Stereo Correspondence Evaluation in Outdoor Augmented Reality

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Motivation

In marker-less applications of augmented reality (AR), one of the most practical techniques to obtain a depth map of the surrounding environment, for further registration of virtual objects in the real scene, is the use of stereo images with stereo correspondence algorithms.

Studying the performance of stereo correspondence methods for AR applications requires an appropriate evaluation scheme that is designed for the particular target application. Existing evaluation models, that is, Middlebury [8] and Kitti [2] stereo benchmarks, both take a general approach towards evaluating the stereo correspondence solutions. This has compelled us to take steps towards an evaluation scheme that is specifically designed for outdoor applications of AR, based on important factors in an AR system.

Objective

To design a comprehensive evaluation scheme for stereo correspondence methods in outdoor Augmented Reality applications based on some of the most important factors in AR, that is, the processing speed and the accuracy of depth results as perceived by the human visual system (HVS).

Methodology

1. Stereoacuity in binocular vision, that is, the minimum detectable depth between two points at different distances from the observer, is determined [1].

2. The minimum requirement of providing a reasonable augmented world for the user is investigated [3].

3. Various metrics are estimated and reported in the framework of outdoor augmented reality: Average disparity error, Average outliers, Average stereoacuity, Average execution time.

4. Disparity error is converted to effective stereoacuity and compared against average stereoacuity thresholds in HVS as determined by standard stereo tests, to make a practical analysis.

5. A unique masking model is proposed to focus on areas of depth edges and their surroundings, due to their importance in perception of depth and occlusion in HVS.

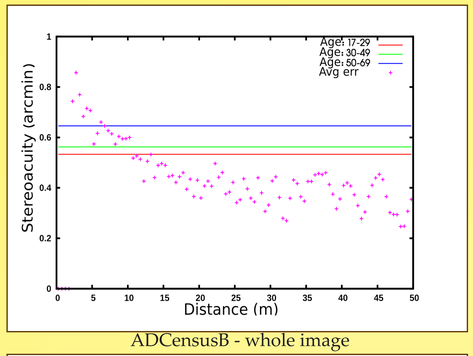
Validation

We evaluate two stereo matching methods in our system:

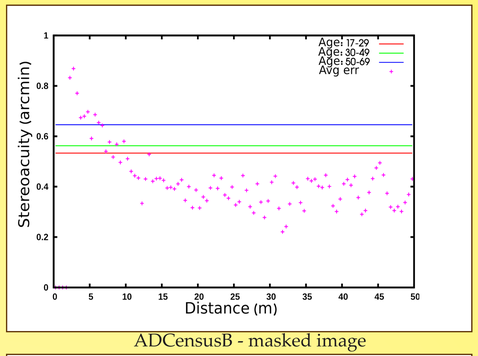
1. The OpenCV implementation of SGBM [4]
2. Our implementation of ADCensus [6], called ADCensusB

A practical analysis for these two methods was made in our proposed model in the framework of outdoor AR applications.

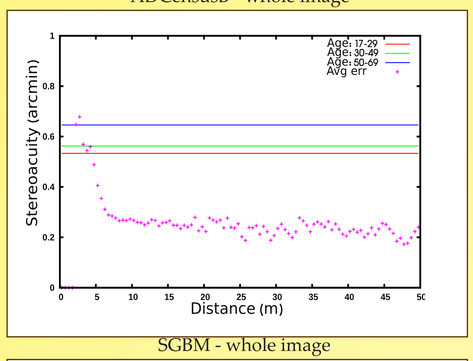
Results



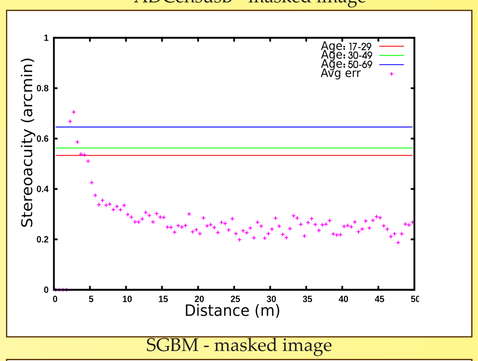
ADCensusB - whole image



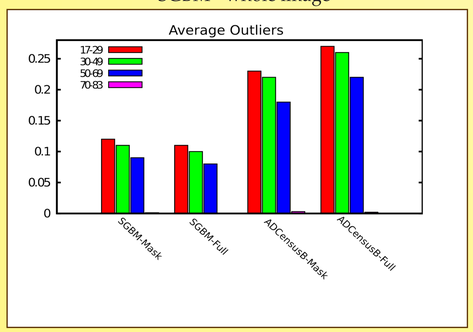
ADCensusB - masked image

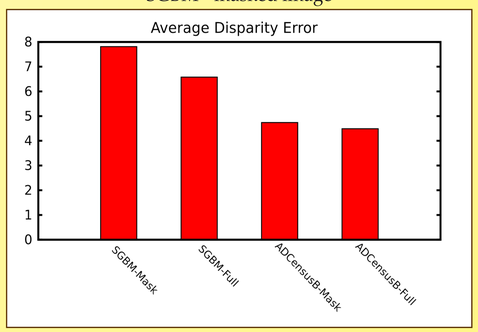


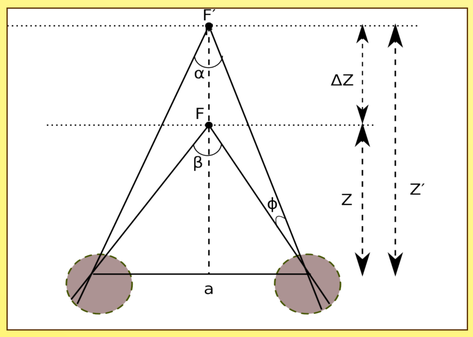
SGBM - whole image



SGBM - masked image







$\theta = \beta - \alpha$

$\theta = \frac{a\Delta Z}{Z^2}$

Algorithm	Execution Time (ms)
SGBM	0.54
ADCensusB	272.82

Conclusion

In this study, we presented a hypothesis stating that the scheme for evaluating stereo algorithms should be designed based on the specific requirements of the target application. This concept was then applied to the particular application of AR in outdoor environments. As a result, a practical analysis on the performance of the stereo algorithms in generating disparity results, in terms of accuracy and execution time as perceived by the HVS, was conducted.

Reference

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