Motivation

- We want to design light patterns for systems that use both a projector and a camera to capture the scene.
- The camera is responsible to find the corresponding projector pixel for every observed pixel:

\[ a_{ij} = \text{Decode}( \text{Neighbourhood}(c_{ij}) ) \]
- If we can find a pattern such that for every observed camera pixel, we find the corresponding projector pixel then we can do stereo imaging.
- Can we determine the optimal pattern to project light to make the task of finding correspondences the easiest?

Method

- We would use differentiable rendering to generate light patterns in using end to end optimization between the projector and the camera.
- Using end-to-end optimization allows our method to discard assumptions on the environment while generating light patterns using gradient descent.
- We use the fix our decoder to be zero-noise cross correlation decoder presented in [2], where the observations are obtained from the Mitsuba renderer [4].
- For each observation, column in the camera image \(a_i\), we compute the probability of observing the corresponding code vector \(c_i\). Define this map to be \( p(j, i) \).
- We compute the ground truth \( p(i, j) \) using the camera depth map and the intrinsics, then our loss becomes:

\[ L(c) = \sum -p(i, j) \log(p(i, j)) \]

Experimental Results

- Test setup:

  ![Test setup image](image)

- Patterns were optimized for 200 gradient steps, each with a batch size of 8.
- For each sample of the batch, we sample a random orientation and position for the cube as well as the level of ambient light.

Related Work

Hand Tuned Patterns

- We can design the patterns and the specific decoder using a list of heuristics, that maximize the ability of the camera to detect under noise assumptions [1].
- However, the patterns are not tuned for specific materials nor is there any criterion for the quality of the pattern.

Optimized Patterns

- Under an epipolar transport model and a simple but optimal decoding algorithm in the maximum likelihood sense, we perform an optimization for the pattern that minimizes the missed correspondences [2].
- The optimization can be carried out using a random texture to tune arbitrary structured light systems [3].
- Can we perform the pattern optimization using differentiable rendering, with less assumptions on the light transport?

References