USV Hydrographic Solution showed its advantages in Project of Ponds Sludge Removing

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SUMMARY
Pond sludge is an accumulation of waste that settles at the bottom of the pond and it causes harm to the living environment of lakes and damage water quality hugely if it accumulated a lot. Lakes are main or backup water supply source in cities so keeping water quality from the harm of pond sludge is crucial. City like Wuhan is built upon the numerous lakes in many sizes so cleaning the water is a challenge to the vessels and operators. With the help of the USV the surveying job can be easily done and conveniently taking to different site, greatly speed up the preparation of sludge removing project.

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1. PROJECT BACKGROUND

1.1 Pond Sludge Challenge

Pond sludge goes by many names; mulm, muck, sediment, and a few more colorful terms. It is simply an accumulation of organic debris that settles on the pond bottom. Most commonly the sludge will be a mixture of leaves, fish waste, decaying plant debris, dead algae, and debris washed into the pond with rain runoff. Ponds around the urban area are also a transfer pool or temporary storage of the civil wastewater (or some waste unknown to the source) so the sludge accumulation is faster and more severe than lakes in nature. Then the mass decomposition process of the organic material hugely reduces oxygen levels in ponds and creates anaerobic conditions. This oxygen-free zone can harbor harmful bacteria as well as produce hydrogen sulfide. The hydrogen sulfide will begin to cause harm to other living things in the pond environment starting with the beneficial bacteria. It also can create unpleasant odors in the pond. Thus, the ponds can never be an environmentally friendly and civil water supply.

Tangxun Lake is the biggest lake in an urban city in Asia, covers a region from North Latitude 30°22'to30°30', from East longitude 114°15'to 114°35', playing an important role in the city's water supply system and ecosystem. According to the city's natural freshwater management plan that Tangxun Lake should keep water quality of level III in national standards which means it can be a temporary habitat for living and can be used as the backup fresh water in cases. However, due to the pollution and lack of sludge cleaning the quality down to level V. Therefore, cleaning this big lake and restoring the quality is the main job in Wuhan City in 2019.

1.2 Project

The whole quality restoration project consists of drainage management and illegal emission enforcement. 13 drainage sites are recognized and the current thick pond sludge within a range of 120 meters of each site are sludge removal area. 82582m3of sludge in an area of 165501 m2 is scheduled to be removed. See the picture below as a reference.

1.3 Challenge

There are challenges for the sludge removal and also not easy for the preparation—field surveying and mapping before and after sludge
removing.
First,
transportation challenge. As the big lake are divided into many small ponds and separated by banks and roads, even there are connection tunnels below the bridges but it makes the boat difficult to cross each parts to reach every the drainage site in different places.
Second, shallow water and thick sediment risks. As the water becomes shallower when getting close to the drainage sites due to the thicker and thicker sediments, only light vessel can reach there to measure the depth. Sending a man to the muddy area is not a safe solution as well.
Finally, the unideal condition means they need more time on the surveying rather than sludge removing work, leading to the risk of overdue.

2. SURVEYING

Therefore finding an efficient way to survey the pond should be considered. And USV, the solution of that part will be introduced later.

2.1 Surveying Plan

The total mapping area is 165501m2 with requirement of map scale on 1:500, for pre-dredging survey and the water area should be measured again for the after dredge survey, thus the volume dredged will be calculated.

2.2 Onsite Checking

The ponds are still in most of the time making it ideal for the USV to survey, even the site are distributed in different ponds. The aquatic grass,
divided trees and wood, fishing nets, and plastic wastes bring some difficulties and affect the accuracy and project progress. See the pictures below

Drainage Site Status Analysis of the Sludge Removing Project

Challenge	Status	Affection	Solution
Sites distribution	Only 3 sites are close to each other making the surveying work efficient, but has to carry equipments to the rest13	Not convenient for surveying, has to move to different place by transportation.	Survey the site with priority
Shallow shore	Rocks, sands and concrete solid waste distributed in site 3,4and 5	Solid waste may damage the boat	Using Camera on the boat to check the accessibility before getting closer. Send person to survey the boat unapproachable area.
Aquatic plant	Most of the sites lives the plants	Possibility to twist the propeller Not easy to survey the depth of it.	Using boat camera to check before getting closer. Using a better design propeller Send person to do the field survey to fill the data unapproachable to the boat.
Fallen leaves and wood body	Mainly in site1 and site 3,4,5	Easy to twist the propeller Easy to disturb the sounding result by the wooden body, making the digitized depth jumping	Using boat camera to check before getting closer. Using a better design propeller Using professional software to do post processing to delete the wrongly digitized depth
Plastic waste	All ponds	Easy to twist the propeller Easy to disturb the sounding result making the digitized depth jumping	Using boat camera to check before getting closer. Using a better design propeller Using a manned boat as backup
Fishing net and cable	Few	Damage the propeller	Using boat camera to check before getting closer. Using a better design propeller
Fish	Lives in all ponds 。	Easy to disturb the sounding result making the digitized depth jumping	Using professional software to do post processing to delete the wrongly digitized depth

2.3 Lake and Lakeside Survey

The mapping is based on the 1954 Beijing Coordinate system, with a gauss-3 projection and 1984 national level datum, by the CORS service. Each drainage site marked two known points for result checking.

In the pre-dredging survey, not just the pond but part of the shore should be surveyed. On some soft muddy shore where is risky to stand a man, a **reflectorless** total station is necessary.

2.4 Hydrographic Survey

The main work of the surveying is the bathymetry part. Considering the challenges mentioned above, using a USV for the hydrographic survey is necessary and efficient in the majority of the condition of the ponds.

The hydrographic survey principle is simple to understand. Sound will be reflected by the object on the bottom, by calculating the period and sound speed that the depth can be measured. The formular goes like this:

$$Z = Vt/2$$

V means the sound speed in water and t means the time span of sounder emitted from transducer and back to the transducer after being reflected.

Combining the draft that the real depth can be measured. However, the speed varies when temperature and solvend. Using Cm as the averaged speed, then the depth range is：

$$Z = Cm(tr-ti)/2$$

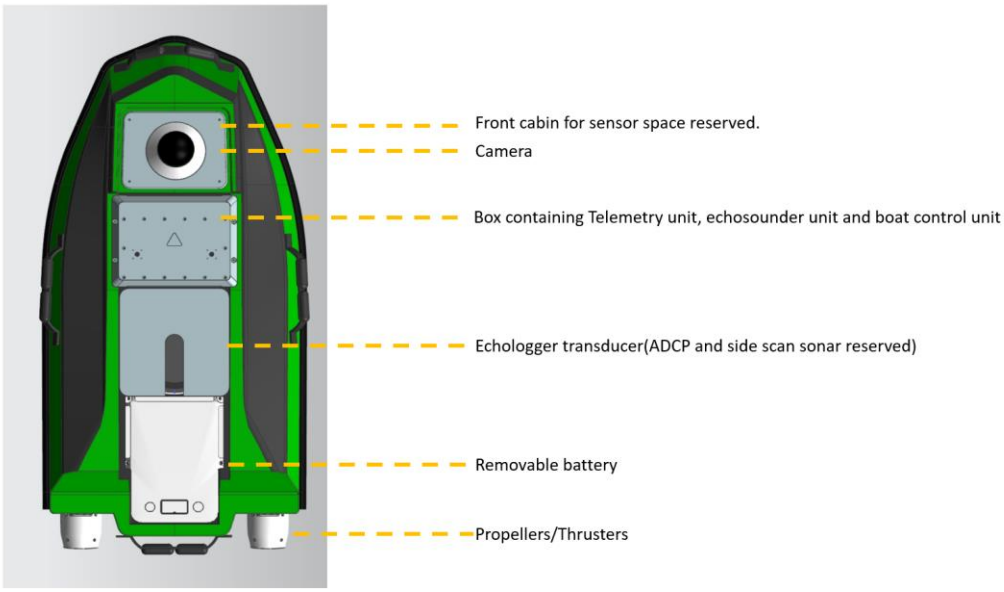
When ti means the time when sound emitted and tr means time when sound received.

2.5 USV System Introduction

The USV system consists of three major parts, the telemetry and remote control part, the vessel part and the sensors part.

There are only a simple android based controller with ranging up to 2km with the boat. All operation like surveying and autopilot work can be conducted on the laptop and using the controller as the router to communicate with the boat remotely. On the boat are the

chosounder and GNSS receiver to install(almost 0 offset horizontally) while the real time front camera can help users to check the condition at the front side , to avoid the risks.



2.6 Workflow of USV

2.6.1 Setup the telemetry

Setup the communication between the laptop ashore and the boat before putting it on the water with the powerful long-range android controller. An intuitive camera image will be displayed on the screen as well.

2.6.2 Deploy and design the route

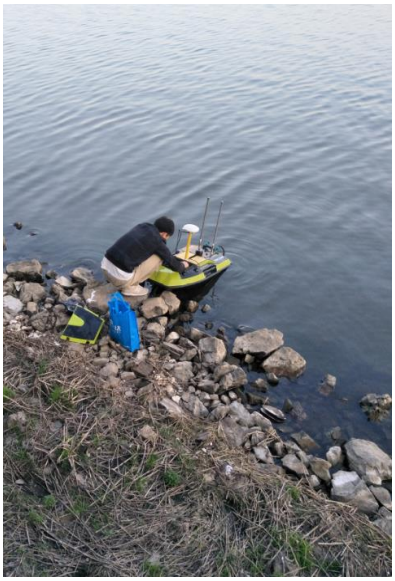
Deploy the boat on the water, make it sail along the border; and then design the survey lane in this safe zone.

2.6.3 Survey in auto pilot or manual mode

Make the boat sail and survey in auto-pilot mode, and switch to manual mode if necessary on some special occasions. During the sailing the gain, power, and threshold can be adjusted by

the Hi-MAX software automatically or manually on the laptop, making the work efficient and fast.

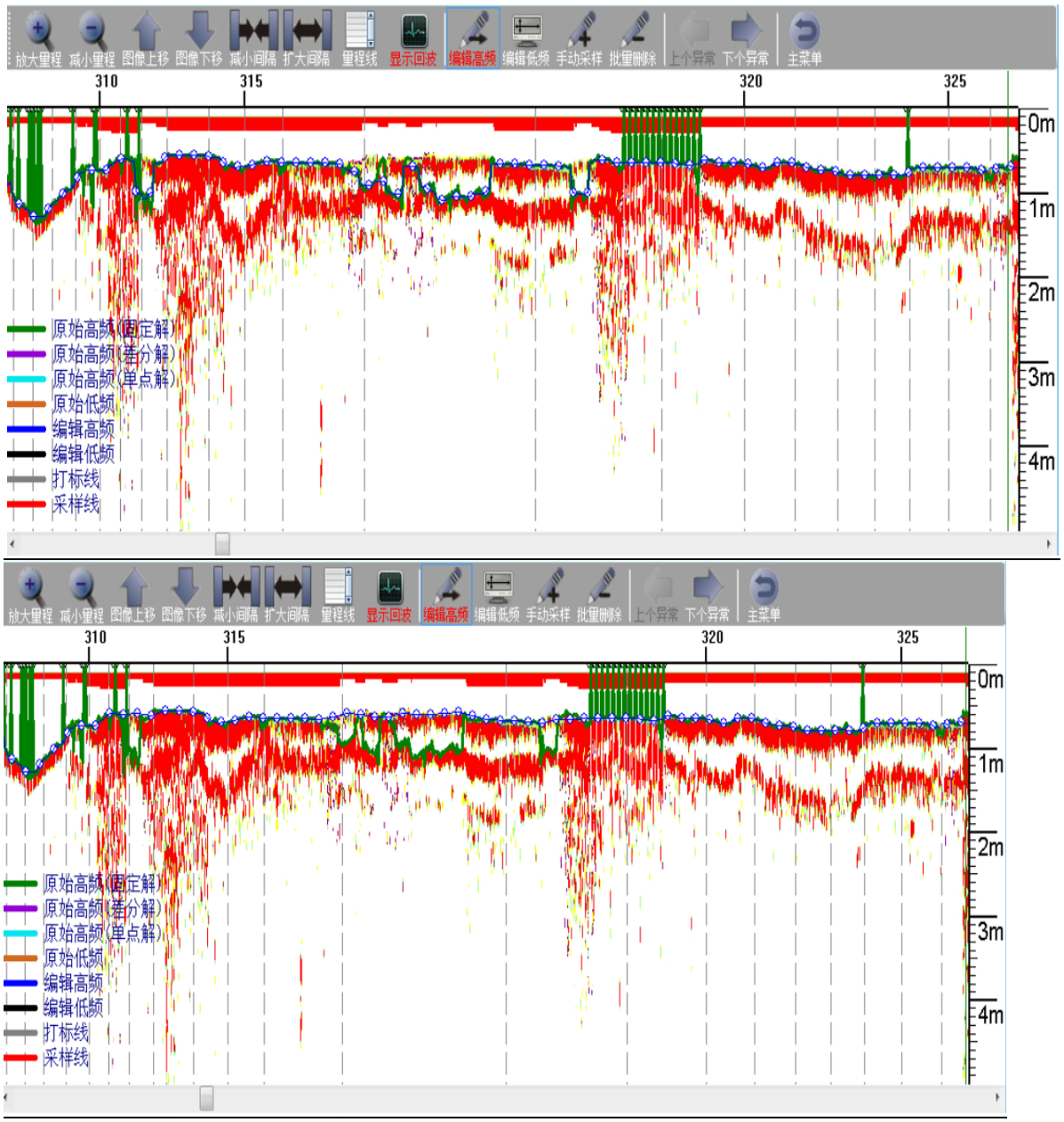




2.6.4 Post processing

Hi-MAX Software is an easy-to-use software not just for a real-time survey but for post-processing. With professional depth sampling technology, the echogram can be overlayed with digitized depth, helping users to easily check the fake and wrongly recognized digital depth and correct it to the real one. Scenarios like surveying in the aquatic plan area, fish area, and other unknown interferences. In the pictures below you will see the raw digitized depth

and the corrected result by automatic averaging or manual drawing according to the echogram.



2.6.5 Date Export & Mapping

Export the DXF format data and edit it in the CAD software, the contour mapping result with a 1:500 scale is completed when 11 maps are all done. Due to confidential reasons, the result cannot show here.

3. REVIEW

Some factors that were concerned during the project and should be concern in the future.

a. Dry season with lower water level.

The time of the project was held before the rainy season which leads to the low water level, so it may be safer for the surveyor. However, some places may be too shallow to survey by boat, and need an in-person survey.

b. Traffic jam in rush hour.

Going to work before the rush hour to avoid the traffic jam, speeding up to the field sites.

c. Equipments batteries.

A battery of the USV is sufficient for 4 hours of sailing and surveying but need to prepare one more pack as backup. Meanwhile, the power supply for GNSS receivers and laptops should also be considered. So a backup pack of batteries is recommended. We all understand that the effective working time only happens when all equipment working with a sufficient power supply

Time Table of Start and Finis for the Survey Project

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Jobs	Start Time	End Time	Notes
Site Checking	12nd April, 2019	12th April, 2019	
Control Points Setup	13rd April, 2019	13rd April, 2019	
Surveyor and equipment arrival	14th April, 2019	14th April, 2019	
Shore Surveying	15th April, 2019	16th April, 2019	
USV Arrival	16th April, 2019	16th April, 2019	
USV Survey	17th April, 2019	19th April, 2019	
Office Work	20th April, 2019	21st April, 2019	Mapping, earthwork
Final Result Submit	22nd April, 2019	22nd April, 2019	Result checking, accptance, print
Returned	23rd April, 2019	23rd April, 2019	

From the table above that we can easily find the advantage of USV surveying, just 3 days to handle the bathymetry work by its high mobility, aquatic grass proof and flexibility.

BIOGRAPHICAL NOTES

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