DESIGN AND DEVELOPMENT OF MULTI-INPUT SENSOR ALGORITHM FOR AUTONOMOUS UNDERWATER VEHICLE (AUV) APPLICATIONS

MOHD SHAHRIEEL MOHD ARAS, MUHAMMAD HERMAN BIN JAMALUDDIN, HYREIL ANUAR BIN KASDIRIN

Mechatronics Department, Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka

Abstract— This project is to design and develop a multi-input algorithm of sensors for Autonomous Underwater Vehicle (AUV) applications which is having high performance automated detection and monitoring on underwater application or for surveillances and defense application. The monitoring and detection will be based on multi-input received from the intelligent and active vision and sensors implemented in the AUV. The sensors implemented in AUV such as vision system, hydrophone system and sonar system. The new design of vision system for AUV with the implementation of wireless camera, whereby, produce clearer image. The ultrasonic sensor is a main device to transmit and receive the signal from the obstacle. The ultrasonic sensor will be combined to the ultrasonic circuit. Hydrophone is an underwater microphone which with the help of pressure impulses of acoustic waves converts them into electrical signals which in further are used for communication. It was designed to be used underwater for recording or listening to underwater sound.

*Keywords***:** AUV, Vision, Sonar, Hydrophone.

I. INTRODUCTION

An Autonomous Underwater Vehicles (AUV) is very challenging research area and valued for both their expand ability and replace ability because they can be deployed in hazardous environments without risking human divers. This emerging field is very economical as AUVs has the potential for cheap scalability makes it ideal for large scale and long term data collection tasks. An AUV is a robotic device that is driven through the water by a propulsion system, controlled and piloted by an onboard computer, and maneuverable in three dimensions [1],[2]. This level of control, under most environmental conditions, permits the vehicle to follow precise preprogrammed trajectories wherever and whenever required [3],[4],[5].

Sensors on board the AUV sample the ocean as the AUV moves through it, providing the ability to make both spatial and time series measurements [6]. Sensor data collected by an AUV is automatically geospatially and temporally referenced and normally of superior quality [7]. The sensors implemented in AUV such as vision system, hydrophone system and sonar system. In this paper will describe for the sensor that mention such as vision, sonar and hydrophone sensor.

II. GENERAL DESIGN OF AN AUV

There are several aspects in AUV electrical and mechanical design need to be looked at closely so that the design will be successful. In order to design any underwater vehicle AUV, it is essential or compulsory to have strong background knowledge, fundamental concepts and theory about the processes and physical laws governing the underwater vehicle in its environment. Therefore, the major design aspects that need to be considered [8],[9],[10] are identifying hull design, propulsion, submerging and electric power. Figure 1 is the method that we are using to design an AUV.
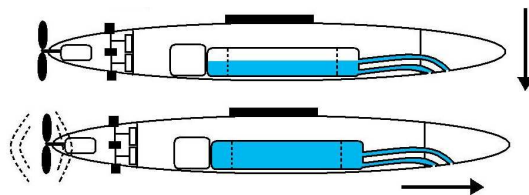

Figure 1: Concepts of AUV

Figure 2, 3 and 4 shows the real AUV for this project that will be attached with multi-input sensors system.

Figure 2: An AUV (top view)

Figure 3: An AUV (side view)

Figure 4: An AUV (front view)

III. DESIGN PROCESS

A- Vision system

Figure 5 shows the step to set up the wireless camera with the video monitoring. When all the equipments had been set up, the power supply is switch on and the frequency at the receiver is tuned so that the wireless recordable receiver will view the image.
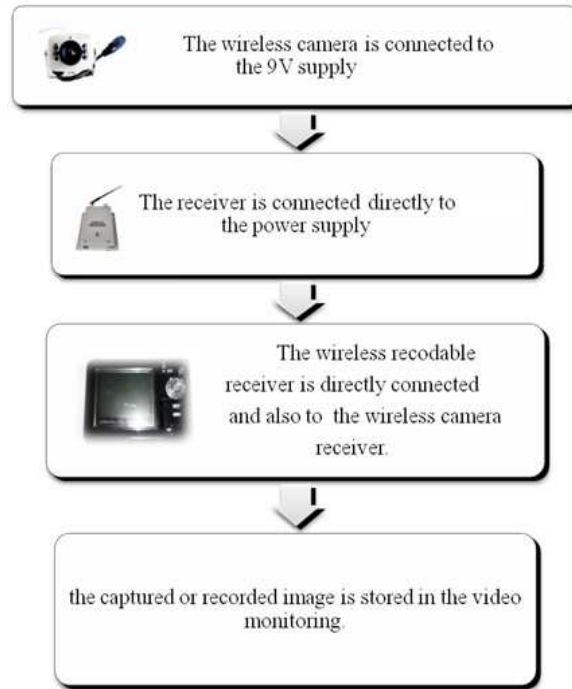
Figure 5: Process to set up the equipments

Analysis is done for this particular project as to prove the ability of this new vision system either it can view the clearer image or not. The main purpose of this analysis is to captured clear image that had been submerge in the water.

B-Hydrophone system

The hydrophone have many advantages such as dielectric substance, contain in shielded, provides a broadband and highly sensitive to underwater sound vibrations. Because of that reason, the Dolphin Ear DE2000 Series Hydrophone is applied in this project. Figure 6 shows the Dolphin Ear DE2000 Series Hydrophone and their specification as shown in Table 1.0.
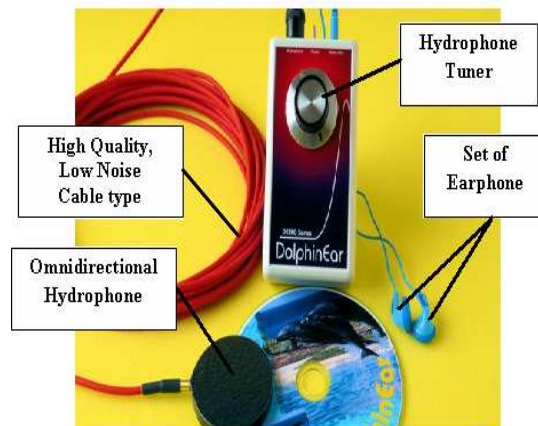

Figure 6: Dolphin Ear DE2000 Series Hydrophone

TABLE 1.

SPECIFICATION OF DOLPHIN EAR DE 2000 HYDROPHONE

Element	Description
Hydrophone Transducer Type	MPC (Piezo)
Configuration	OmniDirectiona
Hydrophone Packaging	Rugged epoxy case, (approx. 60mm Diameter x 8 mm Thick)
Cable Type	High Quality, Low Noise, Neoprene/PVC jacketed for long life
Cable Length	Standard: 8, 16, 24, 32 metres, optional: lengths to 100 metres.
Preamp	Supplied with Line/Earphone Output
Audio Output	MONO. Adjustable Level ~ approx. 50 mW
Output Connector	3.5mm (1/8") stereo jack
Earphones	Samarium Cobolt in-ear type ('walkman-style')
Power	Approximation 7 mA at 9V
Battery	Standard 9V (PP3) transistor radio battery

C- Sonar system

Ultrasonic is sound with frequencies above 20 kHz. Since the sensor that use in this project is at 40 kHz, they are definitely ultrasonic and not audible [11]. Before start the project, it necessary to know the basic of the operation the hardware or the software. The main hardware that needed in this project is ultrasonic sensor while the software that need is this project is mikroC function as a compiler. Basically, the microcontroller tells the ultrasonic sensor to go. Then, ultrasonic sensor emits a mostly inaudible sound; time passes, and then detects the return echo [12],[13]. It then immediately send a voltage signal to the microcontroller, which by keeping track of the time that passes and calculate the distance of the objects detected. Figure 7 shows the connection of the hardware that involved in this project development.
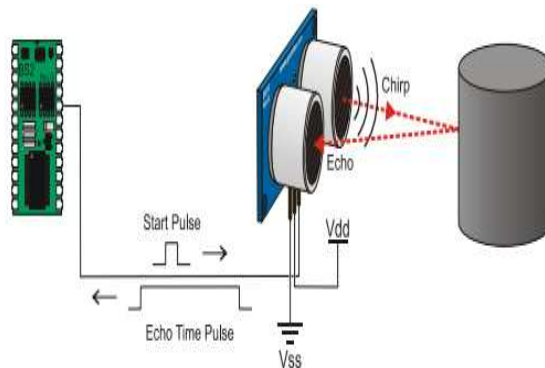

Figure 7: The connection of the hardware

IV. RESULT

The image that had been captured will be ranting based on the image description of the image. Table 2 shows the image rating and description that need to be considered in order to rating an image [14].

TABLE 2.
RATING OF IMAGE

Rating		Description
Excellent	10	An image extremely high quality, as good as could be desire.
Fine	8	An image of high quality, providing enjoyable viewing.
Passable	6	Image is acceptable a quality image.
Marginal	5	Image is poor in quality
Inferior	3	Very poor quality of an image but still could watch it.
Unusable	1	An image so bad and could not be predictable.

The testing is being done in three different conditions of water which are in the clear water, mix-up water with detergent as well with the sludge water. Different conditions or type of water environment are selected because different environment might yield different result for determining the appropriate distance for producing clearer underwater images as shown in Figure 8.
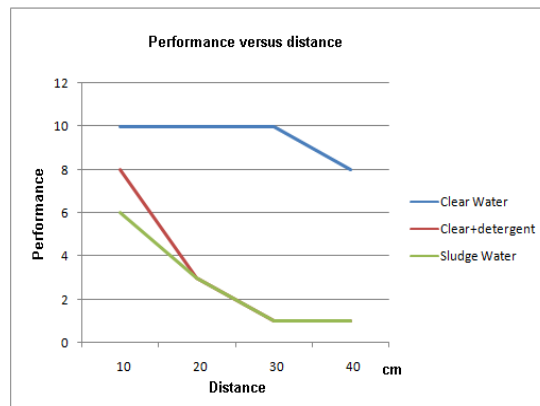

Figure 8: Performance versus distance for three different types of water.

Figure 9 shows the hydrophone system for AUV which are hydrophone and monitoring. The sound signals will be obtain by placing the Omni directional hydrophone into underwater [15],[16]. After that, the sound signals are recorded by voice recorder and save the digital recording into hard disk of laptop or computer. Then, the sound signal is analyzed by using Spectrogram software. After that, the system is applied to the Autonomous Underwater Vehicle as shown in Figure 10.

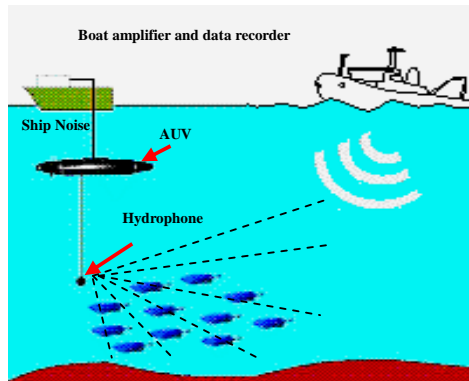Figure 9: Hydrophone System for AUV

Figure 10: Applying the Hydrophone System to AUV

The hydrophone system is tested and applied in order to make sure there is in good condition. Therefore, the hydrophone system is tested in Rumah Akuarium, Taman Botanikal, Air Keroh Melaka. The underwater species are *Puyu, Lampam Sungai, Krai*, Silver Dollar, *Kelah*, Baro Brad Oscar, *Sebarau*, Tortoise, Tiger Borb, *Kala*i, and *Patin*. Figure 11 shows the Spectrogram of Tortoise.
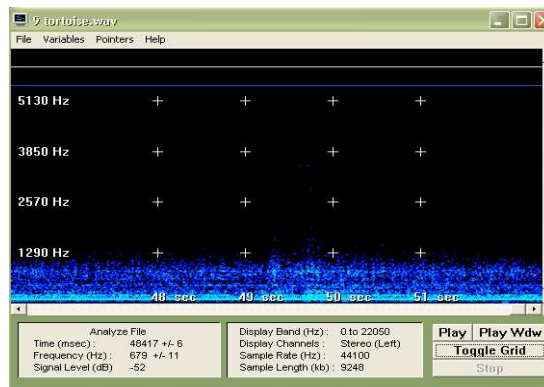

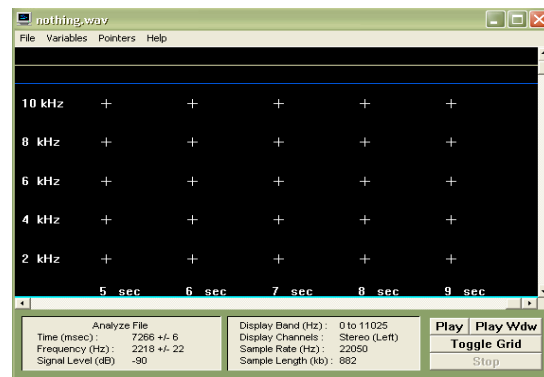Figure 11:   Spectrogram of Tortoise

Figure 12:   Spectrogram for Passive Area

Figure 12 shows the spectrogram for an underwater in passive condition. After that, data will be use to provide the sampling rate of underwater species in details.

Figure 13 shows the PING Ultrasonic Sensor Distance circuit. The PING sensor has a male 3-pin header that function used to supply ground, power and signal. The header may be plugged into a directly into solderless breadboard, or into a standard 3-wire extension cable [17]. Refer to the Figure 14 shows the pin definition of PING ultrasonic distance sensor circuit. Table 3 refers the pin definitions of the circuit.
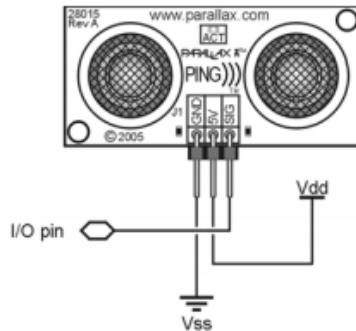
Figure 13: PING Ultrasonic Sensor Distance

Figure 14: Pin Definition of PING Ultrasonic Distance

TABLE 3.
PIN DEFINITIONS

GND	Ground (Vss)
5V	5 VDC (Vdd)
SIG	Signal (I/O pin)

A. Developed a Controller Board and Ultrasonic Distance Circuit

Based on the project, the controller board for PIC16F877A is developed. The board is divided into 2 sections which are; the burner section and the controller section. All the distance that detected by the ultrasonic sensor will be displayed on the 2x16 LCD that already attached to the microcontroller board. The size of this board is about; 10cm X 30 cm. Figure 15 shows the circuit of controller board.

Burner   LCD

Figure 15: Circuit of controller board.

Then, the microcontroller part will be combined with the ultrasonic distance sensor circuit. The ultrasonic sensor will be replaced with the proowave ultrasonic TXR sensor. Figure 16 shows the proowave ultrasonic TXR sensor.
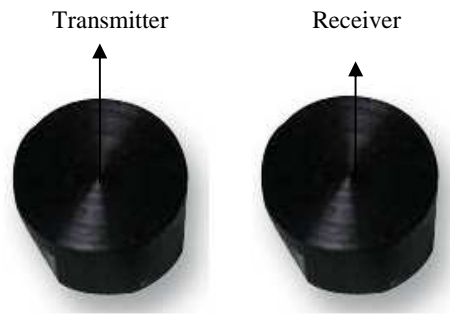
197

Figure 16: Proowave Ultrasonic TXR

V. CONCLUSION

New design of vision system with the implementation of the wireless camera as the vision system is successfully. It has found that this new design of vision system had improved slightly of the quality of the submarine image that being captured. However, there are still the limitation regarding to capturing underwater images due to a difference density between marine environment and ground environment.

The hydrophone tested in excellent condition, so it proven by developed the hydrophone system. The hydrophone system is including of process to record the underwater sound. Then, the underwater sound is simulated into sampling rate frequency to produce the data bank of underwater sound in Malaysia. It also can be used for testing and learning conventional and advanced control algorithms and techniques to other underwater systems.

With a limited budget a small autonomous underwater vehicle has been developed. The mechanical structure is produced. Future development and improvement with show that this compared to other AUV projects, smaller and cheaper concept will succeed.

ACKNOWLEDGEMENTS

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