

# 3D Measurement of the Baseline Direction in Stereo Cameras Using Image Magnification Ratio

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Stereo vision is one of the most widely used technologies for three-dimensional perception in advanced driver assistance systems and automated driving applications. By observing the positional difference of corresponding features between two cameras, a stereo camera can estimate the distance to surrounding objects with relatively low hardware cost. However, the accuracy of disparity-based stereo measurement strongly depends on the geometric relationship between the cameras and the observed object. When an object is located near the stereo baseline direction, the disparity becomes extremely small, resulting in a significant degradation of distance estimation accuracy. This limitation becomes increasingly important in modern surround-view sensing systems that employ wide-angle or fisheye cameras to achieve nearly omnidirectional perception.

This study investigates an alternative distance estimation principle that can complement conventional disparity-based stereo measurement in regions where disparity information becomes unreliable. Instead of relying solely on positional differences between corresponding image features, the proposed approach utilizes the difference in apparent object size observed by the left and right cameras. The underlying assumption is that the target surface can be locally approximated by a planar model. Under this assumption, the ratio of object magnification between the two images contains geometric information related to the position of the object. By exploiting this relationship, it becomes possible to estimate distance even in scenarios where conventional stereo triangulation loses effectiveness.

To support wide-field-of-view fisheye camera systems, cylindrical projection is adopted as the rectification model. Conventional perspective rectification often causes severe spatial resolution degradation near the image periphery when applied to fisheye imagery. Cylindrical projection preserves angular resolution more uniformly in the horizontal direction and is therefore more suitable for wide-angle stereo configurations. Nevertheless, even with cylindrical projection, triangulation accuracy deteriorates as the viewing direction approaches the stereo baseline. The proposed magnification-ratio-based method is designed specifically to address this limitation.

The effectiveness of the proposed approach was evaluated through both numerical simulations and image-processing experiments using computer-generated fisheye images. A stereo camera system with a field of view of approximately 190 degrees was modeled, and planar target boards were placed at multiple distances from the cameras. Two complementary evaluations were conducted. First, numerical simulations were performed by introducing controlled measurement errors into both disparity and magnification estimates. Second, synthetic fisheye image datasets were generated, and image alignment techniques based on the Lucas-Kanade framework were used to estimate disparity and scale directly from image data. The resulting measurements were converted into three-dimensional positions and compared with the known ground truth.

The simulation results showed a clear difference between the characteristics of the two measurement principles. Disparity-based estimation provided higher accuracy over most viewing angles but exhibited rapidly increasing errors as the incidence angle approached ninety degrees. In contrast, the accuracy of the scale-based method remained relatively stable and in some cases improved slightly near the baseline direction. Around viewing angles close to 88 to 90 degrees, the proposed method achieved lower distance errors than conventional stereo triangulation. Similar tendencies were observed in the image-processing experiments using synthetic fisheye images. While the disparity-based approach remained superior over much of the field of view, the proposed method produced comparable or better performance in regions where disparity information became insufficient.

These results indicate that image magnification ratio can serve as an effective complementary cue for distance estimation in fisheye stereo systems. Although the proposed approach relies on a planar surface assumption and therefore cannot completely replace disparity-based stereo measurement, it offers a practical solution for improving measurement robustness in geometrically challenging regions. Potential applications include stereo camera calibration, wide-angle three-dimensional sensing, and fusion frameworks that dynamically combine disparity and scale information depending on viewing geometry.

Future work will focus on integrating the proposed scale-based measurement with conventional stereo estimation, reducing sensitivity to plane-model assumptions, and validating the method using real-world automotive datasets. Such extensions would enable more robust three-dimensional perception across the entire field of view of fisheye stereo camera systems and contribute to the development of safer and more reliable surround sensing technologies for automated vehicles.