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LoRaWAN based Movement Tracker for Smart Agriculture

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ABSTRACT

In this paper, a prototype for an animal movement tracking system had been developed for Smart Agriculture 4.0. The system collects the data from the GPS module to determine the location of the animal, particularly farm animals. This animal tracking device will employ LoRaWAN as the medium for data transmission. The GPS module and LoRa device are connected to the ESP32 board to read and transmit the data. The data will be sent to the server via LoRa and displayed using the LCD display at the server for monitoring purposes. This prototype had been tested and can only be used on one tracking device at a time. This prototype also is used in the range of about 300 meters long before the signal loss hence proving it to be suitable to be used in the agriculture sector where Wi-Fi signal can be at scarce.

Key words: Animal Tracker, GPS, IoT, LoRaWAN, Smart Agriculture

1. INTRODUCTION

Nowadays, as the wireless sensor technology evolves dramatically, vast transformations of system innovations are s]\een across various industries.Wireless Sensor Network (WSN) technology able to provide data collectionfor various areas of industries, transmitted wirelessly. WSN is currently utilized in many fields such asmeasuringof lands, monitoring and controlling [1].Thus, the growth of recent Fourth of Industrial Revolution (I.R 4.0) paradigm, which highly influenced the evolution of manufacturing technologies where a cyber-physical system, Internet of Things (IoT) and cloud computing are significant. The I.R 4.0 brings together smart automation and digital data communication where devices able to connect and process globally over the network.

As I.R 4.0 and IoT gained their popularity, the global challenges to address the issues of increasing the quality and quantity of food production had taken significant effect with the implementation of Agriculture 4.0 [2]. Agriculture 4.0 is also referred to as smart farming or future farming technology. IoT-based applications which perform monitoring and tracking of devices, usually adopt the short-range communication technology to transmit the data to the cloud, database server or any mobile devices. However, recently, the need of long-range network coverage and very low power demand, Long Range Wide Area Network (LoRaWAN) technology has become a favourable method for smart monitoring system especially in agriculture [3][4].

In [5], a GPS-based Animal Tracking System had been developed in order to detect the animal’s movements specifically to monitor the wildlife migration patterns. The animal’s location is being detected by using GPS. Then, the location information is being transferred to the database via the base station using a peer-to-peer network protocol. The work had shown to be able to detect the location within the accuracy of 15m. However, the limitation in this work is the transmission of the location data to the database due to the need for numerous numbers of base stations for its large deployment area.

In [6], a method known as GATA is developed in order to detect the movements and monitor any animals which moved from forest to residential area. This method used GPS and sensors to realize the prototype. Wi-Fi technology is used to transmit data between the transmitter and the receiver. However, the prototype is fully depended on the reliability of the Wi-Fi availability, and the coverage distance is only 500m between both transceivers. Next, work [7] presented monitoring and tracking the animals by using a Bluetooth network. RFID-based animal movement tracker is also presented in [8]. The work proposed the use of RFID to track the location of the animals. This work will estimate the location of the animals by using an active RFID tag and connect via a wireless network. However, in this work, [7] and [8], showed that both the RFID and Bluetooth coverage is low due to the short range of the network protocol.

While in [4], a model of a system based on LoRaWAN network for long-range and low power consumption data transmission from the sensor nodes to the cloud services had been proposed. It showed that LoRaWan protocol is suitable for long-range communication network where wireless coverage is at scarce. In [9], a prototype of a low-cost IoT-Based System to monitor the location of a whole herd had successfully been built and tested. However, the system is still dependable on wireless network availability.

GPS and LoRaWAN sensors were then shown to be efficient in tracking the location of emergency vehicles in urban areas,as presented in work [10]. The incorporation of LoRaWAN technology in this work had seen the consumption of power by each unit is efficiently reduced; also the transmission coverage of wireless signals will be high as compared toother similar technologies such as ZigBee, RFID tags etc.

Lastly, in [11], a LoRaWAN based movement tracker prototype had been developed and tested. Though the system is proven to work in LoRaWAN environment, the location of the tracker needs to be manually extracted from the flash drive.

Hence, this work is an extension of [9].This workemployed LoRaWAN protocol, and the location of the tracker can be displayed directly at the LED LCD display added to the server.

2. RESEARCH METHOD

Iterative waterfall model is the method that was chosen for this project development. This model is used because it can adapt to the changes in development. Besides that, this model can repeat to the previous phase if there are any modification needs to be made at any stage.

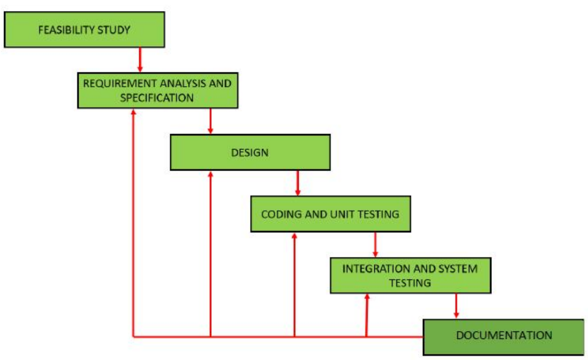

Figure 1: Iterative waterfall model

2.1 Feasibility Study

A feasibility study is done to perform the analysis and evaluation of the project proposed. This is to determine whether it is feasible or not to be implemented. Thus, the feasibility study determined all the problems statement, gaps, objectives and all the work to complete the project. At this phase, comprehensive research is being performed regarding their project details, either hardware or software.

2.2 Requirement Analysis and Specification

In this phase, all relevant information and challenges regarding the project will be collected and documented. It is important to discuss and propose any possible solutions to address the issues specified. Afterwards, the specific solution will be specified in details to provide an efficient system.

In this phase, in order to address this work objectively, there are several components of hardware and software that had been determined. There are two sections which are the transmitter and receiver module. The transmitter module will be attached to the animal targetted where its movement will be monitored. The transmitter module will be the tracking device while the receiver module will be the server where the location information is sent and displayed. For the transmitter module, the prototype used the LoRa SX1278 ESP32 433Mhz Wi-Fi module and LED LCD Display 12C Module. For the receiver module, LoRa SX1278 ESP32 433Mhz Wi-Fi module and Neo-6m GPS module are integrated. Software used includes programming C++ language for both modules.

2.3 Design Phase

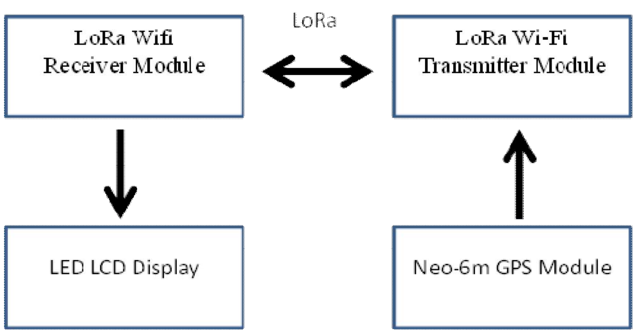

Figure 2: Project Block Diagram

In this phase, a project block diagram and design flowchart are being developed. The project diagram and flowchart show the development of the prototype. In this phase, the diagram of the device either transmitter or receiver module.

Figure 2 shows the project block diagram of this working prototype. This figure shows that the hardware components required and the transfer of the location data collected from GPS and send to the receiver module through LoRa and location data will be displayed at LCD.

Figure 3 depicts the flowchart of the system. Firstly, the connection of LoRa from both the receiver and transmitter are established. Secondly, the GPS module will retrieve the tracking device location and submit to LoRa in order to send the data to the server. Lastly, the data received by the receiver will pass to the LCD to be displayed.

2.4 Coding and Unit Testing

In this phase, all the components that are being used in this project will be tested for its functionality before uploaded its software program. This phase is to ensure that there was no error when all the components are being assembled together. It is also to confirm that there is no error regarding the functionality of the components. If everything functions well, the project will move to the next phase.

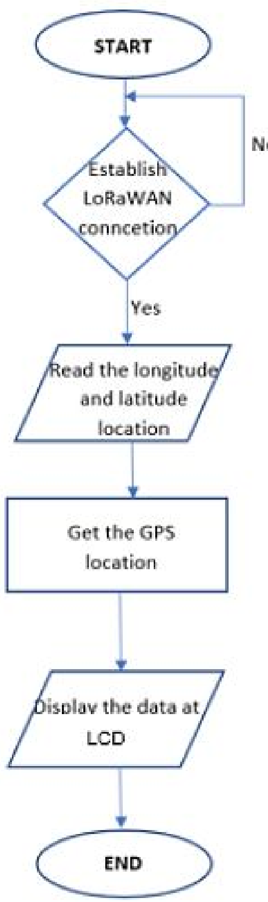

Figure 3: Flow Chart

2.5 Integration and System Testing

In this phase, the prototype will integrate the hardware and software in order to achieve the objective of this work. Then, the prototype will be tested in order to enable GPS location detection and LoRa connectivity for both modules. In this phase, firstly, the connection between the tracking device and the server is tested. Once successful, the location estimation from the GPS module and location data transmission using LoRa will be tested for its functionality and accuracy.

3. HARDWARE AND SOFTWARE

3.1 Hardware

ESP32 433Mhz Wi-Fi module shown in Figure 4 is based on Wi-Fi 32 that had been implementing SX1278 which is LoRa chip on the board. This SX1278 use three frequency which is 433, 868 and 915 MHz. This esp32 board has access to Wi-Fi. This board with LoRa chip can produce +20dBm power output and have 4M byte(32M Bit) Flash. This device requires two for client-side and the gateway side.

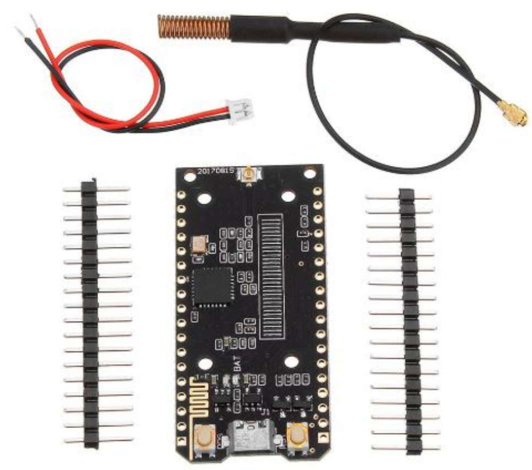

Figure 4: LoRa SX1278 ESP32 433Mhz Wi-Fi module

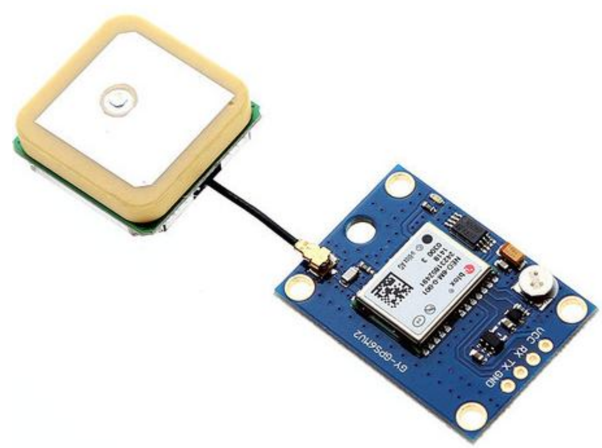

Figure 5: Neo-6m GPS Module

Neo-6m GPS Module shown in Figure 5 is a GPS device suitable for indoor applications because of its high sensitivity. This module also comes with a rechargeable battery for backup if any errors occurred. This module has a built-in EEPROM that can save configuration settings. This module can operate between 3.3V to 5V. Neo-6m GPS module comes with LED signal indicator. This device is also very light in weight.

Figure 6 shows the LCD display that will implement in this prototype. This LCD display will connect to the server microcontroller board. Thus, it will get the data and display the output at the LCD display. This LCD display can support up to 5V only.

Figure 6: LED LCD Display 12C Module

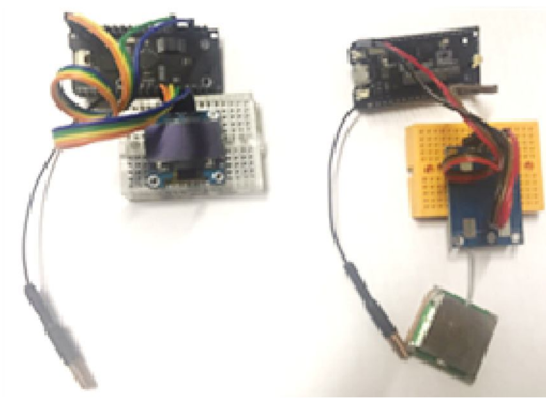

Figure 7: Hardware Prototype

Figure 7 shows this work LoRaWAN Animal Tracker prototype. Hardware needed to for this development is LoRa SX1278 ESP32 433Mhz Wi-Fi module, LED LCD Display 12C Module and Neo-6m GPS module. The location collected at the server from the tracking device will be displayed at the LCD display.The breadboard in Figure 8 is used as the medium between the devices. Usually, this will function if two devices that have node-connect directly. This device needs to use along with jumper cable. The jumper must be a male-to-female connector.

A jumper wire in Figure 9 is just a simple wire that has a connection pin at the end of the wire. Those pins are to connect two points between different devices without soldering. These wires come in many colours, but the colour does not mean anything special. These wires have three types which are male-to-male, female-to-female and male-to-female. The male side has protruding that can use to plug into a thing. Meanwhile, the female side does not have to protrude and use to connect thing into it.

Figure 8: Breadboard

Figure 9: Jumper Wire Set

3.2 Software

Arduino IDE is open-source and free software. This software is used to build an electronic project for Arduino microcontroller. This software will run on a computer or laptop to write, test and upload programs to the microcontroller board.

3.3 Software Development

Figure 10 shows the configuration that had been set up for the client side of this project. This configuration is used to read the LoRa packet at the board.

```
void cbk(int packetSize) {
  packet ="";
  packSize = String(packetSize,DEC);
  for (int i = 0; i < packetSize; i++) { packet += (char) LoRa.read(); }
  rssi = "RSSI " + String(LoRa.packetRssi(), DEC) ;
  LoRaData();
}
```

Figure 10: TransmitterProgram

In Figure 11, the program code to enable the display if the LoRa connection established. It will show 'Heltec.LoRa Initial Success' at the LCD display at the transmitter device.

```
void setup()
{

  Serial.begin(115200);
  gps_serial.begin(9600, SERIAL_8N1, 12, 17);


   //WIFI Kit series V1 not support Vext control
  Heltec.begin(true /*DisplayEnable Enable*/, true /*Heltec.Heltec.H

  Heltec.display->init();
  Heltec.display->flipScreenVertically();
  Heltec.display->setFont(ArialMT_Plain_10);
  logo();
  delay(1500);
  Heltec.display->clear();

  Heltec.display->drawString(0, 0, "Heltec.LoRa Initial success!");
  Heltec.display->display();
  delay(1000);

}
```

Figure 11: Server Program Code

4. RESULT AND DISCUSSION

Figure 12 shows the output that will be displayed at the LCD when the transmitter and receivermodule had been powered up. This figure shows that the LoRa connection is successful. Besides that, it also indicates that the receivermodule is waiting for the incoming data from the transmitter module.

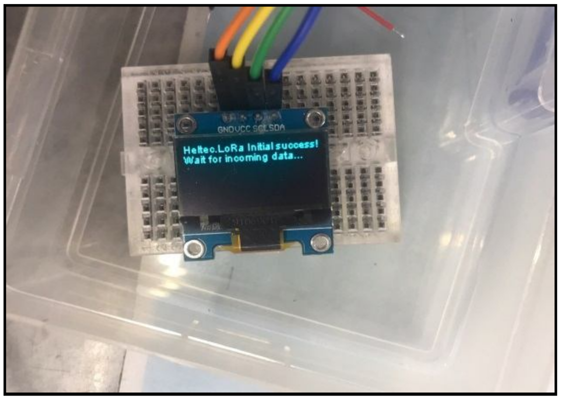

Figure 12: Tracking Device Output

Figure 13 shows the tracking device output when the system is running. The output will display at the LCD located at the server. As shown in the output is '*pktNum'*. This 'pktNum' is packet number which means if there is a connection between tracking device and server, the amount of the packets will continue to increase until the system is turnedoff. '*Long'* is the longitude of the tracking device which is acquired from the GPS module.

Meanwhile, '*lat'* is the latitude acquired from the GPS module of the tracking device. This latitude will also change according to the tracking device movement. Altitude is the reading of the height of the GPS module from the ground level.

Figure 13: LCD Result

In this work, the server had been located at a static venue at a residential house. The accuracy of the system needs to be tested to determine the reliability of the system. Initially, the tracking device is located near the location of the server is located.

The location of the tracking device is displayed at the server's LCD display in terms of longitude, x, and latitude, y, which are acquired from the GPS module. The accuracy of these location data received at the server will be compared to the location found from *latlong.net*. The map shows the longitude and latitude readings of the server location with respect to the address entered. Figure 14 depicts the location information and the map shown from *latlong.net.*

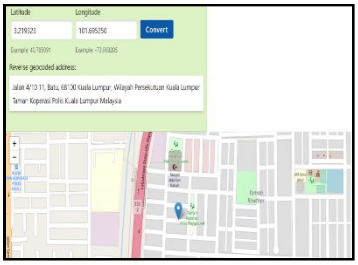

Figure 14. Latitude and Longitude of the Server Location

Table 1 shows the result observed from this prototype testing. In this preliminary work, the results showed that the GPS location obtained from the GPS-module and further transmitted to the server using the LoRa network are similar to the true reading given by *latlong.net.*

5. CONCLUSION AND FUTURE WORK

The objective of this work is to develop a prototype of an animal tracking system by using LoRaWAN as the network communication protocol. The prototype consists of LoRa and GPS module where the location is determined and transmitted.

Table 1. Comparison of Estimated Location and True Location

No	Estimated-Location	True-Location
1	x = 101.695250 y = 3.219323	x = 101.695250 y = 3.219323
2	x = 101.695848 y = 3.219185	x = 101.695848 y = 3.219185

The location information received at the server from the tracking device which is in mobile had shown accurate results hence proving that the project had achieved its objective. In future work, this tracking device will be tested on farm animals for the purpose of tracking and monitoring their movements.

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