CSE463 Computer Vision

Homework 2

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Problem:

Calculating disparities of given consecutive stereo images and calculating the error of the measurements with respect to given disparity ground truth image.

Solve:

For the problem above, we took 6 sample scene image sets. These scenes contain 8 different images. The images are in the same y-axis and z-axis, only x-axis is changing. So, this gives us 7 stereo images. Also, each scene contains its ground truth disparity image. This ground truth images are going to be compared with our measurements.

Firstly, we supposed to calculate ORB features for each image and match them with the consecutive image. After that, we calculate the disparity of the matches as, "f (x, y) = x_{left} - x_{right}". As a result, we have a disparity image, but this is not enough to find the disparity of all the scene.

After calculating disparity with ORB Features, we have a disparity that not enough to our needs. At this point, we use the block matching technique to detect entire scenes disparity. The result of that operation will give us the disparity of all the scene. This technique calculates the matching points for each point in the first image. This way, entire disparity of the scene will be calculated.

At the end of the process, I calculated the Mean Square Error for each disparity measurements with respect to given ground truth image.

As we can see below, ORB features are not enough display all scene. If we want to calculate all scene, we should use Block Matching technique.

Algorithm:

1. Open ground truth image and two consecutive images.
2. Calculate ORB features for both the consecutive images.
3. Match the calculated features with OpenCV BFMatcher.
4. For each matched point, calculate the disparity with $x_{first} - x_{second}$ calculation and put the result in the output image.
5. Normalise the ORB output image and display it.
6. Call the compute method of the object that crated with StereoSGBM_create function of OpenCv. Normalise the result and display it.
7. Calculate the absolute differences of each pixel for ground truth image and the result of 6st step of the algorithm. Normalise the result and display it.
8. Calculate the Mean Square Error with the given form $\sqrt{\sum_{x=1}^{N} \sum_{y=1}^{M} f \cdot (x, y \cdot) + g(x, y)}$

Result:

With all the calculations and comparisons described above, we can see the main differences with the ground truth as:

1. Sharpness is mostly lost in our calculations.
2. Actual disparity values are missed a bit but overall, the result is satisfying. In each images below, ground truth and our calculations are very similar.

Barn1 Scene Results:

```
barn1/
Mean square error for image pair 0 and 1  =  1272.419309565471
Mean square error for image pair 1 and 2  =  1314.0119325362107
Mean square error for image pair 2 and 3  =  1407.4914151356081
Mean square error for image pair 3 and 4  =  1242.505455915233
Mean square error for image pair 4 and 5  =  1347.5062092932828
Mean square error for image pair 5 and 6  =  1313.4272686400311
Mean square error for image pair 6 and 7  =  1399.2687979974726
```

Figure 1 MSE for scene barn1

Figure 2 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 3 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 4 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 5 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 6 Ground Truth, Orb Results, Result of measurements, GT - Measurements

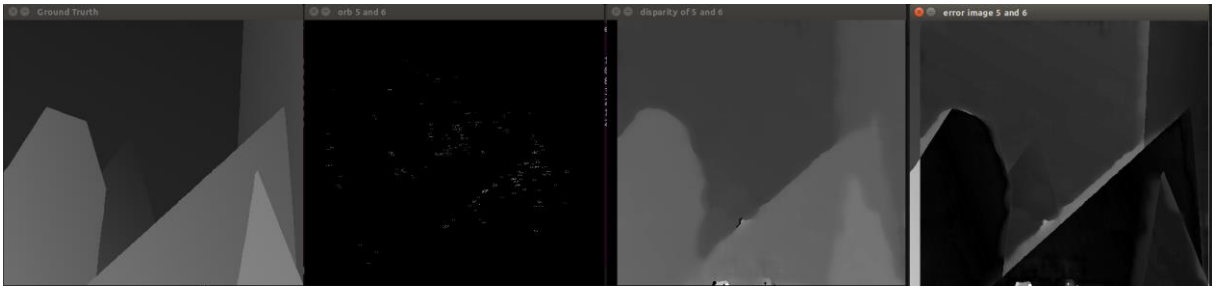

Figure 7 Ground Truth, Orb Results, Result of measurements, GT - Measurements

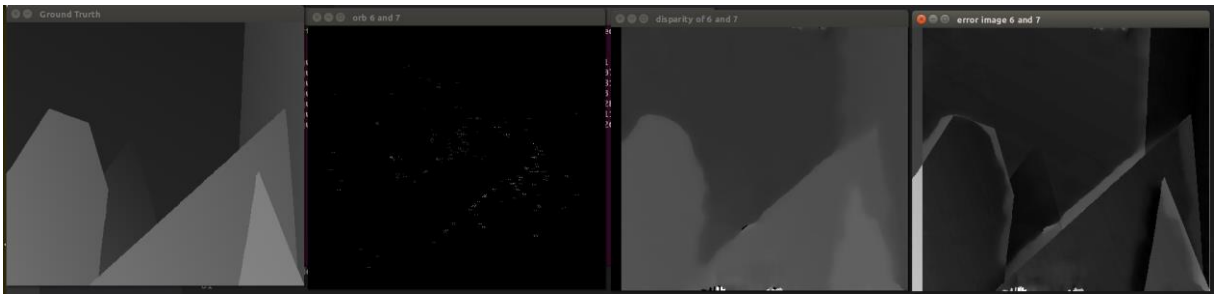

Figure 8 Ground Truth, Orb Results, Result of measurements, GT – Measurements

BARN2 Scene Results

```
barn2/
Mean square error for image pair 0 and 1  =  758.7872123542696
Mean square error for image pair 1 and 2  =  735.4890252090581
Mean square error for image pair 2 and 3  =  731.7214307513887
Mean square error for image pair 3 and 4  =  748.6220594518709
Mean square error for image pair 4 and 5  =  737.6602453763047
Mean square error for image pair 5 and 6  =  774.3062809009339
Mean square error for image pair 6 and 7  =  833.5726789965208
```

Figure 9 MSE for BARN2 scene

Figure 10 Ground Truth, Orb Results, Result of measurements, GT - Measurements

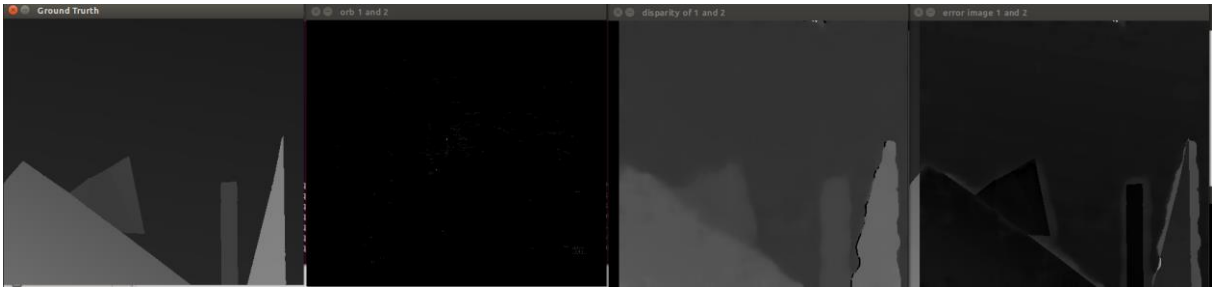

Figure 11 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 12 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 13 Ground Truth, Orb Results, Result of measurements, GT - Measurements

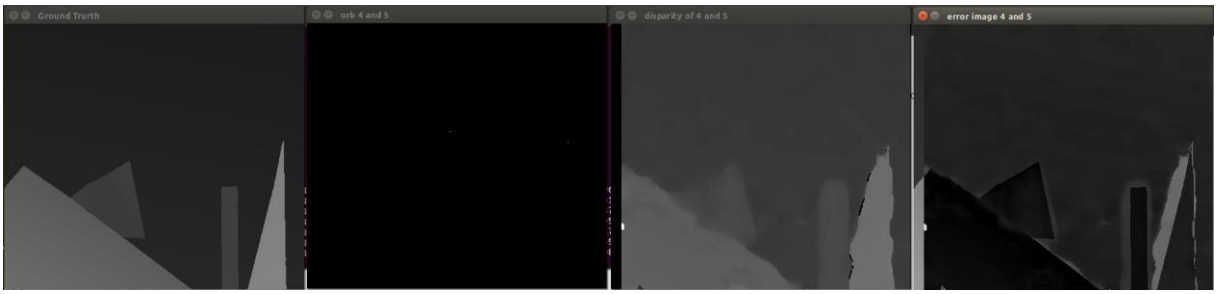

Figure 14 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 15 Ground Truth, Orb Results, Result of measurements, GT - Measurements

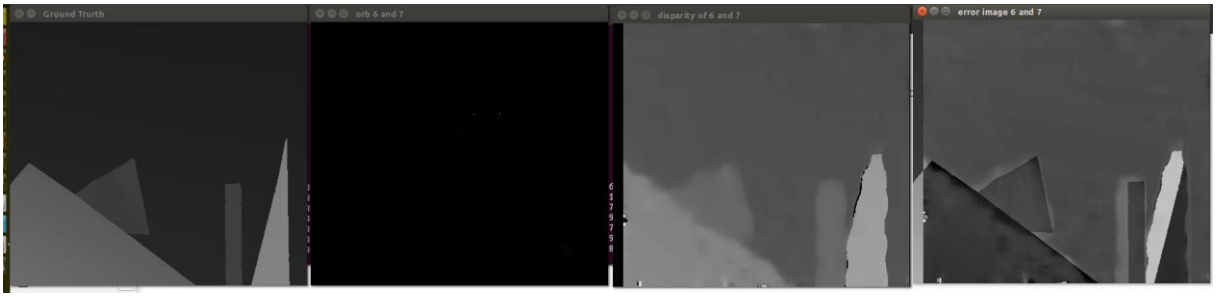

Figure 16 Ground Truth, Orb Results, Result of measurements, GT - Measurements

BULL Scene Results

```
bull/
Mean square error for image pair 0 and 1  =  1171.0363150333692
Mean square error for image pair 1 and 2  =  1253.104738351124
Mean square error for image pair 2 and 3  =  989.4920502142775
Mean square error for image pair 3 and 4  =  1372.7489892285405
Mean square error for image pair 4 and 5  =  1115.28073078625
Mean square error for image pair 5 and 6  =  1220.5625344753385
Mean square error for image pair 6 and 7  =  1310.1859577021694
```

Figure 17 MSE for BULL scene

Figure 18 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 19 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 20 Ground Truth, Orb Results, Result of measurements, GT - Measurements

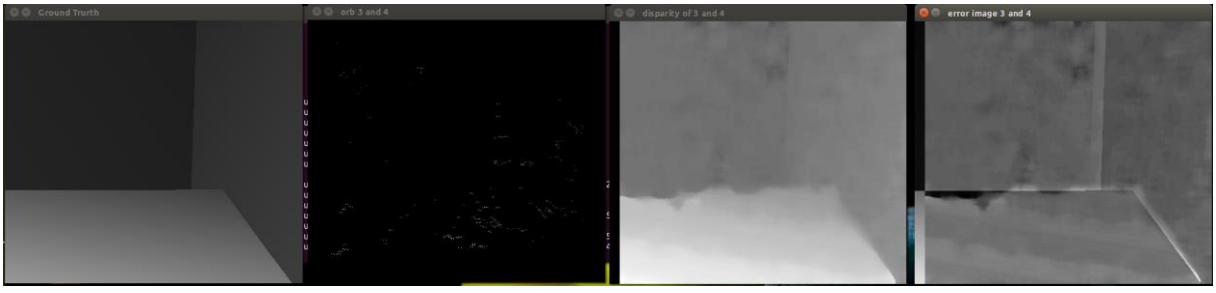

Figure 21 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 22 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 23 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 24 Ground Truth, Orb Results, Result of measurements, GT - Measurements

POSTER Scene Results

```
poster/
Mean square error for image pair 0 and 1  =  2574.916677170553
Mean square error for image pair 1 and 2  =  2202.8088772845954
Mean square error for image pair 2 and 3  =  2378.021974130428
Mean square error for image pair 3 and 4  =  2516.735440112842
Mean square error for image pair 4 and 5  =  2355.2940668047177
Mean square error for image pair 5 and 6  =  2595.2843131958825
Mean square error for image pair 6 and 7  =  2422.724317997659
```

Figure 25 MSE for POSTER scene

Figure 26 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 27 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 28 Ground Truth, Orb Results, Result of measurements, GT - Measurements

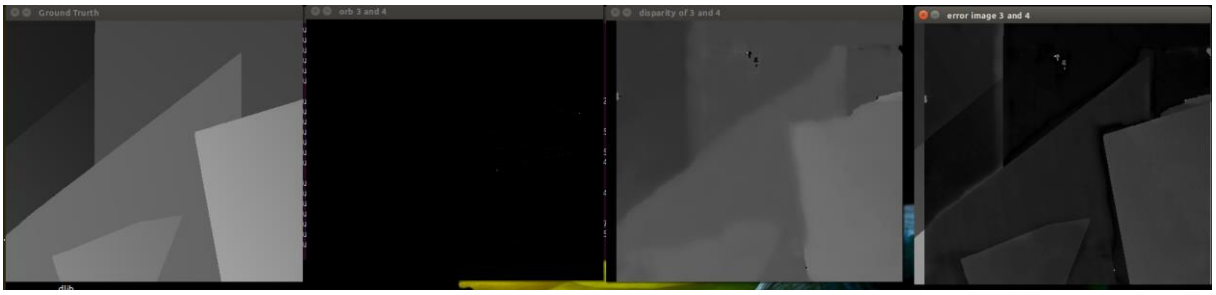

Figure 29 Ground Truth, Orb Results, Result of measurements, GT - Measurements

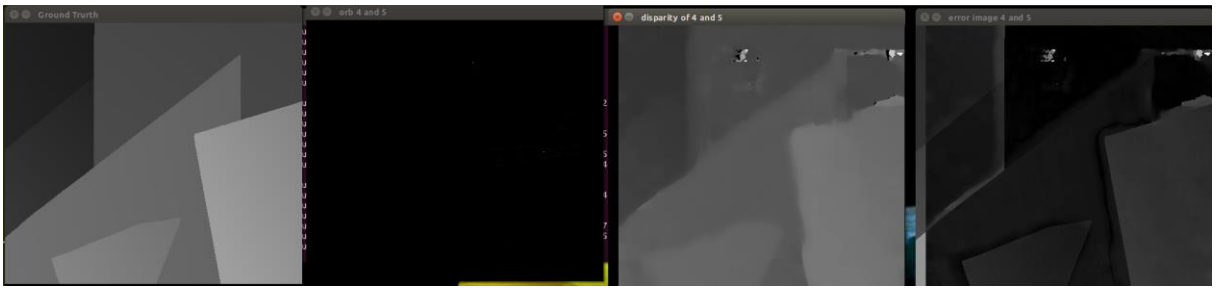

Figure 30 Ground Truth, Orb Results, Result of measurements, GT - Measurements

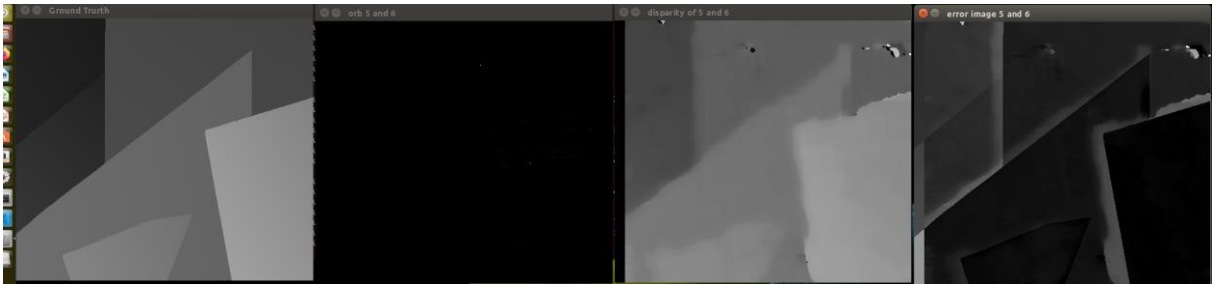

Figure 31 Ground Truth, Orb Results, Result of measurements, GT - Measurements

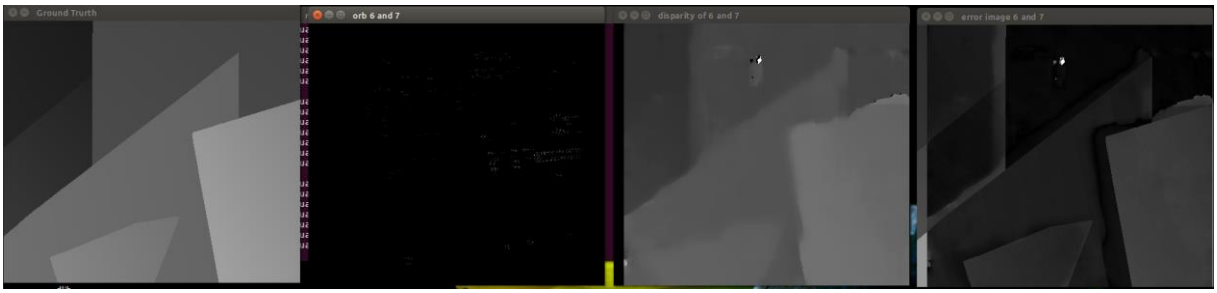

Figure 32 Ground Truth, Orb Results, Result of measurements, GT - Measurements

SAWTOOTH Scene Results

```
sawtooth/
Mean square error for image pair 0 and 1  =  1713.579438515644
Mean square error for image pair 1 and 2  =  2115.6536502546687
Mean square error for image pair 2 and 3  =  1753.8953917050692
Mean square error for image pair 3 and 4  =  1939.4615753092407
Mean square error for image pair 4 and 5  =  2024.0388673296143
Mean square error for image pair 5 and 6  =  1896.3559301479506
Mean square error for image pair 6 and 7  =  1844.2812454523405
```

Figure 33 MSE for SAWTOOTH scene

Figure 34 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 35 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 36 Ground Truth, Orb Results, Result of measurements, GT - Measurements

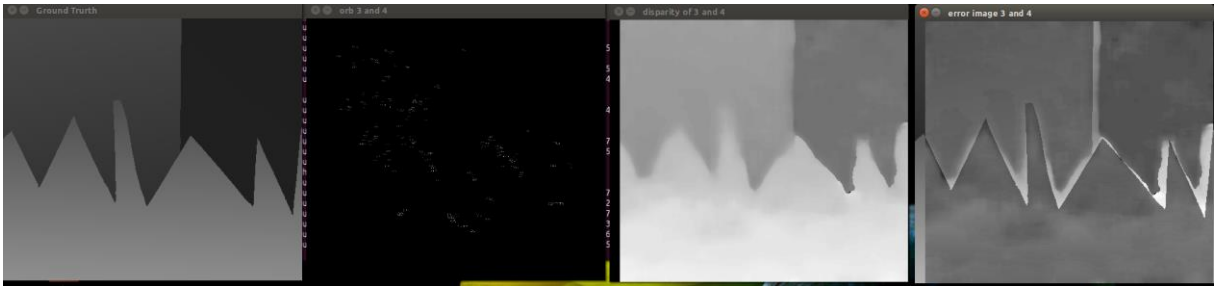

Figure 37 Ground Truth, Orb Results, Result of measurements, GT - Measurements

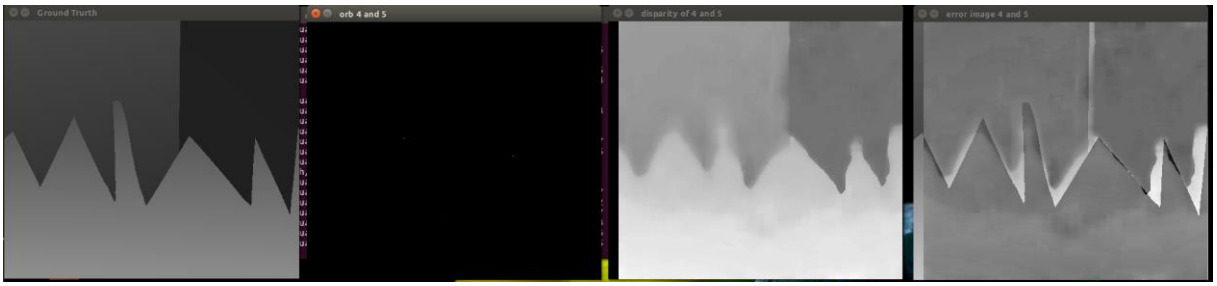

Figure 38 Ground Truth, Orb Results, Result of measurements, GT - Measurements

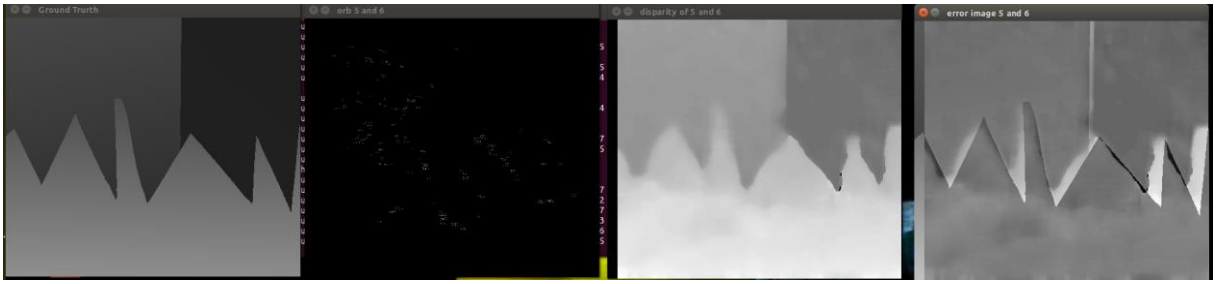

Figure 39 Ground Truth, Orb Results, Result of measurements, GT - Measurements

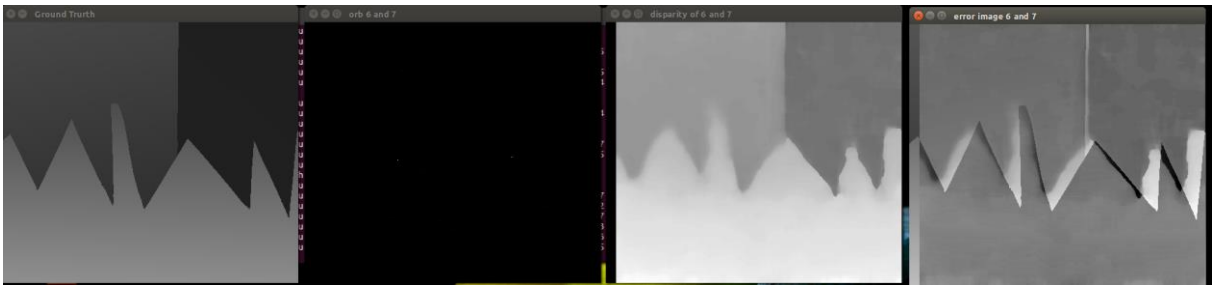

Figure 40 Ground Truth, Orb Results, Result of measurements, GT - Measurements

VENUS Scene Results

```
venus/
Mean square error for image pair 0 and 1  =  1318.5764038454597
Mean square error for image pair 1 and 2  =  1588.7025905114847
Mean square error for image pair 2 and 3  =  1492.4495975261998
Mean square error for image pair 3 and 4  =  1376.447136961413
Mean square error for image pair 4 and 5  =  1385.7321954975876
Mean square error for image pair 5 and 6  =  1599.8983287410813
Mean square error for image pair 6 and 7  =  1467.1369493809484
```

Figure 41 MSE for VENUS scene

Figure 42 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 43 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 44 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 45 Ground Truth, Orb Results, Result of measurements, GT - Measurements

Figure 46 Ground Truth, Orb Results, Result of measurements, GT - Measurements

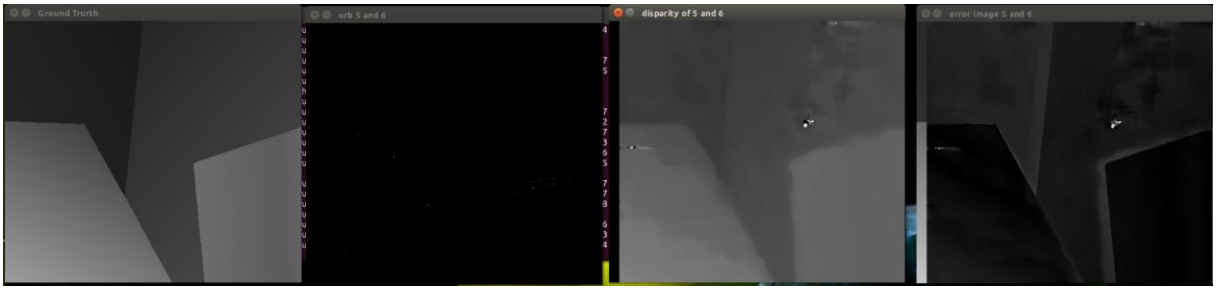

Figure 47 Ground Truth, Orb Results, Result of measurements, GT - Measurements

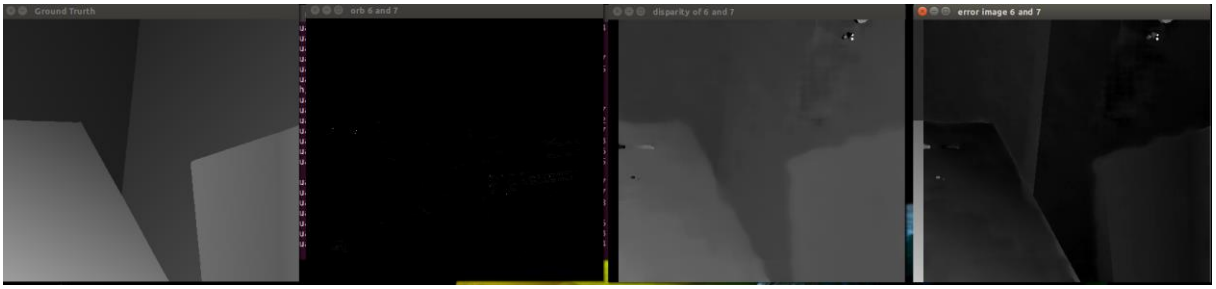

Figure 48 Ground Truth, Orb Results, Result of measurements, GT - Measurements