# MONITORING AND CONTROLLING MARINE ACTIVITY USING IOT SYSTEM

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***ABSTRACT***

*Marine activities at sea are very popular with the people of the world. Various marine activities such as swimming, boating, fishing and even shipping are often done on the coast and sea. However, loose control and monitoring cause various problems such as accidents, marine life threats and even pollution. The current method uses a vessel monitoring system (VMS) as well as a geographic information system (GIS). This method of course uses high costs because the information obtained is international. There are also barriers to obtaining sensitive information. This makes it difficult for local authorities to obtain uniform information on centralized water activities. This study proposes a smart and centralized system of control and monitoring of water activities. The novelty of this study is to recognise and detect a foreign object on the surface of the sea. In addition, this study made a virtual barrier between safe and dangerous zone. This system can control all marine activities with the use of mobile equipment installed on the body of the user or even the vessel used. The system will control and monitor all activities centrally. In the event of an emergency or violation of the law, this system will deliver an immediate message to the authorities. The system is evaluated based on user distribution and control environment. System performance audit shows that this system method successfully controls and monitors water activity within 1 kilometre from the coast.*

***Keywords: vessel management system, marine activity, control and monitoring intelligence system***

## 1.0 INTRODUCTION

Shipping, fishing, diving and even sailing activities are the favourite economic resources of individuals today [4]. However, these activities threaten marine life due to uncontrolled control and monitoring. The steps taken by the authorities are now based only on the data observed from the Vessel Monitoring System (VMS) and also the Geographical Information System (GIS) [11]. VMS is used to control fishing activities as well as shipping traffic in a country's waters [1-7]. However, the use of VMS is limited to registered vessels only. Thus, vessels from foreign parties are difficult to identify on behalf of law enforcement of maritime law between races [8-11]. Besides, the use of GIS is also very limited because the use of data from satellites is very expensive and also takes time to analyze for emergency purposes [12-15].

Furthermore, all of these existing systems are systems from foreign countries that require time for local individuals to understand the process of use and how to work effectively [17-18]. The data observed by this equipment is also difficult to analyse because the working system is not in the local mould. There are also situations where VMS and GIS are unable to perform effective operations because not all vessels apply VMS equipment due to costly costs, accidentally closed equipment, and unsatisfactory communication network access connections [19-21]. Besides, every piece of equipment used for VMS as well as GIS requires periodic maintenance which can confuse vessel owners if these individuals are not skilled in using technology [22-25].

Interrupted communication due to the weather can also inhibit the function of VMS and also GIS. Thus, the environmental conditions of the operating area become difficult to report to the main VMS station. This makes it very difficult for emergency activities from the authorities to conduct search and rescue (SAR) activities. Extensive sealevel conditions also make SAR activities difficult because the location of the signposts to know the position of operations cannot be identified when the weather is bad due to obstructed communication systems [23].

As an alternative measure to solve this problem, the Unmanned Aerial Vehicle (UAV) system was introduced to monitor and control the coast as well as the sea. The UAV is supplied with cameras and Global Positioning System (GPS) equipment to carry out monitoring and control activities. However, the communication system between the controller and the UAV is limited. This causes the UAV to lose control and cause damage [24].

Thus, this study suggests mobile devices that can receive and transmit data as well as function with remote sensing through tracking devices. This study uses the Long Range Radio (LoRa) communication system as the main communication platform and also light detection and range (LIDAR) as a remote sensor that identifies objects around smart monitoring and control equipment.

## 2.0 MATERIALS AND METHOD

This study proposes a method of smart monitoring and control using intelligent systems. This study brings together equipment such as Dargino LoRa Shield Wireless, Arduino nano, GPS detector, LIDAR detector and WiFi Shield module. Dargino LoRa Shield Wireless is a receiver and transmitter module between gateway terminals as well as equipment for observation purposes. The prototype developed helps detect the presence of foreign objects within a 1-kilometre radius. The presence of these foreign objects is identified by using the LIDAR detector and comparing the characteristics of the object with the database. The detected object is also compared to the latitude and longitude position observed by LoRa end-node equipment as well as LoRa gateway. If the corresponding data is not obtained, then the system will send a warning signal to the authorities. Figure 1 and figure 2 show the communication process between the LoRa end-node and also the LoRa gateway. As for figure 1, there is the detection of objects as is usually done by radar.

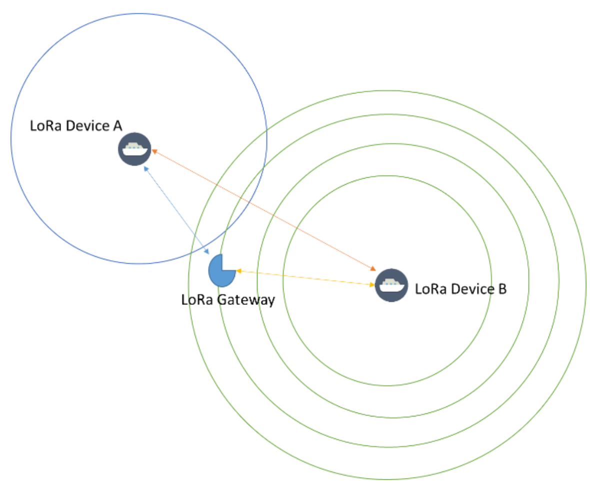



Fig. 1: The proposed method to monitor and control marine activity

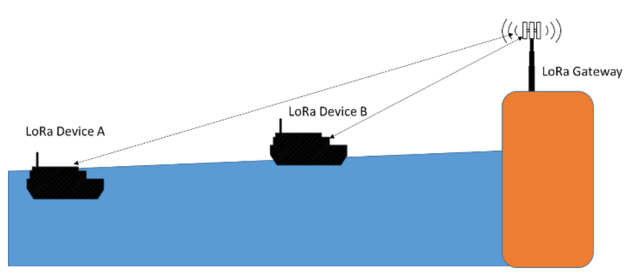



Fig. 2: Communication between LoRa End-Node and LoRa Gateway

## 2.1 Long Range Radio (LoRa)

LoRa stands for Long Range Radio. This module supports the internet of things (IoT) system. This system uses a band communication network of 433 MHz, 868 MHz and 915 MHz. this system can change the band itself according to the suitability of the environmental conditions. Communication systems are not interrupted by bad weather and can perform functions with minimal energy consumption as well as wide distribution of communication networks without loss of data packets. Figure 3 shows LoRa module used in this study.

Fig. 3: LoRa Module

### 2.1.1 Lora Gateway

LoRa gateway had been set up to obtain a connection from LoRa devices to the internet and server. Figure 4 shows the block diagram of the proposed LoRa gateway system. This LoRa is connected to the computer via a WiFi shield as a main controller and microprocessor. This system is equipped with 12-volt panel solar and rechargeable battery.

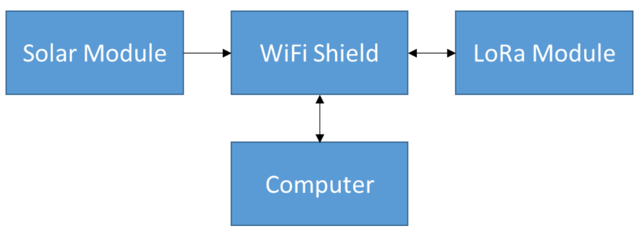



Fig. 4: The block diagram of the proposed LoRa Gateway

### 2.1.2 Lora End-Node

LoRa End-Node has been designed as a stand-alone device, which can be equipped with another microcontroller. Figure 5 shows the LoRa End-Node block diagram with GPS Module and LIDAR Module. From figure 5 it can be seen that the end-node consists of LoRa modules with antennas operating at 2-dBi and 433 MHz Whip Antenna. LoRa module is connected to Arduino Nano that processes all signals both input and output. The GPS module is Ublox neo-6m. Panel solar power supply the system with Lithium-Ion Battery (3.7V) which supplies energy via TP4056 Battery Charger Module. Although module TP4056 supplies 5V for Arduino Nano and also down 3.3V voltage regulator module for LoRa module.

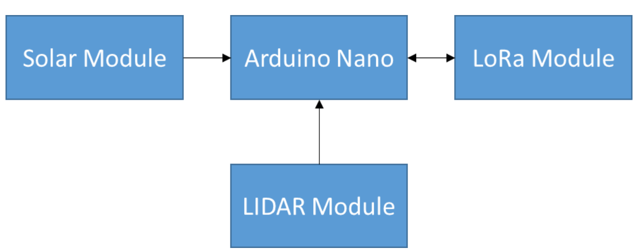



Fig. 5: The block diagram of the proposed LoRa End-Node device

### 2.2 Lidar Module

The general perception source for LiDAR sensor is to observe spatial information of the full 3D environment around the platform. Either one or more sensors are used on the platform, for cloud resources generated from individual sensors are calibrated and combined into a cloud network. Existing techniques for objects based on LiDAR detectors detect either based on neural networks or classification through dimension filtering. Both of these approaches are still difficult to function effectively because they still give rise to false identification, trained networks rely heavily on data set training, while techniques based on dimensional screening are ineffective when existing objects exist. This disadvantage can be overcome by using visual sensors for the classification of objects in the field of visual view, network model processing data in combined methods that result in high computing requirements. This study proposes to use visual object detection via a lightweight model for the selection of focus areas in visual views displayed with LiDAR cloud. The LiDAR cloud is treated simultaneously to eliminate the base and clustering performed in a specific concentrated area of the object visually detected around it. This reduces the number of detection errors and excessive computational requirements for clustering tasks. Furthermore, the flow of visual data and LiDAR sensors can be restored independently, while computing with the intensive part of visual detection can be modified according to environmental conditions. The proposed approach for tracking objects is very important for embedded platforms, and varying environmental conditions. Figure 6 shows LIDAR sensor used in this study.

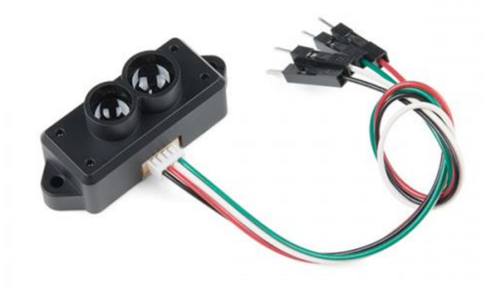


Fig. 6: LIDAR sensor

### 2.3 Operation Mechanism

The open space is ideal for the LoRa gateway to cover a wide area and be connected to a local server or cloud. Media communication between these devices can be achieved using a mobile phone or Wi-Fi network. The GPS sensor captures the input data of the LoRa end-node device location, and the Wi-Fi or cellular module sets up a direct connection to a local or cloud server. The server is connected to a mobile application installed on the smartphone of the enforcement officer. System design requires a cloud server as the centre of information processing and data visualization, delivered by cellular or Wi-Fi modules. Thus, information can be easily accessed by enforcement officers whenever they need it. Live data is sent in real-time so that enforcement officers can easily monitor and track the location of the victim or intruder. At the control centre, direct notifications can be sent to enforcement officers when the user is outside the coastal area so that the user can be immediately taken home to a safer place in the event of an unexpected event. There is an emergency notification function that can be activated when the user is in an emergency when they lose track around the coast. This function is detected by tracking the focus area where the user's last location can be detected by the system.

### 2.4 Evaluate the backtrack trajectory and prototype efficiency

This study tests the efficiency of the prototype communication function before this prototype uses Easy Dead Reckoning Algorithm (EDR) as a backtrack trajectory. LoRa is the main platform for communication in this study. So, the failure of communication may disturb this study. To evaluate the communication efficiency, this prototype will be tested with a Received Signal Strength Indication (RSSI) [9].

The test was equipped with Tx and Rx polarization antenna that had been installed in a vertical direction with a polar pattern omnidirectional antenna. The LoRa end-node supply with a value of Tx power is 14 dBm and the value of Rx for LoRa gateway antenna gain is 5 dBi.

LoRa gateway placed in the open area with the 1-metre height antenna. LoRa end-node will move to surround the LoRa gateway area with acknowledging distance. During the movement of LoRa end-node sends data every 10 seconds and the LoRa gateway will give feedback when received the message.

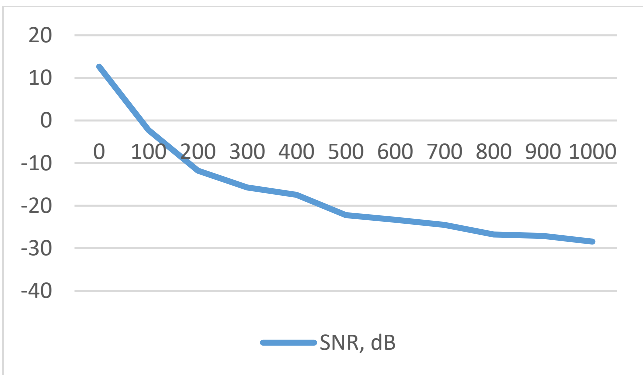
Each movement with the setup distance will be marked as the position. Then, all the positions will be evaluated with the EDR algorithm. The EDR algorithm for this study is shown in figure 7.

**Algorithm 1: Easy Dead Reckon**

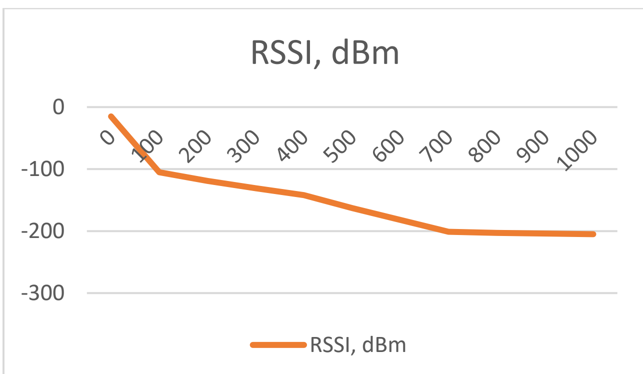
```
1:Input:A(lon1,lat1,t1),B(lon2,lat2,t2)
//lon=longitude; lat=latitude t=time
//A and B are original position
2: Output: C(lon3,lat3,t3)
//C is prediction point
3: if t2<>t1 then
4: lat3 = ((lat2-lat1)/(t2-t1)*t3+lat1-
          (lat2-lat1)/(t2-t1)*t1)
5: lon3 = ((lon2-lon1)/(t2-t1)*t3+lon1-
          (lon2-lon1)/(t2-t1)*t1)
6: end if
```

Fig. 7: Easy Dead Reckon Algorithm

## 3.0 RESULTS




(a) SNR,dB




(b) RSSI, dBm

Fig. 8: (a) SNR and (b) RSSI Chart test results

Based on the chart in figure 8, this study found that efficient communication for LoRa module is not more than 1 kilometre. The line for SNR and RSSI values is sloping closer to the value of 1000 meters. This is because the farther the LoRa end-node from the LoRa gateway, the less energy emitted will be received. However, during the open and clear space with no obstacles along the way of this prototype may the result will be better.

Table 1 shows the value of the communication test. Based on this table the SNR is -28.44 dB when RSSI is -205 dBm. The maximum distance is near 1000 metres.

Table 1: LoRa communication test result

| **Distance, m** | **SNR, dB** | **RSSI, dBm** |
|---|---|---|
| 0 | 12.64 | -15 |
| 100 | -2.25 | -105 |
| 200 | -11.79 | -119 |
| 300 | -15.74 | -131 |
| 400 | -17.45 | -142 |
| 500 | -22.21 | -163 |
| 600 | -23.33 | -182 |
| 700 | -24.5 | -201 |
| 800 | -26.76 | -203 |
| 900 | -27.12 | -204 |
| 1000 | -28.44 | -205 |

The limit distance of marine activity is 12 nautical miles, which are about 22.224 kilometres. Based on the results, the communication roaming limit to less than 1 kilometre in open space. Therefore, this prototype can not be efficient during the distance between LoRa gateway and LoRa end-node is far.

## 4.0 CONCLUSION

In this study, smart monitoring and control of marine activity can be used within 1 kilometre from a coastal area. Which are best for leisure activity. While deep-sea fishery activity may out coverage area. Therefore, for future works, the system may be enhanced with the ability of a communication repeater to boost the communication coverage area. This system may use as a sea bouy to allocate the safe area for leisure activity.

## 5.0 ACKNOWLEDGEMENT

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## REFERENCES

[1] H. Huang, X. Cui, X. Bi, C. Liu, F. Hong and S. Guo, "FVRD: Fishing Vessels Relationships Discovery System Through Vessel Trajectory," in *IEEE Access*, vol. 8, pp. 112530-112538, 2020.

[2] M. I. Marzuki, P. Gaspar, R. Garello, V. Kerbaol and R. Fablet, "Fishing Gear Identification From Vessel-Monitoring-System-Based Fishing Vessel Trajectories," in *IEEE Journal of Oceanic Engineering*, vol. 43, no. 3, pp. 689-699, July 2018

[3] T. Røste, K. Yang and F. Bekkadal, "Coastal coverage for maritime broadband communications," 2013 MTS/IEEE OCEANS - Bergen, Bergen, 2013, pp. 1-8.

[4] Sunarmo, A. Affandi and S. Sumpeno, "Clustering Spatial Temporal Distribution of Fishing Vessel Based lOn VMS Data Using K-Means," *2020 3rd International Conference on Information and Communications Technology (ICOIACT)*, Yogyakarta, Indonesia, 2020, pp. 1-6.

[5] Hery, S. Lukas, P. Yugopuspito, I. M. Murwantara and D. Krisnadi, "Website Design for Locating Tuna Fishing Spot Using Naïve Bayes and SVM Based on VMS Data on Indonesian Sea," *2020 3rd International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)*, Yogyakarta, Indonesia, 2020, pp. 89-93.

[6] A. Prayudi, I. A. Sulistijono, A. Risnumawan and Z. Darojah, "Surveillance System for Illegal Fishing Prevention on UAV Imagery Using Computer Vision," *2020 International Electronics Symposium (IES)*, Surabaya, Indonesia, 2020, pp. 385-391.

[7] H. Susanto and G. Wibisono, "Marine Vessel Telemetry Data Processing Using Machine Learning," *2019 6th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)*, Bandung, Indonesia, 2019, pp. 128-135.

[8] Q. Bing, R. Jiang and F. Hong, "Exploiting Social Network Characteristics for Efficient Routing in Ocean Vessel Ad Hoc Networks," *2019 IEEE 38th International Performance Computing and Communications Conference (IPCCC)*, London, United Kingdom, 2019, pp. 1-8.

[9] H. Susanto and G. Wibisono, "Machine Learning for Data Processing in Vessel Telemetry System: Initial Study," *2019 International Conference of Artificial Intelligence and Information Technology (ICAIIT)*, Yogyakarta, Indonesia, 2019, pp. 496-501.

[10] S. Zhang, D. Yang, X. Tang, W. Fan and W. Zhu, "Design of Management and Retrieval Method for Distributed Beidou Position Data," *2018 2nd IEEE Advanced Information Management,Communicates,Electronic and Automation Control Conference (IMCEC)*, Xi'an, 2018, pp. 369-373.

[11] Z. Zainuddin, Wardi and Y. Nantan, "Applying maritime wireless communication to support vessel monitoring," *2017 4th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, Semarang, 2017, pp. 158-161.

[12] A. Munir, N. Febrian, A. Daneraici Setiawan and Chairunnisa, "Signal analysis of GMSK modulation-based CubeSat automatic identification system receiver," *2016 3rd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, Semarang, 2016, pp. 439-442.

[13] M. Shahzamal and M. F. Pervez, "Mobility modelling of marine fishing boats for communication network simulation," *2016 5th International Conference on Informatics, Electronics and Vision (ICIEV)*, Dhaka, 2016, pp. 122-128.

[14] S. Amabdiyil, D. Thomas and V. P. M. Pillai, "Marine vessel detection comparing GPRS and satellite images for security applications," *2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, Chennai, 2016, pp. 1082-1086.

[15] Xiaoxuan Wang, Qiaoling Zheng and S. Zhang, "Research of voyage extraction based on beidou vessel monitoring system data," *2015 23rd International Conference on Geoinformatics*, Wuhan, 2015, pp. 1-5.

[16] M. I. Marzuki, R. Garello, R. Fablet, V. Kerbaol and P. Gaspar, "Fishing gear recognition from VMS data to identify illegal fishing activities in Indonesia," *OCEANS 2015 - Genova*, Genoa, 2015, pp. 1-5.

[17] Q. Aini, M. H. Purnomo and A. Affandi, "Gossip algorithm approach and AODV in Vessel Messaging System: A comparison of performance," *2014 IEEE International Conference on Control System, Computing and Engineering (ICCSCE 2014)*, Batu Ferringhi, 2014, pp. 159-163.

[18] M. Wada, M. Sano, K. Hatanaka and H. Taka, "Digital diary system for fishery and applications of fishery management," *2012 Oceans*, Hampton Roads, VA, 2012, pp. 1-6.

[19] Byoung-Ho Song, Iick-Ho Song, Jun Woo Shin, Min-A Jung and Seong-Ro Lee, "Case based reasoning system based risk context awareness in the digital marine vessels," *2010 International Conference on Information and Communication Technology Convergence (ICTC)*, Jeju, 2010, pp. 443-447.

[20] Xiu-fang Cui and Yong Chang, "Notice of Retraction: Research on vessel monitoring system," *2010 2nd International Conference on Mechanical and Electronics Engineering*, Kyoto, 2010, pp. V2-387-V2-389.

[21] N. Kourti, G. Schwartz and I. Shepherd, "Integrating active and passive satellite-based technologies to improve European fisheries monitoring and control," *IEEE International Geoscience and Remote Sensing Symposium*, Toronto, Ontario, Canada, 2002, pp. 2126-2128 vol.4.

[22] S. Muhammad and G. Kim, "Visual Object Detection Based LiDAR Point Cloud Classification," 2020 IEEE International Conference on Big Data and Smart Computing (BigComp), Busan, Korea (South), 2020, pp. 438-440.

[23] F. Xiao, Y. Jin, Y. Yin and Y. Li, "Design and Research of Marine Search and Rescue Simulation System," 2010 Second International Conference on Information Technology and Computer Science, Kiev, 2010, pp. 372-376.

[24] J. Huang and W. Cai, "UAV Low Altitude Marine Monitoring System," 2014 International Conference on Wireless Communication and Sensor Network, Wuhan, 2014, pp. 61-64.

[25] N. Hayati and M. Suryanegara, "The IoT LoRa system design for tracking and monitoring patient with mental disorder," 2017 IEEE International Conference on Communication, Networks and Satellite (Comnetsat), Semarang, 2017, pp. 135-139.

[26] A. Zourmand, A. L. Kun Hing, C. Wai Hung and M. AbdulRehman, "Internet of Things (IoT) using LoRa technology," 2019 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS), Selangor, Malaysia, 2019, pp. 324-330.