Multiple Baseline Stereo

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Outline

1. Introduction and motivation
2. Similarity Measurements
   - Square Differences
   - Other common metrics
3. Epipolar Geometry
   - Rectification
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Introduction

The goal of stereoscopy in computer vision is to explain and mimic the human visual system to give machines the ability to perceive depth and estimate it.

In this project we will explore surface reconstruction based on a set of images acquired with different baselines.
Introduction and motivation

Similarity Measurements

Square Differences

Epipolar Geometry

Other common metrics

Multiple Baseline Stereo

Conclusion and Discussion

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Similarity Measurements

In Computer Vision key issues such as

- Pattern Recognition
- Object Tracking
- Image Registration
- Movement Analysis and Video Analysis
- Stereo Matching

can be solved by introducing similarity metrics and measurements.

Reference Paper: 6 families and more than 50 metrics

The use of Sum of Square Differences is

**Sum of Absolute Differences**

$$SSD(i, j) = \sum_{(i,j) \in W} (l_1(i, j) - l_2(x + i, y + j))^2$$  \hspace{1cm} (1)
Other metrics

\[
SAD(i, j) = \sum_{(i,j) \in W} |I_1(i, j) - I_2(x + i, y + j)| \tag{2}
\]

\[
NCC(i, j) = \frac{\sum_{(i,j) \in W} l_1(i, j)l_2(x + i, y + j)}{\sqrt{\sum_{(i,j) \in W} l_1(i,j)^2 \sum_{(i,j) \in W} l_2(x + i, y + j)^2}} \tag{3}
\]

\[
SHD(i, j) = \sum_{i,j \in W} l_1(i, j) \oplus l_2(x + i, y + j) \tag{4}
\]
Rectification

Optimize disparity computation by using rectified images
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The standard stereo model

\[ d = |u' - u| \implies \frac{B}{z} = \frac{d}{f} \implies d = \frac{fB}{z} \] (5)
Introducing multiple images with multiple baselines in the general model

\[ d_i = fB_i \frac{1}{z} = fB_i \zeta \quad \Rightarrow \quad \zeta = \frac{d_i}{fB_i} \] (6)

Reference Paper

Set Up

Multiple Baseline Stereo
Results

First data set: Theoretical repeated pattern: large number of ambiguities

Figure: Synthetic images of the data set

Figure: Associated disparity maps
Ambiguity resolution

Figure: SSD according to disparity and SSD / SSSD of inverse depth
Comparison of results

Figure: Surface reconstruction based on smallest and multiple baseline
Other data set

Figure: Images of the test data set

Figure: Associated inverse depth maps
Comparison of results

Figure: Surface reconstruction based on largest and multiple baseline
Conclusion

In this project, we presented a stereo matching method that uses multiple stereo pairs with various baselines to improve distance estimation to reduce the ambiguity issue.

Improvements and future investigations

- Improve Results
- Introduce Optical Flow and link with disparity
- Link between Hardware, Maths and Implementation
Thanks for your attention!

Questions?