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# A NOVEL CONCEPTUAL DESIGN OF AN UNDERWATER ROBOT USING BIOMIMETICS.

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*Abstract :* Underwater Robots can operate and explore various regions of the ocean that are too hazardous or challenging for humans to access. Humans are unable to work in underwater for extended periods of time at depths more than a few meters and to collect the data necessary help with surveys or mining. Underwater robots are particularly helpful in this situation and can simply take over this work. The design and development of a system for people that can withstand the conditions and difficulties faced in deep sea research is exceedingly tough and expensive. To achieve effective working and stability of the underwater robot using biomimetic design and a wireless communication-based has been proposed in this study.

***Key words*:** Underwater Robot, Biomimetics, Conceptual Design

## I. INTRODUCTION

A robot is an automatic system that can perform any task without human intervention and works more efficiently than human beings. Unsafe or difficult for people to access areas of the ocean can be explored by an underwater robot. It is advantageous to use underwater robots to explore and study the ecosystems in the oceans and seas across the world because 75% of the planet is covered by water. Humans are incapable of collecting the data required for surveys or mining when working underwater for extended periods of time at depths more than a few meters. Robots that can operate underwater are especially useful in this case and can simply take over the work. Several kinds of underwater robots are Autonomous Underwater Vehicles (AUV) and Remotely Operated Vehicle (ROV) underwater robots are the two categories of underwater robotics. The AUV is a self-driving robot that gathers and stores data on its own. It return's back to the ship or predefined area after surviving or completing a task so that the data can be gathered. Humans utilize cables to control ROV; it accepts control signals via cables, consumes electricity via cables, is only used by outside operators, and transfers data directly. ROV tether-connected to the controller console Closed frame for reducing drag through precise examination erroneous inspection connected via cable to a power source can include tooling and grippers Speed up your movement. AUV is a closed or open frame is used. Visual examination a general visual assessment, Closed frame for reducing drag, Time is limited because of the power batteries. Among underwater robots' benefits are robotics is a vast, unknown subject, and each design is guaranteed to be unique. wide range of chances because the majority of our planet is under water there are too many possibilities for commercial uses, any type of water source, including a swimming pool or a nearby pond, can be used as a testing setting. The drawbacks of underwater robots include Electronics hate water, thus if the circuitry is not water-proofed, you must organize all of your circuits. Deeper depths necessitate more complex designs and much investigation, very few aquatic robots would require very little support and very few resources would be accessible. Not every land-based sensor operates in the same manner in the water. The working of marine-based robots is substantially impacted by density and weight, whereas land-based robots may easily ignore these factors.

Biomimetics is the choice of or adaptation to an existing design in nature. This aids in effectively resolving the issue, which has a natural remedy. The way that organisms naturally adapt to different habitats teaches designers important insights about resource management. In order to increase locomotion efficiency, maneuverability, and adaptability, biomimetics was used as a design principle for underwater robotics. This method has demonstrated amazing vitality and great growth potential. But the majority of designs aim to resemble a particular aquatic life or its particular function. The design of underwater robots using biomimetic principles that take into account the collaboration and coordination of numerous individuals could be a potent tool for creating robotic systems that go much beyond simple mimicry of a particular aquatic organism. The need for underwater robots with high stability and maneuverability has become increasingly pressing as a result of the growing demand for such devices in the context of professional explorations, measurements, and inspections.

Gelli et al. (2018) have designed an Autonomous Underwater vehicle named Zeno environmental nautical operator (Zeno)for the purpose of archaeologists with a capability to run for a duration of 1 hour. A low-cost crater is designed which mainly helps to provide sufficient flow of water to the thrusters and avoiding the access to the thrusters by the external bodies such as hand and ropes. Santhan Kumar et al. (2018) have created an AUV for the purpose of deep underwater exploration which is pre-programmed using Raspberry pi controller to follow the waypoint with an endurance of 2 hours. During the survey any marine animals like fish can be captured by the camera incorporated in the AUV, it starts to track and follow the marine animal when the communication of tracking gets lost the vehicle moves to the nearby waypoint. Jun Shintake et al. (2019) have fabricated two robots with a shape of fish and jellyfish structure using Dielectric elastomer actuators. It consists of laminate of soft silicone layer and the miniaturized electronic components like DC/DC converters, LiPo batteries and microcontroller boards can enable untethered locomotion and sensing abilities for robots. With such components embedded, 10 cm long robots may swim for a few hours using a 2 cell LiPo battery of 240 mAh.

Ahmed Chemori et al. (2019) have developed a biomimetic U-CAT turtle for the approach of depth control using non-linear RISE Feedback and PID controller. In terms of tracking performance, the nonlinear RISE feedback controller has been observed to exhibit better results compared to the PID controller. Jebelli et al. (2017) have installed mass shifter inside the AUV to account for thruster movement and enable pitch mobility. It has two modes: First mode for the horizontal movement using the mass shifter and thruster angle for obstacle manoeuvring and Second mode for the Vertical movement through body pitch angle which saves energy and changes direction in deep waters. Ayushman Barua et al. (2018) have created a path planning for an identification mission in a lemniscate form using an AUV to gather precise measurement data of the object and the vehicle will traverse in multiple times from various angles, creating a lemniscate shape with the object at the center. The choice of a lemniscate shape ensures that the vehicle passes the object twice, resulting in higher quality video recordings. Once the lemniscate is completed, the vehicle will return to its pre-planned path to resume the mission. Therefore, the path must be planned from the endpoint of the lemniscate.

Eleni Kelasidi et al. (2016) have demonstrated the effectiveness of the Sight (LOS) guidance law in achieving straight line path following for lateral undulation and eel-like motion patterns in underwater snake robots. By this, it could increase the efficiency of the control of underwater snake robot in practical applications. According to the test result, underwater snake robots are more energy efficient than ROVs in terms of transportation cost and total energy consumption compared to all other motion modes. Pengyao Yu et al. (2017) have designed and simulated a dynamic model of disk type underwater gliders and various motions were studied the performance of a various action like omni-directional motion for virtual mooring, horizontal saw-tooth and vertical saw-tooth motion under simulation process. The simulated result shows the feasibleness and movability of the disk type underwater glider. Yueqi Yang et al. (2018) have proposed a fault-tolerant control, multi-jointed self-propelled method with a stuck tail joint to reduce the yaw effect caused by faults in the 2D plane and the torque of the head in the robotic fish can be controlled. Dynamic analysis enables the fish's other joints to quickly adapt to impact from stuck joints, minimizing lateral displacement due to posture adjustment. The proposed fault-tolerant control method exhibits stability and anti-interference ability with the head swinging on the yaw angle plane. A feedforward compensator designed based on dynamic analysis and specific control of the Central Pattern Generator's (CPG) parameters improves the robotic fish's fault tolerance.

Daniele Costa et al. (2017) have created an ostraciform swimming robot which has high waterproof resistance and the ability to withstand high pressure. Despite of having lower propulsive efficiency, the robot has been validated to reach depths of 100 meters without any damage. The whole body is 800 mm in length, weighs 6kg (including fins), and has an average speed of 0.42 body lengths per second. Ilya D. Galushko et al. (2018) have developed a prototype of an underwater robot with a variable geometry of the hull using pneumatic propulsion in the form of anisotropic body concept to determine its hydrodynamic characteristics. Variational geometry reduces hydrodynamic resistance, depending on fluid flow parameters and structure. This leads to high maneuverability with the ability to change pitch, yaw, and roll angles. The outer shell's variable shape enables sharp maneuvers, immersion and ascent modes, and high-speed movement above 0.5 m/s with low noise. It also minimizes pressure and velocity pulsations, reducing resulting vibrations and noise.

Keita Isaka et al. (2019) have developed a drilling robot based on earthworm locomotion for sea floor exploration and successfully developed for land, demonstrated the ability to create curved boreholes of 1670-mm turning radius and 613-mm depth. The development of a sea floor robotic explorer design especially aimed for horizontal excavation and collection of rare earth element samples. By convention, these elements get deposited 2-3 m beneath the deep-sea floor. Wide-scale area exploration is possible by deployment of multiple robots to autonomously search beneath the seabed. Taavi Salumäe et al. (2019) have presented a new control architecture and its implementation for a biomimetic four-fin underwater robot U-CAT in hovering mode. They use fin-based locomotion to achieve high maneuverability and for quiet and safe locomotion. U-CAT is an agile 6-degrees of freedom maneuverable vehicle developed for autonomous and semi-autonomous inspection of confined spaces. The control system used in U-CAT was remotely operated vehicle mode and fully autonomous mode. U-CAT is 56 cm long and weights approximately 19 kg, internal battery allowing at least 6 hours of autonomous operation. They use sensors of MPU-6050 IMU for measuring the robot's attitude, GEMS 3101 analog output pressure sensor with 18-bit. Asghar Khan et al. (2019) a novel concept designed of a multi-legged underwater manned seabed walking robot is presented. The robot will be used in both shallow water current (1–2 m/sec) and deep water up to 500 m. It is powered by an external electric power source through tether cables. The robot walks using six legs and swims by two paddles. It allows the robot legs and body to adjust its posture against water current or any other disturbing force. Underwater manned seabed walking robot (UMSWR) is predominantly forward walking, moving slowly with a speed of 0.5 m/sec within a limited range of 500 m radius from the source ship. It has the ability to turn left or right, and the navigation is very simple to control. UMSWR has a total of 36 joints and all these joints are controlled by Brushless Direct Current (BLDC) electric motors, with one for each joint. This paper discusses about the novel conceptual design of an underwater robot using biomimetic inspired crab design

## 2. CONCEPTUAL DESIGN

According to the early research and survey of the autonomous underwater robot, based on efficient traveling and stability chosen biomimetics design. Where else there are so many biomimetic designed underwater robots is already developed, from that we have chosen some of the best conceptual design for the efficient traveling and stability of the robot which has been listed below.

### 2.1. Crab Shaped Design

The main reason for choosing this design is its ability to perform two types of motion: it can move on land and swim in water. It uses its legs for motion, and its hard exoskeleton provides protection against predators while also allowing it to blend into its surroundings for camouflage. This design can withstand damage to a certain level. However, its efficiency in crawling motion is greater than in swimming motion; it can swim up to a depth of approximately 165 feet. If it becomes stuck in underwater plants or other obstacles, it can easily get free. While this design was developed for swimming purposes, the efficiency of the crab's natural design falls short in swimming, thus necessitating the adaptation of a new design for efficient swimming. It does not have a steam line body so the friction will be more. The movement of swimming will be slow, and it does not meet the requirement. Crabs typically have a thick exoskeleton that is mostly made of highly mineralized chitin carbohydrate polymer) occurring primarily in crab shells and is equipped with two chelae (claws). Crabs have jointed legs and frequently move sideways. Before moving forward or backward, crabs flatten their final pair of legs into swimming paddles. The different views of the crab shape-based design are presented in the Figure 1.

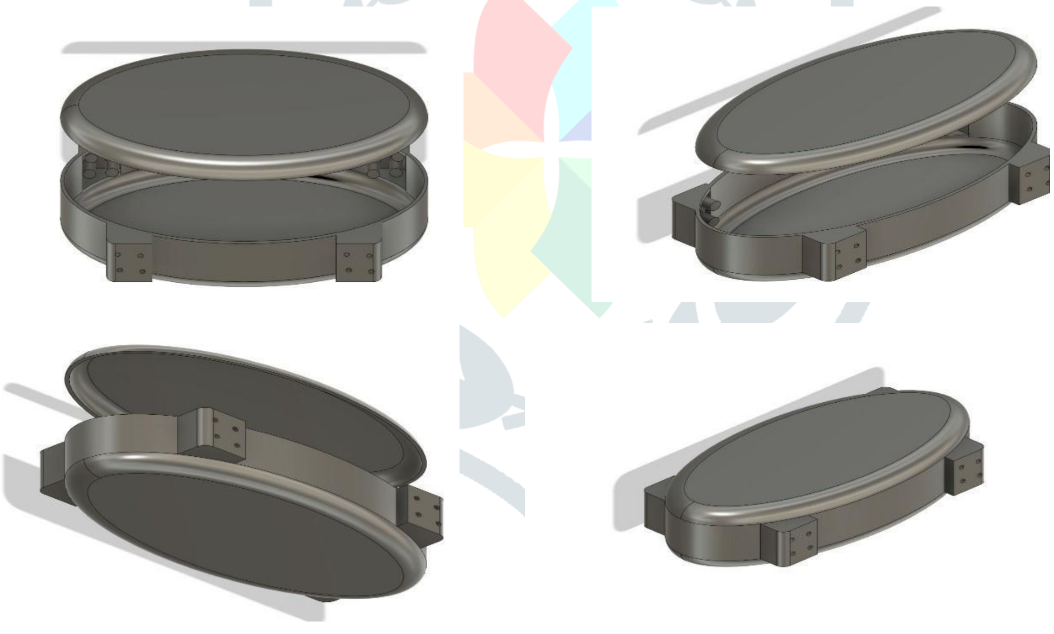

Fig 1. Different views of crab shaped design

### 2.2 Turtle Shaped Design

A reptile known as a testidune or turtle possesses a unique shell structure that serves various functions. The shell is formed from the turtle's ribcage and comprises bone and cartilage. Turtles have thinner, water-resistant shells that allow for streamlined movement when swimming. The shell has two parts: a plastron at the bottom and a carapace on top. These two structures meet at the sides to form a sturdy skeletal frame. The turtle shell consists of several layers, each with its own unique composition and role. The outermost layer comprises scutes, which are broad scales. These scutes, similar to human hair, contain keratin, a substance that makes them comparable to human fingernails. Since keratin is dead tissue without nerves or blood supply, it is not capable of experiencing pain or sensations. The reptilian skin is visible beneath the scutes, and the head, tail, and feet have the same skin as the rest of the body. Turtles extend all four legs as they move through the water, using their webbed feet to paddle. When turtles need to breathe, they surface after diving and paddling around. Sea turtles, in particular, have shells that enable them to move through water more efficiently. They are excellent divers, with leatherback sea turtles capable of diving up to 1,000 feet. Despite their shells, turtles are proficient swimmers because they alter their buoyancy in the water. Some turtle species have shed most of their hard shells, while others have reduced the thickness and size of their shells over time to facilitate swimming. Sea turtles have long flippers instead of webbed feet like their freshwater counterparts, which help them move efficiently through water. The powerful front flippers act as paddles, while the smaller back flippers serve as rudders to aid in steering. Sea turtles are hydrodynamic swimmers, thanks to their streamlined shells and flippers. The different views of the turtle shape-based design are presented in the Figure 2

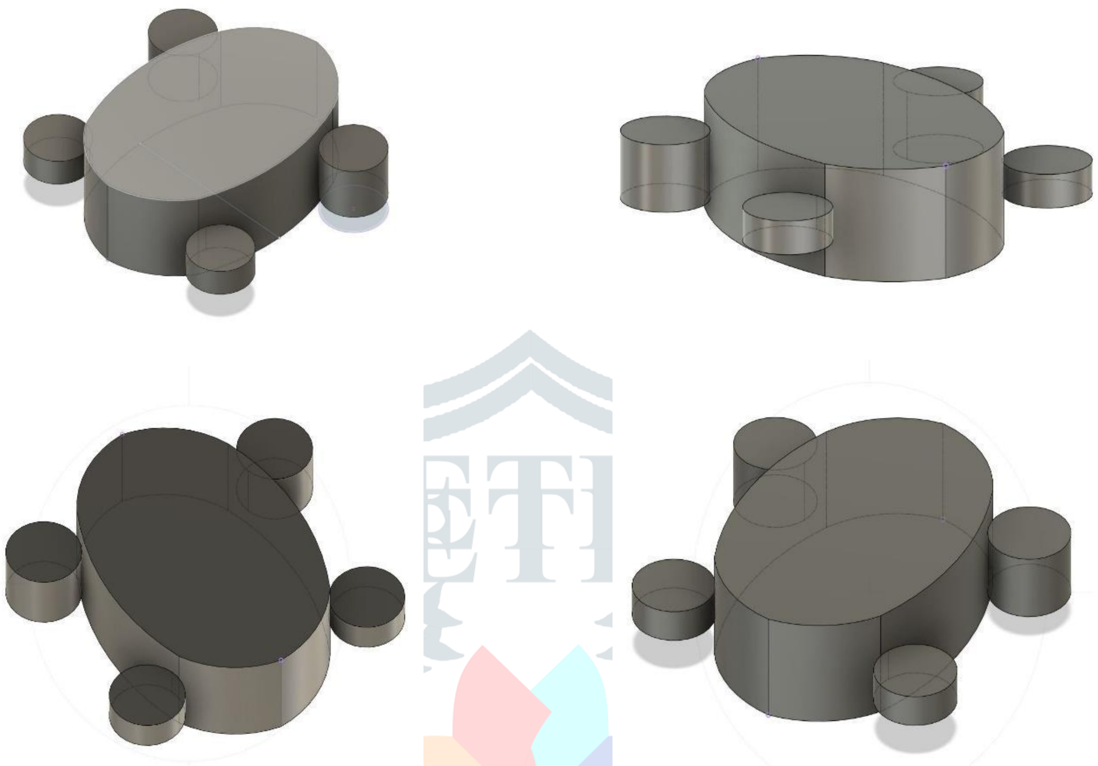

Fig 2. Different views of turtle shaped design

**3. RESULTS AND DISCUSSION**

As per the characteristics of the above concerned design the crab's method of locomotion is less effective than that of the turtle since the crab relies on crawling, which is impossible in deep oceans, compared to the turtle's usage of swimming, which has no such restrictions and facilitates transit in such waters. Due to insufficient spacing, it is much more difficult to incorporate electrical components and place actuators in the crab shaped design thus, it is preferable to do so in the turtle. The swimming efficiency of the turtle is more efficient than the crab with a speed of 1.4 to 9.3 km/h and even though they can swim up to 35 km/h when startled whereas the crab can only dive up to 165 feet only but the turtle can dive up to 1000 feet. While the turtle employs propulsion systems that have been positioned externally in the walls, the crab uses actuators, which offer no prospect of water sealing of the robot since buoyancy causes more pressure, which leads to water penetration. According to the research on the characteristics both biomimetic design, the turtle shaped design is more efficient in terms of swimming, speed, depth and stability

**4. CONCLUSION**

According to the novel conceptual design of the above mentioned two biomimetics structure 1. Crab shaped design 2. Turtle shaped design, it is concluded as follows

- In underwater, the turtle can dive up ultimately more than the crab with a speed of 0.9 to 5.8 mph.
- The shells of the turtles can adopt with the various sea currents in underwater and also with the buoyancy.
- The turtle-based design has a sufficient spacing for placing electrical components.

Further, the design of Turtle shaped structured underwater robot and study of its performance are under progress.

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