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Design and Development of a Solar Panel Microcontroller Based Shallow Water Detection System with Radar

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Abstract: *This study investigates the design and development of a microcontroller-based shallow water detection system, aimed at enhancing safety in areas prone to shallow water hazards. The project leverages advanced microcontroller technology, sensors, and real-time monitoring to identify and alertusers about the presence of shallow water levels in various environments. The system is designed with a focus on accuracy, reliability, and user-friendliness, ensuring that it meets the safety needs of diverse applications such as navigation,flood management, and recreational water activities.The shallow water detection system utilizes an ultrasonic sensor integrated with a microcontroller to measure water depth accurately. The collected data is processed and displayed on an LCD, providing real-time feedback on water levels. If the water depth falls below a predetermined threshold, the system triggers an alarm, alerting users to the potential risk. The device was tested with 30 participants, including boat operators, water safety personnel, and researchers, who evaluated the system's ease of use, functionality, and effectiveness.Results from the testing phase indicate that the system is highly effective in detecting shallow water levels, with a minimal margin of error. The alarm system successfully alerts users in real-time, minimizing risks such as damage to watercraft, accidents, or other hazards associated with shallow water environments. The system is portable, energy-efficient, and can be customized for specific applications, making it a versatile tool for both professional and recreational use.Based on the findings, the study concludes that this microcontroller-based shallow water detection system is well-suited for implementation in various settings, including marine navigation, irrigation management, and flood control. Its real-time monitoring and alert capabilities make it an invaluable tool for preventing accidents and ensuring safety. Future research could focus on integrating wireless communication and IoT functionalities to expand its applications and enable remote monitoring, enhancing its utility in larger-scale operations.*

Keywords: Solar Panel, Microcontroller based Shallow Water Detection, Radar

I. INTRODUCTION

In the realm of marine safety for small fishing boats, microcontroller based systems, particularly those utilizing Arduino Nano and Arduino Uno platforms, are becoming increasingly valuable for detecting shallow waters and underwater hazards(Pearce, R. H. et.,al 2018). These systems enhance the safety of small-scale fishers navigating in challenging and often unpredictable marine environments, where the risk of grounding or collision with submerged obstacles such as rocks, sandbars, or coral reefs is high(Gould, R. A. et.,al 2011). Development of a real-timeshallow waterdetection and warningsystem used Arduino Uno combined with ultrasonic sensors to detect shallow waters. Their system issues warnings when boats approach dangerous shallow areas, improving safety without requiring complex technology(Leatherman, S. P. et.,al 2024) .Integrative approaches to shallow waternavigation systemsusing microcontrollerscombined Arduino Uno with multiple sensor types, including ultrasonic, infrared, and sonar, to detect underwater obstacles and shallow areas (Saha, S.S. et,.al 2021). The integration of these sensors into a unified system enhances the safety of small fishing boats navigating shallow waters. Micro controller-Basedcurrent and obstacledetection for safermarinenavigation developed a system based on Arduino Nano that uses flow sensors and depth sensors to detect underwater currents and obstacles. This provides small boat operators with vital information to avoid hazardous conditions in shallow water(Domeh, V. et.,al2023).Utilizing predictivemodels for small boat navigation safety focused on predictive models using data from Arduino-based systems combined with sensors like ultrasonic and sonar. This research aims to enhance hazard detection in shallow waters by providing predictive insights into potential danger (Temitope Yekeen, S. et.,al 2020).Energy efficientmicro controllersolutions for marinenavigation safety designed arduinonanobased systems for detecting underwater hazards with low power consumption. His energy-efficient solution is ideal for small-scale fishing operations in remote areas with limited access to electricity.In conclusion, design for marinesafetysystems work focused on creating interfaces for Arduino-based systems that provide real-time alerts about shallow water and underwater obstacles, ensuring that fishers can quickly interpret the data to improve their safety (Glaviano, F.et.,al2022)

II. REVIEW OF RELATED LITERATURE

This literature developed a real-time shallow water detection and warning system using Arduino Uno and ultrasonic sensors. This system aims to detect shallow waters and provide early warnings to boat operators, preventing accidents caused by boats running aground (Kamis, A. S. et.,al 2022). The system's simplicity and reliance on affordable, readily available components make it an attractive solution for small-scale fishing operations. This study emphasizes the potential of microcontroller-based systems to improve marine safety without requiring complex technologies(Miano, J. I. et.,al 2019). Detection of underwater currents and obstacles expanded on previous research by focusing on the detection of underwater currents and obstacles, using Arduino Nano integrated with flow sensors and depth sensors. This system provides small boat operators with vital information about water conditions, including current strength and submerged obstacles, which is crucial for avoiding hazardous situations. The real-time nature of the data makes it possible for fishers to make immediate adjustments, enhancing their safety in shallow waters and regions with varying currents(Gandhi, S. et.,al 2024). Predictive hazard detection models investigated predictive models for hazard detection in shallow waters using data from Arduino-based systems. By combining ultrasonic and sonar sensors, this research aimed to build models that could predict potential dangers, such as sudden changes in water depth or the presence of submerged objects. These predictive models add an extra layer of security by alerting boat operators to possible hazards before they become a direct threat. This approach holds promise for improving safety by enabling proactive responses to potential risks(Durlik, I. et.,al 2024). Energy-efficient solutions for remote areas focused on developing energy-efficient solutions for small boat navigation safety, particularly in remote areas where power supply is limited. Using Arduino Nano, this system integrates low-power sensors to detect underwater hazards without draining the battery quickly. The energy-efficient nature of the system makes it especially suited for small-scale fishers operating in isolated regions, where access to electricity may be scarce. This design prioritizes long-term sustainability while ensuring continuous hazard detection (Lal, J. et.,al 2024). Explored the importance of user-friendly interfaces in marine safety systems. Focusing on Arduino-based solutions, her research aimed to create intuitive designs that offer clear real-time alerts about shallow water and underwater obstacles. The goal was to ensure that fishers could easily understand and respond to safety alerts, improving their ability to navigate safely. By incorporating feedback from users, the study emphasizes the significance of creating systems that are not only technically efficient but also easy to operate in high-pressure situations(Schmidt, R. et.,al 2020). Overall, the integration of microcontroller-based systems, particularly those utilizing Arduino platforms, with sensors like ultrasonic and sonar devices, holds significant promise for improving the safety of small fishing boats(Lahoz-Monfort, J. J. et.,al 2021). The research reviewed in this section demonstrates that these systems are not only cost-effective but also effective in detecting shallow water and underwater hazards, helping small-scale fishers navigate safely in unpredictable marine environments. With continued advancements in sensor technology, machine learning, and system integration, these systems will play a crucial role in enhancing maritime safety and supporting the livelihoods of fishing communities worldwide (Gladju, J. et.,al 2022).

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III. CONCEPTUAL FRAMEWORK

Material inputs in innovating the device is carefully planned, designed, constructed, tested and evaluated in order to achieve efficiency of the innovation.

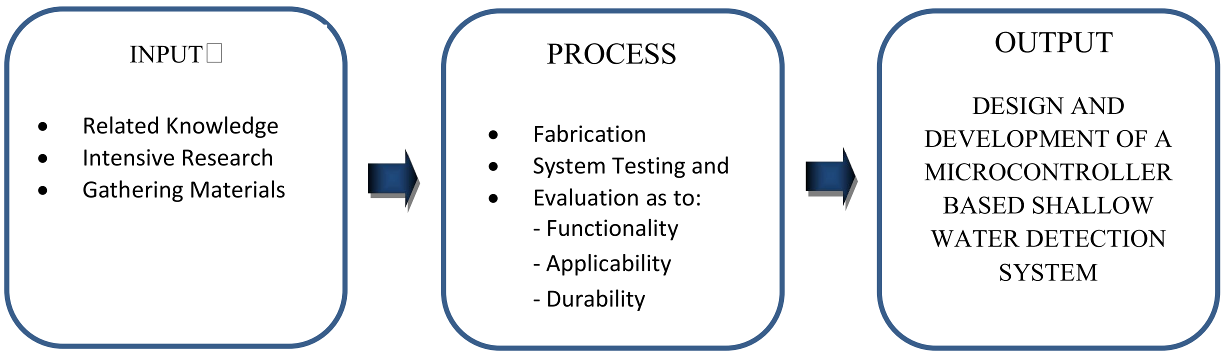

Figure 1: Conceptual Model of the Study

Figure 1. The figure represents the flow of the study. The first box represents the gathering of allmaterials needed in the said project. The second box entails the designing and fabrication of the project. This area discusses the whole design of the project, its diagram and the connection point. Base on the materials gathered fabrication stage will follow by following the procedural design of the project and device testing.

The third box complies the overall output and its aspect must be provided and serves as a data to ensure the effectiveness of the project. It should be evaluated how effective this project so that it will be measure its applicability, quality and its value.

Material inputs in innovating the device is carefully planned, designed, constructed, tested and evaluated in order to achieve efficiency of the innovation.

Objectives of the Study

The main objective of the study is to produce shallow seas detector for safety system for fisher-boats.

Specifically, the study aims to:

1. To Designthe innovated device in terms of :
    1.1 Technical Description
    1.2 Costing
2. To establish the procedures and process in the development of the device.
3. Evaluate the respondents' level of acceptability of the proposed device in terms of the following aspects:
    3.1 Functionality
    3.2 Applicability
    3.3 Durability
    3.4 Safety
    3.5 Reliability
4. Develop use's manual of the device.

Significance of the Study

The proposed study focuses on protecting a property thru enhancement and utilization of technology.

For **the Owner/s and or the end user/s of the fisher man**to have a peace of mind and remove worries to become the next victim of shallows seas or coral reefs.

Protecting lives and livelihoods. Fisher-boat operators often face dangerous conditions while navigating in shallow waters, especially in adverse weather or low visibility.

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Technological Innovation. The development of an intelligent shallow water detector represents a significant technological advancement in marine safety systems.The study contributes to innovate in sensor technology, signal processing, and integration with marine navigation systems.

Future Researchers. The prototype may be the bases of the other researchers for future conduct of project studies in improving grounded on lapses found the present study.

Scope and Limitations

Despite these limitations, this project aims to make significant contributions to the enhancement of safety systems for fisher-boats through the development of an intelligent shallow seas detector. By addressing the identified scope and limitations, the research endeavors to advance the state-of-the-art in maritime safety technology and mitigate risks associated with shallow sea navigation.

Definition of Terms

Smart Detector for Shallow Seas. An intelligent sensor or system that can identify shallow places in the ocean by combining artificial intelligence algorithms for analysis and decision-making with technologies like sonar, radar, or depth sensors.

Safety Framework. A collection of parts, comprising both software and hardware, intended to improve communication devices, and collision avoidance systems are a few examples of this.

Boats used for fishing. Small artisan boats to bigger trawlers or fishing vessels are examples of vessels used for fishing, whether for commercial or recreational purposes.**Sensor.**A device that detects or measures physical properties (such as depth, temperature, or pressure) and converts them into signals that can be interpreted by electronic instruments or systems.

Shallow Seas. Coastal or nearshore areas of the ocean characterized by relatively shallow depths. These areas may pose navigational hazards to boats, particularly those with deeper drafts.

User Interface (UI). The means by which a user interacts with a system. In the context of the safety system, this may include displays, controls, and alerts designed to convey information and facilitate user actions.

Project Design

Below is the architectural design of the research device (An Shallow Water Detector), included the labeled parts of the research project.

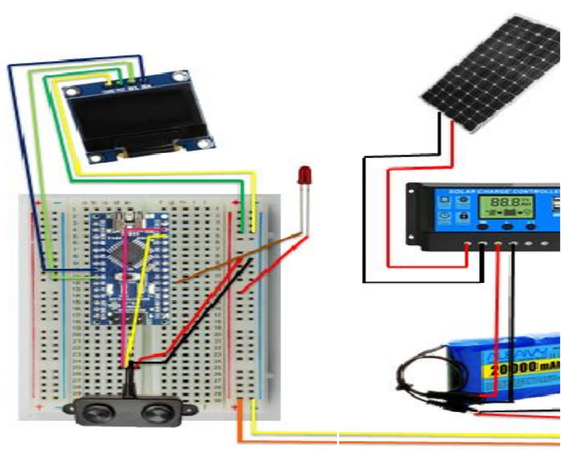

FIGURE 2:Project Development

The following are procedural steps in making the project.

1. Gather all necessary material needed in making the said project.
2. Check and make sure that all the devices to be use is functional and not defective.

3. Connect all the wiring's starting from the shallow water detection, such as sonar, radar, and image processing techniques.
4. Check all the wiring components if it is exactly connected to the right connecting point.
5. Test the components if it is functioning will.
6. After setting all the components, checking the proper wiring connections, now the power interrupter control is ready to use.

The Research Study includes consideration on the following method of operation:

Installation: In shallow waters, boaters and divers can encounter hazards like sandbars, rocks, or even underwater structures. An intelligent shallow water detector could warn of these obstacles, helping to prevent accidents.These detectors could be used to map the underwater features ofshallow areas, creating detailed bathymetric charts for various purposes. This can be useful for navigation, understanding underwater ecosystems, or planning construction projects in shallow waters. By detecting underwater features and perhaps vegetation, these devices could aid fisheries researchers in understanding fish habitats in shallow waters.

Operation Procedure

In determining the performance of the device,the following procedure was followed:

1. Check the whole system whether all the components are correctly installed.
2. Inspect wiring connections that would possibly make up accidents.
3. Prepare the required materials for the conduct of operation
4. Observe proper or correct installation.

Testing Procedure

In order to assure that every part of the device is working properly, the following test procedure should be done:

1. Testing all the materials to be used in making the project.
2. Check each connection points.
3. Set particular distance for the sensors to activate.
4. Test the device and conduct an assessment and efficiency on it.

Evaluation Procedures

Evaluation is a way to determine the acceptability of the proposed project. Selected people were asked to rate the performance of the device. These respondents were composed of selected residents in Surigao City who have specialized on the field. Prior to the actual demonstration/evaluation of the device, the researcher explained the function of the device as well as its specification of the prototype. Before the evaluation sheet was given to the respondents, its content was discussed by the researchers. When the evaluation has been accomplished, the result was tabulated and computed to find the mean of every criterion as well as the overall mean.

The respondents will then evaluate the said proposed project based on usability, quality of design, functionality, safety, and efficiency. The evaluation sheet is provided where respondents can write their comments and suggestions for further improvement of the device.

IV. RESULTS AND DISCUSSION

This chapter presents the project description, capabilities and limitations, project test results, and the final evaluation.

Acceptability of Microcontroller Based Shallow Water Detection System based on its Functionality

4.21 – 5.00	Excellent
3.41 – 4.20	Very Good
2.61 – 3.40	Good
1.81 – 2.60	Fair
1.00 – 1.80	Poor

Criteria and Statement	Mean	Qualitative Description
A. Functionality		
Function of the device is meet as it expected.	4.05	Very Good
The device performs the task effectively.	4.10	Very Good
The device has a minimal error.	4.05	Very Good
The device can be enhanced or updated.	3.75	Very Good
The quality and consistency of the device's outputs.	4.15	Very Good
Average Mean	4.02	Very Good

The table uses five distinct statements about the functionality and performance of a gadget to evaluate the "Functionality" criterion. Each claim outlines a uniquefeature of the device's operation. The average ratings or scores assigned to each statement are shown in the "Mean" column. As an illustration, Statement 1 scored on average 4.45, Statement 2 scored on average 4.35, and so on. The overall evaluation of each statement's functionality is reflected in the mean score.

Based on each statement's mean score, the "Qualitative Description" column offers a qualitative evaluation or description of it. All five statements garnered "Very Good" result which indicates that the device function as it expected.

Acceptability of Microcontroller Based Shallow Water Detection System based on its Applicability

B. Applicability	Mean	Qualitative Description
The device's effectiveness in specific real-world applications or environment.	4.15	Very Good
The device meets the needs of intended user group.	4.20	Very Good
The device withstands the specific environmental and usage conditions of its intended application.	4.35	Excellent
Measure how quickly and easily users can adopt the device, considering factors like training requirements and the user interface's intuitiveness.	4.15	Very Good
Level of maintenance required for the device and the availability of user support and resources.	4.20	Very Good
Average Mean	4.21	Excellent

The table displays the respondents' perceptions, which assess the "Applicability" criterion based on five distinct assertions about how well-suited and adaptable the device is to various applications and user requirements. The average ratings or scores assigned to each statement are shown in the "Mean" column. As an illustration, Statement 1 obtained an average score of 4.15, Statement 2 an average score of4.20, and Statement 3 an average score of 4.35,Statement 4obtained an average score of 4.15, and Statement 5 an average score of 4.20 respectively. The total evaluation of the applicability of each statement is represented by themean score.

Based on each statement's mean score, the "Qualitative Description" column offers a qualitative evaluation or description of it. Statements 1 and 2 in this situation were both given the rating "Very Good," meaning that they were highly regarded and thought to have good application. However, Statement 3 was given the rating of "Excellent," indicating that it was extraordinary and met or the intended user group. While Statements 4 and 5 earned also a "Very Good" rating which implies that the prototype can be use quickly and user can adopt to it and it doesn't have a high maintenance cost.

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Acceptability of Microcontroller Based Shallow Water Detection System based on its Durability

C. Durability	Mean	Qualitative Description
The device withstands physical forces, including compression, tension, and torsion.	4.15	Very Good
The device's performance under various environmental stresses, such as temperature extremes, humidity, dust exposure, and water resistance.	4.45	Excellent
The materials used in the prototype behave under repeated use over time, which may include abrasion resistance and wear testing.	4.05	Very Good
Device performance under high and low temperature conditions.	4.10	Very Good
Device longevity and performance of the battery under typical usage conditions, including charge/discharge cycles.	4.10	Very Good
Average Mean	4.17	Very Good

The table evaluates the "durability" criterion based on five distinct statements about the unit's ability to withstand high temperatures, resist deformation, and be well-designed. The average ratings or scores assigned to each statement are shown in the "Mean" column. As an illustration, Statement 1 obtained an average score of 4.15, Statement 2 an average score of 4.45, and Statement 3 an average score of 4.05, while both statement 4 and 5 have an average score of 4.10. The durability of each assertion is evaluated overall and represented by the mean score.

Each statement is given a qualitative evaluation or description in the "Qualitative Description" column based on its mean score. In this instance, Statements 1, 3, 4 and 5 were both given the rating of "Very Good," indicating that they were highly regarded and thought to have good longevity. Statement 2 was given the rating of "Excellent," signifying that its design was of the highest caliber and that it was extraordinarily well regarded.

The device's durability was determined to be favorable based on the information in this table. Statement 1, which focuses on the device can withstand physical forces, was given a "Very Good" rating, indicating that the device demonstrated good resilience and kept its form under a variety of circumstances. An "Excellent" rating was given to Statement 2, indicating that the device's design was of the highest caliber, which is essential for durability. According to statement 3, 4 and 5 with a "Very Good" grade, the device showed good durability even in high-temperature situations and longevity and performance of the battery under typical usage condition.

D. Safety	Mean	Qualitative Description
The device has an emergency shutoff mechanism, warning indicators, and user manuals for safety usage.	4.15	Very Good
Device absence from harmful substances, such as battery leaks or toxic materials.	4.10	Very Good
The physical design of the device to identify sharp edges, pinch points, or moving parts that could pose risks during use.	4.10	Very Good
The device potential electrical hazards, including short circuits, overloads, and proper grounding.	4.05	Very Good
The device's ability to manage heat during operation.	4.15	Very Good
Average Mean	4.11	Very Good

Acceptability of Microcontroller Based Shallow Water Detection System based on its Safety

Emergency shutoff mechanism and warning indicators, the absence of poisonous compounds, no sharp edges, and the provision for protection are the five specific assertions that the table uses to evaluate the "Safety" criterion. Mean: Each statement's average score or rating is shown in the "Mean" column. As an illustration, Statement 1 obtained an average score of 4.15, Statement 2 an average score of 4.10, Statement 3 an average score of 4.10, Statement 4 obtained an average score of 4.05, and Statement 5 with an average score of 4.15. The overall evaluation of each statement's safety is represented by the mean score. Qualitative Description: Each statement is given a qualitative evaluation or description based on its mean score in the "Qualitative Description" column. All five of the statements in this instance were given the rating "Very Good," indicating that they were highly regarded and thought to have good safety precautions.

Criteria	Mean	Rank	Qualitative Description
A. Functionality	4.02	4	Very Good
B. Applicability	4.21	1	Excellent
C. Durability	4.17	2	Very Good
D. Safety	4.11	3	Very Good
Grand Mean	4.13		Very Good

The device's safety was determined to be satisfactory based on the information in this table. Statement 1, which focuses on having an emergency shutoff mechanism and warning indicators, obtained a "Very Good" rating, meaning that the device was created with a quick shut-off mechanism that can be triggered during emergency. The device was free of dangerous or harmful materials that might endanger users, according to Statement 2, which similarly obtained a "Very Good" rating. The equipment appeared to have adequate safeguards in place to shield users from potential risks, as evidenced by Statement 3, 4 and 5 with "Very Good" assessment, which addressed the provision for protection.

Overall Acceptability

The table shows how well a Microcontroller Based Shallow Water Detection System meets a variety of criteria based on mean scores, rankings, and qualitative descriptions. Four different criteria—Functionality, Applicability, Durability, and Safety—are listed in the table. These standards most likely represent various features or traits that are being assessed for acceptability. The average ratings or scores assigned to each criterion are shown in the "Mean" column. For instance, the mean score for functionality was 4.02, the average for applicability was 4.21, and so on. The entire evaluation or assessment of each criterion is reflected in the mean score.

The ranking of each criterion according to its mean score is shown in the "Rank" column. Applicability had the highest rank (1) in this instance, indicating that it had the greatest mean score of all the criteria. Safety obtained the third rating, Durability the second position, and so on. Based on each criterion's rank, the "Qualitative Description" column offers a qualitative evaluation or description of it. In this table, every criterion was given the rating "Very Good," indicating that it performed admirably and complied with all specifications. The "Grand Mean" is the sum of all mean scores. In this instance, the Grand Mean is calculated as 4.13, reflecting an overall evaluation of "Very Good" for the overall acceptability.

It can be deduced from the presented table that the evaluated categories, including Functionality, Applicability, Durability, and Safety, were rated as "Very Good" in terms of their acceptability. The top ranking went to Applicability, with Durability and Safety coming in at numbers two and three, respectively. Overall, this table implies that the acceptability-based criteria were highly scored and performed well, indicating a favorable overall evaluation

Summary

This study aimed to evaluate the effectiveness of a microcontroller-based shallow water detection system. The focus was on its functionality, reliability, applicability, and overall usability in detecting shallow water conditions, as well as its potential applications in various fields, such as safety, environmental monitoring, and industrial usage.

The system was tested with 30 respondents who possessed sufficient knowledge of water detection systems and microcontroller technology, allowing for an in-depth assessment of its materials, functionality, usability, and overall effectiveness.

Findings.

Based on the comprehensive evaluation of the Microcontroller-Based Shallow Water Detection System, the following key findings have emerged:

Functionality:

- The system demonstrated high effectiveness in detecting shallow water levels accurately. Respondents found the device's sensing capabilities to be reliable, and it consistently met its design criteria. Minimal errors were reported, highlighting its practical application potential for various environmental and industrial needs.

Reliability:

- The device showed strong reliability, consistently detecting shallow water accurately across different conditions. Users noted its dependable performance with minimal downtime's or malfunctions, suggesting it can handle real-world applications effectively.

Applicability:

- The system was considered versatile and widely applicable in various scenarios, such as flood monitoring, water level management, and industrial safety measures. Its ability to be integrated with other monitoring and alerting systems made it highly appealing to users in terms of real-world applications.

Durability:

- The system exhibited high durability, withstanding different environmental conditions, including temperature variations and potential physical stressors. This ensured long-term usage and reduced maintenance needs.

User Safety:

- For user safety was a core focus, as the system incorporated safe electrical components, clear instructions for handling, and necessary protections to prevent accidents or damage during use. Safety measures, such as automatic alerts for critical water levels, made it a secure choice for operators.

V. CONCLUSION

In conclusion, a microcontroller-based shallow water detection system provides an innovative and reliable solution for water monitoring applications. Its practical, accurate detection capabilities contribute to safety, environmental monitoring, and industrial needs. The hands-on use of microcontroller technology enables users to engage with state-of-the-art water sensing technology, promoting safer, more efficient water management practices.

VI. RECOMMENDATIONS

Users are encouraged to actively engage in practical exercises involving the shallow water detection system. By exploring its functionalities and understanding its integration with microcontroller platforms, they can enhance their technical skills and better comprehend water management systems. Collaborative troubleshooting with peers will provide diverse perspectives, fostering deeper knowledge of the system's operation and potential improvements.

Future Researchers:

As a future researchers are encouraged to build on this work to further improve detection accuracy, durability, and integration capabilities. Investigating additional sensor types, enhancing connectivity features, and incorporating data analytics could expand the system's applications and provide even greater utility across multiple domains

REFERENCES

[1]. Domeh, V., Obeng, F., Khan, F., Bose, N., & Sanli, E. (2023). An operational risk awareness tool for small fishing vessels operating in harsh environment. Reliability Engineering & System Safety, 234, 109139.

[2]. Durlik, I., Miller, T., Kostecka, E., & Tuński, T. (2024). Artificial Intelligence in Maritime Transportation: A Comprehensive Review of Safety and Risk Management Applications. Applied Sciences, 14(18), 8420.

[3]. Gandhi, S., & Patil, D. P. (2024). UOWC Integration with ROVs: A Fiber-Optic Approach for Enhanced Underwater Exploration. Journal of Electrical Systems, 20(2s), 993-1003.

[4]. Gladju, J., Kamalam, B. S., & Kanagaraj, A. (2022). Applications of data mining and machine learning framework in aquaculture and fisheries: A review. Smart Agricultural Technology, 2, 100061.

[5]. Glaviano, F., Esposito, R., Cosmo, A. D., Esposito, F., Gerevini, L., Ria, A., ... & Zupo, V. (2022). Management and sustainable exploitation of marine environments through smart monitoring and automation. Journal of Marine Science and Engineering, 10(2), 297.

[6]. Gould, R. A. (2011). Archaeology and the social history of ships. Cambridge University Press.

[7]. Kamis, A. S., Fuad, A. F. A., Anwar, A. Q., & Monir Hossain, M. (2022). A systematic scoping review on ship accidents due to off-track manoeuvring: A systematic scoping review on ship accidents due to off-track manoeuvring. WMU Journal of Maritime Affairs, 21(4), 453-492.

[8]. Lahoz-Monfort, J. J., & Magrath, M. J. (2021). A comprehensive overview of technologies for species and habitat monitoring and conservation. BioScience, 71(10), 1038-1062.

[9]. Lal, J., Vaishnav, A., Kumar, D., Jana, A., Jayaswal, R., Chakraborty, A., ... &Pavankalyan, M. (2024). Emerging innovations in aquaculture: Navigating towards sustainablesolutions. International Journal of Environment and Climate Change, 14(7), 83-96. Leatherman, S. P.,

[10]. Leatherman, S. B., & Rangel-Buitrago, N. (2024). Integrated strategies for management and mitigation of beach accidents. Ocean & Coastal Management, 253, 107173.

[11]. Miano, J. I., Empig, E. E., Gaw, A. R., Mendoza, O. S., Adlaon, D. C., Cañedo, S. B., ... &Sumalpong, A. S. (2019). Microcontroller-based vessel passenger tracker using GSM System: An aid for search and rescue operations. Editorial Preface From the Desk of Managing Editor, 10(9).

[12]. Pearce, R. H. (2018). Do-it-yourself": evaluating the potential of Arduino technology in monitoring water quality. Unpublished Bachelor's dissertation. doi, 10.

[13]. Saha, S. S. (2021). Robust and Efficient Neural Inertial Localization and Complex Activity Recognition. University of California, Los Angeles.

[14]. Schmidt, R. M., Schitter, G., & Rankers, A. (2020). The design of high performance mechatronics-: high-Tech functionality by multidisciplinary system integration. Ios Press.

[15]. Temitope Yekeen, S., & Balogun, A. L. (2020). Advances in remote sensing technology, machine learning and deep learning for marine oil spill detection, prediction and vulnerability assessment. Remote Sensing, 12(20), 3416