CSE463 Homework 3 (Optional)

Ayşe Begüm Nur

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Abstract

This report describes the implementation and evaluation of a stereo correspondence algorithm that uses oversegmentation methods to match image segments. The performance of the algorithm is compared with ground truth disparity maps provided by the Middlebury Stereo Vision Page. The report includes detailed descriptions of the oversegmentation methods, the correspondence algorithm, and the numerical comparison of the results.

1 Introduction

Stereo vision is a critical area in computer vision, which aims to estimate the depth of a scene by comparing two or more images taken from different viewpoints. This project implements a stereo correspondence algorithm that leverages oversegmentation methods to improve the accuracy of segment matching. The results are compared to the ground truth disparities provided by the Middlebury dataset.

2 Oversegmentation Methods

2.1 SLIC Superpixels

The Simple Linear Iterative Clustering (SLIC) algorithm is used to segment the images into superpixels. The algorithm groups pixels based on color similarity and spatial proximity, producing compact and nearly uniform segments.

2.2 Felzenszwalb's Efficient Graph-Based Segmentation

Felzenszwalb's algorithm is another method for oversegmenting images. It constructs a graph based on pixel similarity and performs a hierarchical clustering to form segments. The method is efficient and can handle large variations in segment size.

3 Correspondence Algorithm

The correspondence algorithm matches segments between the left and right images based on color similarity and row alignment. The steps are as follows:

1. Segment the left and right images using the chosen oversegmentation method.
2. Compute the mean color and row position for each segment in both images.
3. Match segments between the left and right images by minimizing the Sum of Absolute Differences (SAD) of their mean colors, ensuring that matched segments are on the same epipolar line.
4. Estimate the disparity for each segment by averaging the disparities of the matched segments.

4 Evaluation and Comparison

4.1 Numerical Comparison

The performance of the algorithm is evaluated using the Mean Absolute Error (MAE) between the estimated disparity maps and the ground truth disparities from the Middlebury dataset.

Here is the terminal output of the average MAE calculations for the datasets:

```
C:\Users\BEGUM\AppData\Local\Programs\Python\Python311\python.exe C:\Users\BEGUM\PycharmProjects\CSE463\hw3.py
Processing dataset: barn1
Processing image: im2.ppm with disparity map: disp2.pgm
Average MAE for barn1 using SLIC: 0.540318024045225
Average MAE for barn1 using Felzenszwalb: 0.380862891287019
Processing image: im6.ppm with disparity map: disp6.pgm
Average MAE for barn1 using SLIC: 0.5510079763114947
Average MAE for barn1 using Felzenszwalb: 0.3754058451561866
Processing dataset: barn2
Processing image: im2.ppm with disparity map: disp2.pgm
Average MAE for barn2 using SLIC: 0.4580393149055335
Average MAE for barn2 using Felzenszwalb: 0.47523289264972696
Processing image: im6.ppm with disparity map: disp6.pgm
Average MAE for barn2 using SLIC: 0.44900221675520174
Average MAE for barn2 using Felzenszwalb: 0.4483977712913453
Processing dataset: bull
Processing image: im2.ppm with disparity map: disp2.pgm
Average MAE for bull using SLIC: 0.2971918835057425
Average MAE for bull using Felzenszwalb: 0.23671080060315677
Processing image: im6.ppm with disparity map: disp6.pgm
Average MAE for bull using SLIC: 0.2960978907043289
Average MAE for bull using Felzenszwalb: 0.2310549230207966
Processing dataset: poster
Processing image: im2.ppm with disparity map: disp2.pgm
Average MAE for poster using SLIC: 0.44355231868043576
Average MAE for poster using Felzenszwalb: 0.35968738430819935
Processing image: im6.ppm with disparity map: disp6.pgm
Average MAE for poster using SLIC: 0.45791002375491874
Average MAE for poster using Felzenszwalb: 0.3679186556216675
```

Figure 1: Terminal output showing the average MAE calculations for different datasets using SLIC and Felzenszwalb methods.

```
Processing dataset: sawtooth
Processing image: im2.ppm with disparity map: disp2.pgm
Average MAE for sawtooth using SLIC: 0.648859747566865
Average MAE for sawtooth using Felzenszwalb: 0.5225944160247621
Processing image: im6.ppm with disparity map: disp6.pgm
Average MAE for sawtooth using SLIC: 0.6546147582614811
Average MAE for sawtooth using Felzenszwalb: 0.5262551163199476
Processing dataset: venus
Processing image: im2.ppm with disparity map: disp2.pgm
Average MAE for venus using SLIC: 0.36919806513372133
Average MAE for venus using Felzenszwalb: 0.3980815618409896
Processing image: im6.ppm with disparity map: disp6.pgm
Average MAE for venus using SLIC: 0.36801628542181386
Average MAE for venus using Felzenszwalb: 0.3920279719739023
```

Figure 2: Continuous terminal output showing the average MAE calculations for different datasets using SLIC and Felzenszwalb methods.

4.2 Visual Comparison

The visual results for the datasets are shown below.

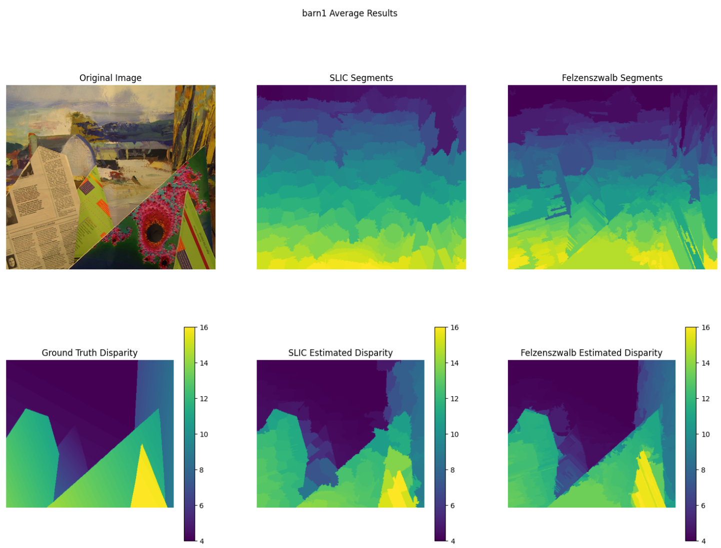

Figure 3: Visual results for the barn1 dataset (image 2). The images show the original image, the segments produced by SLIC and Felzenszwalb methods, the ground truth disparity, and the estimated disparities.

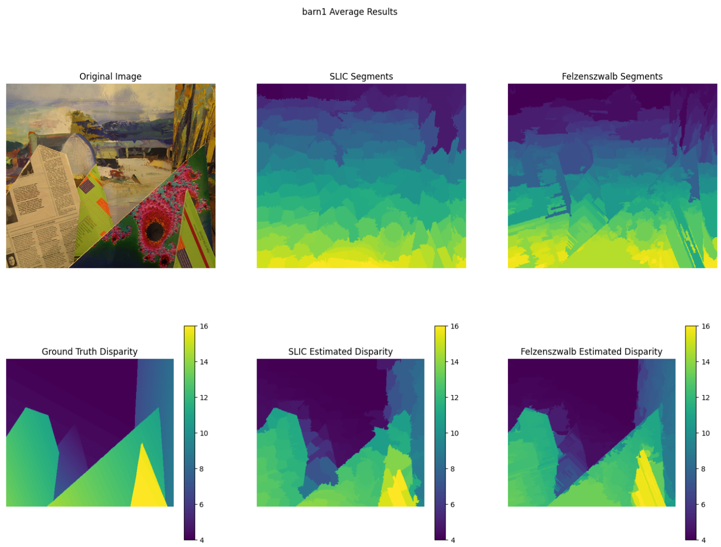

Figure 4: Visual results for the barn1 dataset (image 6). The images show the original image, the segments produced by SLIC and Felzenszwalb methods, the ground truth disparity, and the estimated disparities.

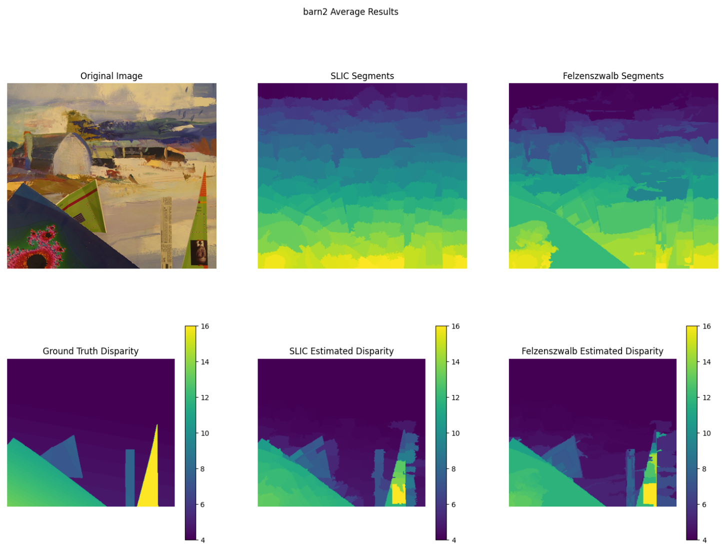

Figure 5: Visual results for the barn2 dataset (image 2). The images show the original image, the segments produced by SLIC and Felzenszwalb methods, the ground truth disparity, and the estimated disparities.

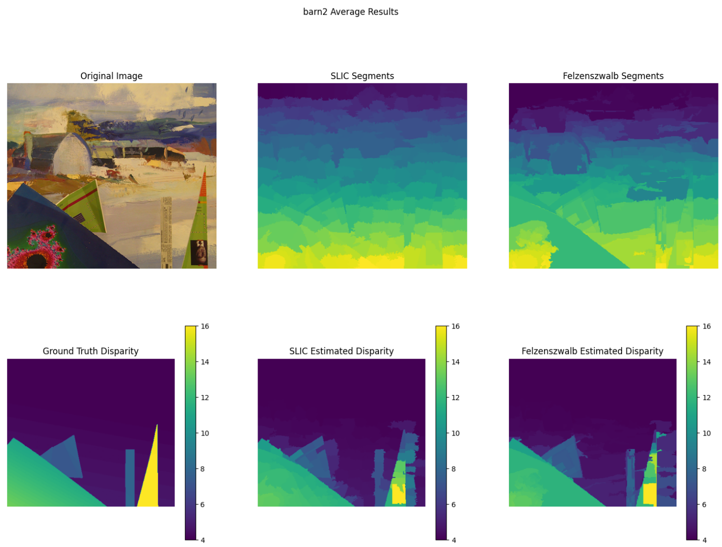

Figure 6: Visual results for the barn2 dataset (image 6). The images show the original image, the segments produced by SLIC and Felzenszwalb methods, the ground truth disparity, and the estimated disparities.

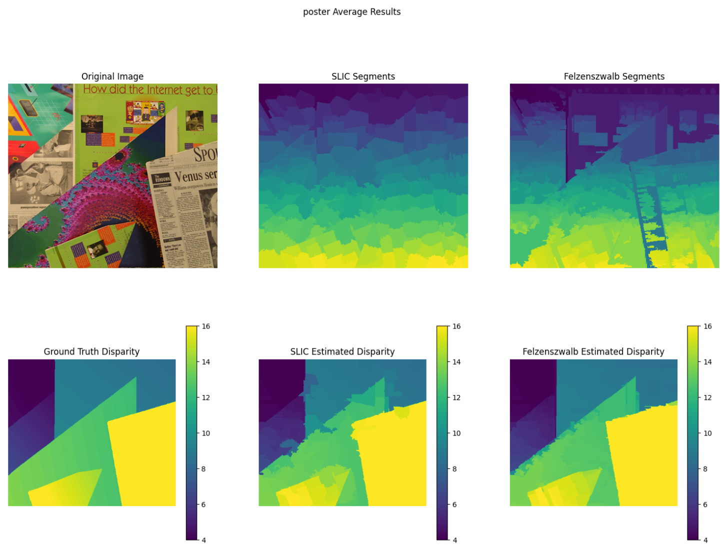

Figure 7: Visual results for the poster dataset. The images show the original image, the segments produced by SLIC and Felzenszwalb methods, the ground truth disparity, and the estimated disparities.

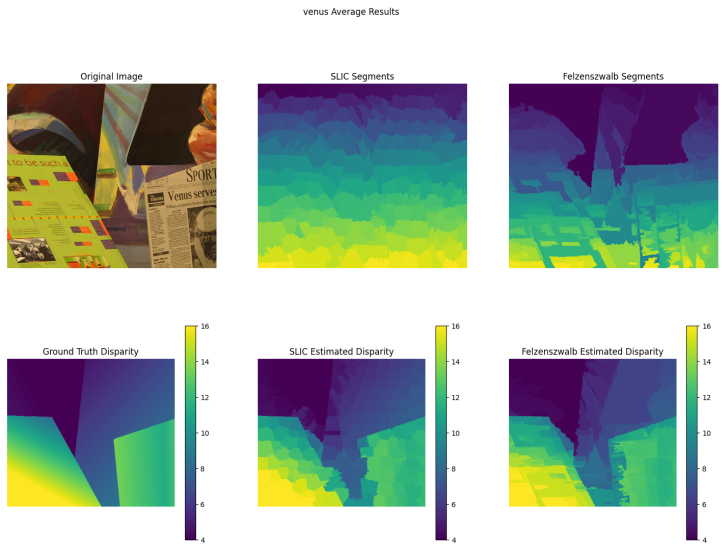

Figure 8: Visual results for the venus dataset (image 2). The images show the original image, the segments produced by SLIC and Felzenszwalb methods, the ground truth disparity, and the estimated disparities.

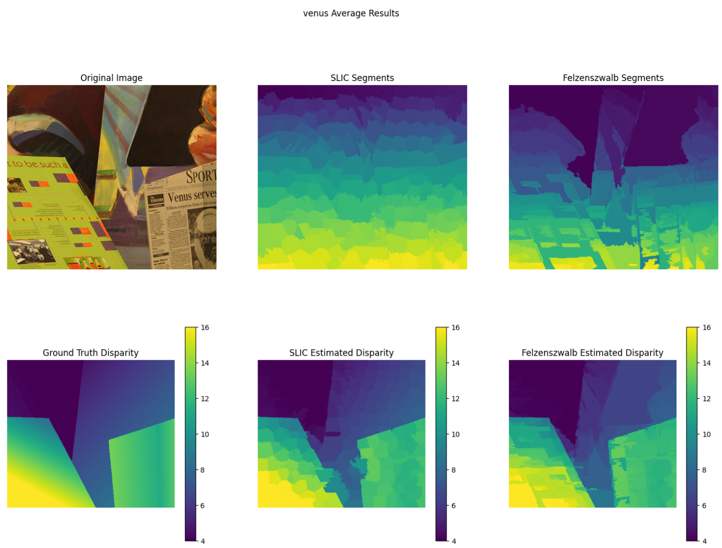

Figure 9: Visual results for the venus dataset (image 6). The images show the original image, the segments produced by SLIC and Felzenszwalb methods, the ground truth disparity, and the estimated disparities.

5 Discussion

The results indicate that both SLIC and Felzenszwalb methods can produce reasonable segmentations and disparities. However, certain challenges such as segment alignment and color similarity can affect the accuracy of the correspondence. The Felzenszwalb method tends to perform better in areas with large disparity variations due to its ability to create more variable segment sizes.

6 Conclusion

This project demonstrates the use of oversegmentation methods to improve stereo correspondence algorithms. The SLIC and Felzenszwalb methods provide effective segmentations that facilitate accurate segment matching. Future work could explore more sophisticated matching criteria and the incorporation of additional image features to further enhance performance.

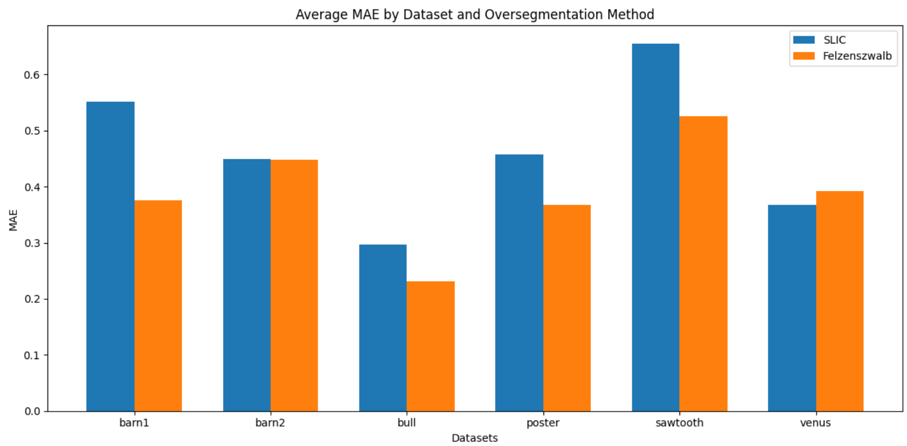

Figure 10: Bar chart showing the average MAE for different datasets using SLIC and Felzenszwalb methods.