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SMART IOT PONTOON MANEUVERING ALONG RIVER CURRENTS

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ABSTRACT

Maneuver river currents are very helpful in understanding environmental and eutrophication conditions as well as fishery activities in the river estuary. The study aims to invent and develop the smart IoT pontoon for hydrological surveying in polluted and dangerous conditions with non-stop operation. the study uses a bulb made by polyethylene (PE) with echo-sounder equipment and high-end Global Navigation Satellite System (GNSS) device. Wireless communication such as local mobile 4G/3G is employed to collect geographic positioning and bathymetric data from rivers. The integrated system is called the smart IoT pontoon is developed and identify maneuver river currents. The study was conducted in the Thachin river in Nakhon Pathom province in Thailand. The depth of the river was collected from the echo-sounder single beam and the speed of movement was calculated from the high accuracy position that was collected from the RTK GNSS system. The results found that the speed of the pontoon movement has a negative correlation of different angle directions. This solution brings many benefits to bathymetric surveyors who work on river and ocean in bad weather and water polluted areas. The results of the study provide an IoT Smart technology for river currents behavior such as environmental monitoring and flood warning systems.

Disciplinary: Multidisciplinary (River Engineering, Navigation Engineering, Civil Engineering, Information Technology).

1. INTRODUCTION

River flows and its characteristics play an important in the evolution of terrigenous aquatic substance and a better understanding of river currents for its temporal and spatial modification is important to improve knowledge of environmental such as problems of eutrophication, aquacultural activities, and conditions problems in river and waterway (Rabouille et al., 2008). The currents of the Thachin river estuary are mostly influent by diluted wastewater from the industrial and urban areas of Nakhon Pathom province. The Thachin river and its surrounding area is the main region for several large industrial estates, which concentration is on heavy industries such as chemical and petroleum factories, in Nakhon Pathom province. In 2005, the agricultural, industrial, and domestic consumption sectors suffer a conflict in water resource allocation caused by a severe drought in the region. At that time, it was so severe that the region had to transport water by truck from surrounding areas to the industrial and residential areas in the area. The importance of water level measurement for water security included the Thachin river and Nakhon Pathom province. By conducting a water assessment for the Thachin river and Nakhon Pathom province. using the water balance and scenario analysis (Pollution Control Department, 2015.) that was able to create flood and drought risk areas.

The study aims two objectives, the first objective is to develop and integrate the Unman-operated pontoon for hydrological surveying in polluted and dangerous conditions with non-stop operation. The second objective is to identify the maneuver river current as speed current and angle of flow behavior. Therefore, the objectives of the study will bring great profit for all hydrological surveyors who use pontoon for river currents behavior such as environmental monitoring and flood warning systems.

2. LITERATURE REVIEW

Water discharge from the river is often high and different levels from season to season (Dai et al., 2008, 2011a). Therefore, its developmental characteristics are formed by the large kinetic movements between seasons of the year (Lie et al., 2003). This process greatly influences the flow of the ecological environment on the river, the sea and fishery productivity (Chang et al., 2014; Wu et al., 2014). Due to the complicated evolution of this fluctuating environment, many studies have been based on temperature and alum data or simulation of environmental data to diagnose the flow speed in unmeasurable river sections. (Chang et al., 2006). The use of remote sensing technology has allowed the study of flow patterns in the direction and currents speed of monthly and seasonal river flows and stated the disadvantage of the method used on the various spatial level of satellite data (Kim et al. 2009). However, almost all numerical flow characteristics results from short-term observation and remote sensing data do not meet the demands of hydrodynamic observations. These are necessary data in the region as long-term, continuous observation data, at multiple fixed points. In this study, we conducted a continuous observation of the flow properties in a longitudinal section of the area of the Thachin river by using smart IoT pontoon to obtain a better understanding of the river currents data in real-time.

The study concentrates on the river basin of the Thachin river, which is identified by semi-regular and regular tides. The river in this region changes from alternating current to a clockwise flow. In the rainy season, the strong wind often affects the flow of small flux and the flow begins to move south along the coast immediately after it merges into the sea. In addition to the diluted Thachin River, the flow of Thachin estuary also includes river currents and coastal currents. The diluted Thachin River creates tidal currents, both spatial and seasonal changes that are crucial to coastal currents due to monsoon winds and residual currents (Zhu et al., 2004a, b). The Gulf of Thailand located on the East direction of the Thachin river is the main flow system that influents coastal currents. Floating Survey Tank with water monitoring is needed. A bulb-shape tank with a selection of material is an aggressive corrosive chemical. Polyethylene PE with rotationally molded products and engineering design will provide the highest quality rotationally floating tanks for water environment monitoring.

3. METHODOLOGY

Bathymetry is referred to as water topography and related to underwater area as oceans, rivers, and reservoir. It studies the underwater landscape depths measurements and creates river current behavior such as river depth, speed of pontoon and azimuth angle change of surveyed areas. The bathymetric measures can create maps or charts that show the bottom topography, and with the information from the river and seafloor, characterization can create waterways navigation channel charts. The main methodology for identifying currents behavior that has applied in this study is described in Figure 1.

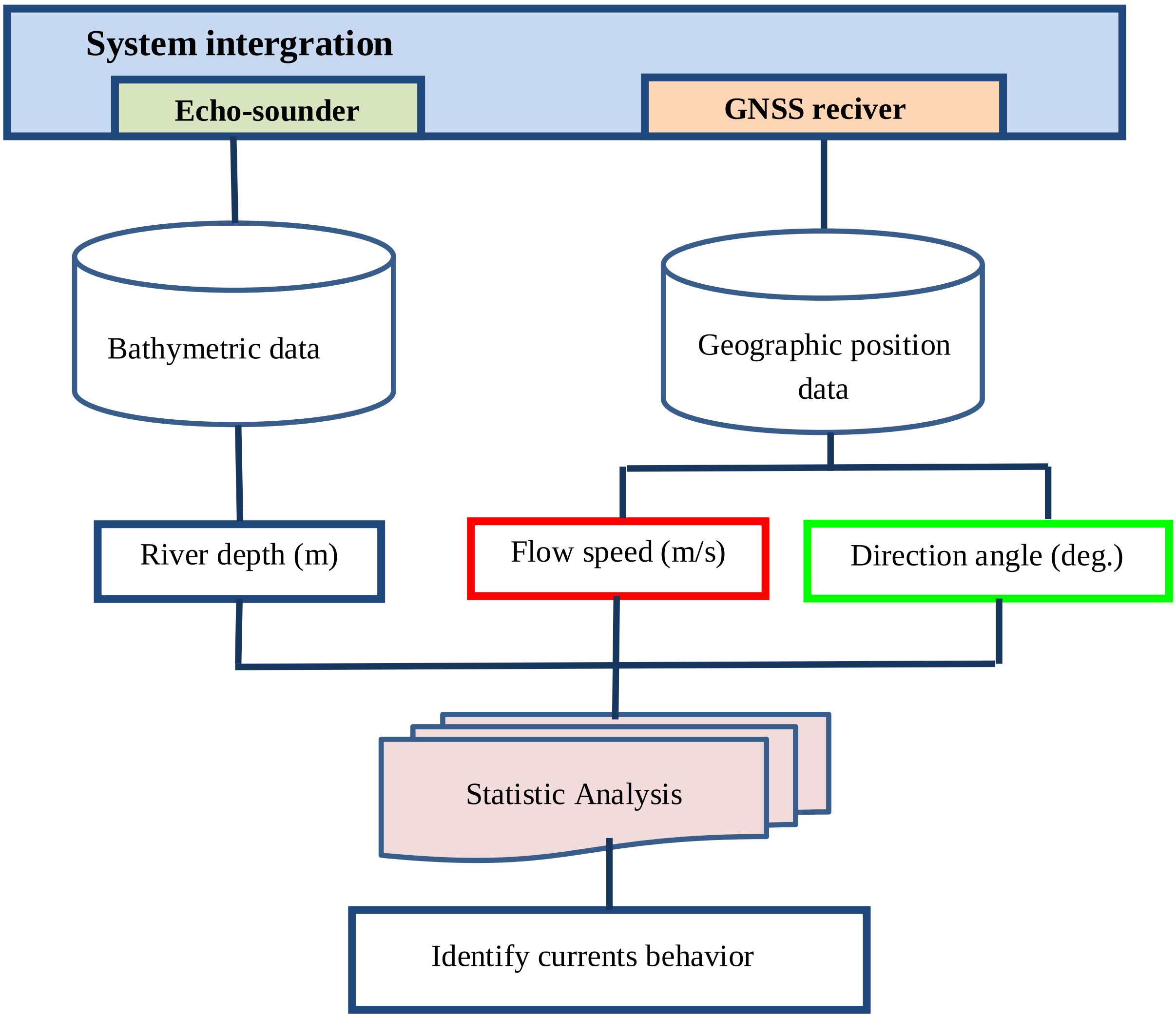

Figure 1: Methodology for identifying currents behavior

3.1 SYSTEM INTEGRATION

The research provides Software integration that is an alternative way to replace the traditional hydrographic survey. This work is in association with the report of Tanpaibool et al. (2020).

3.1.1 FLOATING SURVEY TANK DESIGN

A high-quality thermoplastic that has excellent physical and chemical attack resistance. High tensile ability, ability to shape in a mold, high strength, puncture and tear resistance, with good hot weld strength, UV resistance, chemical resistance, environment, and toughness. Polyethylene is perfectly befitting for containers and tanks because of its general strength and excellent chemical resistance to a wide range of humidity and temperature products.

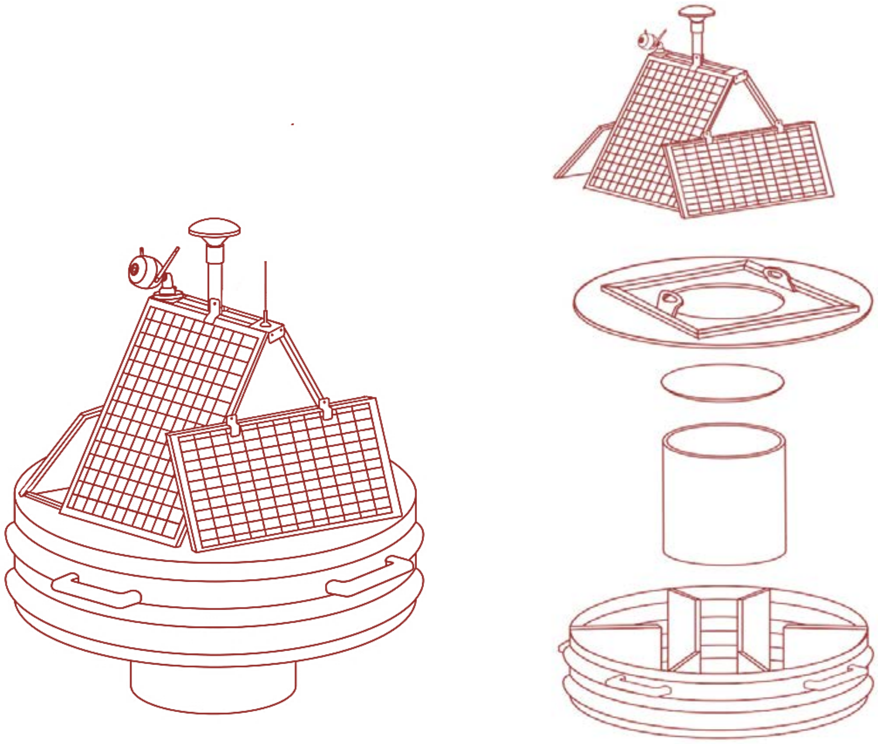

Figure 2: A side view and top view of the floating survey tank.

Polyethylene is for use in outdoor applications build upon on its thickness of the wall and material type with UV light stabilizers. The bulb-shape tank made by PE will be designed with Diameter 50 cm and Height 80 cm as described in Figure 2. Polyethylene is a high resistance plastic that has an operating in a very hot condition with a limit than Polyethylene 100°C. Because of its good chemical obstruction, the tank made by Polyethylene has a strong material to protect from broken and crack. Polyethylene pontoon is recommended for applications in hot temperatures or where high collision and strength are required. The pontoon with a rough, irregular interior surface is suitable for river and ocean surveys in all weather conditions.

3.1.2 ECHO SOUNDER EQUIPMENT

The accuracy of the Echo-sounder is ± 0.02 m + 0.1% x D (where D means the depth of the water). The device has 0.3m to 200m in the detection range. It is perfect for shallow and deep-water surveying by the minimum 0.3 m range. The modular design of the echo-sounder has a user-friendly interface for upgrade and upgrade while the user-friendly operation makes it simple to operate in any weather condition.

The hydrological software has advanced analysis for water depth and automatically filters the secondary echo data. The main parameters as gain, power, and range are adjusted manually and automatically. The software provides hydrological parameters and its configuration that make users get high-quality results by limitation noise error data.

3.1.3 GPS EQUIPMENT

The GNSS receiver is a low-cost, hand-held GNSS receiver operated for land and water surveying applications (Anantakarn and Witchayangkoon, 2019). Applying a GNSS receiver (Witchayangkoon, 2000), the users have the free App for Land Survey and post-processing software also provided. All survey applications, including real-time RTK positioning and data collection for PPK, can be achieved by a low-cost solution with the GNSS receiver (Anantakarn et al., 2019; Witchayangkoon, 2000).

3.1.4 EQUIPMENT INSTALLATION

Echosounder and GPS equipment is integrated and install as in Figure 3. Sounder Equipment and NTRIP Modem and GNSS receiver are integrated and installed in the Tank, see Figure 3. To make the tank floating properly for movement, the weighting material is filled and adjusted for optimal surface movement conditions.

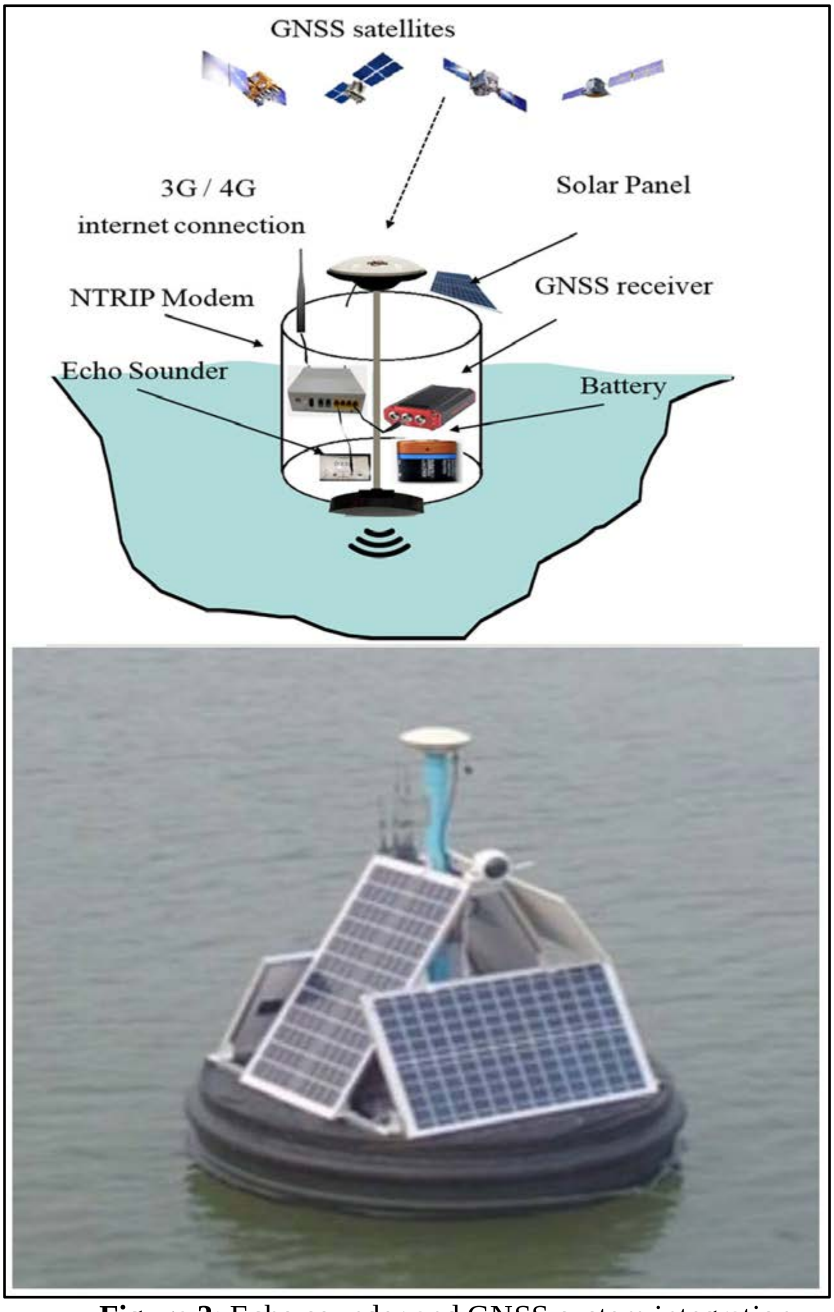

Figure 3: Echo sounder and GNSS system integration

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3.2 THE STUDY AREA

The Thachin river has been recorded for poor to very poor water quality for a prolonged period. (Pollution Control Department, 2015). A large amount of wastewater has been discharged into the river from agriculture, industry, and households. Thailand's environment qualities of rivers upper part have been severely reduced and pollution goes with water into rivers. The Thachin estuary has been warned of bacteria and nutrient contamination from nitrogen, phosphorus, and phosphates. Nutrient pollution damages food sources for aquatic animals, reduces water quality, destroys river habitats and algae grow faster than the ecosystem can recover Thachin river area is selected in Nakhon Pathom province for this study. The site is located about 40 km West of Bangkok on the Thachin river as shown in Figure 4 (UTM north and east coordinates).

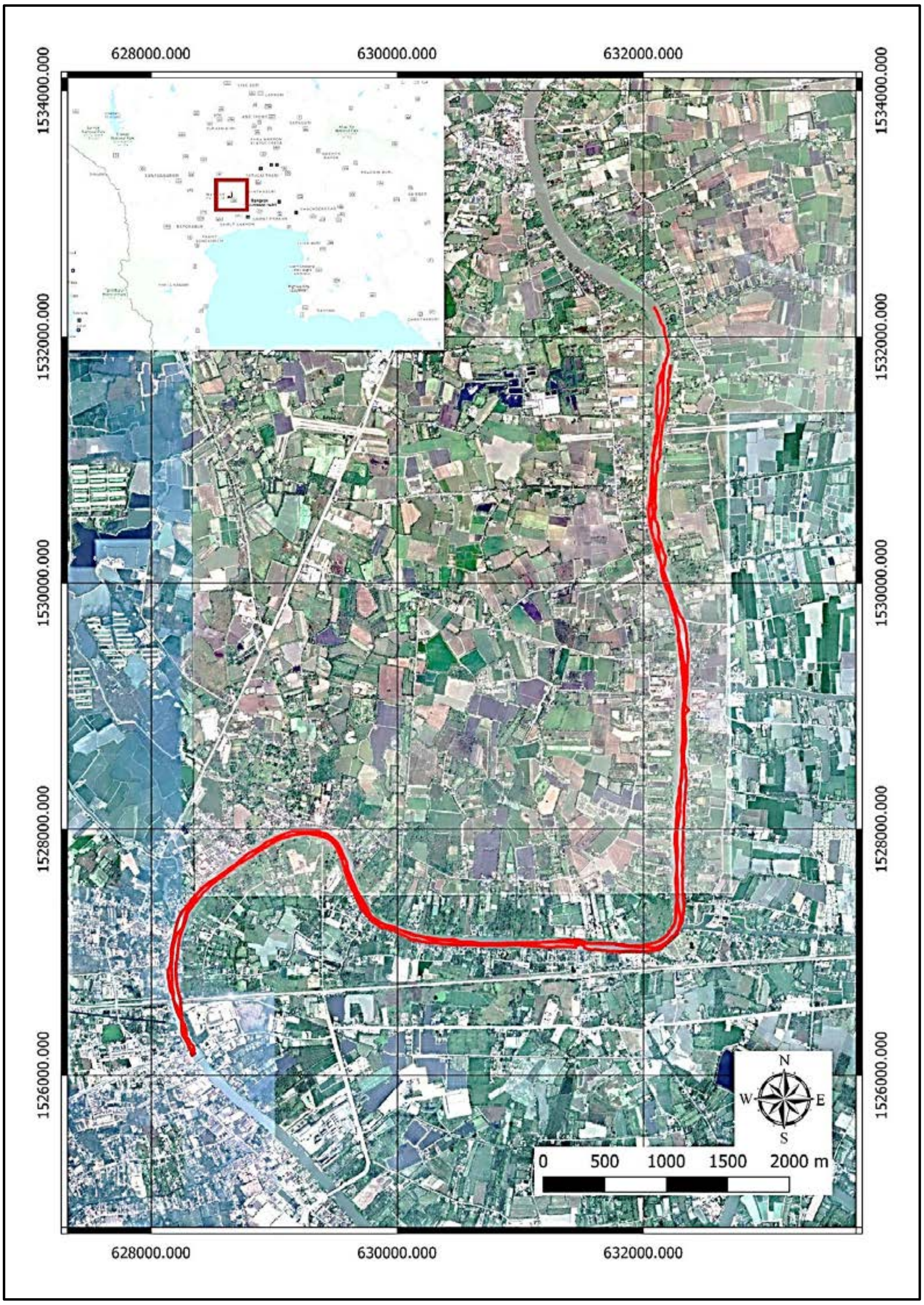

Figure 4: Experimental river route along the Thachin river estuary of Thailand.

3.3 SURVEY AND FIELD DATA COLLECTION

The pontoon collected the data in the river as a length of 11 km with 3 repeated paths, total length is about 33 km. It is naturally floating and self-movement by river current flowing. The surveyed data includes bathymetric and geo-coordinate data that were recorded in the 5-second interval. The detailed of surveyed data collection is illustrated in Figure 5. The field survey has been conducted during 15-18 January 2020 with 10,814 data surveyed points.

River depth data in m can be measured directly from Echo-sounder equipment.

Pontoon speed data in m/s can be calculated from distance and time that extract from the GNSS RTK system. The distance between the 2 Distance between two coordinate points of survey *P(x1, y1)* and *Q(x2, y2)* is

$$D\,(P,Q) = \sqrt{(x_2 - x_1)^2 - (y_2 - y_1)^2} \qquad (1).$$

The azimuth angle of the pontoon movement as the cartograph the coordinates of the two known points in the flat map coordinates compute the map azimuth (in decimal degrees) is

$$\alpha \;=\; \frac{180}{\pi}\, atan2\,(x_2 - x_1, y_2 - y_1) \qquad (2).$$

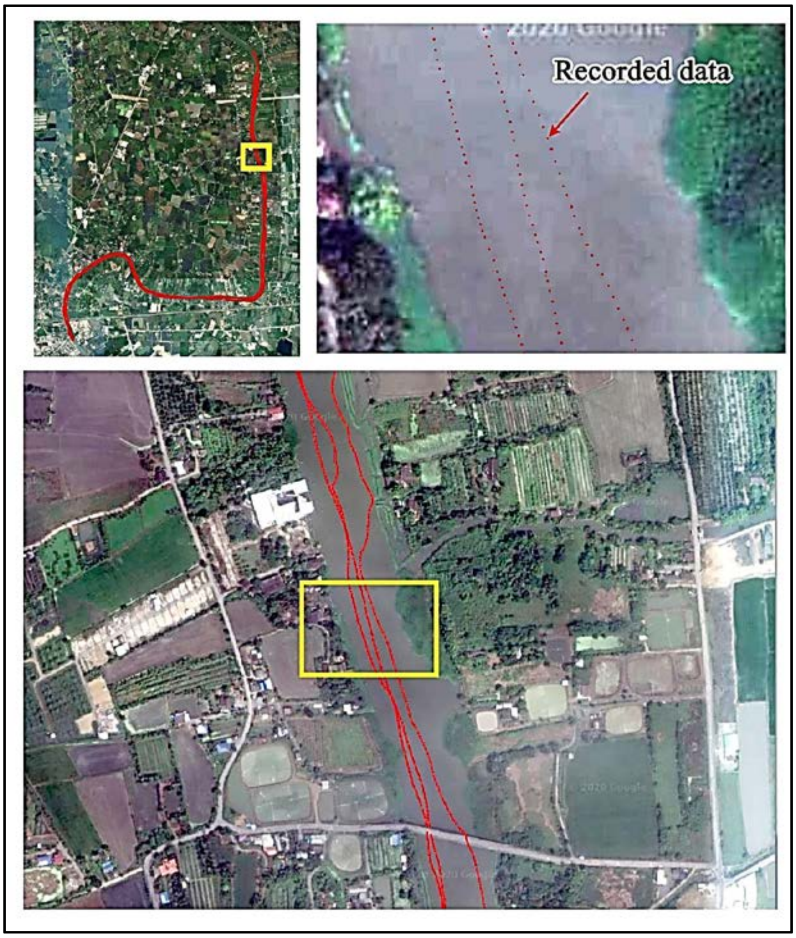

Figure 5: Bathymetric and geo-coordinate data recorded at a 5-second interval.

The different angle is detained from

$$\Delta\alpha = \sqrt{(\alpha_2 - \alpha_1)^2} \qquad (3).$$

4. RESULTS AND DISCUSSION

The surveyed data has been processed by using open source free GIS software Quantum GIS Ver. 3.10 as presented in Figure 4. The result of the data description includes river depth, pontoon movement speed, and different azimuth angles. The river water depth data was measured by the Echo-sounder ranges from 2 meters to 12 meters with 6 meters to 9 meters of water depth as the main level depth as described in Figure 6. The river current speed as the pontoon movement measured by GNSS mode RTK gives the average speed as 0.5 meters per second (m/s) with a minimum at 0.2 m/s to a maximum at 0.9 m/s as displaying in a statistical histogram in Figure 7. The different angle detected by the pontoon azimuth angle of movement direction is identified in Figure 8 as 0.9 degrees to 1 degree and the highest frequency at 1600 occurring for 1 degree as mostly changing all the time.

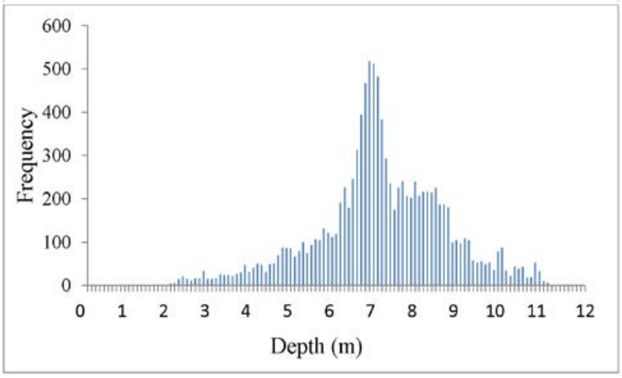

Figure 6: Collection of river depth data.

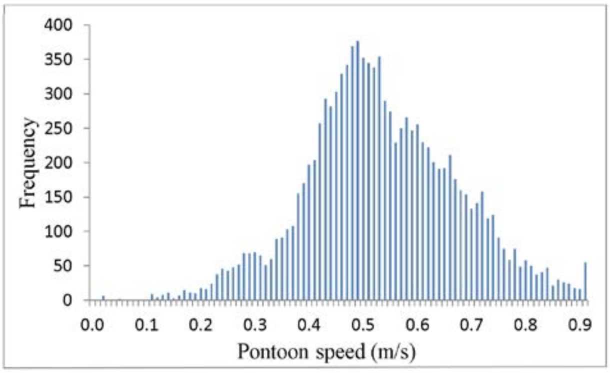

Figure 7: Collection of pontoon speed data

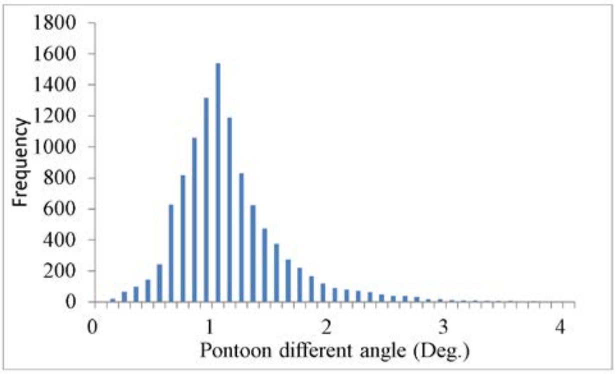

Figure 8: Histogram of pontoon different angles

Based on the histograms, the river depth data mostly range from 6m to 9m and the deepest we can get is about 11m. Pontoon moving speed is average at 0.5 m/s and the different angles mostly are 0. 9deg to 1deg. The three variables of river depth, pontoon movement speed, and different azimuth angles are also plotted in Figure 9.

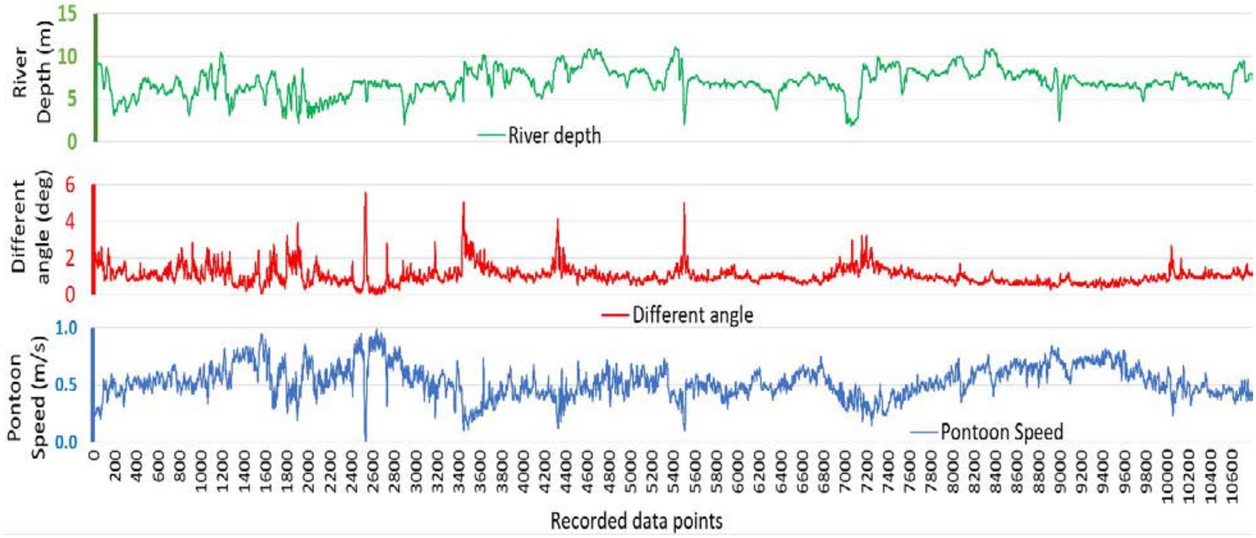

Figure 9: Data collection

From the Correlation Matrix shows correlation coefficients between variables, it is found that current speed and different current angles are negative correlation as the coefficient of -0.7575 while there is no correlation between river depth and current speed or current angle different as in Table 1.

Table 1: Correlation coefficients between variables

Variables	River depth (m)	Current speed (m/s)	Current different angle (deg)
River depth (m)	1		
Current speed (m/s)	-0.109	1	
Current different angle (deg)	-0.010	-0.758	1

For identifying the correlation from the two variables of the river current speed and different angles, the regression is generated from these data that plotted in Figure 10.

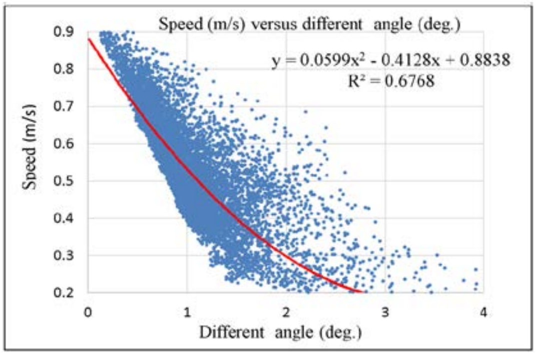

Figure 10: Relationship between river current speed and different angles.

The results found that the speed of the pontoon movement has a negative correlation of different angle directions and the correlation coefficients (R square) in non-linear regression is 0.6768.

5. CONCLUSION

The unmanned pontoon recommended in this study can be used to solve the challenges of working in natural environments especially in the polluted water area. Maneuver river currents characteristics such as water depth, current speed and angle of flow can be collected as 2-meter distance interval of measurement for the river length about 13 kilometers. The statistic description shows the detailed data variables as the main river depth at 6m to 9m, the average current speed is at 0.5 m/s and the different angles mostly are 0. 9 deg to 1 deg. The depth of the river was collected from the echo-sounder single beam and the speed of movement was calculated from the high accuracy position that was collected from the RTK GNSS system.

The objectives of the study were achieved. Firstly, it demonstrates that the smart IoT pontoon can operate for collecting maneuver rive currents with the main information of river water depth, current speed and angle of flow. Secondly, statistic analysis results that the current speed has a negative correlation of angle of flow and the correlation coefficients (R square) in non-linear regression is 0.6768. The study plays a key role in river current characteristic and in improving the methodology for hydrological surveying and equipment operate to provide a stable and better measurement of water quantity and quality.

6. AVAILABILITY OF DATA AND MATERIAL

Data in this study can be provided upon contacting the corresponding author.

7. ACKNOWLEDGMENT

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