

ENPM-673 Project 3

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1 Stereo Vision

[Link to Stereo vision code and output.](#)

Computer stereo vision is the extraction of 3D information from digital images, such as those obtained from a single camera with two different positions or from two different cameras. By comparing information about a scene from two vantage points, 3D information can be extracted by examining the relative positions of objects in the two panels.

To perform stereo vision we have to do the following steps:

1. Calibration:

- First we input the two consecutive frames for the scene and convert them to gray scale.
- The next step is to extract the features from each frame using SIFT method and match them using KNN method, followed by computing the best fundamental matrix using 8 points with the aid of RANSAC.
- Then the Essential matrix is computed using the camera matrix provided and the fundamental matrix calculated.
- After that we decompose the Essential matrix into rotation matrix and translation matrix. Then we obtain the correct rotational and translation matrix by performing Linear triangulation. This completes our calibration step.

2. Rectification:

- In this step we first find the epipolar lines in the two images and plot them on the images.
- Then we find the Homography matrix for each image and perform perspective transform so that the images are seen at the same level and parallel to the camera.

3. Correspondence:

- In this step we try to create disparity map using sliding window technique.
- In sliding window we select a window on a line in the left image and try to match the window along the same line in the second image.
- The window selection is done on the basis of least square error. The window with least LSE is selected as the corresponding window.
- The previous 2 steps are done for the entire image.

4. Depth Map:

- Finally we find the depth of the pixel in the image using the disparity map obtained in the previous step, the baseline and the focal length of the camera provided to us.
- The formula for calculating the depth map is

$$Depth = \frac{baseline * f}{disparitymap} \quad (1)$$

2 Pipeline

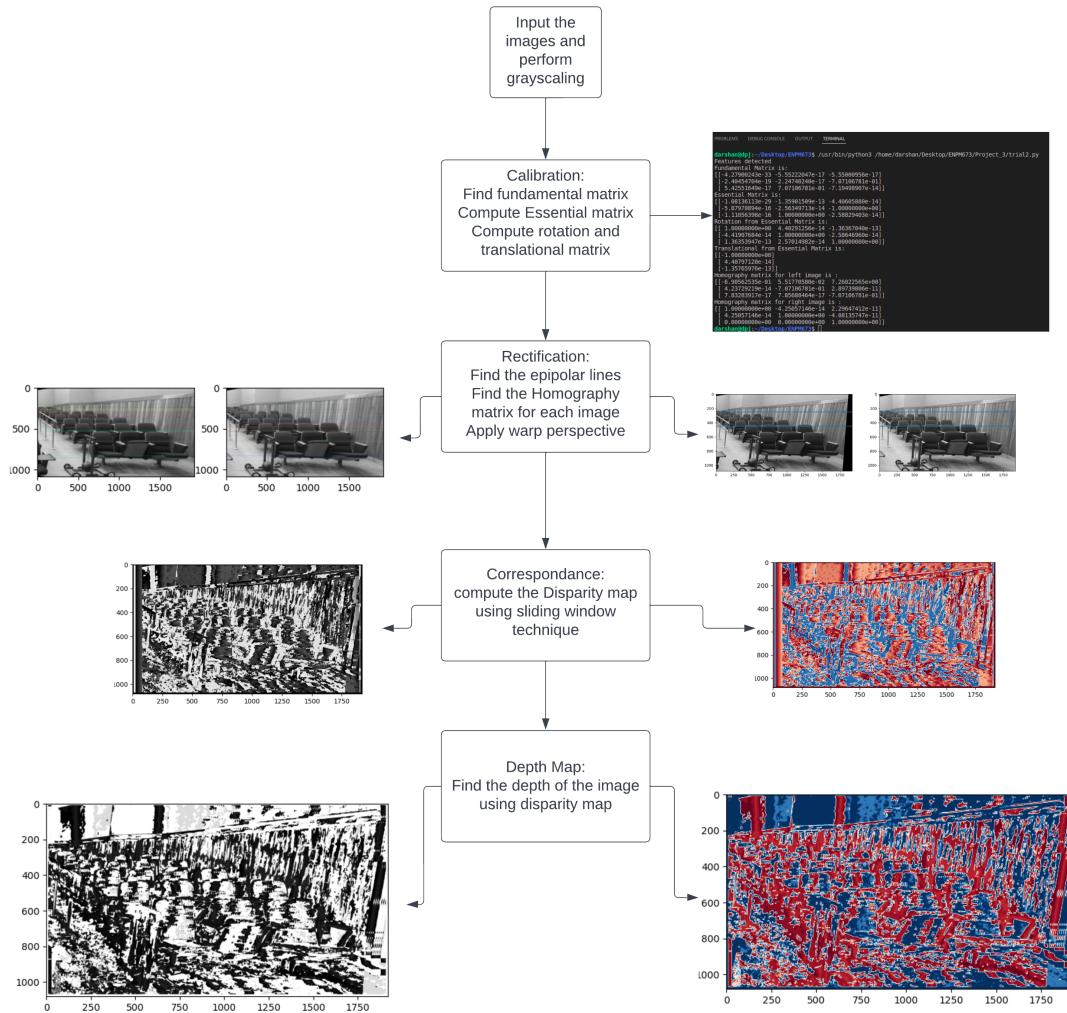


Figure 1: Pipeline for stereo vision

3 Outputs

3.1 Dataset 1



Figure 2: Input Images

```

PROBLEMS DEBUG CONSOLE OUTPUT TERMINAL
darshan@dp:~/Desktop/ENPM673$ /usr/bin/python3 /home/darshan/Desktop/ENPM673/Project_3/trial2.py
Features detected
Fundamental Matrix is:
[[ 1.247115e-31  3.3667985e-16  1.09202530e-16]
 [-1.000000e+00 -1.65252154e-17  7.07106781e-01]
 [-2.64461329e-19  1.65252154e-17  7.07106781e-01]
 [-2.64461329e-19 -7.07106781e-01 -3.23014494e-14]]
Essential Matrix is:
[[ 3.09911804e-28  8.29621426e-13  2.66813159e-13]
 [-1.31886003e-15  4.95799145e-14  1.00000000e+00]
 [-7.88176188e-16 -1.00000000e+00  4.95258159e-14]]
Rotation from Essential Matrix is:
[[ 1.00000000e+00  0.00000000e+00  0.28432714e-13]
 [-2.60019324e-13  1.00000000e+00 -4.95441086e-14]
 [ 8.28407760e-13  4.95736962e-14  1.00000000e+00]]
Translation from Essential Matrix is:
[[ 1.00000000e+00]
 [-2.6000711e-13]
 [ 8.2976262e-13]]
Homography matrix for left image is :
[[ 7.11301800e-01 -4.2984142e-02 -6.67862901e+01]
 [ 2.55875220e-13  7.07106781e-01 -1.72789826e-18]
 [ 4.71341370e-16  4.71871775e-16  7.07106781e-01]]
Homography matrix for right image is :
[[ 1.00000000e+00 -2.54965199e-13  1.37674760e-10]
 [ 2.54965199e-13  1.00000000e+00 -2.44767762e-10]
 [ 0.00000000e+00  0.00000000e+00  1.00000000e+00]]
darshan@dp:~/Desktop/ENPM673$ []

```

Figure 3: Various outputs from the program

Epilines in both images

Rectified images

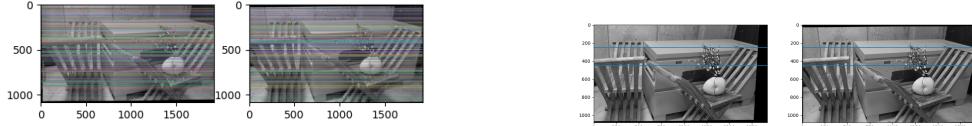


Figure 4: Rectification

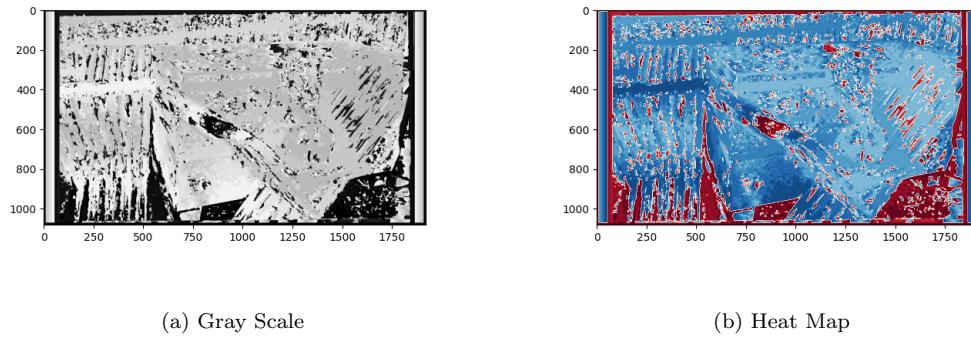


Figure 5: Disparity Map

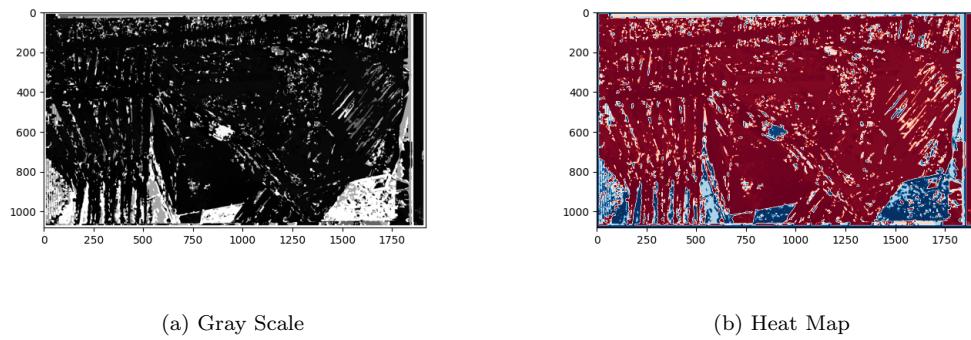


Figure 6: Depth Map

3.2 Dataset 2

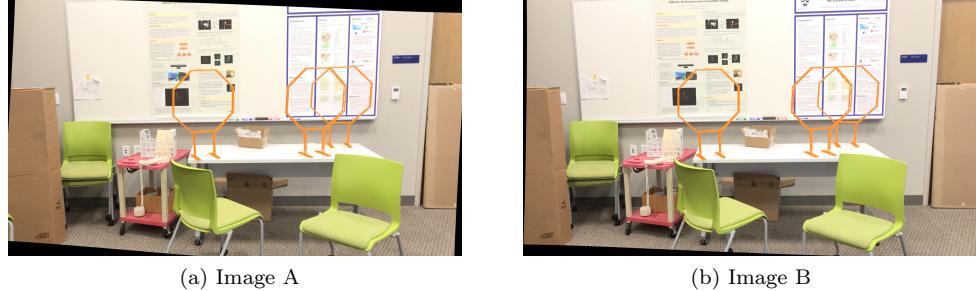


Figure 7: Input Images

```

darshan@dpj:~/Desktop/ENPM673$ /usr/bin/python3 /home/darshan/Desktop/ENPM673/Project_3/trial2.py
Features detected
Fundamental Matrix is:
[[ 9.76912915e-29  5.26498705e-17 -2.78943535e-13]
 [-3.86666666e-10  8.12572359e-17  7.07106781e-01]
 [ 2.12384192e-13 -7.07106781e-01  8.64116667e-12]]
Essential Matrix is:
[[ 2.46537432e-25  1.2978053e-13 -3.54005870e-13]
 [-7.40037053e-13  6.81954697e-14  1.00000000e+00]
 [ 1.65282161e-13 -1.00000000e+00  6.81270076e-14]]
Rotation from Essential Matrix is:
[[ 1.00000000e+00  0.00000000e+00  6.10449975e-13]
 [ 1.88734273e-13  1.00000000e+00  6.80966042e-14]
 [-6.10414948e-13  6.81600874e-14  1.00000000e+00]]
Translational from Essential Matrix is:
[[1.00000000e+00]
 [3.53936433e-13]
 [1.29622105e-13]]
Homography matrix for left image is :
[[ 1.15029864e-01  1.54777821e-02  4.94730582e-01]
 [-2.39177387e-13  7.07106781e-01  2.31922155e-10]
 [-2.25917337e-16  1.85479350e-16  7.07106781e-01]]
Homography matrix for right image is :
[[ 1.00000000e+00  3.54278925e-13 -1.91334948e-10]
 [-3.54278925e-13  1.00000000e+00  3.40151018e-10]
 [ 0.00000000e+00  0.00000000e+00  1.00000000e+00]]

```

Figure 8: Various outputs from the program

Epilines in both images

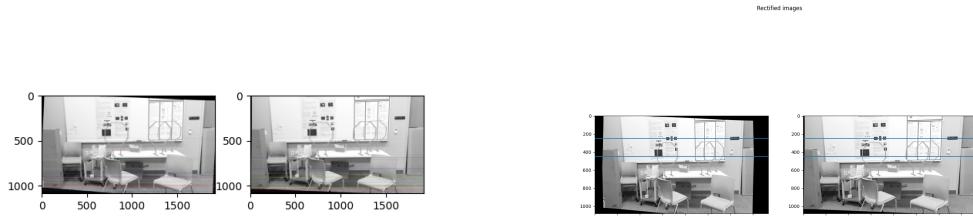
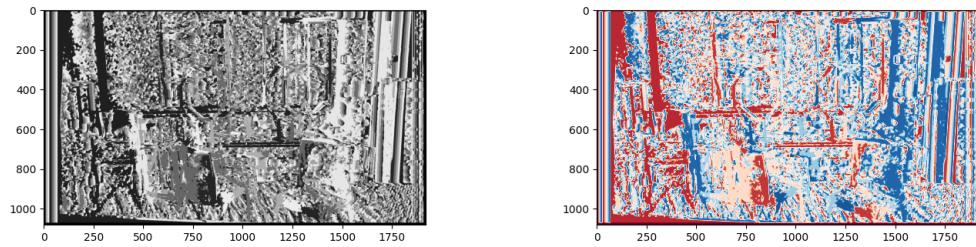


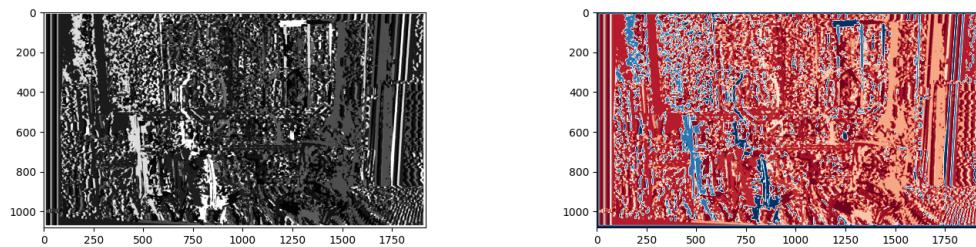
Figure 9: Rectification



(a) Gray Scale

(b) Heat Map

Figure 10: Disparity Map



(a) Gray Scale

(b) Heat Map

Figure 11: Depth Map

3.3 Dataset 3



Figure 12: Input Images

```

PROBLEMS DEBUG CONSOLE OUTPUT TERMINAL
darshan@doj:/Desktop/ENPM673$ /usr/bin/python3 /home/darshan/Desktop/ENPM673/Project_3/trial2.py
Features detected
Fundamental Matrix is:
[[ -4.27980243e-33 -5.55222047e-17 -5.55099956e-17]
 [ -2.40454704e-19 -2.24740246e-17 -7.07106781e-01]
 [ 5.42551649e-17 7.07106781e-01 -7.19498997e-14]]
Essential Matrix is:
[[ 1.00000000e+00 4.5501159e-13 -4.40605588e-14]
 [-5.07970894e-16 2.56349713e-14 -1.00000000e+00]
 [-1.11056398e-16 1.00000000e+00 -2.56829403e-14]]
Rotation from Essential Matrix is:
[[ 1.00000000e+00 4.40291256e-14 -1.36367040e-13]
 [-4.41907684e-14 1.00000000e+00 -2.58646960e-14]
 [ 1.36353947e-13 2.57014982e-14 1.00000000e+00]]
Translation from Essential Matrix is:
[[ -0.00000000e+00
  4.40797120e-14
  -1.35765976e-13]]
Homography matrix for left image is :
[[ -6.99562535e-01 5.51770588e-02 7.26022565e+00]
 [ 4.23729219e-14 -7.07106781e-01 2.89739806e-11]
 [ 7.81210000e-01 8.69100000e-01 7.07106781e-011]]
Homography matrix for right image is :
[[ 1.00000000e+00 -4.25057140e-14 2.29647412e-11]
 [ 4.25057140e-14 1.00000000e+00 -4.08135747e-11]
 [ 0.00000000e+00 0.00000000e+00 1.00000000e+00]]
darshan@doj:/Desktop/ENPM673$ 

```

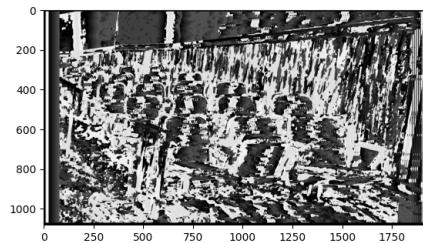
Figure 13: Various outputs from the program

Epilines in both images

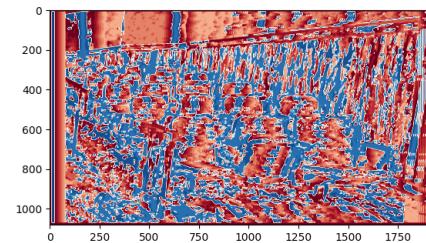
Rectified images



Figure 14: Rectification

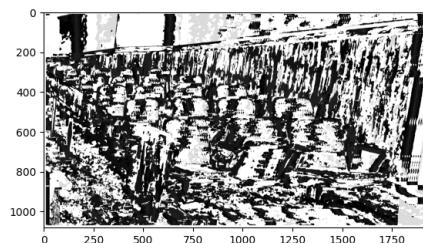


(a) Gray Scale

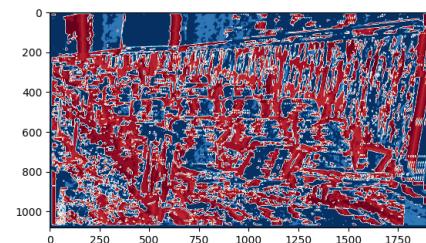


(b) Heat Map

Figure 15: Disparity Map



(a) Gray Scale



(b) Heat Map

Figure 16: Depth Map