Calibrating a Fisheye Lens Camera

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Camera Calibration

- Camera calibration is the process of computing the parameters of a camera
- Motivation: recovering 3D information from 2D images [4]
- Two major categories of calibration [5]
  - photogrammetric (using objects)
  - self-calibration (correspondences)

Fisheye Lens Camera Model (1)

- Fisheye lenses have a wide field of view
  - 180˚ fisheye lenses used for measuring solar radiation in ecosystems [1]
- Model [2]: (draw on blackboard!)
  - 3D point projects to 2D point in plane formed by the 3D point and the optical axis
  - linear dependence of the distance 2D point – center with the angle 3D point – axis

Fisheye Lens Camera Model (2)

- An angle of 90˚ corresponds to a point on the edge of the circle
- Projection equations

$$u = \frac{2 \times \tan^{-1}(\sqrt{x^2 + y^2} / z) \times R}{\Pi \sqrt{x^2 + y^2}} \times x + pu \times W$$

$$v = \frac{2 \times \tan^{-1}(\sqrt{x^2 + y^2} / z) \times R}{\Pi \sqrt{x^2 + y^2}} \times y + pv \times H$$

- Intrinsic parameters: R, pu, pv
- Extrinsic parameters: ax, ay, az, tx, ty, tz

Calibrating the Fisheye (1)

- Calibration is split in 2 parts
  - Intrinsic calibration
    - several approaches, using linear/circular patterns
    - our method
      - capture images of calibration board with MxN squares
      - detect corners in each image, undistort their positions
      - for the correct values of the intrinsic parameters, the undistorted corners are collinear → use collinearity as an error measure for a tuple of intrinsic parameters

Calibrating the Fisheye (2)

- use Simplex, a non-linear least squares optimization technique

- Extrinsic calibration
  - if intrinsics are known, same as pinhole
  - generic method
    - specify 3D points and their 2D projections
    - error measure for an extrinsic parameters tuple: average distance between specified points and points projected with the extrinsic parameters
    - again, use Simplex

Results

- For synthetic images, relative errors < 0.1%
- Typical time for intrinsic calibration (20 images 512x384): 20 s, 2 min procedure total
- Typical time for extrinsic calibration: 10 s, procedure total depends on measurements
- Extrinsic calibration performance: stereo + distances between points and epipolar lines
  - results: max < 2 pixels, avg < 1 pixel for 1024x768

Future work

- The ultimate goal is precise tracking
- Investigate the influence of radial distortion coefficients
- Evaluate the quality of calibration with more “physical” measures
  - yard stick
  - planarity tests

References

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