Search and Rescue Ducks

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***Abstract*— The goal of this project is to develop and implement a rapid way to search for and rescue victims in an unknown environment. The objective of this competition is to use an autonomous robot capable of moving around in the lab area, searching for rubber ducks, moving them to a safe place, and releasing them.**

I. Techniques From the Class

A. Shortest Paths

We map the lab area as a 6×10 grid space, and create 60 nodes, each with a distance of 1 meter to its adjacent neighbour, as potential waypoints for the robot to traverse. Once we know the set-up of the environment, we remove the nodes where the obstacles are and mark two nodes, one as the rescue area and the other as the disaster area. We then use *Network X* to compute a shortest path connecting the two points and use this path to drive the robot. Having this piece-wise trajectory, we put the robot in a for loop that iterates through all nodes in the path and end the loop until it hits all the waypoints and reaches the destination point.

B. Blob Detection

For autonomous duck capturing, we utilize visual servoing as the control policy. Our blob detection algorithm uses the color of the ducks and produces a set of detection results that include the center coordinates *(x, y)* and the width and height of the largest blob detected in the frame. To enhance the reliability of vision detection, we manually adjust the sensor settings by increasing the contrast and applying lens correction. This adjustment helps improve the quality of the captured images, thereby enhancing the accuracy and effectiveness of the vision detection system.

C. PID Controller

We implement a proportional controller for both robot localization using the OptiTrack system and perception using the camera. In the former implementation, the controller adjusts the v in proportion to the distance, and the w in proportion to the orientation towards the desired position. In the latter one, the proportional controller adjusts the v in proportion to the size, and the w in proportion to the center of the blob.

II. Techniques Outside the Class

A. Remote Procedure Call

In our system, we communicate with the OpenMV microcontroller board via RPC, invoking the detection procedure over a network. As visual servoing navigation is only necessary for specific parts of the journey, we choose to invoke remote procedures when needed. RPC offers us a convenient means to integrate novel sensors into the system.

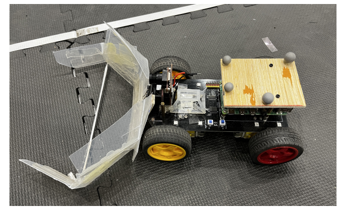

Fig. 1. *Robot with capturing mechanism.*

III. Strategy

A. Capturing Mechanism

The curved and rigid plastic push blade in our improved design represents a significant upgrade from the midterm version. We have widened the blade for two primary reasons: to prevent obstruction of the camera's vision and to enhance the capture capacity. Constructed from durable plastic, the blade is capable of absorbing impact in the event of the robot encountering an obstacle or becoming trapped by the mats. To maintain its shape and apply sufficient strength when capturing multiple ducks, we have incorporated a string mechanism. Due to the minimal friction between the ducks and the mats, pushing them proves to be a more effective method compared to scooping them up.

B. Random Walk Navigation

During the visual servoing phase, we employ a random walk as our navigation strategy to search for ducks in the disaster area. Once the robot reaches a spacious area, away from obstacles, we guide it to traverse a circular-like path. After every 30-degree change in orientation, the robot performs a forward movement. This approach allows the robot to maintain a relatively fixed position while expanding its field of view for vision detection. Incidentally, if any ducks happen to get trapped within the curved blades, the robot's hard-coded movement helps rearrange the ducks and safely relocate them within the capture.

IV. Summary

Our unique capturing mechanism played a pivotal role in securing the robot's victory in the competition. Thanks to the large capacity of the push blades, the robot successfully captured ducks both along its path and within the disaster area. With strategic planning, the robot efficiently and effectively rescued and released the ducks. The simplicity of the design and the straightforward logistics greatly contributed to the feasibility of interacting with the ducks.

V. Link to the Recorded Video

`https://drive.google.com/drive/u/0/folders/1B_OpH78jWSxmbH-nFRTLQw57f6jRC3R1`