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Designing Underwater Drone/Robot Using Fish Symmetry & Replication for Outer Structure & System Control for Efficient Underwater Environment Exploration & Surveillance

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Abstract: *The proposed paper focuses on design of underwater drone/robot which can be self controlled or operated manually with the help of Tx/Rx Module. The design focuses on use of Electroactive Polymer material & a fish like structural design which gives the underwater drone/robot improved acceleration with minimum water resistance & therefore high efficiency. The Pressure Sensor senses the pressure on the body of the underwater drone/robot & is thus giving appropriate values to computation control for adjusting the depth of the drone. Furthermore, the actuators are used for gripping a object beneath waves.*

Keywords: *Piezoelectric Actuators, Series Elastic Actuators, Pressure Sensor, Computational Controller*

I. Introduction

A revolution was buzzed by introduction of Aerial drones into almost every aspect of the day-to-day living of the globe, from Film Shooting, to Photography, to TV News Coverage, to Environmental Monitoring, to Archaeology, to Surveillance & various concepts are developed for aerial drones being adopted & adapted to work in underwater environment. Underwater drones working beneath the waves could be used by oceanographic scientists, photographers, archaeologists, commercial divers, militaries & undersea explorers for their underwater monitoring activities. The underwater drone will bring about a change the way the underwater works are being carried out & focuses on monitoring the underwater environment. [1]

II. Literature Survey

As per research done on Swimming Piscine, it proves that when swimming, a fish can achieve propulsive efficiency more than 90%. Furthermore, the fish can accelerate and maneuver in a far better way than any man-made boat or submarine, and produce relatively less noise and water disturbance. Thus, many researchers studying on underwater robots try to evolve type of locomotion in their prototypes. [1] [2]

Underwater robots such as Sailboat were developed in order to make measurements at the surface of the ocean. One such typical sailboat robot is Vaimos. Since the propulsion of sailboat robots uses the wind, the energy of the batteries is used for PC, communication and for actuation so as to tune the rudder and the sail & If the robot was equipped with solar panels, than, the robot could theoretically navigate forever. [3]

Interval analysis [4] is an effective & efficient tool for solving nonlinear type problems. In the field of robotics and automatic control of the robot, it has been used to study rigorously the stability of difficult linear [5] or nonlinear systems [7], to characterize the capture domains [5] [8] & to compute for nonlinear type of controllers [9] & to build observers that are reliable [10] [11] [12]. In this context, there also exist some of the point numerical techniques [13] which use Lipschitz properties of the systems or ellipsoidal methods [14] when the system is designed to be linear. Now, the interval methods can take advantage of the propagation tools constraint to provide effective & efficient resolution algorithms [15] & their ability to integrate with the nonlinear state equations [16]. When the system is designed to be both nonlinear and uncertain, in a set-membership context, the stability analysis becomes a difficult problem and to our knowledge, no reliable system algorithm is available in this context. It first shows that interval analysis can be used for the reliable stability analysis of uncertain & nonlinear systems. It also focuses on designing of actual autonomous & uncertain system which is a sailboat robot. The principle of the approach is to represent the uncertain systems by inclusion of differential systems [17] & to perform the Lyapunov analysis to transform the stability problem into a set-inversion framework. The notion of V -stability which is derived from Lyapunov theory for stability analysis of nonlinear systems shows that the V -stability can be cast into a set inversion problem which can be further solved efficiently and in a guaranteed way by interval-based algorithms. The differential inclusions are a generalization of state equations when set-membership uncertainties occur & the V - stability is extended to deal with differential inclusions. A convincing experimental validation demonstrates the applicability and the robustness of the resulting controller. [18]

Underwater exploration using drone is a physically demanding task. The robotic vehicle must navigate in an unpredictable surrounding environment which may include many disturbances and non-uniformities due to the transient changes which are exerted from the liquid. These physical forces which are applied to the underwater vehicle (UV) can lead to an inaccurate navigation and sometimes even failure of the operation as the traditional propeller driven systems are unable to adapt to the dynamic environment. Some of the operational examples are surveillance in military, countermeasure for mine, inspection and pollution mapping. UV's have particularly the high cost of transport during the low speed mobility [19]. This is where the fish excel, resulting in generation of the large transient forces efficiently by coordinating their body motion [20] [21]. In addition, there is adversely the dynamic environment which can be advantageous to fish locomotion, as they demonstrate their ability to extract energy from the upstream vortices [22]. Thus there is great potential so as to improve UV's by imitating the swimming fish with the highest locomotive performance operating within the desired environment and Reynolds numbers. Although there are still many aspects of locomotion which needs to be addressed, linear propulsion could be considered as the greatest challenge. Most of the work in biomimetic underwater propulsion has major focus on hydrodynamic mechanisms. Some of the examples of novel design approaches and their maximum speeds are Barrett's hyper-redundant parameterized Robotuna which have achieved a velocity of 0.65 body lengths/ second (BL/s) (0.7m/s) [23], Yu's optimized discrete assembly prototype have achieved a velocity of 0.8BL/s (0.32m/s) [24], Liu's G9 Carangiform swimmer have achieved a velocity of 1.02BL/s (0.5m/s). [25]

III. Technical Description

The proposed paper focuses on system design for underwater drones & their ability to work efficiently in a different environment. The drones developed for underwater environmental purposes are different from the Aerial Drone & its design from body to dynamics is typically different and challenging. Unlike the Aerial Drones which only has a challenge to wind resistance, underwater drones have several challenges beginning from underwater pressure on the drone to water resistance & operation. The proposed paper focuses on soft gel like material for body design which is more preferable for underwater drone along with a structure dynamic like a fish which shall provide good acceleration and speed.

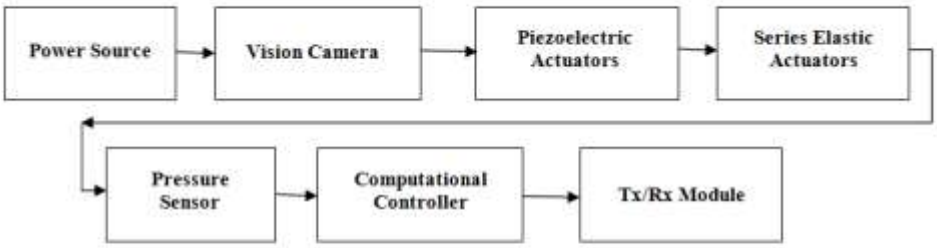

Fig. 1: Block Diagram of Transmitter/Receiver Module at Underwater Drone/Robot End

The transmitter/receiver block diagram at drone end is as shown above. The power source is a 12 Volt Lithium Polymer Battery. The Vision Camera enables the underwater drone to capture the vision having capability of Night Vision Camera. The Captured image could be stored in Memory card or it could give live feed at the receiver end. At the receiver end, based on the visual recognition the drone movement can be controlled or could also be implemented with self movement with the help of computational controller. The piezoelectric actuators works on the principle of piezoelectric effect due to which the material expands which is generally used to expand and compress outer body parts which can be used as legs while walking beneath the water or as expandable wings while moving at a certain place. Further to it Series Electric Actuators is used to hold certain thing or to move aside any obstacle coming in between the movement of the underwater drone. The body of underwater drones is made of Electroactive Polymers (EAP/EPAM) which is a plastic material which contracts substantially and can give activation strain up to 380% from electricity which enables underwater robots/drones to float or swim easily. The Pressure Sensor checks for the pressure on the underwater robot/drone & accordingly adjusts the underwater robot/drone depending on the correction value received from Computational Controller which not only takes care of underwater drone depth, but also gives self movement capability depending on the control action selected.

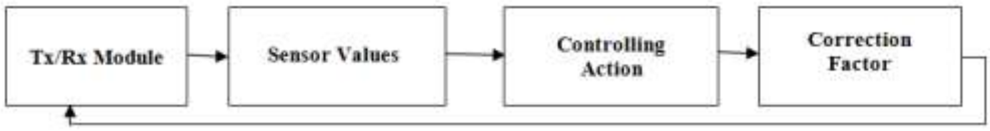

Fig. 2: Block Diagram of Transmitter/Receiver Module at Controller End

The transmitter/receiver block diagram at controller end is as shown above. The Tx/Rx module at controller end is used to transmit the signals in accordance to the correction factor which is applied based on the sensor values received & computational & controlling action based on the algorithm & correction factor outputted. The controller end also saves the visual imagining received from transmitter of underwater drone & could be used for surveillance purpose. The receiver also monitors the battery level of the underwater drone. The values received from correction factor are responsible for specific release & compression of the actuators on the underwater drone. The controller end monitors the activities of the drone in automatic mode & during manual mode; it provides the required controlling action.

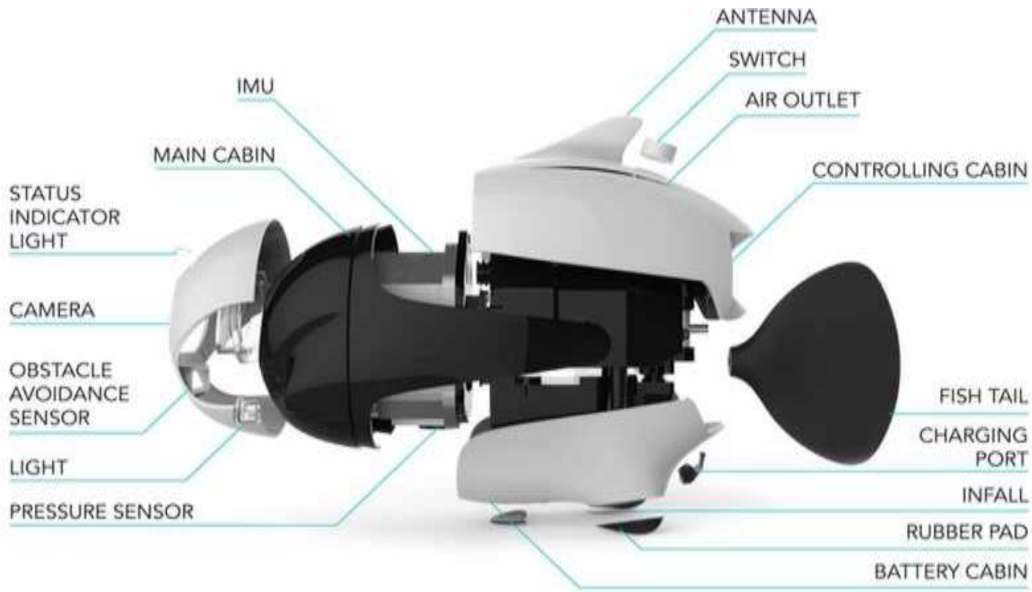

Fig. 3: Proposed Model for Underwater Drone/Robot (Picture Courtesy: Google)

The above figure demonstrates the proposed model of the paper which uses the Electroactive Polymer Material (EAP/EPAM) which enables the underwater robot/drone to float & swim easily with less water resistance due to its shape & design.

IV. Conclusion

The proposed paper focuses on design & concept of underwater robot/drone & its behavior in underwater environment. The proposed system is different from the ROV’s & other Search & Rescue robot’s used for underwater exploration. The design is inspired by the fish structure which gives efficiency to the drone/robot underwater & is specifically focusing on increased acceleration & minimum water resistance. The obstacle avoidance protects the drone/robot to avoid any underwater obstacle and the camera input gives the live feed to the controller end for applying correction factor. The model is proposed model & major work could be carried on such prototypes which would be beneficial in underwater environment exploration & for sensing the life beneath the waves.

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