Reactive Reefs: Coral Imaging

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Why Coral Reefs

- They are alive
- They are at the base of marine ecosystems
- They protect coastline against waves
- They are “sensors” for observing climate change
• 6~10 students travel to a remote coral reef once a year
• They snorkel to visit ~200 sample sites and monitor:
  – Sensitivity to temperature
  – Genetic behaviors
  – Growth and decay
Where in the World

Bing maps
Where in the World

Ofu-Olosega, American Samoa

Coral reefs surround the island

Bing maps
We are targeting 100x resolution improvement

- Centimeter Accuracy

*At that resolution, coral species become identifiable*
Reactive Reefs

“Gigapixel” Imagery

Aerial Mapping

Underwater Photography

not covered in this presentation
Reactive Reefs

“Gigapixel” Imagery

Aerial Mapping

Equipment and Approach

Fluid Lensing

3D Reconstruction

Map Examples
Aerial Mapping

ggfilms.com
Aerial Mapping Equipment

- 3D-Robotics Quad-Copter, GoPro Camera
- Custom housing – protection from water, sand
- Lithium-polymer batteries – ~10min flight
sUAS carrying a downward-pointing camera travels the reef, taking many pictures

Post processing combines these into large maps

➢ sUAS enables high-resolution high-frequency mapping
Low Flights – High Resolution

- 25 m Altitude
- 27 Flights
- 1 km along Beach
- 200 m from Beach
- 4.3 km Path Total

These regions have sample sites

This region is not monitored

Bing maps
An Example Aerial Image

“Porites” coral species

Waves create optical distortions
Fluid Lensing

- Fluid Lensing removes the strong optical distortions from light refracting through the water’s surface.
- Processed images have resolution down to ~1cm.
• Image processing can use multiple images from different views to reconstruct three-dimensional representations of the reef.
3D maps are used to estimate coral volume
Repeated measurements can monitor growth/decay at the reef scale, an unprecedented capability
Flight Video

Available at:
http://www.vedphoto.com/reactive-reefs
An Example Map

Thousands of images stitched together to form a map.
An Example Map

Unprecedented aerial image resolution
An Example Map

Maps scaled to Compare Resolution

- sUAS enables high-resolution high-frequency mapping
Summary

Reactive Reefs:
“Gigapixel” Imagery

Aerial Mapping

Equipment and Approach

Fluid Lensing

3D Reconstruction

Map Examples
Active and Future Work

• Active mapping work in Australia
• Fluid Lensing Theory Development
• Quadcopter Endurance Development
• Species Recognition with Machine Learning and Multispectral Imaging
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Questions?

More information available online

http://www.vedphoto.com/reactive-reefs
Thank You!

More information available online

http://www.vedphoto.com/reactive-reefs
• Machine Learning algorithms in development to identify regions of coral, and potentially segment regions by species

Authors: Hardik Kabaria, Ashish Goel, Kristen Moore
Aerial Mapping Equipment

- 3D-Robotics Quad-Copter
- Custom housing - protection from water, sand
- Custom camera gimbal – nadir pointing
- 5400 mAh LiPo batteries – ~10min flight
- Go-Pro Camera filming video at 60fps
- Waypoint navigation with “Mission Planner”
High Flights – Map Overview

- 125 m Altitude
- 4.5 Flights
- 2km along Beach

Not a closed loop...
The quadcopter’s lid ripped off in the crash. All electronics bathed in salt water for 30 minutes.
Rebuild

Fried Parts:
- Speed Controllers
- Gimbal Controller
- Power Module

Salvaged Parts:
- Auto Pilot
- GPS, Telemetry, RC Radios
- Motors
- Camera

Rebuilt from spare kit components in one day