Underwater Image Dehazing with a Light Field Camera

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Motivation
Motivation

Lizard Island, Australia  Port Royal, Jamaica
Motivation

Photo: Jaffe Lab
Motivation

Photo: Jordt (2014)
Light Field Cameras

• Real-time RGB-D
• Passive optical sensors
• Compact form factor
• Increased depth-of-field
Real-time Underwater 3D Reconstruction

Real-time Underwater 3D Reconstruction

Pure vs. Turbid Water

Disparity map in pure water

Disparity map in turbid water
Contribution: We present a pipeline for dehazing of underwater light field images incorporating a physical model of underwater light propagation.
Underwater Light Field Image Dataset

Contribution: Provide a comprehensive light field dataset for underwater image dehazing.

https://github.com/kskin/data
Technical Approach

Algorithm 1 Proposed approach for dehazing an underwater light field image.

**Input:** \( L(x, y, u, v) \)

**Output:** \( \tilde{L}(x, y, u, v) \)

1. \( J(x, y, u, v) \leftarrow \text{InitialDehaze}(L(x, y, u, v)) \)
2. \( \tilde{J} \leftarrow \text{SynthesizeViews}(J(x, y, u, v)) \)
3. \( \tilde{L}(x, y, u, v) \leftarrow \text{GuidedImageFiltering}(\tilde{J}, J(x, y, u, v)) \)
Dehazing Model

\[ I(x) = J(x)e^{-\eta d(x)} + A(1 - e^{-\eta d(x)}) \]
Dehazing Model

\[ I(x) = J(x)t(x) + A(1 - t(x)) \]
Dehazing Model

\[ I(x) = J(x)t(x) + A(x)(1 - t(x)) + L_\alpha(x) * APSF \]

- Non-uniform illumination
- Glow patterns

Synthesizing Views
Recovering Epipolar Images
Results

In air  Raw underwater  Our result
Results

Disparity map using raw underwater image

Disparity map using corrected image
Conclusions

• Presented an underwater light field image dehazing pipeline that incorporates a physical model of light propagation
• Provided an underwater light field image dataset
Future Work

• Gather light field images of more complex scenes
  • Greater depth disparity
  • Varying turbidity

• Further leverage light field structure
  • All-in-focus filter [1]
  • Consistent motion between sub-aperture images

• Incorporate more components of physical model for underwater light propagation
  • Recovering range in underwater imaging

Final Thoughts

- Underwater light field camera – contact kskin@umich.edu
- Deep learning approach to underwater image restoration

Honolulu, Hawaii