Fish Density Estimating Boat

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Abstract— **Object counting in aquaculture is an important task, and has been widely applied in fish population estimation. With the rapid development of sensor, computer vision, and acoustic technologies, advanced and efficient counting methods are available in aquaculture. The Fish Counting Boat integrates raspberry pi as the central controller alongside a USB camera, GPS for location tracking, and dual motors for propulsion. This innovative setup enables efficient fish counting and tracking in aquatic environments. Leveraging machine learning techniques in the software component, the system automates fish detection and counting processes, enhancing accuracy and reliability. By utilizing image analysis algorithms, the USB camera captures real-time footage of the surrounding underwater environment, enabling the identification and enumeration of fish species. To create a prototype of a boat with the developed software that has features for remote work also in the variety of harsh weather and environmental conditions, which can be remotely controlled using Internet. Designed system enables fish spatial location (GPS coordinates). In order to detect the presence of fish, several machine learning techniques are used. Object detection with the help of TensorFlow and YOLO have been used. The measurement method for estimating the fish density using the boat is based on a sequential calculation of the number of occurrences of fish on the set trajectory.**

Index Terms— ***Raspberry Pi, GPS, Object Detection, Image Analysis Algorithm.***

1. Introduction

Animal abundance estimation in marine environment is necessary in modern fisheries management and marine ecosystem protection. Fish stock assessment in natural lakes or oceans is important for maintaining the balance of ecosystems. The cultured fish stock in aquaculture facilities determines the feeding amount, and providing the appropriate quantity of feed helps to reduce water pollution and ensure the rapid and healthy growth of fish. Furthermore, automatic object counting in aquaculture reduces the labor burden throughout the entire aquaculture process, including fish density control and counting.

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Automatic object counting is gaining increasing attention across various fields such as cell counting, traffic vehicle flow monitoring, pedestrian density warning, and wildlife abundance estimation in reserves. In aquaculture, machine learning techniques are utilized to detect the presence of fish underwater, facilitating automated fish counting. Python, Yolo and TensorFlow are the software tools and primary object detection methods employed in this study. Counting in aquaculture is typically done manually or through statistical methods, which can be time-consuming and tedious. As labor time increases, the accuracy of counting declines.

Our main objective is to design a prototype boat capable of detecting areas with high fish density. Develop a solution to enhance fish estimation in aquaculture and provide fishermen with a technology for accurately and simply identifying areas of high fish density.

2. Basic Working Principle

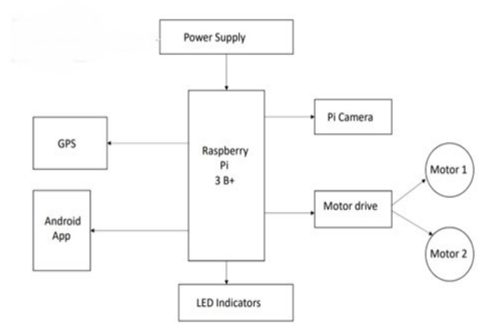

Fig.1. Block diagram of Fish Density Estimating Boat

In the proposed system, Raspberry Pi 3 Model B+ serves as the primary component for controlling the system, leveraging its built-in wireless connectivity features. DC motors are connected to the propeller, facilitating the movement of the boat. Control signals for the motors are transmitted from an Android application on the user's device, which connects to the Raspberry Pi's IP Address.

In front of the Raspberry Pi camera, an image of a group of fishes is displayed. The pi camera continuously captures images of the scene. Fish detection is achieved through image processing techniques, wherein code is employed to draw a rectangular box around each fish detected by the camera. The fish density is computed by dividing the fish count with the area of the captured image. This measure, along with the estimated fish density and the coordinates of the current location, is transmitted to the user's Android device via a Telegram bot. The location data is acquired through an Android application connected to the Raspberry Pi's IP Address, providing real-time updates on the current location.

To sustain continuous operation, a solar panel is employed to recharge the Li-ion battery, ensuring uninterrupted functionality.

3. Connection Diagram

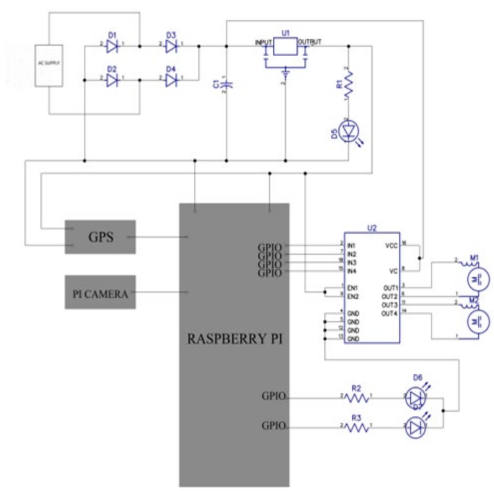

Fig.2. Circuit diagram of Fish Density Estimating Boat

The extended circuit features a Raspberry Pi 3 Model B+ serving as the primary controlling unit. GPIO ports, along with the ground port of the Raspberry Pi, are utilized for transmitting control signals to the motors, interfaced with the input pins and ground pin of the L293D Motor Driver. Two DC motors are then connected to the output pins of the L293D Motor Driver. Additionally, a Raspberry Pi camera interfaces with the CSI port of the Raspberry Pi for image capture.

A rechargeable battery serves as the DC power source for the operation of the DC motors. The power circuit includes components such as AC supply, bridge rectifier, capacitor, controller, and LEDs, constituting the main power supply of the system. Connections from the power circuit lead to the GPIO pins of the Raspberry Pi, facilitating power distribution. Moreover, the GPS module is integrated with the GPIO pins for location tracking.

The boat system comprises a pair of motors positioned on either side of the boat, with propellers attached to each motor. Forward propulsion of the boat is achieved by activating both motors simultaneously. Directional control is attained by selectively activating the propellers. To steer left, the right motor is activated, whereas to steer right, the left motor is engaged while the right motor is deactivated.

4. Hardware

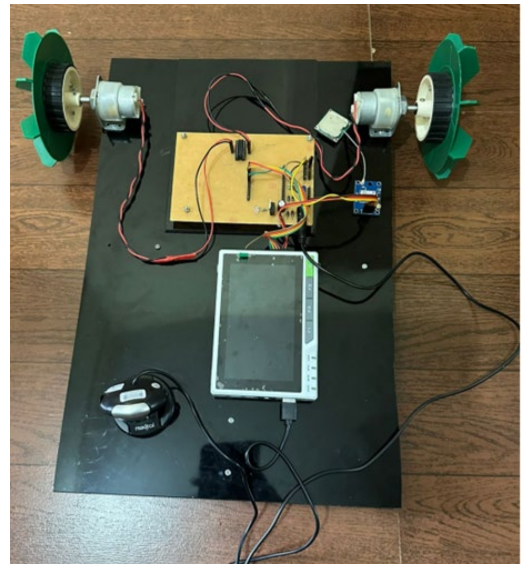

Fig.3. Hardware Implementation

The system comprises a Raspberry Pi reterminal, USB camera, DC motor, motor driver, voltage controller, propeller and GPS. The USB camera interfaces with the Raspberry Pi through its USB port for image capture. Two propellors are affixed to the DC motor to facilitate the movement of the boat on water surfaces. Motors are connected to the motor driver, which, in turn, interfaces with the GPIO pins of the Raspberry Pi for control.

For remote location tracking of fish-populated areas, a GPS module is connected to the GPIO pins of the Raspberry Pi. A PCB circuit was designed using DipTrace software to facilitate easy modification. Once the circuit design was finalized, a printed circuit board (PCB) was fabricated. An essential consideration during PCB design was its size.

The PCB encompasses the power circuit, featuring a bridge rectifier for converting AC to DC, and a voltage regulator for stabilizing the supply at 5V DC from a 12V DC source. Additionally, it includes perforations for connecting GPIO pins of the Raspberry Pi and interfaces for the motor driver connections.

Fig.4. Raspberry Pi Reterminal

Fig.5. Back view of Boat

5. App Development

An Android application was developed using Android Studio to control the direction of the boat motor. The application features buttons for forward, reverse, left, and right movements, enabling intuitive control of the boat. Additionally, users can view the count of detected fishes and the current location within the app.

The application operates based on IP address connectivity, necessitating both the Raspberry Pi and the mobile device on which the app is installed to be connected to the same Wi-Fi network. Users input the IP address of the connected Wi-Fi network, after which the control interface for the boat navigation becomes accessible. Figure 6 illustrates the home page of the application, where users are prompted to enter the IP address of the network linking both the Raspberry Pi and the mobile device.

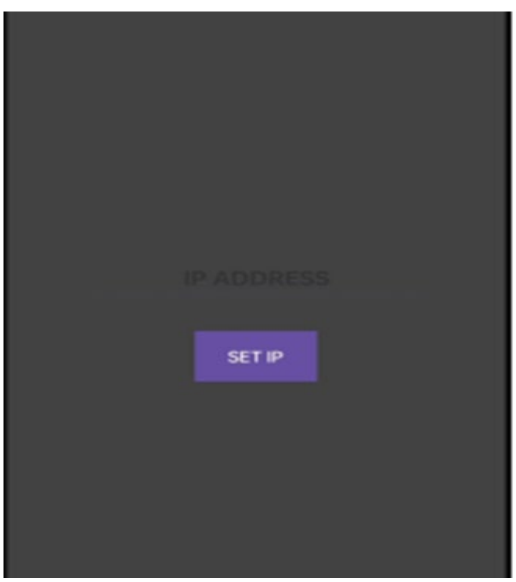

Fig.6. Home page App

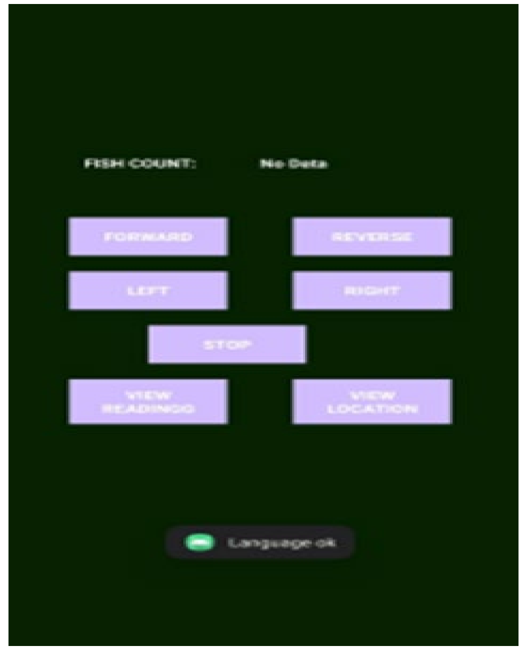

Fig.7. Interface of Android App

Figure 7 depicts the user interface of the application, featuring directional controls such as forward, reverse, left, and right buttons. Additionally, the interface offers options to display the fish count and current location.

A. Algorithm Of Model Training for Fish Detection

- Step 1: Import the requisite libraries for fish recognition, machine learning, and file handling.
- Step 2: Set the dataset path to the directory containing subdirectories for each fish.
- Step 3: Initialize empty lists for samples and labels to store fish encodings and corresponding labels.
- Step 4: Loop through each fish in the dataset. For each fish, iterate through their subdirectory and load each image.
- Step 5: Load each image and use object recognition algorithms to extract fish features.
- Step 6: Append the extracted face encodings to the list of samples and use the label as fish.
- Step 7: Convert the list of labels to a numpy array for compatibility with machine learning models.
- Step 8: Train the YOLO model using the collected fish encodings and corresponding labels.
- Step 9: Save the trained model to a file using a serialization method (e.g., joblib).

6. Results And Discussion

The output of the fish density estimating boat is accessible through a dedicated Android application developed specifically for this project. The USB camera captures images continuously at 5-second intervals, detecting and counting fishes within its field of view. This fish count is displayed within the Android app and is continuously updated for user monitoring.

Figure 9 illustrates the obtained results and output on the Raspberry Pi screen. Additionally, Figure 10 showcases the camera screen, which updates every 3 milliseconds, displaying the detected images. Figure 8 presents the output within the mobile application, which also serves as a control interface for boat movement. The application features control buttons enabling users to navigate the boat to different locations, with real-time boat location updates displayed within the app.

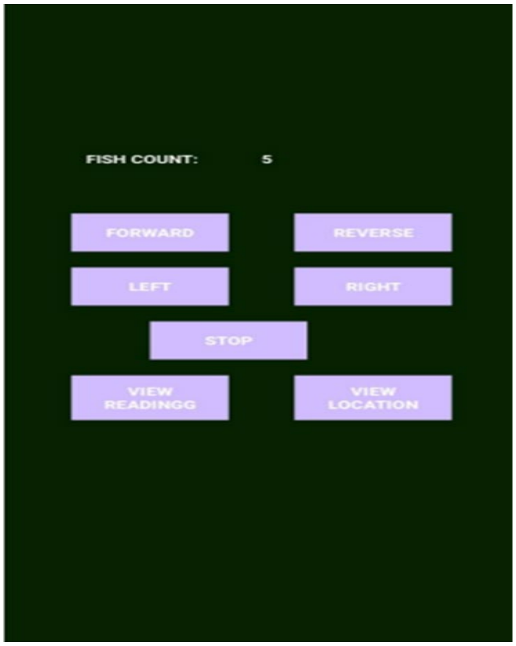

Fig.8. Output

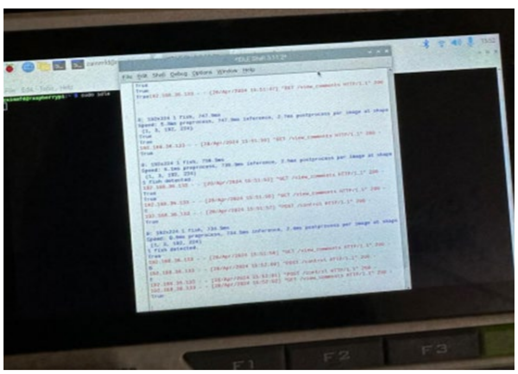

Fig.9. Output in Raspberry Pi screen

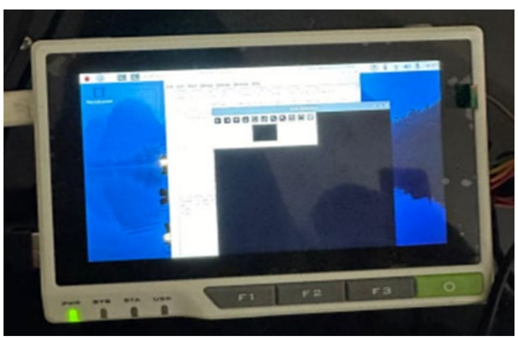

Fig.10. Popup of Screen showing Images

7. Conclusion

The developed model represents a prototype boat designed for fish count and density estimation. Controlled via an Android application, the boat utilizes DC motors for forward propulsion. The system includes an alert mechanism to notify users when fish density exceeds a predefined threshold. Through the Android application, users receive information regarding the obtained fish count, estimated fish density, and current location, facilitating real-time monitoring of fish populations in water bodies.

This system holds significant potential for monitoring and analyzing fish populations, with implications for aquaculture preservation and management. It offers opportunities for further research and application in fish density estimation, as well as in the broader context of aquaculture observation and conservation efforts.

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