Underwater Bio-Mimic Robotic Fish

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Abstract

Design and fabrication of biomimetic underwater robotic fish. A robot fish is a type of bionic robot that looks and moves like a real fish. Two motors, an Arduino microcontroller, Bluetooth, and a pump are required to complete the underwater robotic fish project. Motors are employed for quick forward and rotating motion, and the pump assembly aids in deep water diving. In addition, sensors assist the robot in making intelligent judgments such as obstacle detection, direction shift, and so forth. Additionally, essential information such as live streaming, pressure, and temperature are provided. The innovative compromising the agility and performance of the robot that helps to achieve the real motion of the fish, making robot competent for aquatic-based design of robot that helps to reduce the complex structure without applications such as underwater exploration, oceanic supervision, pollution level detection, and military detection This project is also beneficial.

Keywords: Servo motor, Arduino microcontroller, Bluetooth, camera, temperature sensor, water pump, power supply.

Introduction

A flexible tail mechanism allows a fish-like underwater robot to swim quicker and more softly while consuming less energy. The design of the robotic fish is based on the locomotion mechanism utilised in a variety of applications such as ocean development, military operations, and marine environment protection, and it necessitates a high-performance automated underwater vehicle (AUV). Robotics is the study of creating devices that can take the place of humans and mimic their actions. Robots can be employed in a variety of scenarios and for a variety of objectives, but many are now used in hazardous areas (such as radioactive material inspection, bomb detection and deactivation), manufacturing operations, or in situations where humans are unable to live example, in space, underwater, in high heat, and clean up and containment of hazardous materials and radiation. S. Surya and R. Ravi (2020) proposed that the simulation findings reveal that our suggested technique minimizes energy depletion and extends the sensor node's life time. By using high-quality monitoring mechanisms, the application of the suggested work aids in the monitoring of the structural health of buildings, bridges, and towers.[1] Robots can take on any shape, but some are designed to seem like people. This is said to aid robot adoption in certain replicative activities that are normally performed by humans. Walking, lifting, speaking, cognition, and any other human activity are all attempted by these robots. Many of today's robots are influenced by nature, making bio-inspired robotics a growing area. Today, we require a variety of technologies for monitoring and studying our environment. Underwater vehicles of this type have been developed in recent decades to investigate and experiment with water. T. Nallusamy and R. Ravi (2018) proposed that the NBV model functions in conjunction with the model of email worm transmission. This study simulates and contrasts viral spread in relation to node energy and network traffic[2] Fish, an aquatic animal with outstanding man-ability and improved propulsion efficiency, is the best solution for underwater research. The two motors on this Robot's propulsion mechanism allow it to swim in the water. Sensors, actuators, and microprocessors, as well as a control mechanism, are all essential hardware and software components of underwater robots. With its propelling mechanism, this Robot is meant to swim in the water of two servo motors. It may also descend into the water thanks to a ballast tank system. We built and constructed autonomous robotic fish to detect and follow an underwater object in this research.

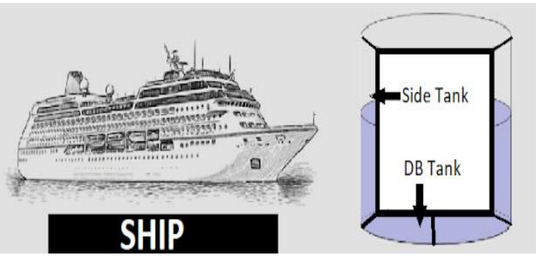

Fig 1 Ballast Tank System

Design of Underwater Robotic Fish

A streamlined head, a body, and a tail make up the most basic biomimetic robotic fish. All control modules, including a wireless communication module, batteries, and a signal processor, are housed in the head, which is often composed of a stiff plastic substance (fibreglass). The body could be made up of several jointed segments connected by servomotors. The rotation angle of the joint is controlled by servomotors. Pectoral fins are placed on both sides of the body in some designs to ensure stability in the water.

Motive power is provided via an oscillating caudal (tail) fin coupled to joints and operated by a motor.

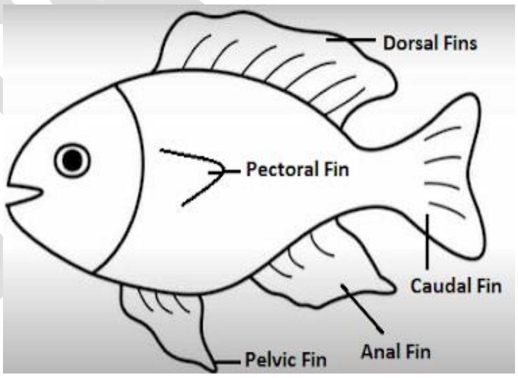

Fig 2 Skeleton of Robotic Fish

Principle of Underwater Robotic Fish

The most essential aspects of robot fish research and development are improving their control and navigation, allowing them to 'communicate' with their environment, travel along a certain course, and respond to directions to make their 'fins' flap. The three primary principles of underwater robotic fish are:

• Anguilliform: Propulsion by a muscle wave in the animal's body that goes from head to tail, similar to an eel.

• Carangiform: Salmon, Trout, Tuna, and Swordfish have oscillating tail fins and tail peduncles.

• Ostraciiform: Like the Boxfish, oscillates only the tail fin without moving the rest of the body.

Mechanical design for underwater robots fishes can be divided into four types.

• Changing wave: The body wave is used to propel from head to tail. With so many hinges and joints, a smooth motion of the entire body is essential.

• Body Foil: The fish pushes the water away from them by oscillating its tail fin and moving its body in a wave pattern.

• Oscillating wing: This approach relies on an oscillating wing-shaped tail fin to provide nearly all of the propulsion force.

• Oscillating plate: In this manner, fish only vibrate at the tail fin, similar to a plate.

Fish Body Design

The purpose of this fish design is to efficiently bio-mimic the shape of streamlined fishes like tuna, which are swift aquatic swimmers in the oceans. The Tuna fish uses the BCF style of propulsion, which is one of two general forms of fish swimming: body-caudalfin (BCF) propulsion and median-pectoral fin propulsion. The BCF mode is classified into four categories: thunniform, anguilliform, subcarangiform, and carangiform modes (Videler, 1993). The frac-tion of the body that actively engages in undulation differs between the modes. The carangiform way of swimming has been observed in a tuna fish (BCF propulsion). Active undulation is restricted to the posterior one-third of the body in carangiform phase. The body design has three major components: the anterior portion, the posterior portion, and the tail.

Mechanics of Underwater Robotic fish

An underwater robot is a waterproof robot that can move in water in response to commands from the operator. There are two halves to this robot: one that transmits and one that receives. Acoustic signals (for example, sonar), light signals, electromagnetic signals, and bionic sensors are used in most underwater sensing systems. The position of a submerged object is determined by monitoring the transit duration and phase difference of acoustic pulses, which may operate over a much greater range and are unaffected by water turbidity. Sensing is done using bionic sensors. platforms that can bend, stretch, or morph into different shapes to sense environmental stimuli such force, displacement, pressure, temperature, or chemicals by tiny mechanical deformations. Underwater electromagnetic signals can be used for navigation, sensing, and communications, among other things. A cable can provide short-range navigation while also reducing the required range for mobile communications. As a controller, an Arduino Nano board is used. The mega 328 is a microcontroller with 32Kb of flash memory. The 12V LiPo battery provides power to the robotic fish.

Construction

The anterior half of the link has a profile made up of two circular arcs that mix with the flat area of the beginning of the middle part of the link, as shown in the illustration. This also eliminates any non-differentiability points at the point of contact between this component and the prior link's posterior part. Furthermore, the profiles have been chosen to avoid any places of non-differentiability on the link's surface. The smooth profile allows the wire to travel freely inside the grooves on the surface without causing too much friction. Furthermore, the wire moves perfectly along the link's surface, avoiding any spots where the wire loses contact with the link's surface which would have thrown off the precise calculation of the Wire lengths are substantially more complicated to run). However, in this scenario, the wire's running length equals the length of the grove's path, assuming perfect contact. Middle Element is the flat area of the connection is characterised by this part of the link's design, which is pretty straightforward. Posterior Part is the link's posterior section has two circular arcs that perform the same purpose as the link's anterior section. The wire glides across a grooved circular arc on the end section of the wire. The length of the wire is the only portion of the connection that is not fixed and changes depending on the angle between the two links.

Controller Design

Surge, sway, heave, pitch, and yaw are the five degrees of freedom available to the fish. The frequency of undulation of the tail fin, mean position of the servo-link mechanism, and movable mass dis-placement in the barycentre mechanism are used to manage them. The following paragraphs go over these control inputs in great depth. To begin, observe that this is an under-actuated system, as there are only three control inputs available to control a dynamical system with flexibility in five of the six dimensions conceivable. Assume that the robotic system is required to achieve a reference speed known as cruising speed. The real speed, on the other hand, begins at zero (rest) and attempts to stabilise at the cruising speed number by the action of the controller. Figure 6 shows how the error, or the difference between actual and cruise speed, is compounded by a gain factor and used to offer feedback. The PD-controller is benchmarked in this figure by having it negotiate a sophisticated way-point tracking that resembles the figure of 8. It demonstrates the controller's efficacy in surface swimming. A 3D controller will be developed in the future.

Sensors in Underwater Robotic fish

For the propulsion mechanism with a specific angle of rotation, servo motors are employed. The servo motor angles for the fish's motility are controlled by PWM (Pulse Width Modulation) pulses. The water collection is powered by a DC motor. The adjustable servo motor angles regulate the fish's speed. The temperature is measured with an LM35. The built-in ADC converts analogue signals to digital data, which may then be sent to the base station through wireless connection. The robotic fish has a camera attached to it. This camera aids in the monitoring and surveillance of the underwater environment.

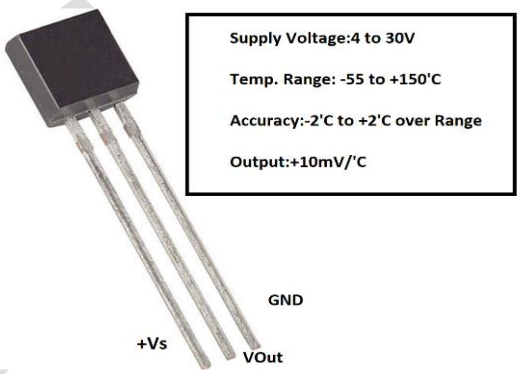

Fig 3 LED Sensor

• Photo Sensor: The fish will turn in the direction where the sensor detects the most light. If both sensors detect the same quantity of light, this indicates that the source of irradiance is straight ahead, and the robot will proceed.

• Pressure Sensor: The pressure sensor will be utilised to tell the robot how deep it is submerged, as well as to detect any agitation of the water in its immediate vicinity.

• Humidity Sensor: This device can be used to determine whether or not the robot is submerged in water.

• Audio Sensor: A microphone can be fitted to allow audio signals to be detected. A bigger surface area as well as many more microphones would be necessary to detect the position of the sound source.

Assumptions

1. Fish are active when there are no waves, this is when the water is quiet and deep.

2. The fish is travelling at a constant positive velocity of U.

3. The coefficients of hydrodynamics are considered to be constant.

4. Off-diagonal terms in the relevant tensors mentioned ahead are ignored, implying that a decoupled dynamics model is used.

5. The control forces and moments outlined in the following section account for the influence of body flexibility.

6. Design factors are expected to passively stabilise roll.

Software Tracking

We created a vision-based tracking in our control software that processes the frames taken by the upper camera of the experimental setup in order to retrieve the position of the agents during an experiment and to operate the Fish. To extract the moving items, each frame is subjected to a backdrop subtraction. For closed-loop control, the robotic fish poses are used to estimate the poses of the robotic fish. This programme also controls the robotic fish caudal peduncle's beating. In terms of global architecture the robotic fish mobility is which are transmitted from the main application and contain the locomotion parameters. Each robotic fish has the characteristics mentioned in the following section implemented onboard. The robotic fish can emit events in the event of an impediment or a power outage thanks to the event-based protocol. The IR proximity sensors are used to identify obstacles: when an IR signal received by the sensors exceeds a particular threshold, the robotic fish avoids the obstruction by rotating in the opposite direction of the received signal for a certain length of time. It enables the robotic fish to avoid colliding with objects such as walls and other robotic fish.

Movement of Underwater Robotic Fish

Fish employ the following tools to swim efficiently:

- Fins are used to glide and turn.
- The air bladder allows you to move up and down.
- Body with a streamlined shape to reduce pressure drag.

Slime coat: To reduce drag caused by friction.

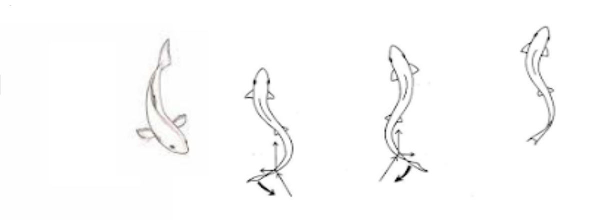

Fig 4 Movements of Robotic Fish in Underwater

Communication

To use Bluetooth to send and receive data with the robotic fish from the base station. Robotic fish may be operated manually or automatically using an Android application and a Bluetooth communication module. The data is transferred to the computer via the floating antenna for live streaming.

Proposed System

PVC is used to create the fish. PVC is a lightweight and durable material. Four servo motors power the robotic fish system. The movable joints are coupled to the servo motors. Two motors for the fish's right and left fins, as well as one for the body and another for the tail. For robotic fish locomotion, the body is made up of several jointed segments, and high torque servo motors are the major issue for position change and fast speed. It also provides the flexibility and stability required for stable mobility.

To detect objects, two infrared sensors are affixed to the fish's eyes, and a temperature sensor is attached to the fish's body. The robotic fish's drive circuit is designed on a PCB. Two lithium batteries are used to power all of these gadgets. The relay is also connected to the Arduino as well as the water pump.

Uses

Fish robots have recently become popular in a variety of applications, including maritime studies, military operations, and environmental protection. It necessitates high-performance autonomous underwater vehicles, particularly for propulsion, as well as significant advantages in terms of flexible manoeuvrability. The sensors on the mouth of the Robotic fish can be used to study the oxygen levels in the water. It may learn about the various species in its surroundings by swimming among them and reporting on fish health.

• We can monitor waterbodies using this robotic fish.

• A video and picture capturing facility will aid in the observation of aquatic wildlife.

• Collecting water samples for water pollution monitoring is simple.

• This robotic fish can be equipped with a GPS tracker for navigation.

• This fish can also be equipped with an LED light for cleaning purposes.

Conclusion

Robotic fish have been created for this project to perform real-world tasks such as underwater object identification and tracking, navigation, and entertainment. A caudal fin, controlled and operated by a sensing circuit, servomotor, and computer algorithms, aids the robotic fish's mobility. Both mechanical and controller ideas are given in this study. We can make the posterior body flexible and light-weight by installing servos at the head rather than at each joint. It has also been demonstrated how a flexor-extensor mechanism can be used to replicate the undulation of fish. Though the flexor-extensor mechanism has been utilised before in conjunction with the human arm to represent undulation and a variety of other motions, we were the first to employ it while lowering the number of servos. Robotic fish provide enormous potential for innovation. Around 70% of the world's aquatic bodies have yet to be explored. Exploring the waters is becoming increasingly vital as the world's population grows and puts pressure on terrestrial resources. Robotic fishes will undoubtedly be the stars of the show when it comes to efficiently navigating the oceans and seas. The robot's two servo motors, which provide propulsion, enabling it to actively manage degrees of freedom while also helping it to simulate the motion of a real fish. The robotic fish dives in smoothly and effectively thanks to the depth control mechanism created utilising a ballast tank.

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