

Variable Baseline/Resolution Stereo

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Abstract

We present a novel multi-baseline, multi-resolution stereo method, which varies the baseline and resolution proportionally to depth to obtain a reconstruction in which the depth error is constant. This is in contrast to traditional stereo, in which the error grows quadratically with depth, which means that the accuracy in the near range far exceeds that of the far range. This accuracy in the near range is unnecessarily high and comes at significant computational cost. It is, however, non-trivial to reduce this without also reducing the accuracy in the far range. Many datasets, such as video captured from a moving camera, allow the baseline to be selected with significant flexibility. By selecting an appropriate baseline and resolution (realized using an image pyramid), our algorithm computes a depthmap which has these properties: 1) the depth accuracy is constant over the reconstructed volume, 2) the computational effort is spread evenly over the volume, 3) the angle of triangulation is held constant w.r.t. depth. Our approach achieves a given target accuracy with minimal computational effort, and is orders of magnitude faster than traditional stereo.

1. Introduction

Stereo is a well-studied problem in computer vision [14]. Recent work has been very successful in solving the correspondence problem, which is to decide which pixels in one image correspond to which pixels in another. Techniques employing graph cuts and belief propagation can achieve error rates of less than 1% (on laboratory data). However, for many applications the goal is ultimately not pixel correspondence but depth accuracy. Even with perfect correspondences, the depth error in traditional stereo grows quadratically with depth, which means that the accuracy in the near range far exceeds that of the far range. While the accuracy in the far range is unusably bad, the accuracy in the near range is unnecessarily high and comes at significant computational cost. Accuracy can be improved by incorporating multiple views. These views provide additional information which aids in the correspondence problem, but

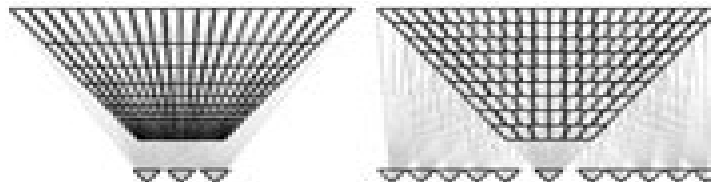


Figure 1. Left: Standard stereo. Note that the distance between depths increases quadratically. Right: Variable Baseline/Resolution Stereo. The distance between depths is held constant by increasing the baseline and selecting the appropriate resolution.

they can also improve the depth accuracy geometrically by increasing the angle of triangulation. In many applications, such as structure from motion from video [12], or recently reconstruction from community photo collections [4], the choice of views for stereo is quite flexible. Our technique focuses on selecting the best cameras, as well as the most appropriate sampling in the images, to compute a depthmap that meets the desired geometric accuracy with minimal computation. Specifically, we increase the baseline to increase accuracy in the far range, and we reduce the resolution (using a gaussian pyramid) to reduce computational effort in the near range. Additionally our novel algorithm is compatible with most matching and optimization strategies, and will work with any higher level post-processing typically used in stereo, e.g. depth fusion [10, 19].

Many applications today require accurate 3D models of real-world scenery. For example, mapping applications such as Google Earth and Microsoft Virtual Earth have recently incorporated textured 3D models of cities. These models are typically extracted from aerial and satellite images and lack ground level detail. Several research projects aim to produce 3D reconstructions of cities from photographs or video acquired from ground level. The amount of image data required to observe an entire city can be enormous. Therefore, processing speed, as well as accuracy, is an important consideration. Furthermore, scenes captured

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