International Journal of Automation, Mechatronics & Robotics– IJAMR
Volume 1 : Issue 2 [ISSN 2374 – 1546]
Publication Date : 25 June 2014

The Modelling of an Autonomous Triple Mode Vehicle

G V Sai Yeswanth, Sakshi Singh, Akash Kannegulla, R Karthikeyan

Abstract— **This paper presents the modelling of a novel autonomous Triple Mode Vehicle. The presented design satisfies the dimensional and material constraints for a vehicle which can maneuver on land, water and underwater. This autonomous vehicle can be used for surveillance with the help of RADAR and its location can be tracked using Global Positioning System. Using RADAR we present the resulting amplitude variation with the distance of object from the source.**

Keywords— **Triple Mode Vehicle, RADAR, Navigation.**

I. Introduction

In the recent years, Robotics has been a technological revolution. Many techniques have been implemented which have contributed to the development of underwater Robotics [1] [2]. The varied applications of underwater robotics encourage further work in this area.

There has been similar progress in the on-land Robotics field. Besides, there have also been developments in the Dual mode /amphibious vehicles in the past which also had efficient mechanisms [3] [4]. But, there are not many robots which have a combination of the above two functionalities.

In this paper we present a novel mechanism, where the Robot can maneuver on land, on water (like a ship) as well as underwater. We term this robot as a Triple Mode Vehicle, which is used for surveillance using Radio Detection and Ranging (RADAR) mechanism. Global Positioning System is adopted for determining the location of the vehicle.

II. Design

A. *Dimensional Constraints*

For a rover to maneuver on land with high stability, the dimensional ratio of 16:9:5 (Length: Breadth: Height) is preferable. On the other hand, the factors that have to be considered for an underwater vehicle include weight, volume and the type of material used to construct the body.

G V Sai Yeswanth, Sakshi Singh, Akash Kannegulla, R Karthikeyan
Amrita School of Engineering, Bangalore campus,
Amrita University, India - 560035

Considering the stability factors of a land rover and an underwater vehicle, the dimensions we propose for the Triple Mode Vehicle are:
Length = 1 meter
Breadth = 0.56 meter
Height = 0.31 meter
The model of this vehicle is designed using Solid Edge v19 as shown in figure 1.

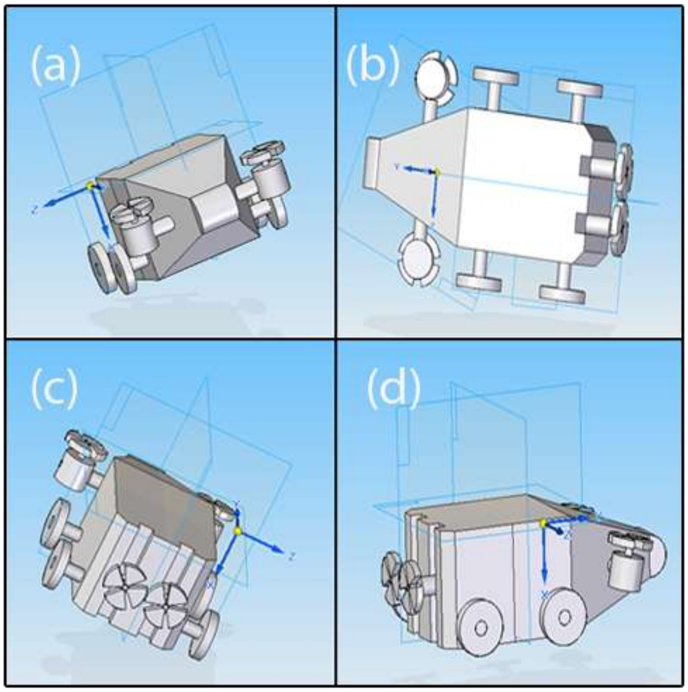

Figure 1. (a) Front View of the vehicle which shows the positioning of propellers. (b) Top View of the vehicle. (c) Rear View. (d) Side View.

B. *Material Constraints*

Submarines use metals like flexible steel, Titanium and glass reinforced plastic. We use an alloy as building material of this robot which satisfies the floating and sinking requirements of the robot. It is known that corrosion rate is higher in salty water. Hence, for the construction of the vehicle, stainless steel – UNS S31803 has been used which has a good strength - to - weight ratio and corrosion resistance. UNS S31803 is a standard Duplex stainless steel having a mixed microstructure of austenite and ferrite. The density of UNS S31803 is 7.805 g/cm^3. It has twice the strength of normal stainless steel, lower thermal expansion and higher thermal conductivity. It is more resistive to pitting and stress corrosion. Therefore, it is widely used for underwater applications.

III. Working Mechanism

For navigation of the vehicle on land, the four-wheel drive is used. Propeller system is used for navigating on water and underwater. A tank is embedded inside the vehicle, which is filled or emptied as required, in order to maintain the sinking depth of the vehicle.

The tank can be filled by a solenoid valve and emptied using a DC water pump. Once the tank is filled, the vehicle submerges inside the water and further sinking depth can be achieved using the propeller system.

The two propellers shown in figure 1(a) can rotate 360^o and two more propellers as shown in figure 1(c) can rotate upto 180^o. These four propellers together, are used for navigation. This working mechanism is depicted in figure 2.

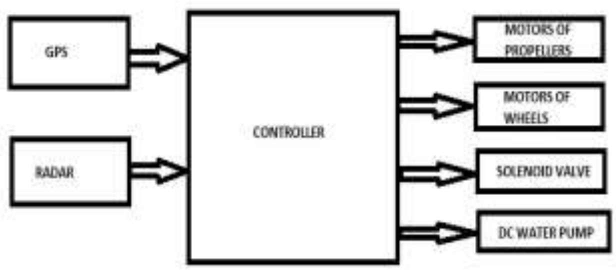

Figure 2. The working mechanism having inputs as GPS and RADAR with outputs as motors, solenoid valve and DC water pump.

Global Positioning System gives the location of the vehicle which can be used to restrict it's navigation to a confined area. RADAR is used to track the movements of ships/objects (during navigation on land) in the surrounding area and this tracked information can also be saved.

Since this vehicle is autonomous, a path is assigned to it, which it follows using Global Positioning System. The vehicles verifies the coordinates at regular intervals and follows the path as per the algorithm shown in figure 3,

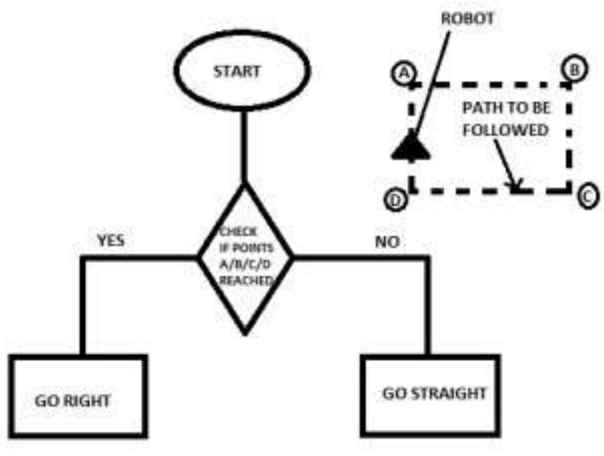

Figure 3. The dotted line represents the path of the vehicle. The algorithm shows the choice of direction based on coordinates.

A. Global Positioning System

The Global Positioning System (GPS) is a satellite navigation system which involves 24 satellites, and can provide location information on any part of the Earth. These GPS satellites orbiting the Earth transmit radio signals continuously. Based on measurements of the amount of time that the radio signals take to travel from satellite to a receiver, GPS receivers calculate the distance and determine the location in terms of longitude, latitude, and altitude, with high accuracy. Information from four satellites is used in order to exactly determine the location. GPS receiver based on the time taken to receive the signals sent by satellites estimates its location.

GPS consists of three segments as shown in figure 4. Here, Space Segment consists of satellites, Control Segment consists of master control system and User Segment consists of GPS receivers which contains an antenna and are tuned to particular frequencies.

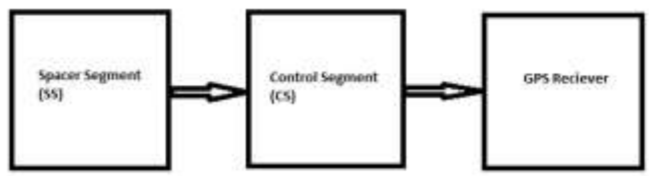

Figure 4. Segments of Global Positioning System.

NMEA 0183 protocol is used in GPS receivers to transfer position data to controller. The output data string is in the format:

$ID<message ID>, <field 1> <field 2> <field 3> <field4> <CR><LF>

The sentence begins with the start character "$." Next five characters represents the sender and type of message. Field 1 tells the latitude information. Field 2 tells the direction- North (N) or South (S). Field 3 gives longitude information and Field 4 desribes the direction- West (W) or East (E).

B. Radio Detection And Ranging

RADAR is a technology used to detect the presence, direction, height and distance of objects using electromagnetic waves. The capability of electromagnetic waves to travel through vacuum, make them perfect for use in space. In electromagnetic spectra Radio waves occupy frequency from 3 KHz to 300 GHz and having large wavelengths, they are capable of travelling long distances when sufficient power is provided. The basic principal of Radar involves three main phenomena – Reflection, Scattering and Diffraction, which take place when an electromagnetic wave hits any object. So we send a wave into a given direction and if a reflection of this transmitted wave is observed then, the presence of an object is indicated.

To exactly know the distance of the target from the transmitter we use the Radar equation,

$$R_{max} = \sqrt[4]{\frac{P_S . G^2 . \lambda^2 . \sigma}{P_{E\,min} . (4\Pi)^3}}$$

Where, R_{max} is the maximum range up to which an object can be detected by the system, P_S is the Power of the transmitted signal, G is the Gain of the antenna, λ is the wavelength of the transmitted wave, $P_{E\,min}$ is the minimum signal strength that can be detected by the antenna without distortion, σ is the Radar Cross Section, where it is defined as ability of an object to reflect the signal back in the same direction of incoming signal. Higher RCS means that an object can be detected easily and it depends on many constraints like material of the object, size, incident angle and relative size with respect to wavelength.

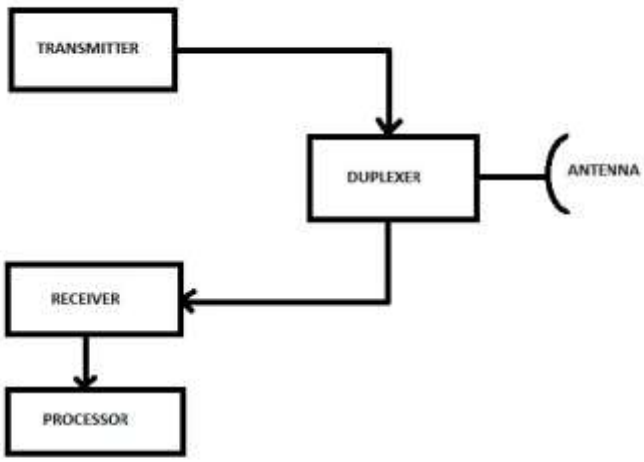

Figure 5. Block diagram of the Radio Detecting and Ranging system.

The transmitter and receiver are connected to the antenna through duplexer as shown in figure 5. The duplexer allows transmitter and receiver to use only one antenna. It switches the path between them from time to time. Receiver is connected to a processing block which takes in the raw data and puts in a format that can be saved for further reference.

In the following figures 6 and 7, a setup of the antenna and the objects to be detected is illustrated. We show that the amplitude of the reflected radar waves varies proportionately with respect to the distance of the object from the antenna.

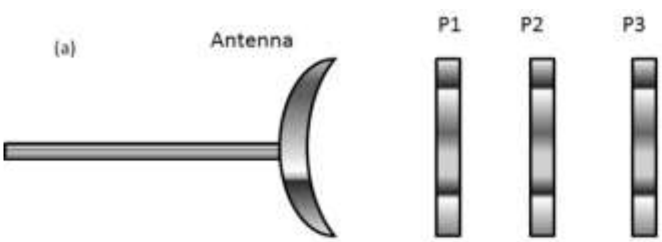

Figure 6. shows three different positions of objects placed in front of the antenna.

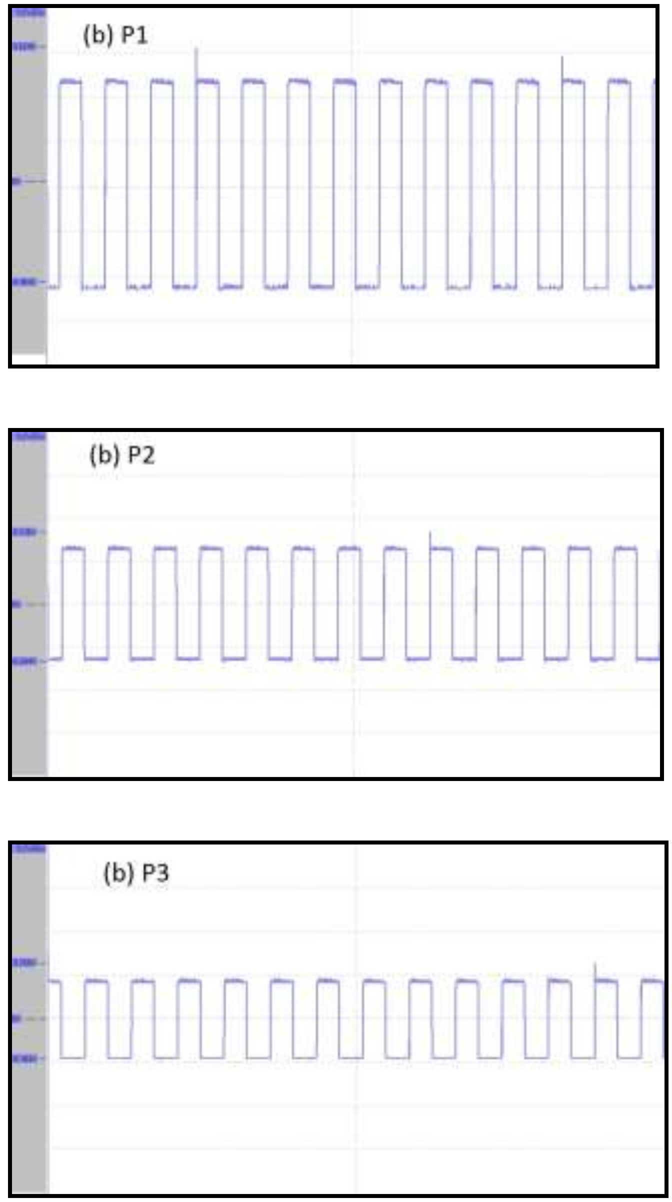

Figure 7. Signal strength reducing from position-1 (P1) to position-3 (P3).

IV. Conclusion

Many efficient designs and models exist of amphibious vehicles, underwater robots and land rovers, which are used in variuos applications. This paper presents a novel design of a vehicle which can navigate in each of the above three modes. This can be used for surveillance, for detecting ships or objects (on land) using RADAR. The future development of this vehicle includes artificial intelligence for better autonomous navigation using fuzzy logics and instantaneous transmission of tracked information, instead of just saving it.

Acknowledgment

We would like to express our sincere gratitude for all the help and support provided by Amrita School of Engineering, Bangalore, for providing a good research facility to simulate our designs and in carrying out essential research work at Microwave laboratory which helped us in developing this paper.

References

[1] Kazuo ISHII, Teruo FUJII, and Tamaki URA, " Neural Network System for On-line Controller Adaptation and Its Application to Underwater Robot", Proceedings of the 1998 IEEE International Conference on Robotics and Automation, Leuven, Belgium, May 1998.

[2] Peter Corke, Carrick Detweiler, Matthew Dunbabin, Michael Hamilton, Daniel Rus, and Iuliu Vasilescu, "Experiments with Underwater Robot Localization and Tracking", 2007 IEEE International Conference on Robotics and Automation, Roma, Italy, 10-14 April 2007.

[3] Tran, T. H., Q. P. Ha, R. Grover, and S. Scheding. "Modelling of an autonomous amphibious vehicle." In *Proc. Australian Conference on Robotics and Automation*. 2004.

[4] Frejek, Michael, and Scott Nokleby. "Design of a small-scale autonomous amphibious vehicle." *Electrical and Computer Engineering, 2008. CCECE 2008. Canadian Conference on*. IEEE, 2008.

About Author (s):

G V Sai Yewanth is pursuing his B.tech in Electronics and Communication Engineering in Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore, India. His research work is concentrated on Robotics and Automation. His current research is on RFID simulations in GNU Radio.

Sakshi Singh is pursuing her B.Tech in Electronics and Communication Engineering in Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore, India. As an undergraduate she performs research in Signal processing, Artificial Intelligence, Speech and Auditary perception and thus implementing it in Robotics.

Akash Kannegulla is pursuing his B.Tech in Electronics and Instrumentation Engineering in Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore, India. His past research work was on Robotics, Mechatronics and THz imaging mechanisms. The current research work involves Artificial Intelligence in Robotics.

R. Karthikeyan has received his B.E in Electronics and Instrumentation Engineering (1997) from Bharathiar University, Coimbatore and M.E in Computer Science and Engineering (2004) from Manonmaniam Sundaranar University, Tirunelveli, India. During the period (September 2009 – May 2010) he was deputed to university of Turku, Finland as a visiting researcher. Currently he is working as faculty in Amrita Vishwa Vidyapeetham University, Amrita School of Engineering, Bangalore, India. His research interest include Advanced Control System, Artificial Intelligence, Robotic control and Signal Processing.