Camera Calibration in Computer Vision

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Abstract

Images are a good way to capture a scene, relay a message, or leave a lasting impression of a symbol, logo, or clip art. With the high volumes of visual data and the need for a quick and accurate interpretation of the data in both the private and public sector have caused engineers to explore methods of image understanding. Computer Vision is the discipline that studies how to reconstruct, interpret, and understand a 3D scene from its 2D images in terms of the properties of the structures presented in the scene. It combines the knowledge in computer science, electrical engineering, mathematics, and biological sciences among others disciplines. It is difficult to establish a clear division between computer vision and image processing. A paradigm to be considered is the type of computerized processing involve. Image processing types includes low, mid, high level. Current applications in Computer Vision include hazard detection and avoidance, 3D imaging technologies, automated surveillance, gesture recognition, and gaming. At the heart of each field above lies the use of homogeneous coordinates and matrix mathematics to store, process, and generate meaningful outputs. The use of projective geometry along with camera calibration is used, in many instances, to reconstruct 3D scenes from 2D images.

Research Objective

The goal of the RET program sponsored by Texas A&M University's ETID Department is to provide secondary educators the opportunity to engage in research and curriculum development with faculty mentors. The focus of this specific research was:

1. Learn about Computer Vision and its applications.

1. Acquire an understanding of linear algebra, projective geometry, and camera calibration for 3D reconstruction.

1. Develop an instructional module composed of a lesson and activity based on current research.

Methodology

Euclidean Geometry and Projective Geometry

• Euclidean Geometry describes angles and shapes of objects with intersecting, parallel and perpendicular lines.

•Projective Geometry describes how geometric figures and objects are projected or transformed onto another plane.

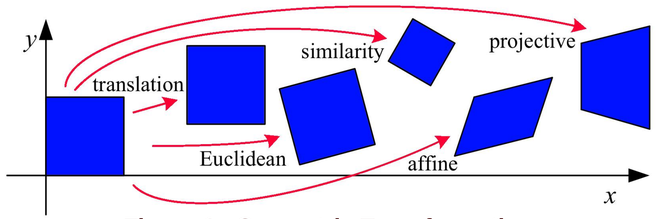

Figure 1. Geometric Transformations

Summary of Z. Zhang's Camera Calibration Procedure

• Print a pattern, attach it to a planar surface, take pictures of pattern.
•Detect the feature points in the image and know pattern dimension.
•Use closed-form solution to estimate intrinsic and extrinsic parameters.
•Estimate the coefficients of radial distortion by solving the linear least-squares and refine all the parameters.

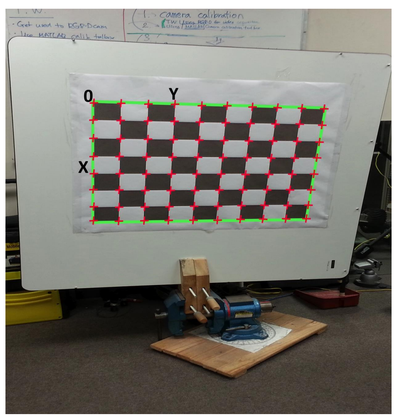

Figure 2. Feature Point Detection

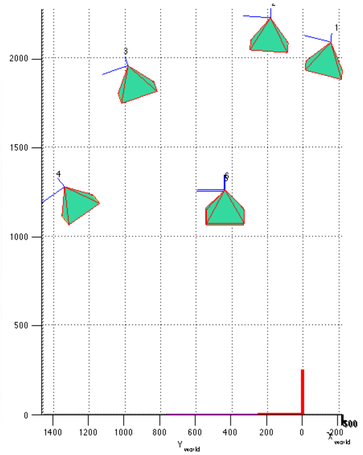

Figure 3. Extrinsic Parameters (World-Centered)

Results and Conclusions

Why do we need Camera Calibration?

- Calibration must be done as a step in 3D Computer Vision.
- Any calibrated camera can be used as a quantitative sensor.
- Quantitative data is obtain from 2D images for 3D purposes.
- We can determine an object's distance, height, location, etc.

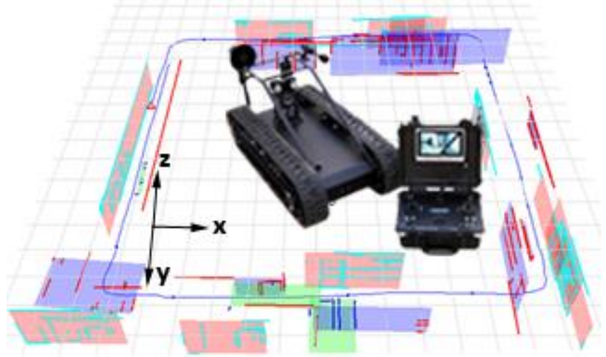

Figure 4. Vision-Based Robot Navigation

Classroom Instructional Module

1. Students should have a basic understanding of Computer Vision.

1. Demonstrate an understand Euclidean and Projective Geometry.

1. Learn about matrix operations and Linear Transformations.

1. Apply Linear Transformations to points and figures using traditional methods and current software technology.

References & Acknowledgements

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