Visibility Restoration in a Scattering Medium Using Light-field Data

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Introduction

In this work, we aim to develop a potentially real-time algorithm for improving the visibility of images captured in a scattering environment, such as turbid water. As will be seen later, the dehazing problem is highly correlated with depth. For this purpose, we propose light-field imaging realized by an affordable compact plenoptic camera, i.e. Lytro Illum [1].

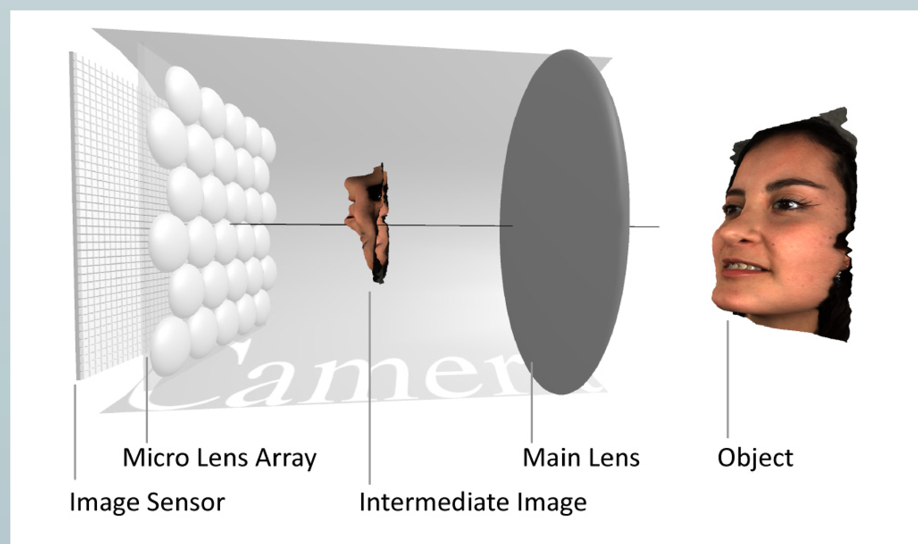
Related work

Single image methods [2, 3] lack the depth information, hence they assume some priors to be able to solve the problem. Polarizer-based methods [4] demand the effort to capture multiple images while rotating the polarizer in front of the sensor and therefore, are obviously not real-time.

Contribution

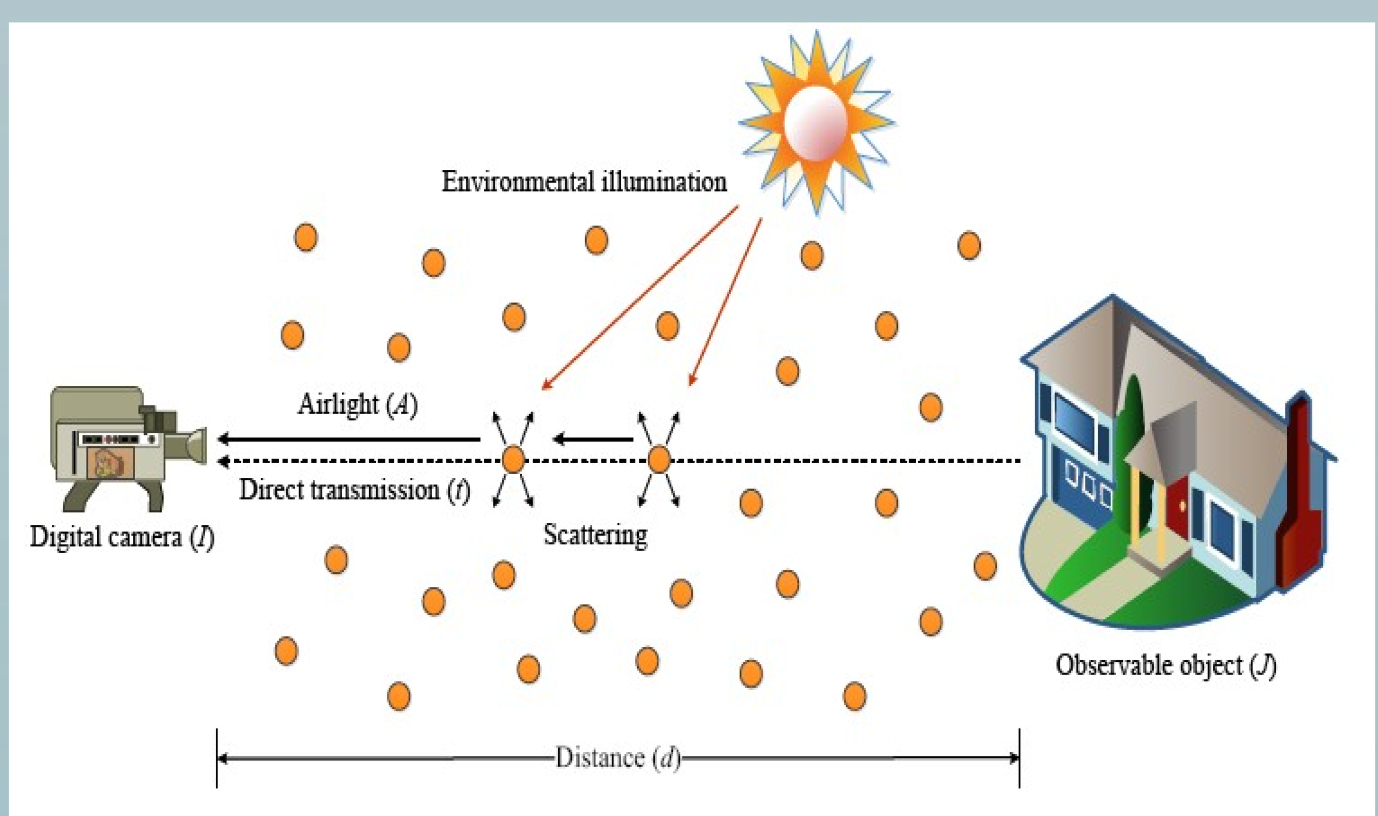
Thanks to the plenoptic camera capturing an array of images in one shot, we develop a real-time algorithm for dehazing. In this framework, having increased the recorded input scene information without trading-off the time, we can apply our dehazing algorithm to any arbitrary scene with no priorities.

Plenoptic camera (Lytro Illum) [1]



Internal structure of the camera [https://raytrix.de/]

Formulation



Schematic model of a imaging in a scattering environment [3]

$$I(\bar{x}) = J(\bar{x}).exp(-\beta d(\bar{x})) + A.(1 - exp(-\beta d(\bar{x})))$$

Proposed algorithm

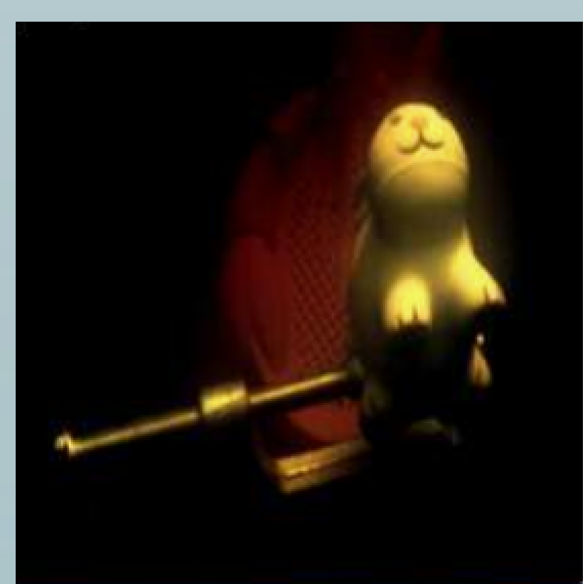
Input: *I(x)* Captured image
Output: *J(x)* Dehazed image, *d(x)* Depth map

Given ambient light A and parameters of medium:

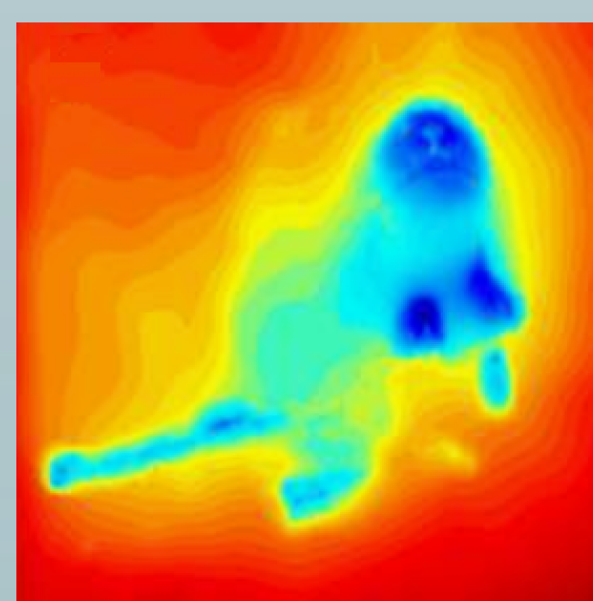
1. Initiating a fixed depth value *z_ref*
2. Deriving 1-order restored image *J1* based on *z_ref*
3. Using *J1* to compute a depth map *d1*
4. Enhancing depth map *d1* based on the transmission cue method in [5]
5. Using improved depth map to compute the finally restored image *J(x)*

Results taken from [5]

The center view image captured by camera (in turbid water)



The restored image



The restored depth map

Applications

1. Visibility enhancement of sea animals in aquariums
2. Visibility enhancement of roads for drivers

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Bibliography

[1] *https://support.lytro.com/*
[2] R. T. Tan, et al. "Visibility enhancement for roads with foggy or hazy scenes," *Intelligent Vehicles Symposium*, IEEE, 2007.
[3] S. Huang, et al. "Visibility restoration of single hazy images captured in real-world weather conditions," *IEEE Transactions on Circuits and Systems for Video Technology* 24.10, 2014.
[4] S. Shwartz, et al. "Blind haze separation," *Computer Society Conference on Computer Vision and Pattern Recognition*, IEEE, 2006.
[5] J. Tian, et al. "Depth and image restoration from light field in a scattering medium," *International Conference on Computer Vision*, IEEE, 2017.