LIST OF RECOMMENDATIONS:)

- [ ] LORA license?
- [ ] Try 2 different LORA modules and compare applicability to desired condition
- [x] ~~Will this be stationary?~~
- [ ] Identify actual setup Tx and Rx for the entire experiment.
- [ ] Provide testing for height characterization.
- [ ] Provide testing for distance characterization, Determine minimum and max distance that the system can handle.
- [ ] Simulate in actual intended environment. Different weather conditions.
- [ ] Include Signal to noise calculations.
- [ ] Data reception calibration and testing. Include LCD for the message.
- [ ] Audio signal calibration and testing.
- [ ] Include testing and calibration of GPS vs commercial grade device
- [x] ~~add more objectives, combine objectives 2 and 3.~~
- [ ] include actual application, testing environment
- [ ] provide tables for testing parameters like strength of the signal, system evaluation, degree of error, calibration, statistical analysis
- [ ] include test for different weather conditions - include actual prototype design, discuss in detail.
- [ ] discuss procedure for actual testing
- [ ] include and discuss additional features aside from distance and location
- [x] ~~Revise the system flowchart, Follow correct standard flowchart rules and symbols~~
- [ ] Provide Calibration of sensors
- [ ] Provide Statistical treatment of data
- [ ] Provide at least 2 Mapua published paper
- [ ] Consult with adviser regularly

Integrated Handheld Transceiver Device and GPS Tracker using Long Range Wide Area Network (LoRaWAN)

by

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Chapter 1

INTRODUCTION

Communication plays an essential role in people's daily lives as its main purpose is to exchange information and communicate with other people. Communication during and after a calamity is one of the most important parts of disaster management as it connects the affected people in a community to rescue teams and also to their family members. A transceiver is a combination of both transmitter and a receiver which can both transmit and receive information through a transmission medium that can be used to help ease communication during emergency situations. The use of LoRaWAN technology can help resolve problems with communication due to a cellular network outage especially during typhoons or natural disasters. LoRa (Long Range) modulation provides a low power, long range connectivity, and allows transfer of data for a range of as long as 15km in urban areas and a longer distance range for rural areas without the use of GSM or WiFi connection.

Recent study about advanced communication using LoRa for natural calamities showed a proposed system that is a Stand-alone device LoRa used for long range communication. To avoid communication problems in disaster, the research provides an alternative solution using Raspberry pi and LoRa transceiver which is used for advanced communication. The study chose LoRa as their transceiver over others, since LoRa can work from long ranges and the data rates are preferred. The microcomputer used is the Raspberry pi because it can handle more complex operations compared to an Arduino. Though having an alternative way of communicating with others, integrating with a location tracker will have a more accurate and easier way of locating the other when in natural disasters.

The use of a two-way communication system is needed and can play an important role in reducing risks and saving lives in times of emergencies. To establish effective emergency communication and coordination to different areas in the city, a device such as a transceiver which has the capability to monitor and track locations, and also receive and gather information is needed. LoRa technology is one of the technologies used in IoT networks that has a long range, low-power wireless radio frequency platform, and a low power consumption which can be used for years. The use of a GPS also has its own advantage between the emergency response team and the affected areas in the city. A GPS is used to help the emergency response team to easily track the real-time location of a person and quickly respond for help. This device can also serve as a modern rescue equipment for those who live in areas where no internet or cellular connection is available to send out their real-time locations and coordinate with the rescue team especially during and after an intense disaster like typhoons.

The general objective of this research is to be able to use the LoRa's technology to a half-duplex communication device that is integrated with GPS tracker to be used for emergency purposes mainly, natural calamities. The device will include specific features that are emergency disaster proof. The specific objectives of this research will be the following: (a) To create a two-way communication prototype system between two transceivers using LoRaWAN (b) to fully make use of LoRaWAN's data communication from long range distances (c) to be able to measure the distance between two transceivers can communicate.

In this research study, a transceiver device integrated with a GPS tracker was combined with Long Range Wide Area Network (LoRaWAN) technology to specifically contribute to the development of its capabilities on message transmission and location tracking. One of the essential and oftentimes overlooked parts of emergency and disaster management is the effective exchange of information between the emergency responders and those who are affected by the emergency. With the use of LoRa technology, two-way communication will be possible between the two devices and can be implemented for a low cost compared to other low-power WAN technologies. Effective exchange of information during emergencies and disasters will help in reducing the potential for injuries and also help the emergency responders to get a more accurate location of those in need of assistance. The transceiver can be beneficial specially to citizens who live in areas that are prone to floods and tropical storms and can serve as an alternative to commercial cellular systems especially when other modes of communication are down.

The research study is limited to an alternative means of communication in critical times like natural disasters. The application of LoRaWAN is to be able to communicate from one end to another when cellular networks, towers and other present-day means of communication go down. That will be the main reason for the difficulty in communicating with other people. The location tracker integrated will be used in locating one transceiver from the other transceiver and vice versa. The transceiver device will be used to send data to the receiver device which will be stationarily placed in locations such as city halls, barangay halls and other LGUs in the area. The LoRaWAN is not for large data payloads, so continuous monitoring will not be applicable since the data transfer rate of LoRaWAN varies from 300 bps to 37.5 kbps depending on the spreading factor and the bandwidth of the communication channel which is up to 500 kHz.

Chapter 2

REVIEW OF RELATED LITERATURE

A. Handheld Transceiver

Figure 2.1 Handheld Transceiver

Hand-held transceivers are a transmitting and receiving device that comes with a battery. For it to operate, the user must push the button found on the device to transmit data while speaking to an integral microphone. An antenna is also found on the top of the device that has a length of 6 to 18 centimeters [1]. Push-to-talk radio communication lines are an effective means of communication especially during a disaster or the like since it has an accurate and reliable transmission. There are two types of transceivers, handheld or vehicle-mounted, and handheld transceivers are the most commonly used [2]. The number of units of hand-held transceivers being used in the industry, business, and communication are continuing to increase as it is found to be convenient and flexible for operators [3].

B. GPS Tracker

Figure 2.2 GPS Tracker

GPS receivers receive the signal from at least three satellites to calculate distance and use a triangulation technique to compute its two-dimension (latitude and longitude) position or at least four satellites to compute its three-dimension (latitude, longitude, and altitude) position [4]. The observer will receive an SMS containing the exact position of the tracker (longitude, latitude, height, date and time....) [5]. GPS tracking system was developed where in the data that has been collected is available most of the time. It can be used as a GPS-logger, record and transmit data. Also, GPS tracking is less expensive than other methods of location tracking like drones' censuses [6].

C. Solar Energy

Figure 2.3 Solar Panel

Solar energy is one of the energy sources being widely used and is highly popular among the energy sources available because it is renewable, and for its continuity, and direct and easy use. The solar panels have photovoltaic cells that are used to convert the solar energy collected into electrical energy and store it in the battery [7]. The amount of sunlight that the earth receives everyday is unlimited and is available at no cost. The advantage of using solar energy is that it is free and available in large quantities of supply that can be used by everyone [8]. Solar panels are popularly used in remote areas where the distribution of electricity is not reached. The installation of solar panels may have a high cost but once installed, it will provide free source of electricity and will pay off for the next years [9].

D. Internet of Things (IoT)

The Internet of Things is an Internet infrastructure which refers to the interconnection of devices that collect and transfer data and are embedded with a software and sensor [10]. With the use of IoT, new applications such as in radio-frequency identification (RFID), and wireless, mobile, and sensor devices, anything that can provide information can be done virtually and can be remotely controlled by any device connected to the Internet [11]. Advancements in low-power wide area network (LPWAN) technology, which is specifically made for IoT applications, allows the possibility for cheaper construction and longer battery life of mobile sensors [12]. IoT applications are mostly cloud-based which combine the functions and characteristics of a computer and makes it possible for the IoT related devices to be capable to receive, interpret, and transmit data to analyze data and make decisions [13]. One of the important areas of applications of IoT is in emergency cases and since the communication infrastructure is mostly the problem in these situations, the use of IoT and its remote sensing and monitoring system can help rescuers, health persons to save lives [14].

E. LoRa Messaging System

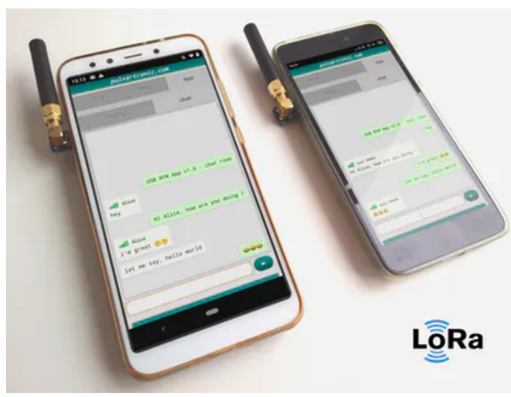

Figure 2.4 Messaging System

With the use of the LoRa network, it is possible for things or devices to join the internet without the use of cellular mobile communications such as 3G or GSM, and Wi-Fi [15]. The LoRa network aims to provide low power messaging services to isolated areas not reached by GSM signals. In emergency situations, the LoRa network can be used as an alternative for exchanging messages at long distances where most cellular services are down. [16]. One of the key features of LoRa is its ability to adjust its communication parameters, such as the Spreading Factor (SF) and the Coding Rate (CR) makes it possible for it to develop strong and low power links and therefore allowing for more data to be transferred and received. In exchange for increasing these parameters, the Time on Air (ToA) of packets is prolonged [17].

F. LoRaWAN

Figure 2.5 LoRaWAN

LoRaWAN is one of the low power wide area network (LPWAN) technologies that have received significant attention by the research community in recent years. It offers low-power, low-data rate communication over a wide range of covered areas [18]. LoRaWAN is designed to allow connectivity for connected objects, such as remote sensors. [19]. LoRa is a long-range radio transmission module which can transmit signals in the ISM band frequency range from 902 MHz to 928 MHz. The LoRa supports Mesh networking. This LoRa module operates in the ISM band frequency and helps in transmitting signals even during disasters up to a radius of 15Km without the help of any base stations ortowers. [20].

G. Raspberry Pi

Figure 2.6 Raspberry Pi Microcomputer

Raspberry Pi is a System on Chip (SoC) that is a design where a single board has all the important circuits such as the Central Processing Unit (CPU), Graphics Processing Unit (GPU), and different input, output and processing circuits. A feature that the Raspberry Pi also has is the General Purpose Input Output (GPIO) pins that enables the computer to program hardware, and collect data through different means [21]. Raspberry Pi uses the Advanced Reduced Instruction Set Computing Machine (ARM) technology which reduces cost, heat, and power consumption. It functions like a computer and also has GPIO ports and USB ports that are used to control the devices with sensors and can be used for multiple purposes. Raspberry Pi comes with a Linux based operating system that supports programming languages like Python, C, C++, etc. [22].

H. LoRa Frequency Band

LoRaWAN assigned different radio frequencies for every country. LoRa applications can operate as non-specific short-range devices in the Philippines. LoRa uses unlicensed radio spectrum in the Industrial, Scientific and Medical (ISM) bands at 433 MHz, and 868 MHz to enable low power, wide area communication between remote sensors and gateways connected to the network. The LoRaWAN Channel

Plans are given for every country, the table below are the channel bands and the channel plans assigned for the Philippines that are owned by the Philippine government and other companies [23].

Band/Channels	Channel Plan
915 - 918 MHz	Other
868 - 869.2 MHz	EU863 - 870
869.7 - 870 MHz	EU863 - 870
433.05 - 434.79 MHz	EU433

Table 2.1 Frequency Bands Available for LoRa Applications in the Philippines

Chapter 3

METHODOLOGY

Conceptual Framework

A. Messaging System

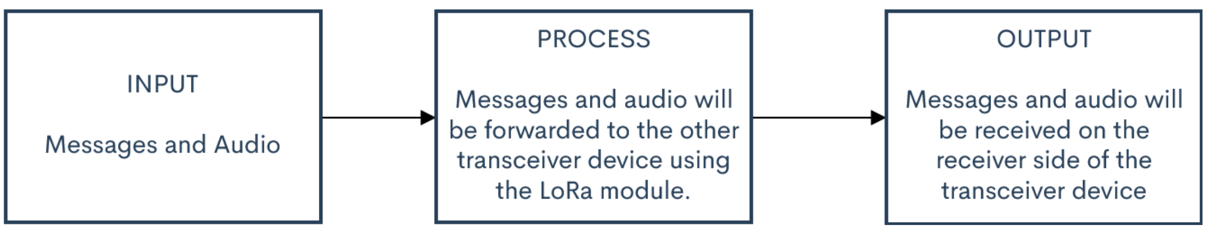

Figure 3.1 Messaging System Conceptual Framework

Figure 3.1 is the conceptual framework for the transceiver device. The messages and audio from the transmitter part of the transceiver device serve as the input for this study. The user has the option to use the pre-saved and pre-recorded messages and audio or record and type their own customized messages. The transmission of data will be done using the LoRa module to be able to transfer data at a long range between the two transceiver devices. In the receiver part, a LoRa module is also connected to the microcomputer module for the output data to be received. The two devices can then have a two-way communication after the information has been received from the transmitter side.

B. GPS Tracking System

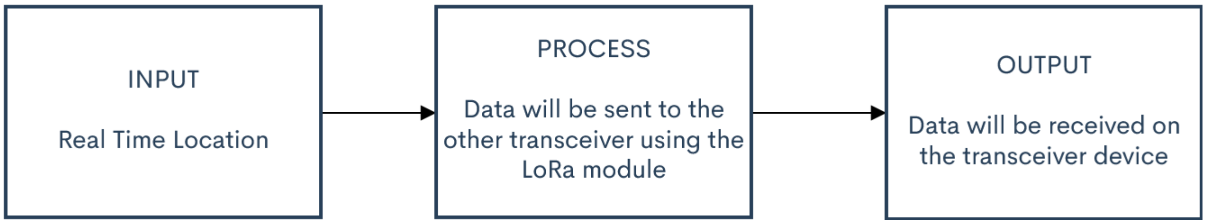

Figure 3.2 GPS Tracking System Conceptual Framework

Figure 3.2 shows the conceptual framework for the GPS tracking system in the study. The real-time location of the user will be sent from the transceiver device to the end-transceiver device, and vice versa. The data from the transmitter part will be sent through the LoRa module and is received on the receiver part.

Hardware Development

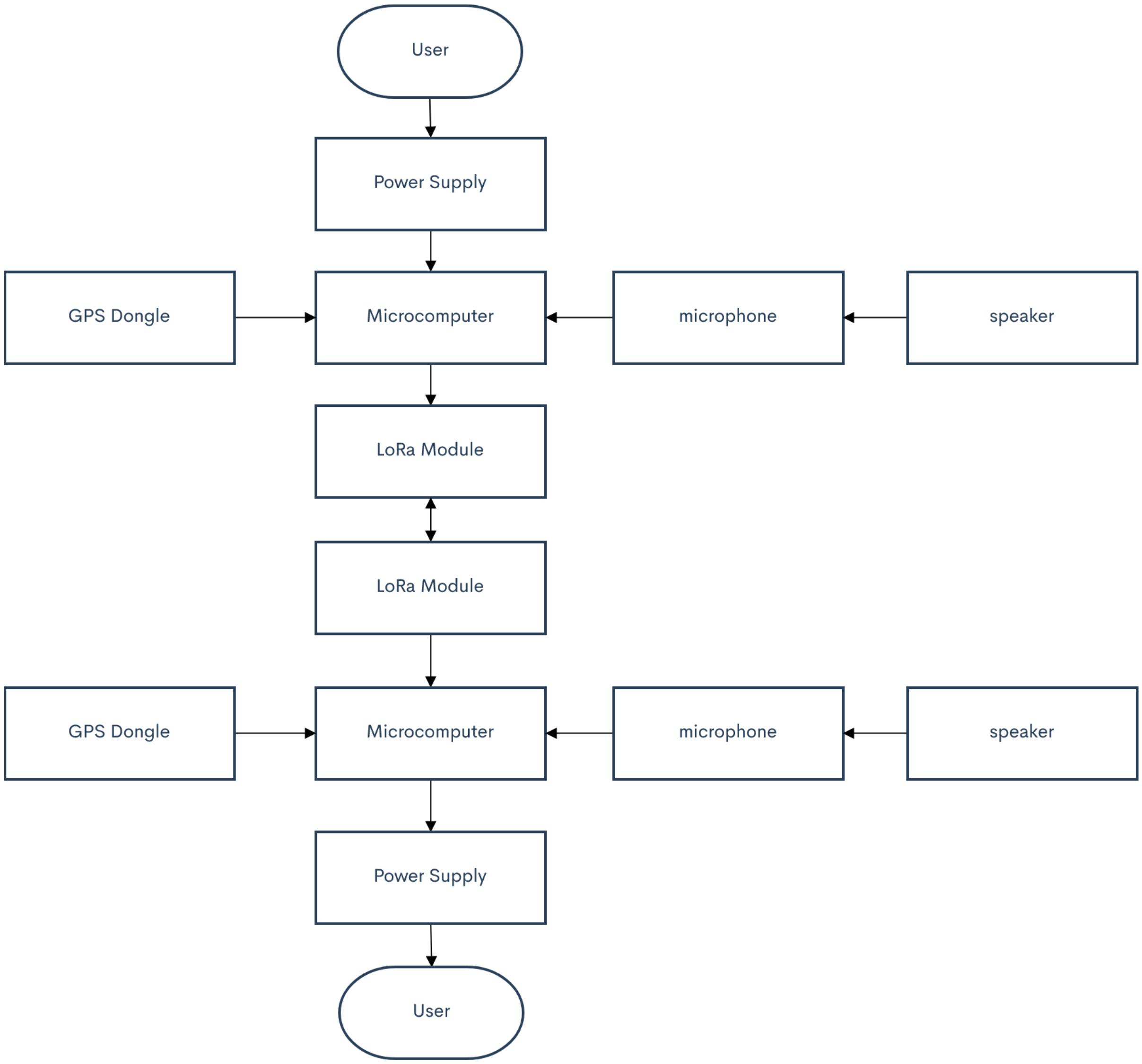

Figure 3.3 Block Diagram of the System

Figure 3.3 shows a proposed diagram of the system. Both the transmitter and receiver part will be composed of a microcomputer (preferably a Raspberry Pi), a LoRa Node, and attached to the microcomputer are a GPS dongle, microphone and speaker. The setup will be connected to each other through the LoRa module, it allows communication between both users. Microphones are attached for future use in changing the pre-recorded audio. Pre-Recorded audio will be saved on the microcomputer and it will be bound to the push buttons. GPS Dongle will also be connected to the microcomputer, it is responsible for sending the location coordinates of user1 to user2.

Hardware Setup

A. Transceiver Device Setup

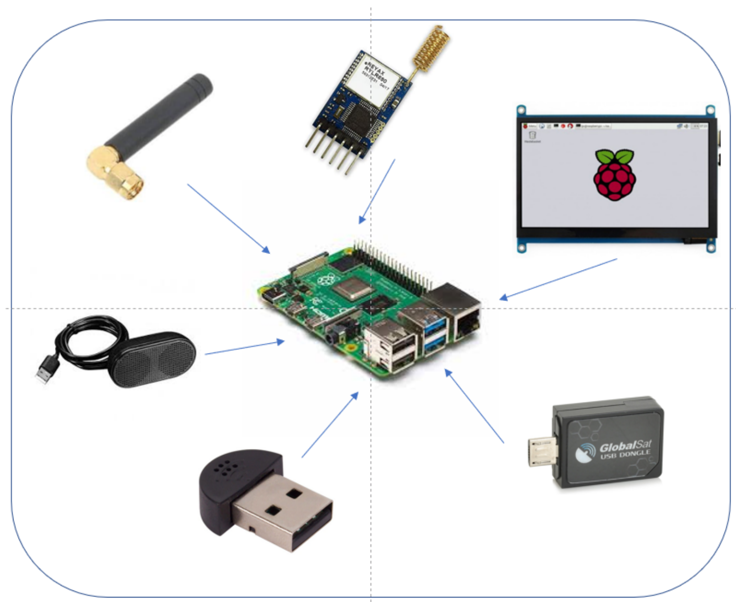

Figure 3.4 Hardware Setup of Transceiver Device

Figure 3.4 shows the hardware setup for the main part of the device which is the transceiver device. LoRa module is connected to the Raspberry Pi and will be used to be able to transmit and receive messages from each other. GPS dongle is also connected to the Raspberry Pi that will send coordinates to the other end device. A microphone and a speaker is also connected to the raspberry pi if the user needs to create a new recorded message. A keypad is used to create a customized textual message that will be projected to the display screen. For the power source, the device will have three options, it can either be usb powered, solar powered or hand cranked generator. The integration of solar panel and hand cranked generator is the option when usb power source is not available.

System Flowchart

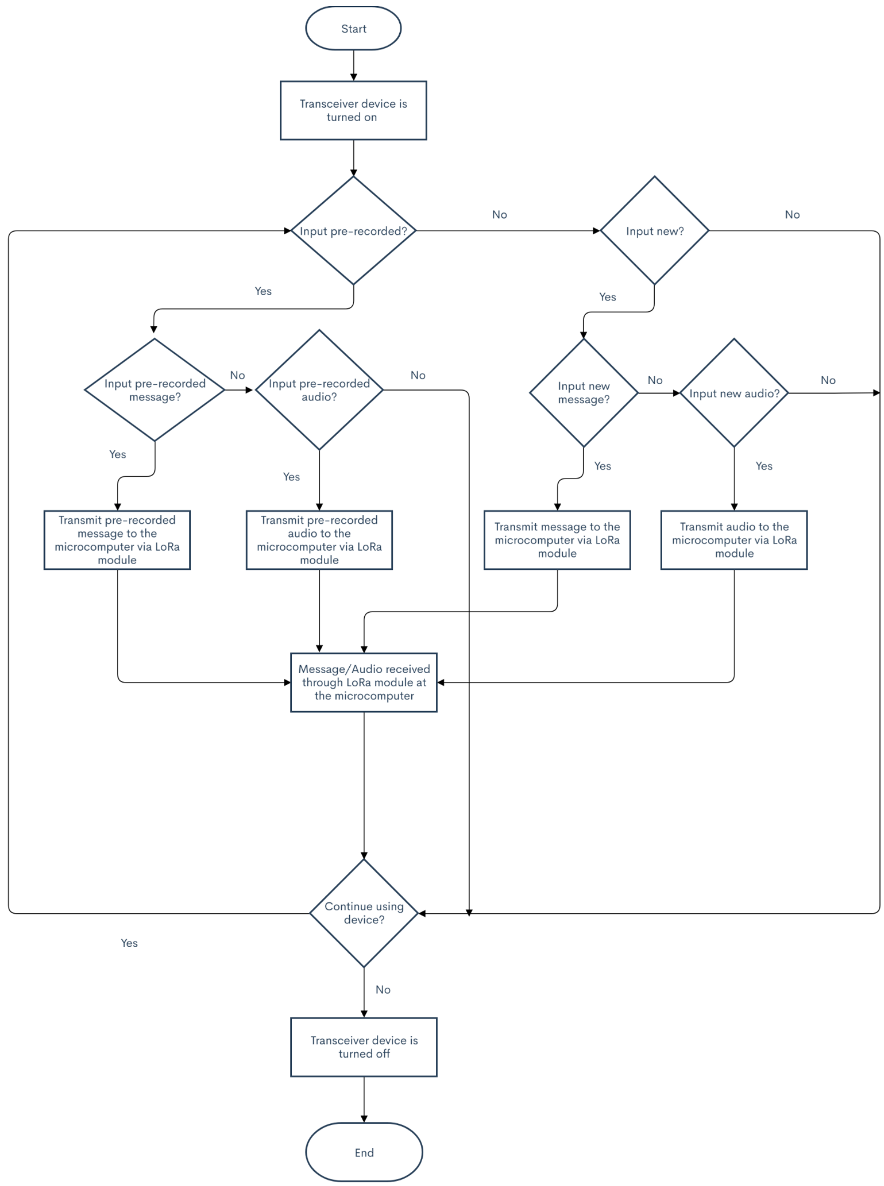

Figure 3.5 Messaging System Flowchart

Figure 3.5 shows the flowchart for the messaging system. Both transceiver devices are connected with a microcomputer module. Push buttons will serve as the input containing the pre-recorded audio message and pre-saved textual message. The LoRa module will transfer the message to the other microcomputer that is also connected with a LoRa module to create a two-way communication between the two end devices.

Testing

A. Messaging System - distance between the two transceivers

Distance: 2km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				
n				

Table 3.1 Messaging System Table for 2km

Distance: 4km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				
n				

Table 3.2 Messaging System Table for 4km

Distance: 6km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				
n				

Table 3.3 Messaging System Table for 6km

Distance: 8km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				
n				

Table 3.4 Messaging System Table for 8km

Distance: 10km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				

2				
3				
.				
.				
n				

Table 3.5 Messaging System Table for 10km

Distance: 12km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				
n				

Table 3.6 Messaging System Table for 12km

Distance: 14km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				

n				

Table 3.7 Messaging System Table for 14km

Distance: 16km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				
n				

Table 3.8 Messaging System Table for 16km

Distance: 18km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day
1				
2				
3				
.				
.				
n				

Table 3.9 Messaging System Table for 18km

Distance: 2km				
Trial	Test Message/Audio	Message Received?	Rainy Day	Sunny Day

1				
2				
3				
.				
.				
n				

Table 3.10 Messaging System Table for 20km

The tables shown above are for the trials for the data transfer from one transceiver to another with the use of the LoRa module. At least twenty (20) trials will be conducted in every increment of two to the distance of the experimental setup to test if the message will be received from the transmitter part of the transceiver to the other end, which is the receiver part of the transceiver device, and vice versa. The trials per distance will also be tested in different kinds of weather conditions. The trials for the setup will be done to know the effectiveness of the proposed design and the maximum distance it can reach and also to be able to determine the effectiveness of the device in certain weather conditions.

B. GPS Tracking System

Actual Coordinate: X = ; Y=		
Trials	X Coordinates	Y Coordinates
1		
2		
3		
.		
.		

n		

Table 3.11 Transceiver Device 1 for GPS Tracking

Actual Coordinate: X = ; Y=		
Trials	X Coordinates	Y Coordinates
1		
2		
3		
.		
.		
n		

Table 3.12 Transceiver Device 2 for GPS Tracking

The tables shown above are for the trials in sending the location of Transceiver 1 to Transceiver 2 and vice versa. At least 15 trails will be conducted for each device. The transceivers will be in different locations for the testing to the GPS tracker. The trials for the setup will be done in order to determine the accuracy and consistency of the GPS Tracking device or the location tracker.

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