Design and Development of a Robotic Platform for Environmental Monitoring: A Preliminary Study

Mohd Rizal Arshad
School of Electrical and Electronic Engineering,
Engineering Campus, Universiti Sains Malaysia,
14300 Nibong Tebal, Penang
rizal@eng.usm.my

ABSTRACT

Environmental monitoring of rivers, lakes, and other ecosystems has become a major economic, social, and academic concern. This is in large part due to the damaging effects of industrial pollution and over-use by population growth and suburban sprawl. New and novel methods have been implemented to monitor environmental parameters which ultimately indicate how affected is the surrounding area. Underwater robotics now plays an important role in the monitoring of ecosystems, due to advantages of low-cost, safety, and convenience. This paper presents the design and development of a portable robotic platform for underwater inspection and monitoring application. The system consists of a robotic platform, a vision module, controller module and sensor attachment extension or slots. The system is used to monitor or track changes in the environmental parameter targeted for very specific application. A manipulator is also available for sample gathering a[illegible]er gripping or object-manipulation application. The system is equipped with visual and non-visual data acquisition set-up and is versatile to be used for various other applications. This paper is about the design and development of a mobile robotic platform for environmental monitoring, specifically for underwater application.

Keywords
Robotic System, Environmental monitoring, Intelligent Sensor

INTRODUCTION

Environmental monitoring is a very important tool to indicate or measure the condition of our environmental parameters. Intelligent sensors are used coupled with the inspection platform to assist in the inspection process or steps. Mobile underwater robotic platform can play this role effectively. Specific system can be designed for very specific application for enhance accuracy and reliability. Environmental monitoring system in a portable module platform has a very wide range of application in early disaster detection, emergency planning strategy, and over-" environmental monitoring. Various parameter can be [illegible]ured, be it mechanical, electrical or for chemical based properties. Relevant sensors and instrumentation can easily be attached to a portable platform which can be controlled remotely or following a programmed path of motion. Environmental parameters are the symptoms or indication of stable or worsening condition. Pre-emptive measures can be taken to reduce the impact of large-scale breakdowns or impending disaster. A portable inspection system mainly based on visual acquired data can assist managers or engineers to make decision at the earliest stage possible, once the problems are identified.

Overall vehicle design

The design of the underwater inspection system consists of the hardware and software component. The hardware aspect includes the vehicle structure, actuator selection, controller parameters and sensor integration. While the software part is mainly about the integration and control operation of the hardware set-up.

Vehicle Structure

Instead of a traditional submarine hull, the robot is built around a stainless steel open frame to which any subsystems, sensors, actuators, and controller boxes can be easily clamped and attached (as shown in fig.1)

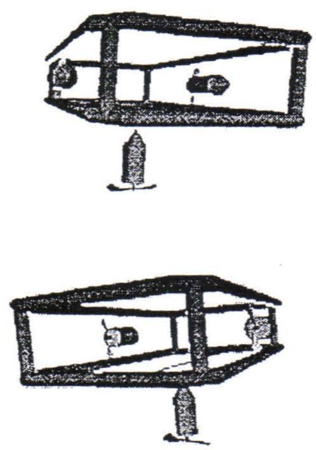

Figure 1: Modular design of the frame

Fig.1 shows two views of a computer simulation of the robot frame with its three motors. All subsystems or modules can be easily attached, removed, or repositioned as needed to satisfy different task requirements and missions. Buoyancy is also readily adjustable by attaching floatation devices or weights as needed to the frame. The modular design offers an additional advantage. It facilitates transportation of the platform by separation of all major components and re-assembly on-site.

Controller Set-up

The controller system for the robot is mainly using two Micro-controller modules which are connected together in during system operation. The control algorithm for every aspect of the platform was pre-programmed in the micro-controller processor. Figure.2 shows the overview of the vehicle architecture.

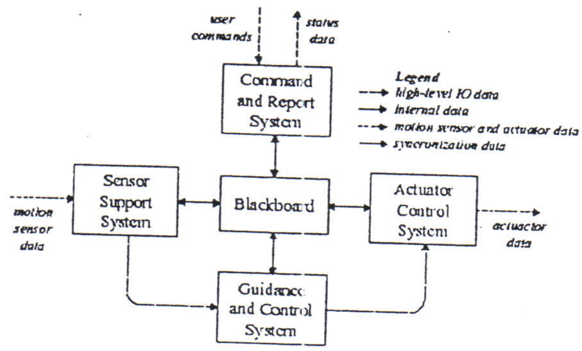

Figure 2: Overview of the Vehicle Control Architecture

The Blackboard at the centre of the controller block is the main controller device, where the control algorithm is installed. The robotic platform can be set to semi-autonomous operation of direct control command mechanism. This will depends on the type of application chosen. Figure.3 shows a block diagram of a fuzzy control mechanism for intelligent control algorithm with sensor and user input integration.

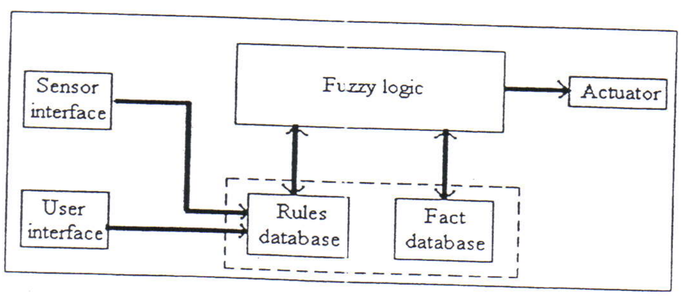

Figure 3: Fuzzy Control Set-Up

Vision system Set-up

Vision is an important feedback tool for a robotic system. It is needed for location determination and identification of objects or external scene. Images captured by the camera will be a processed by the processor. It provides current real-time status of the surrounding area and also can act as servoing control method for the vehicle. Figure.4 shows an example of a vision set-up or the vision system for image acquisition and visual servoing for the robotic platform. The system shown uses stereographic input images.

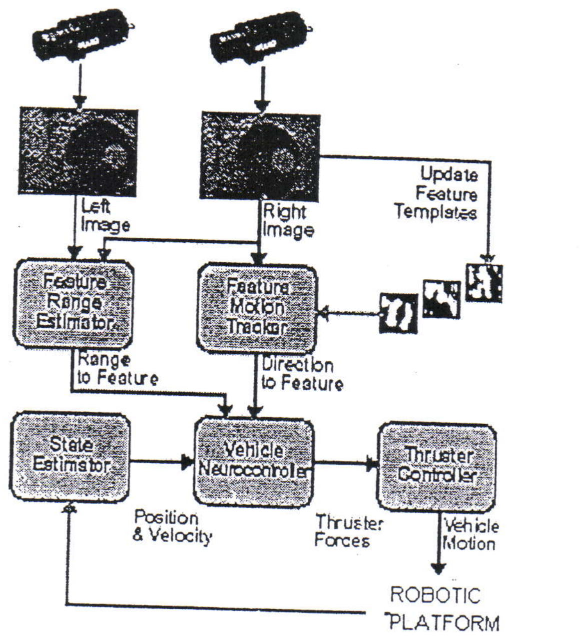

Figure 4: Vision System for Robotic Platform

Other types of sensors are also utilized for proper operation of the robot. Depth, direction and leakage are some of the parameters need to be considered.

Software Set-up

Modular software approach are utilised in this project in order for every sub-system to be designed and assembled independently and later integrated together. Although this approach pose some problems, it is useful so as to ensure all the sub-system will function as expected.

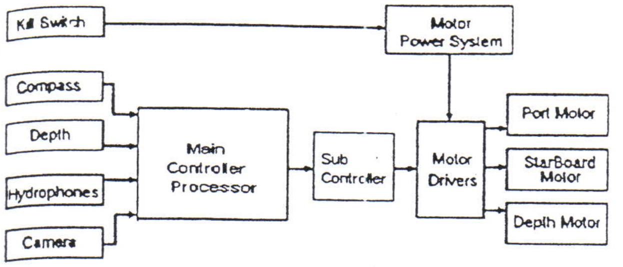

Figure 5: Software Connection for the Robotic Platform

The software used for programming the micro-controller is the main software utilised throughout the system. With it, all the peripheral hardware, i.e. sensors and motors, are configured and controlled. Figure 5 shows the software connection used in the system control.

EXPERIMENTAL SET-UP

Experiments were conducted in two condition, control and actual inspection condition. The prototype robotic platform (see figure 6) with its actuator and sub-system attached was tested for its control reliability and overall system performance, e.g. navigation and stability. The tests were conducted in lab tank and in actual site test. No actual environmental sensing transducer was attached to the robot during the tests because the aim of this stage is to come out with the optimum design only.

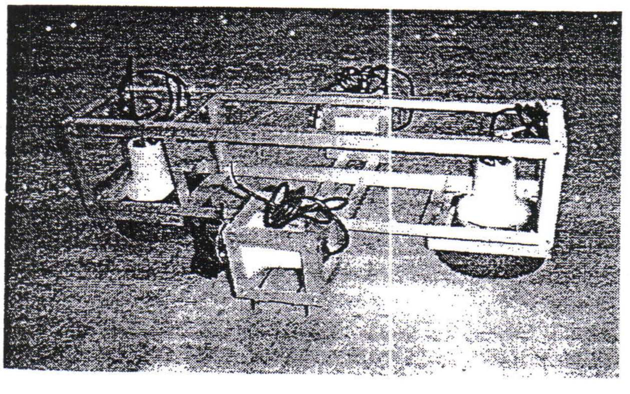

Figure 6: The Prototype Robotic Platform (Frame Only)

RESULTS AND DISCUSSION

Since this is a preliminary study in the design of the underwater robotic platform, no specific data or parameter were measured. Visual performance (mainly depth and motion control) and reliability inspection of each sub-system was observed, instead. From the tests it was found that the issue of stability is very important. The near-neutral buoyancy of the vehicle is important for stable image acquisition. The arrangement of the actuator or motor for propulsion affected the stability during robot movement. Adaptive and fast control algorithms are also required for a better response time and overall control of the vehicle. Size and the quantity of sensors to be attached to the platform must not compromise this aspect of the platform. The attached platform sensors can also be used to complement the data gathered using the specific environmental parameter sensors or transducers. For the power requirement, it is not a major issue, since the platform is a tethered-type. Unless autonomous operation is required, then the power consumption and supply duration need to be properly considered. Another aspect is the portability issue, which may affect the practicality of the system as an environmental parameter monitoring tools.

CONCLUSIONS

In this preliminary study, valuable understanding and approach have been gain. Specifically in the design and development of a suitable underwater robotic platform for environmental monitoring. The design must be robust, reliable and portable, and has enough compartments for sensors to be attached. The control software must also be flexible and open for integration with attached devices while maintaining proper control of the specific task given.

ACKNOWLEDGEMENT

The author would like to thank Yayasan FELDA and Universiti Sains Malaysia(USM) for financial and logistic support.

REFERENCES

1. D. Yoerger, J-J. Slotine, "Robust Trajectory Control of Underwater Vehicles," IEEE Journal of Oceanic Engineering, vol.OE-10, no. 4, pp.462-470, October1985.
2. R. Cristi, F. Papoulias, A. Healey, "Adaptive Sliding Mode Control of Autonomous Underwater Vehicles in the Dive Plane," IEEE Journal of Oceanic Engineering, vol. 15, no. 3, pp. 152-159, July 1990.
3. J. Lorentz, J. Yuh, "A survey and experimental study of neural network AUV control," IEEE Symposium on Autonomous Underwater Vehicle Technology, Monterey, USA, pp 109-116, June 1996.
4. S. Hutchinson, G. Hager, P. Corke, "A Tutorial on Visual Servo Control," IEEE International Conference on Robotics and Automation, Tutorial, Minneapolis, USA, May 1996.
5. K. Nishihara, "Practical Real-Time Imaging Stereo Matcher", Optical Engineering, vol. 23, pp. 536-545, 1984.
6. T.Fossen,"Underwater Vehicle Dynamics," *Underwater Robotic Vehicles: Design and Control*, J. Yuh (Editor), TSI Press, pp.15-40, 1995.

7. K. Goheen, "Techniques for URV Modeling," *Underwater Robotic Vehicles: Design and Control*, J. Yuh (Ed), TSI Press, pp.99-126, 1995.

8. J.L.Fuller, "Robotics: Introduction, Programming and Projects", 2nd Edition. Prentice Hall, 1999.

9. J. Yuh, "A Neural Net Controller for Underwater Robotic Vehicles," IEEE Journal of Oceanic Engineering, vol. 15, no. 3, pp.161-166, 1990.Engineering, vol. 15, no. 3, pp.161-166, 1990.