1. Introduction

Radial lens distortion is the displacement of image points along a radial axis from a single point on the image plane. This point is known as the principal point, and does not always necessarily align with the image sensor centre. Therefore, in order to be able to fully model and correct radial lens distortion, it is necessary to accurately determine the principal point.

Several methods exist for finding the principal point of a wide-angle or fish-eye camera. However, these use complex systems using external lasers, an iterative average over several calculations or by adding coefficients (and thus complexity) to the distortion model.

2. Project Goals

It is the aim of this part of my project to provide a simple analytical method of estimating the principal point of a fish-eye camera, without the need for multiple images or complex external equipment.

3. Five point perspective

To determine the principal point, we use a five-point perspective model to describe the fish-eye distortion. In the standard pin-hole perspective model, parallel sets of lines converge at a single point, known as the vanishing point (VP). In fish-eye perspective, parallel sets of lines converge at two vanishing points. The principal point lies on the line between the two VPs (the horizon line).

4. Estimating the principal point

In order to find the principal point, we will need at least two sets of parallel lines in the test diagram. We use a checkerboard pattern and extract the parallel lines from it. Using the fact that lines in 3-d coordinates are transformed to circles in the image plane in a fish-eye camera, we fit circles to each line using a standard least-squares method. It is then simply a matter of finding the intersection points of the two horizon lines. This is demonstrated in the figure.

5. Accuracy of the estimation

We created a set of synthetic test images with varying levels of radial distortion, noise, light falloff, perspective, rotation and edge modular transfer function as well as a variable principal point. We used these to measure the accuracy and robustness of our estimation algorithm. We found that our average error was 3.98 pixels. We compared this with the commercially available ImaTest software, and found that ImaTest had an average error of 8.71 pixels in its estimation of the principal point.

6. Further Information

This section of my project is in the process of being written as a journal for publication.

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