Lake cleaning robot

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***Abstract*— The goal of this project is to build a camera-and OpenCV-based autonomous robot that can clean lakes by detecting, collecting, and monitoring trash. A garbage conveyor system, real-time navigation, and smartphone app control are all part of it. Users are notified when the trash level is reached via an ultrasonic sensor. An eco-friendly solution for dealing with aquatic waste, the modular, buoyant design can support loads up to three kilograms.**

1. Introduction

Water is important for life, although natural water bodies like ponds are increasingly endangered by pollution owing to industry, urbanization, and neglect. Ponds are vital for biodiversity, groundwater recharge, and recreational uses. However, floating garbage, plastics, and biological waste are producing ecological imbalance, harming aquatic life, and hurting human health.

These contaminants also decrease the natural beauty and usefulness of these ecosystems, making their upkeep an important requirement. Traditional cleaning techniques, such as physical labor and mechanical equipment, are unable to manage the expanding complexity and size of pollution. Manual cleaning is labor-intensive, time-consuming, and generally unfeasible for big water bodies. Mechanical systems, although effective, are expensive to install and operate, and their designs generally lack the flexibility to adapt to different pond sizes and circumstances. This underscores the need for creative, cost-effective, and sustainable solutions.

The Pond Cleaning Robot provides a cutting-edge alternative to this issue. Combining powerful sensors, intelligent navigation, and modular design, this autonomous robot can successfully collect floating waste, avoid obstructions, and monitor trash levels. Ultrasonic sensors offer accurate obstacle identification, while IR sensors monitor the trash container's capacity, telling users when it needs emptying. These characteristics guarantee the robot performs effectively and minimizes the chance of disruptions.

Built with lightweight and buoyant materials like Sun board sheets, the robot stays steady in tough circumstances and can manage substantial volumes of debris without impairing its navigational ability. The modular design allows for expansion and customization, making it appropriate for varied pond sizes and situations. By decreasing human interaction, the robot decreases labor expenses and offers an ecologically benign answer to pond management. It provides a sustainable alternative to conventional approaches, connecting technical innovation with ecological protection. This initiative helps to cleaner water bodies, preserves aquatic species, and promotes the quality of life for those depending on these essential ecosystems. With the Pond Cleaning Robot, we take a crucial step toward conserving our natural resources for future generations.

2. Literature servey

Ingle et al. studied solar-powered river-cleaning robots as a sustainable solution to water pollution, using automation and renewable energy. The robot, equipped with solar panels, a motorized mechanism, and a conveyor belt, effectively gathers and stores rubbish for disposal. It functions independently, adjusting to varied water conditions, however issues like maintenance, obstacle detection, and weather resilience continue. The research focuses merging robots and renewable energy to enhance sustainable environmental protection. [1]

The research "GPS Guided River Cleaning Robot," published in 2023 by Bharath B P, Srivani E N, Bharath S, and Akhil V Narayan, offers an automated device meant to battle river pollution using GPS technology. The robot independently navigates predefined courses to clean waterways, collecting floating garbage like plastics using a conveyor belt system. It functions effectively in both small and big water bodies, driven by a motorized propulsion system. The report identifies possible renewable energy integration, such as solar power, to minimize operational costs and environmental effect. Benefits include lower labor expenses, better safety, and continued operation in hazardous situations. Challenges include navigating strong currents and uncertain weather. Further improvement is recommended for obstacle identification and waste segregation features. [2]

The 2020 research "Swachh Hasth-A Water Cleaning Robot" by S. Janai, H. N. Supreetha, S. Bhoomika, R. P. Yogithashree, and M. Pallavi provides a cheap, robotics-based solution for water pollution. The robot gathers floating garbage using a conveyor belt system, which puts waste into a storage facility for disposal or recycling. It functions autonomously, reducing human effort and enables cleaning in difficult-to-reach regions. The battery-powered robot may combine solar panels for energy efficiency. Its lightweight, portable form enables for simple deployment in diverse water bodies. The research tackles difficulties including handling different quantities of garbage and guaranteeing stability in strong currents, while also highlighting the necessity for maintenance and continuing improvements. [3]

The research "Control System Design of Remote-controlled Floating Garbage Cleaning Robot Suitable for Small Water Area" focuses on a remote-controlled robot developed for small water bodies like reservoirs and ponds. It has a customizable navigation system and real-time feedback methods for accurate operation. The robot incorporates a conveyor belt to collect floating debris and a storage container for garbage. Its lightweight and modular design provides simple deployment and adaptation. AI components like sensors boost efficiency and safety. The robot's battery-powered motor provides ecologically benign operation, with possibilities for future solar panel integration. Challenges like as water currents and debris density are addressed by upgrading control algorithms for greater performance. [4]

The 2018 research "Pond Cleaning Robot" by H. M. Soumya and Basavaraj Gadgay offers a robotic system for automating pond cleaning to minimize labor and enhance efficiency. The robot gathers floating garbage like plastic and algae using a conveyor belt and stores it temporarily for appropriate disposal. It functions semi-automatically, with remote human control, and is powered by a battery-operated motor. The research advises incorporating solar panels for longer functioning and eco-friendliness. Challenges include adaptation to different water conditions and debris varieties. Future upgrades include incorporating improved sensors for greater performance. [5]

The 2019 paper "A Water Surface Cleaning Robot" by E. Rahmawati et al. offers a robotic device aimed to solve water pollution by collecting floating trash like plastics, leaves, and garbage from water surfaces. The robot utilizes a conveyor belt to collect and store waste while traveling independently in small to medium-sized water bodies using an electric motor. Its tiny, portable form allows for quick deployment, and it is energy-efficient, with possibilities for solar power integration. The research underlines the necessity of sensors for obstacle identification and discusses problems including scalability, handling diverse forms of trash, and maintenance. Future developments might concentrate on boosting performance in bigger bodies of water, enhancing trash sorting, and refining autonomous navigation. [6]

The research "Design and Manufacturing of a Semi-automatic Robot for Cleaning Water Bodies" by Aashirwad R. Morye et al. discusses a semi-automatic robot meant to solve water pollution by removing floating trash like plastic and leaves from lakes, rivers, and ponds. The robot combines both autonomous and manual activities, offering operators freedom while automating cleaning procedures. Key components include a conveyor belt for garbage collecting and a motorized propulsion system for mobility. It is portable, modular, and energy-efficient, utilizing rechargeable batteries. Challenges include incorporating obstacle sensors, optimizing the waste collecting system, and assuring stability in diverse water conditions. Future advancements might concentrate on complete automation, increased waste segregation, and better sensor capabilities. [7]

The article "Design and Development of River Cleaning Robot Using IoT Technology" offers an automated river cleaning robot that employs IoT to boost its functionality and effectiveness in eliminating river pollution. Equipped with a conveyor belt for collecting garbage including plastics and biological waste, the robot travels over the river using an electric motor. IoT sensors give real-time data on waste density, water quality, and robot status, allowing remote monitoring and control. This minimizes human participation and boosts autonomy, while IoT technology aids with self-diagnosis, improving dependability and lowering downtime. The robot is lightweight, portable, and energy-efficient, with potential for solar power integration. Challenges include assuring stability in fast-flowing water and optimizing the waste collection mechanism. Future developments may center on better sorting systems and navigation algorithms. [8]

The article "Effective Aquatic Waste Removal through Lake Cleaning Robot for Smart City Environment" offers an automated lake cleaning robot meant to solve water pollution in smart cities. The robot employs a conveyor belt or similar mechanism to gather floating debris like plastics and leaves, depositing it in an onboard chamber. Integrated with IoT technology, it delivers real-time data on rubbish levels and water quality, enabling remote monitoring and management. Powered by rechargeable batteries, the robot is energy-efficient, with possibilities for solar power integration. Its compact form enables it to clean both small and big bodies of water. Future advancements may include better navigation algorithms, obstacle detection, and waste segregation systems. [9]

3. Proposed Methodology

3.1 Block diagram :

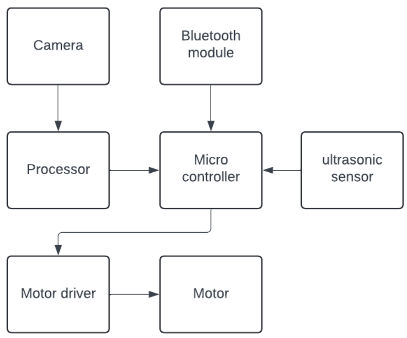

Fig 3. 1 Block diagram

The autonomous lake cleaning robot is meant to gather plastic detritus, concentrating on red plastic waste. It employs a camera to record frames for image processing, recognizing red plastic, and communicates the data to an Arduino. The Arduino controls the motors, allowing precise motions to gather the garbage using a moving conveyor belt. The belt carries the rubbish to an onboard chamber, and an ultrasonic sensor assures optimum functioning. The robot rotates in place while no red plastic is detected, then begins collecting once it discovers waste. This system illustrates the convergence of hardware and software for environmental remediation.

3.2 Flowchart :

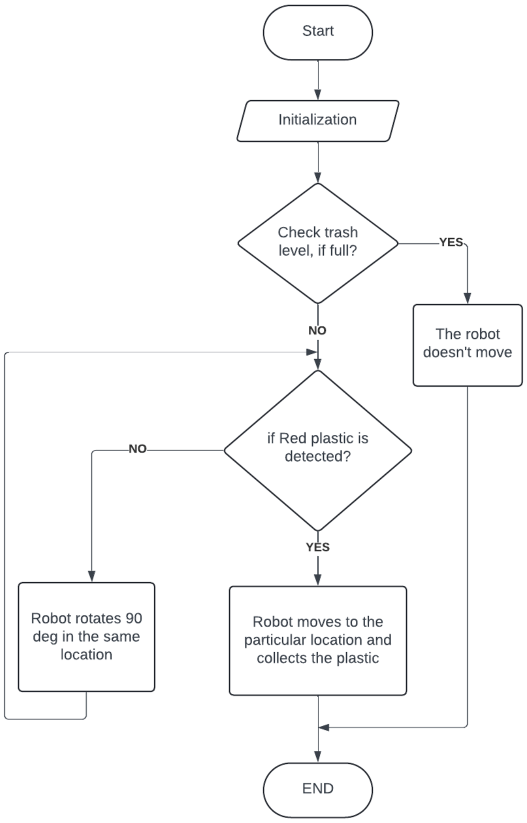

Fig 3. 2 Flow Chart

The robot begins with a series of tests to verify everything appropriately. The first step is to examine the waste level in the collecting system. If the waste is full, the robot halts its activities; otherwise, it continues with its duty. The following phase entails looking for red plastic, the target waste. If spotted, the robot moves to the collecting area and collects the red plastic using sensors and algorithms. If no red plastic is detected, the robot turns 90 degrees to change direction and resume its search for more garbage. This rotation helps the robot cover more regions and guarantees no locations are missed. After the rotation, the robot reassesses the surroundings for new things. If the garbage is not full and no red plastic is detected, it continues to search farther, increasing the odds of identifying waste. The robot's actions repeat as it intelligently adjusts to its surroundings, guaranteeing effective cleaning and rubbish collecting. This rigorous technique enables the robot to work autonomously and successfully.

3.3 Circuit diagram :

The autonomous garbage collection robot is created with linked components to identify, approach, and collect red plastic litter while monitoring trash levels. The method starts with a laptop and camera, collecting photographs of the area. The laptop employs visual processing, such color detection, to recognize red plastic. After analyzing the picture, the laptop estimates the distance to the discovered item. This data is delivered to the Arduino via serial connection, which controls the robot's mobility with an L298N motor driver, coupled to DC motors that direct the robot's motions.

The NodeMCU, a key component of the autonomous trash collection robot, acts as the secondary microcontroller responsible for handling communication with the laptop and directing the robot's movement. The laptop is utilized mostly for image processing, where it recognizes red plastic items in the robot's surroundings. Once the red plastic is identified, the laptop estimates the distance from the item, which is critical for precision robot navigation. The distance data is supplied to the NodeMCU via serial connection. The

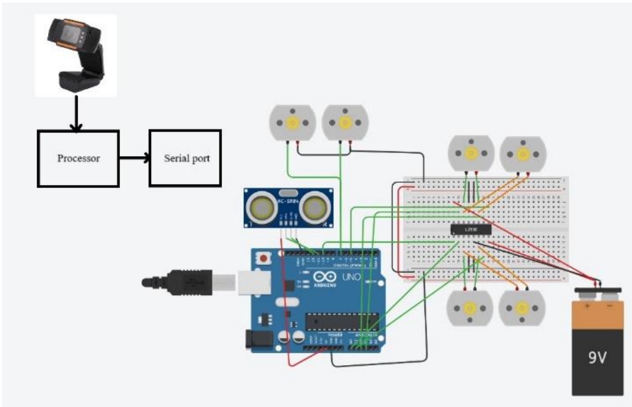

Fig 3. 3 Circuit diagram

NodeMCU decodes the data and directs the robot's movement by commanding the motors using the L298N motor driver.

Beyond regulating the robot's navigation, the NodeMCU is also responsible with handling the robot's waste collection system. It employs an ultrasonic sensor to continually check the garbage level in the robot's collecting container. The ultrasonic sensor works by producing sound waves and measuring the time it takes for the waves to bounce back after striking an object in this example, the waste within the bin. This data is then utilized to compute the distance to the garbage, and when the trash bin reaches its maximum capacity, the NodeMCU generates an alarm. The system's real-time performance is recorded and updated continually on Google Sheets, allowing for remote monitoring and data tracking. This capability guarantees that the robot does not spend time collecting garbage while the bin is already full, and it supports efficient trash management by keeping track of the system's performance.

A crucial differentiating characteristic of the NodeMCU is its ability to function independently of the Arduino. While the Arduino's major job is to regulate the robot's mobility and connect with the garbage, the NodeMCU performs autonomous duties like as monitoring the trash level and interfacing with cloud services. This division of roles not only makes the system modular but also boosts its overall efficiency. The NodeMCU can smoothly communicate with third-party services, such as Google Sheets for real-time data recording, or other platforms for future integration, making it very versatile for future growth or updates.

Manual control is another key component of the robot, providing operators the ability to overrule its autonomous activities when required. The manual control system is linked into the robot with an Arduino Bluetooth module. This Bluetooth module allows the user to wirelessly connect to the robot via a smartphone or similar Bluetooth-enabled device. Through the Bluetooth connection, the user may directly control the robot's motions, enabling a handy approach to handle the robot's operations in various conditions. This manual mode is especially beneficial in confined locations or when the robot hits objects that it cannot avoid on its own. The operator may intervene to move the robot out of a tight space or change its course as necessary. This capacity to transition between autonomous and human control guarantees that the robot stays useful and efficient in a range of real-world circumstances, giving both convenience and dependability.

The robot's conveyor system plays a significant part in the waste collecting operation. Once the red plastic waste is spotted by the camera and recognized by the image processing system, the conveyor belt is triggered to carry the plastic to the collecting bin. The motors powering the conveyor system are coupled to the same L298N motor driver as the robot's movement motors, guaranteeing coordinated operation between the two systems. This connection streamlines the design and allows for good coordination between navigation and garbage pickup. The conveyor belt's movement is regulated in unison with the robot's navigation, enabling the system to efficiently transport the plastic into the specified collecting chamber.

The complete system, including the robot's motors, sensors, microcontrollers, and communication modules, is powered by a single 12V battery. This concentrated power supply implies that all components may perform independently without the need for external power sources, making the robot self-sufficient. The 12V battery supplies enough power to run the robot for extended periods of time, allowing it to continually patrol an area, collect waste, and return to its base without needing to be recharged periodically. This assures that the robot can execute long-term rubbish collection activities in a variety of scenarios, from urban districts to industrial locations. The 12V battery is chosen for its endurance and longevity, making it appropriate for continuous operations in real-world applications.

The integration of many technologies image processing, ultrasonic detection, Bluetooth control, and autonomous navigation makes this garbage pickup robot a highly intelligent and efficient system. The robot can detect and collect red plastic waste autonomously, while regularly monitoring and managing the trash level to reduce overfilling. The employment of the laptop for image processing, the Arduino for motor control, and the NodeMCU for trash level monitoring and cloud connection allows the system to be versatile and adjustable. This design not only increases the robot's working but also enables flexibility for future expansions and upgrades.

In addition, the Bluetooth module gives an added degree of adaptability, providing manual control when required. Whether the robot is operated autonomously, collecting garbage, or manually controlled, it offers an effective solution for waste management. The system's modular structure allows for straightforward updates, and the real-time data recording in Google Sheets gives significant insights into the robot's performance. The integration of all these components into a single autonomous trash collecting system highlights the promise of robotics and automation in tackling current environmental concerns, making this robot an excellent tool for decreasing waste and enhancing efficiency in waste management operations.

The robot's potential to operate autonomously, adapt to its surroundings, and transition between autonomous and manual modes means that it can conduct a wide variety of duties in diverse circumstances, delivering a versatile and adaptive solution for waste management. With its intelligent design and robust functionality, this autonomous garbage collecting robot is a huge step in creating more sustainable and efficient solutions for environmental clean-up and waste management.

4. Results and discussions

The fundamental objective of this software is to enable an autonomous robot, equipped with an Arduino and camera, to identify and navigate towards red plastic debris in an aquatic environment. The system is supposed to be incredibly efficient by integrating technologies like real-time image processing, color identification, motion control, and environmental monitoring to assure effective garbage collecting. These capabilities allow the robot to execute autonomous operations, modifying its behavior based on real-time data to identify, approach, and collect red plastic rubbish while limiting its movement and ensuring it does not cause any mishaps. The robot's intelligence technology allows it to constantly evaluate its surroundings, locate particular trash, and collect it automatically, all with little human intervention.

At the basis of the robot's ability to recognize red plastic garbage is its usage of a camera and the OpenCV image processing package. The camera constantly takes video frames, which are analyzed in real-time to recognize the red plastic objects in the robot's surroundings. OpenCV is a widely used and effective toolbox for real-time computer vision and image processing tasks, allowing the robot to understand and adapt to its environment nearly immediately. The method utilizes color detection inside the HSV (Hue, Saturation, Value) color space, which is suited

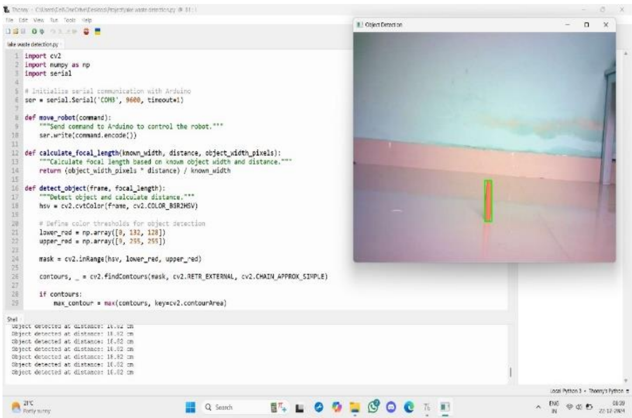

Fig 4. 1 Red object detection

for color-based object identification. The usage of the HSV color space is useful since it is more resistive to changes in lighting conditions compared to the typical RGB color system. By concentrating on the red hue spectrum, the system can quickly detect the intended trash, guaranteeing that the robot only gathers the specified waste material.

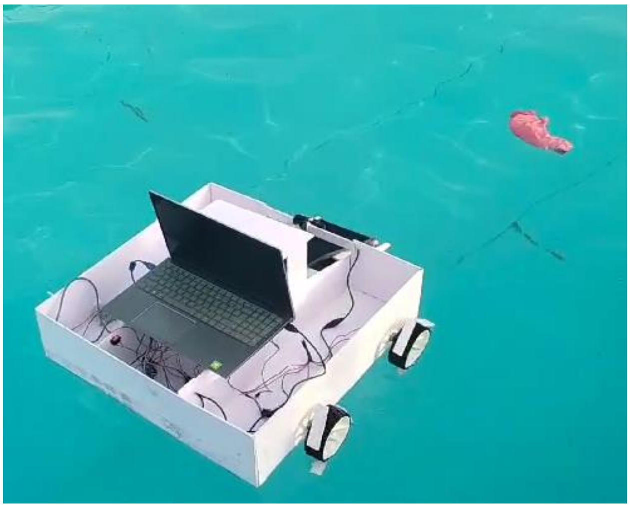

Fig 4. 2 Lake cleaning robot

Once the red plastic is discovered, the algorithm utilizes a predetermined focal length, which was previously calibrated, to measure the distance between the robot and the detected item. This calibration process is crucial, since it allows the robot to make educated judgments on its approach towards the debris. After identifying the object's distance, the captured frame is separated into three regions: left, center, and right. This split enables the robot to make accurate movement choices depending on the placement of the item inside the frame. If the item is on the left side of the frame, the robot will turn left; if it is on the right side, it will turn right; and if it is positioned in the middle, the robot will go forward. This region-based navigation guarantees that the robot travels effectively toward the destination, minimizing needless diversions and optimizing its path for waste pickup.

In circumstances when the robot does not detect any red plastic, it will wait for a brief while, then spin 90 degrees to scan a different direction for trash. This circular mobility is a critical feature, since it enables the robot to continually monitor its surroundings, improving the probability of discovering rubbish. By turning and searching in multiple directions, the robot may optimize its coverage area and enhance its odds of discovering and collecting rubbish. The real-time analysis of each camera frame guarantees that the robot reacts promptly to changes in its surroundings, altering its movements appropriately to detect and gather the red plastic garbage.

Another key component of the system is the Ultrasonic Sensor-Based Trash Collection Monitoring System, which promotes the automation and efficiency of trash management. Ultrasonic sensors are frequently utilized in automation systems owing to their ability to calculate distances precisely using sound waves. In this scenario, the ultrasonic sensor is applied to monitor the fill level of the garbage collecting container in real-time. The sensor operates by releasing sound waves and measuring the time it takes for the waves to bounce back after impacting an item. Based on this data, the system calculates the distance to the garbage and decides when the trash bin is full. If the bin hits a predetermined threshold, the system generates a signal indicating that the trash container has to be emptied, ensuring that the robot does not continue to gather waste after the bin is at capacity. This function helps minimize overloading of the collecting system and guarantees that the robot can perform properly without running into complications caused by an excessively filled bin.

Fig 4. 3 Collecting red plastic

Once the red plastic is identified, the robot moves toward the target, adjusting its actions based on the object's proximity. When the garbage is right in front of it, the robot moves forward to retrieve the thing. If the object is not aligned with the robot's path, it will turn left or right to reach it. Once the red plastic is reached, the robot activates its conveyor system, which assists in collecting and moving the waste into the collection container. The conveyor system is vital to the robot's efficiency, as it ensures that the gathered garbage is suitably preserved for future disposal. The system's performance in an aquatic context illustrates its versatility, displaying the robot's skills to conduct precise garbage collection, navigate efficiently, and recognize items in real-time. This potential to function smoothly in a variety of situations makes the robot an effective alternative for waste management in aquatic settings.

5. Conclusion

A creative and successful waste management solution is the autonomous trash collection robot, which was built for aquatic environments like lakes and swimming pools. The system effectively recognizes, navigates, and collects rubbish with the least amount of human contact thanks of the integration of cutting-edge technologies including image processing, ultrasonic sensors, and real-time communication. The robot can accurately discover and approach the red plastic waste by utilizing a camera and OpenCV for image processing to identify it based on color detection. A fixed focal length is utilized to estimate the distance between the robot and the target, allowing the robot to alter its actions accordingly. The robot stops if the object is too close, turns if it is to the left or right, and advances if it is in the center. Furthermore, the trash container's fill level is regularly monitored by the ultrasonic sensor, which guarantees that the system functions properly without overloading by offering real-time feedback and warnings when the container is full.

During rigorous testing in a swimming pool, the robot's autonomous abilities exhibited amazing accuracy and effectiveness. After the red plastic waste was successfully discovered by the detecting system, the robot approached it, utilized the conveyor system to pick it up, and then proceeded on hunting for additional rubbish. The robot's operational efficiency was further boosted by its continued rotation when no item was observed, which made sure it didn't miss any probable rubbish. With its durable design and capacity to transport up to 3 kg of waste, the robot is not only handy but ecologically responsible, helping to keep rivers cleaner with minimal human participation.

The system's Bluetooth and Wi-Fi connectivity features allow manual control and remote monitoring via a mobile app, offering the user even more options. Real-time monitoring of the robot's performance and trash collection progress is made feasible by the integration of data storage in cloud platforms like Google Sheets. This gives an added advantage for optimizing collection programs and assuring fast and effective waste management operations. The robot is suitable for lengthy operation in aquatic circumstances as its components are powered by a 12V battery, which provides long-lasting working.

A major achievement in automated waste management systems is represented by this trash collection robot. It is a valuable tool for boosting environmental cleanliness because of its autonomous waste identification, navigation, and collecting capabilities as well as its real-time monitoring and communication capabilities. The gadget displays both technical proficiency and a devotion to sustainability by minimizing the need for physical effort and lessening the influence of contaminants in aquatic environments. This robot may be enlarged for more broad usage and deployed in other water bodies as technology progresses, giving a scalable and realistic method to rubbish control on a global scale.

6. Future Scope

Autonomous garbage collection robots have a bright future ahead of them, with various prospects for improvement and usage across a number of industries. A broader range of waste, including paper, metal, and biological materials, may be discovered by enhancing the robot's detecting capabilities with advanced sensors like thermal cameras and machine learning algorithms. Larger or more intricate surroundings will be more efficient when AI driven navigation methods like SLAM are applied. With fleets running autonomously and optimized by cloud-based technologies and the Internet of Things, the robots may be utilized in industrial-scale waste collection, covering enormous territories.

Improvements in energy storage would minimize the need for recharging, while renewable energy sources like solar panels would improve operational length. Better decision-making may be helped by the analysis of data obtained by the robots, which may give insightful information on environmental trends and waste management. User participation would be boosted by better communication features including real-time monitoring and reporting. These robots may also be utilized in teaching campaigns to enhance public awareness of aquatic environment degradation. In the end, these advances would enhance waste management practices and promote global sustainability activities.

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