Sea Turtle Tracking System

Umar Auwal Bala
School of Engineering
Asia Pacific University of Technology and Innovation (APU)
Kuala Lumpur, Malaysia
auwalbala81@gmail.com

Raed Abdulla
School of Engineering
Asia Pacific University of Technology and Innovation (APU)
Kuala Lumpur, Malaysia
raed@staffemail.apu.edu.my

Syed Mohd Bahrin
School of Engineering
Asia Pacific University of Technology and Innovation (APU)
Kuala Lumpur, Malaysia
syed.mdbahrin@staffemail.apu.edu.my

***Abstract*— Sea Turtle Conservancy (STC) is a global leader in the study, safety and protection of sea turtles. The mission of this is to guarantee the survival of sea turtles through advocacy, research, education and conservation of the habitats upon which they depend. Sea turtles are significant measures of the health of the world's marine and coastal ecosystems. In this paper, a smart cost effective and low power consuming control and monitoring system were proposed to provides complete real-time tracking alert to the personnel in charge of monitoring the safety of the turtle in the event of any threat along with the indication of their real-time location using a Neo-6M GPs sensor and RF module for tracking and proximity tracking respectively. The proposed system enables real-time tracking accuracy of 98.75% for an average of seven different locations, with a fast response time of 0.45seconds to detect new GPS location when the sensor is varied along a tested area.**

Keywords—Internet of Things, Arduino NodeMCU, Cloud Storage, Machine Learning, GPS, MySQL, ambient air quality, GUI, Parts per million

I. Introduction

For years an animal tracking system has been used to analyze animal behaviors for many reasons, such as to observe a migration pattern and environment interaction [1] Tracking mobile objects is an important mission in environmental monitoring and remote surveillance. This involves tracking animals [2]. In the last decades, radio frequency identification (RFID) has been introduced in many industrial fields, and low-cost devices have been developed to monitor consumer goods. Understanding movement patterns and the factors that affect animal distribution are integral components of behavioral ecology, conservation and protected area management [3]. The reduce of sea turtle populations has serious repercussion for countless marine animals as well as our own species. In short, sea turtles are a significant strand in the web of ocean life, sea turtles aid to sustain the oceans, and the oceans sustain life on the planet.

[4] proposed an Animal Identification and Data Management using RFID Technology to reduce the rate of missing farm animals from farms database. The proposed system functions by inserting active RFID tags inside the animals and it displays the current location of the animals. The location of the animal is sent via Short Message System (SMS) when the animals cross the set boundaries or migrate suddenly from their natural environment. The Alert sent to the authorities is mad available by the aid of a Global System for Mobile Communication (GSM). The animal database is updated by the veterinarian based on its vaccination, breed, reproductively and internal factors.

[5] proposed a system to track animals to determine swarm behavior which tends to overcome the challenge of inaccurate data collection in sea animals and efficient storage and utilization of the data collected. The proposed system employs an IMU8420-10 microcontroller which consists of an accelerometer module to detect body position, 3-axis gyroscope module to determine body state, a magnetometer to determine the magnetic pull in the body and in which direction and a barometer to check the altitude of the body in line with its alignment. This module is incorporated with a GPS sensor to obtain the coordinates of the animal being monitored.

[6] proposed a sensor for real-time animal condition and movement monitoring to aid further understanding of animal behavior which is in line with conservation efforts to evaluate how multiple conditions and pressure might affect the animal ecosystem. The proposed system consists of wearable composite magnets and magnetic sensors integrated into a miniaturized wireless communication module with a flexible battery. The magnetic field of the composite magnet is sensed by a 3-axial magnetic sensor, and the measured data is wirelessly transmitted using Bluetooth low energy communication standard to a smartphone and dashboard. This proposed system was tested on a crab and a sea turtle for a period of one day to determine the response to the movement of the legs. The proposed system attained an accuracy of 95.45% based on the number of small steps, medium steps, big steps, highly active and resting state of the animal. The limitation of the proposed system is that it was tested with a small sample size of 5 which increases its accuracy. Further testing can be conducted with a large sample size to validate the system.

[7] proposed a wearable health monitoring system for animals to overcome the problem of waiting for veterinary experts. The proposed system consists of four sensors used to monitor the animal health which are; temperature, respiratory, blood pressure and Echocardiogram (ECG) sensor modules. The proposed system obtains the body vitals which is integrated Uno sends the body vitals to the cloud to enable visualization and diagnosis by the veterinary experts. This proposed system was tested on a dog and it attained an accuracy of 91.2%. The gap identified from the test results of this proposed system was the LM35 temperature sensor utilized which due to its physical properties takes time to cool down after being exposed to harsh weather.

[8] proposed an instrumentation for monitoring animal movements. The proposed system allows two cameras to record at night under infrared illumination. The top of the bird head is marked which creates a suitable target for the bird to enable recognition by the image recognition algorithm. This proposed system methodology was validated using 45 videos (basically 500,000 frames at 60 fps) which included recordings in darkness. The proposed system test results on the video frames showed no sign of false matches, and the undetected matches were displayed under certain circumstance like when the object was out of range or indistinct. The gap identified in this proposed system was that some of the video frames appeared blurred due to the slow shutter speed of the camera used for video acquisition.

[9] proposed an integrated management and visualization of animal telemetry observations: serving data from a wide variety of platforms used in animal telemetry which to reduce the challenge of the ever-increasing volume of these data holdings. The Animal Telemetry Data Management and Visualization System (ATN DAC) it incorporates a clean and intuitive Google Maps system based on Google Esri Satellite, whereby the location of the animal is identified on the maps by using various color coded icons for various tag types. The gap identified in the proposed system is the current ATN DAC version being utilized which has the animal telemetry data capability is very not feasible for large implementation due to the cost of installation and maintenance, which makes it not sustainable on the long-run.

[10] proposed a large animal detection and continuous traffic monitoring on highways to reduce the rapid increase in animal-vehicle collision. The proposed system shows a here Large Animal Warning and Detection System (LAWDS) employs a 360˚-scanning radar to monitor a stretch of highway. Low false alarm rate and environmental impact make LAWDS attractive for operational use. LAWDS also distinguishes vehicles from large animals and analyzes highway traffic metrics such as traffic volume and vehicle speeds. This proposed system was tested and the results shows the tracks generated over a 30-minute period during operation. The gap identified in the proposed system is that although the researcher was able to identify the large animals it's still important to classify the animal to minimize threat to the animals crossing the street at night.

Due to the presence of GPS sensor available for sea turtle monitoring to monitor the location where the laid eggs and its movement. Its ultra-sensitivity prevents false alarm. In addition to the turtle monitoring, temperature sensor sensors are used on the turtle to monitor the condition of the turtle in case it need treatment or death. In this project, an integrated system will be designed and developed that will monitor the sea turtle and its eggs on the conservation center. There are high threats caused by humans and natural obstacles that are driving sea turtle to extinction whereas this system will control and monitor.

The aim is to design a smart cost effective and low power consuming control and monitoring system that provides complete real-time tracking alert to the personnel in charge of monitoring the safety of the turtle in the event of any threat along with the indication of their real-time location using an Arduino Uno ESP8266 with WI-FI capability and highly inflammable LPG (Liquefied Petroleum Gas) leaks have reached alarming rates which beckons for questions and concerns. This life-threatening domestic hazard are found to occur frequently due to lack of proper forewarning before it becomes a mass fire. Therefore, accurate fire detection is required to reduce false alarms, improve the detection time and limit the potential damage.

II. BLOCK DIAGRAM AND OPERATION OF THE PROPOSED SYSTEM

The major stages in the proposed smart sea turtle tracking system are described as follows:

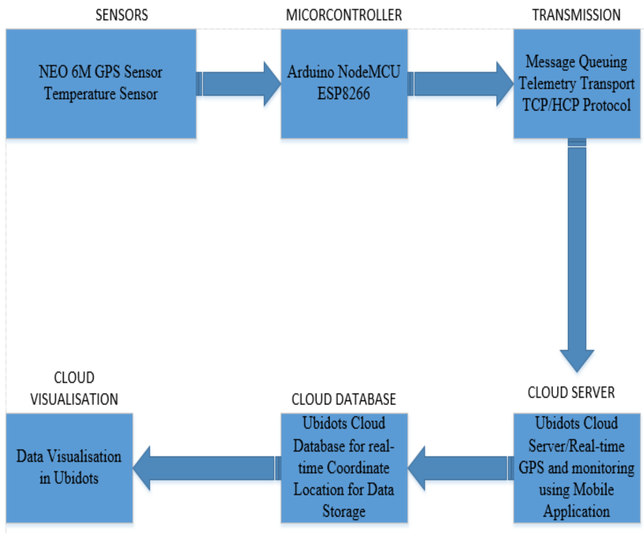

Fig. 1. System Block diagram

A. *Data Acquisition and transmission*

Data Acquisition is performed by a GPS sensor to track and monitor the location and movement of the turtle with a temperature sensor attached to monitor the temperature of the turtle. The proposed system employs an Arduino NodeMCU ESP8266 to acquire the location data from a NEO 6M GPS sensor. The GPS sensor acquires the location in form of National Marine Electronics Association (NMEA), the incoming data contains other geographical data such as the time it was taken, the country, the area of the location where the GPS signal is pinged, which are irrelevant for the proposed application. The Arduino NodeMCU filters the data and extracts the longitude and latitude of the current location. The Arduino NodeMCU ESP8266 is also interfaced with a waterproof DS192 temperature sensor, which reads the body temperature of the turtle to determine its current state.

The Data Transmission components of the system are responsible for conveying data collected from the sensors on the environment and sea turtle conditions to the cloud using Message Queueing Telemetry Transport (MQTT).

B. *Cloud Storage and processing*

The Longitude, Latitude and body temperature data is further relayed to Node-Red platform which is hosted on IBM server for long term storage and monitoring using Internet connectivity on the microcontroller, typically via a smartphone's Wi-Fi or cellular data connection.

Sensors in the data acquisition part form an Internet of Things (IoT)-based architecture as each individual sensor's data can be accessed through the Internet via the Node-Red server. A storage/processing MySQL database is used for long-term storage and generation of online report. A temporary storage which is commonly referred to as a cloudlet, is used to augment its storage/processing capability whenever the local mobile resources do not fulfil the application's requirements.

The cloudlet can be a local processing unit (such as a desktop computer) which is directly accessible by a mobile phone through wireless fidelity (WI-FI) network. Moreover, the cloudlet can be used to transmit the aggregated data to the cloud in case of limitations on the mobile device such as temporary lack of connectivity or energy.

C. *Cloud Analytics*

Analytics utilises data collected from sensors and generate patterns, filters random data and evaluate system performance. Additionally, Visualization is a key requirement for any such system because it is impractical to ask the user to pore over the voluminous data or analyses from sensors. Visualization methods that make the data and analyses accessible to them in a readily digestible format are essential if the sensors are to impact home safety.

III. IMPLEMETATION AND FLOWCHART OF THE SYSTEM

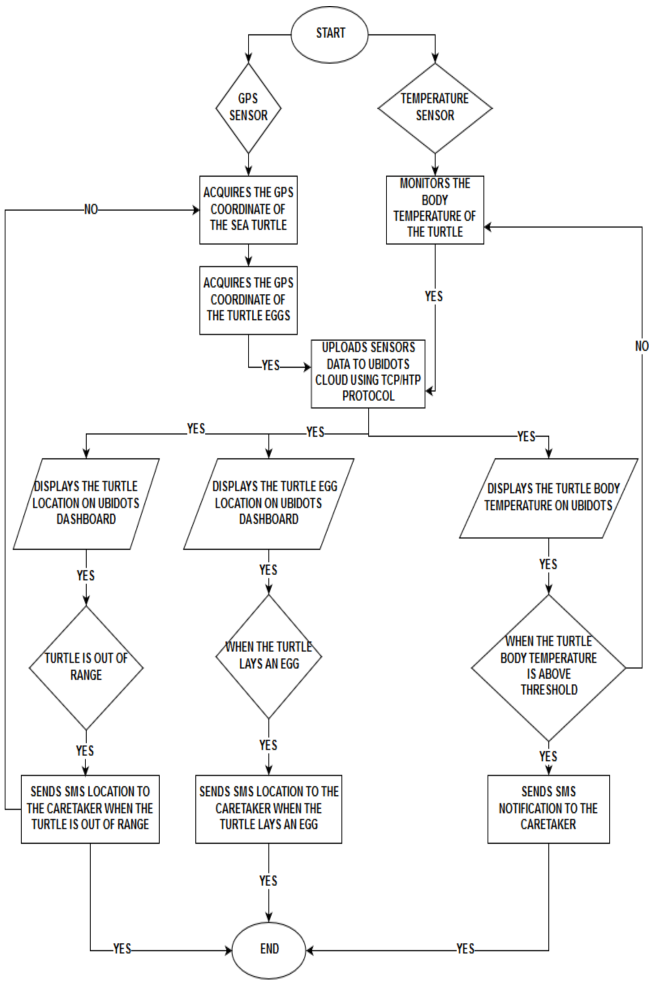

Fig. 2. Flow chart of the proposed fire management system

The deliverable system is designed by an approach as indicated in Fig 2. whereby an Arduino ESP8266 NodeMCU microcontroller continuously monitors the location of the sea turtle on land and monitoring the body temperature of the sea turtle.

While the proposed system aims to fully track the activities of the sea turtles on land, it also detects when the turtle has laid an egg. The proposed system detects the sea turtle egg location when the current sea turtle is stagnant at a point and it remains for 12 hours or more, the location is pinged to the caretakers.

The real-time location of the sea turtle and the egg location is uploaded to the Ubidots cloud platform using MQTT protocol. The location of the sea turtle and the eggs are visualised using a real-time map connected to google Esri satellite Application Programming Interface (API).

The tracking of the proposed system is fully exercised when the sea turtle exceeds the confined radius, it sends a location to the animal caretakers. This is because the sea turtle is out of safe zone and is vulnerable to poaching by man. Likewise, when the sea turtle produces an egg, it sends a message to the animal caretakers. Which is due to the fact that the sea turtle eggs need a good weather condition for incubation, further monitoring and protection of the eggs by the caretakers is carried out. The body temperature of the sea turtle is being monitored using the water proof temperature sensor, and when the body temperature exceeds the threshold value, or decreases below its set threshold value. An SMS is sent to the animal caretakers because it shows that the sea turtle requires medical attention. These parameters can also be monitored with the aid of the mobile application via IOT. Fig 3. exemplifies the electrical representation of the implemented sea turtle monitoring system.

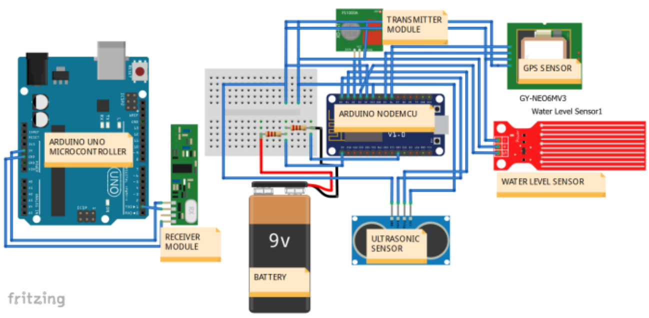

Fig. 3. Schematic diagram for the overall system diagram

IV. SYSTEM TESTING

In this section the two main tests are performed namely: the individual component testing which was carried on the sensing, monitoring and communication modules and the overall system testing was performed to prove the concept of sea turtle tracking and the system's performance.

A. Global Positioning System (GPS) accuracy test

To perform the GPS tests, initially seven different locations were the sea turtle monitoring system will be placed were identified. Followed by running the data acquisition stage of the system in six different locations one after the other locations. Finally, the latitude and longitude coordinate data were obtained from the IOT cloud layer. The main aim of this test was to observe the accuracy of the coordinate system obtained from the GPS sensor when the location is changed.

The latitude and longitude data obtained from the system are tabulated and compared with the actual coordinates as shown in Table I.

TABLE I. SMOKE CONCENTRATION TEST RESULTS

Location Name	Actual Coordinates		Tested Coordinates	
	Latitude	Longitude	Latitude	Longitude
Vista Komanwel A	3.060581	101.683992	3.06057	101.683801
One South	3.043233	101.708365	3.042995	101.706215
Fortune Park	3.03626	101.707408	3.036189	101.707381
Endah promenade	3.03628	101.707408	3.036189	101.707381
Arena Green Apartment	3.0529	101.6876	3.052913	101.68662
APLC TPM	3.048322	101.6922806	3.04822	101.692785
APU NEW Campus	3.055793	101.700025	3.05692	101.700022

It can be observed from the Latitude and Latitude bar chart in Fig 3. and Fig 4. that the accuracy of the sea turtle monitoring GPS system was an average of 98.75%. The GPS accuracy was compared to the online "latitude/longitude finder -MY NASA DATA", and it was observed that the discrepancies were in the last two digits after the decimal points. This is accredited to the method of decoding the NMEA sentence initially obtained from the GPS sensor to readable coordinates in latitude and longitude by using the tiny library in the Arduino IDE. This process of decoding this value decreases the efficiency and in most cases some values are neglected and approximated, which causes discrepancies when data is collected and compared.

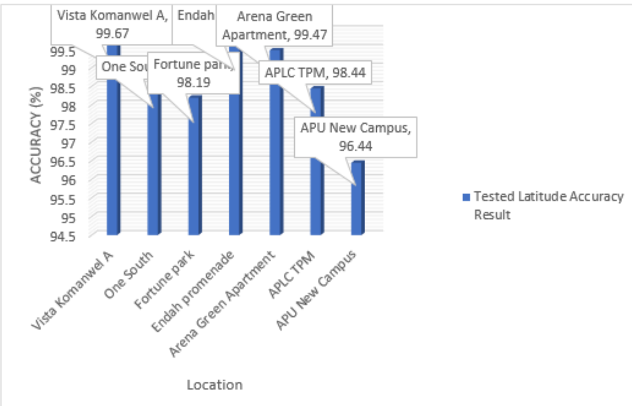

Fig. 4. GPS latitude accuracy test bar

Taking inference from the accuracy plot in Fig 6. and 7. respectively, it was observed during testing that the GPS test in Asia pacific University New campus, out of 10 samples, 4 samples continuously produced the latitude and longitude of Jalan Teknologi 5, which reduced the accuracy of the results recorded. These values were compared with navigation software Waze and out of 5 samples, 2 samples had the address of Jalan teknologi 5. This deals more on the mapping of certain regions by Google satellite, compared to the accuracy of the system, and some regions like the APIIT APLC had an accuracy of 100% and 98.67% for latitude and longitude which an average of 7 samples.

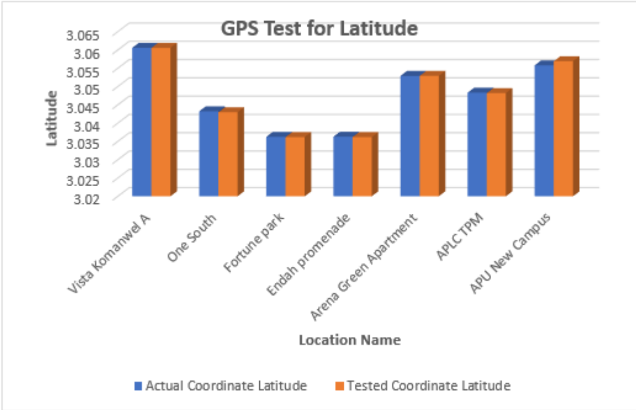

Fig. 5. GPS latitude test bar plot

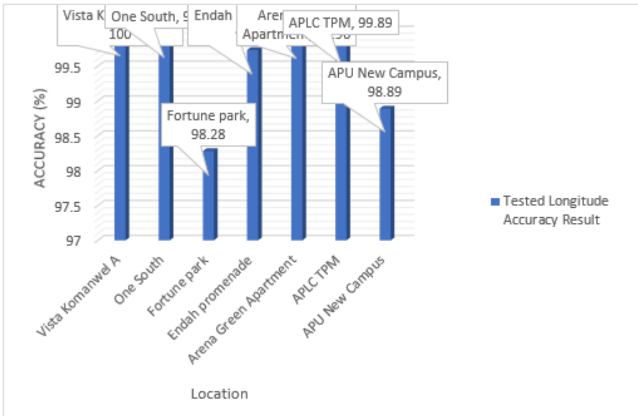

Fig. 6. GPS longitude accuracy test bar plot

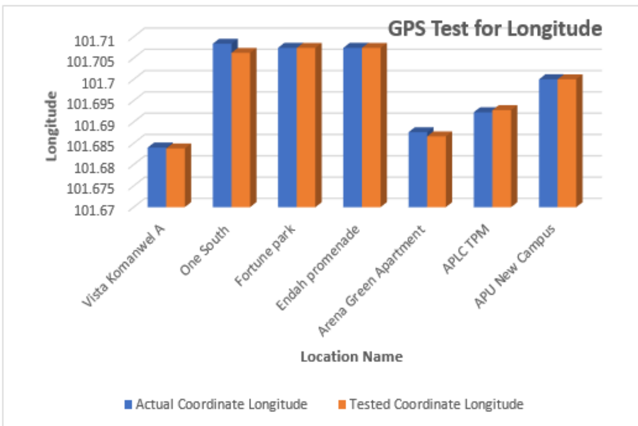

Fig. 7. GPS longitude test bar plot

B. Proximity Radio Frequency (RF) test

To execute the test, the first step was to setup the receiver and transmitter module on a separate Arduino boards, in an empty and enclosed room. The receiver Arduino board is connected to a 433 MHz transmitter and sends a ping signal to the receiver. The transmitter Arduino board is attached to an ultrasonic sensor to measure the distance moved away from the receiver by the transmitter, integrated with an LCD 16x2 to give real-time display of the distance for data collection purpose. Finally, the transmitter end of the RF module is integrated with a buzzer to trigger an alarm when the distance exceeds 100cm.

The other Arduino Uno board on the receiver is integrated with an RF receiver to receive the ping sent by the RF transmitter, both modules operate at a frequency range of 434 MHz. A stopwatch is used to record the detection time. After the test was completed the RF transmitter and receiver distance and detection time data was collected and tabulated as shown in Table II.

TABLE II. PROXIMITY TEST RESULTS

S/N	Receiver (RX) and Transmitter (TX) Distance (cm)	Receiver detection Time (Seconds)	SMS Message	Buzzer Alarm Condition
1	5	0.12	"SEA TURTLE WITHIN RANGE"	"OFF"
2	10	0.15	"SEA TURTLE WITHIN RANGE"	"OFF"
3	15	0.21	"SEA TURTLE	"OFF"
4	**20**	**0.24**	**"SEA TURTLE WITHIN RANGE"**	**"OFF"**
5	25	0.30	"SEA TURTLE WITHIN RANGE"	"OFF"
6	30	0.33	"SEA TURTLE WITHIN RANGE"	"OFF"
7	35	0.41	"SEA TURTLE WITHIN RANGE"	"OFF"
8	40	0.43	"SEA TURTLE WITHIN RANGE"	"OFF"
9	45	0.47	"SEA TURTLE WITHIN RANGE"	"OFF"
10	50	0.53	"SEA TURTLE WITHIN RANGE"	"ON"

From the graph in Fig 8. a directly proportional relationship is observed from the distance between the RF receiver and transmitter module and the receiver detection time. The test location of the sea turtle which contained the transmitter module was varied further away from the receiver (user), the detection time at which the ping arrived at the receiver as recorded by the stopwatch was increasing constantly

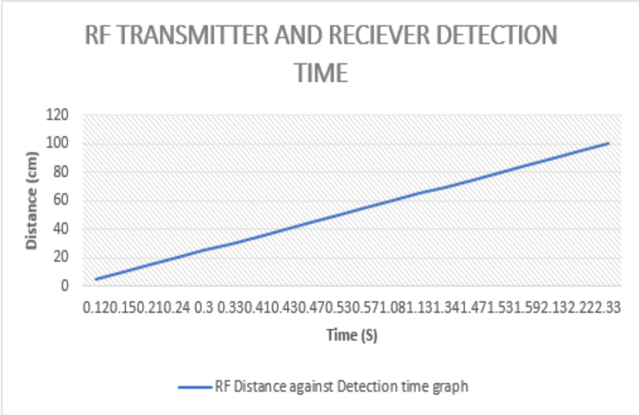

Fig. 8. RF transmitter distance and receiver detection time plot

The delay in detection of the ping at the RF receiver module was mainly since the receiver requires more power to detect ping at further distance and the available power from the Arduino Input/output (I/O) pin is 0.048Watt. According to its datasheet of the RF module, 0.065Watt is required which could only be provided by an external power supply which would reduce the lifespan of the communication module. The increase in delay from the receiver is attributed to the RF module utilized which has a frequency of 433MHz which is very sensitive and can easily pick up interference from other RF devices, this caused the delay in pings detected from the transmitter module. This illustrates that the signal which is to be received from the sea turtle is detected from far field up to 100cm but with a higher detection time (high delay) of 2.33 seconds, compared to close distance of 5cm with an unnoticeable delay of 0.12 seconds. Although the RF module utilized has a frequency which could be received up until 100meters but a threshold of 50cm was set on the implemented system to track the sea turtle.

V. HARDWARE RESULTS AND SIMULATION

This section provides the results and simulation for the sea turtle monitoring system with regards to the objectives specified.

Fig. 9. Constructed hardware prototype

the holder for the system components which is designed by an approach whereby it accommodates all the important features required to simulate the implemented system in a closed environment and reiterate the implementation of each objective. The container utilized which encompass the components is air tight to prevent water coming in when mounted on the turtle back and also attached firmly on the back of the turtle

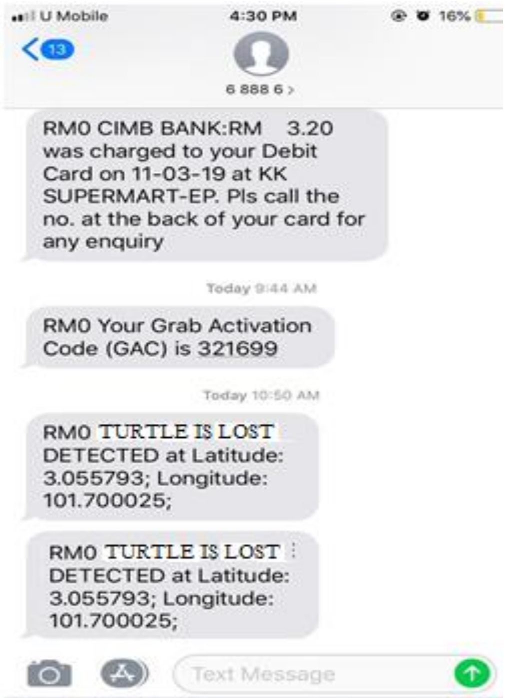

Fig. 10. Screenshot of the SMS notification sent to the user

Fig 10. shows the Short Message System (SMS) received from the data acquisition and transmission stage of the implemented system. Also, the message describes that the turtle has laid an Egg, including the GPS location of the hotspot in longitude and latitude.

Fig 11. illustrates the Ubidots cloud GUI interface for the sea turtle monitoring system sub-system. It exhibits all the relevant parameters requires for the implemented system to perform efficiently. The sensor parameters displayed were used to set the threshold values, if the battery level is low it triggers the actuators and sends a warning signal. The battery level indicates the back-up battery, in an event of power-outage to control the system.

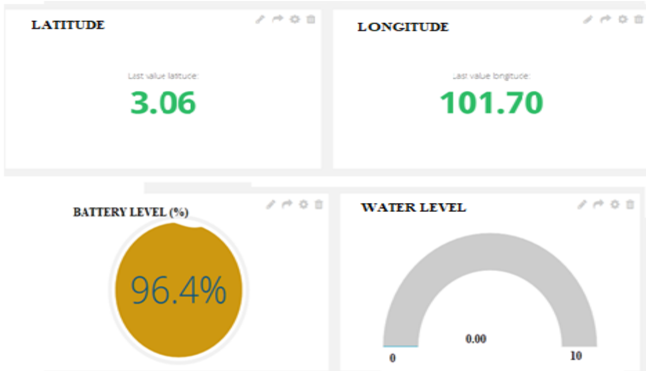

Fig. 11. Screenshot of the IOT dashboard

VI. CONCLUSION

To conclude, the aim and objectives stated in this papaer are accomplished successfully. Basically, a real-time sea turtle monitoring system has been developed. For effective tracking and monitoring, a Neo-6M GPs sensor was utilized and an RF module was used as proximity tracker. An IOT user interface was designed in a mobile application to enable real-time monitoring. For future development, Long Range Wireless Area Network (LORAWAN) can be used for system implementation in place of Wi-Fi network. This will improve the speed of sensor data sent to the cloud and reduce the emergency SMS response time to 1-3 seconds. LORAWAN is independent of the strength of the network for effective transmission of data to the cloud, the only condition is the system must be within range. The main gap identified in the implemented system is the that the system relies on Wi-Fi network for communication. This was observed during the testing of the system that often there is a delay in transmitting sensor data to the cloud. This is related to the Wi-Fi strength. This in turn affect the system's response, since Wi-Fi connectivity is at "LTE" and an event for fire detection is simulated the SMS is sent faster than when the network is at "3G".

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