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DESIGN AND IMPLEMENTATION OF UNDERWATER POSITIONING SYSTEM USING GPS SURFACE NODE AND ACOUSTIC SIGNALS

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Abstract - It is very difficult to measure the underwater position of target/object. Further, GPS can not used in underwater, because satellite signals are not worked in underwater. Also the accuracy of position measurement is greatly affected by many factors of the underwater environment. By considering the facts, this research experiment is overcome the problem, the main aim of this system is use GPS on the sea surface, Which is mounted on the node. Due to the use of GPS , we known the position of node on the sea surface. Calculate the distance of the object/target by use of ultrasonic module.

Keywords *– Ultrasonic module, servo motor, arduino uno, UART, arduino IDE, MATLAB.*

I. INTRODUCTION

In recent years, the need for underwater robots to be used for research in the fields of ocean has become ever greater. For autonomous underwater robots, an accurate positioning system for wind area and long term is very important in order to develop their full potential. Applications are common and relatively to essentially a specialized area like:

- the tracking vehicles, towed sensors,
- locating and marking out underwater structures, pipelines and cables,
- the monitoring of drilling and dredging operations,
- survey and monitoring of numerous objects.

Acoustic positioning systems were developed in the 1950s and 60s to provide support to various US research projects and activities [6]. Over the years, prompted by demand from the offshore energy industry exploring deeper and deeper water areas, acoustic positioning and tracking systems have undergone a lot of technological changes.

II. POSITIONING SYSTEM METHODS

Underwater acoustic positioning systems are generally categorized into three broad types or classes :

A. Long Baseline (LBL) :

LBL systems take their name from the distance between seabed transponders or beacons which can be as much as several kilometers, usually not more than 50~2000 m. LBL system is a high accuracy solution. Depending on the frequency applied the accuracy varies from 0.02 m for extra high frequency, 0.15 for medium and 0.5 low frequency. The higher frequency the lower accuracy. The conventional long-baseline acoustic position systems normally use Kalman Filter correction to handle the problem of positional errors [8]. A typical LBL positioning system consists of one transceiver and at least three transponders. The transceiver is mounted on a submersible or a surface vessel, which is the target to be positioned. The transponders are installed on the seafloor to form an array (Fig. 1). Before positioning the target, transponders will be deployed on the seafloor. Their positions (or at least the distances between each other) need to be known precisely. The deployment and retrieval of transponders on the seafloor are performed by a surface ship, or by divers or an underwater automatic vehicle. The transceiver on the target pings each transponder on the seafloor. The travelling time of the transmitted signal from the target to the transponders and backwards is measured. Knowing the sound velocity at the site allows this measurement to be converted directly to the travelling distances. Once the distances from all transponders to the transceiver are obtained, a unique point where all these distances intersect is obtained via calculations and this point is the position of the transceiver. This method is called “trilateration”. The calculated transceiver's position is within and referenced to the transponders array [7]. There are various types of signalling available for use in acoustics. These include tone based, such as pulsed, chirp modulation signalling and digital spread spectrum signalling (Wideband Technology).

B. Ultra Short Baseline(USBL) :

The development of the first USBL was stimulated by a requirement to support diving vessel operations. These needed an additional independent localised method for dynamic positioning (DP) to ensure safe operations. At that time (1977), before the advent of Differential GPS, radio positioning systems were not capable of providing the necessary positional accuracy and precision needed for 24 hour diving operations in the North Sea's new fields. The name comes from the short baseline which is established between elements of transducer. The USBL methodology is applicable only for shallow water positioning or deep water low accuracy positioning, because USBL position accuracy deteriorates with depth quite fast. The accuracy of the system is estimated as 0.2–1% of slant range. USBL generally provided a reliable local relative system that complemented other short range high precision systems such as taut wire and Artemis. Its use rapidly spread to a number of survey activities and applications most notably in the positioning of a variety of underwater sensors units relative to a survey vessel [5].

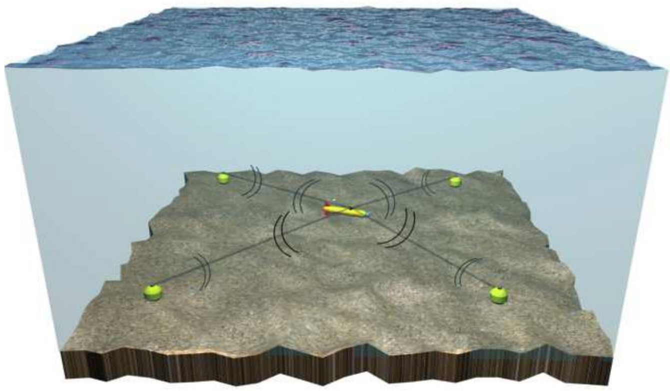

Figure1 : Long Baseline LBL system[1]

Figure2 : Ultra Short Baseline SBL system[1]

C. Short Baseline (SBL) :

Short baseline systems use a baseline consisting of three or more individual sonar transducers that are connected by wire to a central control box. Accuracy depends on transducer spacing and mounting method. When a wider spacing is employed as when workin from a large working barge or when operating from a dock or other fixed platform, the performance can be similar to LBL systems[3]. When operating from a small boat where transducer spacing is tight, accuracy is reduced.

Like USBL systems, SBL systems are frequently mounted on boats and ships, but specialized modes of deployment are common too. For example, the Woods Hole Oceanographic Institution uses a SBL system to position the Jason deep-ocean ROV relative to its associated MEDEA depressor weight with a reported accuracy of 9 cm.

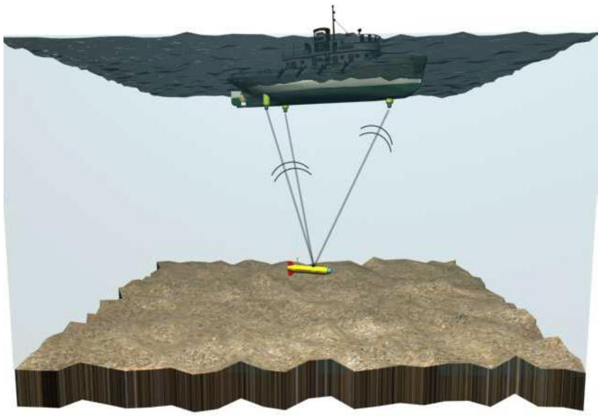

Figure3 : Short Baseline SBL system[1]

III. LITERATURE SURVEY

Chatpadol Klungmontri, Itthisek Nilkhamhang, Wutthiphat Covanich and Tsuyoshi Isshiki, presented Underwater Positioning Systems For Underwater Robots Using Trilateration Algorithm. This paper presents a simple model of underwater positioning system for ROV. The proposed system is designed for a specific application such as investigating dam cracks. It includes 2 underwater speakers, hydrophone and pressure sensor. The trilateration algorithm is employed to locate various positions of ROV. Results show suitable frequencies for this model are 2kHz and 10kHz[2].

Masahiko Sasano, Shogo Inaba, Akihiro Okamoto, Takahiro Seta, presented Development Of A Regional Underwater Positioning And Communication System For Control Of Multiple Autonomous Underwater Vehicles. Authors develop a new complex underwater positioning and communication system. The semi-submersible ASV moves horizontally by cruising speed, and achieves the underwater positioning and communication of multiple cruising AUVs. The hovering type AUV moves vertically and plays a role of relay system of underwater communication with multiple cruising AUVs. The sea surface LBL system helps for individual positioning of each AUV, in addition to its INS. The integrated underwater system would help the control of multiple AUVs at the regional survey area[3].

Andrea caiti, Francesco di corato, Davide fenucci, Benedetto allotta, Riccardo costanzi, Niccolò monni, Luca pugi and Alessandro ridolfi, presented experimental results with a mixed usbl / lbl system for auv navigation. In this paper the configuration includes a set of fixed lbl nodes and an usb system on board the auv. The results shows that , with a low cost, and in presence of significant delays in reception of acoustic fixes, the navigation error is kept bounded within acceptable limits[4].

IV. UNDERWATER POSITIONING SYSTEMS

In this work, the underwater positioning system is divided into two parts. The first part is the network model, and the second part is the positioning algorithm.

A. Network Model

In this underwater positioning system,, we are using an ultrasonic Distance sensor. It generates sound waves beyond the scope of human hearing and measures distance by calculating the time required by these waves to hit an obstacle and travel back. This is similar to the principle used by bats and cruise ships.

Another component that we are going to use is a servo motor. It differs from the usual DC motor in that it can turn very precisely to a given angular position and hold its state there. When a servo motor is given pulses of a specific duration, it moves to the corresponding angular position.

Also using both these components to get a 180 degree field of view for our robot. Shown in figure 4.

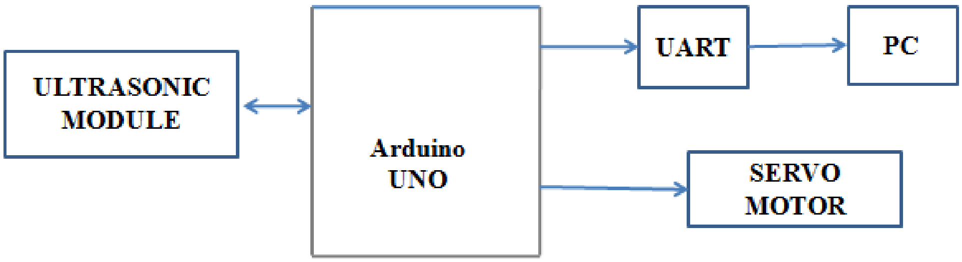

Figure4 : Design of the underwater positioning system

First system will be started**.** Then set the PWM of servo motor. Trigger the ultrasonic module. Calculate the width of the signal. If width of the signal is between 150us-25ms then distance = width/58 otherwise continue to trigger the ultrasonic module. and then the system will repeat these procedures as shown in Figure 5.

B. Positioning Algorithm

Speed of ultrasonic wave is 347 m/s equivalent to 0.0347cm/µsec(Temperature dependent)Timer count multiplied with 200nsec (0.2µsec), internal clock period gives the echo time (say, Et).
As per the eqn:

Speed = distance/time
=> echo distance (Ed) = echo speed(Ev) *echo time(Et) ie,
=> distance (Ed) = 0.0347cm per µsec (Ev) * Et µsec

The obtained distance will be twice the actual distance since it gives the to and fro distance of the object as per the to and fro time equated to the equation: (ie, Et stands for 2Et).
Thus the obtained distance divided by 2 gives actual distance of the obstacle.

Actual distance = Ed/2.

As per the above illustration your equation is,

Ed = Ev *(Et/2) implies
Et = 2 * Ed /Ev equivalent to Et = (2/0.0347) *Ed
Implies Et = 58 *Ed equivalent to

Ed (in cm) = Et(in µsec)/58

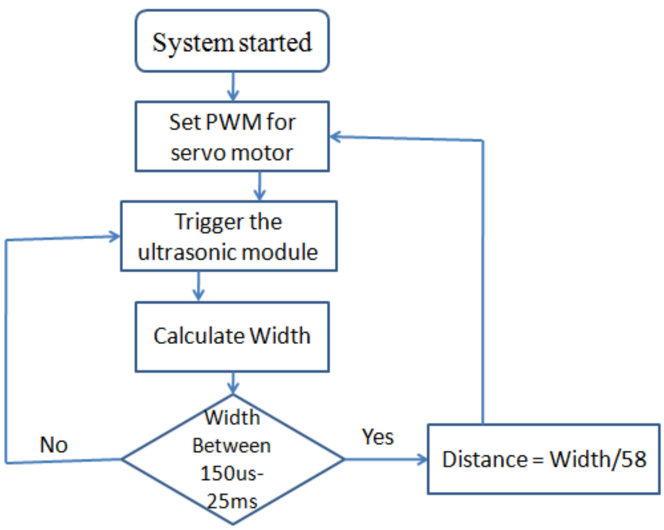

Figure8: Flowchart of the underwater positioning system

V. RESULTS

- The Arduino software shown in figure 9.

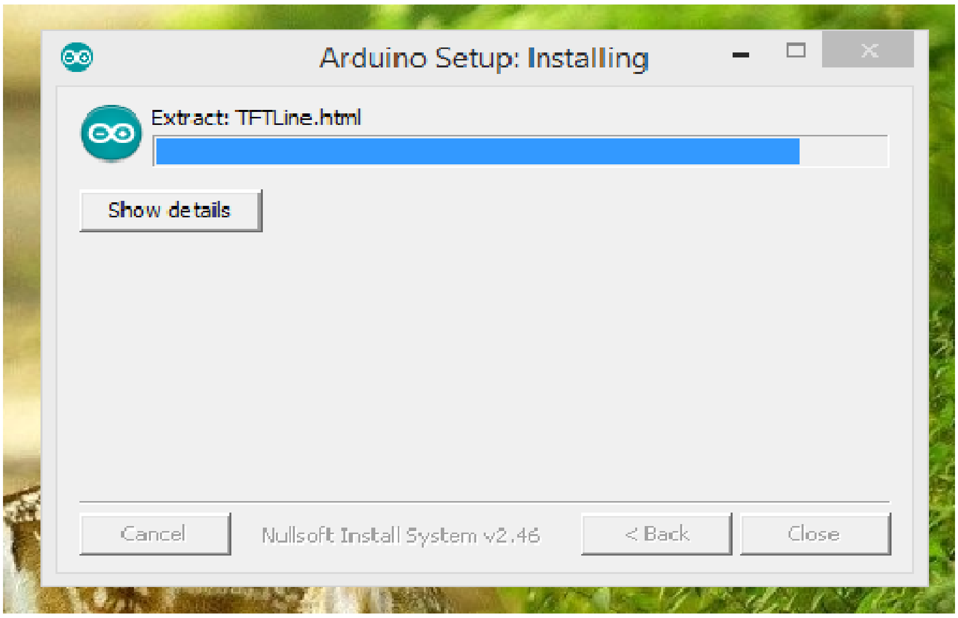

Figure9: Arduino IDE

- Hardware Setup of underwater positioning system.

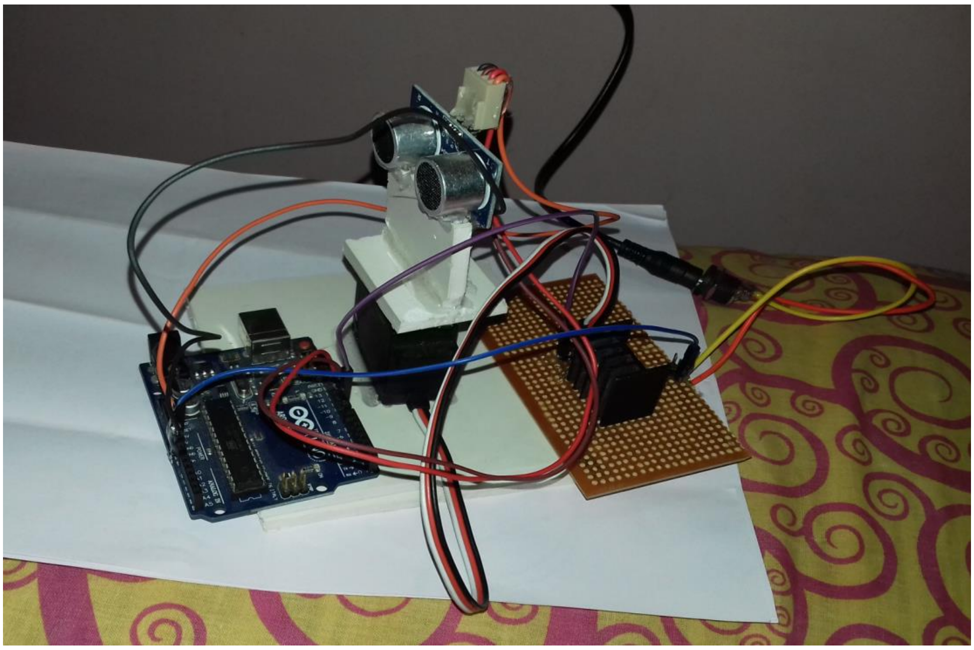

Figure10: Hardware setup

- Connection of servo motor and ultrasonic module with controller in Arduino 1.6.5.

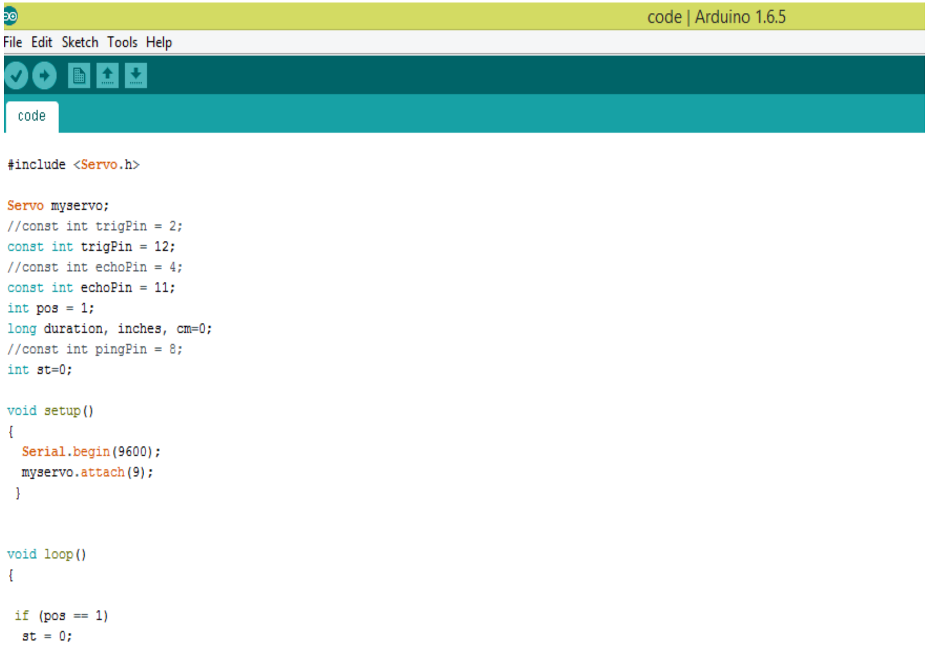

Figure11: Arduino 1.6.5 connection

- Result of Arduino IDE With COM 5.

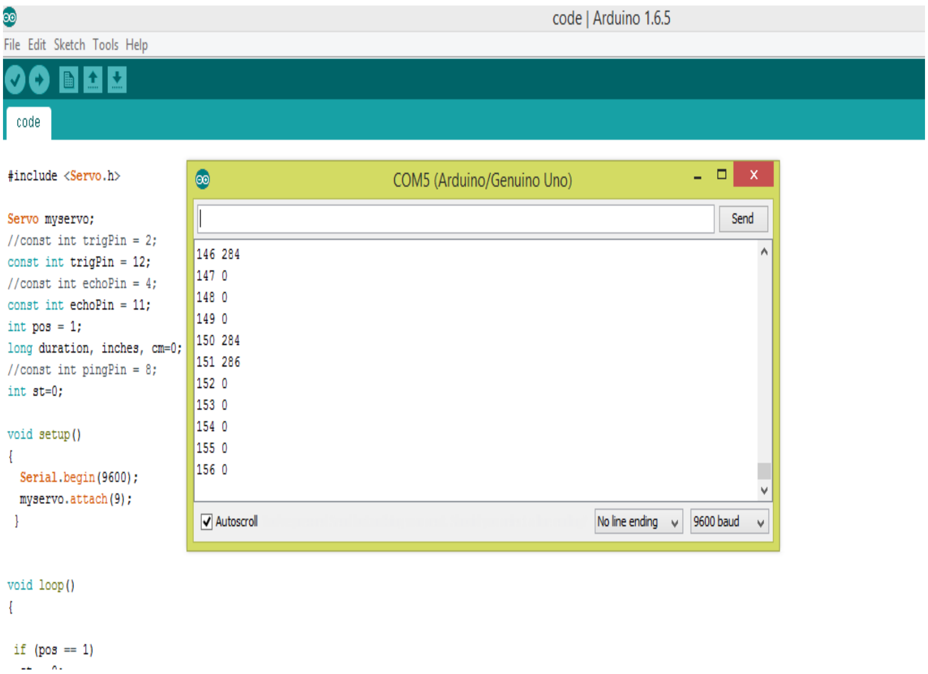

Figure12 : Result of Arduino

- Result of matlab distance graph up to 100cm.

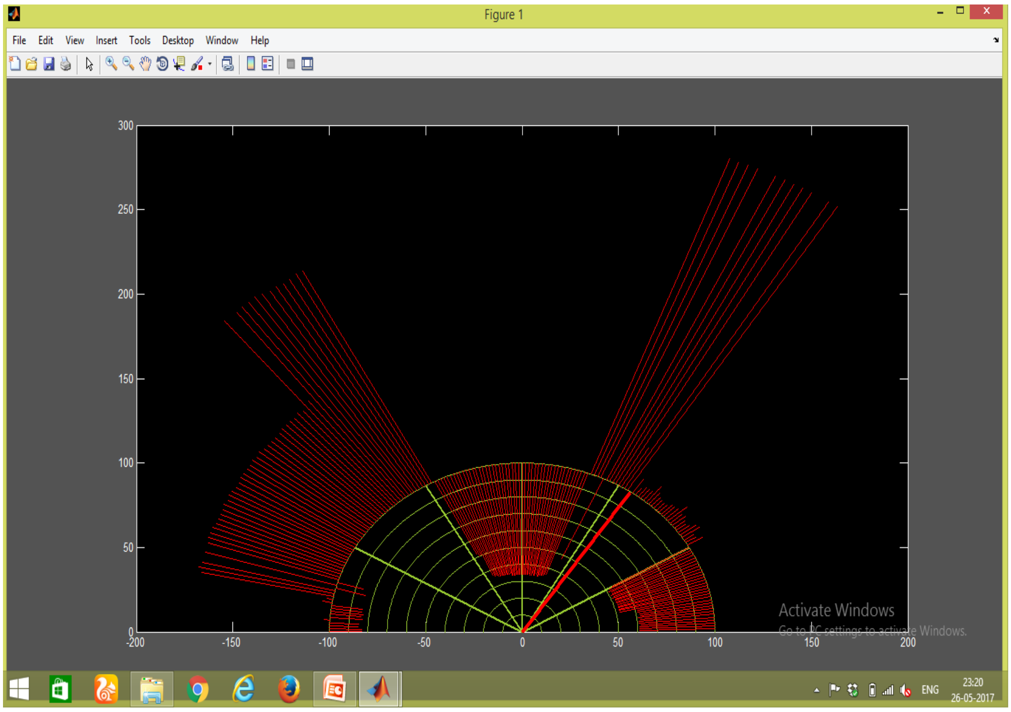

Figure13 : MATLAB result

VI. CONCLUSION AND FUTUREWORK

This paper presents a simple model of underwater positioning system for target/object. It includes ultrasonic module, servo motor and Arduino uno.PWM algorithm is used to determine the position of object. Result is shown in MATLAB up to 100cm and also in arduino IDE up to 400cm. In future work, we will conduct experiment with controlling the node position using Wi-Fi module.

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