2015 4th International Conference on Informatics, Environment, Energy and Applications
Volume 82 of IPCBEE (2015)
DOI: 10.7763/IPCBEE. 2015.V82.12

Development of Environmental Survey Robot for the Mekong River

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Abstract. The Mekong River is one of the largest international rivers in Asia. In recent years, the river has been rapidly developed. As a result of dam construction, the river has faced several environmental problems. Therefore, monitoring of environmental change to the river is essential to its sustainable development. Up to now, environmental surveys have been carried out by many researchers aboard boats, taking a lot of time, being especially dangerous in the wet season. In this research we proposed an environmental survey robot for the Mekong River. Our robot automatically used sonar to measure river-depth, while simultaneously using GPS to get present position. We evaluated its performance in the Mekong River through a practical test, confirming that it could easily be run by remote control from land and succeeded in drawing 3D topographical profile maps for Google Earth.

Keywords: the Mekong River, sonar, river-depth, environment

1. Introduction

The Mekong River is one of the largest rivers in Asia, running 4,620km through Myanmar, Laos, Thailand, Vietnam and Cambodia and originating in the Un-nan district of southern China. There are 33.6 million people and more than 100 distinct tribes in the Great Mekong River Basin (GMRB). Moreover, as 1000 freshwater species have been discovered so far, the GMRB is regarded as one of the most important regions of biological diversity. Recently, the GMRB has faced rapid economic development and rising population. As demand for electricity grows, more focus is placed on hydroelectric power generation from dams. Of 19 new dams planned for the mainstream of the Mekong River, 4 are already in operation. Dam construction affects the environment of the GMRB in various ways. 85% of people in the GMRB work in agriculture and fish caught in the Mekong River account for about 80% of animal protein consumed. Therefore, monitoring of environmental change is essential to the sustainable development of the GMRB [1, 2, 3, 4].

The Mekong River Commission (MRC) reported deep pools in the Mekong River in southern Laos and northern Cambodia. A deep pool is defined by Chan et al. [3] as follows: Significantly deeper than surroundings so that it may become disconnected from the main river. Deep pools are also defined ecologically as being of significance for the conservation of a number of fish species. The MRC proposed that the pools be utilized as useful indicators for monitoring the health of the whole Mekong River system. Items surveyed from the pools were as follows: (i) location, (ii) distribution, (iii) size of fish, (IV) fish population. These surveys are required for sustainability and to establish obvious relationships between the pools and the environment of the Mekong River. Most of these surveys were carried out using hydro-acoustic sonar mounted on small boats, manually controlling by researchers aboard the boats. However, this takes a lot of time and is sometimes dangerous in the wet season.

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In this paper we proposed an environmental survey robot for the Mekong River. This robot could be controlled remotely via wireless communication or independently run itself in conjunction with the GPS [5, 6]. The measured depth profile data for the river could be displayed in 3D on the computer's display and mapped to Google Earth. It enabled us to measure the river depth safely and easily get the 3D tomography of the riverbed. Using our robot, survey of the environment of the Mekong River could be executed by anyone trained in how to use it. This paper consists of the following 3 sections: We outline the environmental survey robot system in section 2. We demonstrate our robot and show the results in section 3. Conclusion and future works are presented in Section 4.

2. Outline of the environmental survey robot

Position and depth data were needed to draw 3D topographic profiles for the riverbed. Our system was equipped with sonar and GPS. Fig. 1 shows a schematic diagram of the environmental survey robot. To guard against users accidentally falling into the water, the robot could be controlled from the land (radio control mode) or independently run using its position data given by the GPS (independent running mode). Users could select radio control mode or independent running mode. In independent running mode, the robot could run independently based on the independent navigation algorithm described in Section 4. The robot basically consisted of three units, one being equipment to survey the river-depth using the sonar with the GPS. The sonar could output date on position and depth in NMEA0183 format and send this to a microcomputer. The second unit consisted of the control device for the rudder and boat speed. The third was a personal computer to control the boat and receive data via wireless communications. The wireless communication system was made using Zigbee Pro, which could send data more than 1.5km from the transmitter. Two units on the boat were organized and controlled by an Arduino microcomputer. Two 12V DC batteries were used to power the boat and controllers.

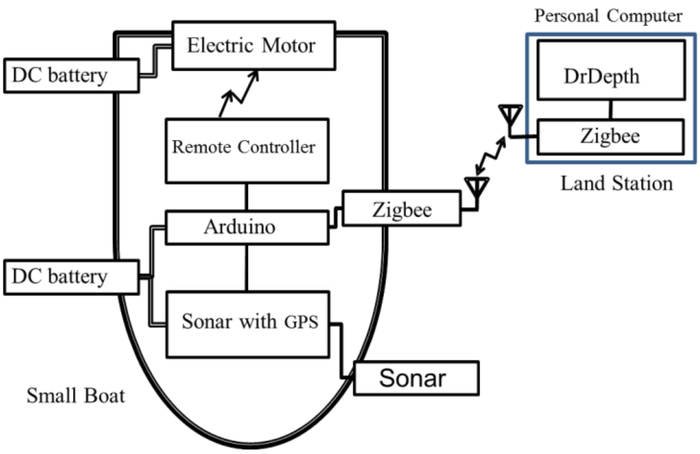

Fig. 1: Schematic diagram of the depth-survey robot

Fig. 2: Sonar with GPS and its attachment

2.1. Sonar fitted with GPS

We measured position and depth using sonar (Lawrence HDS-5) with GPS attached to the screw nearby, shown in Fig. 2. It enabled us to get the position and the depth simultaneously. The specifications of the sonar are shown in Table 1. The sonar had two kinds of acoustic waves, 50Hz and 200Hz, for scanning the riverbed. At 50Hz, we could scan the riverbed around the boat with a wider scanning range of 35 degrees, making it suitable for the deeper river-depth survey. At 200Hz the scanning angle was narrower, but at higher resolution in the depth survey. As our target was the area of shallows, we adopted a wave of 200Hz to get depth data in more detail. The sonar had an SD card to save the measured data and after scanning it could be utilized for drawing the 3D profile of the Mekong River using 3D drawing software, DrDepth [6].

Table 1. Specification of HDS-5(GPS & Sonar)

GPS	Number of channels	16CH
	NMEA0183 Output	GGA
	Accuracy	5m in horizontal
Sonar	Frequency	50/200kHz
	Output power	Max. 250W
	Measuring Range	0.4m～1500m
	Accuracy	< 1.5%FS
	Resolution	1cm
Power	Power Supply	10～18VDC

2.2. Electric Motor

An electric motor, RIPTIDE RT55/SP/AP (product of Minn Kota LTD), was utilized for driving the boat. It could be remotely controlled from land. The interface circuits between remote controller and microcomputer were designed using photo-couplers.

2.3. Independent Navigation Algorithm

To control the boat, information on things such as attitude, altitude, direction and speed of the boat could be used. This was updated every 3 seconds and then the rudder could be controlled by a timer interrupt-program based on that. To judge if the boat had reached the waypoint or not, the distance between the present position of the boat and waypoint was calculated using Hubeny's equation [7] shown in (1),

$$D = \sqrt{(M\times\Delta P)^2+(N\times\cos P\times\Delta R)^2} \tag{1}$$

where D denotes distance between the boat and waypoint, P is average latitude of the boat, ΔR and ΔP are longitude deference and latitude deference between the boat and waypoint, respectively. M means meridian curvature radius, N is double prime vertical circle curvature radius.

$$M = \frac{6334834}{\sqrt{(1\text{-}0.006674\times(\sin P)^2)^3}} \tag{2}$$

$$N= \frac{6377397}{\sqrt{1\text{-}0.006674\times(\sin P)^2}} \tag{3}$$

When the boat came within a 10m radius of the waypoint, its rudder turned to the next waypoint. If the boat did not reach the waypoint, after the azimuth angle between the present bow direction and the waypoint was calculated, the rudder angle could be decided.

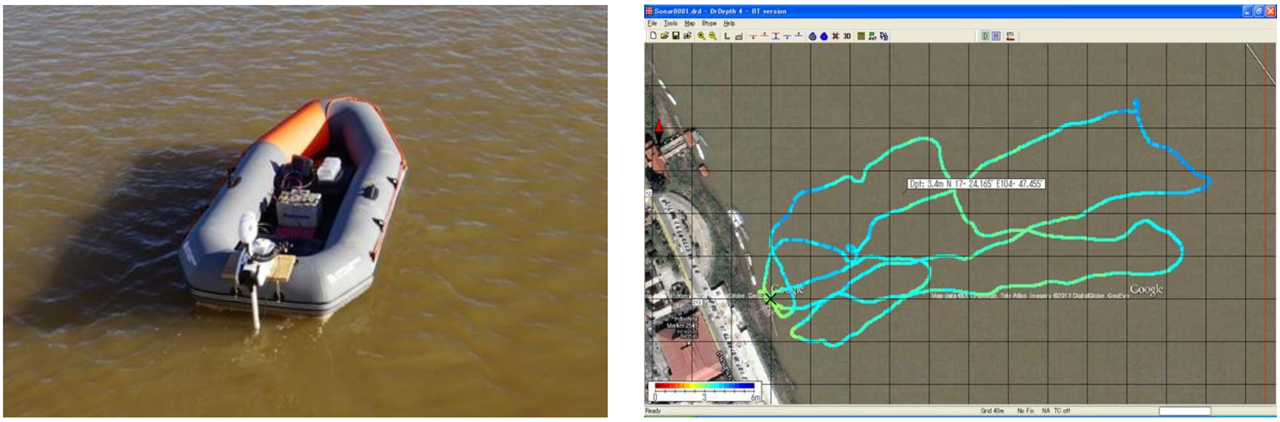

Fig. 3: Trial in the Mekong River and wake of the running robot (in Amphur Muang Nakhon Phanom, Thailand)

3. Experimental Result

We performed the experiment in the Mekong River in the north-eastern region of Thailand at Nakhon Phanom city, bordering Laos, 10:00-12:00, 23 Dec., 2012. The experimental area was 500m x 200m. It was fine and in the dry season, so the water flow speed near the river bank was about 1.5 knots. We prepared a small boat made from PVC because it was easy to carry and handle (shown in Fig.3).

First, we tried to run the boat in independent running mode. However, since the GPS sometimes couldn't capture a signal from the only 2 or 3 satellite stations in the region, the accurate position of the boat couldn't be measured. To cope with this problem, the DGPS system needed to be applied.

Next, we tried operating the boat in remote control mode from land. A game controller connected with Arduino was used for controlling the steering motor and electric power of the boat. Fig. 3 shows the wake of the boat while running mapping to Google Earth. The experimental results of the tomographic profiling of the Mekong River are shown in Fig. 4 and Fig. 5. The dark shading is related to the depth of the river, darker parts indicating deeper areas of the riverbed. We can see that the deepest place was the centre of the river (on the border line between Thailand and Laos) and it gradually became deeper continuing along to the centre.

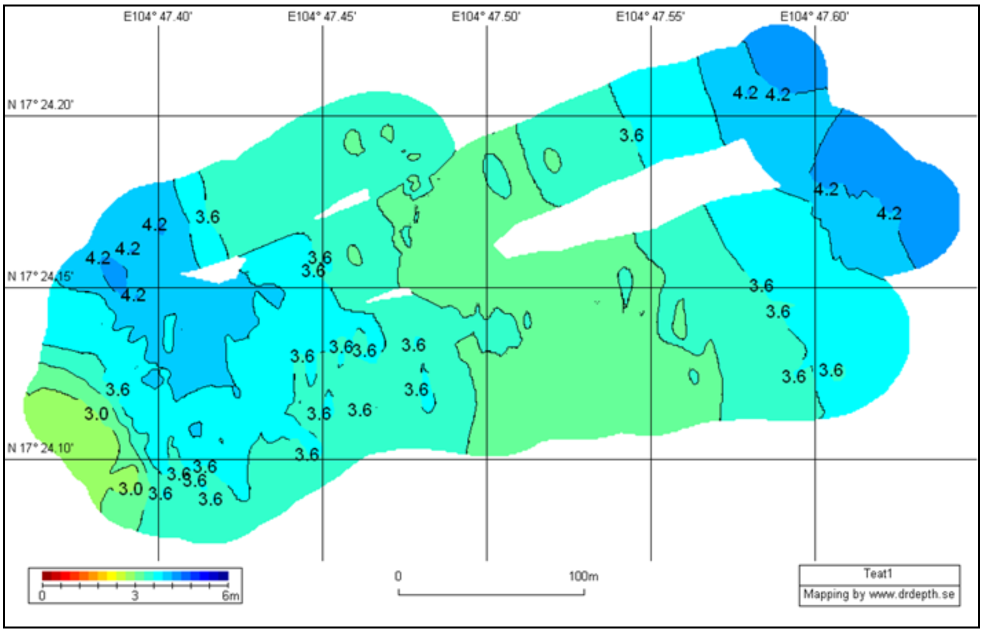

Fig. 4: Experimental Result of 2D topographic profile of the Mekong River.

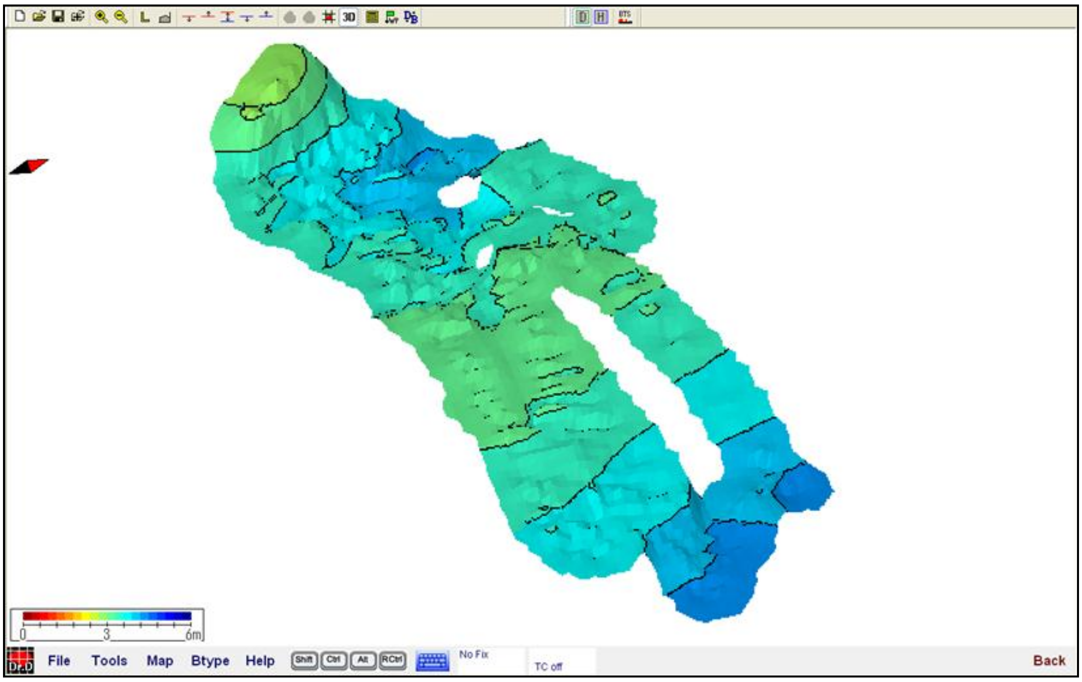

Fig. 5: Experimental Result of 3D topographic profile of the Mekong River.

4. Conclusions and Future Work

We constructed an environmental survey robot for the Mekong River. The robot could be controlled in two modes: independent mode and remote mode. We evaluated the performance of the robot. Owing to lack of satellites viewable by the GPS, the independent running mode did not work. In remote control mode, we could control the boat easily and get the depth profile for the Mekong River.

However, some parts of the profile data were lost, it being necessary to develop a user interface enabling us to map the data to Google Earth in real time. In the future, we hope to improve its usability by monitoring the steering position and output power of the motor in real time. We also plan to add several devices, such as a temperature sensor and water-flow sensor, to our robot for surveying the environment of the GMRB. Moreover, we plan to develop a method to estimate fish population and species from the sonar image.

5. Acknowledgements

This research was carried out by Nakhon Phanom University (Thailand) and the National Institute of Technology, Yuge College (Japan), based on an International Agreement for Academic and Educational Exchange between both and was partially supported by The Technical Promotion Organization of Yuge College.

6. References

[1] Natsumi Takahashi: Regional Integration in the Mekong Sub-region, April, 2013.

[2] New involvement of Japan and the United States in the Mekong River Commission, Working paper No.4, SFC Research Center, Japan Platform, April, 2013.

[3] Mekong River Commission: Hydro-acoustic Survey of Deep Pools in the Mekong River in Southern Lao PDR and Northern Cambodia, MRC Technical Paper, No.11 January, 2006.

[4] Chan, S. S. Putrea and S. Lieng: Using local knowledge to inventory deep pools and important fish habitats in Tonle Sap and mainstream around the Great Lake in Cambodia. MRC conference Series, 7: 43-63, 2005.

[5] T. Tabusa, K. Sawamura et. al.: Development of Small Scanning Boat by Automatic Cruise and Making of 3 Dimensional Topography of Mekong River, (in Japanese), Navigation (186) 15-23, 2013.

[6] T. Tabusa, T. Mukai, K. Kuzume, S. Prainetr and D. Konyoung: Joint Development of the Robot for Automatically Measuring the 3D Depth Profile of the Mekong River, (in Japanese), Kosen Kyoiku (37), 647-652, March, 2014.

[7] http://www.Kashmir3d.com/kash/manual/std_siki.html.