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Underwater Autonomous Vehicle for Plastic Detection

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Abstract – An Underwater Autonomous Vehicle for Plastic Detection is a system developed to navigate underwater to identify plastics in the water bodies. The system has been built with materials which gives it the capability to submerge up to five metres underwater.

Our system proposes to detect the presence of plastic bodies underwater in real time with the help of an onboard camera which relays the data back to the user. The system is tethered with wires which also serves as a medium for communication and power supply to the system. An improvised electric thruster from bilge pumps controls the movement of the system.

A CNN algorithm is designed to perform predictions from the input supplied by the onboard camera. The model is trained with a dataset consisting of images of plastic, trash, metal, glass and cardboard.

Keywords—Communication, Electric Thrusters, Image Processing, Underwater Vehicle

I. INTRODUCTION

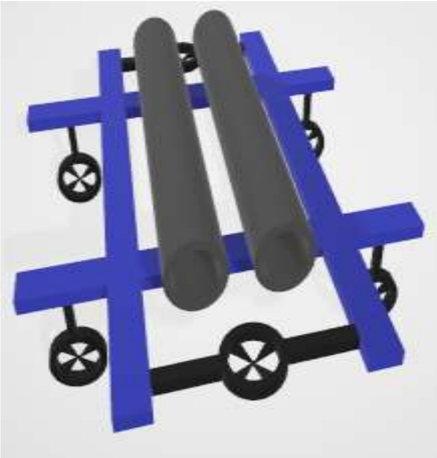
The nuisance of marine debris and its harmful consequences on Mother nature has been well documented over the last few decades. The most harmful effect is the damage it is causing on the aquatic life. There are images and videos of this debris getting lodged into turtles, fishes, dolphins etc. Most of this debris becomes toxic when it encounters an organic compound. Sometimes, these animals who ingest the marine debris are caught while fishing and served as food to human beings. Consumption of these toxins leads to several health issues in human beings, which, if one were writing a novel would say that it is a result of karmic balance by the universe. According to research, majority of the marine debris is constituted by everyday plastic. Plastic, since its invention, has been an integral part of human lives and can be found in every corner of the planet in excessive amounts. These plastics take more than a hundred years to degrade, so they can also be classified as non-biodegradable. It is harmful to dispose them in landfills as this will cause soil pollution. So, an effective solution is to dispose them in water bodies. This was the approach accepted by many countries before it was realised that this process was more harmful then helpful. Since then, there have been a lot of measures taken to clean up our oceans and other water bodies.

Ever since it was found that the dumping of debris in water bodies has some very adverse effects on human as well as aquatic life, steps were taken to reduce further dumping of debris in water bodies and clean up the already present debris. The latest act was the introduction of automated vehicles to identify and collect the debris quickly and efficiently.

II. UNDERWATER AUTONOMOUS VEHICLE

Underwater Autonomous vehicle – Several parameters have to be considered before constructing an UAV such as

A. Design – The proper and effective design of the vehicle is an absolute requirement before construction of the vehicle. The design of the vehicle will vary when compared to a land vehicle because of the varying factors that come into picture once the vehicle is in motion. Research suggests that an object which is cuboidal or cylindrical is met with least resistance when traversing through water. Our system involves the use of a spherical tube as the shape of the vehicle.



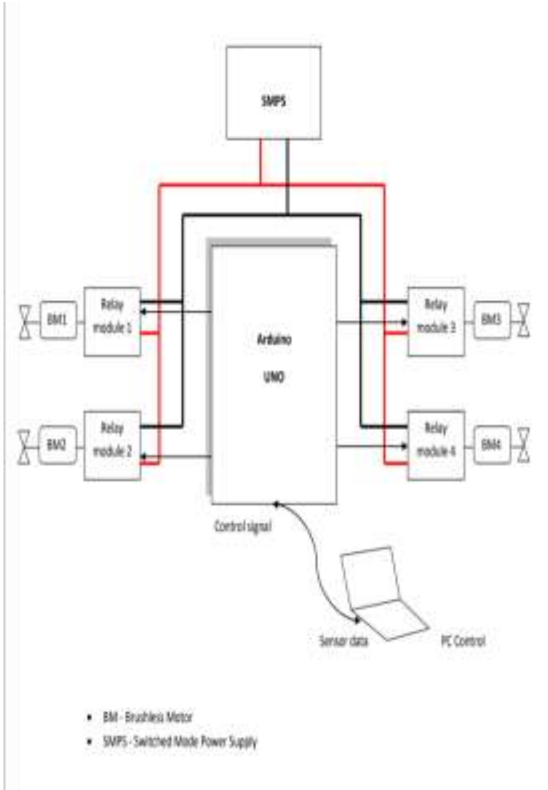
B. Build material – Use of heavier objects like steel or metal is not effective as it increases the overall weight of the vehicle. The weight of a vehicle will be less in water when compared it on land, however, to overcome the water resistance of a heavy vehicle, will increase the pressure on the thrusters causing it wear out quickly and draw additional power from the power source. Here, a combination of polycarbonate and PVC were used as build material.

C. Control unit – This consists of electronics such as a microcontroller, relays and USB cables. This is used to receive instructions from the user and control the thrusters of the vehicle.

D. Electric thrusters – Thrusters must be selected carefully after considering the weight of the vehicle and how much acceleration is required through its data sheets. A propeller shell can be used to obtain maximum efficiency of the thruster while drawing the least amount of power. For this project, the thrusters were made from a DC motor pump by removing the impeller and replacing it with a propeller.

E. Power supply – For an underwater vehicle, the most precious commodity is the power supply. The design and the thrusters should ensure that the power supply must last longer. As this project is a prototype, an SMPS connected to AC mains was used as power supply.

The entire system was controlled by an Arduino Uno microcontroller based on commands received from the user through an USB cable. Then system was waterproofed by applying epoxy paste. 3D printed holders were used to lock down the electric thrusters on to the system. The final dimension of the vehicle was measured to be 112x102x17 cm and weighed approximately 10 Kg.



III. IMAGE PROCESSING

To build this model, a nonspecific image identifier setup of TensorFlow, Google's machine learning library and a Deep Learning pre-trained CNN model called Inception was used. The process involves

A. Dataset creation – Images of plastics, metals, cardboards from google repository was used with each picture having different angles to improve accuracy of results.

B. Training – The CNN model Inception is again trained with the help of the dataset created. The model is trained with an 85 – 100% accuracy.

C. Testing – After training, the model is tested and implemented on the vehicle. For every input, the model predicts the probability of the object with respect to every type of objects in the dataset. Probability of around 0.8 to 1 is measured to be optimum.

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The dataset is separated to be used as training, testing and validation images. 80%of images are reserved for training and the remaining 20% are used for testing and validation purposes. The destination of image is determined by generating the hash number of the file and allotting a probability to the image from the formula,

probability = (hash of file) % (max no of images per class+1) * (100.0/max no of images per class)

.

To avoid overfitting, the maximum number of images was restricted to 600 images per class.

An example from the dataset can be seen below:

IV. RESULT

	plastic (score = 0.90439) glass (score = 0.08462) trash (score = 0.00429) metal (score = 0.00367) paper (score = 0.00179) cardboard (score = 0.00124)
	plastic (score = 0.33055) trash (score = 0.30301) metal (score = 0.16175) paper (score = 0.13590) glass (score = 0.04585) cardboard (score = 0.02294)

The model only predicts the probability of the image being a certain class and it is left to the discretion of the user whether to accept the predictions of the model or not since the model is trained to detect multiple classes and not just two, a linear classification would not be possible and since the images taken underwater are not of a good quality, the predictions of the model would not be very accurate.

V. CONCLUSION

Although this project was aimed to be used in water bodies, slight changes made to the UAV will convert it to a land vehicle where it can be used to detect and remove plastics on land. The UAV built from this project weighed around 10Kgs and could accelerate up to 2m/s. The electric thrusters drew 15A of current for maximum torque delivery. It is because of this huge power consumption; AC mains were used to supply power.

The image classifier model used was able to successfully distinguish plastic from other materials with an accuracy of 80%. The quality of the camera used with the vehicle was directly proportional with the accuracy of the results from the model.

The project is concluded with the satisfaction that our prototype can be used to make a difference in this world.

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