Automatic Detection of Seagrass Holes Using Floating RGB Camera Platform

Progress Report – November 6, 2017

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Floating RGB Camera Platform

A device was constructed to carry a camera for recording underwater video and images. This device is a prototype for an airboat that is currently under construction. Unlike most surface vehicles whose propellers prevent use at very shallow depths, this platform is able to explore up to the shore. Seagrasses can be approached without damaging them. The camera is perpendicular to the surface such that it captures an overhead view of the seafloor. Such a view is useful because each image corresponds to a very small patch. If the boat is above seagrass, the image will be predominately of seagrass. With a tilted view, more of the scene would be in view which is expected to make classification using an entire image less effective since more regions are in the scene. The goal is to categorize based on the character of the image as a whole based on features such as overall color and texture. Some proportion of images should be difficult to classify since they may be along a border between two regions or the features be obscured by submerged objects, etc. However, the goal is to map seagrass meadows and holes in these meadows, not individual seagrasses. So, as long as a certain percentage of images are classified correctly, usable maps could be generated by smoothing out regions based on the neighbors. If a single image is classified as “not seagrass” but is surrounded by seagrass, then this is not enough to be considered a meaningful hole. But if several nearby images are classified as “not seagrass” and form a sizable area, then this region can be considered a hole. The required sizes and thresholds are to be determined.

Data Collection

The camera platform was deployed to collect shallow seafloor video at two locations on two separate mornings, October 1 and October 14. Almost 2 hours of video were recorded. These videos have GPS coordinates for each frame. Stage 1 of the project is to find enhancement processes and features to extract that aid classification. Stage 2 is to perform the processes and feature extraction and use the classifier to construct a map that will allow automatic seagrass hole detection. A training set was constructed by selecting 307 frames from the videos and labeling these frames as “seagrass”, “not seagrass”, and “unknown”.

Image Enhancement

Because the goal is to classify these images using a variety of features, it is desirable to reduce variation that is due to noise, turbidity, and lighting since these do not reflect the subject matter of interest. Turbidity is of major concern since the local waters are known to be murky and the nearshore is especially so. Noticeable issues are large amounts of noise and green tint. Techniques exist for correcting underwater images by modeling the haze produced by the turbidity of the environment [1]. However, such techniques rely on “pure haze” regions in the image to estimate the actual lighting. These regions are the empty water areas in an angled view of the seafloor where the far-off background has no objects in view. However, this platform looks straight down and no such regions are available. There was a usable piece of information from the literature, however, that was applied for color enhancement. Even though water has red light in low quantity, enough is able to penetrate at shallow depths to make the gray world color balancing assumption true. Therefore, gray world color equalization was applied, which strongly negated the green tinting. This should make comparison of color-based features more accurate. While experimenting with white balance techniques would also have shown this to be effective, having such heuristics gives confidence that the chosen method is likely to work generally and not just on the particular data set. A Gaussian blur was applied to reduce noise and further lessen impact of turbidity, as well as to support the edge detection that is to be done since they are affected by noise.

Feature Extraction

Manually viewing the recordings shows that images with seagrass are typically much more chaotic than those without. These images have a greater range of colors, many sharp edges, semi-straight lines, and more green and red. Images without seagrass are typically more homogeneous, with few details. However, some feature rocky bottoms that do have edges. These appear to be less pronounced that those of the seagrass and are still of seemingly lower dynamic range. These observations helped to guide the selection of features used for classification. For experimentation, many filters are being applied. Once the most useful discriminating features have been determined, only those will be used in order to increase efficiency for onboard classification. Sobel was applied in order to detect edges since it is less affected by noise than Laplacian. But since Laplacian is stronger for sharp edges, it was also evaluated. Canny filter was also used for edge detection. In order to extract numeric features for classification, the mean, sum and entropy of all three were calculated. Color features were also considered. An initial idea was to use the proportion of red as a feature since red seems to be more pronounced in the seagrass images (which often are brown-green), but all channels are in equal proportion because of the color equalization previously performed. And the non-balanced images are too tinted to be accurate. Therefore, the color space was converted to HSV; the mean, max, min, and range of the hues was extracted. The dynamic range was expected to be a useful classifier since the color appeared to be have more variety when seagrasses present. There are other features that have not yet been tried, but will be soon. The Hough transform can be used to focus on straight edges, which may allow differentiating the straighter plant edges from the rocky seafloor which is often smooth and curved. Also, plan on finding more sophisticated texture measurements as well as fourier transform features.

Classification

For seagrass hole detection, two categories are of interest: “seagrass” and “not seagrass”. However, manual inspection reveals images where it is unclear due to water turbidity. Such images should be considered “unknown”. The purpose of the airboat is an autonomous science agent that can perform its own analysis on collected data. Therefore, unsupervised methods are desired. However, initial clustering attempts were not very successful. For this project, it seems better to focus on supervised classification; can learn what image processing is useful for discrimination before tackling the unsupervised learning aspect. Decision tree classification was used because it gives insight into what features are most valuable. Tree pruning can be useful for reducing unneeded feature extraction. While separate paragraphs, the feature extraction and classification steps were done at the same time. Many tree experiments were done while extracting features. The most accurate tree found so far correctly labels 86.32% of the training set. The features included in this tree are the entropy of the Canny filter, the Canny mean, and the Hue Range. Before including Canny, Sobel had performed better than Laplacian. But once Canny features were included, the accuracy increased by ~5%, and the tree building algorithm did not include features from Sobel or Laplacian. In order to test the tree, a test set needs to be made by labeling more frames from the videos.

Next Steps

The classification tree is expected to be improved by further feature extraction, but we would like to ensure that the full detection system is in place. Therefore, the next step is to sample frames from the videos, classify those frames, and use the GPS coordinates associated with the frame to place that classification on a map. A grid will be created where the GPS coordinates will be used to assign to the closest discreet grid location. Depending on the final rate at which the platform can classify images (and the GPS error), there may be holes in the grid signifying missing information. Image smoothing can be used to fill in the holes (such as the dilation techniques). As discussed, minor outliers will be ignored since a threshold will be used to accept a region as being a seagrass hole.

Because field tests can take an entire Saturday morning, it may not be practical to do multiple field tests for fine tuning the system. Therefore, testing may be done using data previously collected by the platform but on the platform’s hardware to ensure that efficiency requirements are met. A testing video can be recorded, but the detection can happen by replaying that saved video file. The GPS coordinates are saved, so it can simulate being out in the field.

Code

https://github.com/ekrell/SeagrassMappingRGB

References

[1] Li, X., Yang, Z., Shang, M., & Hao, J. (2016, April). Underwater image enhancement via dark channel prior and luminance adjustment. In *OCEANS 2016-Shanghai* (pp. 1-5). IEEE.