Two-View :

Depth Estimation

Frame Rectification + Triangulation Of Objects

A group project by –

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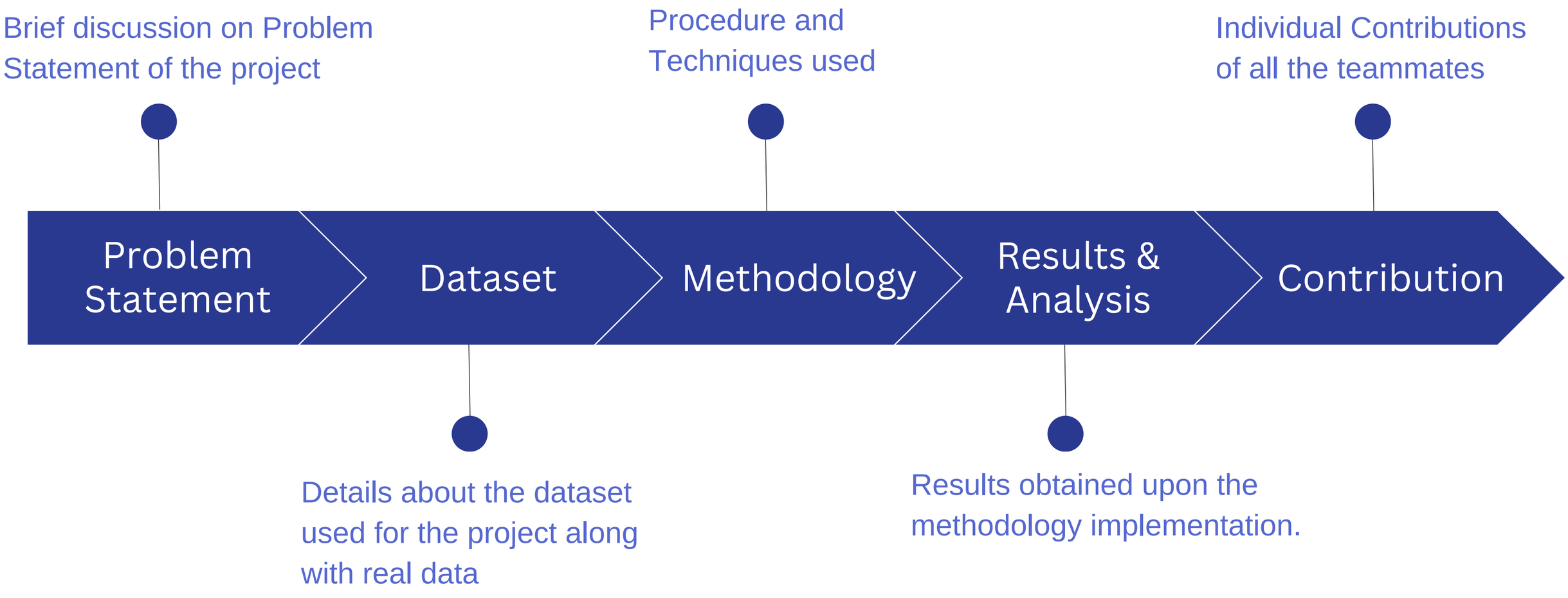
Content Progression of the PPT



Problem Statement

- The problem statement is to accurately estimate the disparity or optical flow between corresponding pixels in stereo image pairs or image sequences.
- How to use the stereo image pairs in the dataset to estimate the depth and report the disparity image and the errors.

MiddleBury Dataset

- The Middlebury dataset is a stereo vision dataset that includes a set of high-quality image pairs and their corresponding ground truth disparity maps.
- Includes 12 evaluation train sets with ground truth disparity maps.
- Ten evaluation test sets with hidden ground truth disparity maps.
- Each set includes a left and right image pair.
- The sets vary in complexity with challenging lighting conditions and occlusions.

Real Dataset

- This Real dataset is a stereo vision dataset that includes a few sets of image pairs clicked by the team members.
- Includes over five evaluation sets.
- Each set includes a left and right image pair.
- The sets vary in complexity with challenging lighting conditions and occlusions.

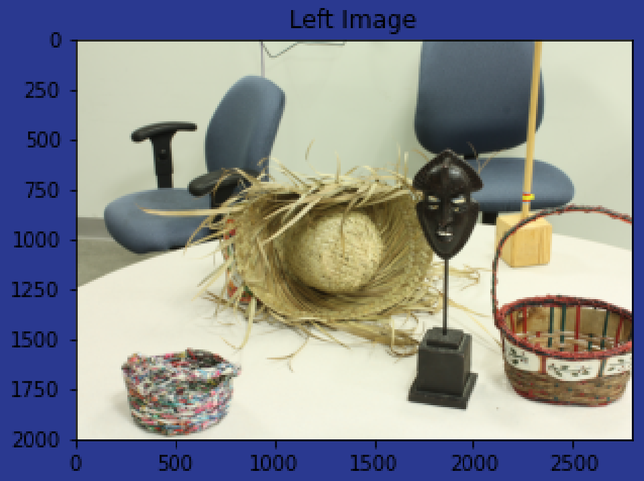
Left Camera

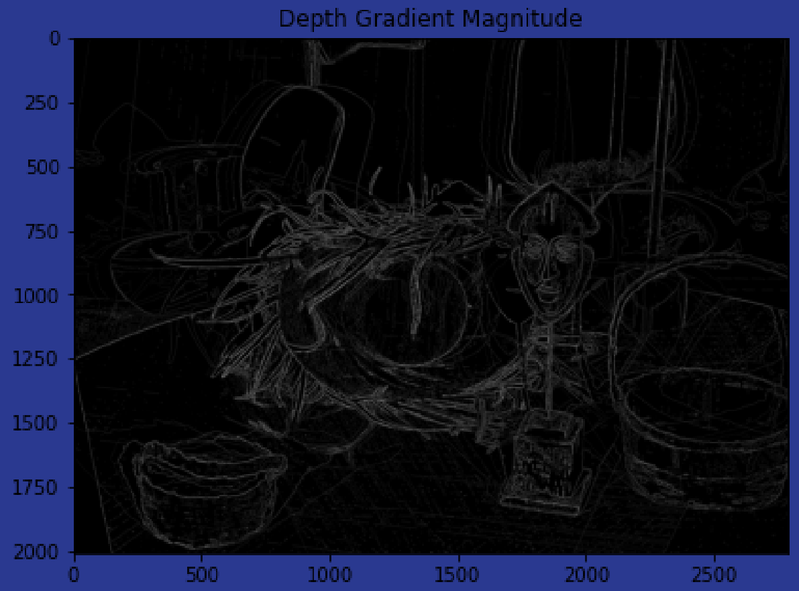
Right Camera

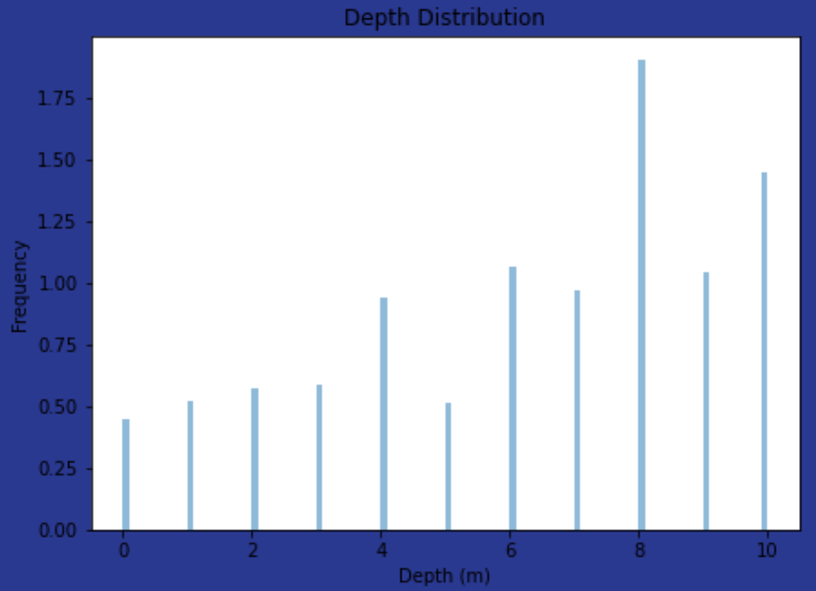
In these examples, the left and right images show a scenery, and the disparity map indicates the relative depth of the scene.

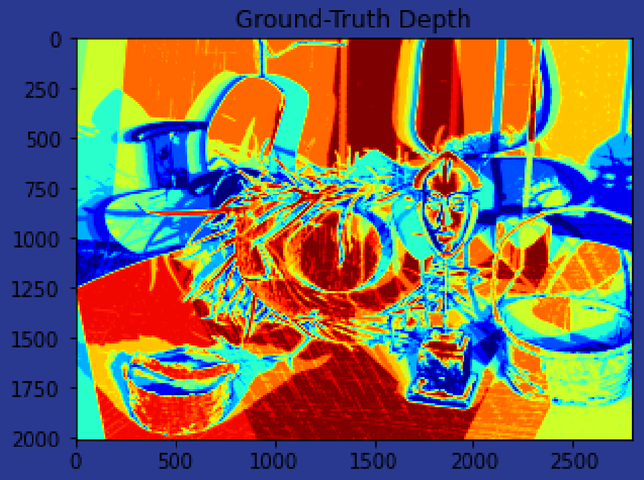
The lighter areas in the disparity map indicate regions closer to the camera, while the darker areas indicate farther away.

Analysis on a Sample Image









Depth Statistics:

Min: 0

Max: 10

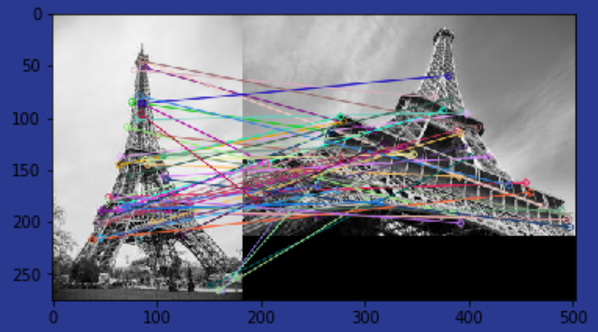
Mean: 6.1967

Median: 7.0

Std: 2.9742

Methodology

Rectification

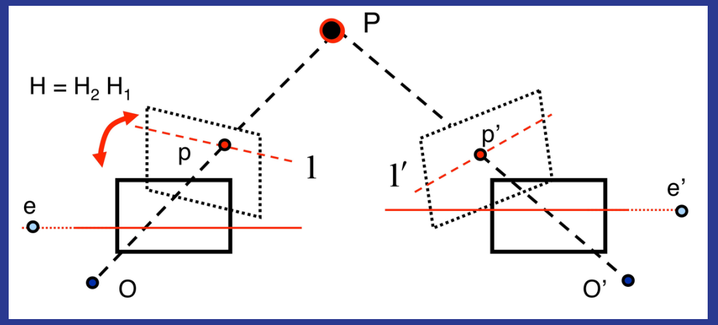


SIFT Matching using OpenCV Brute Force Matcher

Match's Filtered using Lowe's Ratio Test

matrix

Fundamental matrix calculated using RANSAC



To find homographies for both image planes to be parallel to the baseline we use cv2.stereoRectifyUncalibrated function.

Methodology

Disparity map

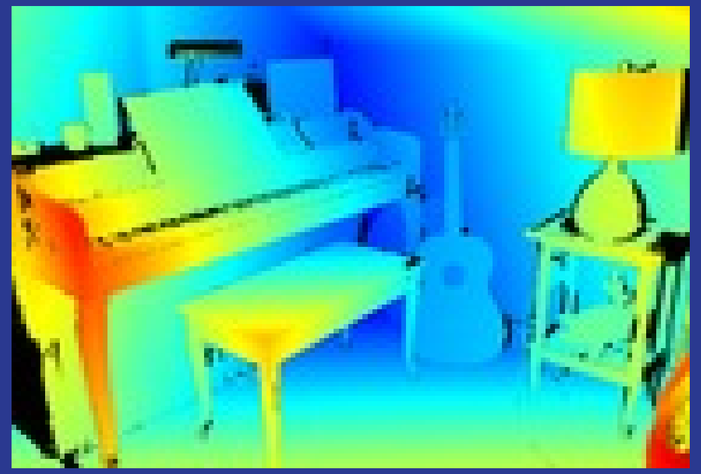
- After rectification the epipolar lines are parallel and are horizontal, hence corresponding point for a given point can be found on the line correponding to the y-coordinate
- Matches can be found by comparing windows/ blocks around the pixels and metric for comparing used is Sum of Squared Differences. Block size used is 15x15
- Difference between original and matched pixel correpsonds to disparity
- Disparity is inversely proportional to depth as objects closer seem to be shifted more when images are taken from different positions.
- depth = (focal length * baseline)/disparity

Results & Analysis

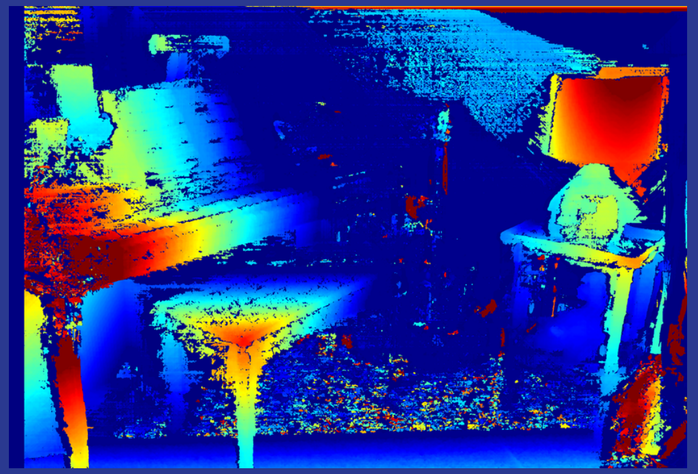
Results

On Middlebury Dataset

Actual Image



Ground Truth Disparity



Generated Output

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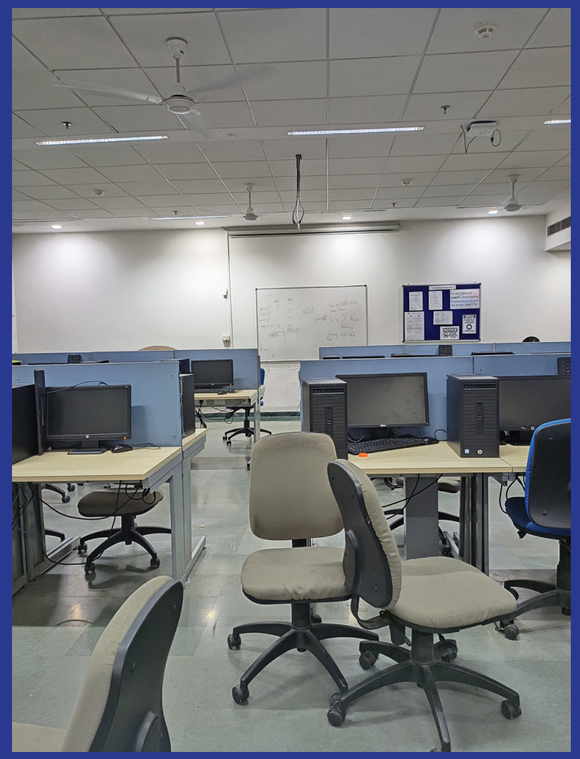
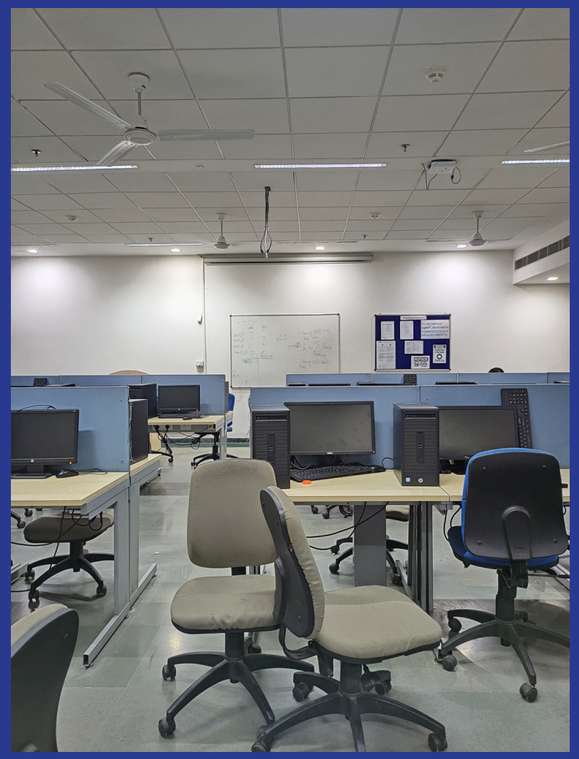
Average MAE on Middlebury set: 0.2361108809709549
Average RMSE on Middlebury set: 0.34587088227272034
```

Results

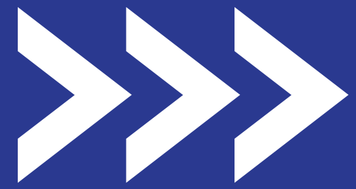
On Our own Dataset

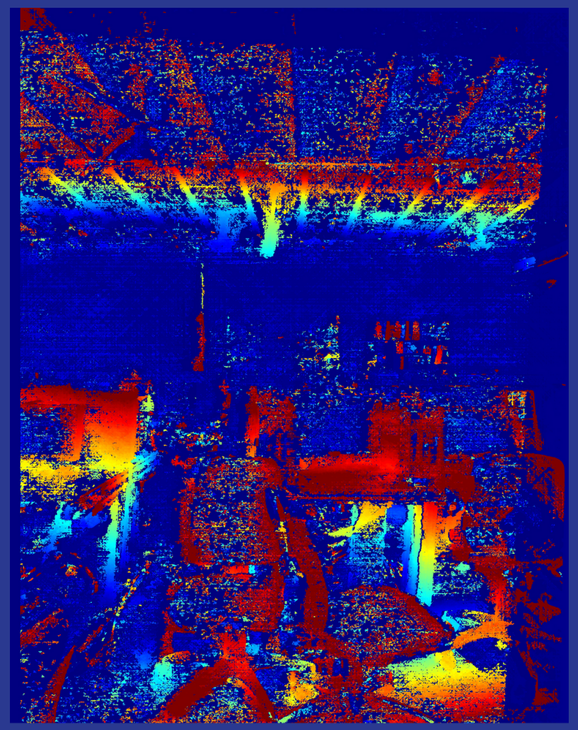


Left Image



Right Image





Disparity

Error analysis

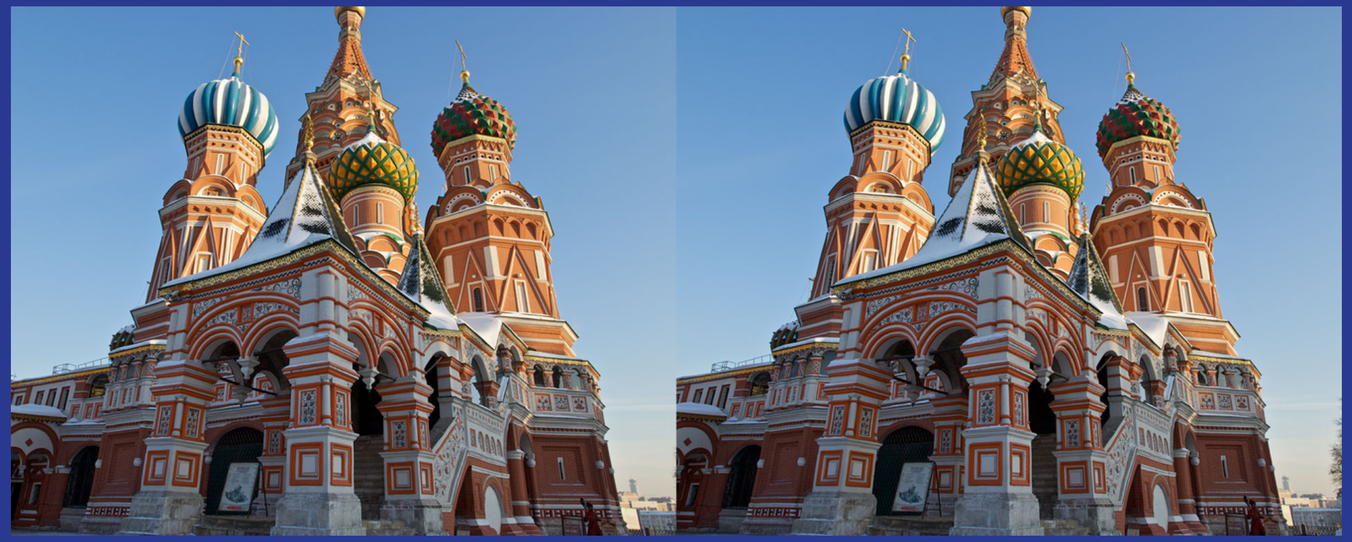
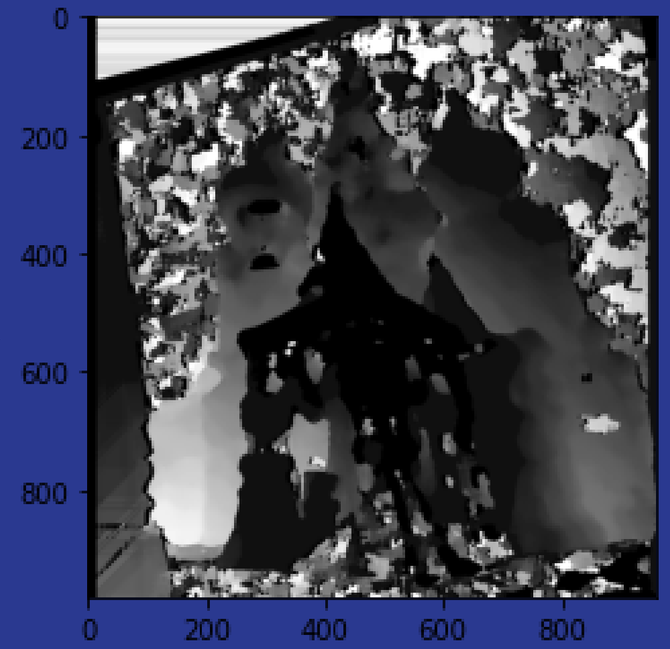


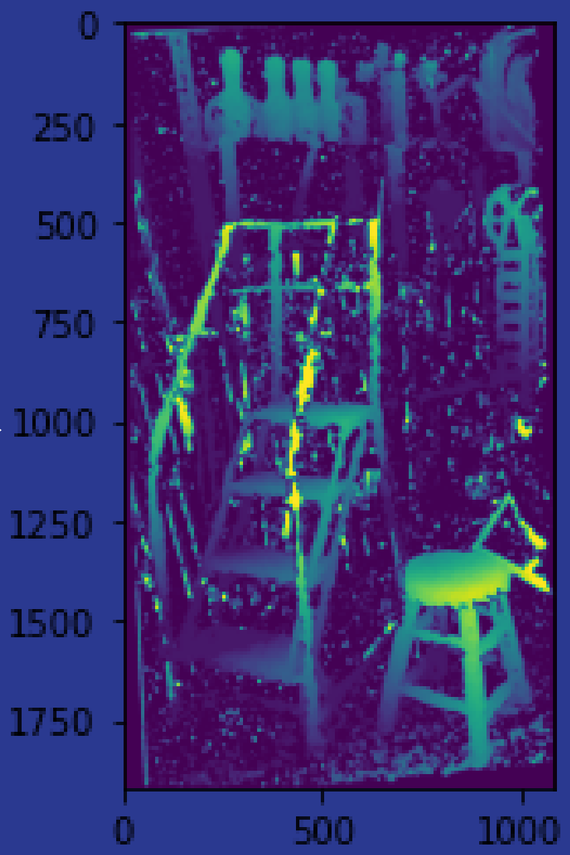
Image source: https://wppa.nl/docs-by-subject/stereo-images/wppaspec/oc1/lnen/cv0/ab227/pt3838



In the generated disparity map, it can be observed that the sky region has high variance

This can be because the sky in the original image is textureless and is of uniform composition throughout, hence during correspondence matching some pixels can be matched to pixels far from actual corresponding pixel, causing high disparity

Error analysis



Changes in the intensity of ambient lighting can affect the brightness and contrast of the stereo images, leading to errors in feature detection and matching. This can cause errors in the triangulation of the correspondences and lead to inaccuracies in the estimated depth maps.

In the example, due to lighting, the background pole is estimated much nearer to the camera than it is in real.

Individual Contribution

- Ayush: Implementation of Depth Estimation + Dataset Collection
- Krishnam: Implementation of Depth Estimation + Presentation
- Rupin: Implementation of Depth Estimation + Data Analysis

Thank You!