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AN AUTONOMOUS ROBOT FOR CLEANING WATERSURFACES

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ABSTRACT

Water is essential to our daily lives, serving as a vital source of life for people, animals, and ecosystems alike. For many towns andcommunities, rivers and other bodies of water remain a primary source of drinking water. However, the increasing amount of waste in these water bodies poses a serious threat – not only to the environment but also to human health. Even a single piece of litter, carelessly discarded, can contribute to the pollution of our rivers, lakes, and creeks. While water is typically treated before itreaches our homes, heavily polluted water bodies cannot be fully purified, making it unfit for consumption.

To ensure clean water continues to flow from our taps, it is crucial to protect and maintain our river systems. This need for preservation is the driving force behind our project: an autonomous water surface cleaning robot designed to collect floating debris from rivers, lakes, and other bodies of water. The robot will operate without human supervision, navigating designated areas and collecting waste along its path. Equipped with a camera, the robot will provide real-time video footage, allowing it to identify and target waste effectively.

The waste will be collected via a conveyor belt system, which will transport the debris to a storage area on the robot. Once full, therobot will dock for waste removal, ready to continue its mission. Our goal is to keep our water bodies clean, ensuring a healthier environment and safer water supply for all.

KEY WORDS: *Water Pollution, Environmental Conservation, Autonomous robot.*

1. INTRODUCTION

Waste has been identified as an environmental problem that arises persistently year after year and remains unresolved. Garbage is often found dumped into rivers, waterways, or reservoirs, leading to blocked water flow, dirty and foul- smelling water, and frequent overflows causing disasters such as flooding. Cleaning waste from water areas typically requires extensive resources, such as cleaning staff and the useof excavators. This study is aimed at providing an alternative solution to the waste problem in water areas through the development of robotics technology capable of operating in such environments. The proposed applied research is expectedto serve as an alternative means to prevent disasters, particularly flooding. Robotics technology in the form of an eco-robot is developed, with the primary task of collecting waste. The robot is designed to be manually controlled using remote control. The development method referred to in this research is ADDIE, which includes the analysis of the robotic cleaning system, the design of the robot, the development of the robot, its implementation for cleaning waste in limited water areas, and the evaluation of its effectiveness in cleaning trash from more extensive areas. The focus of this article is on the design and development of the robot.Previously, robots for cleaning water surfaces have been developed, with limited results available in open references discussing the development of such purpose-built robots. This work is aimed at the developmentof a more versatile and efficient system using an aqua robot. The robot is seen as having significant potential to expand its functionality in the future, including activities such as the removal of algae, leaves, and twigs; spraying chemicals in targeted locations; checking water quality; and deploying payloads autonomously.

2. LITERATURE SURVEY

During the months of August, September, October, and November of 2022, a literature review for this project was completed. The focus was given predominantly to literature addressing advancements in automated water robots. Relevant literature sources have been included in the References section. The following journals were reviewed to gather information.

2.1 Detection of Waste Materials Using Deep Learning and Image Processing[1]

A framework was planned and developed with a deep learning approach for effective waste segregation. Images were recognized using a convolutional neural network along with an image processing method to identify waste based on shape, color, dimension, and size. This technique enabled the system to

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automatically learn relevant features from sample images of trash and recognize those features in new images.

2.2 Automatic Collaborative Water Surface Coverage and Cleaning Strategy of UAV and USVs[9]
An autonomous water cleaning approach was designed, and a system architecture for cooperation between UAVs and USVswas ingeniously established. Autonomous obstacle avoidance path planning methods were developed for enabling autonomous navigation and cooperative cleaning by robots.

2.3 Detection With Deep Learning: A Review[2]
The development of deep learning and convolutional neural networks was reviewed, focusing on typical generic object detection designs and various adjustments. Practical tips for enhancing detection performance were provided. This study contributed to the training of models using custom training datasets.

2.3.1 Pond Cleaning Robot[10]
A robot was designed to remove waste materials from water surfaces and safely dispose of them in the water body. A Bluetooth-enabled pond cleaning robot was deployed to extract trash, plastics, and waste from the Godavari River in Nashik. The basic design and configuration required for such a robot were outlined.

2.3.2 Arduino-Based Tracking System Using GPS andGSM[12]
A location tracking system was created by integrating GPS and GSM with a microcontroller. Vehicles or items connected to a tracking device were located using GPS. A smartphone and Arduino UNO were effectively utilized in the proposed system. Updates were sent and received regarding object locations through a database using the GSM module.

2.3.3 SMURF
A fully autonomous water surface cleaning robot called SMURF was developed using cutting-edge sensors and a novel coverage path planning method. Garbage and contaminants were collected and stored while environmental variables were monitored. Remote control and monitoring of SMURF were enabled, making it a potential solution for maintaining clean and healthy water bodies.

2.3.4 A Modified YOLOv3 Detection Method for Vision-Based Water Surface Robots[11]
A modified YOLOv3 object detection method was introduced for a vision-based water surface garbage capture robot. Deep learning and computer vision techniques were incorporated to enhance the accuracy and speed of object detection. This modified method provided precise information, aiding in the preservation of water quality and ecosystem health.

2.3.5 A Smart Autonomous Floor Cleaner with an Android- Based Controller[8]
An intelligent cleaning robot was developed, capable of autonomously navigating and cleaning floors while being controlled and monitored through an Android device. Mapping, path planning, and obstacle avoidance algorithms were utilized to ensure efficient navigation and cleaning.Additional features such as scheduling options, cleaning mode selection, and virtual boundaries were incorporated.

3. PROPOSED METHODOLOGY

The primary objective of this research is focused on the development of an autonomous robotic system designed to efficiently clean water surfaces by collecting and removing pollutants such as plastic waste, algae, and debris. The system is intended to be navigated through various aquatic environments with minimal human intervention. Advanced sensing and path- planning algorithms are to be utilized to optimize cleaning performance while ensuring the safety and sustainability of the water ecosystem.

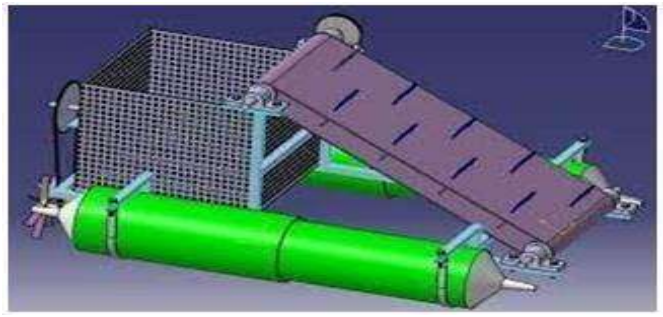

Fig. 1: Robot Model using a Conveyor belt

3.1 NEO-6M Module[3]
The GPS NEO-6M module is recognized as a compact, low- power, and cost-effective GPS (Global Positioning System) solution that is widely utilized in applications such as navigation systems, asset tracking, UAVs (unmanned aerial vehicles), robotics, and more.

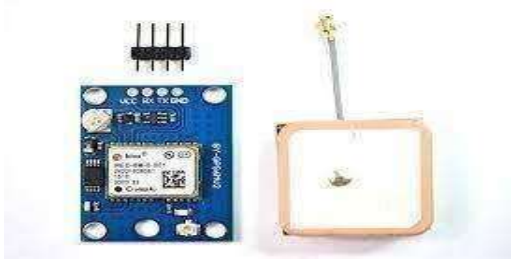

Fig. 2: NEO-6M

It is built on u-blox's industry-leading GPS chipset technology, ensuring high sensitivity and excellent performance in acquiring and tracking GPS signals even in challenging environments with weak signal strength orinterference. Several features are provided by the module, including a compact size, low power consumption, serial communication, and NMEA protocol support. Low power operation is enabled, making it suitable for battery-powered applications where power efficiency is prioritized. Accurate time information, a built-in ceramic patch antenna, and reliable positioning performance are provided. Configuration and control are achieved through AT commands, which allow

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customization of settings. Integration with host systems is carried out through serial communication, with NMEAsentences being parsed to extract GPS information. For applications requiring higher accuracy or additional features, more advanced GPS modules are offered by u- blox in their product lineup.

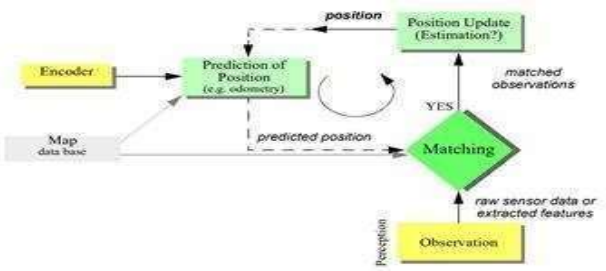

Fig. 3: Block Diagram

3.2 HC-05 Module[4]

The HC-05 Bluetooth module is widely acknowledged as a popular and reliable solution for wireless communication between electronic devices. It is based on the Bluetooth 2.0+EDR specification, with a communication range of up to 10 meters. Communication with the host system is conducted using a serial interface, commonly referred to as UART, which supports standard serial communication protocols such as 8-N-1. The module is designed to operatein either master or slave mode and is configured and controlled using AT commands. The range is influenced bythe surrounding environment and potential obstructions. Customization of settings, such as the Bluetooth device name, pairing code, communication baud rate, and operating mode, is made possible using AT commands. Operation is supported on a voltage supply of 3.3V, and secure and encrypted communication is enabled through the Secure Simple Pairing (SSP) protocol. Extensive use is made of the module in domains such as home automation, robotics, wireless sensor networks, and Internet of Things (IoT) projects. Compatibility is ensured by adhering to manufacturer documentation, with integration simplified through the use of online tutorials and libraries.

Fig. 4: HC-05 module

3.3 HMC5883LModule[5]

The HMC5883L module is described as a three-axis digital compass used for measuring magnetic fields. A three-axis magnetometer is featured, which measures the strength and direction of magnetic fields along the X, Y, and Z axes.

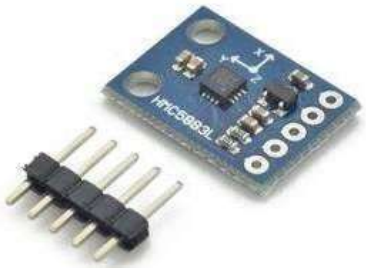

Fig. 5: HMC5883L

Digital output for the measured magnetic field data is provided, ensuring compatibility with various microcontrollersand development boards. High accuracy and resolution are offered, with a typical accuracy of 2–3 degrees and a resolution of up to 0.2 milligauss. Built-in calibration functionality is included to compensate for external magnetic interference or offsets. Optimization of power consumption and measurement speed is achieved through different operating modes. Features such as adjustable measurement range, data output rate configuration, and automatic gain control are integrated. Extensive support is provided through various libraries and code examples for integration into different platforms, making the module a popular choice for magnetic field sensing and orientation determination.

3.3 A2212/6t 2200kv BLDC Motors[6]

The A2212/6T 2200KV motor is identified as a brushless motor used in RC aircraft and multirotor drones. Brushless technology is utilized, offering advantages such as higher efficiency, longer lifespan, and reduced maintenancerequirements. Substantial power is delivered for its size, with compatibility ensured with a range of electronic speed controllers (ESCs). Three wire leads are featured: one connected to the ground or negative terminal, one for the positive supply voltage, and one for signal control. Cooling and maintenance are required to prevent overheating during extended operation, with regular inspection recommended for ensuring optimal performance and longevity. Safety precautions are advised, with handling conducted carefully and manufacturer guidelines followed to ensure proper operation.

Fig. 6: A2212/6t 2200kv BLDC Motors

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Electronic Speed Controllers[7]

The ESC (Electronic Speed Controller) 30A is described asa device commonly utilized for controlling Brushless DC (BLDC) motors. It is designed to act as an intermediary between the power source and the BLDC motor, with control signals received from a compatible controller to adjust the motor's speed and direction. A continuous current of up to 30 Amps is handled, with speed regulation achieved through Pulse Width Modulation (PWM). Safety features, such as low voltage protection, over-temperature protection, and current limiting, are included to prevent damage to the motor and ESC. Initial configuration and calibration are required, with proper installation and wiring emphasized for achieving optimal performance and safety.

Fig. 7: Speed controller

4. EXPECTED RESULT

A fully functional prototype of the autonomous water- cleaning robot is expected to be yielded by the research, with effective debris detection, navigation, and waste collection capabilities being demonstrated. The robot is designed to operate autonomously in both still and flowing water bodies, with adaptability to environmental changes being showcased. Significant efficiency in cleaning, compared to traditional manual methods, is anticipated to be demonstrated. Furthermore, performance metrics, including the area cleaned per hour and waste collection efficiency, will be analyzed and documented, providing a benchmark for future improvements and scalability.

5. CONCLUSION

In conclusion, autonomous river cleaning robots are advanced robotic boats that are designed to autonomously clean rivers and water bodies. Various features and technologies, such as navigation systems, cleaning mechanisms, filtration systems, energy sources, communication systems, and safety features, are incorporated into these robots. They operate without human intervention, using their capabilities to navigatewaterways, collect debris and pollutants, filter water, and transmit data for monitoring and analysis. Significant benefits for environmental conservation are contributed bythe development of autonomous river cleaning robots. Pollution reduction and water ecosystem preservation are promoted by these robots, as they efficiently remove debrisand pollutants from rivers. The contamination of water sources is prevented, marine life is protected, and the overall cleanliness of water bodies is improved by these robots. By leveraging advanced technologies and autonomous capabilities, continuous operation is enabled, large areas are covered, and adaptability to different river conditions is ensured. A sustainable and cost-effective solution for river cleaning is offered by these robots, reducing the reliance on manual labor and increasing the efficiency of cleaning operations. While challenges, such as handling complex debrisor addressing specific local conditions, remain to be overcome, great promise is held by the advancement of autonomous river cleaning robots for the future. By combining technological innovation, environmental stewardship, and collaborative efforts, cleaner and healthier rivers can be worked towards, contributing to a more sustainable planet.

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