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Development of a Remotely Operated Vehicle for Coastal Exploration

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Abstract:- This engineering project aims to develop a remotely operated vehicle (ROV) for efficient coastal exploration. Currently, divers are deployed to do coastal exploration and coral surveying. However, this poses a lot of issues. Firstly, it is expensive to start a diving operation. In addition, it poses a risk to the divers, as they may be endangering their lives when diving. It is also time-consuming and inefficient. The ROV is made using PVC pipe sections, brushless DC (BLDC) motors and a radio control unit, to allow control of the vehicle in the sea and across long distances. A GoPro 7 camera is added to the ROV as well. The proposed solution is able to help solve the problem quite well as it can safely analyse the corals without destroying them. There are some applications for this. Firstly, the GoPro 7 attached to the ROV allows users to observe the underwater surroundings. Also, now divers are not needed to dive into the water to look at the corals as it can all be done by the ROV, which also helps reduce cost because dive operations are not needed.

Keywords:- *Remotely Operated Vehicle (ROV), BLDC Motors.*

I. INTRODUCTION

➢ *Background Information*

The purpose of this project is to develop a remotely operated vehicle (ROV) for efficient coastal exploration. Coral reefs are one of the most valuable ecosystems on Earth [1], bringing various benefits such as coastal protection, tourism and advancement of research [2,3]. Furthermore, these coral reefs provide humans food by feeding the fishes that humans eat, with over 1 billion people estimated to rely on coral reefs for food [4]. However, these systems are extremely susceptible to changes. The accumulation of stress from human activities as well as long term environmental changes, such as rising ocean temperatures and ocean acidification [5], have caused corals to bleach in many parts of the world. This makes monitoring of coral reefs extremely essential so as to ensure that this vital ecosystem will not be destroyed.

Currently, divers are deployed to do coastal exploration and coral surveying. However, this brings about a lot of issues. Firstly, diving operations can be expensive. Secondly, divers can be at risk of various dangers, including but not limited to, pulmonary embolism, malfunctioning equipment and attacks from marine life [6,7]. Lastly, divers can damage the coral reefs by accidentally kicking them or disturbing sand which ends up smothering the corals, destroying the ecosystem instead of monitoring it [8]. Thus, this project aims to solve the current problems of diving through the development of an ROV, such that it requires minimal human supervision to operate, whilst ensuring that it is cost-effective, fast and able to safely monitor the coral reef system. Hopefully with this development, threats to coral reefs can be detected and resolved immediately, preserving this precious ecosystem.

➢ *Engineering Goals*

The ROV developed should achieve the following engineering goals:

1. Buoyant in water
2. Able to maneuver quickly in water
3. Light
4. Cost-efficient
5. Requires minimal human intervention to operate
6. Poses minimal to no damage to surroundings

II. METHODS

A. Vehicle Design and Prototype

➢ *ROV Body Design*

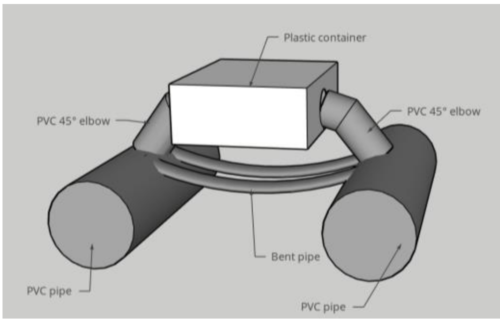

Fig 1:- Sketchup diagram of ROV body design

For the main body of the ROV, a dual hull design is used, which was inspired by the design of the catamaran (*Fig. 1(a)*). This catamaran design has a few advantages, including increased stability and speed, as well as being able to spin in place [9], making the ROV extremely maneuverable in the open waters. PVC pipes sections of various lengths and diameters were used to create the hulls of the ROV. Finally, each hull is attached to each side of a plastic container, which will be used to store the electronics

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explained in the next section. The final product is shown in Fig. 1(b). Finally, the GoPro 7 Camera is attached under the ROV, which is used to take images and videos underwater.

➢ *Circuit Design*

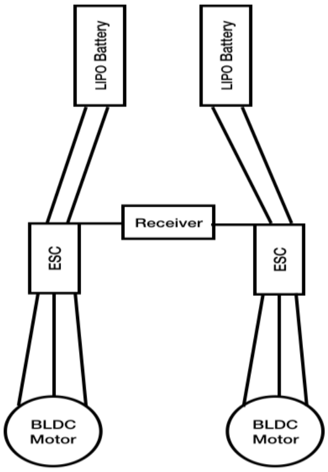

Fig 2:- Schematic diagram showing the connections of electronic components

Two brushless motors are each connected to an Electronic Speed Controller (ESC). Each ESC is connected to a different channel of a receiver of a radio control unit, before being connected to a 3 Cell Li-PO battery. The final circuit design can be shown in Fig. 2. The use of the radio control unit is essential because it has a transmission range of up to 250 metres, making it suitable for coastal exploration. Propellers from computer fans are then attached to the brushless motors. Electronics test (Section 3.2) is then conducted to check whether components work properly.

B. MATLAB Machine Learning Program

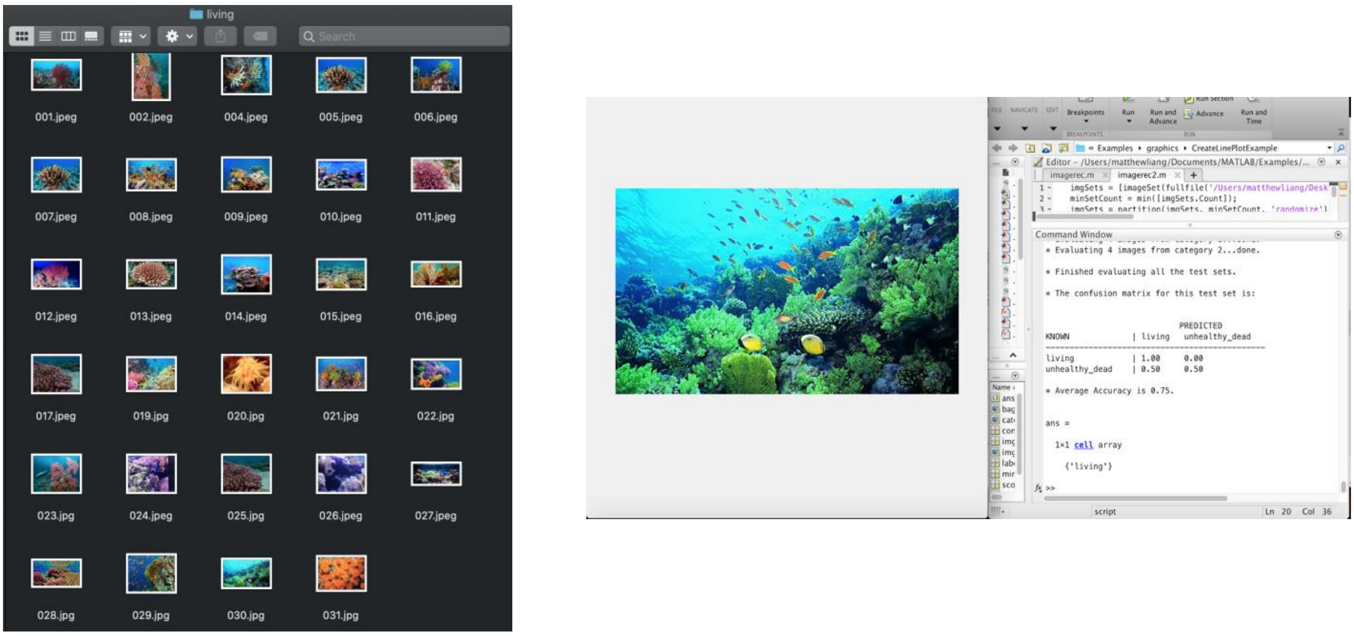

Fig 3:- (a) and (b): Image of folder containing healthy coral training images (left) and image showing results of identification (right)

Before coding the program, we first collected different pictures of healthy corals and unhealthy or dead corals, separating them into two different folders. The pictures would make the training sets, which teach the program how to identify whether the coral is healthy or not.

The MATLAB program then picks out feature points from the training sets using the speeded-up robust features (SURF) detector, before grouping similar features together to create a visual vocabulary [10]. Finally, when the new image of a coral is scanned into the program, feature points from that image are collected and are checked against the visual vocabulary created initially, allowing said image to be classified, with the prediction outputted as an array.

III. TESTS AND RESULTS

➢ *Floatation Test*

The ROV is placed into a pond to test its ability to float as well as its stability. From this test, we are able to conclude that our ROV is extremely buoyant, and is able to remain stable when it is at rest, making it suitable for the aims mentioned above. The latter is important because it allows stable footage to be recorded while the ROV hovers at a particular location and observes the surroundings there.

➢ *Electronics Test*

Fig 5:- Testing the motors

Before putting the ROV into the water, it is crucial to ensure that all electronic components are connected and are fully functional. After connecting the circuit shown in Fig. 3, the receiver is paired with the transmitter, before testing whether the motors work as expected. From this test, the propellers of the ROV are able to rotate as shown in Fig. 5, which means the motors worked as expected and as such the electronics test is passed successfully.

➢ *Video Recording*

Fig 6:- Footage of surroundings in the pond taken by GoPro 7

The GoPro is attached onto the ROV before connecting the camera via Bluetooth/Wi-Fi to a mobile device. This is to allow the camera to livestream, allowing users to observe the surroundings in real time. Then, the ROV is placed in the pond again, with the camera submerged in the water. From the test, it is found that the livestreaming function does not work because it is difficult for signals to travel through water, causing signals to be lost. However, footage can still be recorded by the camera. Upon analysing the footage, it is found that the camera is able to take clear footage of the surroundings, making this test successful to a large extent.

➢ *Machine Learning Code*

Fig 7:- Dead coral samples

Image samples not in the training sets are used for this test. The living coral image samples found online were used for testing. For the dead coral samples, real samples of dead corals were collected beforehand as shown in Fig. 7, so images of these corals were used as a test sample.

Tests	First test	Second test	Third test	Fourth test	Fifth test	Accuracy
Living coral image	Living	Dead	Living	Living	Living	80%
Dead coral image	Dead	Dead	Dead	Dead	Dead	100%

Fig 8:- Accuracy of machine learning model

Then, the program is run 5 times for each image, with the prediction of each run recorded as shown in Fig. 8. Finally, the accuracy is calculated by taking the percentage of predictions made being correct. From this test, it can be found that the accuracy is at least 80%, which is a rather high accuracy for a machine learning model, so this model is successful in differentiating between living and dead samples to a large extent.

IV. DISCUSSION

➢ *Evaluation of Engineering Goals*

From the tests, it can be concluded that the ROV is able to fulfil the engineering goals set in section 1.2, because it is able to maneuver well in water and the artificial intelligence program works as expected, reducing the need for human intervention. Yet, these are achieved with minimal costs, making the ROV successful to a large extent.

➢ *Areas for Improvement*

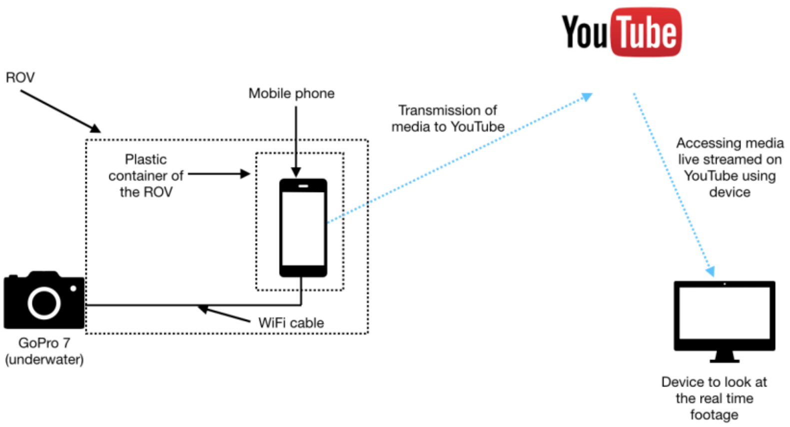

Fig 9:- Proposed setup to enable live streaming

Currently, the maximum range the ROV can travel is up to 250 m. This means that the ROV cannot travel too far from the shore, limiting the area it can explore. However, this can be tackled by obtaining better radio control units which increases the travel range of the ROV up to 1 km.

In addition, the livestream feature is not very tenable, because when the camera is underwater, WiFi signals would not be able to travel from the phone to the camera easily, not allowing real time footage to be recorded especially when the ROV is far away from the phone. However, this can be circumvented as shown in Fig. 9. A WiFi cable, which serves as a conduit to transfer signals, can connect the camera to a phone stored in the plastic container of the ROV. Since GoPro 7 supports livestream onto social media platforms such as FaceBook and Youtube, users can use a device to watch the livestream via these platforms.

Regarding the machine learning program, its accuracy can be improved by adding more training sets. This richer triangulation ensures that the data is more diverse, allowing the program to better identify new coral samples.

V. CONCLUSION AND FUTURE WORK

In conclusion, our ROV works as expected as it is able to survey the surrounding underwater. This would be significant because it is faster than a diving operation, allowing authorities to be notified earlier if regions of dead coral reefs are found. Additionally, it is much more cost-effective, allowing resources to be channelled for other purposes instead of coral surveillance. Lastly, it requires minimal human intervention, because an unmanned vehicle is used for coastal exploration, minimising the damage done to the coral reefs whilst not endangering human lives, which is something diving operations cannot guarantee. A possible future extension is to install sensors on the ROV, for it to collect water samples and take various measurements, such as water temperature, before sending them to researchers. This is because coral health is dependent on a few factors, such as the salinity, temperature and pH level of water [11]. Thus, these would allow researchers to investigate into what causes the corals to bleach and die in order for them to take the necessary actions.

REFERENCES

[1]. Corals. (n.d.). Retrieved February 19, 2020, from https://oceanservice.noaa.gov/education/kits/corals/coral07_importance.html

[2]. Coral Guardian. (2014, January 9). Why are coral reefs so important? Retrieved February 19, 2020, from https://www.coralguardian.org/en/coral-reef-important/

[3]. Queensland Museum (n.d.). Importance of Coral Reefs - Biodiscovery and the Great Barrier Reef - Queensland Museum. Retrieved February 19, 2020, fromhttps://www.qm.qld.gov.au/microsites/biodiscovery/05human-impact/importance-of-coral-reefs.html

[4]. Carilli, J. (2013, June 17). Why Are Coral Reefs Important? Retrieved February 19, 2020, from https://www.nature.com/scitable/blog/saltwater-science/why_are_coral_reefs_important/

[5]. Coral Guardian. (2019, April 6). Coral reefs at risk. Retrieved February 19, 2020, from https://www.coralguardian.org/en/coral-reefs-at-risk/

[6]. Leisure Pro (2017, January 2). 5 Dangers of Scuba Diving. Retrieved from https://www.leisurepro.com/blog/scuba-guides/5-dangers-of-scuba-diving/

[7]. Khao Lak Dive Center and Resort (2019). What are the Risks of Scuba Diving? Diving Safety. Retrieved February 19, 2020, from https://www.khaolakexplorer.com/similan-guide/risks-of-scuba-diving/

[8]. Threats to Coral Reefs. (2017, November 23). Retrieved February 19, 2020, from https://blog.padi.com/2017/10/23/threats-to-coral-reefs/

[9]. Parkinson, A. (2015, August 17). Sailboat Debate: Monohull vs. Catamaran. Retrieved February 19, 2020, from https://www.yachtsinternational.com/owners-lounge/sail-debate-monohull-vs-catamaran

[10]. MathWorks (2016). Image Category Classification Using Bag of Features. Retrieved February 19, 2020, from https://www.mathworks.com/content/dam/mathworks/tag-team/Objects/i/88400_93009v00_Image_Class_Bag_Features_2016.pdf

[11]. Henkel, T. P. (2010). Coral Reefs. Retrieved February 19, 2020, from https://www.nature.com/scitable/knowledge/library/coral-reefs-15786954/