Depth Estimation of Light Field Images Using Optical Flow

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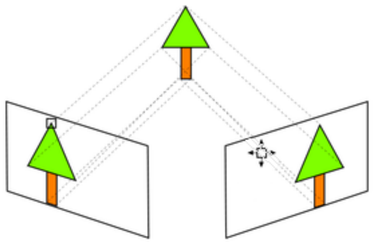
Motivation

Recovering depth from 2D images typically requires 2 or more images from different viewpoints, with a feature matching algorithm. For greater simplicity, I explore the use of a single light field image, with an optical flow (OF) algorithm.



Stereo image

Light field image

Related Work

Adelson et.al. [1] prototyped a plenoptic camera that captured shifted viewpoints of an image, and proposed a basic OF algorithm.

Others have used techniques such as defocus cues, feature matching cues, and combination of them [2].

I combine Adelson's OF algorithm with image regularization, and camera parameters to estimated true depth.

References:
1. Edward H. Adelson and John Y. A. Wang. Single lens stereo with a plenoptic camera. IEEE Trans. Pattern Anal. Mach. Intell., 14(2):99–106, February 1992.
2. Michael W. Tao, Sunil Hadap, Jitendra Malik, and Ravi Ramamoorthi. Depth from combining defocus and correspondence using light-field cameras. December 2013.

Technique

1. Compute OF

Given the value of a ray at pixel coord (x,y) and viewpoint coord (vx,vy), a shift in viewpoint can be related to a shift in pixel coordinate:

$$I(x, y, v_x, v_y) = I(x - h\Delta_x, y - h\Delta_y, v_x + \Delta_x, v_y + \Delta_y)$$

The value of *h* can be estimated for each pixel.

2. **Regularize Image**

Given noisy values of *h,* we estimate the smooth value *x* with confidence weights *C,* and a TV prior. The loss function is:

$$L(x) = \frac{1}{2}||C(x-h)||_2^2 + \lambda||Dx||_1$$

3. **Estimate True Depth**

Given the following camera parameters

f: camera focal length

D: camera focal plane

b: viewpoint baseline

p: pixel baseline

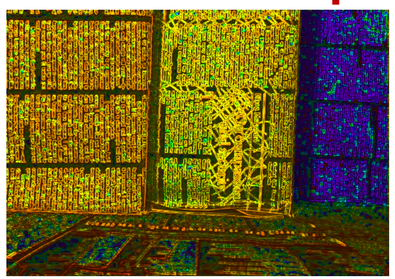
We can estimate the true *x* and true depth, *d*:

$$d = \frac{f}{x + f/D}$$

Experimental Results and Evaluation

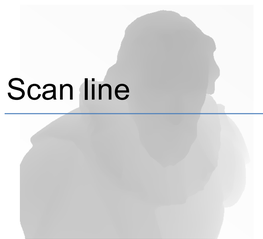
far

near

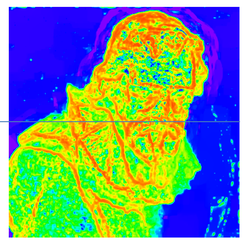


OF, confidence brightened

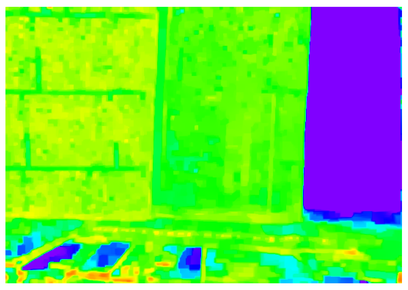
Lytro Output



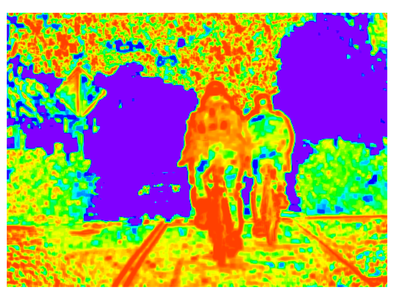
Synthetic Data Gnd Truth



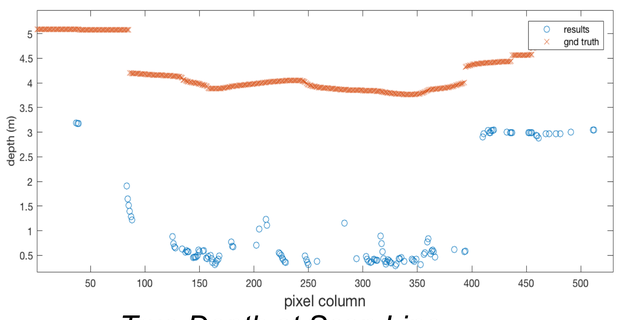
OF + Reg



OF + Regularization



OF + Regularization



True Depth at Scan Line

1. The OF algorithm works well for high confidence areas. It can be improved for featureless areas.
2. There is some offset and scale in the true depth. The calibration and use of camera parameters can be improved.