

# Comparing the Robustness of Different Depth Map Algorithms

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*Motivation: To improve 3D reconstruction techniques in augmented reality (AR). Improved depth map techniques could lead to higher accuracy in creating 3D scenes and improving 3D maps of the world for AR. Comparing the robustness of different techniques could advance research in this area.*

# Goal and Methodology

*Goal:* To compare different depth map algorithms using light fields and to see how it performs when reconstructing 3D scenes.

## Plan of Action

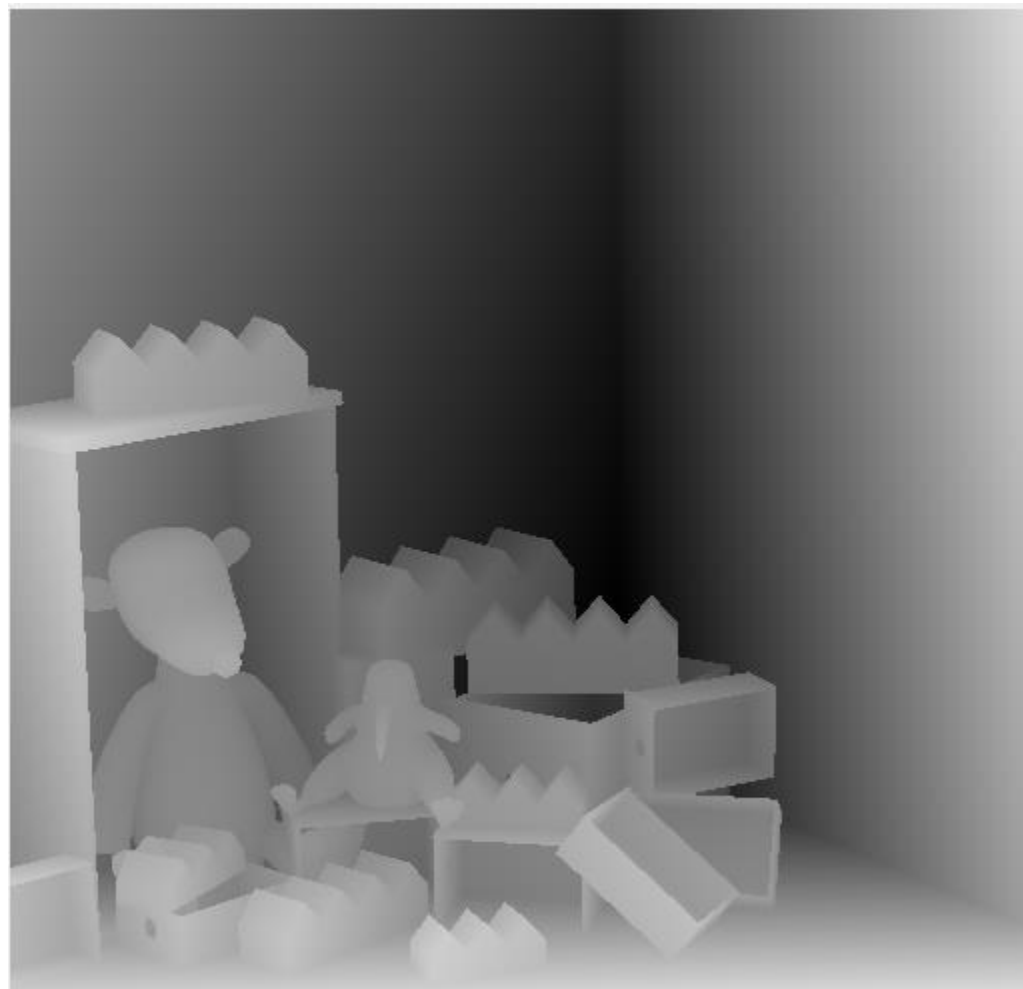
1. Use the light field images from 4D Light Field Benchmark for ground truth depth maps
2. Use 3 different algorithms – focal stack gradient, epipolar planes, line fitting – to extract depth map
3. Evaluate mean squared error of each depth map with ground truth views and computation time

# Original Image



- Dataset: 4D Light Field Benchmark
- 'dino'
- 9x9 light field
- Resolution: 512 x 512 px
- RGB image

# Ground Truth Disparity Map



# Focal Stack

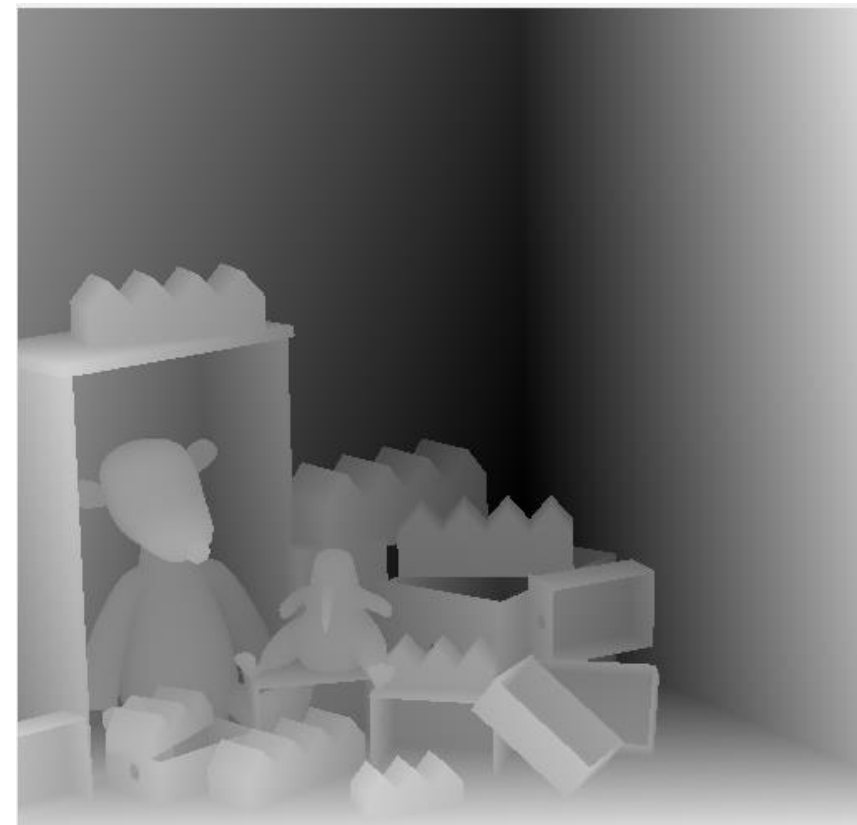
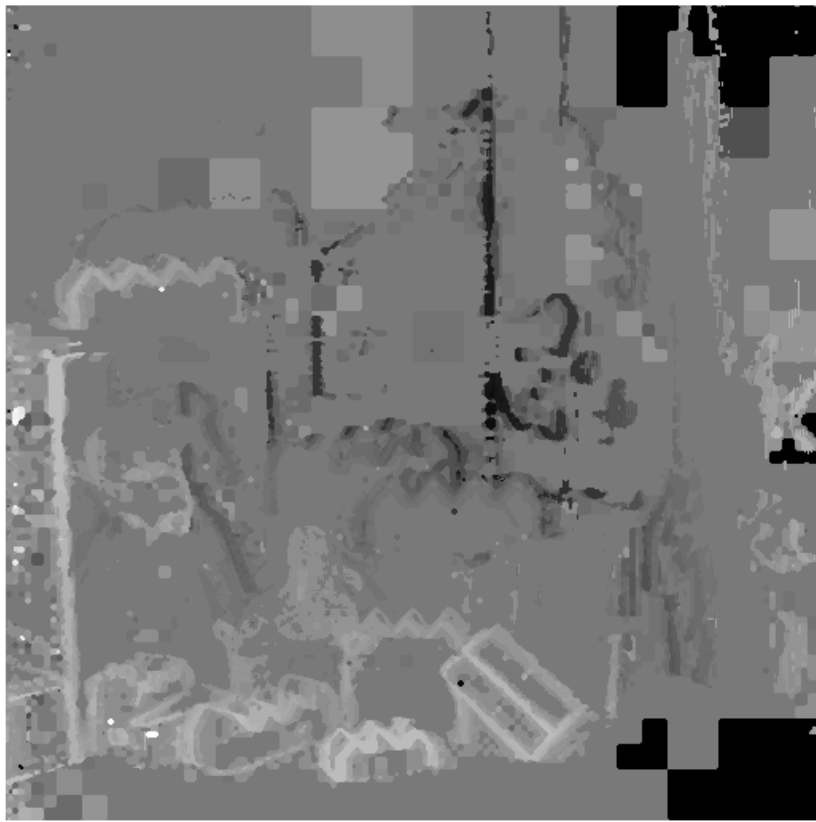


- Shift & add algorithm:

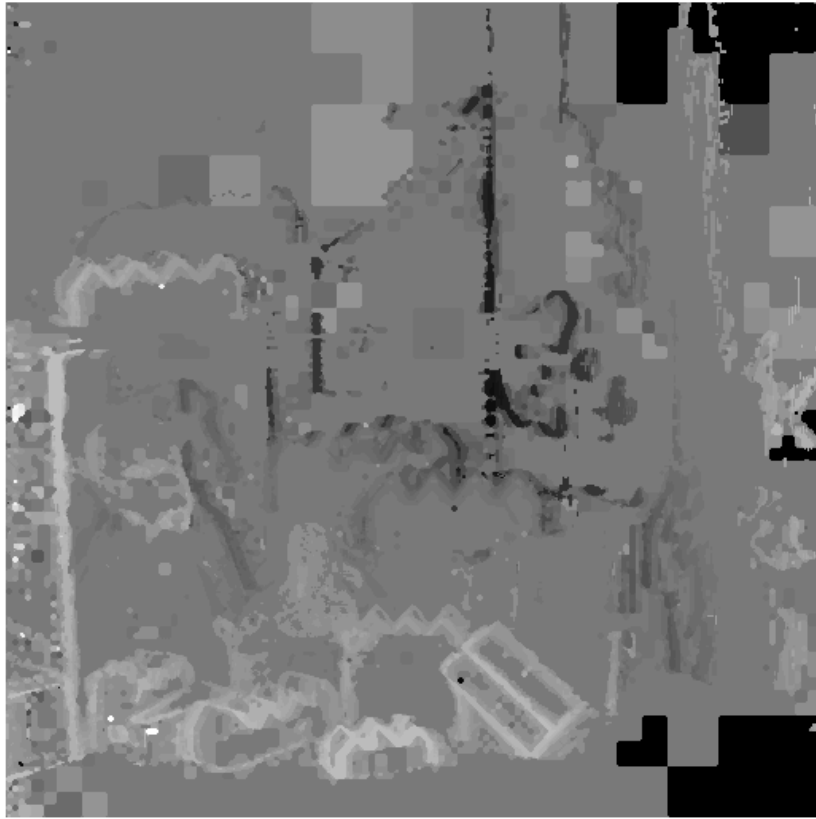
$$\text{Shift by } d_1: i_{d_1}(x) = \int_{\Omega} l(x + d_1 u, u) du$$

- Have different views from LF dataset so no need for shift & add
- Find gradients of each image in focal stack.
- Find maximum gradient for each focal stack and display depth map in HSV

# Epi-polar Plane + Fine to Coarse

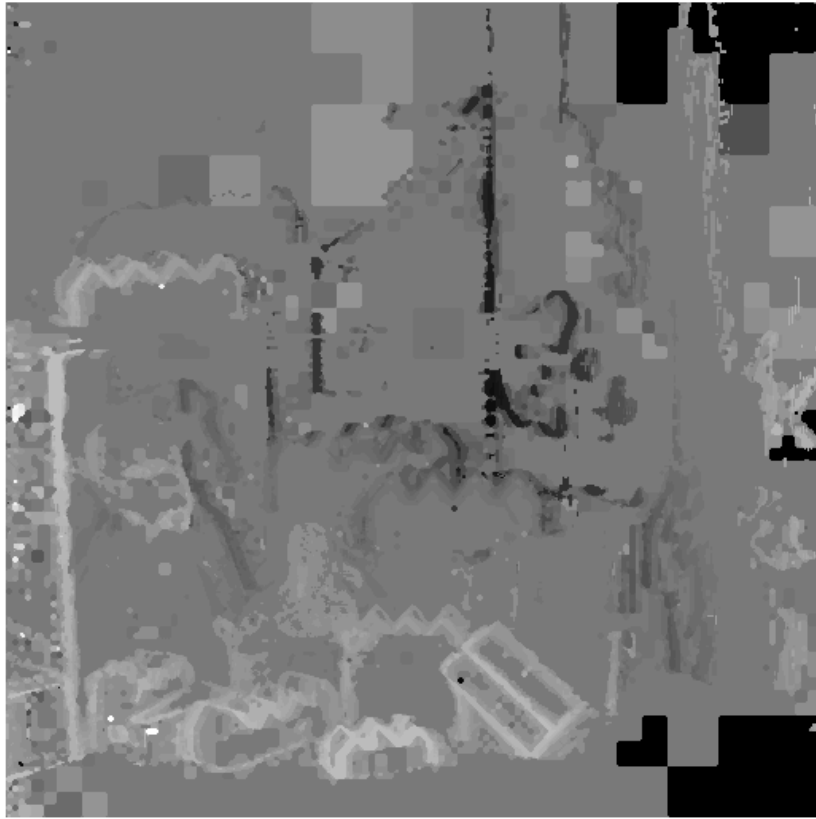


# Epi-polar Plane + Fine to Coarse



- Extract Epi-polar images (EPI)
- Compute Edge Confidence
- Compute Color Density Score ( $S$ ) over all hypothesis disparities ( $d$ )
- Choose the  $d = \text{argmax}(S(u,d))$  and compute depth confidence ( $C_d$ )
- (Filter)
- (Propagation)
- Apply Gaussian and downsample the LF images
- Redo everything
- Upsample it to fill the homogeneous part of the depth map

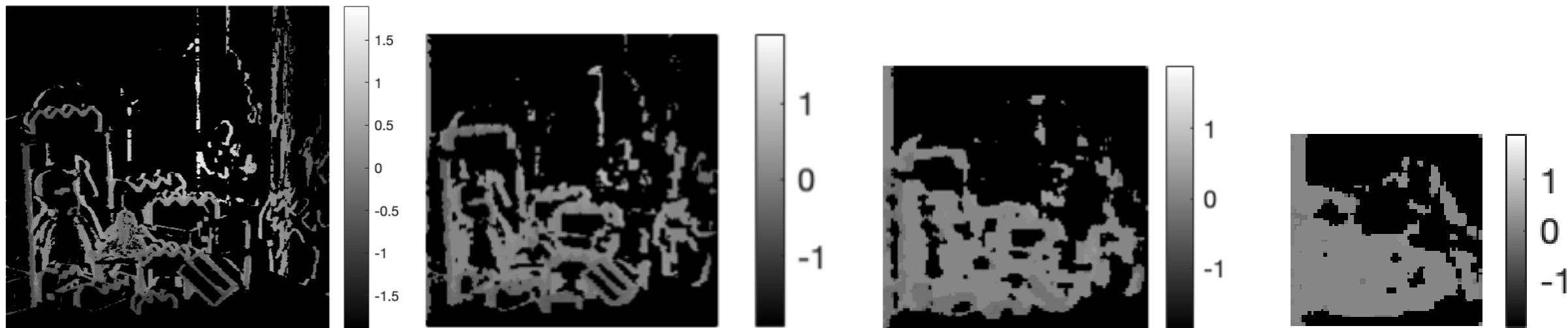
# Epi-polar Plane + Fine to Coarse



- Run time: 218 sec
- Good pixels: 21.69%, threshold = 0.1



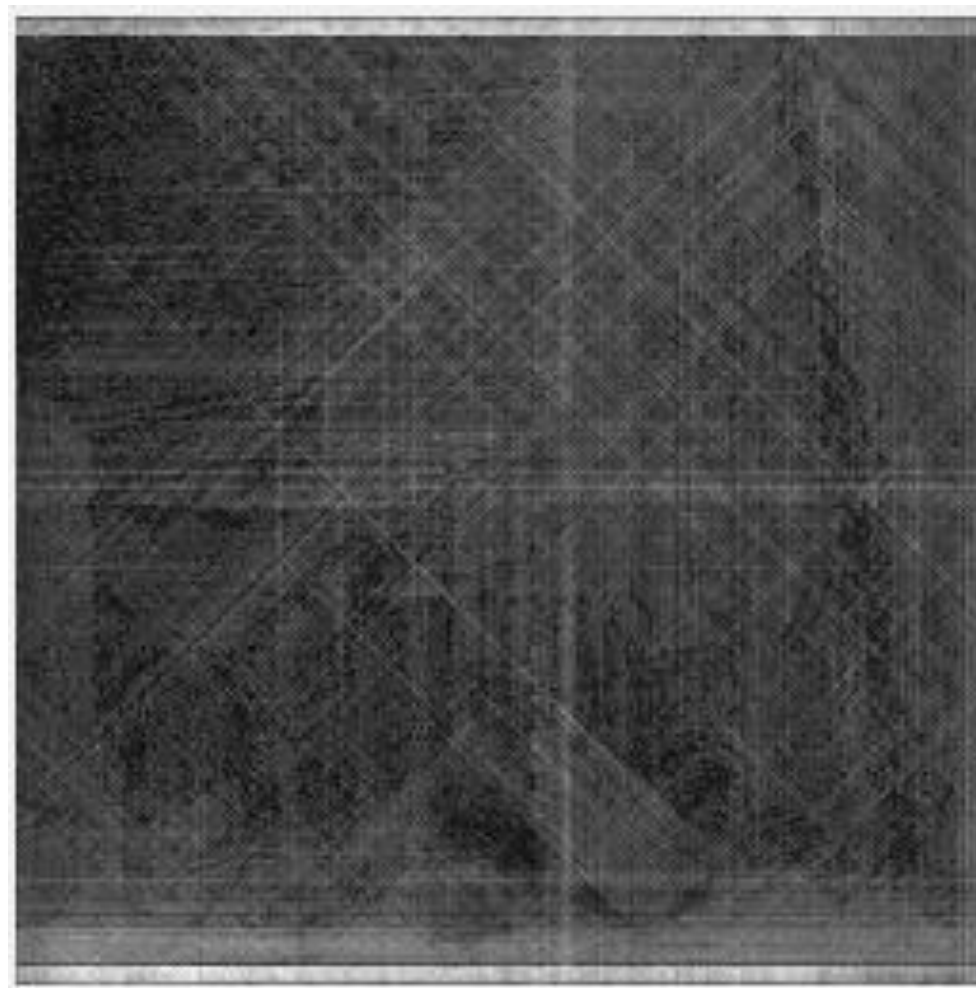
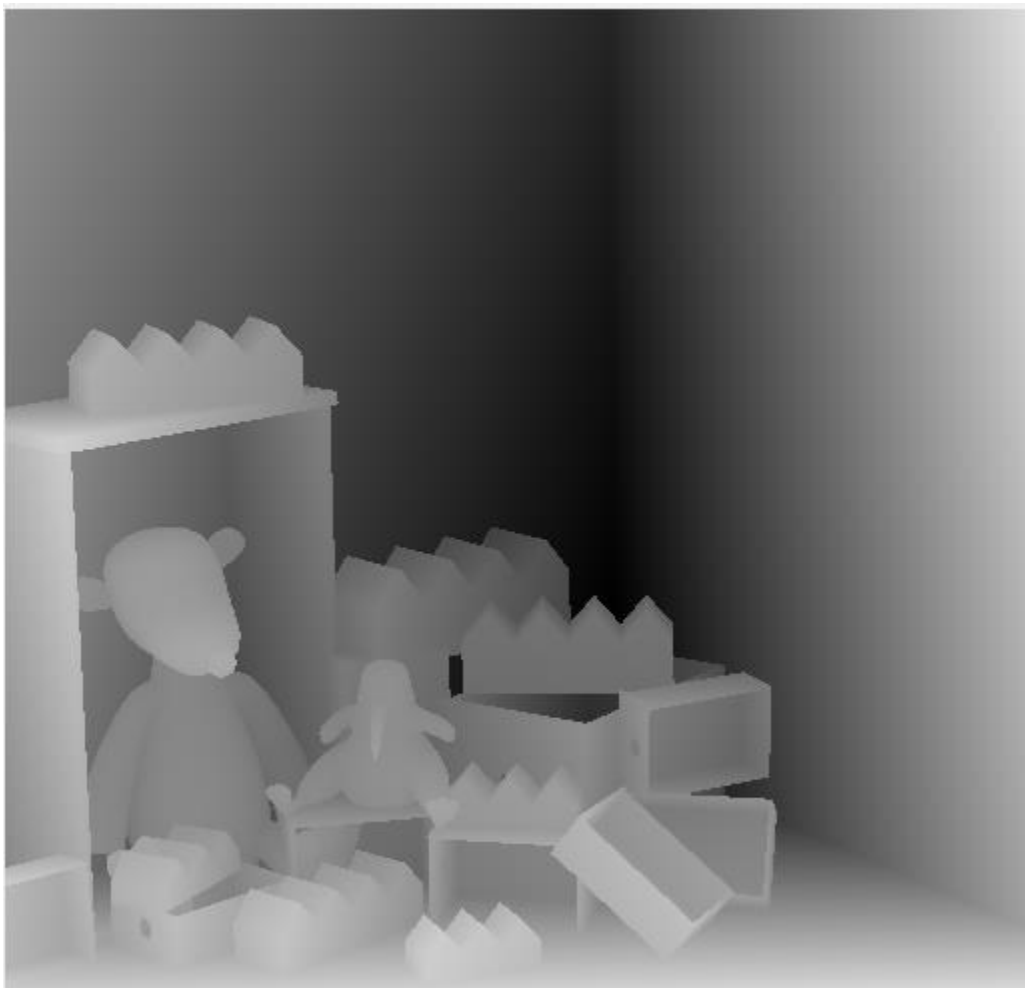
# Epi-polar Plane + Fine to Coarse



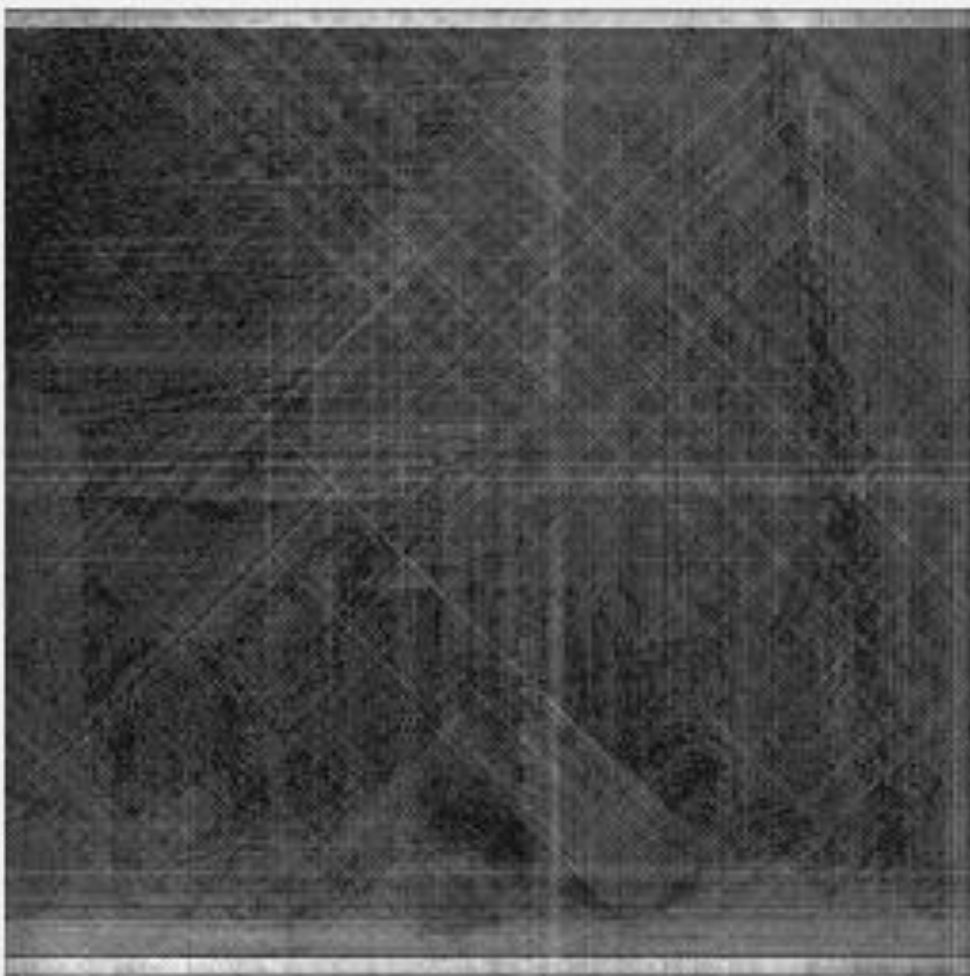
# Epi-polar Plane + Fine to Coarse



# Line Fitting (in the works)



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- Input: first and last views in center row of light field
- Sparse census transform (lc1, lc2)
- Hamming distance between lc1 and lc2 with some disparity (-5:5)
- Semi-global matching (cost aggregate)

$$L_r(p, d) = C(p, d) + \min(L_r(p - r, d), L_r(p - r, d - 1) + P1, L_r(p - r, d + 1) + P1, \min_t L_r(p - r, t) + P2),$$

- Interpolation
- Synthetic Depth Map

# Line Fitting (Sparse Census Transform)

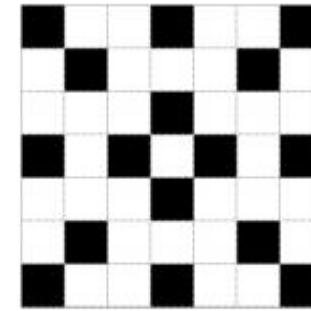
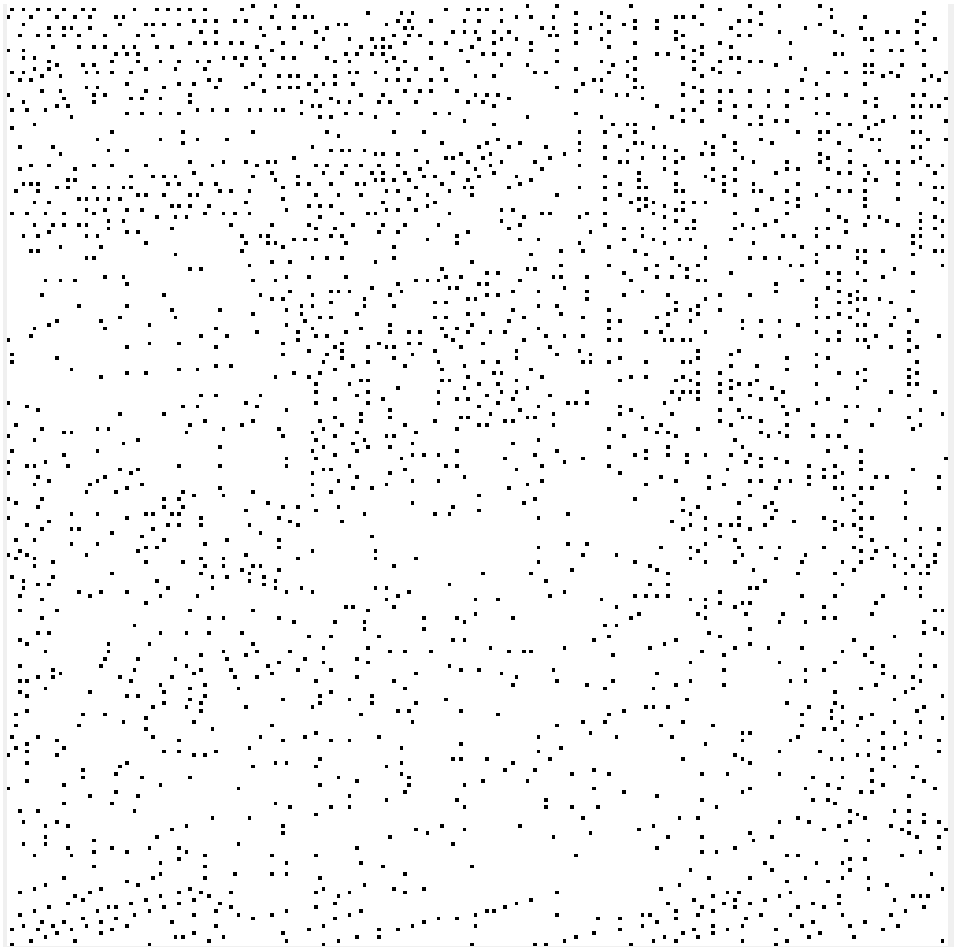


Figure 2. A pattern for sparse Census processing

$$I_c(u, v) = \bigotimes_{[i, j] \in D} \xi(I(u, v), I(u + i, v + j)).$$

$$\xi(p_1, p_2) = \begin{cases} 0, & p_1 \leq p_2 \\ 1, & p_1 > p_2 \end{cases}.$$

# Next Steps

- For EPI+Fine to coarse:
  - Add filters
  - Add propagation step
- For line fitting:
  - Add line-fitting portion
  - Use notch filter to remove striations like from homework 4
  - Calculate run time and # bad pixels
- 3D Point Cloud
- Put depth map in MeshLab