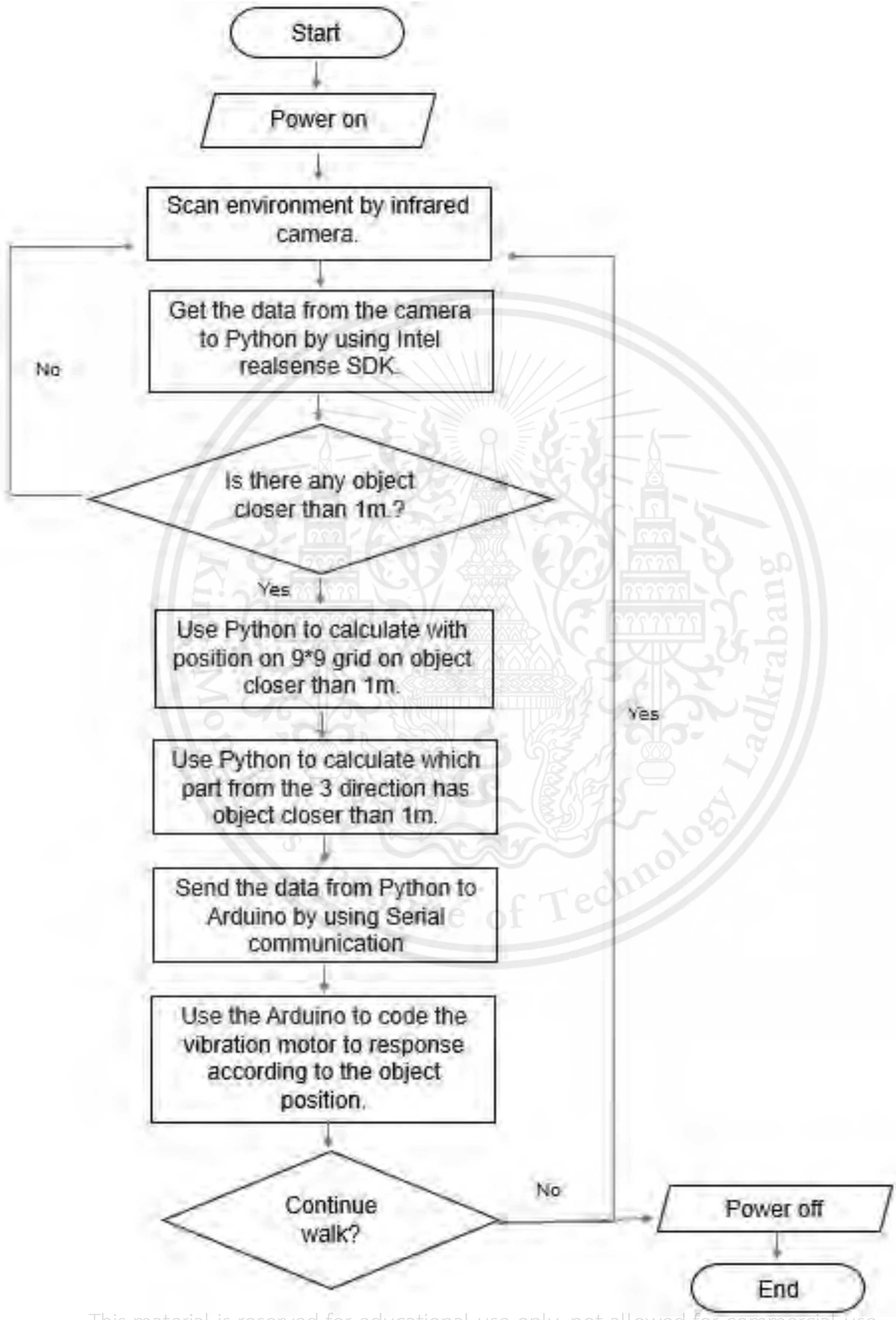
3.2.6 Chest strap

It is utilized for the installation of the camera, as well as different power supplies and the vibration motor that is linked to an Arduino.

Since the chest is a strong region of the body, it was decided to connect the camera using a chest strap. Because the camera has some weight, mounting it atop the head, for instance, can be challenging for the wearer. It would be difficult to install backup batteries as well.

Figure 3.2.6: Example of Chest strap

3.3 Flowchart for the operation system



3.4 Coding part in Python

In the section below is an example code in the Python program to receive data from a camera, process the image to detect obstacles, and then send the numeric data to an Arduino.

Code Python

-*- coding: utf-8 -*-

""

Created on Sat Oct 28 17:06:17 2023

@author: tata-

""

import pyrealsense2 as rs

import numpy as np

import cv2 import serial

import time

We Initialize the RealSense pipeline

pipeline = rs.pipeline() config =

rs.config()

config.enable_stream(rs.stream.depth, 640, 480, rs.format.z16, 30)

config.enable_stream(rs.stream.color, 640, 480, rs.format.bgr8, 30)

Start the pipeline pipeline.start(config)

Initialize the serial connection to the Arduino

arduino = serial.Serial('COM5', 9600) # Replace 'COM3' with the correct serial port

try: while True:

Wait for a new frame

frames = pipeline.wait_for_frames()

depth_frame = frames.get_depth_frame()

color_frame = frames.get_color_frame()

if not depth_frame or not color_frame:

continue

Convert depth and color frames to NumPy arrays

depth_image = np.asanyarray(depth_frame.get_data())

color_image = np.asanyarray(color_frame.get_data())

Define the function to get distance for a given coordinate

def get_distance(x, y):

Replace this with the actual depth_frame.get_distance() function

For this example, we'll assume the distance is 1.0 for demonstration purposes.

return

Loop through the grid and compare distances for three sets

for i in range(9):

for j in range(9):

x = int(35.56 + i * 71.11)

y = int(26.67 + j * 53.33)

distance_n = depth_frame.get_distance(x, y)

```
if i in range(0, 2) and distance_n < 1.0:

arduino.write(b"L\n")
print("l",x,y,distance_n)

arduino.timeout = 0.5  # Set a timeout of 1 second

try:
response = arduino.readline().strip().decode('utf-8')
print(response)          except UnicodeDecodeError:
print("Non-UTF-8 character detected in response")

if
response:          if
response == 'OK':
print("Arduino successfully executed the command")
else:
print(f"Unknown response from Arduino: {response}")          elif i in
range(2, 5) and distance_n < 1.0:
arduino.write(b"C\n")
arduino.flush()          print("c")
elif i in range(5, 8) and distance_n < 1.0:
arduino.write(b"R\n")
arduino.flush()          print("r")
```

Create a 3x3 grid rows,

cols = depth_image.shape

grid_size = 3 step_x = cols //

grid_size step_y = rows //

grid_size

depth_colormap = cv2.applyColorMap(cv2.convertScaleAbs(depth_image, alpha=0.03), cv2.COLORMAP_JET)

for i in range(grid_size):

for j in range(grid_size):

Calculate the center coordinates of each grid cell

center_x = step_x * (i + 0.5) center_y = step_y *

(j + 0.5)

Measure distances in each grid cell

Inside the loop to calculate and display distances in the grid

distance = depth_frame.get_distance(int(center_x), int(center_y))

Send the distance to the Arduino

disshow = "Grid {}-{}: {:.2f}".format(i, j, distance)

Draw grid lines

if i < grid_size - 1:

cv2.line(depth_colormap, (int((i + 1) * step_x), 0), (int((i + 1) * step_x), rows), (0, 0, 255), 1) if j < grid_size - 1:

cv2.line(depth_colormap, (0, int((j + 1) * step_y)), (cols, int((j + 1) * step_y)), (0, 0, 255), 1)

Display the distance text

font = cv2.FONT_HERSHEY_SIMPLEX

font_scale = 0.5

font_color = (255, 255, 255)

font_thickness = 1

text_size = cv2.getTextSize(disshow, font, font_scale, font_thickness)[0]

text_x = int(center_x - text_size[0] / 2) text_y = int(center_y + text_size[1] / 2)

cv2.putText(depth_colormap, disshow, (text_x, text_y), font, font_scale, font_color, font_thickness)

Display the color and depth images

cv2.imshow('Color Image', color_image)

depth_colormap = cv2.applyColorMap(cv2.convertScaleAbs(depth_image, alpha=0.03), cv2.COLORMAP_JET)

cv2.imshow('Depth Image', depth_colormap)

Check for a key press and exit if 'q' is pressed

key = cv2.waitKey(1) if key & 0xFF == ord('q'):

break except

Exception as e:

print(f"An error occurred: {str(e)}") finally:

```
  pipeline.stop()
arduino.close()
cv2.destroyAllWindows()
```

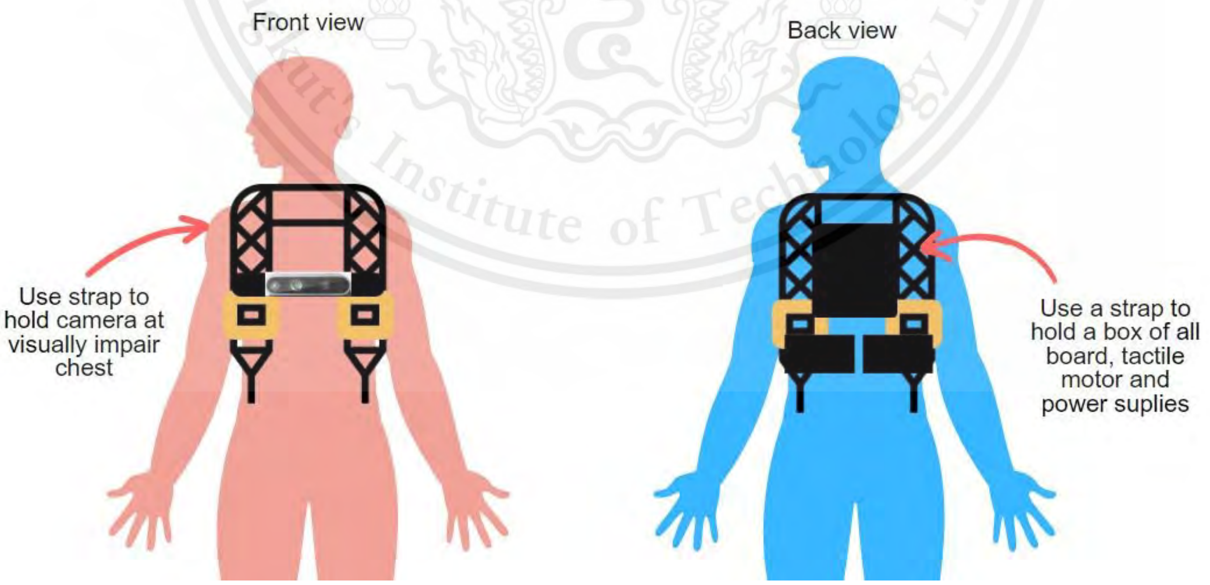
3.5 Design

3.5.1 The researchers designed a navigation device.

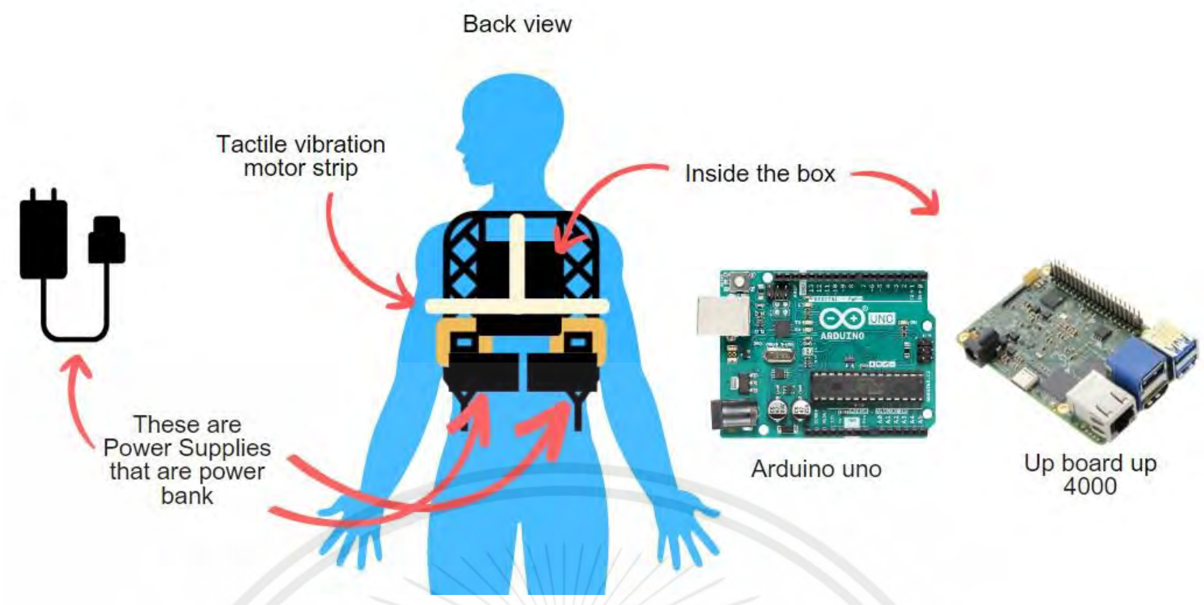
For visually impaired individuals using an infrared camera, specifically the Intel RealSense D435. This camera has the capability to measure the distance between the camera and objects within its field of view using active stereo sensing principles. In this method, it emits infrared light (IR) towards the objects in front of the camera and utilizes stereoscopic vision to determine the distance of objects from the camera. This technology serves as the primary tool for providing data for navigation systems.

The camera is mounted on a chest harness, as shown in the schematic diagram. To meet the initial objectives, vibration motors are attached to the chest harness in three positions (left, front, right), as indicated in the diagram. They are positioned at the center of the back.

Subsequently, an Arduino Uno board is connected to the Intel RealSense 435d camera located on the front and the UP board UP 4000 (which serves the purpose of inputting various codes to the Arduino, replacing a computer). Both boards are installed in the same enclosure, which is attached to the front of the user's chest. Additionally, a backup battery is connected, as depicted in the back view schematic image.



a.



b.

Figure 3.5.1: Example of Schematics Intel RealSense D435 depth camera after installation of accessories [a.] Front view, [b.] Rear view

3.5.2 Software Development for Navigation Device

In this research, the data obtained from the distance-measuring camera is transformed into numerical values and organized in a 3x3 grid, correlating with the positions of objects in the camera's image. This process is accomplished using the Mathlab program. Subsequently, the data is processed and calculated on the UP board UP4000 x7-E3950, which functions as a small-scale computer, simulating the capabilities of a regular computer.

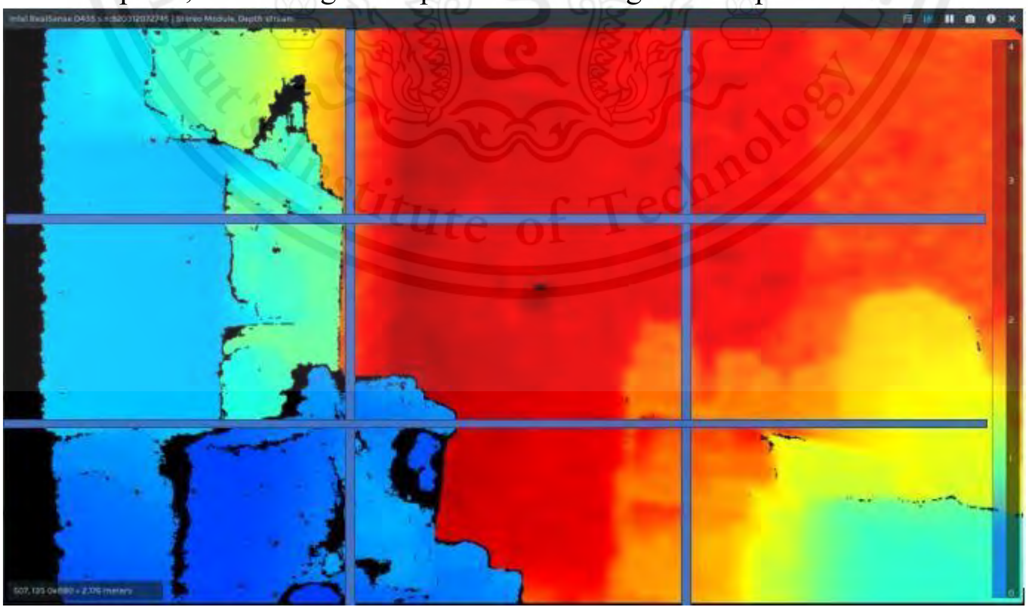


Figure 3.5.2: Example Image Obtained from the Intel RealSense D435 Depth Camera After Dividing the Grid Using Python for Use with Vibration Motors.

Subsequently, the data processed by the UP board UP4000 x7-E3950 is sent to the Arduino Uno for use in controlling vibration motors. These small electric motors operate on the principle of eccentricity or imbalanced weight to induce vibration. In this research, the vibration motors are employed to alert the device user. If there is an obstacle or obstruction in a particular position, the motor in that location vibrates to notify the user and prompt them to avoid that specific path.

CHAPTER 4

EXPERIMENTAL RESULT AND DISCUSSION

4.1 Introduction

In this chapter, we present the comprehensive results of the optimization process, which include representative The Intel RealSense D435 depth camera of various parameters and results that are displayed on our computer. Despite our best efforts, the result of our project could be more satisfactory than our materials. Therefore, we will provide details in discussion of each parameter component.

4.2 Result

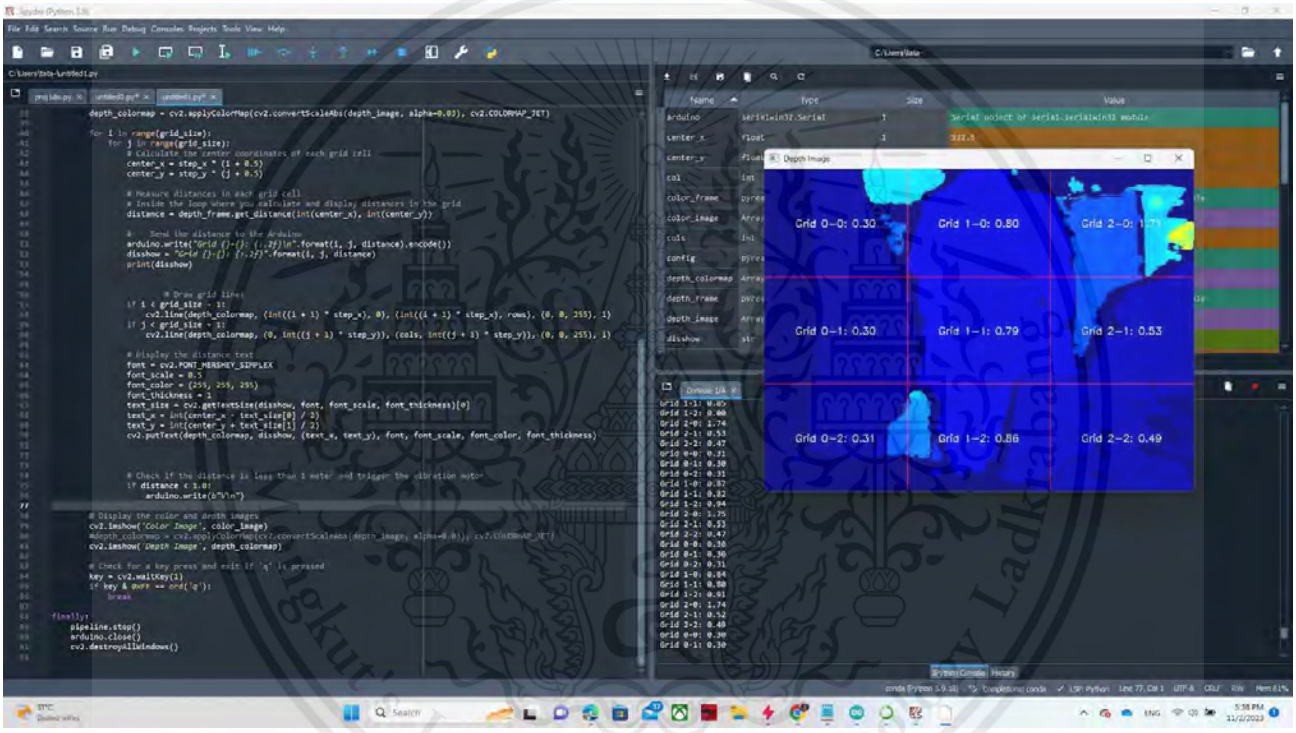


Figure 4.2.1: Object distance calculated from the center of 3*3 grid.

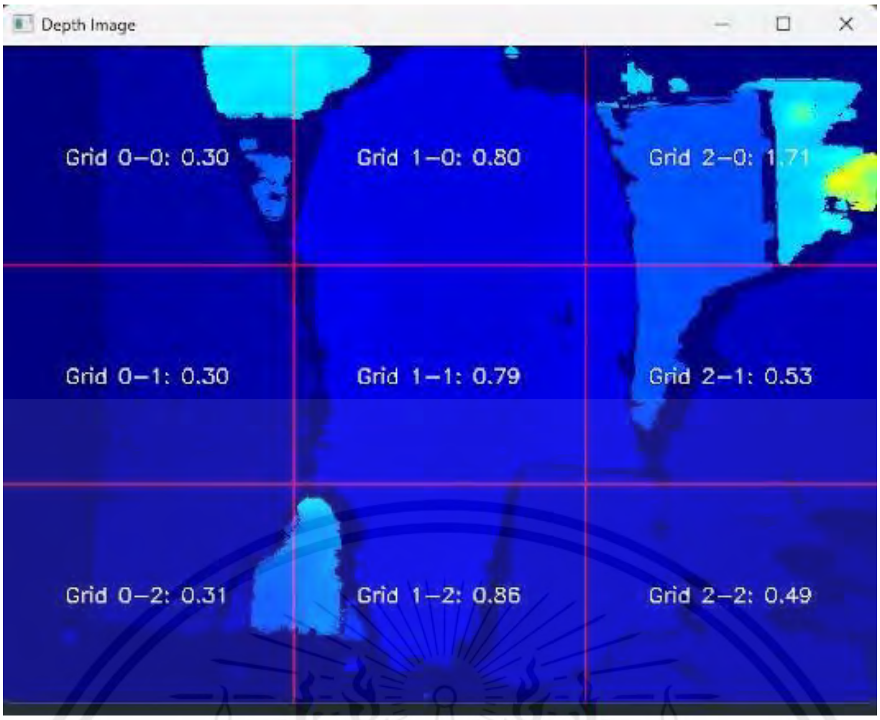


Figure 4.2.2: Zoom in of Object distance calculated form the center of 3*3 grid.

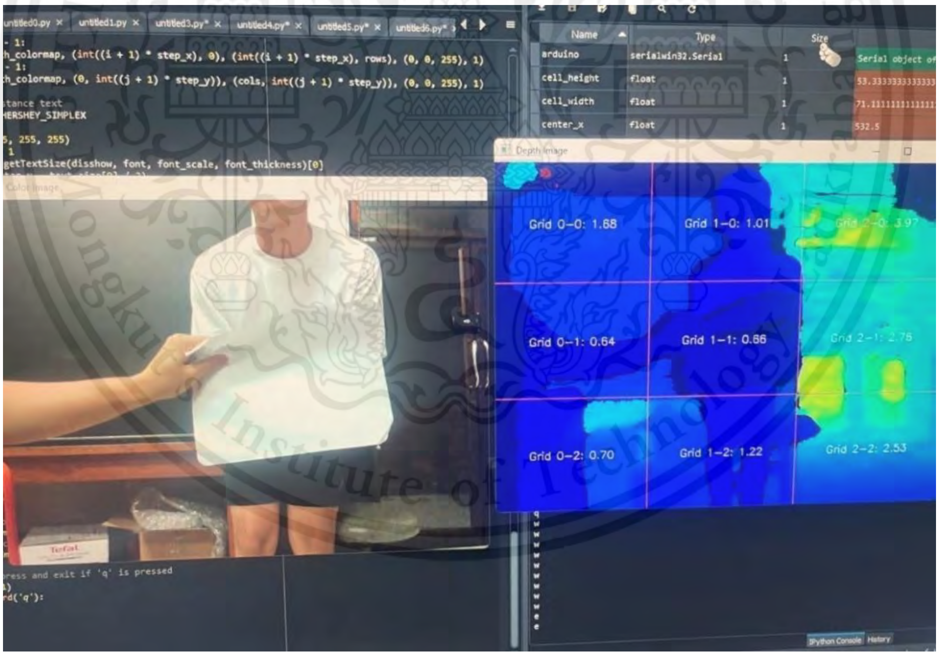


Figure 4.2.3: Object distance calculated form the center of 9*9 grid.

As we have identified our Software development into two parts with Python and Arduino code. For the Python part has a function of collecting the distance data from Intel Realsense 435D and using the data to calculate the distance on the 3x3 grid.

At first, we coded the Python to separate the camera frame into a 3x3 grid in Figure 4.2.2. In each section, we also divide it into a 3x3 grid again to make the distance in each big

3x3 grid more accurate. Then we function it to collect the data from the center of each section from 81 small grids (figure 4.2.3). Then we will use the closest distance that the camera collected to be the variable and the Python will spectate in 3 vertical parts on the camera frame. If they meet the condition, the Python will send the letter to the Arduino part via serial communication either in the right, middle, or left of the camera frame.

As a result, the vibration motor vibrates according to the position of the object on the front view of Intel Realsense 435D.

4.3 Discussion

The product of this research is expected to be a tool designed to assist those who are visually impaired. It uses a camera installed on the chest to recognize and record many kinds of images, including RGB, depth, and infrared. Numerical processing is applied to the data retrieved from these images using the UP board UP4000 x7-E3950, a small computer. The computed values are then sent to the Arduino Uno, which is in charge of the vibration motors attached to the user's harness. This system's main goal is to provide targeted vibrations that alert the user to potential obstacles or roadblocks in their path, enabling effective obstacle avoidance and navigation.

From the experiment, there are some issues that happened.

- With only collecting the distance data from the center of each 3x3 grid we can achieve a very low accuracy that if there is a object that has smaller size than one-fourth of each grid in the 3x3 grid the camera will not be able to detect. Our solution is to divide each one big grid in 3x3 grid into 3x3 smaller grid in it. Then we collect all the distances at the center of each 81 grid and calculate if there is any grid that encounters with the object closer than 1 meter to make the accuracy of the device increase.
- The vibration motor, with the small size of wire attached to the vibration motor, makes it very hard to solder it with the jumper wire and makes it unstable and not durable. The hot temperature of soldering makes this thin wire break easily which makes it sometimes unable to vibrate accurately.
- Intel Realsense 435D, there is an error in the precision of distance measurement on the left section of the camera frame. In addition, the minimum distance that the Intel Realsense 435D can detect is 0.15 meters as displayed in figure 4.3.
- Upboard up4000 Atom x7-e3950, we did not put all the code into the Upboard and still operate it on the computer due to that we are still not able to solve the problem from the vibration motor.

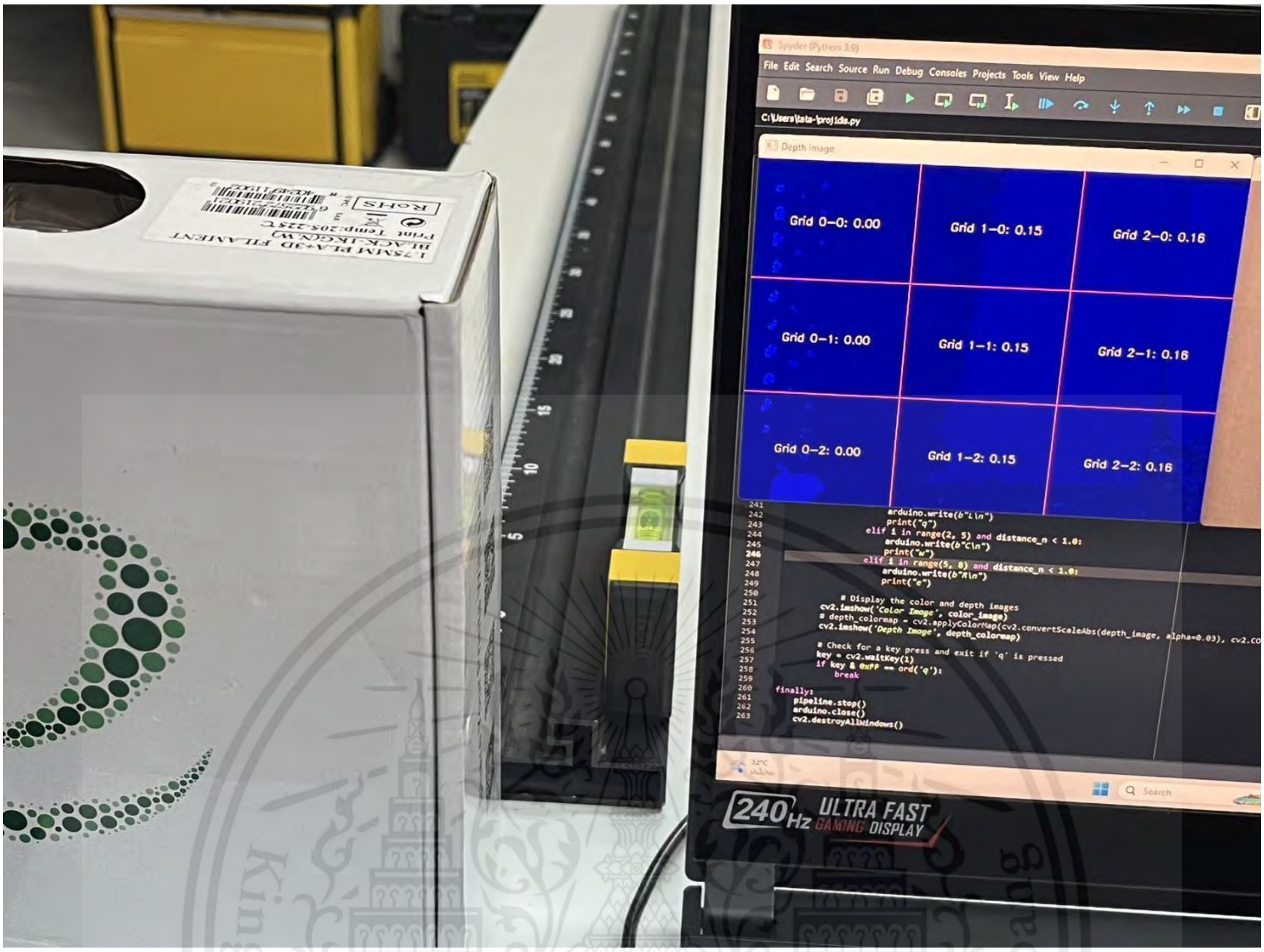


Figure 4.3: Show the display of minimum distance that Intel Realsense 435D can detect.

4.4 Summary

This section represents the object detection experiment with the Intel Realsense 435D and the vibration system.

Our result indicates that our device provides a correct distance and the capability to notify the tester by vibrating the vibration motors correctly to the position of the object according to the calculation from the distance data of Intel real sense 435D.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this chapter, we will summarize the work, then conclude the key parts of working on the precision of the Intel Realsense 435D that can detect an object closer than 1 meter and the vibration motor that vibrates according to the position of the object, and we will give suggestions for our project to be further developed and improved on the project.

5.2 Summary

Chapter 1 is our project background and objective about Visually Impaired people nowadays.

Then Chapter 2 is about the medical relates of the visual impaired, technology for visually impaired in the present, together with theory of depth sensing camera, what is time-offlight and how AI detects object.

After that the experiment's design, model of our technology and material, all of this are in Chapter 3

In chapter 4 will show our result, what camera can see, the grid in coding that we separated for camera will display in this chapter, along with discussion the problem that we found when we do the tests.

And the last Chapter will present the conclusion and how to improve our project.

5.3 Conclusions

The aim of this project is to create a device designed to assist visually impaired individuals, utilizing a camera mounted on the chest harness to detect and capture images, including RGB, depth, and infrared images. The data from these images is then processed into numerical values using the UP board UP4000 x7-E3950, which is a compact computer. Subsequently, these values are sent to the Arduino Uno to control the vibration motors attached to the back of the user's harness. This system aims to alert the user to obstacles and obstructions in their path by vibrating in specific locations, allowing the user to navigate and avoid obstacles effectively.

In conclusion, the result from our experiment is that we can develop the software and integrate the Python and Arduino code to be able to receive the distance data from the Intel Realsense 435D, calculate the distance in each grid on camera frame and make the vibration vibrate according to the position that present the object closer than 1 meter to the camera. With the example display on the computer monitor with OpenCV.

5.4 Suggestion

1. To improve the accuracy of the distance in each grid from the Intel Realsense 435D, we can increase more grid in the camera view. With this method we will be able to average the distances from each grid and get more accuracy.

2. In order to make a vibration motor become stable, we can improve by using the thicker wire which we can solder with more stability and durability.

3. To make this device able to be carried-on device and the system do not have to attach to the computer is to integrate the Python and Arduino into the Upboard up4000 x7e3950 that act as a minicomputer.

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