Multiple Baseline Stereo

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Outline

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.

Outline

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.

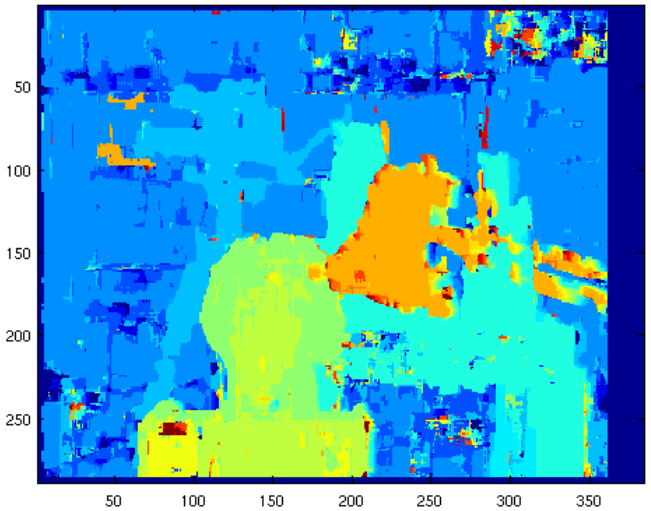
Reference Paper: 6 families and more than 50 metrics

S. Chambon, A. Crouzil, Similarity measures for image matching despite occlusions in stereo vision, Pattern Recognition 44, pages 2063-2075, 2011.

The use of Sum of Square Differences is

Sum of Absolute Differences

$$SSD(i,j) = \sum_{(i,j)\in W} (I_1(i,j) - I_2(x+i, y+j))^2 \quad (1)$$

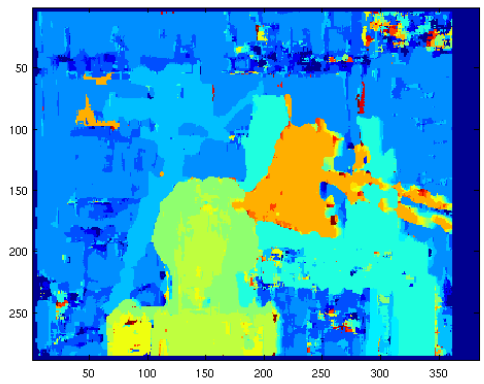


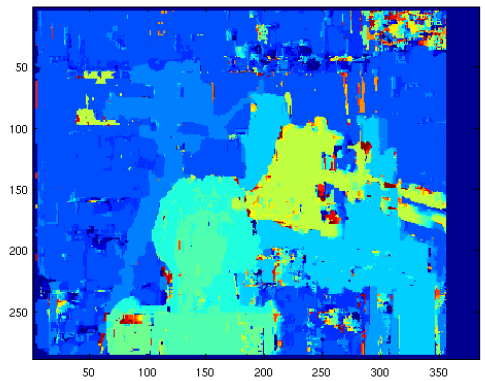
Other metrics

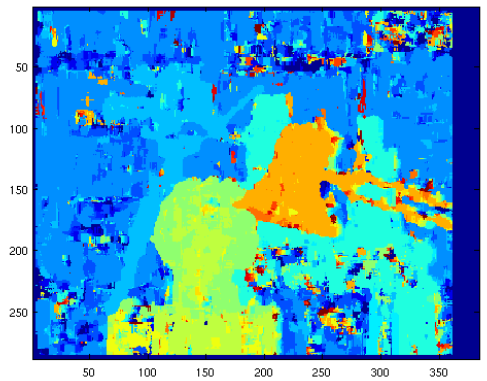
$$SAD(i,j) = \sum_{(i,j)\in W} |I_1(i,j) - I_2(x+i, y+j)| \quad (2)$$

$$NCC(i,j) = \frac{\sum_{(i,j)\in W} I_1(i,j) I_2(x+i, y+j)}{\sqrt{\sum_{(i,j)\in W} I_1(i,j)^2 \sum_{(i,j)\in W} I_2(x+i, y+j)^2}} \quad (3)$$

$$SHD(i,j) = \sum_{i,j\in W} I_1(i,j) \oplus I_2(x+i, y+j) \quad (4)$$



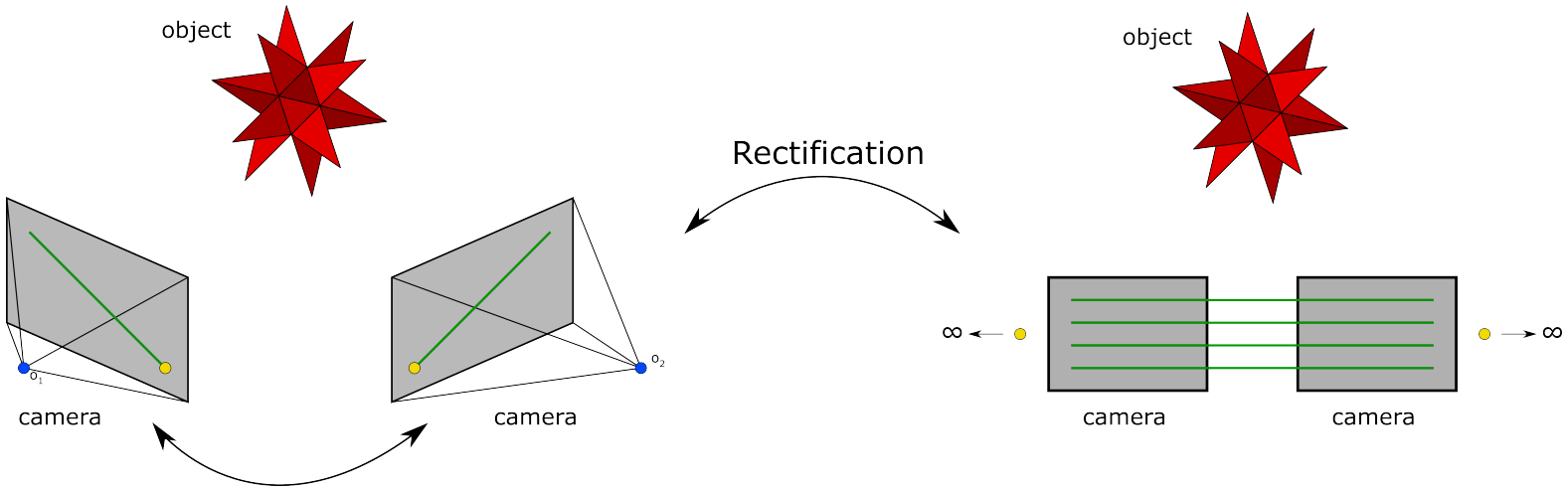




Outline

Rectification

Optimize disparity computation by using rectified images

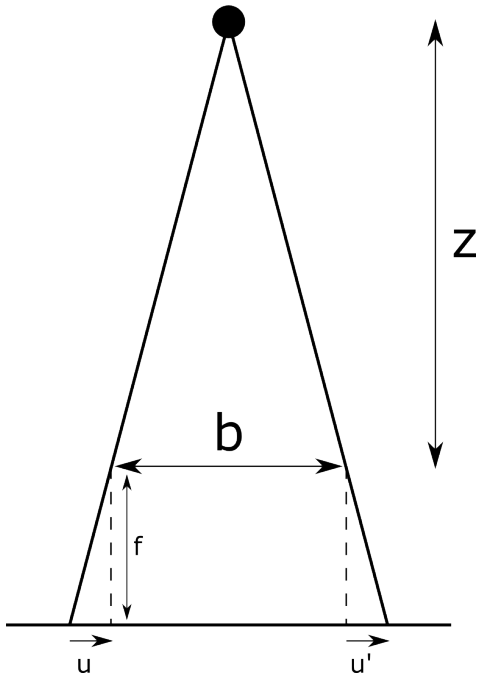


Outline

Theoretical Presentation

The standard stereo model

$$d = |u' - u| \quad \Rightarrow \quad \frac{B}{z} = \frac{d}{f} \quad \Rightarrow \quad d = \frac{fB}{z} \qquad (5)$$



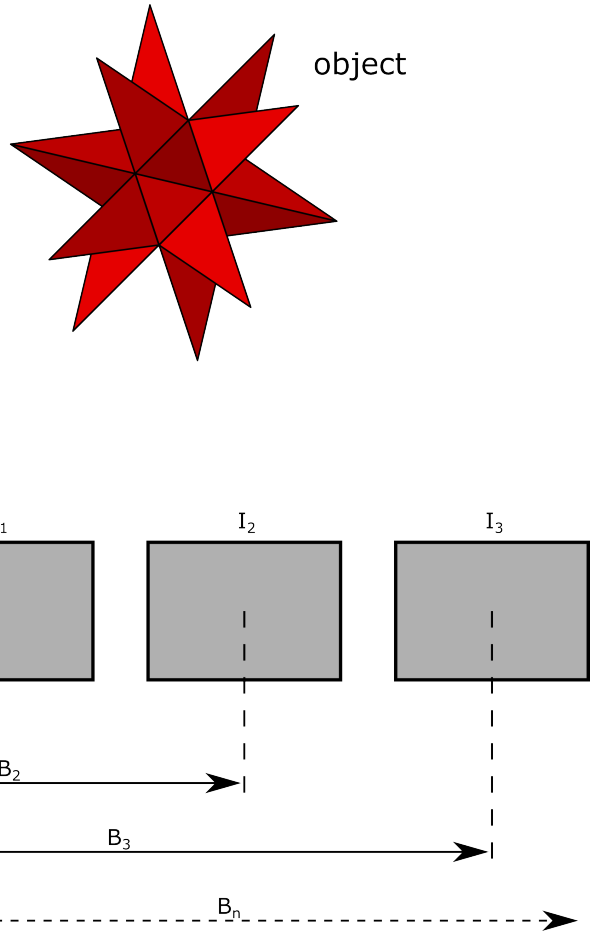
Introducing multiple images with multiple baselines in the general model

$$d_i = fB_i\frac{1}{z} = fB_i\zeta \qquad \Rightarrow \qquad \zeta = \frac{d_i}{fB_i} \tag{6}$$

Reference Paper

M. Okutomi, T. Kanade, A Multiple Baseline Stereo, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 15, No 4, April 1993.

Set Up



Results

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

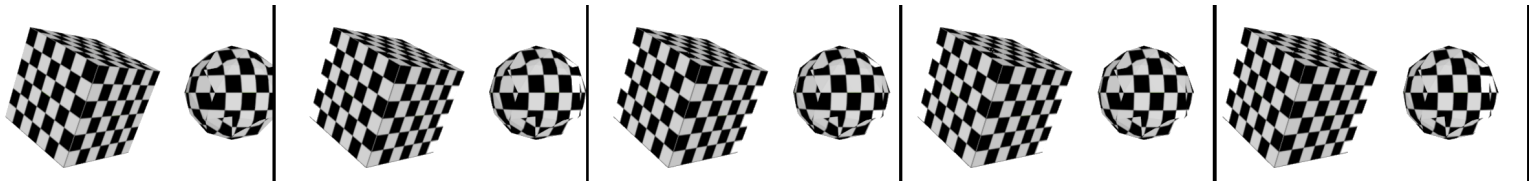


Figure: Synthetic images of the data set

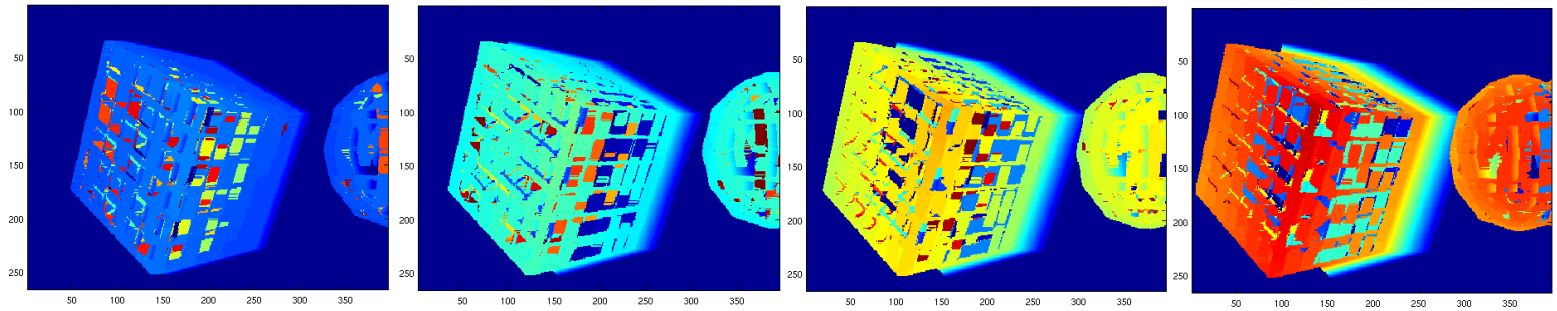


Figure: Associated disparity maps

Ambiguity resolution

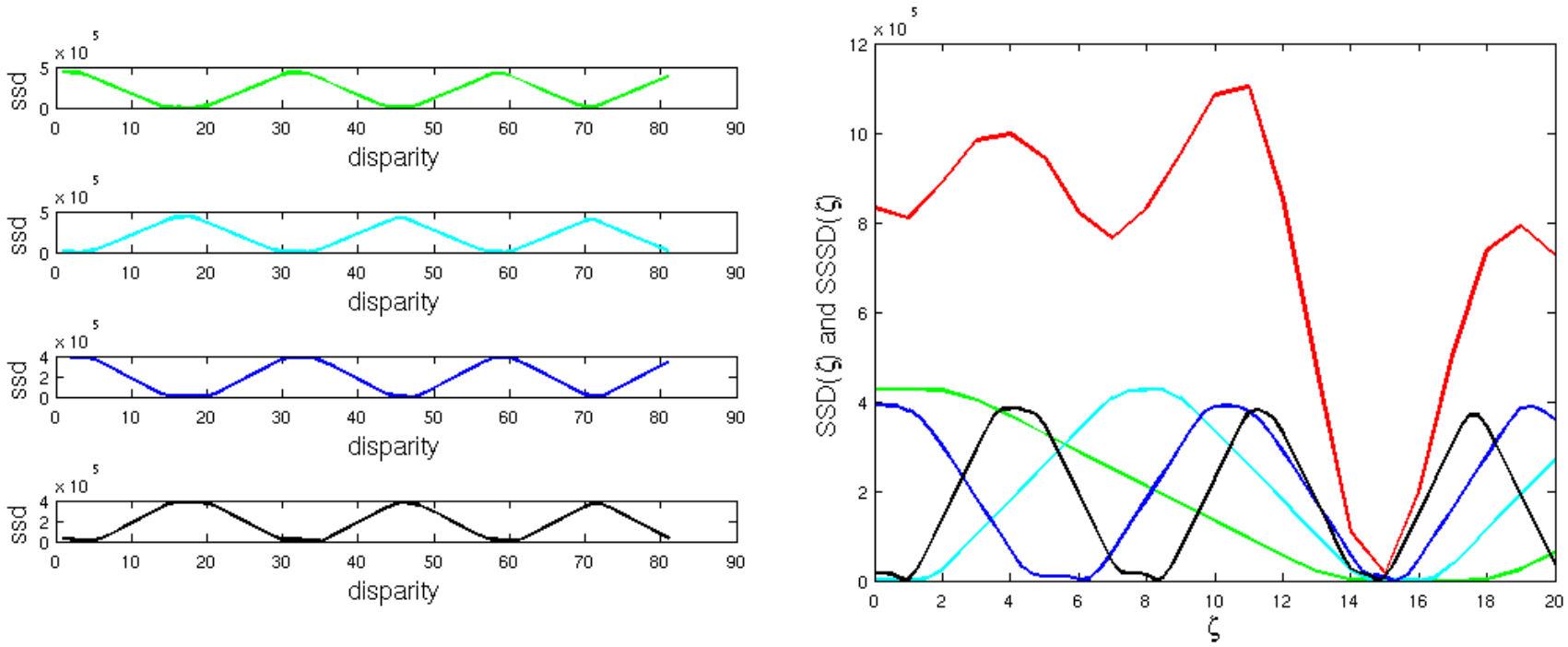


Figure: SSD according to disparity and SSD / SSSD of inverse depth

Comparison of results

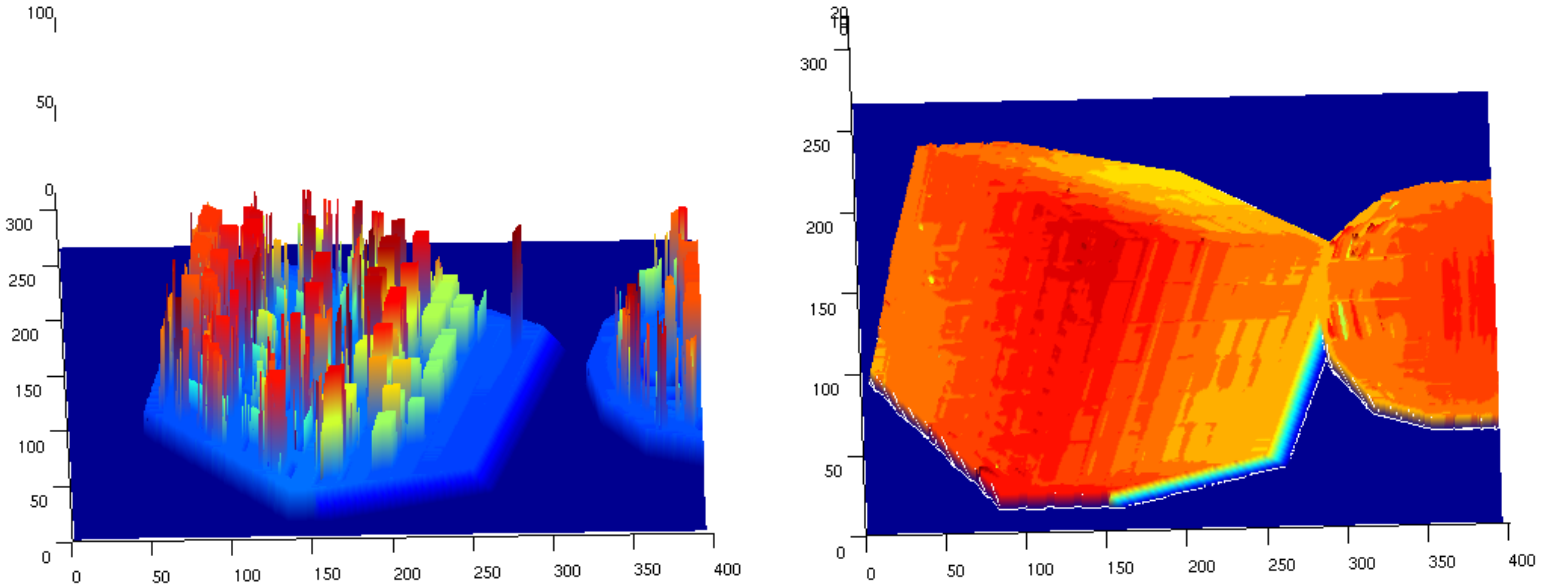


Figure: Surface reconstruction based on smallest and multiple baseline

Other data set

Figure: Images of the test data set

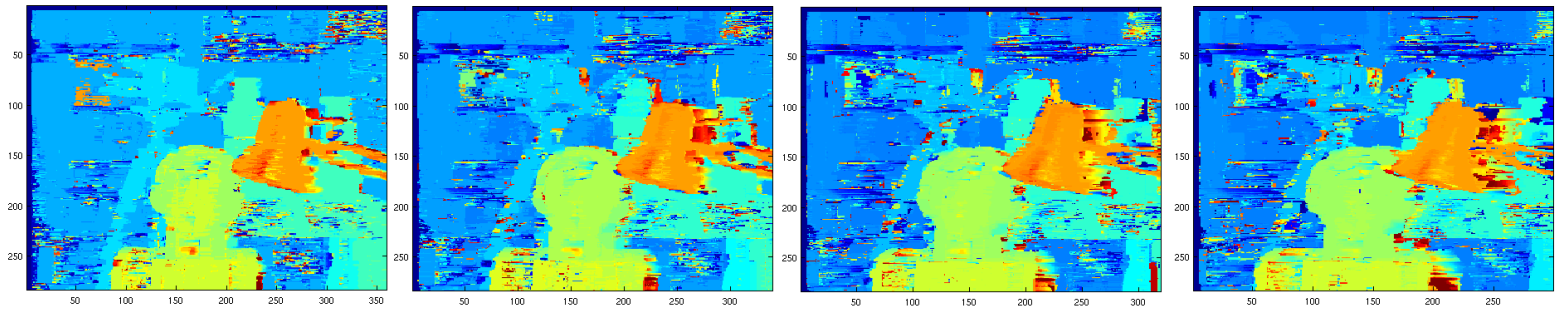


Figure: Associated inverse depth maps

Comparison of results

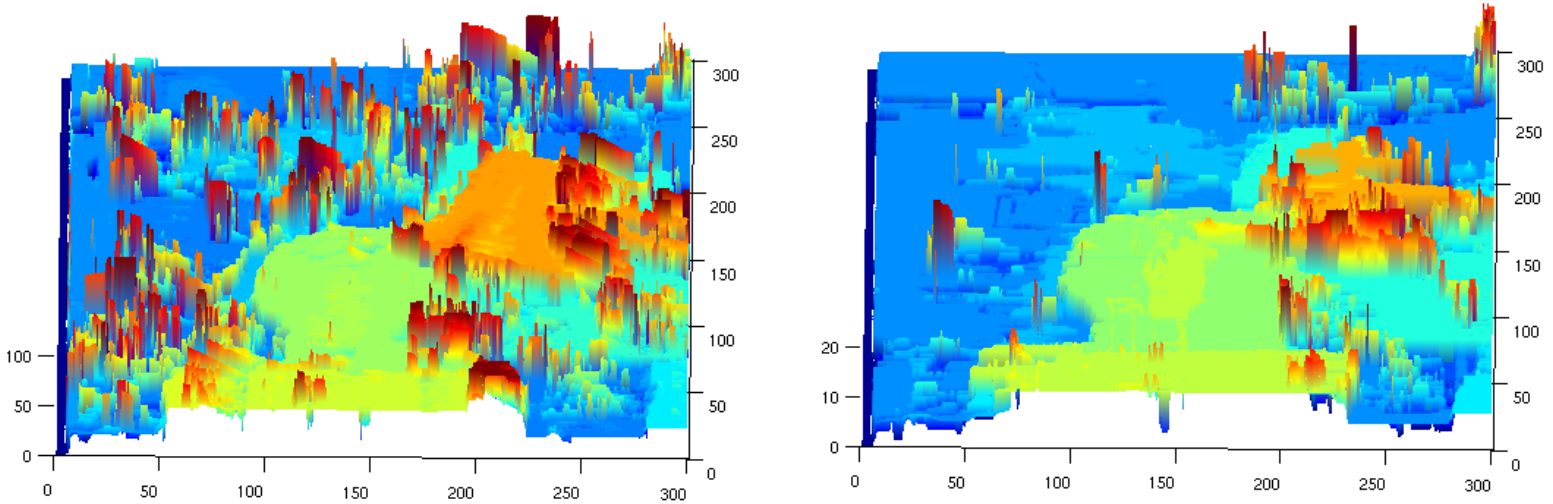


Figure: Surface reconstruction based on largest and multiple baseline

Outline

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 ?