Coral Vision:
Software for Improving Efficiency in Coral Monitoring

Cory L. Walker, Joshua V. Stough
Department of Computer Science
Washington and Lee University
Lexington, VA USA

Lisa Greer, Elizabeth M. Elium, Arthur F. Stier
Department of Geology
Washington and Lee University
Lexington, VA USA

***Goal*: Create a supervised learning method of assessing coral quickly and efficiently**

Motivation

- Monitoring changes in coral reefs can be accomplished by taking multiple images of designated areas of the reef each year and quantitatively comparing live coral abundance from year to year.
- The process previously used to segment the coral in these images was tedious but very precise. Researchers would manually place points along the edges of each branch of coral, segment out the selected pieces, thus determine the total percentage of coral coverage in each image.

Original | Manual Process | Segmentation

- With hundreds of images, this process could take weeks; even with the work divided between four to five researchers.
- Our semi-automatic program is designed to achieve similar results to the manual method while cutting the processing time. This will allow for more time spent collecting and analyzing information on the coral reefs, and help us better understand how they are changing over time.

The Semi-Automatic Method

- With Coral Vision, the user clicks only a few positive points (white) representative of the living coral in the image, and a few negative points (black) that show what is not to be selected.

An initial image open in Coral Vision, ready for segmentation

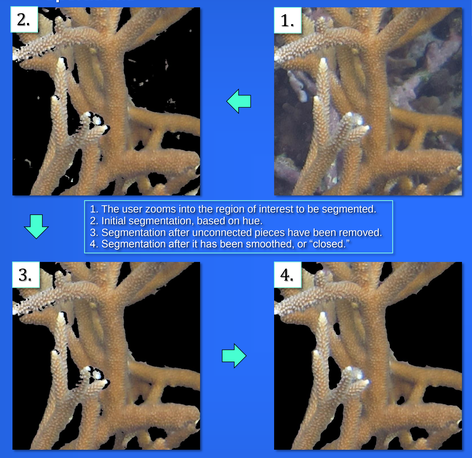
Positive and negative points have been selected in this piece of the image

- Coral Vision was designed and created using MATLAB.

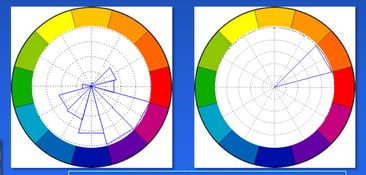
Work performed at Washington and Lee with support from the Washington and Lee University Summer Scholars Program.

Coral Vision 1.0

- Coral Vision 1.0 uses histograms on hue trained over the positive and negative user clicks.
- The initial pixel-wise decision is culled and smoothed using image morphological operations



1. The user zooms into the region of interest to be segmented.
2. Initial segmentation, based on hue.
3. Segmentation after unconnected pieces have been removed.
4. Segmentation after it has been smoothed, or "closed."



Above: Left: This color wheel displays the color bins where the negative points were clicked.
Right: This color wheel displays the color bins where positive points were clicked.

Below: The result of the segmentation process. Selected coral is represented in Coral Vision as hot pink, and combined with any segmentations from the rest of the image.

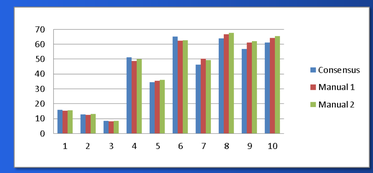
Coral Vision 2.0

- Coral Vision 2.0 uses an improved algorithm based on random forest classification.
- The program determines which pixels should be coral based on their hue, saturation, and value compared to that of the user-selected points.
- A new feature of Coral Vision 2.0 is the magic pen, which allows the user to draw a line across coral. The program then expands this line to fill out the selected branch.

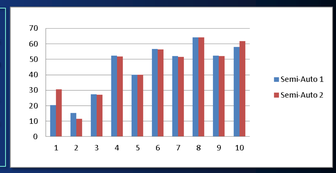
- This feature is especially useful for quick segmentation of sparse areas.

Comparing Methods

- Initial testing was run on Coral Vision 1.0. For Coral Vision to be successful, it needs to imitate the manual results so that it can replace the manual method in future research.
- Two researchers segmented 10 different images using both the original manual method and our semi-automatic method. We also had the original "consensus" manual segmentations of each image, where all researchers agreed on one segmentation, for a total of three manual and two semi-automatic segmentations.
- We then found the discrepancy between segmentations created in each method, as well as the discrepancy between the averages of both methods.



Left: The three bars represent the three manual segmentations of each of 10 images, to show discrepancy in percent live coral cover in each.
Right: Similarly, shows two semi-automatic segmentations of each image, showing the discrepancy between uses of our method.



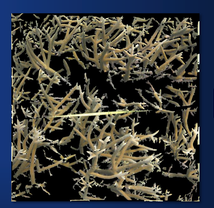
- The average discrepancy between manual methods was 2.56%, while the average discrepancy between semi-automatic methods was only 2.00%. In addition, the manual method required an average of an hour per image while Coral Vision required an average of 20 minutes per image.
- However, the discrepancy between the average of manual segmentations and the average of semi-automatic segmentations was 5.7%, with a median 3.15% discrepancy.
- To satisfactorily imitate a manual segmentation, we need the discrepancy between the two different methods to fall within the 2.56% discrepancy of the manual methods.

Conclusions, Future Directions

- The goal of our project is for Coral Vision to be effective enough to replace the exhaustive manual method of computing percent live coral cover.
- To be considered effective enough to replace the manual method, it must both save time and be able to produce results within the discrepancy range of the manual segmentations.

Manual Segmentation

Versus



Coral Vision 1.0 Segmentation

- Coral Vision 1.0 saved significant amounts of time, but testing must still be done with Coral Vision 2.0 to determine if it has a smaller average discrepancy with the manual segmentations.
- We plan to continue improving on our software until it is suitable for use with coral monitoring research.