Hardware Implementation of Autonomous Surface Vehicle (ASV) using Arduino Mega

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Abstract

Our objective is to make an operating model of an autonomous water surface vehicle (ASV) that's multi-modular in nature, i.e. makes use of multiple modules and sensors so as to sense and actuate the specified functions to suit our desired methodology of travel, conjointly keeping in mind a path-saving algorithmic rule, that takes into consideration GPS reference system to reach out heading and course modification angles. This, in order to capture the desired telemetry and data from the onboard sensors at the specified locations in the path, then return to base for the retrieval of the data for analysis.

The principle of navigation involves two solutions, close range navigation, and broad navigation. An ultrasonic sensor will provide close range navigation, while the GPS module, will help with broad navigation. Both these systems are crucial for the primary function of this vehicle, which is locomotion over a water body. The secondary function is the collection of photographic data of point of interests over the relevant area.

1. INTRODUCTION

The ultimate goal of humankind returning into the second decade of the 21st century has been complete automation. Once it involves automation, transportation has created many-a-leap.

Land transport automation is fairly easier once we have a tendency to compare it to water transport automation. In contrast to land, many things ought to be paid attention to, like water pressure, tidal forces, and winds so on.

An autonomous surface vehicle usually outlined as any water surface vessel which will perform without a crew to direct it. The destination co-ordinates are fed into the vessel first.

The vessel's GPS module creates a path plan accordingly. An ultrasonic sensor is usually used to identify obstacles.

International Regulations for Preventing Collisions at Sea (COLREGs) are a group of rules and rules ordered down so as to be followed by all marine vehicles including autonomous vehicles.

2. PROBLEM STATEMENT

We are building an efficient Autonomous Surface Vehicle by integrating different modules such as Ultrasonic Sensor, GPS module, Compass and Camera module.

We have using the path finding algorithm to find the path to the desired co-ordinates and even obstacle detection algorithm to detect the obstacle.

It also makes use of obstacle avoidance algorithm to avoid the obstacles using specified angle detection and steering algorithm. It uses GPS module for the real time heading and course change angle.

The ASV is prepared such that it uses camera module for taking the pictures of obstacle so as to get to know the type of obstacle present.

3. LITERATURE SURVEY

Unmanned Surface Vehicles (USV) has found many applications in navy and other organizations for variety of missions and applications.

USV has many different applications such as surveillance of coasts, port security and submarine protection.

Many private and government firms use it for oceanographic purposes like ocean depth measurement, water sampling and monitoring.

USVs are also used for hydrographic surveying. Hydrographic surveys helps to ascertain how the features of sea, river or any other water body would affect construction, oil or gas drilling, etc. USVs can greatly accelerate the hydrographic data collection.

There are many USVs present with obstacle avoidance algorithm but we cannot know the nature of the obstacle that was present in front of the vehicle. So, we are trying to build an USV which would help to capture the photograph of the obstacle which the ASV would face while travelling from source to destination.

4. PROPOSED METHODOLOGY

The ASV will be using an RC boat chassis as the main hull. Model construction will happen in three phases. Clinical trial will include dismantling an RC boat and embedding an external development board to test directions. Clinical trial will include autonomous navigation testing using various travel algorithms.

4.1. Phase I

In this phase, the components and internal modules of a boat are removed. Arduino board is placed as an assistant with a L293D motor driver to regulate both DC motor propeller motors for testing left and right boat movements.

Since there is no rudder and hence we do not depend upon point-accurate angles, we use different delays in motor movements to vary the direction of the ship heading by changing motor speeds.

4.2. Phase II

Now as the boat is prepared with some sort of driving system and operating motors, the next step is to run it autonomously. Now, we come up with 2 obstacle avoidance algorithms. We will test both algorithms in a water body.

First algorithm is to stop the boat each time an obstacle is encountered, turning left and right and calculating non-avoidable distance. The side with maximum distance is that the chosen path to steer the vessel. The problem with this algorithm is that stopping momentum is not accounted, thus this results in inefficient direction change.

Second algorithm gets over the defects of the first algorithm. Here each time when an obstacle is encountered, the course angle heading to the destination is calculated. If the destination is $180<t<360$, the boat will move left. If the destination is $0<t<180$, it will move to the right side of the obstacle.

4.3. Phase III

In this phase, GPS and obstacle avoidance modules are brought together using the second algorithm stated above. An OV7670 CMOS camera is attached to the system to act by periodically clicking photos of obstacles and saving them onto SD card for further use.

With this final model, will able to compute the path that varies from 0 - 359 degrees with full rotation, with North to 0 degree, east to 90 degrees, etc.

5. BLOCK MODEL

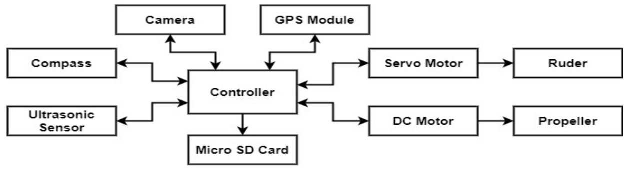

Figure 1: Block Model

5.1. Explanation

This Figure shows the block diagram which represents the basic blocks of system which are used for attaining the functionality of system. In our system, there consists a Controller (Arduino) which handles decision-making, the input ports collect data from sensors (Ultrasonic Sensors). Ultrasonic Sensors used for object detection. Data is being stored in Micro SD Card. GPS Module provides the GPS Data Processing. Compass is used for positioning . Controller sends the information by processing the data of the object, and then the pictures are clicked by the camera of obstacles. Controller handles the motion controlling of motors using a motor driver.

6. FUNCTIONAL REQUIREMENTS

1. Obstacle Detection.
2. Obstacle collision avoidance.
3. Shortest path detection and selection.
4. Surveillance using camera module.
5. Usage of GPS module for real time heading and course change angles.
6. Test possible travel algorithms and choose the best one.
7. Usage of SD card module for storage of data i.e. surveillance pictures.

7. NON-FUNCTIONAL REQUIREMENTS

1. Usage of ASV should be simple.
2. The COLREGs are a set of rules and regulations laid down in order to be followed by all marine vehicles in transit, irrespective of their nationality and command. These rules must be kept in mind while designing any type of marine path algorithm.
3. A water resistant hull cover.
4. Usage of single/dual propellers.

8. SYSTEM LAYOUT MODEL

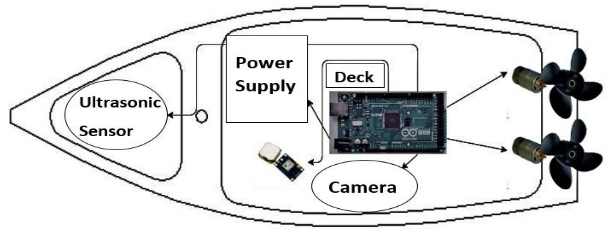

Figure 2: System Layout Model

8.1. Explanation

This Figure represents the System Layout Model, OV760 CMOS Camera clicks the pictures of Obstacles. 4-pin ultrasonic module HC-Sr04 is used for detection of object. Controller handles the motion of 2x DC motors using L293D motor circuit.

9. METHODOLOGY EMPLOYED

We are going to follow the Spiral Model for this project.

a. The spiral model is a risk-driven software development process model. Based on the unique risk patterns of a given project, the spiral model guides a team to adopt elements of one or more process models, such as incremental, waterfall, or evolutionary prototyping.

b. Using this model has an advantage of adapting the additional functionality or changes that can be done at a later stage.

Objective: Working prototype of an ASV.

Risk Analysis: Construction of boat hull, Obstacle avoidance systems, Controller communication.

Design Phase: Design navigation system, and components.

Boat Hull Design: We begin with a plastic container which will hold the required components and still float. Two breaches are required to mount the propellers and the motor shaft. And a third for the camera module. We can reuse the mechanical lid to seal the container. This seal will not be waterproof and may permanently damage the installed components. The interface of the motor shaft to the propeller is also not sealed. This design is very crude and needs to be refined further to implement a reusable water seal, better mounts for motor and other components.

To achieve steering without a rudder we will control the rotational outputs of both the motors to perform thrust-based vectoring, which while limiting in turning rate and turning radius, is very reliable. Thrust vectoring is a principle where given a craft has 2 thrusters which are offset from the center of mass, increasing the thrust in one motor will provide rotation in the clockwise direction to the direction of travel. For this function, a compass module is needed to keep track of the heading of the craft, and to accurately control the direction of travel.

Programming the Arduino Mega: The code for the motor and steering is loaded onto the Arduino board before installing into the hull.

10. MODULAR DIAGRAM

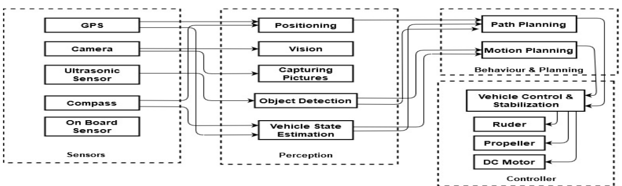

Figure 3: Modular Diagram

10.1. Explanation

Figure 3, represents Modular Diagram where all components of the software –hardware which can be solved and modified independently without disturbing (or affecting in very small amount) other modules of the software.Gps performs the task of positioning of the specified path also checks the State of Vehicle Estimation. Controller sends the information by processing the data of the object, and then the pictures are clicked by the camera of obstacles. 4-pin ultrasonic module detects the object. Compass is used for positioning and planning of DC motors, propeller and ruder.

11. CONCLUSION

This device serves as a technological demonstration for the capability of the given hardware, and allows testing of many navigational systems for various applications like surveillance, scientific data gathering and geological surveys.

The Arduino Mega provides ample connectivity to utilize the on-board array of sensors for navigation and light data processing, and allows for upgradation of the product with additional modules in the future for more advanced applications.

12. FUTURE SCOPE

Modifying the boat hull and adding advanced components like an infrared camera, an accelerometer and gyroscope can vastly improve the efficiency and capabilities of the vehicle.

Different configurations of the cameras can help with underwater data gathering. This will enable surveys of lake beds, shore lines and can also help with finding ghost nets.

The navigation system will be altered to enable locomotion within larger areas.

A rudder can greatly improve the steering capabilities from the present differential thrusting system.

The unmanned surface vehicle market is projected to grow within the forecast period attributable to driving factors like rising need for ocean data mapping and water quality monitoring.

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