Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 04| Issue 04 | July-Aug. | 2024
Journal homepage: https://gjrpublication.com/gjrecs/
Review Article

The Obstacles Autonomous Underwater Vehicles Face

[1]Naima Hafiz Abubakar, Abdulkadir Shehu Bari[2], Lawal Mukhtar Ibrahim[3], Mukhtar Ibrahim Bello[4], *Muhammad Ahmad Baballe[5]

[1]Department of Information Technology, Facaulty of Computing, Bayero University, Kano, Nigeria.
[2]Department of Computer Science, Audu Bako College of Agriculture Dambatta, Kano, Nigeria.
[3]Department of Electrical and Electronics Engineering, Altinbas University Istanbul, Turkey.
[4]Department of Computer Science, School of Technology, Kano State Polytechnic, Nigeria.
[5]Department of Mechatronics Engineering Nigerian Defence Academy (NDA), Kaduna, Nigeria
DOI: 10.5281/zenodo.12759675 **Submission Date:** 10 March 2024 | **Published Date:** 17 July 2024

***Corresponding author:** Muhammad Ahmad Baballe
Department of Mechatronics Engineering Nigerian Defence Academy (NDA), Kaduna, Nigeria
ORCID: 0000-0001-9441-7023

Abstract
Even with more research, many parts of the marine ecosystem remain inaccessible to humans. AUVs, or autonomous underwater vehicles, are superior to humans as tools for ocean exploration. Underwater vehicles play a significant role in both the military and civil domains and are valuable instruments for the discovery of marine resources. An essential component of underwater vehicle control is path planning.

Keywords: Challenges, Autonomous Underwater Robot (AUV), Obstacle Avoidance, Ocean, Machine Learning, Path Planning.

I. INTRODUCTION
Even with more research, many parts of the marine ecosystem remain inaccessible to humans. An autonomous underwater vehicle (AUV) is a more useful instrument for ocean exploration than a human being. As of right now, AUVs are crucial for a number of tasks, including underwater pipeline identification [10], military combat assistance [9], and marine environment investigation [8–10]. AUVs need a strong path planning system in order to complete missions [11], but they will find it challenging to execute underwater activities precisely in a complex marine environment. The effectiveness with which the mission is carried out by the AUV and its safety will be greatly influenced by the quality of the planned path. As science and technology advance, researchers are creating an increasing number of path-planning algorithms. Examples of these include the RRT [15] algorithm, the A* [13] algorithm, the Dijkstra [12] algorithm, the artificial potential field method [14], and other algorithms used in the AUV field.

II. RELATED WORKS
This research proposes a workable rolling speed obstacle solution to address the issue of inadequate path planning and the obstacle avoidance effect of autonomous underwater vehicles (AUVs) in a dynamic environment. This approach builds a suitable three-dimensional model predictive controller based on the rolling window method under a hybrid obstacle avoidance structure, combines the speed obstacle method with the rolling window method, and optimizes the objective function to achieve stable tracking of the reference path. While the window is rolling, a three-dimensional collision cone and speed obstacle cone model are built. The AUV is guided to safely avoid obstacles by tracking the critical collision point if the collision avoidance condition is met. If collision avoidance is not successful, the AUV is guided to regain its trajectory. The rolling speed obstacle approach outperforms the rolling window method and the speed obstacle method by 40% and 30%, respectively, in avoiding dynamic impediments, according to the final simulation and experimental results. This paper's methodology can significantly enhance AUVs' dynamic obstacle avoidance capabilities during real-time path planning [1]. Underwater vehicles play a significant role in both the military and civil domains and are valuable instruments for the discovery of marine resources. An essential component of the field of underwater vehicle control is path planning [21–22]. In the subject of path planning, graph-searching-type algorithms, sampling-based

algorithms, and potential field-based algorithms are currently actively utilized. Nevertheless, conventional approaches show limited flexibility in a dynamically unstructured setting. Machine learning techniques have been progressively introduced into the field of path planning with the rapid advancement of artificial intelligence. These methods have demonstrated benefits in terms of adaptability to an unstructured environment. This article provided a detailed introduction to the intelligent route planning technologies and their properties, with a focus on their use in underwater vehicle path planning. Underwater vehicle technology for coverage path planning and collaboration was summed up. The ultimate development path of underwater vehicles is envisaged with an eye toward addressing the issues with current path planning [2]. Unmanned vehicles [20] have been more and more popular in the last few years, finding ever-greater uses in the military, business, and air, ground, and marine research sectors. Specifically, autonomous obstacle avoidance and adhering to the Rules of the Road when navigating in the presence of other marine traffic are two of the hurdles that unmanned marine vehicles present in their quest for more autonomy. A series of goals for enhancing autonomy are outlined in the USV Master Plan, which was created for the US Navy with the intention of increasing mission diversity and decreasing supervisory involvement. This paper discusses the particular research needs that have been identified from noteworthy studies completed thus far, namely in the areas of navigation, guidance, control, and motion planning. To stop marine mishaps that are blamed on human error, obstacle avoidance methods incorporate the International Regulations for Avoiding Collisions at Sea. Since they open the door to the establishment of laws governing unmanned vessels, the inclusion of these crucial safety features may be essential to future increases in demand for USVs [3]. A basic and difficult challenge in robotics is mobile robot path planning in an unknown environment [23–24]. Dynamic window approach (DWA) is a good way to plan paths locally; however, it is highly dependent on the global reference and prone to failure in an unfamiliar environment because some of its evaluation functions are not good enough and there is no algorithm to determine the weights of these functions. This paper proposes an enhanced DWA based on Q-learning. In order to improve global navigation performance, two new evaluation functions are added to the original set of evaluation functions. Next, we define the state space, action space, and reward function of the chosen Q-learning algorithm for robot motion planning, taking into account the trade-off between efficiency and speed. Next, using Qlearning to adaptively learn the characteristics of the suggested DWA, a trained agent is produced that can adjust to the unidentified environment. Finally, the suggested strategy demonstrates a superior navigation efficiency and success rate in a complicated, unfamiliar environment, based on a series of comparative simulations. To confirm the suggested method's capacity to navigate in both static and dynamic surroundings, experiments utilizing the XQ-4 Pro robot are also conducted to validate it [4]. An affordable and secure instrument that works well for search, investigation, identification, and salvage activities on the sea floor is an autonomous underwater vehicle (AUV). For AUVs, path planning technology is crucial. It consists mainly of modeling techniques and path search algorithms. The technology for AUV path planning has advanced quickly in the last few years. When it comes to complex underwater habitats, AUVs have to contend with different aspects like topography, water pressure, and currents, unlike terrestrial robots. There are difficulties with online obstacle avoidance, path planning in three-dimensional environments, and algorithm resilience. The two key issues that need to be resolved are figuring out an appropriate path-planning strategy and adapting to a complicated environment. In this work, we provide an overview of the fundamentals, benefits, and drawbacks of AUV modeling and path-search technology. This paper's main contribution is a summary of techniques for fixing different technological flaws and enhancing the initial approaches, including dynamic obstacle avoidance, optimization paths, coverage, and processing speeds. This study not only summarizes the features of each method but also shows, in an easy-to-understand manner, the experimental setup, the real-time aspect, the AUV's path planning range, and so on. We also go over the various modeling and path search technologies' application scenarios for autonomous underwater vehicles. Furthermore, we talk about the difficulties posed by AUVs and the future research [5]. A multi-objective ant colony algorithm for underwater robot route planning in marine environments is developed, which aims to address the drawbacks of conventional path planning with a single path length. The objectives of comprehensive planning include safe navigation, energy consumption, and route length. A pheromone classification system and an enhanced pheromone update mechanism are implemented, taking into account varying target performance rankings. In order to determine the best course of action under various navigation targets and enhance the comprehensiveness of the solution, the three targets are optimized simultaneously, and the Pareto solution set concept is presented. The enhanced algorithm's viability and efficacy are confirmed by the simulation findings [6]. The goal of this research is to examine the issue of AUV route planning in maritime environments. The primary element influencing the navigation energy consumption of AUVs should not be disregarded, along with path length and safe obstacle avoidance. These are all important considerations. In addition, the way must meet AUV's mobility limitation; if it does not, AUV cannot use the path. This research offers an upgraded particle swarm (EPA-PSO) path planning algorithm for the aforementioned challenges; the fitness function is built considering path length, energy consumption, and mobility constraints. The potential optimal solutions are kept in the viable solution set, the updated particle velocity law and the particle initialization rule are refined, and ultimately, the ideal solutions are found through comparison. To enable the particles to leap out of the local optimal solution, the particle swarm is endowed with the capacity to jump locally. There is a comparison between the conventional PSO algorithm and the path-planning simulation experiment. The outcomes demonstrate that the AUV three-dimensional path planning procedure can make use of the EPA-PSO algorithm that is suggested in this paper. It may efficiently conserve energy and ensure that the AUV's navigation path satisfies maneuverability standards. The field experiment was finished in

Shanghai, China, and it demonstrated that for the issues covered in this study, it was possible to find a path that would satisfy the maneuverability constraints while consuming the least amount of energy [7].

CONSEQUENCES OF SELF-DRIVING UNDERSEA VEHICLES

1. Stability: Autonomous underwater vehicles possess exceptional stability and agility due to its design. AUVs have a propulsion system made up of one or two thrusters, similar to torpedoes. Additionally, control surfaces are present, which regulate how the vehicle moves. Its structure includes a pressure haul that holds the power electronics and a streamlined fairing that lowers hydrodynamic drag.
2. Low Deployment Cost: A large and intricate support system is not required for autonomous underwater vehicles. They don't require outside power because they have their own energy source. The operating expense of hiring a human operator is also decreased by the lack of external control.
3. Improved Data Quality: In contrast to other unmanned vehicles, like ROVs, AUVs operate without operator control. As a result, it becomes speedier and has a higher data-to-signal ratio. Surveys become quicker and more accurate as a result.
4. Excellent Navigation Algorithms: Prior to starting any mission, instructions are programmed into AUVs. The vehicle is configured with methods for operating payload devices, steps to avoid impediments, and specified geographical positions to follow. It also has navigation needs for following these positions. This guarantees a quick and easy process. It navigates tough terrain underwater by using its sensors as well. Apart from their superior navigation capabilities, AUVs can be configured with actions to take in case of equipment malfunction.

   Because of all these advantages, many people now consider the use of autonomous underwater vehicles to be a safe alternative. Maps of the seafloor are created using it by the oil and gas sector. It is also used by the military for identification and inspection. In many countries, this has improved security and trade. The structure of AUVs can only get better due to the ongoing technological advancements, despite the obstacles that come with it [25]

IV. THE OBSTACLES AUTONOMOUS UNDERWATER VEHICLES FACE

1. Computing and cloud access limitations:
   There are additional difficulties in deploying AI engines underwater, notably because of the restricted processing resources and cloud connectivity. To move closer to autonomy, organizing and analyzing sensor data effectively is a key concern.
2. High development and deployment costs:
   The cost of creating and implementing AI engines for underwater applications is high. Large investments are required for a variety of costs, including R&D, specialized hardware, sensor technology, communication systems, and more.
3. Time-intensive AI training:
   It takes a lot of time and large datasets to train AI engines for complex underwater tasks, which are made more difficult by the demanding conditions of the underwater environment.
4. Data labeling complexities:
   The process of labeling data for AI training is not only expensive but also complicated, and there are still many obstacles in the way of attempts to use unsupervised data processing.
5. Environmental heterogeneity:
   Region-specific data is necessary to ensure maximum performance because the circumstances of underwater ecosystems vary across different locations, making AI engine training more challenging.
6. Sensor integration challenges:
   AUVs use a variety of sensors, including radar, sonar, and cameras. For AI systems, coordinating these sensors and reliably understanding their data remains a difficulty [27].

CONCLUSION

This review evaluates numerous studies on unmanned and autonomous undersea vehicles. publishing. We've seen the author use a variety of methods and approaches to address course planning and exact methods for preventing risks in the ocean [26]. There is also a thorough discussion of the difficulties faced by autonomous underwater vehicles.

REFERENCES

1. Zhang F, Wang X, Tang X, Kumar N, Hu Y, Hu C, “Research on AUV dynamic obstacle avoidance planning based on rolling speed obstacle method”, Transactions of the Institute of Measurement and Control. 2024;0(0). doi:10.1177/01423312241237570.

2. An, D., Mu, Y., Wang, Y. et al. “Intelligent Path Planning Technologies of Underwater Vehicles: A Review”, J Intell Robot Syst 107, 22, 2023. https://doi.org/10.1007/s10846-022-01794-y.
3. Campbell, S. Naeem, W. Irwin, G.W. "A review on improving the autonomy of unmanned surface vehicles through intelligent collision avoidance manoeuvres, Annual Reviews in Control, Vol. 36, Issue 2, 2012, Pp. 267-283.
4. Chang, Lu, et al. "Reinforcement based mobile robot path planning with improved dynamic window approach in unknown environment." Autonomous robots, Vol. 45, Pp. 51-76, 2021.
5. Li, D., Peng, W., Ling, D., "Path planning technologies for autonomous underwater vehicles-a review", IEEE Access, Vol. 7, Pp. 9745-9768, 2018.
6. Hu, C., Fei, Z., "Research on AUV global path planning based on multi-objective ant colony strategy" Chinese Automation Congress (CAC). IEEE, 2019.
7. Zhang, G., Liu, J., Sun, Y., Ran, X., Chai, P., “Research on AUV Energy Saving 3D Path Planning with Mobility Constraints”, J. Mar. Sci. Eng. 2022, 10, 821. https://doi.org/ 10.3390/jmse10060821.
8. Wynn, R.B., Huvenne, V.A.I., Bas, T.P., Murton, B.J., Connelly, D.P., Bett, B.J., Ruhl, H.A., Morris, K.J., Peakall, J., Parsons, D.R., “Autonomous Underwater Vehicles (AUVs): Their past, present and future contributions to the advancement of marine geoscience”, Mar. Geol. Vol. 352, Pp. 451–468, 2014, [CrossRef].
9. Aras, M.S.M., Mazlan, K., Ahmad, A., Azmi, N., “Analysis performances of laser range finder and blue LED for autonomous underwater vehicle (AUV)”, In Proceedings of the 2016 IEEE International Conference on Underwater System Technology: Theory and Applications (USYS), Penang, Malaysia, 13–14 December 2016; Pp. 171–176.
10. Jawhar, I., Mohamed, N., Al-Jaroodi, J., Zhang, S., “An architecture for using autonomous underwater vehicles in wireless sensor networks for underwater pipeline monitoring”, IEEE Trans. Ind. Inform. IEEE T IND INFORM 2018, 15, Pp. 1329–1340. [CrossRef].
11. Yao, T.T., He, T., Zhao, W.L., Sani, A.Y.M., “Review of path planning for autonomous underwater vehicles”, In Proceedings of the 2019 International Conference on Robotics, Intelligent Control and Artificial Intelligence, Shanghai, China, 20–22 September 2019; Pp. 482–487.
12. Kirsanov, A., Anavatti, S.G., Ray, T., “Path planning for the autonomous underwater vehicle”, In Proceedings of the International Conference on Swarm, Evolutionary, and Memetic Computing, Chennai, India, 19–21 December 2013; Vol. 8298, Pp. 476–486.
13. Liang, S., Zhi-Ming, Q., Heng, L.A., “Survey on route planning methods of AUV considering influence of ocean current”, In Proceedings of the 2018 IEEE 4th International Conference on Control Science and Systems Engineering (ICCSSE), Wuhan, China, 21–23 August 2018; Pp. 288–295.
14. Cheng, C., Zhu, D., Sun, B., Chu, Z., Nite, J., Sheng, Z., “Path planning for autonomous underwater vehicle based on artificial potential field and velocity synthesis”, In Proceedings of the 2015 IEEE 28th Canadian Conference on Electrical and Computer Engineering (CCECE), Quebec, QC, Canada, 13–16 May 2018; Pp. 717–721.
15. Taheri, E., Ferdowsi, M.H., Danesh, M., “Closed-loop randomized kinodynamic path planning for an autonomous underwater vehicle”, Appl. Ocean Res. 2019, Vol. 83, Pp. 48–64, [CrossRef].
16. Mukhtar I. B., M. A. Baballe., “Simulation of Obstacle Avoidance Robots”, Global Journal of Research in Engineering & Computer Sciences, Vol. 3, No. 5, Pp. 1–9, 2023, https://doi.org/10.5281/zenodo.8408537.
17. Abdu I. A., Abdulkadir S. B., Amina I., & M. A. Baballe, “The Several uses for Obstacle-Avoidance Robots”, Global Journal of Research in Engineering & Computer Sciences, Vol. 3, No. 3, Pp. 11–17, 2023. https://doi.org/10.5281/zenodo.8030172.
18. M. A. Baballe, Mukhtar I. B., S.H. Ayagi, & Umar F. M., “Obstacle Avoidance Robot using an ultrasonic Sensor with Arduino Uno”, In Global Journal of Research in Engineering & Computer Sciences, Vol. 3, Number 5, Pp. 14–25, 2023, https://doi.org/10.5281/zenodo.10015177.
19. Abdulkadir S. B, Muhammad A. F, Amina I., Mukhtar I. B, & M. A. Baballe, “Elements needed to implement the Obstacle-Avoidance Robots”, Global Journal of Research in Engineering & Computer Sciences, Vol. 3, No. 3, Pp. 18–27, 2023, https://doi.org/10.5281/zenodo.8051131.
20. M. A. Baballe, M. I. Bello, A. Umar Alkali, Z. Abdulkadir, & A. Sadiq Muhammad, “The Unmanned Aerial Vehicle (UAV): Its Impact and Challenges”, Global Journal of Research in Engineering & Computer Sciences, Vol. 2, No. 3, Pp. 35–39, 2022, https://doi.org/10.5281/zenodo.6671910.
21. Muhammad A. B., Mukhtar I. B., Adamu H., Usman S. M., “Pipeline Inspection Robot Monitoring System”, Journal of Advancements in Robotics, Vol. 9, No. 2, Pp. 27–36, 2022.
22. M.A. Baballe, A. I. Adamu, Abdulkadir S. B., & Amina I., “Principal Operation of a Line Follower Robot”, Global Journal of Research in Engineering & Computer Sciences, Vol. 3, No. 3, Pp. 6–10, 2023. https://doi.org/10.5281/zenodo.8011548.
23. Mehmet Ç.,Muhammad B. A., “A Review on Spider Robotic System”, International Journal of New Computer Architectures and their Applications (IJNCAA) Vol. 9, No. 1, Pp.19-24, 2019.
24. Muhammad B., A., Abubakar S., M., “A General Review on Advancement in the Robotic System”, Artificial & Computational Intelligence, Mar 2020, http://acors.org/ijacoi/VOL1_ISSUE2_04.pdf.
25. https://www.dspcommgen2.com/benefits-of-autonomous-underwater-vehicles/.

26. Danladi K.G, Shuaibu O. Y, Mukhtar I.B, & M. A. Baballe. (2024). Consequences of Self-Driving Undersea Vehicles. In Global Journal of Research in Engineering & Computer Sciences (Vol. 4, Number 3, pp. 13–16). https://doi.org/10.5281/zenodo.11130356.
27. https://www.prescouter.com/2024/02/challenges-facing-autonomous-underwater-vehicles-auvs/.

CITATION

Muhammad A. B, Naima H.A, Abdulkadir S.B, Lawal M.I, & Mukhtar I.B. (2024). The Obstacles Autonomous Underwater Vehicles Face. In Global Journal of Research in Engineering & Computer Sciences (Vol. 4, Number 4, pp. 49–53). https://doi.org/10.5281/zenodo.12759675