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Enhancement Embedded System for Control and Monitoring design Underwater Robot

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***Abstract*— An underwater robot is individually designed for a specific task such as ocean mapping, geothermal under ocean, tracking pipe line and monitoring environments. This article presents an enhancement embedded system for control and monitoring design underwater robot which it can be the another choice to design the underwater robot . The electronic circuits are design and interface with many sensors for control and measure the water environment such as oxygen sensor. The major controller is PIC16F877A and PIC18F443 and combines with multiple sensors. The antenna video wireless is applied as the vision controller which used frequency 2.4 GHz to transmit and receive video data. The experiment results show that it can transfer the video of underwater environment and monitoring the oxygen and temperature of water as design. Also the embedded system is more convenient. It can further develop and make it to the large scale.**

Keywords—underwater robot, embedded system, monitoring environemnt

I. Introduction

Embedded systems, which design in wire and wireless system, are recently applied to process control system and monitoring system. In this article, the embedded system is focused to design a controller and monitoring system for the underwater robot. The major task of the underwater robot can be classified in two categories: 1) how vehicle can make a vision in the underwater environment 2) how vehicle can transmit data to control room.

An underwater robot is individually designed for a specific task such as ocean mapping, geothermal under ocean, tracking pipe line and monitoring environments. There is some research work which designed an underwater robot for those tasks. In [1] presents the experiments with underwater robot localization and tracking. The sensor nodes and the robot are deployed manually from a boat. The results show that it is able to self-calibrate the location of its static nodes, and then provides location information to the underwater robot. The localization is better than 2.5 m and comparable with GPS. In [2] introduces a designing embedded fish sensor for underwater robot. Its sensory system is designed by using modified ping ultrasound sensor MAX sonar EZ-1 which is widely used in mobile robot as proximity sensor working at frequency of 42 KHz. Also the Embedded Artificial Neural Network (EANN) is an artificial neural network algorithm that is specially designed to meet the requirement that it must be downloadable object into microcontroller. The experiment results have shown that the success rates are 100% for detection and 94% for classification of two types of fish. In [3] presents a design and control of autonomous underwater robots: A survey. It states that the advanced development in navigation sensors is necessary for more reliable and accurate performance required by many potential applications. Also the autonomous underwater vehicles (AUVs) need robotic manipulators with low power consumption and low noise operation. In [4] presents a localization of an underwater robot with inertial sensor fusion models. An underwater robot comprises of a DSP-based embedded system, accelerometer, gyroscope and underwater ultrasound sensors are also designed for verification of the models proposed. Experiment results show the presented approach could help to localize underwater robot with localization errors within centimeters. In [5] presents a robot control using an underwater acoustic modem. It develops an underwater modem suitable for underwater robot control and designed a protocol to handle the robot. It has also verified the robot control system by experimenting in an underwater environment. In [6] presents a development of stereo vision measurement architecture for an underwater robot. The system is capable to detect an object and measure the distance between the object and the cameras. The platform uses two CMOS cameras, a development board with a low-cost FPGA, and a display for visualizing images. Each camera provides a pixel-clock, which are used to synchronize the processing architectures inside the FPGA. Each camera hardware architecture has been implemented for detecting objects, using a background subtraction algorithm. These synthesis and the operation results have shown that the implemented system is useful to real-time distance measurements achieving a good precision and an adequate throughput, being suitable for real-time critical operation. In [7] presents an embedded vision system for robotic fish navigation. It uses an ARM9-center microcontroller in conjunction with CMOS camera for image acquisition. Meanwhile, a wireless interactive control console is devised, facilitating two-way information transfer. It can access the environmental information captured by the robotic fish in real time and display the obtained results in a visual format online.

As those researches have been developed underwater robot based on the embedded system, however, there is a problem about controller system and data transmission which required real-time operation. In this article introduces an enhancement embedded system for control and monitoring design underwater robot which can be adapted to use with underwater system.

II. Proposed design

The embedded system, which used for control underwater robot, can be applied into three areas:

A. *Direction and Controller*

Major facts that make it difficult to control underwater robots include: the highly nonlinear, time-varying dynamic behavior of the robot; uncertainties in hydrodynamic coefficients; the higher order and redundant structure when the manipulator is attached; disturbances by ocean currents; and changes in the centers of the gravity and buoyancy due to the manipulator motion which also disturbs the robot's main body. It is difficult to fine-tune the control gains in air or during operation in water. Therefore, it is highly desirable to have a robot control system that has a self-tuning ability when the control performance degrades during operation due to changes in the dynamics of the robot and its environment.

The PIC16F877A and PIC18F443 are used as controller to control direction. The motor drive circuit is also designed and used to drive motor. It connected to the microcontroller with 3 cables: 1) Pulse Width Modulation (PWM) cable is used to excite motor signal 2) Direct cable is used to define the direction of motor and 3) Ground cable of circuit. Moreover, RF-module 433 MHz is used to transmit and receive data which connected with RS232 port.

Fig 1 the wireless controller

B. *Vision Controller*

The most common approach for remotely operated underwater vehicle (ROV) communications uses an umbilical line with coaxial cables or fiber optics. This tether supplies duplex communications. While coaxial cables would be effective for simple operations with limited data transmission, fiber optic cables can transmit more data with less electromagnetic interference and are lighter, thinner cables. This is important since cables cause substantial drag and often become snagged. About ten percent of ROVs are lost because of broken tethers

Research and development of untethered autonomous vehicles is needed but communicating with AUVs presents formidable challenges. The main approach today for through-water transmission involves acoustics in which transducers convert electrical energy into sound waves. Since the ocean rapidly weakens the acoustic energy as the frequency is increased, relatively low frequencies are desirable for longer range communications. But at very low frequencies, the required transducer size is impractically large and the data rates are lower. The speed and direction of sound signals vary depending on surface waves, temperature, tides, and currents.

The antenna video wireless is applied as the vision controller which used frequency 2.4 GHz to transmit and receive video data. It connected with the radio corporation of America port (RCA).

Fig 2 the image wireless transmitter and receiver

C. *Environment Monitoring*

The sensory system is one of the major limitations in developing vehicle autonomy. The vehicle's sensors can be divided into three groups: (1) navigation sensor, for sensing the motion of the vehicle; (2) mission sensor, for sensing the operating environment; and (3) system sensors, for vehicle diagnostics. Multiple sensors are often needed for the same task. For instance, information concerning the objects and local terrain surrounding the vehicle can be gathered via a combination of sonar imaging, laser triangulation and optical imaging. Sonar can provide most of the obstacle avoidance information. Video images plus specialized machine vision algorithms can provide high-resolution information concerning the shape and range of near objects and terrain [3].

The dissolved oxygen sensor is used to measure the oxygen in the water. It is a galvanic probe which includes two electric poles.

Fig 3 the oxygen sensor

The oxygen value can be measure in the range of 8-15 mV. This is a very small value which is difficult to report. Therefore it requires an instrument amplifier to amplify these values. In this work, the 180 times amplifier is designed and used as instrument amplifier.

D. *Power System*

While the ROVs can be powered by the mother ship, operating hours of untethered robots are limited by the on board power system. Most power systems for current AUVs rely on batteries that supply limited energy. A typical battery type of lead-acid is used in this experiments.

III. Experiment setup and Implementation

In the implementation, the underwater robot is designed in both parts: hardware and software. For the software part, it follows the diagram in Fig 4.

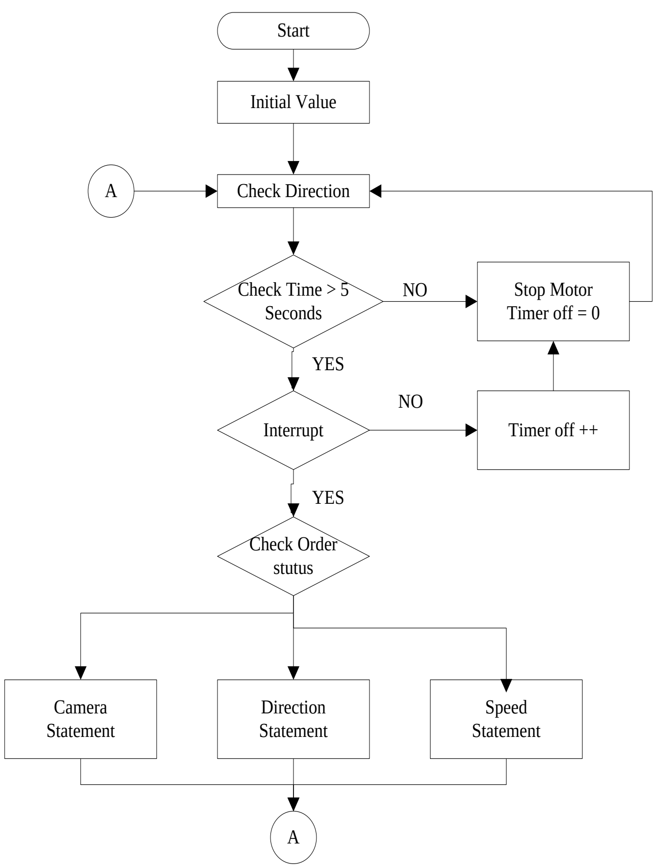

Fig 4

In the hardware part, the electronic circuits are design and interface with sensors such as oxygen sensor. This circuit require a major controller which PIC16F877A and PIC18F443 are used. Also the driving motor boards are design and connect to the microcontroller as shown in Fig 5.

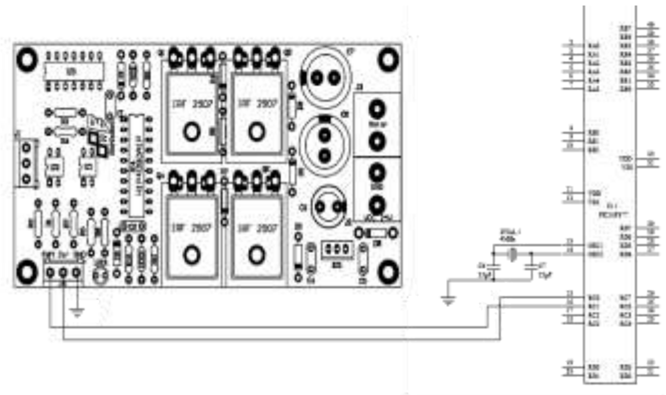

Fig 5 Driving motor broad connected to microcontroller

Those components, which introduces in section II, are used to develop as a underwater robot which is shown in Fig 6

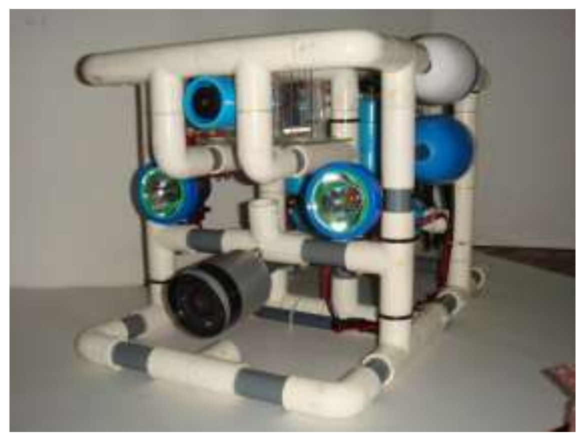

Fig 6 the

IV. Results and Discussion

The experiment results show that the underwater robot can be controlled as design. It can move and dive into the deep water which is designed to dive in the range of 5 meters deep. It can also show the status of camera, lamp and sensor as shown in Fig 7. Moreover, the oxygen level and temperature of water is measured as well.

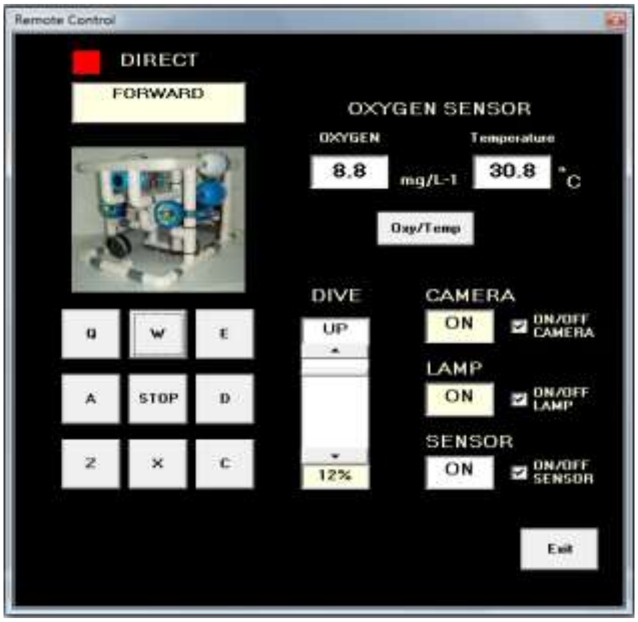

Fig 7 Display and monitoring system

Fig 8 the exam of image of underwater

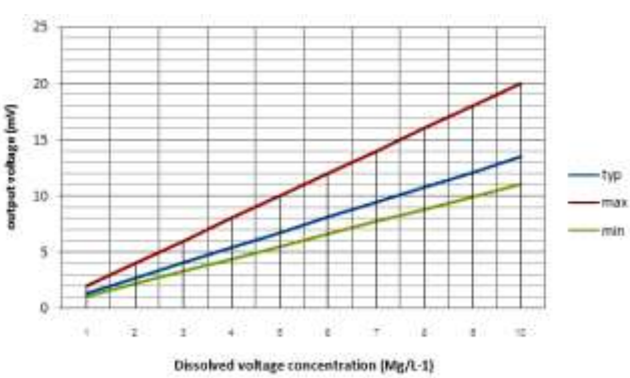

Fig 9 Comparison Oxygen value with voltage output

V. Summary

This article presents an enhancement embedded system for control and monitoring design underwater robot which can be adapted to use with underwater system. The PIC16F877A and PIC18F443 are used as the controller of embedded system. Many sensors are also employed for this experiment specially the oxygen sensor. It notices that the oxygen sensor which provides the voltage output is very useful for monitoring the water environment as show in Fig 9. In the further work, it can be focus to design the stereo camera system, which it can transfer more information of underwater environment.

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