JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Solar Powered Lake Cleaning Robot

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ABSTRACT: The creation of a robot for clearing trash from the water's surface is described in this chapter. Durability, cost-effectiveness, and robustness are three significant challenges we encounter when constructing aquatic robots. Due to the nature of the cleaning work, we designed the vehicle structure that can provide high stability, good ability in maneuver and can easily collect all the waste.

The design and analysis of the floating garbage collecting machine is the focus of this work. The work focuses on the problematic state of our nation's rivers and other bodies of water, which are clogged with sewage waste and loaded with debris, pollutants, toxic materials, etc.Taking this into account, a machine was created to assist in cleaning the water bodies and maintaining water quality. The device floats to different areas of the water body to cleanthe light and floating wastes present in the water. We use solar energy as our alternative source of energy. This device aids in the removal of floating wastesfrom water bodies, which helps to prevent water pollution, provide clean water, and maintain a healthy marine ecology.

INTRODUCTION

Waste is an environmental issue that keeps coming up year after year and still hasn't been fully solved. We frequently discovered trash dumped into rivers, streams, or reservoirs from various locations. The trash can obstruct the flow of water, making it unclean and odorousto the point that it frequently overflows and creates calamities, including flooding. It takes a lotof resources to remove waste from water regions, like cleaning personnel and excavators.

On the earth's surface, there is a tremendous amount of water, yet much of it is unfit for human use. The situation of cleanliness and hygiene, particularly with regard to waste management, has deteriorated significantly over time and is still in danger as a result of the fast growth in population. Major rivers' water quality has gotten worse to a larger level. Househzold wastes, kitchen wastes, bathroom wastes, toilet waste water, as well as wastes from factories, other businesses, and livestock farms, among other things, are deposited in water bodies. The buildup of waste water results in the growth of several disease-carrying organisms and bacteria, including those that affect people and result in mortality, such as malaria and typhoid. Water bodies spread different disease- causing bacteria from place to place, resulting in illnesses like cholera and diarrhea.

In developing countries, growing amounts of dry waste in canals, ponds, and lakes affect waterdrainage and life quality of residents living close to those areas. Often found floating waste issuch as plastic scraps, foams, tree leaves, and aluminum bottles. Accumulation of the dry wastefloating on the water surface can obstruct water drainage in city canals and cause floods. Watersurface cleaning must therefore be done regularly. Due to less specific weight than water, the dry waste such as foams or plastic bottles can be easily observable on water surface. As the waste has a small drag force and water surface tension causes surface waves, the waste usuallyflows away when reaching by ship or boat. The typical waste collected by humans is often doneby using a scoop net with a long handle. However, the operation requires much effort from thecleaning team when the amount of waste is enormous. In this work, we focus on collecting thewaste floating on the water surface automatically and segregate the waste into bio degradable and non-bio degradable and dump them in separate bins.

I. LITERATURE SURVEY

The introduction of a water body cleaning robot controlled through a website using IoT technology is done that aims to prevent direct human contact with water bodies to avoid infections from microbes. Solar energy is employed. The robot's coverage and waste collectiondepend on user input. The design incorporates solar charge control, an IR sensor for object detection, and a user-accessible website via QR code scanning. Users install an application through the QR code, granting them control over the robot's functions. Waste is stored at the water body's bank, and users can operate the robot from there [1].

A semi-automatic drain for sewage water treatment of floating materials is used as an innovative solution to replace manual labor in drainage cleaning. This highlights the crucial role of mechanical drainage systems in industrial applications for proper sewage disposal. Despite the significance of these systems, the manual cleaning of blockages poses challenges and even risks human lives. In response to this issue, the authors propose a design for a mechanical semi-automatic drainage water cleaner. The goal is to efficiently manage waste disposal, prevent blockages, and ensure regular filtration of wastages, ultimately enhancing safety and reducing reliance on manual labor in drainage maintenance [2].

A river cleaning robot is designed to remove waste debris from the water floor and deposit it in a tray. The device utilizes fins connected to a rod outside the boat, and the flow of water from these fins collects floating solid waste. To enhance garbage collection efficiency, the authors propose using an advanced conveyor system and conveyor material. Additionally, instead of relying on battery operation, the robot is powered by a solar panel, aiming to increasesustainability and reduce environmental impact [3].

SMURF introduces a novel autonomous water surface waste cleaning robot. This robot is designed to achieve high-efficiency cleaning without requiring human operation. o initiate cleaning in a new water body, a one-time initialization process is required. During this phase, a cleaning boundary is manually set on a satellite map using an application on a mobile phone, PAD, or PC. A home point is also established to complete the initialization. Once initialized, SMURF autonomously executes its cleaning procedure. It follows a pre-planned coverage path,covering multiple cleaning areas if necessary. After completing the cleaning task, SMURF autonomously returns to the home point, indicating the completion of the cleaning cycle. The robot then awaits trash disposal and charging [4].

The system is a stationary autonomous surface vehicle equipped with a surface waste collectionunit and sensors to monitor both waste and system performance. To direct floating waste to thesystem, a barrier setup is employed. The flight conveyor is activated to pick up floating waste,loading it onto a distributed conveyor belt. Ultrasonic sensors measure the waste level in all dust bins, and when the distributed conveyor is full, the waste is evenly distributed into the bins. Simultaneously, pH and water level in the river are monitored using sensors. The systemincorporates real-time monitoring, with sensor data published on a website for externalviewing [5].

Raspberry Pi, the main computing board, manages image processing, object classification, andmotion controls, while Arduino is connected to the LoRa module and a water testing unit. Therobot employs object classification to segregate ocean pollutants and collect them in a specificcompartment for easier recycling. It features a LoRa-based communication system for device to-device communication and with gateways at the base station. Water testing sensors like pH and conductivity sensors monitor water quality. The robot is fully autonomous, utilizing an onboard GPS module for location tracking. The collected water quality data and pollutant information from the machine learning model can contribute to formulating local laws to reduce pollution and raising awareness about the types of materials ending up in oceansor water bodies [6].

The system is described as a floating waste collector machine in the form of a boat that movesto different areas of a water body, cleaning light and floating wastes. The process involves setting up Bluetooth connectivity between an Android application and a Bluetooth module. After ensuring the connection, predefined instructions are sent to the microcontroller of the mobile handset. These instructions are stored on a specified Android application installed on a mobile device. The application allows the user to provide navigation commands to the Arduinoprogram. Once connected, the boat can be navigated using motor drive for forward and backward movements. Additionally, a conveyor belt connected to a motor is activated to collectwater waste from the water surface [7].

The machine is designed to remove waste debris from the water surface and safely dispose of it from the water body. The motivation behind the project stems from the current condition ofnational rivers, which are filled with sewage, pollutants, toxic materials, and debris, posing a threat to aquatic life. The machine aims to lift surface debris, reducing water pollution and minimizing the risk to aquatic animals. The project's primary goal is to decrease the need for manual labor and reduce the time required for river cleaning. Energy is stored in a battery, which is then utilized to power a motor and chain drive arrangement for effective river cleaning [8].

The primary objective is lifting off waste debris from the water surface and disposing of it in atray. The machine features a conveyor arrangement on a motor shaft, collecting water debris, waste garbage, and plastics from water bodies. Utilizing a four-bar mechanism, the machine rotates at a specific angle to gather rubbish. It has two windows that can be opened and closedusing a remote control to turn the mechanism on and off. A water wheel, bolted on a shaft, moves the machine forward or backward on water. A motor, through a chain drive mechanism,rotates the water wheel. The project includes a tracking system to control the angle of the solararray with respect to sunrays, optimizing solar output [9].

The machine utilizes a chain drive mechanism to lift pans with the help of chains aligned withsprockets. The drain cleaner is designed to clean both small and large sewage through its mechanical structure and operation. When power is supplied to the machine, the motor starts functioning, causing the shaft and connected sprockets to rotate. This rotation drives the chainconnected to the sprocket, leading to the rotation of two lifters attached to the chain at half itslength. Positioned across the drain, the device allows only water to flow through the lower grids, while waste materials such as bottles floating in the drain are lifted by the teeth of the lifters connected to the circulating chain. The waste materials are then stored in a waste storagetank for disposal [10].

The machine intends to lift waste debris from the water surface and dispose of it in a tray. Theentire device is controlled remotely using an RF transmitter and receiver. The RF module includes an RF transmitter and an RF receiver operating at a frequency of 434 MHz, allowingfor wireless control of the machine through serial data transmission. The machine is remotelyoperated and features a continuous rotation of collecting plates and chain drives driven by a motor. The collecting plate, placed between two chain drives, collects waste materials from the river. A conveyor helps throw the collected wastages onto the collecting tray. The machine is propelled on the river by a propeller powered by two PMDC motors [11].

An innovative approach to enhancing the cleanliness of waterways, this system employs a GPS-guided river cleaning robot equipped with sensors and cameras to navigate waterways and autonomously clean up debris. The robot is initially programmed with a pre-set course using GPS coordinates, and once in the water, it follows this course while scanning for debris.As the robot moves through the water, its sensors and cameras detect and identify debris, whichis then collected using an onboard system, typically a conveyor belt that moves debris into a storage compartment. This storage compartment can hold a substantial amount of trash and canbe emptied and replaced as needed and the robot is powered by an electric motor [12].

The use of a battery-operated boat equipped with a belt conveyor to collect garbage from bothsmall and large water bodies. A buzzer is incorporated to add sound features to the project. TheLake Cleaning System robot is propelled in water by DC motors connected to the ESP32. It comprises two DC motors, a relay, ultrasonic sensor, gripper, IR sensor, trash can, and a transistor. The relay facilitates the movement of the robot by controlling the motors. The speedof the motors is set for effective movement. An ultrasonic sensor connected to the ESP32 detects objects as the robot moves on the water surface. A gripper is mounted on the front sideof the robot with proper ground clearance, collecting rubbish and pushing it into a bin locatedbehind the mechanism. The robot continues to gather garbage until a specific height of the bin is reached. This IoT-enabled river cleaning robot provides an efficient and automated solutionfor cleaning water bodies [13].

The utilization of sensors to record various parameters, including obstacle detection and their distance from the boat, as well as identification of living or non-living organisms. The systemdesign is divided into two stages: the first stage involves the assembly of the water boat with sensors, and the second stage focuses on the robotic arm. The system employs two Arduino Uno boards: one controls the wheels of the boat and processes sensor inputs, while the other isresponsible for controlling the robotic arm. The hardware requirements are discussed in detail.The simulation is conducted in two phases: the first phase involves an Infrared (IR) controlledDC motors assembly with sensors to demonstrate the working of the water boat, and the secondphase showcases Arduino-controlled servo motors using push-button switches, illustrating the functionality of the robotic arm. Overall, Swachh Hasth is designed to efficiently address watercleaning through a combination of sensor technology and a robotic arm [14].

The robot aims to remove waste particles from the water floor and collect them in a plate and is designed as a Bluetooth-operated waterway cleaning device. The collection arm is manually operated by an engine through Bluetooth control. The collection plate is positioned between two hollow PVC channels to gather waste materials from the waterway. The entire electrical system is controlled by Bluetooth and a joystick for remote operation. The remote includes switches to control the L23D9 motor, with adjustments made through Bluetooth. This design offers an automated and remotely controlled solution for cleaning rivers, contributing to effective waste removal from water bodies.[15]

II. BLOCK DIAGRAM

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The robot is designed to autonomously sort trash into two bins using a scooping mechanism. The ultrasonic sensors are used to alert the user when the bin is full, while the camera is used for object detection and recognition with raspberry pi as the central processing unit for the robot.

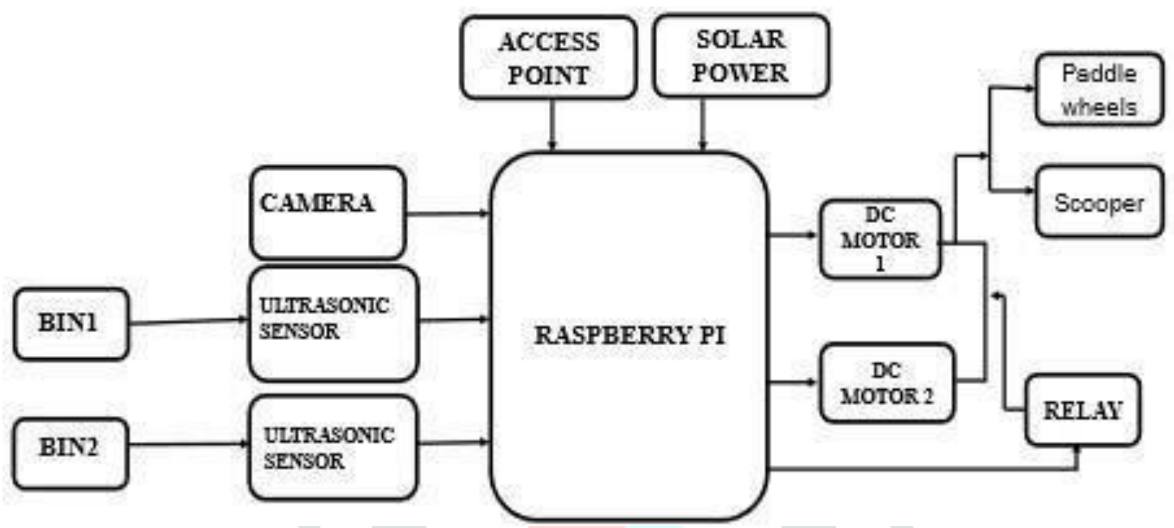
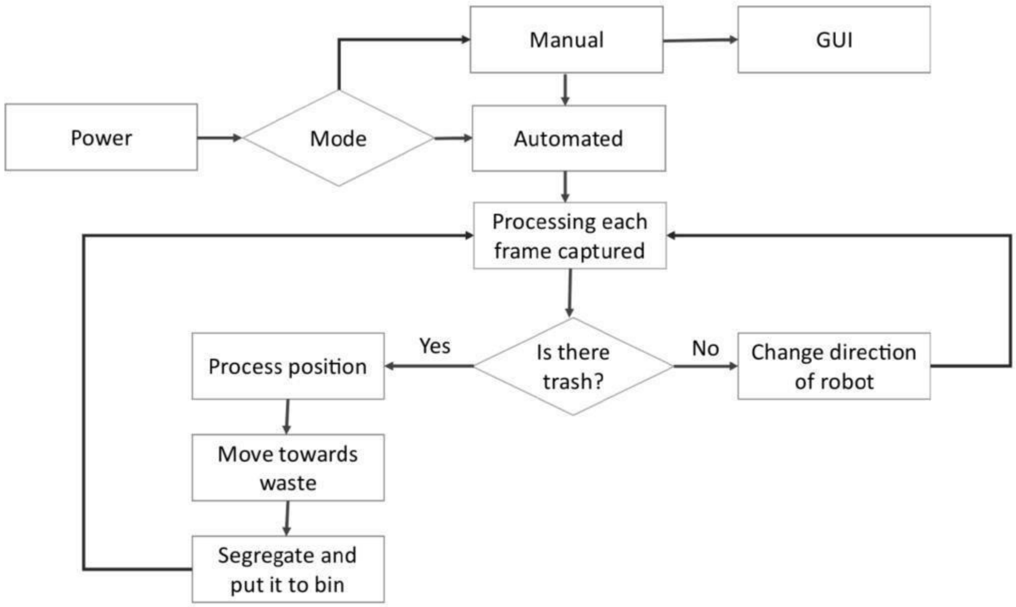


Fig 1: Block Diagram of a solar powered lake cleaning robot with hardware infrastructure

III. FLOW CHART



IV. METHODOLOGY

Using Raspbian OS for functioning the block diagram shown in the fig 1.

1. Autonomous Movement: In this mode, the robot operates autonomously, moving towards floating waste.
2. Waste Detection: The robot uses a pi camera to detect floating waste in its vicinity.
3. Yolo v7 Algorithm: The Yolo v7 algorithm is employed to identify and locate the floating trash swiftly and very accurately.
4. Conveyor Belt Activation: Once waste is detected, a conveyor belt is automatically activated.
5. Waste Collection and Separation: The activated conveyor belt collects the waste and detects them as biodegradable or non-biodegradable waste and then initiates theseparation process.
6. Classifier Movement: If the detected waste is biodegradable, a classifier spins to the right, else it spins to the left.
7. Bin Disposal: The waste is then directed to the appropriate bin, either for biodegradableor non-biodegradable materials and alerts the user if the bin is filled up.

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YOLO Algorithm

Yolo algorithm is briefly explained in this section: The newest member of the YOLO (You Only LookOnce) family of models is the v7 version. Single stage object detectors are YOLO models. Image framesin a YOLO model are enhanced by a backbone. These characteristics are merged and blended in the neck, where they are subsequently transmitted to the network's head. The locations and types of items around which bounding boxes should be created are predicted by YOLO.

To reach its final forecast, YOLO uses non-maximum suppression (NMS) post-processing.
The FCNN (Fully Connected Neural Network) foundation of the YOLO architecture The Backbone primarily pulls out the most important aspects of a picture and transmits them through the Neck to the Head. The Neck compiles feature maps that the Backbone has retrieved and builds feature pyramids. The head's output layers with final detections make up the head in the end. A single-stage real-time object detector is YOLOv7. YOLOv7 introduces a number of architectural improvements that increaseefficiency and accuracy. YOLOv7 backbones do not employ ImageNet pre-trained backbones, similar to Scaled YOLOv4. Instead, the complete COCO dataset is used to train the models.

The Yolo algorithm employs convolutional neural networks (CNN) to detect objects in real time. In this algorithm prediction in the entire image is done in a single algorithm run. Yolo algorithm works using the following three techniques

- Residual blocks
- Bounding box regression
- Intersection Over Union (IOU)

Convolutional neural networks basically consist of four layers: a convolutional layer, a ReLU layer, a pooling layer, and a fully connected layer.

Convolution layers

These layers are used to capture a tiny patch of the pictures after the computer has interpreted the image as a collection of pixels. The characteristics or filters are the names given to these pictures or patches. Convolutional layer performs significantly better at detecting similarities than complete image matching scenes by transmitting these rough feature matches in nearly the same location in the two pictures. The fresh input photos are compared to these filters; if a match is found, the image is appropriately categorised. Here, align the features and the picture before multiplying each image pixel by the matching feature pixel, adding the pixel totals, and dividing the feature's total number of pixels fits that region.

The rectified linear unit, also known as the ReLU layer, is what we use to eliminate any negative values from the filtered pictures and replace them with zero. To prevent the values from adding up to zeroes, this is done. This transform function only activates a node if the input value is greater than a certain threshold; if the input is lower than zero, the output is zero, and all negative values are then eliminated from the matrix.

Pooling layer

The size of the image is decreased in this layer. Here, we first choose a window size, then provide the necessary stride, and then move your window across your filtered photographs. Then take the highest values from each window. This will combine the layers and reduce the size of the matrix and picture, respectively. The fully linked layer receives the decreased size matrix as its input.

Fully connected layer

After the convolutional layer, ReLU layer, and pooling layer have been applied, we must stack all the layers. the fully linked layer that was applied to the input image's categorization. If a 2x2 matrix doesn't result, these levels must be repeated. The real categorization then takes place at the fully linked layer, which is employed at the conclusion.

Modes of operation

1) Manual mode:

In this mode each and every movement is controlled manually using the TCP tool app in mobile by sending information. This mode is designed to make intuitively simple sequences that don't require a lot of calculation.

2) Automatic mode:

In this mode, the machine moves autonomously in the direction of the floating waste, collects the waste, and separates the waste using machine learning. We achieve this by utilizing a USB camera to find the waste. Yolo v7 algorithm is what we're using to find floating trash. When waste is detected, a conveyor belt automatically begins to move, collecting the waste and sorting it into biodegradable and non-biodegradable materials. If the garbage being collected is biodegradable, the classifier spins to the right before returning to its original position. If the waste being collected is not biodegradable, the classifier rotates to the left before falling into the bin that has been set up.

V.RESULTS

The robot is be equipped with solar panels on its top surface. These panels convert sunlight into electricity, powering the robot's cleaning and sorting mechanisms. The robot incorporates a collection mechanism in form of a conveyor belt to gather waste floating on the water surface. A sorting system is integrated to differentiate between biodegradable and non-biodegradable waste. This involves using cameras with image recognition software to identify the type of waste to detect material properties. The robot has separate compartments to store the segregated waste. Biodegradable waste could potentially be composted, while non-biodegradable waste would need proper disposal facilities.

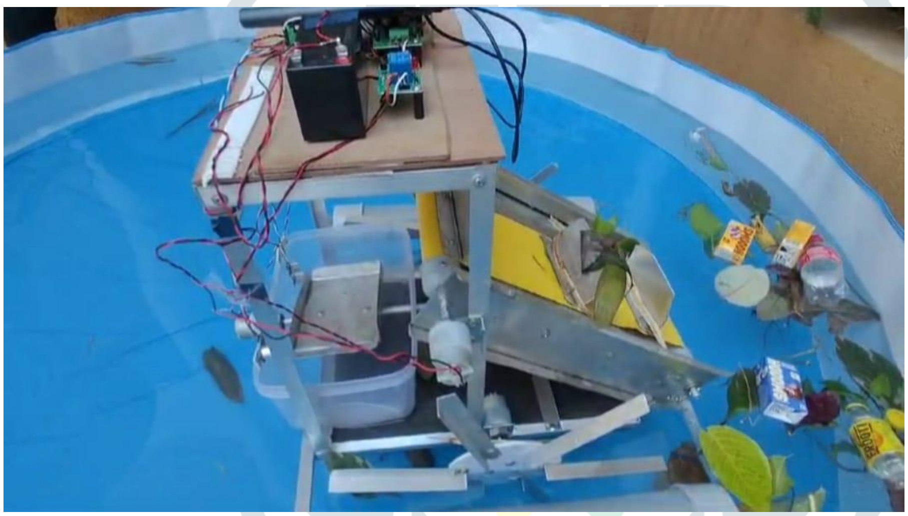

Figure2: Robot picking up the floating waste from the water body

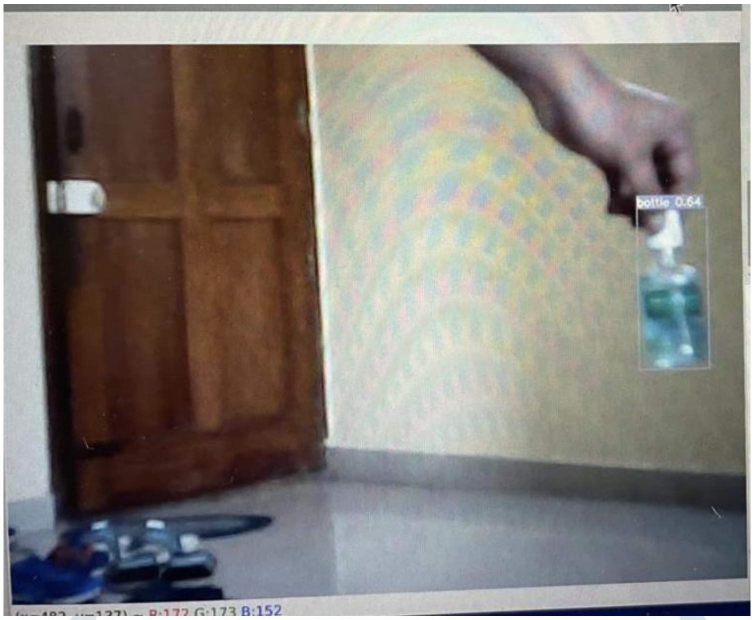

Figure3: camera module detecting the non-biodegradable waste

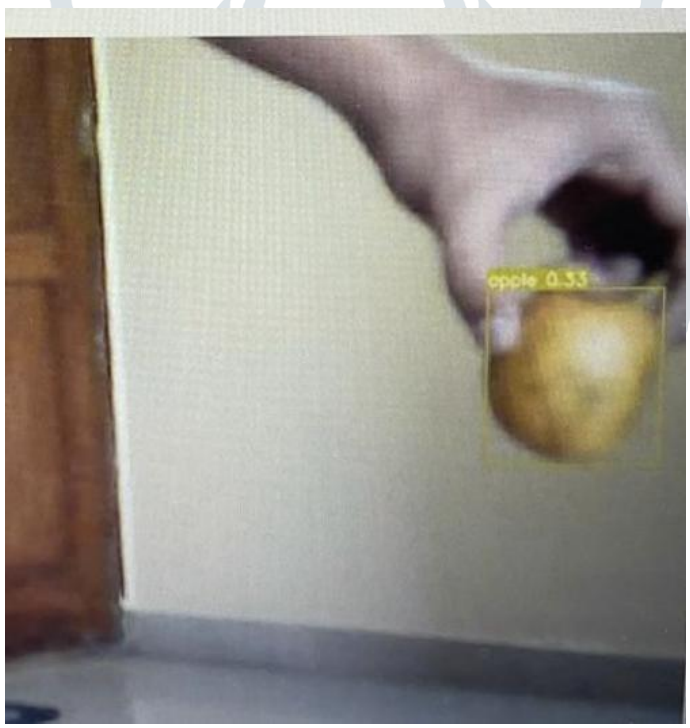

Figure4: camera module detecting the biodegradable waste

VII. CONCLUSION AND FUTURE SCOPE

The solar-powered lake cleaning robot with waste segregation capabilities presents a compelling solution for maintaining clean and healthy lakes. By removing waste, the robot helps improve water quality, protects aquatic life, and prevents the spread of harmful pollutants. Solar power ensures eco-friendly operation, reducing reliance on fossil fuels and minimizing the robot's environmental footprint. Separating biodegradable and non-biodegradable waste allows for proper disposal and potential recycling of non-biodegradable materials.

This innovative technology has the potential to be even more effective with further development. Machine learning algorithms could be incorporated to improve the accuracy of waste classification, ensuring proper segregation of different waste types. Developing more sophisticated sorting mechanisms could allow for the separation of a wider range of waste materials, such as plastics, glass, and metals. Integrating sensors could enable the robot to collect data on water quality parameters like pollution levels or algae blooms, providing valuable insights for lake management.

By implementing these advancements, solar-powered lake cleaning robots with waste segregation can become even more powerful tools for environmental conservation and sustainable lake management.

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