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Arti-fish-ial Robot

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ABSTRACT

Nature's gift has been changing over the time and has evolved many creatures in our environment. One among these is gifting the fishes with extraordinary abilities with high efficiency to swim gracefully. This ability can't be completely used or observed unless they have a virgin environment to swim. The main overview of this paper covers a design of an autonomous fish robot which is capable of obstacle detection and which can be used to detect hazardous pollutants in the water and also to detect the leaks of underwater pipelines. Introduction In nature, fishes move themselves with the help of their fins or by bending their bodies.

Keywords: Robotic fish, Sensors, Undersea Application, Harvesting Natural Resources, Pipe Inspection, Monitoring the Environment and Arduino NANO.

1. INTRODUCTION

With five hundred million years of evolution, fish and other aquatic animals are endowed with a variety of morphological and structural features that enable them to move through water with speed, efficiency, and agility. The remarkable feats in biological swimming have stimulated extensive theoretical, experimental, and computational research by biologists, mathematicians, and engineers, in an effort to understand and mimic locomotion and sensing mechanisms adopted by aquatic animals. Over the past two decades, there has also been significant interest in developing underwater robots that propel and maneuver themselves like real fish do. Often termed robotic fish, these robots provide an experimental platform for studying fish swimming, and hold strong promise for a number of underwater applications such as environmental monitoring. Instead of using propellers, robotic fish accomplish swimming by deforming the body and/or fin-like appendages, mostly functioning as caudal fins and sometimes as pectoral fins. Body deformation and fin movements are typically achieved with motors. Over the years of evolution, they have gained astonishing swimming capabilities and also evolved in their structure as well as size. This has inspired many robotics engineers to build new kinds of aquatic man-made systems, namely robotic fishes. Having this in mind over the years, to study the aquatic life under water they have been improving the robots which can blend in the environment.

Thus one of those methods was the conventional rotary propellers used in the underwater vehicles, as in submarines. Instead of this, the Arti-fish-ial robot relies on servos for its movement. Here, the servos help in the movement of the fish with the help of the fins attached to them. This gives the fish movement and helps in dodging the obstacles on it ways. Water Quality sensing now coming to the environment the fish swims, there has to be pure aquatic surrounding. Water resources and aquatic ecosystems have been facing various materials, chemical and natural threats from weather change, industrial combination and offensive waste disposal.

The harmful diffusion processes like chemical leakages have dangerous impact on humans as well as the being in the water and also affect the sustainability of the ecosystem. And also, there are disturbances like obstacles coming in the way would be creating traffic and be getting in the way of the systems. Manual sampling, via with foothold devices o via boats/ships, would still be a basic practice in the monitoring of aquatic environment.

Aquatic environments have been facing various threats, and monitoring them and reconstructing aquatic process are of great importance to public health and biological balance. Manual sampling is still a common practice in environment monitoring, which is labor-intensive with difficulty in capturing dynamic phenomena of interest.

Thus, with the help of this Arti-fish-ial robot we test the quality of water by detecting the pollutants in it and monitor the environment with this. Thus combining the obstacle detection and the water quality sensing capabilities this paper presents a design of an autonomous robotic fish.

2. EXISTING SYSTEM

Considering the development in robotics over the years, some methods were proposed for autonomous robotic fish and to learn their swimming behavior and pattern underwater.

A paper was proposed at IEEE based on Biologically Inspired Design of Autonomous Robotic Fish at Essex by Huosheng Hu in the year 2006 [1]. This paper gives an overview of a robotic fish research, which is focused on the biologically inspired design of autonomous robotic fish. This experience on building a number of generations of robotic fishes to navigate in a 3D unstructured environment is given, including a launch of the 9th generation of robotic fish in London Aquarium on 6 October 2005 which brought about a gradual change. Another paper was proposed at IFAC on Robotic Fish Design and Control based on Biomechanics by Shaurya Shriyam, Anuj Agrawal, Laxmidhar Behera and Anupam

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Saxena in the year 2014 [2]. This paper gives a theoretical architecture on the design, model and control a robotic fish inspired by the mode of swimming. Here the main focus was to make a simpler model with the same biomechanics.

Thus, by using a novel combination of manipulator link mechanism and flexor-extensor mechanism which helps the fish to look more realistic and flexible. It has also been presented as to how a flexor-extensor mechanism can be used to mimic fish undulation. Now coming to the monitoring of the aquatic environment, there was a paper proposed on the design of robotic fish for aquatic environment monitoring in the year 2015 by Anuradha A. Maindalkar and Saniya M. Ansari [3].

It presented a design of a robotic fish system that integrates an Android smartphone and a robotic fish for debris monitoring. This smartphone based system can accurately detect debris in the presence of various environments. Methodology Hardware Design The robotic unit consists of micro-controllers, sensors and servos which are used for obstacle detection and movement of the robotic fish.

The past decade has also seen great progress in the use of robotic technology, like autonomous underwater vehicles (AUVs), and underwater gliders for aquatic environmental sensing. However, it is difficult to deploy many of them due to the high manufacturing and operational costs.

3. CHALLENGES AND CONDITIONS

The focus of this paper is how to simulate a robotic fish to make it swim like a real fish and realize autonomous navigation. The main objectives of our simulation work are:

1) To simulate the hydrodynamic model of a robotic fish, and to understand the relationship between the robot fish locomotion and the motion control parameters of its joints.

2) To develop fish-like motion control algorithms for a robot fish, and realize or mimic real fish behaviour such as decelerating/accelerating swimming, constant swimming, turning and hovering.

3) To test autonomous navigation algorithms in a robot fish to allow obstacle avoidance, the pursuit of moving targets and swimming at an appointed trajectory, etc. Compared with some traditional simulation work in robotics, the simulator for robotic fish encounters some special difficulties due to characteristics of water as the locomotion medium. Since water is an incompressible fluid, any movement of a robot fish will set the water surrounding it in motion and vice versa.

The main challenges in developing a simulator for such an environment are as follows:

1) Research in fish swimming mechanisms and mathematical models has not yet matured. Although many mathematical models such as resistive hydrodynamic models, 2D wave plate theory, and laterwake theories for oscillating foil propulsion provide great help in explaining how fish propel themselves, there is not a simple and direct method to compute the forces acting on a swimming fish.

2) How to simulate and deal with the water wave effect on robot fish? When mobile robots move, it is not necessary to consider the effect of air on their movement. However for robot fish, water waves supply an important source of noise in swimming behaviour. The common finite element analysis method used for simulating a fluid field is costly in computation and cannot be realistically implemented in real-time.

3) Collision computation between robot fish or between a robot fish and other objects is more complex than found in mobile robot simulations because the body shape of a robot fish changes when swimming.

To deal with these challenges, we have simplified the simulation environment described in this paper by applying the following preconditions:

1) The water in which robot fish swim is a quasisteady fluid. Most fish swimming mechanism research quoted in this paper is based on this supposition which makes it easier to simulate a water wave effect.

2) For a given parameter vector E = {c1, c2, k, ω} (equation (1)) for the movement of the robot fish tail, the value and direction of thrust force acting on the robot fish are determined without respect to the velocity of the robot fish.

3) Viscous drag is considered as the only resistance to the swimming robot fish.

4. PROPOSED SYSTEM

Hardware Design

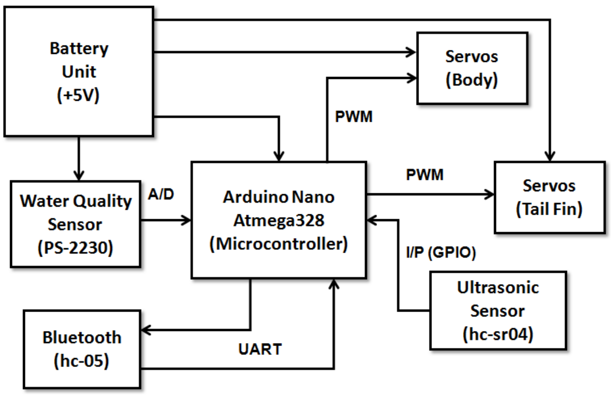

Fig 1.Block diagram for Robotic Unit

Arduino nano is the micro-controller which has been used for the controlling of the servos which helps in the movement of the robotic fish based on the readings given by the ultra-sonic sensors used for obstacle detection and the quality of the water is got with the help of water quality sensor whose readings are sent through the Bluetooth module which is again connected to the micro-controller. The LCD lights on the body of the fish help to obtain the quality of water in terms of percentages (corresponding to their analog values). The block diagram of the system is shown below.

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Servos used are used for the movement of the fish. One goes to the body and the other to the tail fin. This is to help the robotic fish swim more realistic, thus we need two joints between the trunk and the tail fin. As for the actuators we have chosen of common modelling servos: small, powerful enough to move the model and easily controlled by the microcontroller.

The servos are ideal because with the help of these we could manage the movement of the fish, varying at will the position of it, even with a few degrees. This flexibility of the fin allows us to give a more realism to the movement of the fish. To obtain the harmonic motion, each part has been attached to the next one with the help of servos: the body of the servo has been glued on to the body segment while the servo arm (connected to the shaft) shall be glued to the next one. Obviously the model would require a system to detect obstacles. To do this we would require ultrasonic sensors with digital output. These components can be used to detect the obstacles and are quite easy to maintain. This can be used to change the direction of the model once it detects the obstacles. Once the obstacle is detected the sensor gets the message to the microcontroller and this in turn controls the servo and moves them in such a way the direction of the fish changes. The pattern is given in the diagram below.

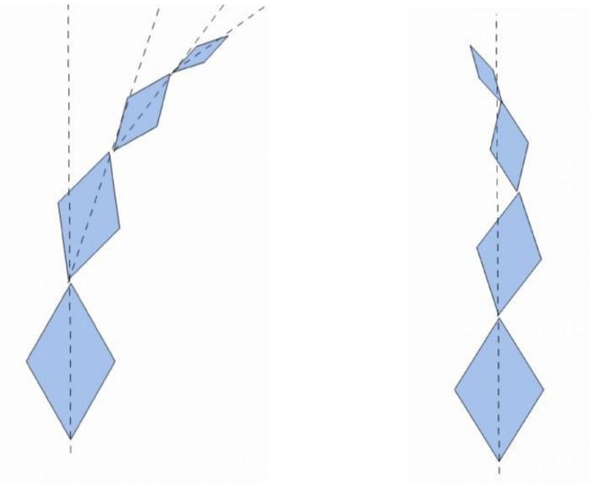

Fig 2.Pattern of the movement of the model

Now coming to the testing of the quality of the water, a water quality sensor is used to detect the pollutants in the water. The temperature, the oxygen level, the turbidity and the ph level is measured and the data is combined and an overall value is given by the sensor. This value is again given to the microcontroller and the value is obtained outside the water with the help of the Bluetooth module which is connected to the UART pin of the Arduino.

One of the most time-consuming tasks in robotic fish development is the fabrication of shell with a streamlined shape with good hydrodynamic performance. Now, we have manually manufactured the shells. The mold has to be redesigned every time when evolving the robot's body. Another disadvantage of such an approach is that the body is not accessible, which creates significant problems when it comes to diagnosis and service of the robot.

Table 1.Technical data of Robot hardware design

Components	Specifications
Arduino Nano	Microcontroller Atmega 328
Ultrasonic Sensor	HC-SR04
Water Quality Sensor	PS-2230
Battery	+5V Battery Unit
Bluetooth	HC-05
Servos	Sg 909g

5. ALGORITHM

The implementation of how the model would work is shown in the form of flowchart below. Initially there are variables assigned to obtain the values from the ultrasonic sensor and the water quality sensor. Once the obstacle is detected the value of how much meters the obstacle is obtained by the sensor. This value is given to the microcontroller. According to the code given when there is an obstacle with less than a particular distance the microcontroller drives the servos and the tilt will be less than the usual i.e., generally the fin which moves at an angle of 30^o will start moving only 15^o . This will help the fish to change the direction respectively.

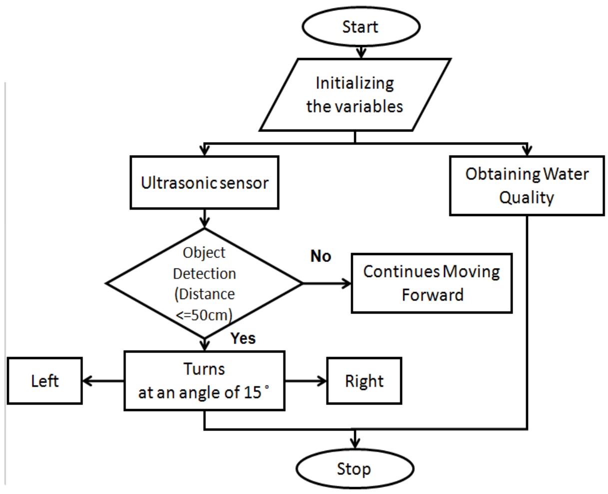

Fig 3.Flow chart

Coming to the water quality value, when the value is obtained it is sent to the microcontroller and it is transmitted outside with the help of the Bluetooth module.

6. CONCLUSION

This paper presents design of a robotic fish which is used to check the water quality and moves around freely in the water on its own. The Arduino platform used here is a easy, simple and effective in use. The obstacles are detected with the help of ultrasonic sensor and the movement of the fish is done with the help of the algorithm efficiently. In our future work, this can be extended to, monitor the aquatic life by adding camera features and try evaluating it under various conditions such as debris flow speed.

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7. FUTURE WORK

The future work can be extended in several directions. First, for the averaging of robotic fish dynamics, it is of interest to explore analytical insight as to why the scaling functions take the specific simple forms. Second, we will also seek to extend the approach to the dynamic model of robotic fish actuated with a flexible tail, as well as explore the validity of the approach for a wider class of systems with oscillatory inputs. Third, for the environmental reconstruction using the proposed successively spanning the sampling area strategy, it will be of interest to explore ignoring weakly linearly independent columns in the rank computation and analyze the propagation of reconstruction error caused by this approximation, and the performance of the proposed analytical matrix reconstruction algorithm. Forth, we will explore the validity of the approach using the robotic fish prototypes developed at the Smart Microsystems Lab.

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