Report Project 3 & 4: Stereo Vision-Based 3-D Reconstruction Using Feature Detection and Disparity Mapping

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*Abstract* — Abstract.

Keywords — Keywords

# Introduction

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# Theory

## Stereo Vision and Depth Perception

Stereo vision is a method that imitates the human visual system to perceive depth. It analyzes disparities between two slightly different images taken from different angles or points of view. The objects at different depths will have different disparities when projected onto the left and right camera sensors. The depth of the objects can be assessed when computing these disparities [1].

## Camera Calibration and Rectification

Camera calibration is crucial to correct lens distortions and establish the intrinsic and extrinsic parameters of a stereo camera system. The intrinsic parameters include principal point and focal length, whereas extrinsic parameters define the orientation and relative position between the two cameras. Camera calibration provides accurate disparity, which leads to precise depth estimations [2].

Rectification turns stereo images into an aligned form where the corresponding points lie on the same scanline. This method helps to simplify the disparity computation. The transformation is accomplished by rectification matrices that adjust the images, where epipolar lines become parallel [2].

## Feature Detection and Matching

Feature detection is significant in stereo matching because it identifies key points in an image which are distinctive and also invariant to rotation, scale, and illumination changes. Some of the feature detection methods include the following:

### Harris corner detector

Identifies areas with significant intensity variations

### Scale Invariant Feature Transform

Extracts key points based on the differences of Gaussian at multiple scales [3].

### Speeded Up Robust Features

Faster alternative to SIFT, and which is based on integral images and the Haar wavelet responses [4].

## Disparity Computation and Depth Estimation

Disparity refers to the pixel shift between the corresponding points in the left and right images, which is computed through the following equation:

Where and are the coordinates of the matched feature points in the left and right images. Furthermore, the depth is determined using the disparity equation shown below:

Whereis the camera’s focal length, is the baseline distance between the two cameras, and is the computed disparity [5]. The larger disparities correspond to closer objects, whereas smaller disparities correspond to farther objects.

## Dense Disparity Mapping and 3D Reconstruction

The dense disparity mapping extends a disparity estimation to all the pixels, not the detected features only. This method uses block matching or semi-global matching (SGM) algorithms to produce a disparity map, which is then visualized as a depth image [6].

After the disparity values are obtained for the pixels, a 3D point cloud representation of the scene is built. Each point is mapped into a 3-D coordinate system. As a result, visualization and analyses of the reconstructed environment can be completed [6].

# Methodology

## First Part

Description.

# Results

Results.

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# Conclusion

Conclusion.

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