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Auv Design: Intelligent Vehicle Using Sensor Fusion Control Scheme

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Abstract: In recent past, large physical changes has been observed on earth and sea due to the drastic change in the global environmental conditions. These changes has increased the sea water level and created the alarming conditions for the humans living near the coastal areas. The underwater robot can solve such challenges (Underwater) precisely and accurately without intervene of human operator. Such vehicles are performing a variety of tasks [1] in subsea, predominantly in the offshore oil and gas industry, civil engineering and marine sciences etc. Apart from these developments, under water remote-sensing, navigation, image processing has also seen a large growth in terms of software's and processing power. Many ROV are suffering from large power backup, accurate object/target identification etc due to the failure of sensory information. A new underwater autonomous system with suitable mechanical constraints, kinematic constraints has been designed. The designed ROV can take decisions under water using artificial intelligence (particularly using Sensor Fusion). The designed schematics with various components along with simulation results of object identification are hereby tried to be concluded.

Keywords: Sensor fusion, underwater robot, ROV, artificial intelligence

I. INTRODUCTION

Field robotic is concerned with the development of robotic tools for non-accessible and often dangerous environments, either on or under land, air or sea. The goal of this field is to develop a system that can be used to facilitate work in a real world domain. Automatic underwater robotic vehicles are currently receiving a considerable amount of attention around the world, as they allow all to explore the work in the area which is, beyond our reach. These vehicles will now have significant importance in environment control and monitoring in aquatic agriculture and the utilization of offshore resources. Clearly the type of task that can be performed by these robots will dictate their own configuration.

Most of the ROVs serve oil and gas companies and the rest of the ROVs maintain subsea telecom cables, aid scientific research, and mine for diamonds. Most of the offshore operations need just a few robots for construction and maintenance for laying cables, operating valves, and anchoring equipment, among other tasks. Some robots are being developed for carrying the payloads [10-11].

As companies expand operations with deeper wells and horizontal drilling, more equipment with complex operations needed at the sea floor and this will require sophisticated technology to run. This includes more sophisticated robots will be needed to do more varied tasks and in greater proportion. And with so many ROVs working in such close quarters, mishaps are more likely. In early June, two ROVs collided, dislodging a tube inserted into a riser pipe. But experts think this record could be improved. The solution probably won't involve engineering new hardware but rather developing more sophisticated software.

ROVs make mistakes most often because their human pilots' do. As there is no tactile feedback, no depth perception, no audio feedback of what's going on down there. To help eliminate human error, we are developing computer software to automate some of the standard things that ROVs do, like testing a rig's blowout preventer. Our automation techniques improve not only the time that it takes to do these tasks but also the quality of the results.

Automating of ROVs is done for refining their awareness about the surroundings, this feature of the robots might be useful for the robots to navigate the cables and moving gear in the gulf.

II. MECHANICAL DESIGN

The objective of the vehicle is, to monitor the sea parameters and to navigate through the ocean. The proposed robot will consists of six modules with mechanical structure. As we did research upon the physics of motion, hydrodynamics of marine life like fishes, cephalopods, whales, tortoises and many more ,we were able to categories the type of propulsion systems into two.

a. Jet propulsion
b. Tail propulsion

All the cephalopods move by jet propulsion technique [2] whereas fishes move by tail propulsion technique. Both the techniques have their own advantages and disadvantages. Jet propulsion technique is an energy consuming way to travelling here and there compared to tail propulsion technique. The relative efficiency of jet prolusion is less [3] than that of the tail propulsion for relative large bodies. Tail propulsion are very useful to maintain the steady velocity whereas jet propulsion is basically useful for stop-n-start aggressive motions. They are basically used for providing bursts of high speeds.

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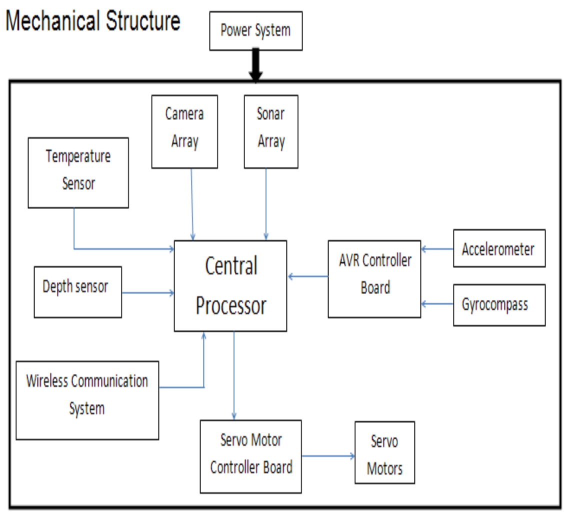

Figure. 1. Block Diagram of the Robot modules

Because of individual advantages of tail propulsion and jet propulsion system [3-4] in context to navigation leads to our idea for submarine. We are used hybrid tail propulsion system.

A. *Technical Details:*

In this design there are six fins, one thruster, one buoyancy adjust mechanism.

a. Fins are basically used for forward linear motion, left turn, right turn, up turn, down turn.
b. Thruster is basically used for sudden backward push, and sudden forward push in emergencies.
c. Buoyancy adjusts mechanism basically used to adjust net weight of the submarine and also used for the vertical linear motions.

Fins are actuated with the help of Ironless rotor low inertia dc servo motors of following specs:
Model no. M35

a. Load 18Ncm
b. Angle of precision 1.8 degree
c. Power up to 20watt
d. Weight 150g
e. Size 35mm (diameter)

50mm Integrated Thruster

a. power upto 100watt
b. Size 72mm(dia) *51mm
c. Weight 0.4kg

This mechanism basically adjusts the buoyant force for adjusting the weight of the bot and for vertical motion.
This mechanism comprises of following parts:

a. One Compressed air cylinder
b. One Ballast body
c. Three Pneumatic valves
d. Tubing

Specs:

a. Capacity 0.3ltr
b. Diameter 51 mm
c. Material Aluminum6061
d. Rating 1800psi to 3000psi
e. Weight 1.5kg

Dimensions of the AUV

a. Breadth(z axis) 28cm
b. Length(x axis): 40cm
c. Height(y axis) 4cm - 4cm (adjustable)

B. *Motion:*

As fins changes the direction of flow of water, this change in momentum gives a push in back according to the Newton law of motion. Single fin gives upward force. But set of fins can be operated in such a way that they can give number of motions.[5]

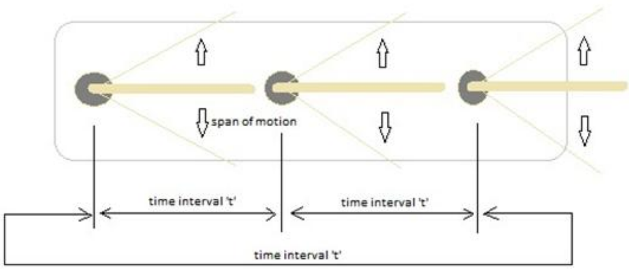

Figure. 2. Example of Various motions

Linear motion that is the motion along the axis of the bot. the set of fins can be triggered in such a way that it can do linear momentum transfer along the axis of the bot. A very similar motion can be obtained by triggering the fins after a regular interval of time. Each predecessor fins with a time interval 't'. This time is same between adjacent fins and fix for a particular velocity, but it varies with change in angular velocity of fins maintain a wave motion in fins. Left and right motion can be achieved by keeping one side fins stop & move the other. Thruster designed to give sudden forward and backward pushes when needed in emergencies. It consists of motor propeller assembly oriented along the axis of the bot.

C. *Final Design:*

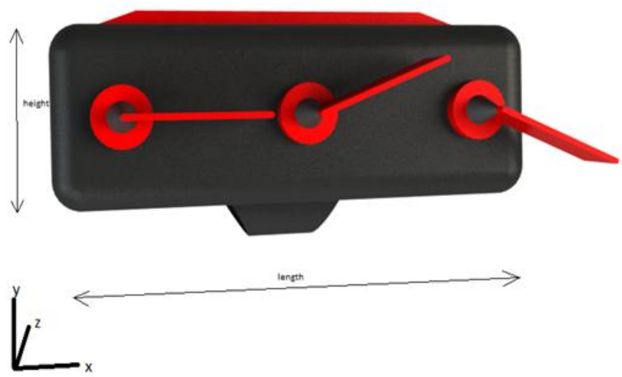

Figure. 3. Final ROV Design

Estimated weights

a. Processor unit: 2kg
b. Battery: 3kg(4 batteries)
c. Servo motors: 1.2 kg(6 motors)
d. Thruster: 0.5 kg
e. Air cylinder: 2kg
f. Supported mechanical parts: 3kg
g. Supported electronics: 0.8 kg
h. Weight of shell: 1.5kg

Total Estimated weight: 12kg
Center of gravity and center of bouncy
Along x axis: 20.5 cm
Along y axis: 6cm

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Along z axis: 14cm

Net weight of AUV in water with ballast body filled with water: 0.5 kg

Volume of ballast body = 40cm*12cm*6.25cm

Net weight of AUV in water with ballast body filled with air: -2.5kg

Centre of buoyancy:

Along x axis: 20cm

Along y axis: 7.84cm

Along z axis: 14cm

Difference between CG and CB: 1.84cm (along y axis)

Drag force:

Velocity of robot= 0.1 m/s^2

Estimated drag coefficient= 0.45

Density of water= 1000kg/m^3

Surface area =0.14*0.28 m^2 =0.0392m^2

Total drag= 0.0882N

Body Material:

We are using three types of materials in order to make the body of the robot.

a. Carbon Fiber
b. Steel Sheet
c. Underwater Glass Sheet

Carbon fiber will be used to make the main body and steel sheet will be used to make the base plate and glass sheet will be used in sections for the cameras.

III. EMBEDDED SYSTEM

Embedded system of the AUV is responsible for the stable operation of AUV under the water and for its smooth motion for the observation of ocean surface. In this unit there are mainly two boards one is Attitude monitoring board and the other is motor control board.

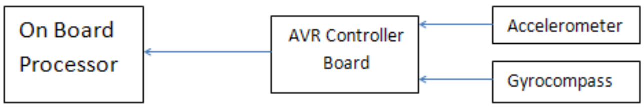

Figure. 4. Block Diagram of Attitude monitoring

Attitude monitoring board gives the information about the orientation of the board in 3 DOF i.e. roll, pitch and yaw. This data is calibrated by the circuit designed for the operation and then the calibrated data is given to the central processor where it takes the appropriate decision based on the data available to it. Then controlling commands gave to the motor controller board to change the speed of motors in order to compensate the deviation from its stable position. Attitude monitoring board consists of Accelerometer, Gyrocompass and AVR micro controller.

We developed the algorithms so that while up and down movement of the robot monitoring board should not interfere with the motor controller board. Apart from this we will use gyrocompass in conjunction with the accelerometer, for more static results, by sensor fusion technique.

A. *Sea Parameter Monitoring and Communication:*

We monitored temperature and depth, we used temperature and depth sensor. These sensors give the calibrated data to the central processor. The program running on processor will store the values time by time in its database. The whole data of the monitoring will be sent to the base station through wireless communication [2] system after reaching to the surface.

This system receives and sent back the commands to the base station. In this module we use 81KT - Miniature Depth Sensor. It gives the calibrated output for both temperature and pressure.

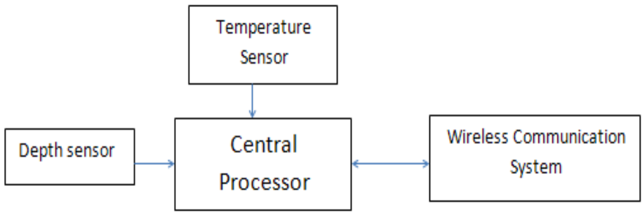

Figure. 5. Various modules of ROV

B. *Navigation System:*

For the navigation system we are using camera arrays in conjunction with the sonar, as camera alone doesn't give the information about the distance of the object from the vehicle.[6] Hence with the introduction of the sonar we will get the information of distance as well. Hence using both camera and sonar we will have the exact information of object, regarding its shape and distance from the vehicle.

We are making our vehicle to maintain a safe distance from the objects. In ocean any moving object can come in the path of the vehicle. Our vehicle can detect such object and can take appropriate actions. It can also search for the objects of our interest. [7]

These cameras have user configurable vision settings and low power requirements. The cameras are internally mounted, thereby not interfering with the streamline motion of the body. The vehicle will be capable of switching between cameras to perform different tasks.

C. *Motion control System:*

Motion control system includes the servo motors and their controller board. This system is responsible for the movement of the robot. While going upward, downward, side motions the speed of motors should be varied accordingly and all these action will be taken by the controller board. Servo motor controller board takes the commands from the central processor and works accordingly.

Figure. 6. Motion control system

Servo motor controller Board

a. 32 bit position, velocity and acceleration control
b. Trapezoidal and velocity profiling permit on-the-fly
c. 16 bit PID servo gains can be changed on-the-fly
d. Multi axis coordinated motion control support
e. 2 or 3 channel encoder input, limit switch inputs
f. Optional Step and Direction inputs
g. May be used with DC brushless or brush-type motors
h. Amplifier includes over current, overvoltage, under voltage and thermal overload protection
i. 4-wire RS485 communications interface can be connect to additional controllers (up to 32 total)
j. Complete documentation and example software available

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D. Image Processing:

Image processing technologies to trace line-like objects are developed. In the test, lane markers were traced in real-time. In aquatic circumstances, there exist few works concerning with the subject. Conditions for tracking of line-like objects in the underwater are fairly different from those in the atmosphere. They differ from each other especially in the range of vision and uniformity of the illumination. The range of view is much longer than the underwater. [8] Illumination uniformity far exceeds in case of the underwater. These all help to predict trajectory of target objects easily after they are once caught. Stable guidance of a vehicle based on the prediction in turn stabilizes camera's view and enables camera to catch the target in good position. In the underwater, information about working circumstances was rarely given. The extent of illumination decides the range of view in the deep waters. Absorption and diffraction in the water limit it [9] within 10 meters in coastal waters. Illumination by spotlights is very inhomogeneous.

The strong absorption of light in the underwater enhances the inhomogeneity. Brightness of illuminated region changes by the same reason if vehicles change their altitude. Clear images cannot be obtained since the diffraction blurs shape of objects.. ROVs and AUVs have various factors to cause fluctuation to their motion. Tidal currents cause unpredictable fluctuation of motion of tethered ROVs. Changes of altitude, pitch and roll of vehicles change direction and position of cables in images. Insufficient ac magnetic fields also result in unpredictable changes of cable direction through motion fluctuation. This makes it difficult to predict direction and position of object in the next picture exactly. So, we work mainly in these three areas.

a. Image capturing
b. Pre-processing
c. Edge detection

E. Power and Cooling System:

We are using four Customize Polymer Li-Ion Battery in order to provide the power backup for whole system under the water. According to our power requirement for satisfactory functioning of the robots these batteries will be sufficient for the 3 hrs of power backup. Due to the generation of enormous heat from electronic circuitry, we have to make provisions of cooling in order to avoid the failure of the system due to heat.

We are using a temperature sensor inside the main chamber which will indicate the temperature inside the chamber. Heat will be mainly conducted through the metallic base plate using blow air mechanism. The speed of blower will be controlled according to the temperature of the chamber.

IV. CONCLUSION

The ROV has been developed and checked in underwater. The design is hybrid of fins and thruster for motion of vehicle, whereas the Controlling is done threw sensor fusion of sonar and Camera data. The vehicle has capability of self control, object tracing and gather useful data intelligently.

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