DEPARTMENT OF INFORMATION TECHNOLOGY

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COMPUTER VISION

A PROJECT REPORT

3-D VISION AND PERSPECTIVE

SUBMITTED TO
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3-D VISION AND PERSPECTIVE IN COMPUTER VISION

Introduction

3D Vision is a fundamental component of modern computer vision systems, enabling machines to interpret the world in three dimensions. It mimics the human ability to perceive depth, shape, and spatial relationships. Perspective, as a geometric principle, allows for the transformation of 3D scenes into 2D images while retaining visual cues about depth and position. This project explores the theoretical and practical aspects of 3D vision and the role of perspective in depth estimation, scene reconstruction, and real-world applications like augmented reality and robotics.

Aim

To understand the principles of 3D vision and perspective projection in computer vision and explore how they enable machines to infer depth and reconstruct 3D scenes from 2D images.

Statement

Computer vision systems often rely on 2D image data to reconstruct and interpret 3D environments. The concept of perspective, derived from projective geometry, allows for the mathematical modeling of how 3D points are captured by cameras. By studying perspective and projection models such as the pinhole camera model, and extending to techniques like stereo vision and structure from motion, this project highlights how depth is computed and used in real-world applications. The understanding of perspective is crucial for enabling depth estimation, object localization, and spatial interaction in AI systems.

Theory and Concepts

Perspective Geometry

- Perspective projection maps a 3D point (X, Y, Z) to 2D coordinates (x, y) using:

$$x = \frac{fX}{Z}, \quad y = \frac{fY}{Z}$$

- Based on the **pinhole camera model**.

- Parallel lines converge at the **vanishing point**, a key visual cue for depth.

- Objects appear smaller as they get further from the viewer, creating a sense of scale.

Camera Calibration

- Intrinsic parameters: Focal length, principal point, skew.

- Extrinsic parameters: Camera position and orientation.

- Calibration is essential for accurate 3D reconstruction.

Depth Estimation Techniques

- **Stereo Vision**: Depth from disparity between two views.

- **Structure from Motion (SfM)**: 3D structure from a moving camera.

- **Monocular Estimation**: Inferring depth from a single image using learned patterns.

Applications

- 3D scene reconstruction in AR/VR.

- Robotics: spatial navigation and obstacle avoidance.

- Medical imaging: 3D scans.

- Autonomous vehicles: depth perception via vision and LiDAR fusion.

Results and Summary

This conceptual study on 3D vision highlights the importance of perspective in enabling machines to understand the real world. By combining perspective projection with camera models and depth estimation methods, computer vision systems can reconstruct 3D scenes and interact with them effectively. The foundational knowledge of perspective aids in developing applications across multiple domains.

Conclusion

3D vision and perspective are vital to modern artificial intelligence systems that perceive and interact with their environment. The use of projection geometry, camera calibration, and depth estimation techniques forms the basis for applications in robotics, AR/VR, and autonomous navigation. This study reinforces the importance of integrating geometric understanding into machine vision systems.