Product: EdVarka

Team: EdVarka
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Abstract

Our robot is a fully automated trash collector for rubbish floating on the surface of water like lake and canal. My main contribution was implementation of computer vision for the robot. I was mainly responsible for object detection, calculation of object positions and animal detection. I believe that this SDP group work has helped me to learn how people with different skills can work together well. People can effectively cooperate and work together by knowing each other's skill and capability.

1. Contribution

The main contribution I made to the group project is Computer Vision. Mainly collaborated with Robot Control Team which integrate Robot systems. Our Robot need to use computer vision to recognize the existence of the object, and compute the center of the object (trash) for robot control program which collect the trash. In addition, Robot need to recognise animal from other object so that robot will not need to collect it. Following are what I implemented for robot computer vision (including the program which is not used).

1.1. CNN

As the first approach to detect and distinguish trash floating on the water, CNN is implemented. Image Scraper is implemented and gathered the images from internet. However, the quality of gathered image data were not enough to train CNN, and the accuracy is not good enough, therefore this approach is dropped.

Test	Duck(Correct)	Duck(Incorrect)	Trash(Correct)	Trash(Incorrect)	Accuracy(%)
General	49	14	43	12	77
Ducks	10	4	0	0	71
Bottles	0	0	14	8	64
Plastic Bags	0	0	15	3	83

Table 1. CNN accuracy

1.2. Object Detection

Prototype of the Floating Object Segmentation program are using Otsu's method [1]. However, it is found that this algorithm is not working well on real water surface images, although it works well on artificial water surface images. To solve this problem, completely different approach is taken. First, image with water surface (without any object) and image with object (if it exist) will be subtracted to get the difference of image. At this step, result of subtraction are normalized. Next, segmentation process will threshold result based on RGB value (Otsu's threshold is not used) and binarize it.

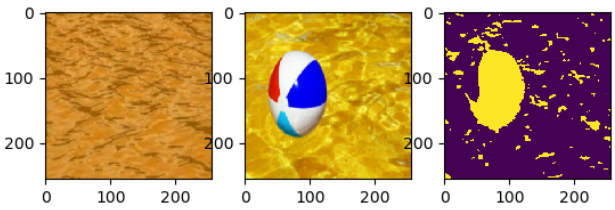

Fig 1. Object segmentation by subtraction of images

For noise removal, segmented image is filtered by program which removes smaller segmented objects (this is different from Gaussian blur noise filtering which is applied at the end of segmentation process). By go through these process, largest segmented area (which should be object) will remain. This also helps program to detect nearest object (which should have biggest segmented area), if there are several object detected.

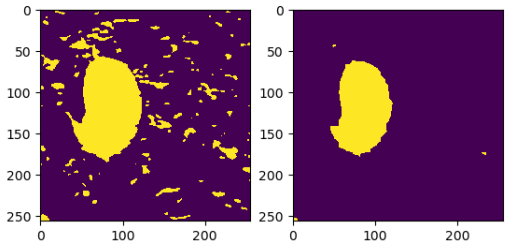

Fig 2. Filtering segmented image to get main object

This resulting segmented image will be used for detection of the object. If the area of the segmented object is big enough (thresholding), then program will conclude object exist, if not object is not detected. This segmented images is also useful to estimate the volume of object detected. When object is in specific range, program can estimate the volume of the object from area of the segmented object. Actually this algorithm is used for computing capacity of the trash which robot collected in Robot control program.

	Object exist	Object not exist
Object detected	48%	5%
Object not detected	9%	38%

Table 2. Object detection results with real images

1.3. Background Removal

In the real world, it is very likely that images taken from robot include some background. Background matters for above object detection algorithm since it will affect the result of image subtraction process (subtracting object image with background from only water surface image will lead

to difference at not only object part but background part). Background removal from image is unavoidable for robot to have higher and broader view which increase the object detect range. The main idea of the background removal is simple. First detect the water horizon by using edge detection. For edge detection, segmented image of background is used (and the image is got by Otsu's segmentation method). Next remove all the object (segmentation) detected above that line.

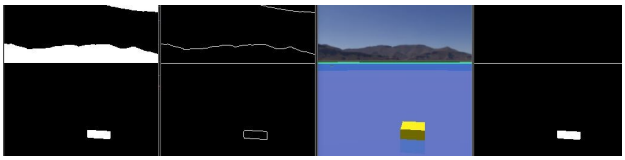

Fig 3. Background removal

1.4. Object Center Detection

Provided segmented image of object (detected by object detection algorithm stated above), center of the object is calculated by using concept of moment. Calculated object position is used for PID controller of Robot control. In the following evaluation, center coordinate is expressed as x-y coordinate in the image, error is euclidean distance of the actual center and calculated one.

Test Image	Actual Center	Computed Center	Error (Euclidean distance)
test1	(58,134)	(60,136)	2.828
test2	(41,70)	(40,68)	2.236
test3	(144,159)	(145,148)	11.045
test4	(120,52)	(119,51)	1.414
test5	(61,90)	(50,71)	21.954
test6	(52,137)	(60,136)	8.062

Table 3. Computed Center of the object

Fig 4. Object center detection

※object detection and center detection works even for transparent plastic bottle and small can.

1.5. Optical Flow Movement Detection

Initial approach for detecting and distinguishing animal from trash was movement detection, since our team assumed animal will move faster then water surface and floating trash. Optical flow detection is implemented for motion detection. This is a program that detects object when the object moves above a certain speed in camera's vision (detection is done by thresholding detected speed of object movement). First several feature pixel is selected from video and traced. By measuring distance of these pixels moved in certain period of time, the speed of these pixels is computed. The sum of these pixel's speed is compared with threshold value and determine whether object is moving in certain speed or not. Usually, less pixels are selected from image when there is no object, therefore this program is robust to water surface movement (movement of water surface will not lead to speed exceeding threshold). However, this approach is dropped since, in real world example, it is very difficult to stop robot at the specific place on the water surface. If robot moves, it will lead to higher relative speed of object looking at, therefore there high risk of false detection of movement.

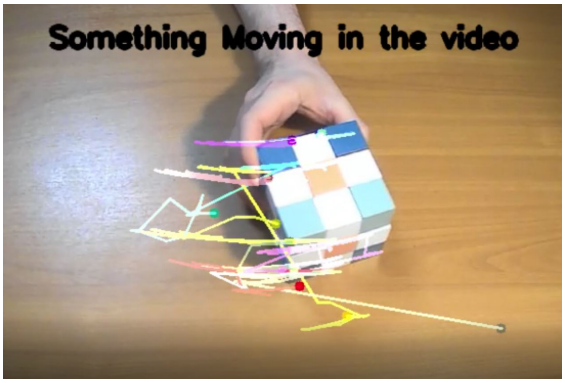

Fig 5. Optical flow movement detection

1.6. Thermography Animal Detection

For next approach to detect and distinguish animal, thermography obtained from IR (thermal) camera is used. Based on assumption that animal will have a higher temperature than water surface or trash captured in camera, vision will be able to detect animal from thermography. Basic idea is animal with higher temperature will have warm color in thermography, and by thresholding that warm color part, it is possible to segment higher temperature part (which should be animal). Detection is depending on area of segmented object (warm part).

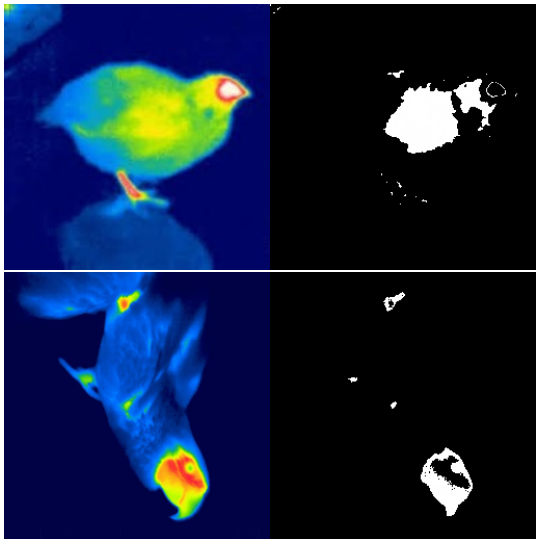

Fig 6. Thermography and segmentation