International Journal of Core Engineering & Management
Volume-7, Issue-08, 2023 ISSN No: 2348-9510

CASE STUDIES IN ROV DEVELOPMENT: INNOVATIONS IN UNDERWATER EXPLORATION TECHNOLOGY

Priyanka Das
Controls Engineer
Cincinnati, USA
priyanka14das@gmail.com

Abstract

Oceanographers and other underwater explorers have been yearning to visit the depths of water bodies for research purposes. Reportedly, these experts have only managed to visit and research about 5% of this sphere of the universe. The invention of Remotely Operated Vehicles (ROVs) has played a crucial role in catching up with this gap. The technology comprises different parts such as cameras, robotic arms, thrusters, impellers, bulbs, tethers, sensors, frames, and control systems. The control system consists of a complex build-up that receives information from various parts, including the camera and sensors positioned at different parts. Despite the multifaceted design of the ROV, there is wide room for improvement. For instance, installing Environmental DNA (eDNA) on the robot will enable it to detect aquatic life in the underwater surroundings by reading their genetic materials and classifying them accordingly. Also, incorporating artificial technology (AI) into the technology will enable it to autonomously follow specific creatures or objects in water bodies and send signals without tampering with their environment and behavior.

Index Terms— ROV, Sensor, Technology, AI, eDNA, Robot, Underwater, Signal, Innovation, Operator, Control, Researcher, Cameras.

I. INTRODUCTION

The current rapid innovative progression of technology has significantly boosted the development of quality ROV. An ROV is a well-designed robot with electrical, hydraulic, and sensor connections, allowing the operator to control and navigate it effectively underwater. The robot is normally unoccupied, and it has advanced technological elements such as cameras, screens, bulbs, frames, and sensors that enable it to transmit signals in the form of audio and video to the operator. The operator interprets these signals, which gives the impression of the underwater environment. ROV's innovation has seen tremendous success due to the efforts of engineers and other experts in this technology. Plans for the robot aim to include Edna and AI elements to enable it to perform more exemplary [2]. With its status, ROV is a highly technological robot that has revolutionized underwater exploration, and its advancement will bring great success for aquatic researchers.

II. INNOVATIONS IN UNDERWATER EXPLORATION TECHNOLOGY

The ROVs contain advanced sensors that work differently to help obtain information and transmit it to the operators. For instance, engineers equip these vehicles with acoustic sensors that detect slight sounds from aquatic organisms and examine their echoes. It also notices the sound changes and the magnitude of the pulses and helps record underwater measurements. The optical sensors in these robots gauge the degree to which light collides with the water [6]. They help read the water clarity, depth, and spread of plankton. The sensor works collaboratively with the motion sensor to measure and record the real-time data on the robot's depth. Despite being useful for recording the underwater surroundings, it allows the operator to control the ROV effectively. Chemical sensors contain special sensitivity elements that detect pollutants, water gases, and different kinds of nutrients. These sensors enable researchers to classify underwater objects, especially those with chemical substances. The sensors are a crucial innovation in the ROVs, contributing significantly to their functioning.

Gutierrez et al case study examines the development of the ROV from the mechanical design perspective [4]. Below are some of the robot's design sketches. The engineers developed these sketches using simple to complex geometric plans.

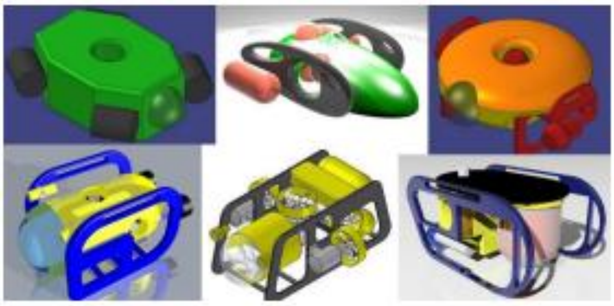

Figure 1: Sketches of ROV design

The basic design of the ROV entails three primary subsystems which are distinctive in their functions. The vehicle is the robot that moves underwater and records the underwater environment, sending signals to the operator. Many elements are attached to this part since it is the largest unit of the three. The second part is the surface control unit, which remains off the water. The operator uses this station to control the vehicle and maneuver it underwater. It contains different parts, including the interface, the powerhouse, which supplies energy to the rest of the system, and the joystick for controlling the vehicle. The third part is the communication unit between the two subsystems. The three distinct parts work coordinatively to deliver the intended function.

Patiris study indicates that engineers use innovative techniques to make submersible ROVs [8]. They assume different methodologies, which lead to the production of underwater robots of different sizes, strengths, weights, torque, and power. The lightest and smallest robots are called the micro-class ROVs; their weight is normally less than 3 kg. The Mini-class ROVs are usually below 15 kg and serve similar purposes to divers. The light work-class robots are relatively heavier and can go to a depth of 1000 meters. The heavy work-class underwater technologies are heavier and can contain two manipulators. The trenching and Burial robots are superior to all these, as they move about 6000 meters with a heavy cable.

According to Dalhatu, Abdullahi Abba et al. study, extensive innovation has produced hybrid ROVs

International Journal of Core Engineering & Management
Volume-7, Issue-08, 2023 ISSN No: 2348-9510

[1]. These powerful technologies fit into the water ROVS and Autonomous Underwater Vehicles (AUVs) categories. Engineers developed the hybrid robot idea in 2006 when they actualized the idea of the autonomous underwater machine called a SWIMMER. This version of underwater technology can perform various tasks, including shallow—and deep-water explorations. In most cases, they help conduct water surveys and research on living creatures or non-living things.
Marzbanrad et al. case study highlights that the ROV's design and development should follow a specific standard [7]. The various parts of the frame should be waterproof. The design must include strategically positioned sensors to give the ROV and operator a clear vision of the environment. A flexible cable like a tether should act as a control command that enables the operator to navigate the robot. The case study argues that the frame should follow a design that allows it to support additional modules.
Furthermore, García-Valdovinos, Luis Govinda, et al. research indicates that autonomy is the common innovation in all underwater robots [3]. The autonomy enables the operator to position-track, station-keep, and control it when it enters the water depth. The presence of sensors is key in sending signals that help perform various maneuvers such as Sliding Mode Control (SMC), intelligent control, or Proportional Integral Derivative (PID) control. The image below shows a sample of the Kaxan ROV. The technology has improved features with different kinds of control abilities.

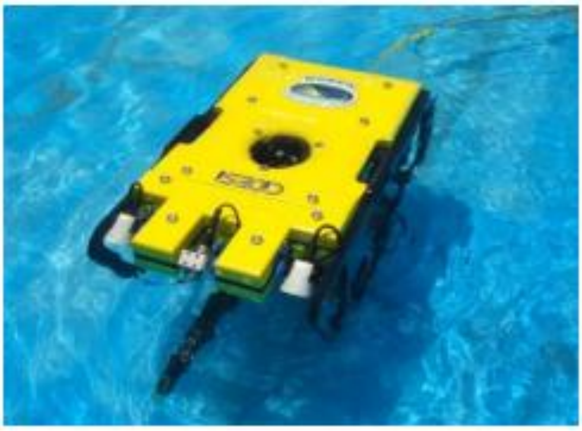

Figure 2: Kaxan ROV

III. FUTURE ROOM FOR UPGRADING THE UNDERWATER ROBOTS

In line with this, introducing AI technology will conceive trained ROVs that can detect living creatures and follow them without interfering with their way of life. These innovations will include smooth communication between the control station and the other parts attached to the frame [5]. The AI platform should be advanced to analyze the data it receives from the surrounding water. To perform these functions well, other elements such as WebGIS are crucial as they will promote the storage, analysis, pictorial visualization, and assessment of the spatial data on the internet.

IV. CONCLUSION

In conclusion, ROVs are advanced robots that move underwater, explore the environment, and send signals offshore. These technologies have extensive innovations, including sensors, hydraulics, and

International Journal of Core Engineering & Management
Volume-7, Issue-08, 2023 ISSN No: 2348-9510

electrical elements, that enable them to perform their intended functions. Despite the abilities of the existing ROVs, some gaps still exist, which engineers are on the verge of filling to ensure they perform exemplary. To boost functionality, engineers should build powerful underwater technologies that can read eDNA and analyze them accordingly. Also, incorporating AI in these technologies will render the ROVs powerful and able to move independently and explore the underwater environment. In turn, their movement will not interfere with the normal aquatic life.

REFERENCES

1. Dalhatu, Abdullahi Abba, et al. "Remotely operated vehicle taxonomy and emerging methods of inspection, maintenance, and repair operations: An overview and outlook." *Journal of Offshore Mechanics and Arctic Engineering* 145.2 (2022): 020801.
2. Flanigan, Dan, et al. "The Development and Deployment of a Programmable Water Sampling
3. System Using an Autonomous Surface Vehicle." *OCEANS 2021: San Diego–Porto*. IEEE, 2021.
4. García-Valdovinos, Luis Govinda, et al. "Modelling, design and robust control of a remotely operated underwater vehicle." *International Journal of Advanced Robotic Systems* 11.1 (2014): 1.
5. Gutierrez, Luis B., et al. "Development of an underwater remotely operated vehicle (ROV) for surveillance and inspection of port facilities." *ASME International Mechanical Engineering Congress and Exposition*. Vol. 44489. 2010.
6. Kravari, Kalliopi, Dimitrios Tziourtzioumis, and Theodoros Kosmanis. "AIRUV: a remotely operated underwater vehicle with artificial intelligence perspectives." *Distributed Computing and Artificial Intelligence, Special Sessions, 17th International Conference*. Springer International Publishing, 2021.
7. Lund-Hansen, Lars Chresten, et al. "A low-cost remotely operated vehicle (ROV) with an optical positioning system for under-ice measurements and sampling." *Cold Regions Science and Technology* 151 (2018): 148-155.
8. Marzbanrad, Alireza, et al. "Design, construction and control of a remotely operated vehicle (ROV)." *ASME International Mechanical Engineering Congress and Exposition*. Vol. 54938. 2011.