

Design of Underwater Robot

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ABSTRACT: One-third of our world is covered by oceans, where exist a numerous things to be explored, which creates a greater necessity for a specialized research platform in underwater. Designing such a platform is not an easy task. Constraints such as waterproof shielding, weight, buoyancy design and control mechanism of the platform should be considered. This paper describes a low cost manta ray shaped small underwater robot controlled via remote using wireless communication is designed. The remote uses motion control parameters to control the robot in wireless to overcome the problems in wired communication. For wireless communication in underwater, the frequency range should be selected suitably to provide effective communication. The robot is made waterproof by plastic shielding and can be able to navigate in cardinal direction with obstacle avoidance. Thus an underwater research platform is designed and experimented in shallow water. Finally the evaluation experiments are presented to verify the basic motions of a prototype robot. The experimental results demonstrates that the motion characteristics of this type of robot are acceptable, and the design is worthy of further research.

KEYWORDS: Mobile robots, Propulsion system, Robot kinematics, Underwater vehicles, Wireless motion controls.

I.INTRODUCTION

A robot is an automatic mechanical device. It can also work in harsh environments. Various kinds of robots have been developed parallel with the progress of computer and information processing technology. There exists a great need for these robots in challenging cases especially underwater. Applications of underwater robots and vehicles have increased dramatically in recent years. Though most of the underwater robots and vehicles are developed for scientific underwater exploratory purpose, there also commercial and military application. For instance submarine accidents and investigations are performed with the help of these, the Gas and Oil industry uses underwater robots for laying pipelines etc. To perform underwater robotic research, an appropriate platform is required. First of all it must be watertight. Even a single unit of water can stop the whole system from operating. So it must be shielded completely to prevent the entry of water. Next the weight of the platform is important. Too heavy, the platform will sink into depths and never to be seen again. Too light it will be hard to sink. Hence design of the outer chassis must be made carefully. The shape and size of the outer chassis plays a major role. It may be a torpedo Shaped or spherical shaped^[7]. Some are biomimetic underwater robots which imitates the behavior of aquatic organisms^[8]. This project proposes a solution for the above problem in an efficient manner.

II. SYSTEM DESIGN

Outer Chassis

The proposed system has two shielding in which the components which are readily affected by water like processor, 434MHZ RF transceiver module, batteries are placed within the inner shielding and the propellers are exposed to water are placed in the outer shielding.

This outer chassis is made to be in the dimension of 12cm breadth and 20cm in length. It should be as small as possible to be demonstrated in a fish tank.



Figure 1: Robot structure overview

The overall design of robot along with its components and connections are shown in Fig 1.

Inner chassis

The difference in inside shielding and the outer one will be 5cm and also in center of the inner body all the electronic components should be added to have heavy weight in the center to sink inside the water easily. This part should be designed carefully to avoid even a single drop of water as the electronic components are prone to problems caused by water. These shielding are usually made by waterproof plastic sheets such as HDPE (high density polyethylene), Acrylic sheets, moulded plastics etc.

III. SPECIFICATION

Structure	Specification
Motors	Servo motor-1 Dc motor-2
Communication	434 MHZ RF transmitter and Receiver module
Power supply	12v 1amps transformer
Processor	Arduino nano v 3.0
Others	Motor driver IC L293D -2 Bridge rectifier, plastic shielding.

Table 1: Specification of robot

The entire robot model was shown in figure 1. In table 1 the specification of our robot is described.

III. COMPONENT DESCRIPTION

Motors

The proposed model consists of 3 motors out of which 2 motors are dc motors with low torque value and another one is a servomotor placed in rear and center positions respectively. The servomotor placed in the center position provides upward movement for the robot. Upward movement is normally provided by means of gravity. Hence to oppose the gravity inside the water upward motion should be highly accelerated. It works on the concept of pulse width where as long as the pulse remains high the motor retain in its original position. Servomotors are often used for their high degree of operation in robotic application.

Dc motors are placed in rear position of the robot model. These motors are responsible for left, right, forward and backward motion. Due to its wide application in marine areas and advantageous characteristics of controlling speed and compact sizes dc motor is preferred.

RF transmitter receiver module

The most existing approach to communicate underwater in ROV (remote operated vehicle) and AUV (autonomous unmanned vehicle) is wired communication by umbilical line with coaxial cable which purely depends on tethering for communication. It is effective only for limited data rate but mostly ROV's about 10% becomes fail due to broken tethering and another disadvantage is tethering needs an operating base which may cost in lacks.

Hence we are going for wireless communication. The basic modes are electromagnetic, optical and acoustic communication. Acoustic communication use very low frequency which provides only low data rate. In optical communication, the devices are expensive and in addition to that if the data rates are increased, the power consumption is also rises. Under time and energy constraints to optimize the performance, the robots need to properly allocate its available resources based on the quality of channel which can be done by using RF range.

Underwater communication depends also on air-water boundary where EMF waves are best choice. Therefore electromagnetic waves are preferred which offers various frequency bands and a large range of data rates. In RF band the low frequency standard is 434MHZ RF Transmitter Receiver module.



Figure 2 Transmitter receiver modules

The 433 MHz RF transmitter receiver modules are shown in fig 3.

Features	Specification
Coverage range	500 ft
Modulation	ASK modulation
Data rate	8kbps
Supply voltage	3-12v
No. of channels	4

Table 2: Specification of RF 433MHZ Transmitter receiver module

Processor

Usually in the receiver side the microcontrollers are used which are capable of receiving the signal from transmitter side and recognize the command using motion controlled parameters and indicate the motor to perform the required action which makes the appropriate action performed by propeller.

In order to compact the size we are in need for another technology. To overcome this problem there involved a new technology Arduino nano. It is small compact and breadboard based on the Atmega 328. It can operate at 5v power supply with 14 I/O and analog input pins. It also drives only small current of 40mA. Another advantage of using Arduino Nano is it can communicate with computer or other devices or other microcontrollers.

It provides a serial communication with digital pins for receive and for transmit. The transmitter and receiver LED'S on board will flash when data is being transmitted and when board is connected to a system via USB. This processor is preset with Arduino IDE software for the require commands from remote control via transmitter. The typical Arduino processor with Atmega 328 and USB power supply is shown below.

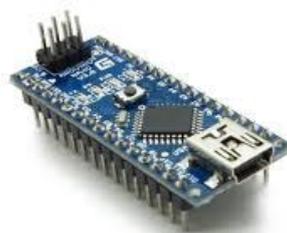


Fig 3: Arduino processor

V. COMMUNICATION

Transmitter side

For transmission and reception in RF band there are lot of devices available. Here, the available low frequency RF module of 434MHZ is used. This allows peer to peer communication with multi channel facility. In transmitter side there are five switches that can be used to control the movement on the receiver side is connected with the transmitter control IC. This TX-2B IC encodes the output state of the switch into a unique data logic for each switches. These data logic bits are given to the data pin of the transmitter, which transform it to an analog signal. This is connected to the wired antenna and which helps to transmit these signals. The basic 434MHZ RF transmitter is shown



Fig 4: RF Transmitter

Receiver side

The Receiver with the same frequency of 434MHz is used at the receiver side. It receives and converts the analog signal into digital bits. These bits are given to the Receiver controller IC which decodes the received signal into the corresponding data logic bits. These informations are given as inputs to the Arduino processor. The Arduino processor is preprogrammed to analyze the received bits from Receiver and transmit control parameters to motors which rotate the corresponding propellers. The 434 RF Receiver is shown.



Fig 5: RF Receiver

The RF transmitter and Receiver boards along with the 433mhz RF modules are shown in the Fig 4 and 5.

VI. SYSTEM ARCHITECTURE

Here the system architecture consists of 2 section hardware and software. Software section consists of electronic interfaces, processors. This is the collection of computer processes the set of robotic task that the system is nominally able to perform. Here the motor driver circuit and the motors works with the control signal set by the Arduino nano processor depending on the received signal sent by the transmitter and pre-programmed conditions in processor using Arduino IDE software.

Hardware architecture is the technological target into which the above mentioned software will be uploaded. This section includes the four switch operated remote control. 434MHz RF transmitter receiver module motor driver control circuit, motors and propellers.

System architecture should be designed in such a way that it has to ensure guarantee in system performance, economical and low energy consumption.

VII. CONTROL CIRCUITRY

In order to provide the appropriate navigation by the robot according to the signal given by the remote control and to avoid the errors, a circuit must be provided to control the functioning of motors and propellers.

This task is implemented by the control circuitry which consists of motor driver circuit, motors and three propellers.

Motor driver circuit consists of a motor driver IC L293D which is a 16 pin IC and capable of driving two DC motors simultaneously in any direction. It works on the concept of H-bridge which is a circuit allows voltage to be flow in either direction. A single L293D IC consists of two H-Bridge circuit which is capable of rotating two DC motors independently depending on the function of IC Pins.

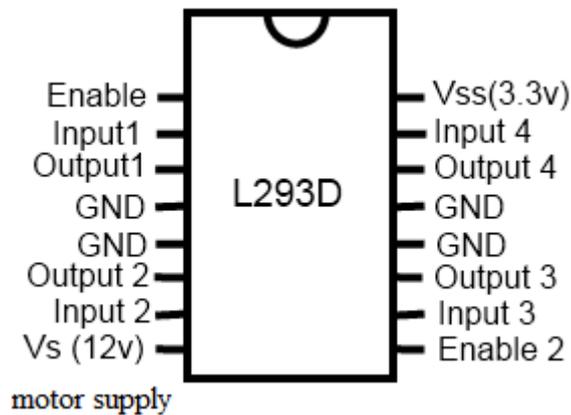


Fig 3: Pin diagram

The pin diagram of the above mentioned IC L293D is shown.

For the left motor to drive pin 1 has to be high. For the right motor to drive pin 9 has to be high.

The digital input for the corresponding movement from remote control is as follows.

Command	Digital input	Result
1	0000	Start/stop
2	0010	Upward
3	0100	Forward
4	0110	Backward
5	1000	Left
6	1010	Right

TABLE 3: COMMAND SET

When a command 2 is given the center servomotor starts rotate and pull the robot in upward direction. When command 3 is given the DC motor 1 and 2 starts rotating in clockwise direction and the robot starts moving in the forward direction .when command 3 is given the DC motor 1&2 starts rotating in anticlockwise direction which makes robot moves backward. When command 5 is given servomotor and DC motor 1 goes to off condition. DC motor 2 rotates in anticlockwise direction and robot moves to left. When command 6 is given servomotor and DC motor 2 goes to off condition. DC motor 1 rotates in clockwise direction and robot moves to right.

Propeller connected to each motor makes a movement depending on the motor movement.

VIII. MISSION STRATEGY

Underwater robots are deployed with different required degree of autonomy. But even simple missions contain different tasks to be sequentially executed. The concatenation of these different tasks is called mission control system. Important function of this is man/machine interface. It deals with monitoring of mission, programming, communication media and results. This mission control aggregates low level robotic tasks into mid-level robotic behaviors.

A .Point stability

The goal is to stabilize the vehicle at a given point, with a given orientation despite external disturbances. It is here done with the help of the control signals from the remote control and the working of the motors fixed at the center and the rear positions.

B. Manipulating

Manipulating is nothing but handling. Say communication link which is executed with the help of 434MHZ RF transceiver module, where buffer is placed on both sides of transmitter and receiver collect the signal from the remote control and implement with control circuitry respectively.

IX. CONCLUSION

The final research platform has three propellers with two for forward, backward, right and left and the other propeller for upward motion. This system is designed to operate on remote controls from the transmitter side remote model. It can also be controlled by tethering or by optical communication.

X. FUTURE WORK

This paper can be further extended in future by installing cameras and sensors for collecting information within the robot so that monitoring can also be done which is more advantageous. It can be applied in the fields like Defense, Homeland security, Ship wreck investigations, Ocean mining, Navigation, Ocean temperature monitoring, which can be used at the time of flight crash, submarine accidents.

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International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization,

Volume 4, Special Issue 4, April 2015

National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2015)

On 20th & 21st March

Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

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