LAB3 RTK GPS Data Analysis

1. Static data test in front of ISEC

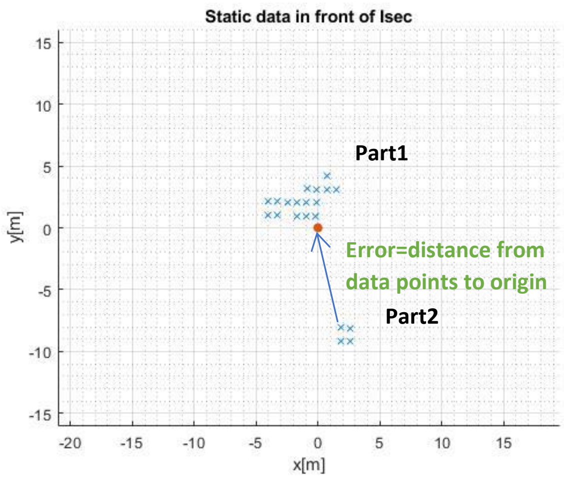

Fig1.a Scatter plot of static data in front of ISEC

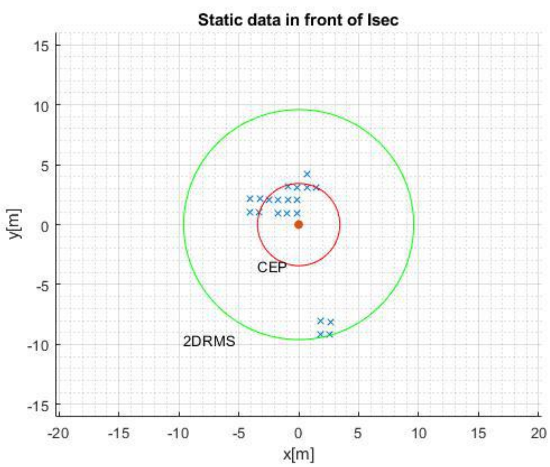

Fig1.b static data scatter plot with error analysis

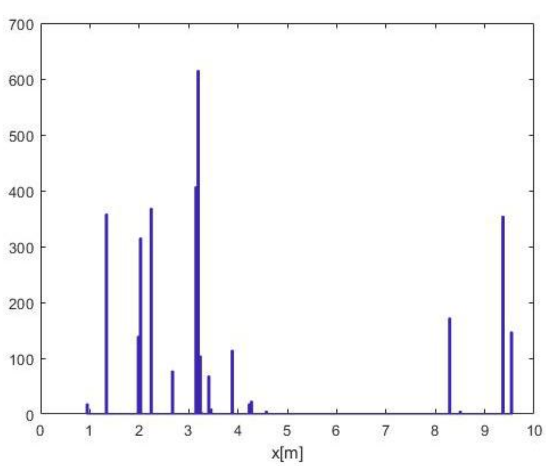

Fig1.c histogram of distance from data point to origin

This data is collected in front of ISEC building, total data length is 3318. The fixed quality of the data stays 5 all the time, which means it’s in RTK float mode.

The red dot indicates the average value of x and y reading, which has already been subtracted.

To analyze the accuracy, we need to look at standard deviation of both axis, RMS, CEP (Circular Error Probable,50%) and 2DRMS (2 times rms,95%).

$$CEP = 0.59(\sigma_x + \sigma_y)$$

$$2DMRS = \sqrt{(\sigma_x{}^2 + \sigma_y{}^2)}$$

σ_x =1.44m; σ_y =4.57m;

RMS = 4.7945m.

CEP=3.43m

2DRMS=9.59m

As you can see from the **fig1.a** the data points ca be clustered into **two major parts**, **which may be caused by multipath effects**, the signal of gps is reflected by the tall building for multiple times. So the error can be represented by the distance from the data point to the origin $r = \sqrt{x^2 + y^2}$ .The histogram of error is shown in **fig1.c**.

The distribution looks like a sum of **two separate non-gaussian distribution**. We can use qqplot to check if it is Gaussian distribution, for the first part it is similar to a Gaussian distribution, but for second part, it’s just some random noise.

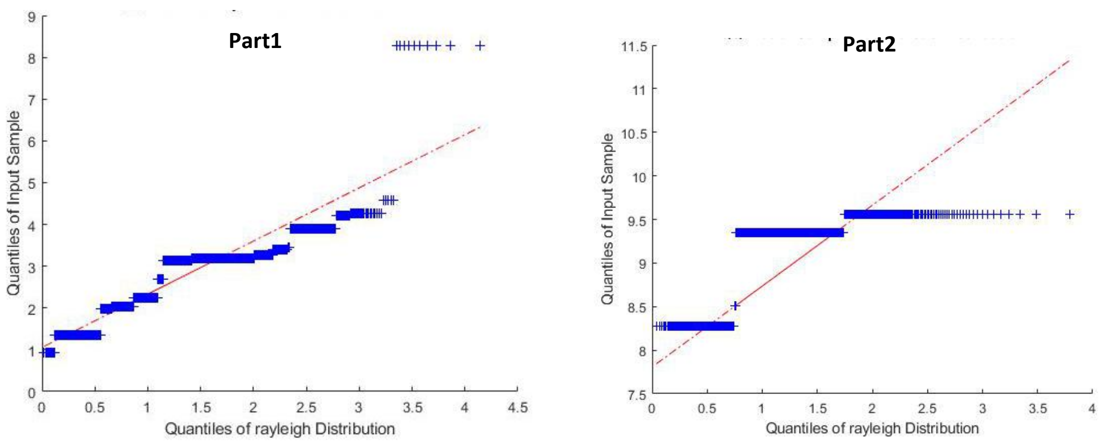

Fig1.d qqplot of distance comparing with normal distribution

2. Static data test on open field

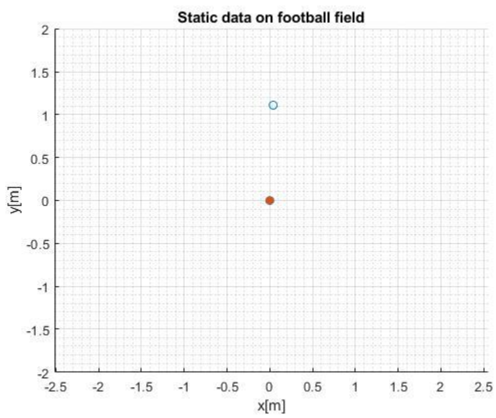

Fig2.a Scatter plot of static data on open field

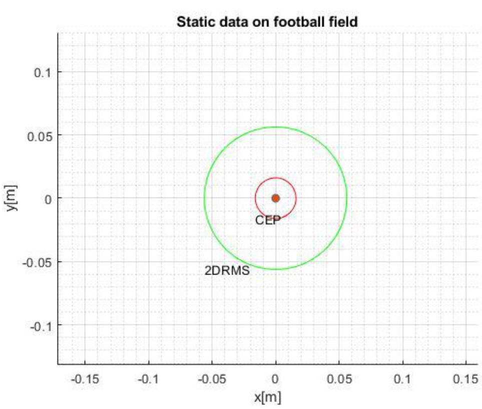

Fig2.b Scatter plot of static data on open field with error analysis

The static data collected at open area (football field) is unbelievably **stable**, the total data length is 3133 data points, only two is non-zero value.

The fixed quality of the data stays 4 all the time, which means it's in RTK fixed mode.

So the error of this data **can be assumed to be 0**.

If we take into consideration of these two outliers,

σ_x =0.001m; σ_y =0.028m;

RMS= 0.0281m

CEP=0.0166m;

2DRMS=0.0562m;

3. **Moving data test in front of ISEC**

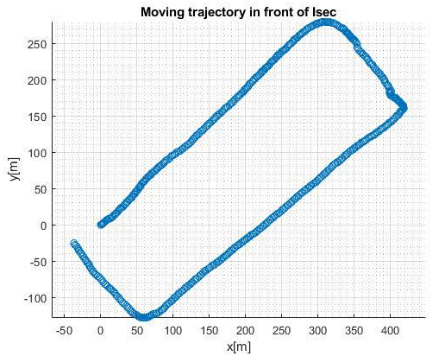

Fig3.a Scatter plot of moving data in front of ISEC

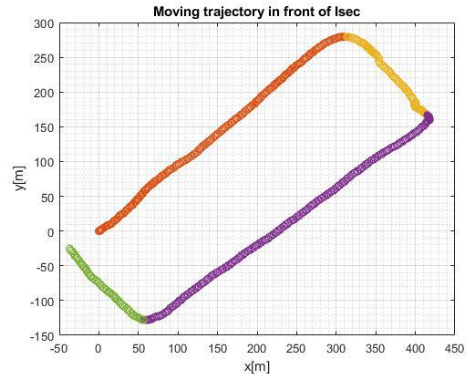

Fig3.b 4 parts of trajectory

The static data collected in front of ISEC. The fixed quality of the data stays 5 all the time, which means it's in RTK float mode. As you can see from B, I divided the trajectory into 4 straight line, and for each line I calculate the linear polynomial fit of the data.

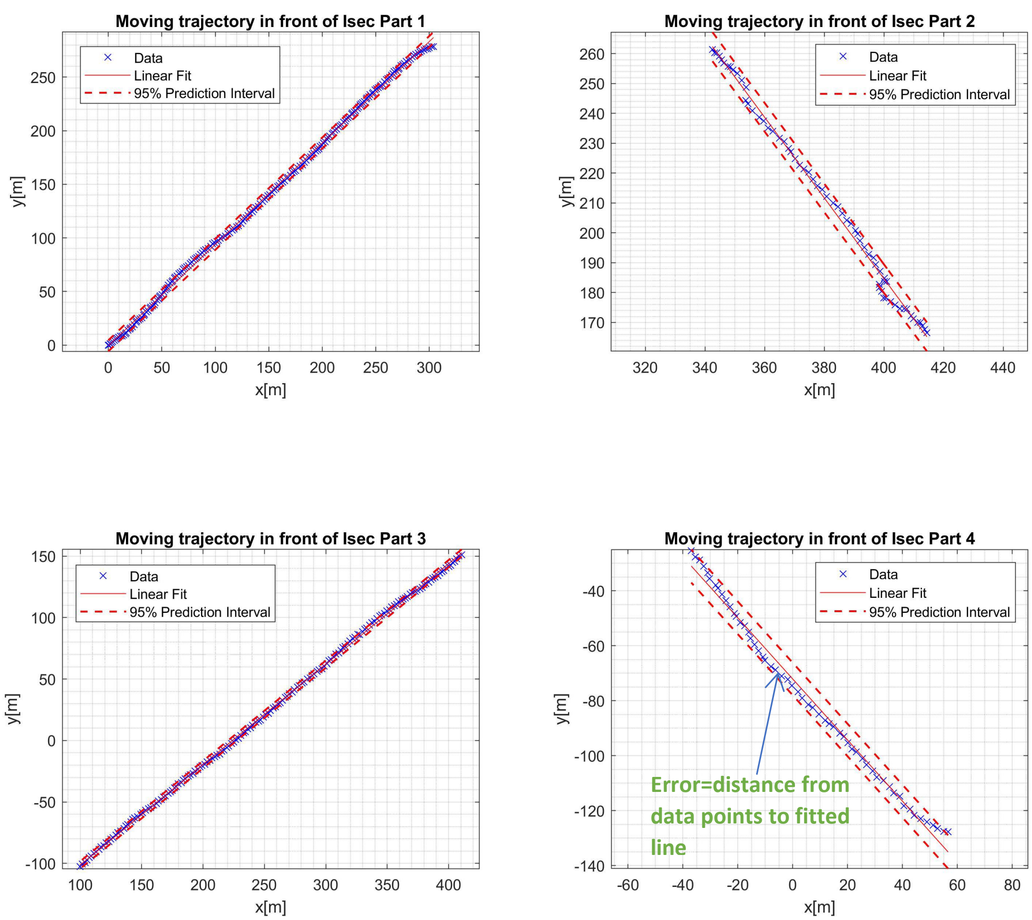

Fig3.c Linear fit and error analysis of moving data in front of ISEC

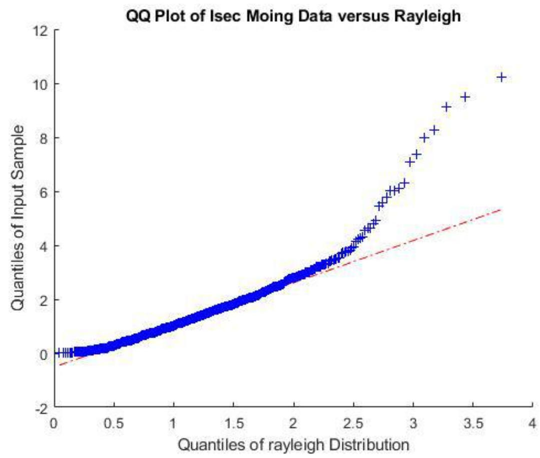

Fig3.d qqplot of moving data in front of ISEC versus Rayleigh distribution

To calculate the error I calculate the normal distance from the data point to the fitted line, then take an average of the result:

$$e = \frac{1}{N}\sum_{1}^{N} d_i \text{ in which } d_i = \frac{\left|kx_i + b - y_i\right|}{\sqrt{1+k^2}},$$

k and b are the fitted polynomial parameters.

For the 4 parts, the errors are 1.785m, 2.023m, 1.221m and 1.526m. So the total error is the weighted average of four parts, that is $\sigma = 1.576$m. For 95% prediction interval, we take $2\sigma = 3.152$m.

As you can see from **fig3.d**, the error is almost a Rayleigh distribution plus some random noise.

4. **Moving data test on open field**

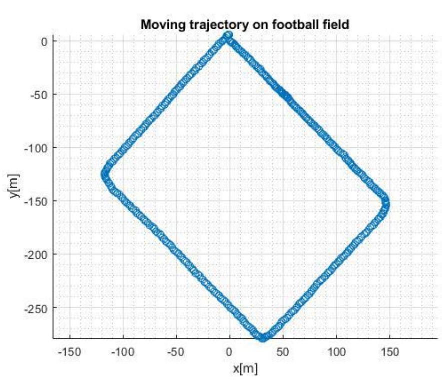

Fig4.a Scatter plot of moving data on open field

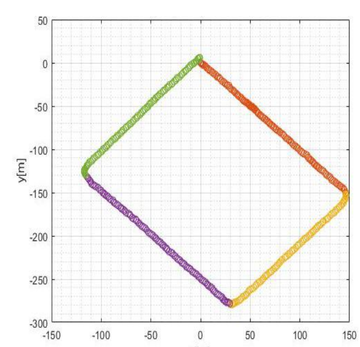

Fig4.b 4 parts of trajectory

The fixed quality of the data stays 4 all the time, which means it's in RTK fixed mode. I divided the trajectory into 4 straight line, and for each line I calculate the linear polynomial fit of the data. To calculate the error I calculate the normal distance from the data point to the fitted line, then take an average of the result.

For the 4 parts, the errors are 0.3225m,0.7469m, 0.4153m and 0.6836m.

So the total error is the weighted average of four parts, that is $\boxed{\sigma = \mathbf{0.51}\text{m}}$. For 95% prediction interval, we take $\boxed{2\sigma = 1.02\text{m.}}$

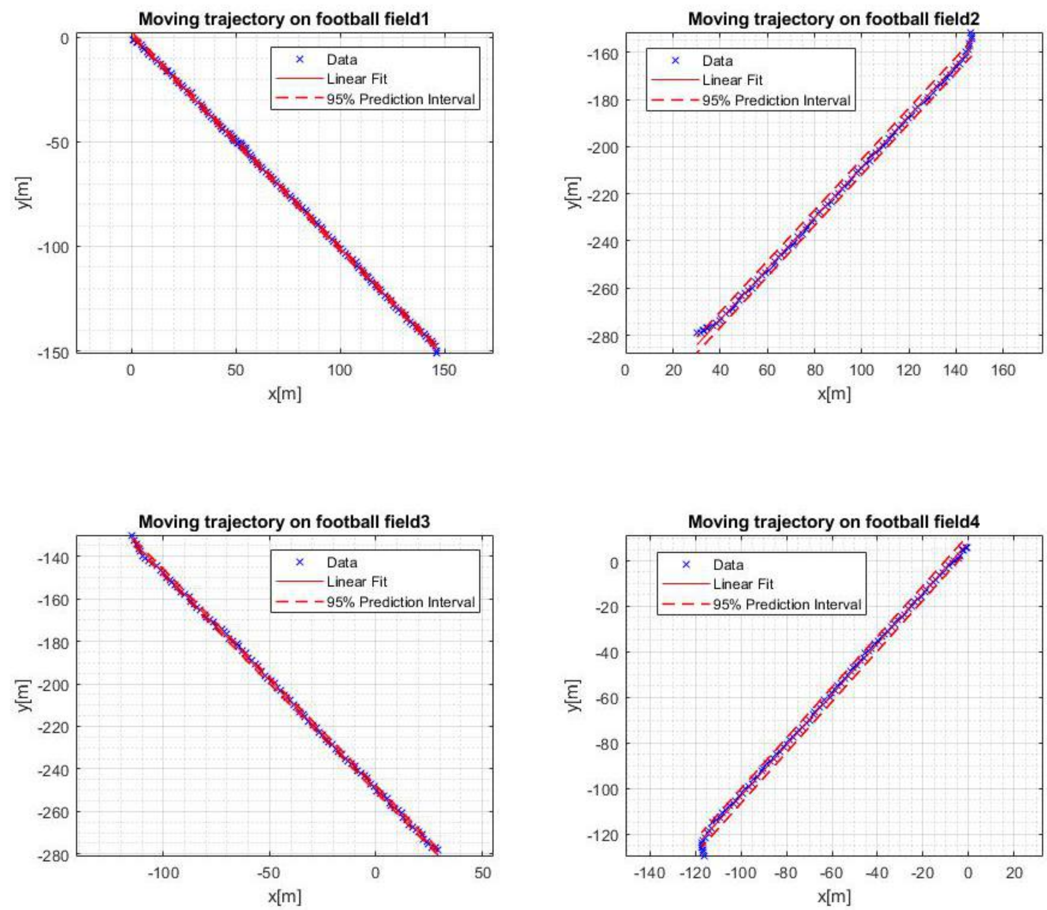

Fig4.c Linear fit and error analysis of moving data in front of ISEC

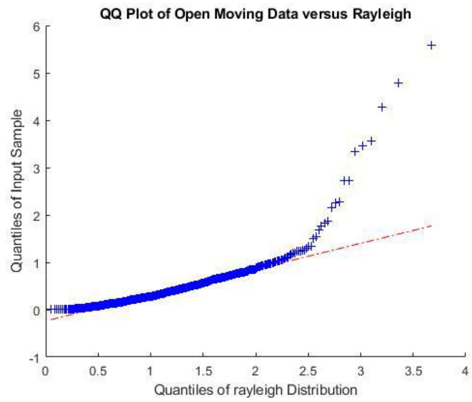

Fig4.d qqplot of moving data in front of ISEC versus Rayleigh distribution

As you can see from fig4.d, the error is a Rayleigh distribution plus some random noise. The trajectory is a perfect close loop on the plot, which verifies the high accuracy of RTK gps.

5.Conclusion

RTK-GPS provides better accuracy than normal GPS. The accuracy level of stationary data is 0.0562m when there's no occlusion and 9.59m when near high building. The accuracy level of moving data is 1.02m when there's no occlusion and 3.152m when near high building.

Comparing with the result of LAB1, in which stationary accuracy level is 4.8m when near high building and moving accuracy of 2.4m when near building. We can see that if there's no occlusion then RTK-GPS can provide high accuracy at centimeter level when it's stationary, and meter level when moving. But if the GPS signal is affected by multipath effect then the accuracy is about the same level with normal GPS.