FLUID LENSING & UAV REMOTE SENSING

MAY 5, 2015 - AFFILIATES’ MEETING

VED CHIRAYATH
PHD CANDIDATE, STANFORD AERO/ASTRO
ADVISOR: PROF. JUAN ALONSO

RESEARCH SCIENTIST
EARTH SCIENCES DIVISION
NASA AMES RESEARCH CENTER

ALL IMAGES COPYRIGHT VED CHIRAYATH UNLESS OTHERWISE NOTED
WHAT IS FLUID LENSING?
Fluid Lensing leverages optofluidic interactions, computational imaging and fluid models to remove optical distortions and significantly enhance the angular resolution of an otherwise underpowered optical system.

Fluid-lensed processed images can be effectively used for accurate 3D reconstruction using structure from motion and typically exceed diffraction-limited performance by 3-10x, depending on the setup, SNR restraints and fluid properties.
Seeing limits arise from atmospheric turbulence & air-water boundaries.

Is there a way to exploit the lensing effect of fluids, in general, to increase the angular resolution of a small system without hardware?

Adaptive Optics Solution
Small apertures limit angular resolution due to diffraction - bad for CubeSat telescopes.
Basic principle - it is possible to simulate any fluid interaction and analyze optical properties to estimate relevant \textit{time and length scales}.

Consider power spectrum of waves and treat as sheet of lensing elements.

Simulate optical coupling with convolution, compare to experimental data for lensing parameter match.
OCEAN SCIENCE APPLICATIONS
WHY REEFS & COASTAL ECOSYSTEMS?

• Global climate regulator
• Lifeline of ocean ecosystem
• Rainforests of the sea
• Climate change mitigation
• Food security - pelagic species
• Coastal protection & Military assets

Source: Scripps Oceanographic Institute
Highest Resolution Aerial Image, Flagpole Landing, Hamelin Pool  (Google 2015)
High resolution 3D model from Fluid Lensing - preliminary Hamelin Pool data
UNDERWATER MAPPING FOR CAL/VAL
AUTOMATED REMOTE BIOSPHERE ASSESSMENT USING FLUID LENSING AND MACHINE LEARNING ALGORITHMS

original 3D fluid lensed solution

organic vs inorganic structure (98.7% accuracy)

automated species ID (85% accuracy)
Overview:
- Selected March 2014
- Delivery February 28, 2015
- 1.5U CubeSat payload architecture
- 2 x next-generation Fluid-Lensing-based computational imagers (visible & NIR)

Applications:
- High-resolution imaging through fluid boundaries, turbulent media & transients
- UAV & CubeSat payload
- Marine, subsurface imaging
- 3D imaging, DEM, high temporal resolution
THANK YOU!

online @
www.vedphoto.com/fluid-lensing

next @
University of Miami RSMAS (April 2015)
NASA ESTF (June 2015)
AGU (December 2015)
4 peer-reviewed journal papers (2015)