SIDDAGANGA INSTITUTE OF TECHNOLOGY,
TUMAKURU-572103

ROBOTIC FISH

Under the Guidance of
Mrs. Shobha S Goudar
Assistant Professor
Department of ECE
SIT, Tumakuru-3

Presented by:

ASRA	1SI17EC012
BHAVANA S	1SI17EC016
CHINMAI S	1SI17EC020
K NANDINI	1SI17EC034

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

CONTENTS

INTRODUCTION

- ROV (Remotely Operated Vehicle) is unoccupied vehicle, fitted with sensors and other tools to collect various types of data.
- ROVs, have applications in many fields including military and science.
- Trash enters water bodies in many ways and pollute the water reservoirs.
- Autonomous vehicles would be helpful to detect and collect debris in the water sources.

MOTIVATION

- Trash in various types of water bodies is common.
- Removal of these pollutants in small water reservoirs like water tanks and swimming pools has to be done frequently.
- Plastic waste are the most common type of debris found on the surface of water.
- Robotic vehicles make this task much easier

OBJECTIVES

The Objectives of the project are:

1. To design a robot which moves smoothly on the surface of water.
2. To remotely control the robotic fish using Radio Frequency (RF) technology.
3. To make the robot capable of finding and collecting the certain kind of trash like small plastic cover and bottle cap in water bodies.

Literature Survey

Remotely operated vehicles propel in two ways:

1. Propulsion using fin movements.

   Swim patterns are generated by caudal and pectoral fins attached to the fish body.

2. Using mechanical propellers.

   thrusters and propellers drive the water robots move forward or backward depending on the direction of rotation or pitch of the propeller.

Object Detection:

➔ Convolutional neural network is a class of deep, feed-forward artificial neural network that produce an accurate performance in computer vision tasks.

Trash collection:

➔ Robotic arm is a one of the electromechanical machine for applications of pick and place objects.

➔ Conveyor systems are reliable, durable and less expensive component to move or carry various things.

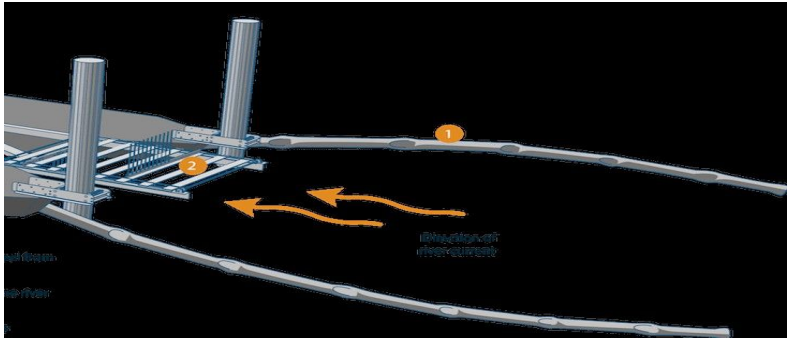

Figure 1: Conveyor system

Block Diagram

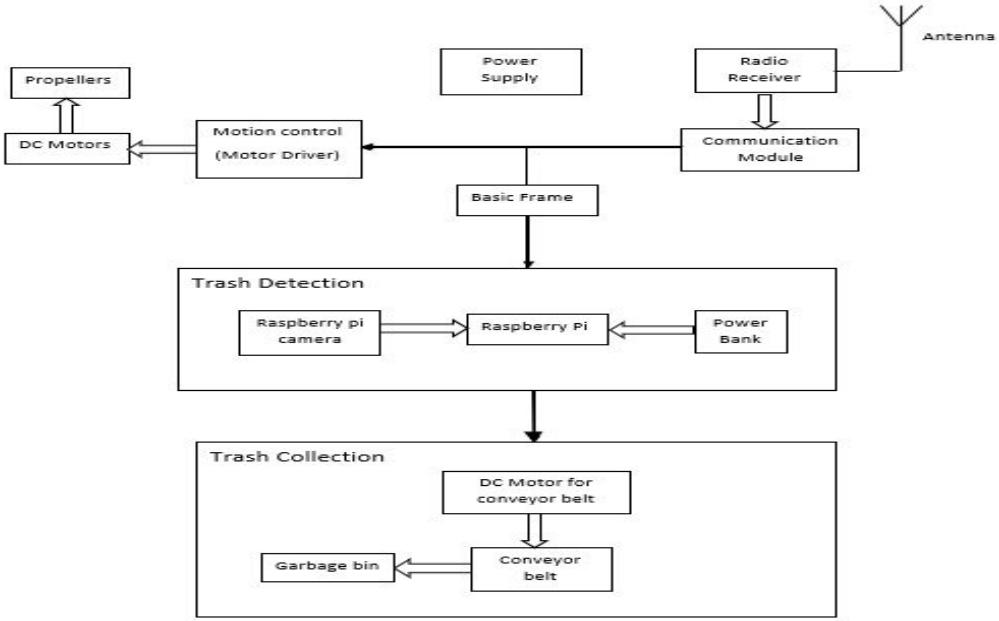

Figure 2: Block diagram of overall system

Propulsion control

- ➔ Pair of mechanical propellers are connected to either side of the robot.
- ➔ As motor rotates the propeller, cyclic lift forces generated by rotating mechanism and they exert linear thrust on the water.
- ➔ The resulting force imparts momentum to the water and pushes the robot forward.

F - Force

M - Momentum

Q - Torque

T - Thrust

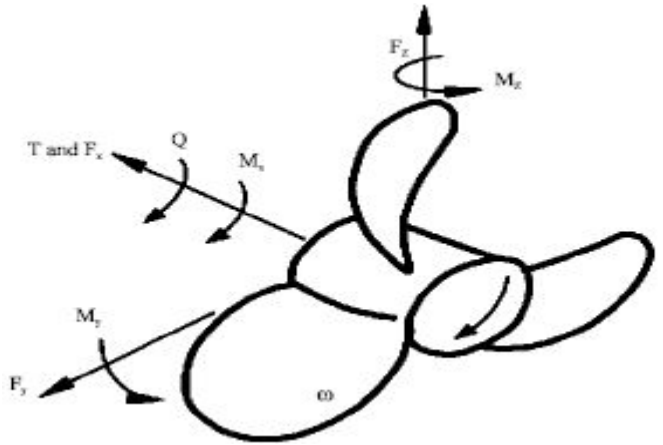

Figure 3: Forces and moments for marine propeller.

- ➔ For backward motion - propellers are rotated in opposite direction.
- ➔ Right or Left turn - either of the two propellers remains stationary.
- ➔ DC motor driver controls the DC motors base on the control commands received by the radio receiver.

Communication Module

- ➔ Robotic fish is remotely controlled using radio technology.
- ➔ Frequency of operation - 2.4GHz.
- ➔ Four control switches are provided to control the movement of the fish.

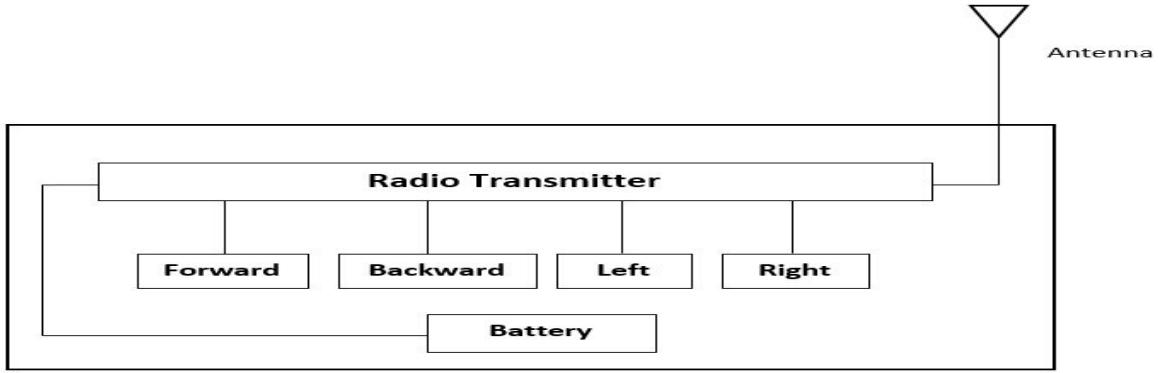

Figure 4: Block diagram remote module.

Trash detection and Collection

- ➔ Video stream is converted into frames and given to detector.
- ➔ Trained detector detects the trash in the frame.
- ➔ Conveyor system transfers the trash from surface water to the garbage bin.

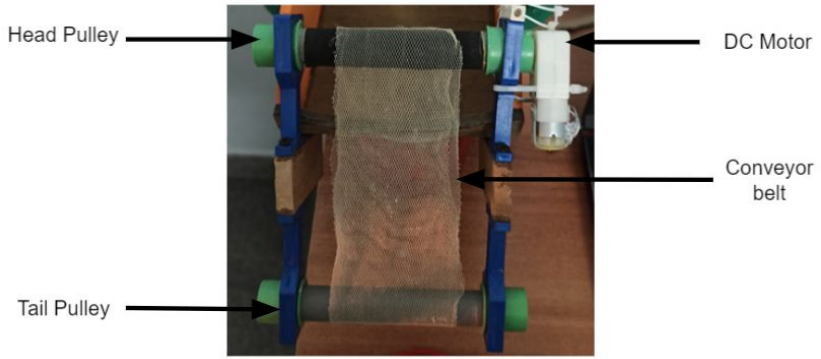

Figure 5: Parts of Conveyor Belt

SYSTEM HARDWARE

- **Raspberry Pi 3B+**
- **Tx and Rx module**
- **DC Motor**
- **Camera**
- **DC Motor Driver**
- **Power Supply - Batteries**

Figure 6: Hardware components

Boat Propellers

- ➔ Device has a rotating hub and blades .
- ➔ Diameter - 12cms.

Figure 7: Propellers

SYSTEM SOFTWARE

- CNN: Convolutional neural network is a class of deep, feed-forward neural network
- Used for Computer Vision tasks such as image classification and detection
- OpenCV: open source library designed to solve computer vision problems
- One can process images to identify objects
- Steps:-
  - Load model
  - Preprocess an input image
  - Pass the image through network and obtain the output classification

Real time object detection using python

- ➔ Mobile net single short object detection is used for real time object detection. This model is implemented using caffe framework
- ➔ Start the video stream.
- ➔ Loop over the frame and construct blob
- ➔ Specify blob as input start timestamp followed by passing input image through network and sorting predictions
- ➔ Feed input to the net which gives detections
- ➔ Look at confidence values and draw bounding box
- ➔ Filter weak detections and compute coordinates of the bounding for object
- ➔ Draw predictions of the frame and show output frame

YOLO v3

- ➔ You Only Look Once (YOLO) : a real time object detection algorithm
- ➔ YOLO takes input image and divides the input image into grids
- ➔ Image classification and localization are applied on each grid
- ➔ It applies Intersection over Union (IoU) and Non-Max Suppression concepts
- ➔ It uses anchor boxes : to detect multiple objects in single grid
- ➔ YOLO predicts the bounding boxes and corresponding class probabilities for objects

MATLAB

- MATLAB is a multi-paradigm programming language and numeric computing environment
- Used for image processing, machine learning, deep learning etc
- Toolboxes : A package of MATLAB files which may contain code, app, data, examples
- Examples of toolboxes :
  - Computer Vision toolbox
  - Image processing toolbox
  - Parallel computing toolbox
- Image Labeler : A MATLAB app used for labeling the data set into different classes

Object detection using MATLAB

Steps followed are:

1. Preparation of dataset
   - ➔ 440 images are collected
   - ➔ Images are labelled manually using Image labeller app into 3 classes: Bottle, Plastic and Bottle Cap
2. Divide the dataset into training (85%) and testing (15%) data randomly
3. Apply Data Augmentation : To improve the network accuracy
4. Define YOLO v3 object detector
   - ➔ Estimate anchor boxes
   - ➔ Load the SqueezeNet Network pretrained on Imagenet dataset

➔ Create YOLOv3ObjectDetector object by adding the detection network source

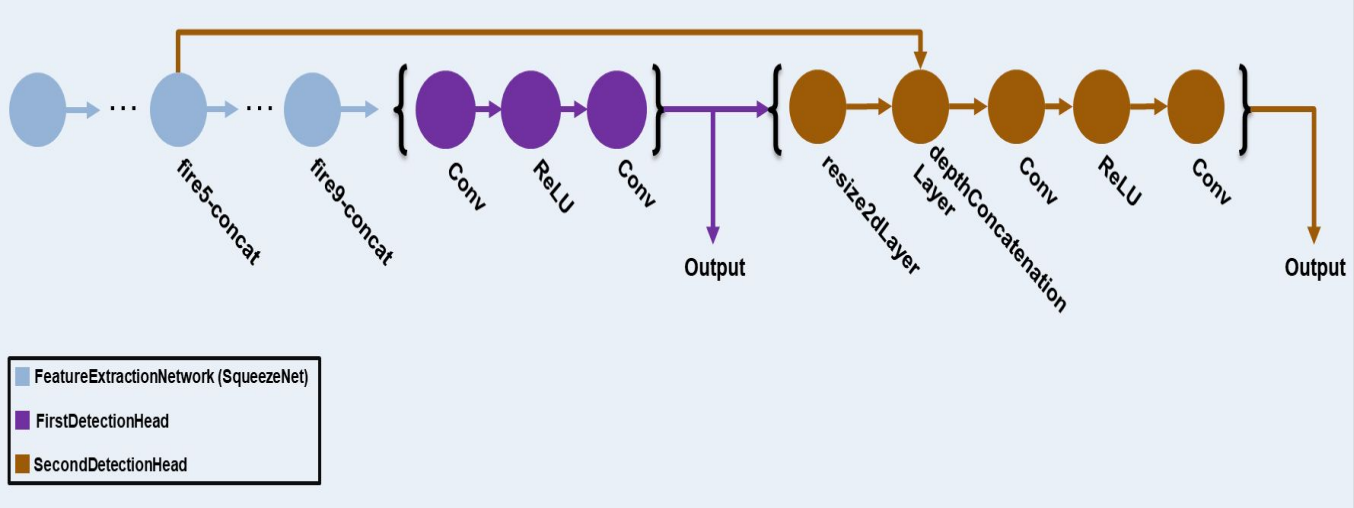

Figure 9: YOLO v3 Network

5. Preprocess the training data

➔ To prepare for training augmented data is preprocessed

6. Specify the training option and train the model

7. Test the trained model

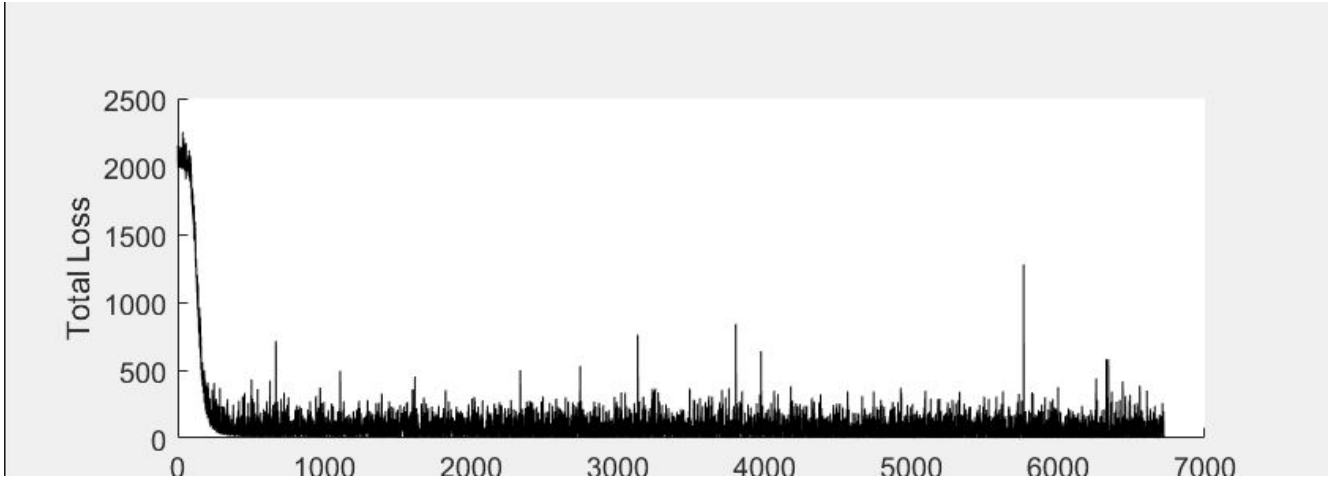

Figure 9: Graph of Total Loss Vs Iterations

Results

- ➔ The robot system is tested in tank with calm water.
- ➔ Once the system is powered, system starts to move with command received by the user through remote module.
- ➔ Four control switches: Forward, Backward, Left, Right.

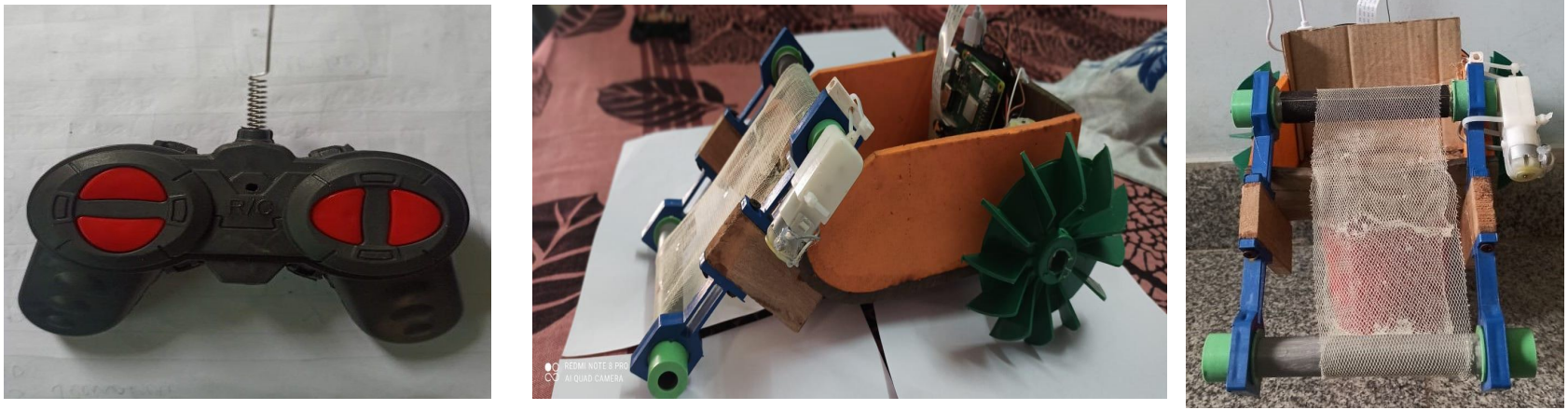

Figure 10: Remote module, side view and front view of the Robot.

Table 1: Robot Specifications

Specification	Value
Weight	600 grams
Overall size	32*25*18 (cms)
Size of garbage bin	14*15*10 (cms)

Object detection – Matlab results

- ➔ Model is trained for three classes: water bottles, plastic covers, plastic caps.
- ➔ MIoU = 0.73

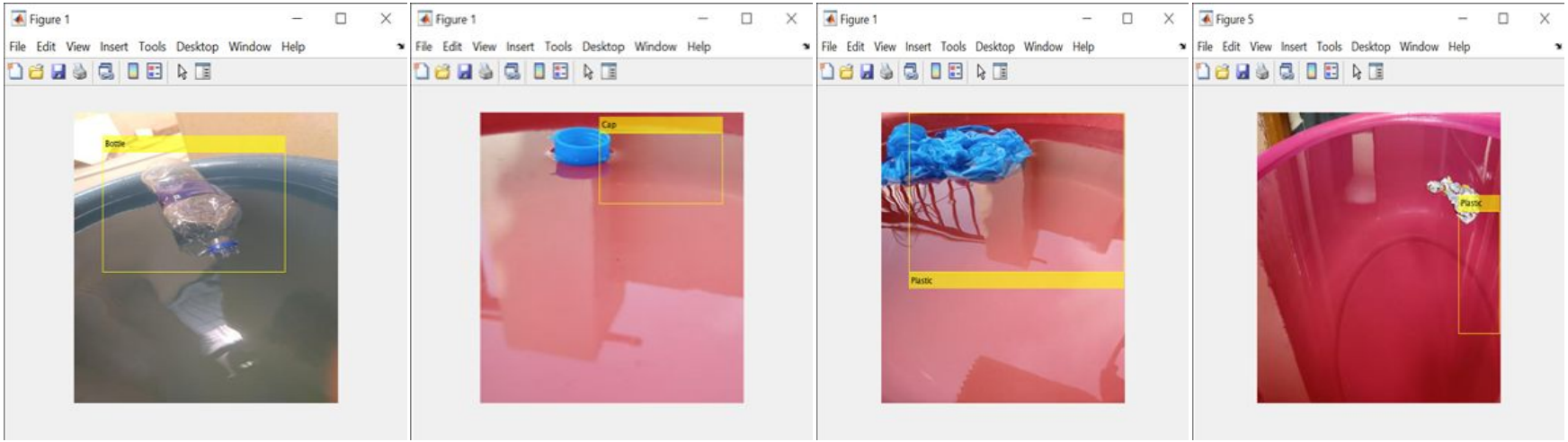

Figure 11: Detection results for 3 classes.

Object detection - Python results

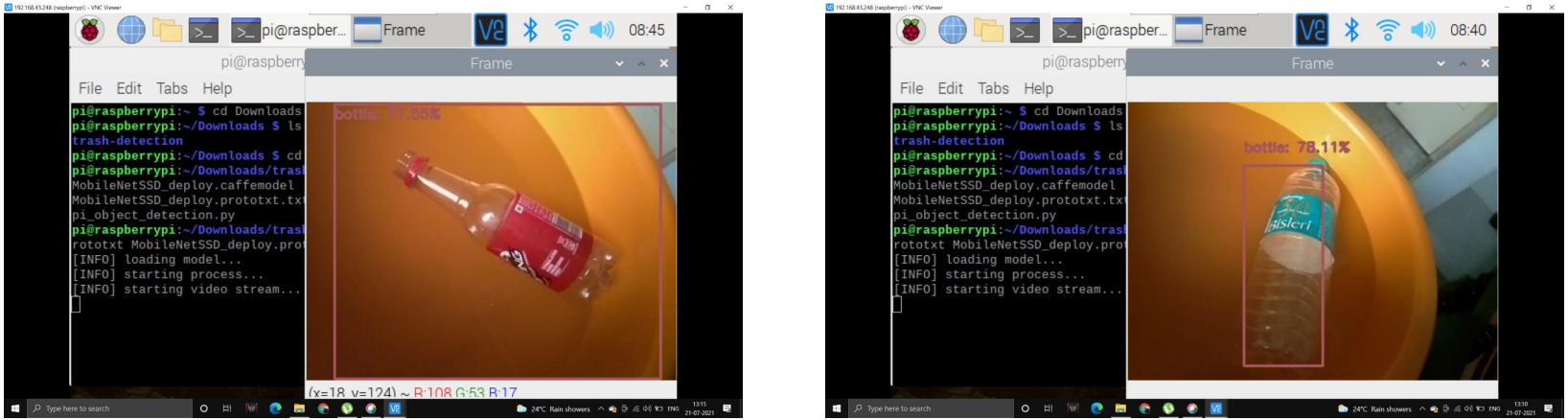

Figure 12: Detection results for python algorithm

Trash Collection Results

- ➔ Conveyor belt smoothly transfers the trash from the water surface to the garbage bin.
- ➔ The model can collect only small sized trash like plastic wrappers, caps.
- ➔ The collected trash is dumped into the garbage bin.

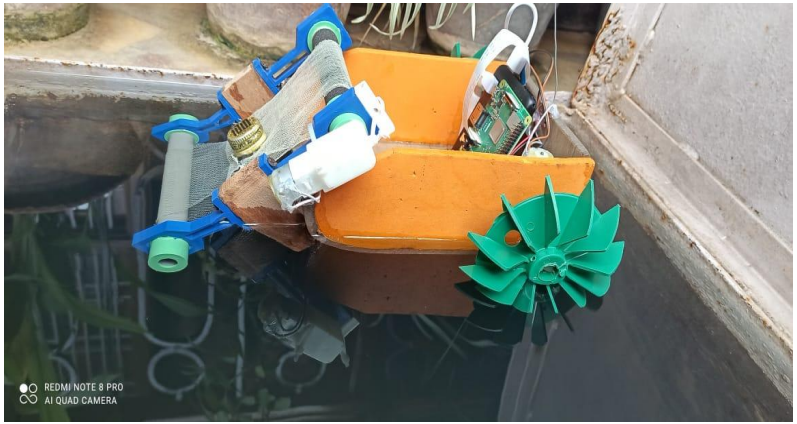

Figure 12: Trash collection mechanism

Figure 13: Garbage bin

Conclusion

- ➔ Water surface cleaning robot is developed and tested in an experimental tank setup.
- ➔ The robot has undulating motion on calm water surface.
- ➔ Robot is capable of detecting like water bottles, plastic caps and plastic bags floating on the water. The model collects small sized trash like small plastic covers and bottle caps.
- ➔ The detection of trash is achieved through YOLOV3 model which is based on deep neural network. The conveyor system aids in collecting the trash.

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Thank You