Contents

1 Introduction

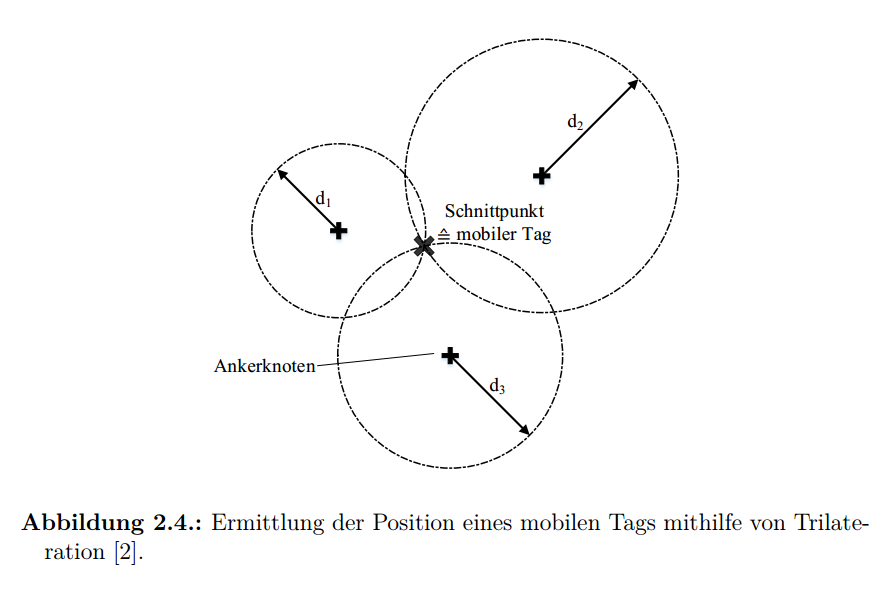
2 Theoretical Background

2.1 localization with distances

In Geometry, the position of a point can be determined by several methods, such as Trilateration and Triangulation. In this thesis, Trilateration is used for location determination. Followed is a brief introduction about Trilateration:

In a two dimensional space, to determine the position of a point, at least 3 distances to 3 different fixed positions are required(these 3 fixed positions should not lie on the same line).

When the exact distances from a mobile Tag to 3 anchor Nodes are known, the position of this mobile Tag can be determined by the intersection point of circles around the Nodes with the corresponding radius.



Intersection point

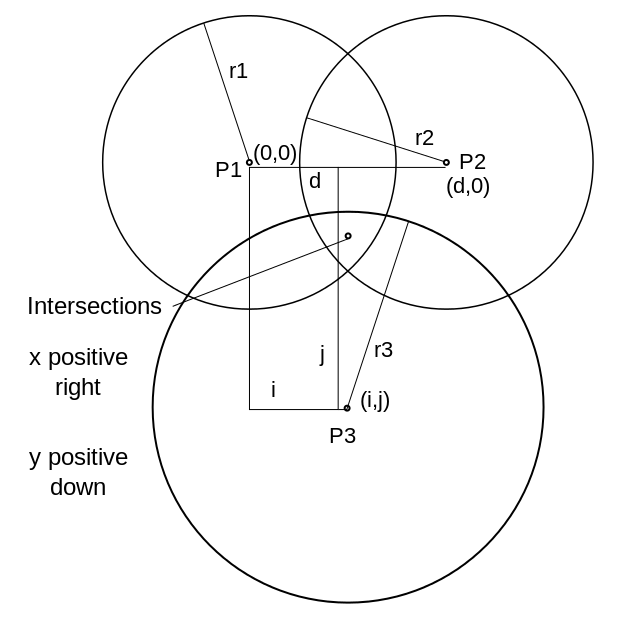
SDA

intersection point:

Mobile tag position

(pic from ‘Patrick thesis P11’)

When noises due to the inherent error of hardware are added to the distances from a mobile Tag to 3 anchor Nodes, the position of this mobile Tag lies within the intersection area of circles.



(pic from ‘https://en.wikipedia.org/wiki/Trilateration’)

2.2 distance measurements base on UWB signal

2.2.1 UWB

2.2.2 distance measurements

Figure\ref{figure3\_1}

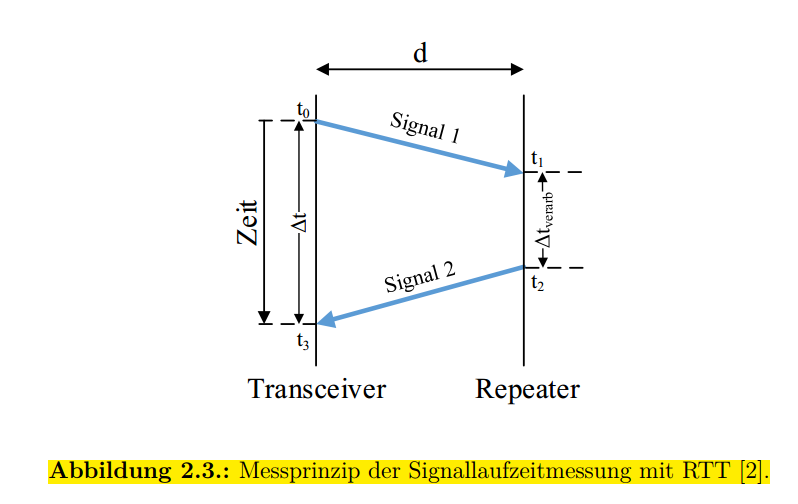
\begin{figure}[ht]%

\centering

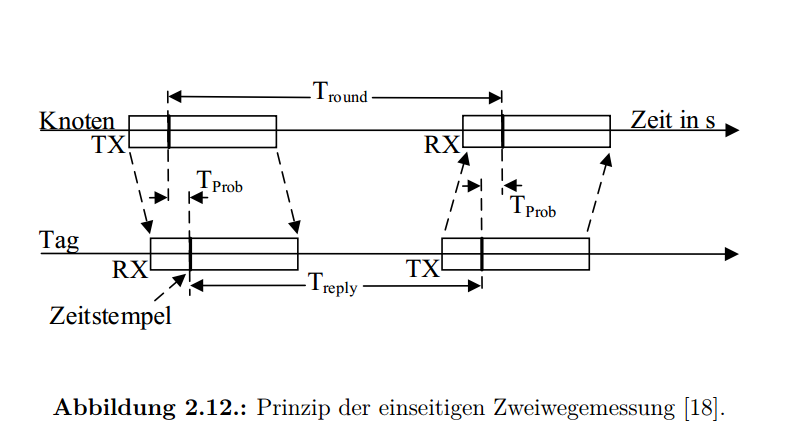
\includegraphics[width=0.6\textwidth]{figures/theoreticalBackground/3circles.PNG}%

\caption{localize the position of a mobile tag with distances to other 3 anchor nodes \cite{Patrick}.}%

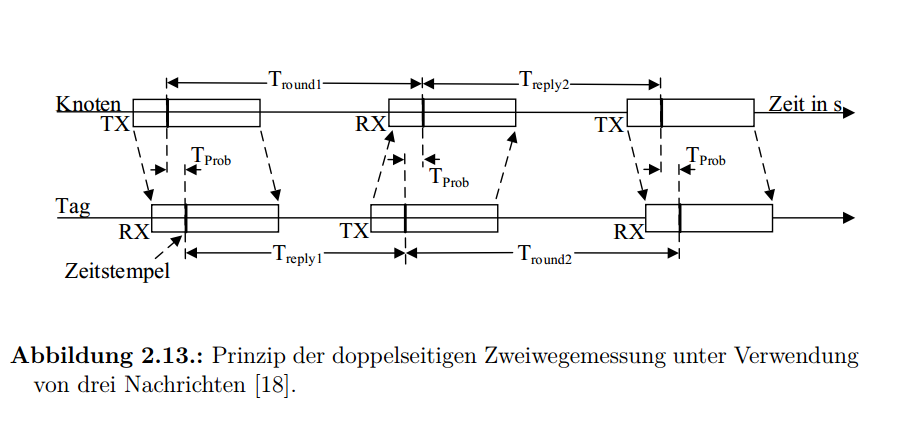
\label{figure3\_1}%

\end{figure}

(pic from ‘Patrick thesis P10’)



(pic from ‘Patrick thesis P24’)



(pic from ‘Patrick thesis P25’)

final\_tx\_ts

node

resp\_rx\_ts

poll\_tx\_ts

final\_rx\_ts

resp\_tx\_ts

poll\_rx\_ts

tag

2.3 KF

The positions of a moving mobile tag can be localized using the measured distances to anchor nodes as illustrated in \autoref{2\_1}.

But when

2.4 EKF

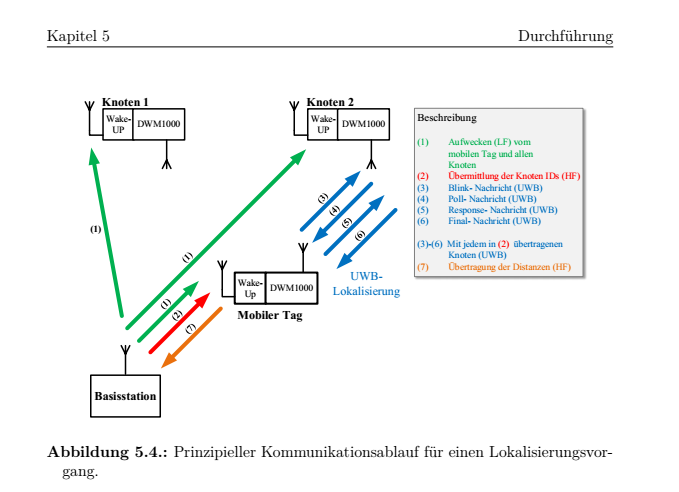
2.5 Self-Calibrations for Anchor-Nodes

2.6 data mitigation

2.7 State of the Art

3--2. Literature Review (State of the Art)

4-- 3.Hardware Improvement

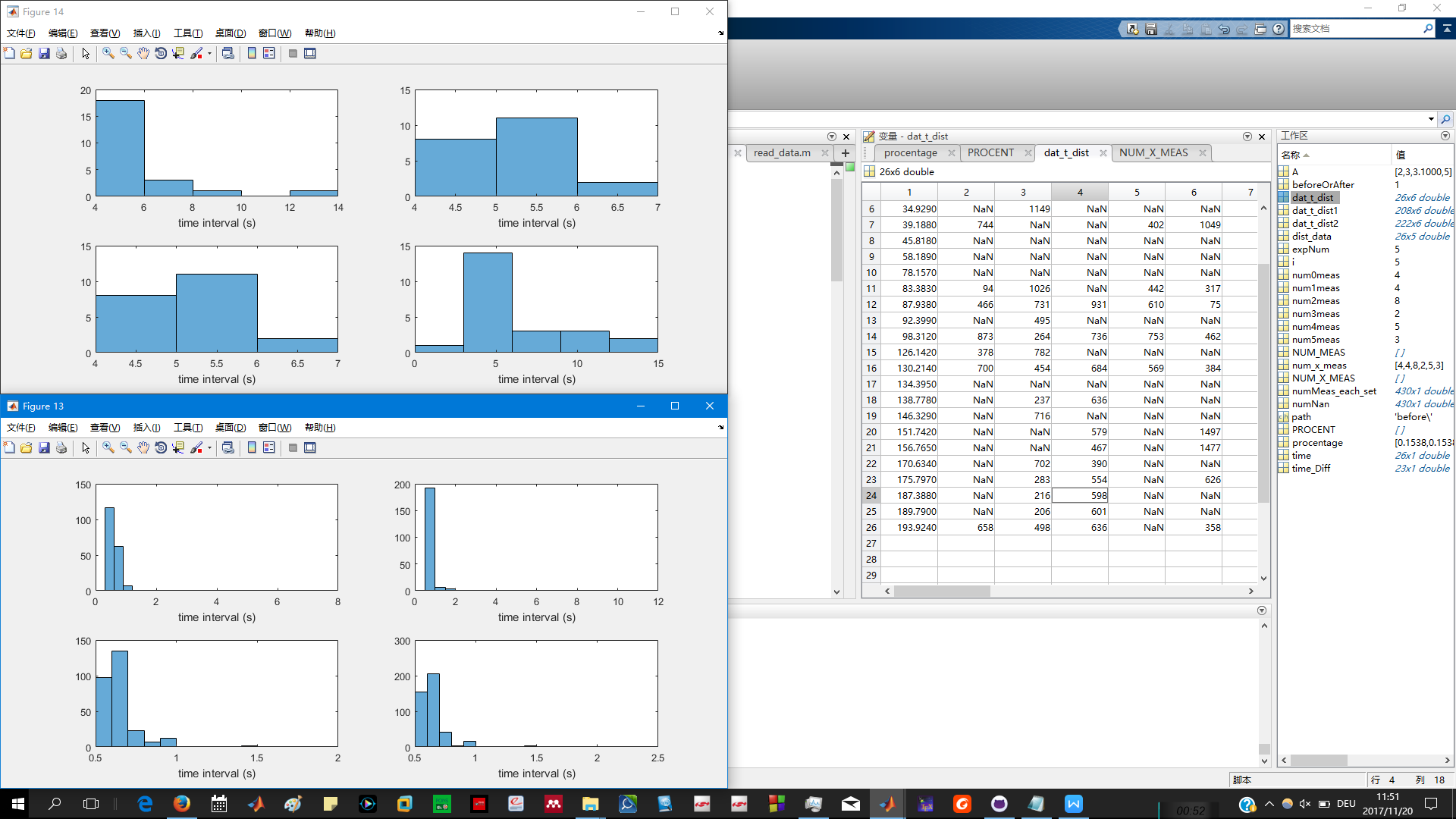


(pic from ‘Patrick thesis P50’)

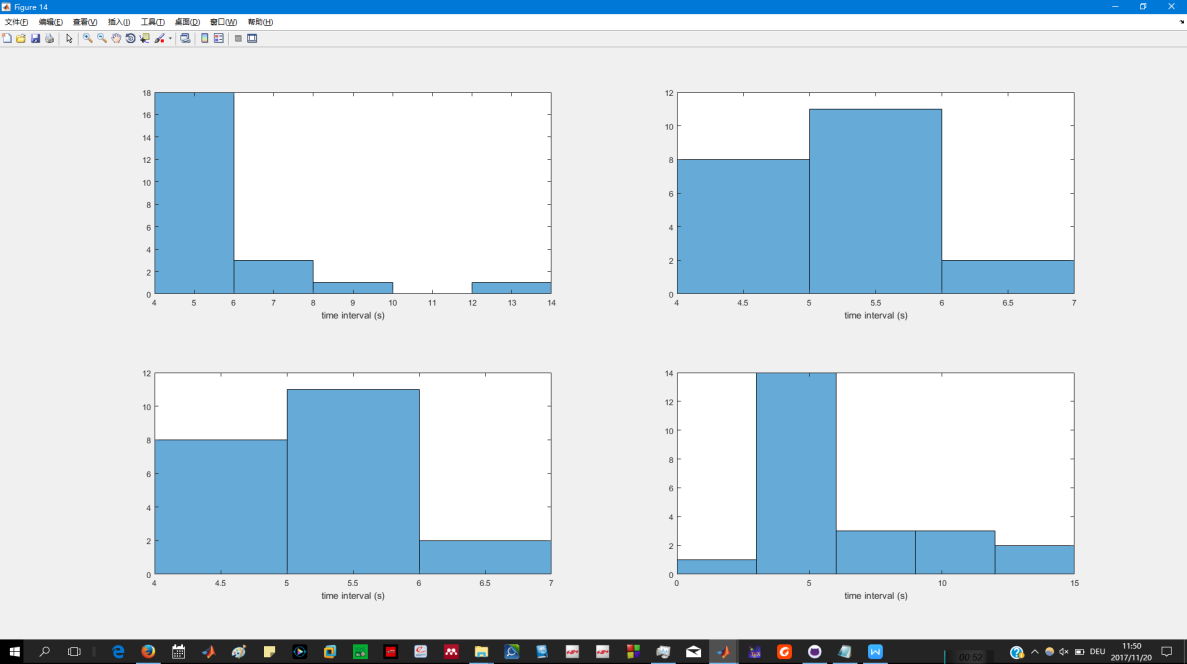
Loop jumper(tag), timing, state machine(loop between nodes)

Sampling rate

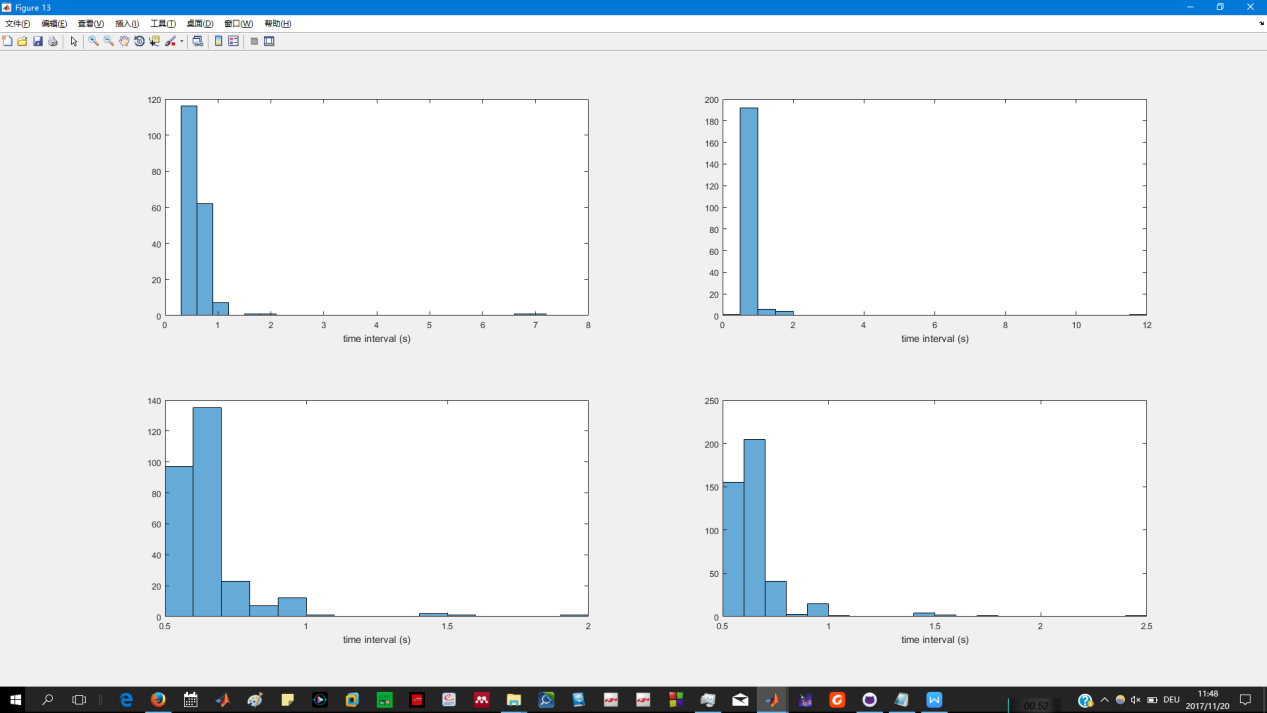
Before and after



Before



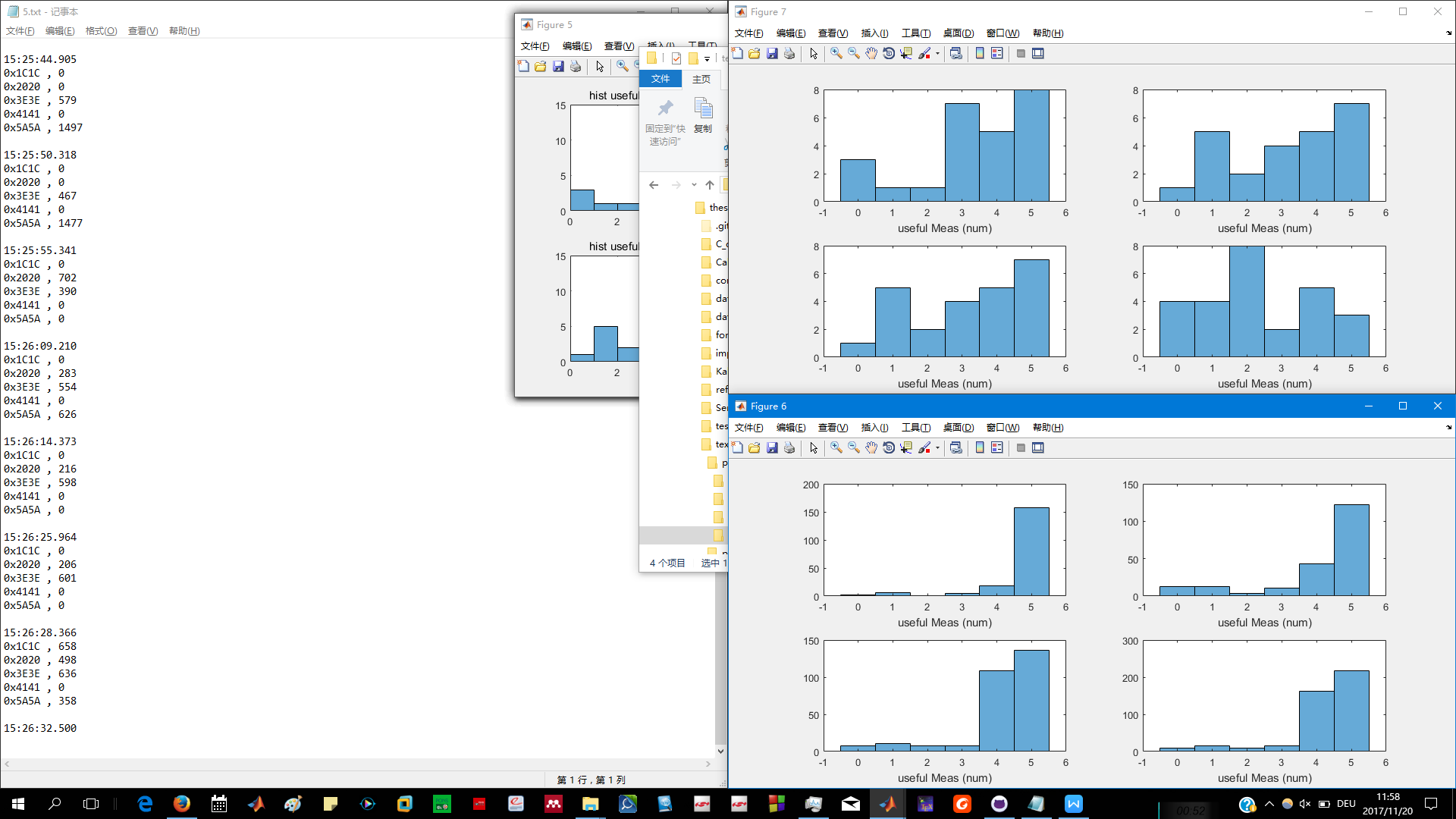
After



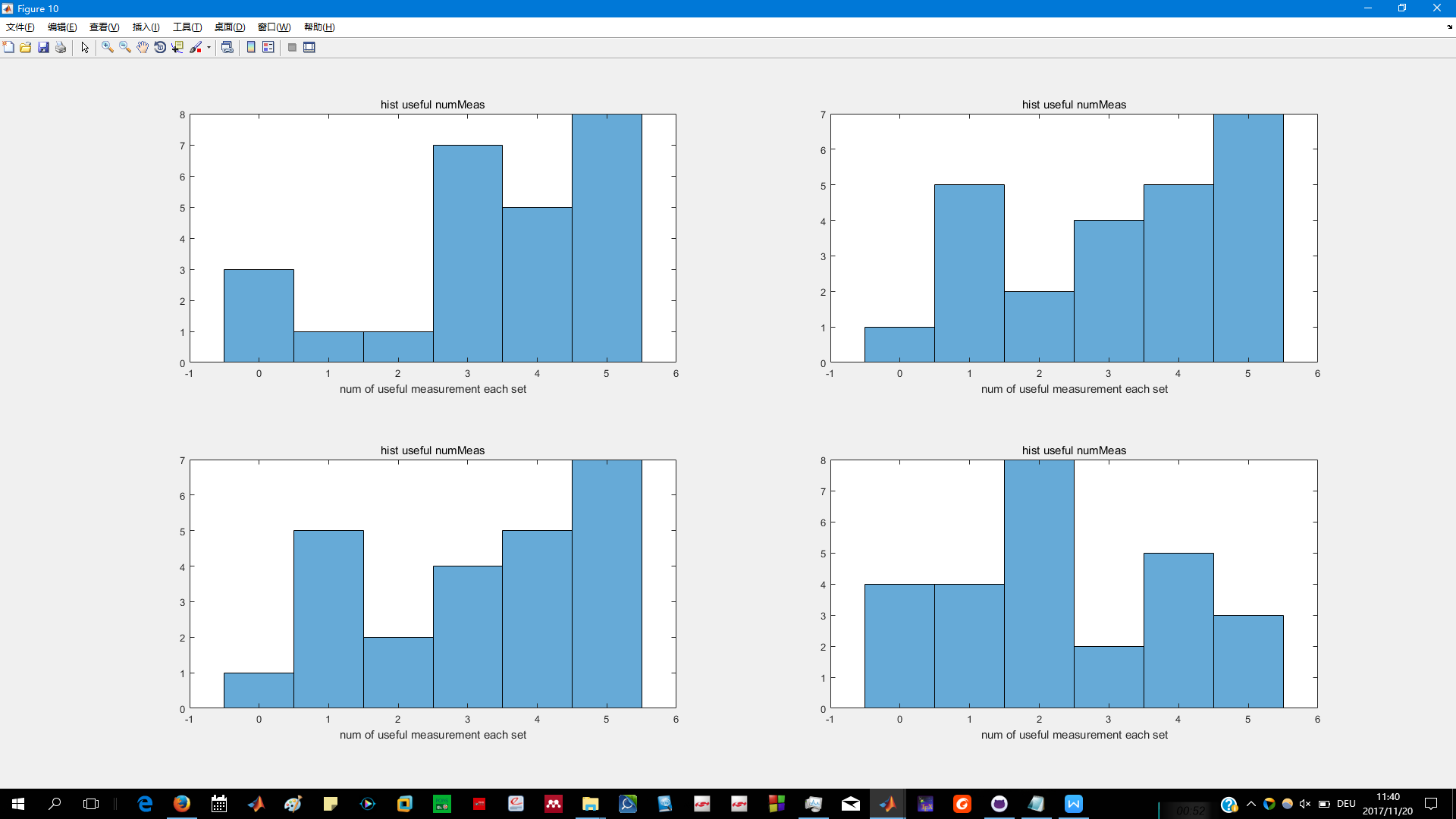
Mat file ‘C:\Users\Yitong\Documents\GitHub\thesis\_indoorLocalization\improvment in hareware’ *hist(time\_Diff,100);*

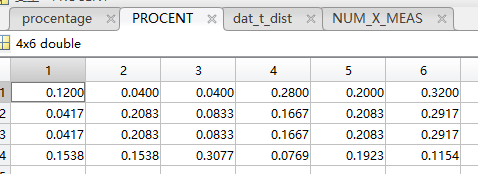
Sampling measurement #

Before and after

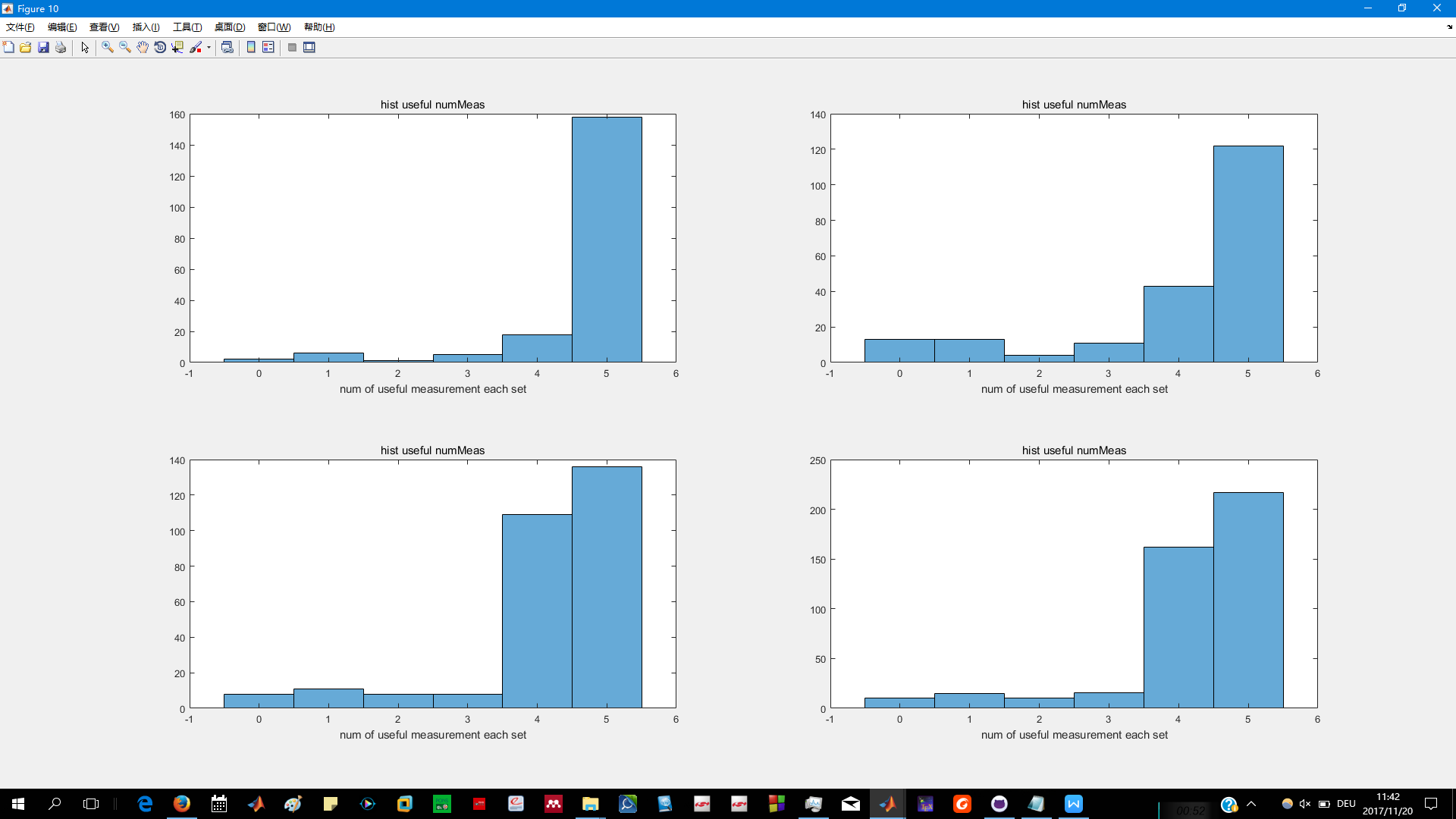


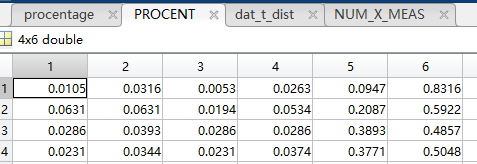
Before



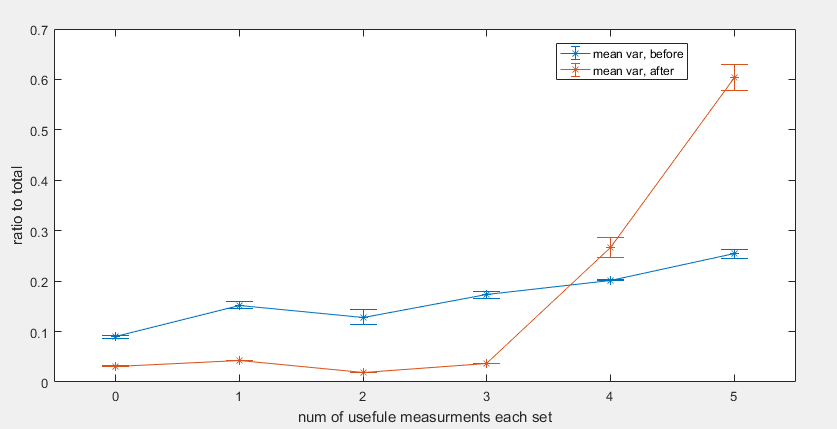


After





Location’C:\Users\Yitong\Documents\GitHub\thesis\_indoorLocalization\improvment in hareware\after’

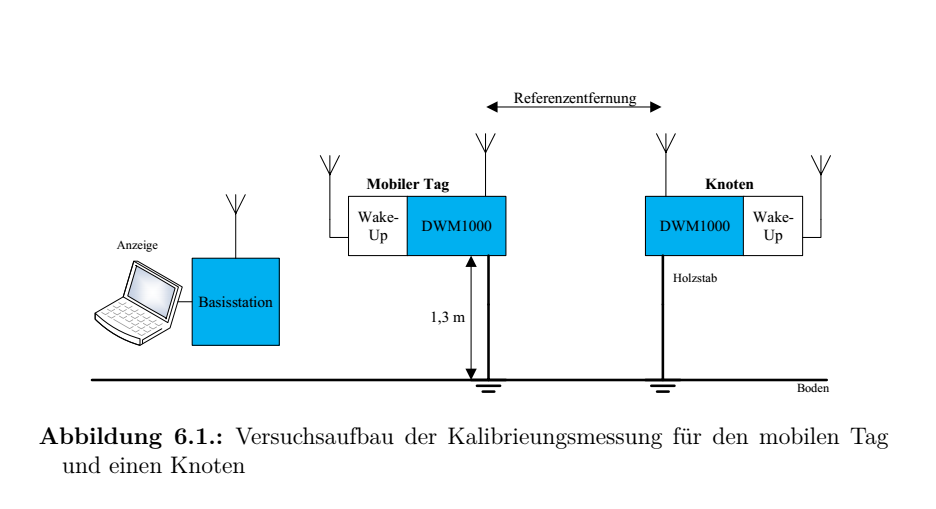


(‘C:\Users\Yitong\Documents\GitHub\thesis\_indoorLocalization\improvment in hareware\compare in numUsafule meas.fig’)

5-- 4 Measurements Collection and Analysis

4.1.1 Calibration

Set up (3,4,5,6,7,8,9m)

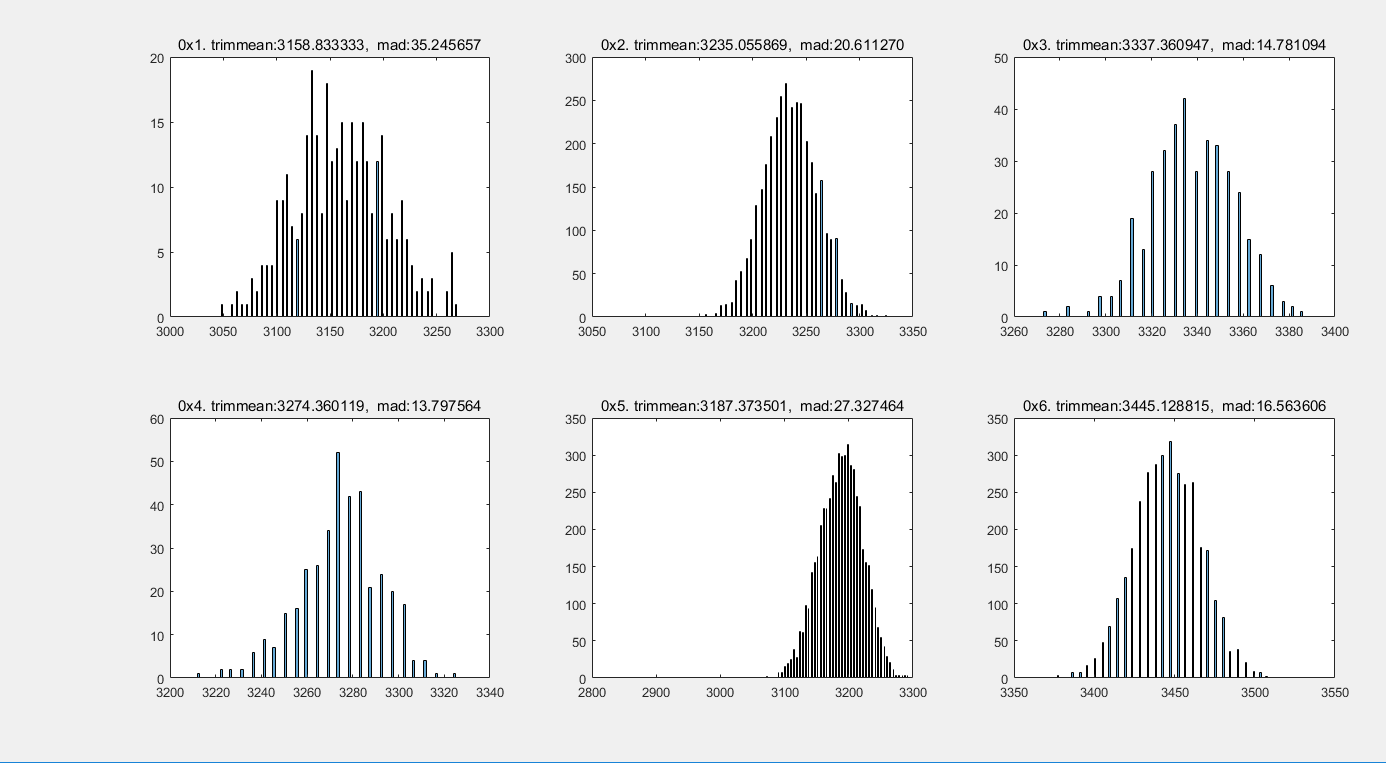


(pic from ‘Patrick thesis P64’)

Measurements Distributions

.................................. heavy tail in front

34568m



(ktest, ztest... results)

...

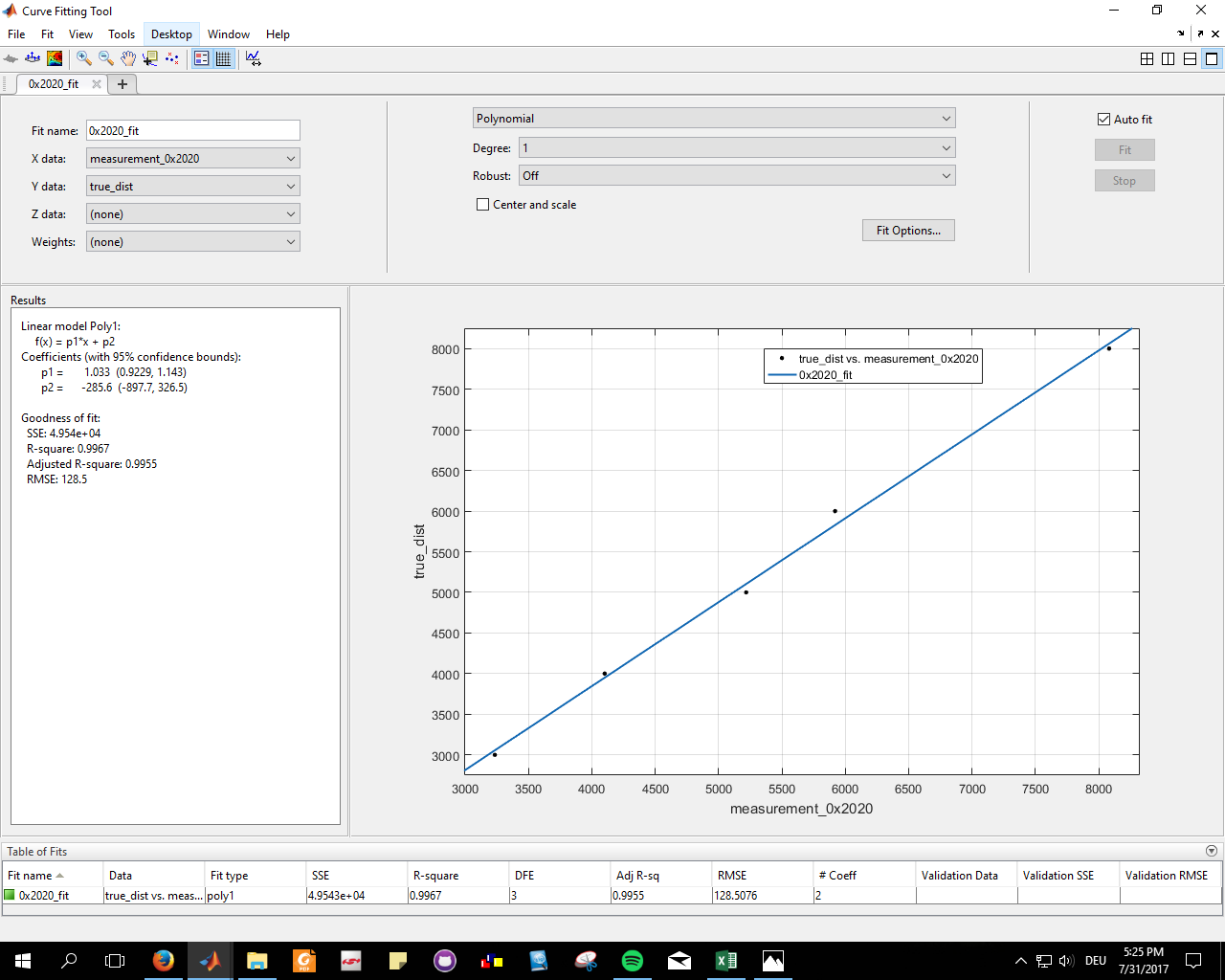
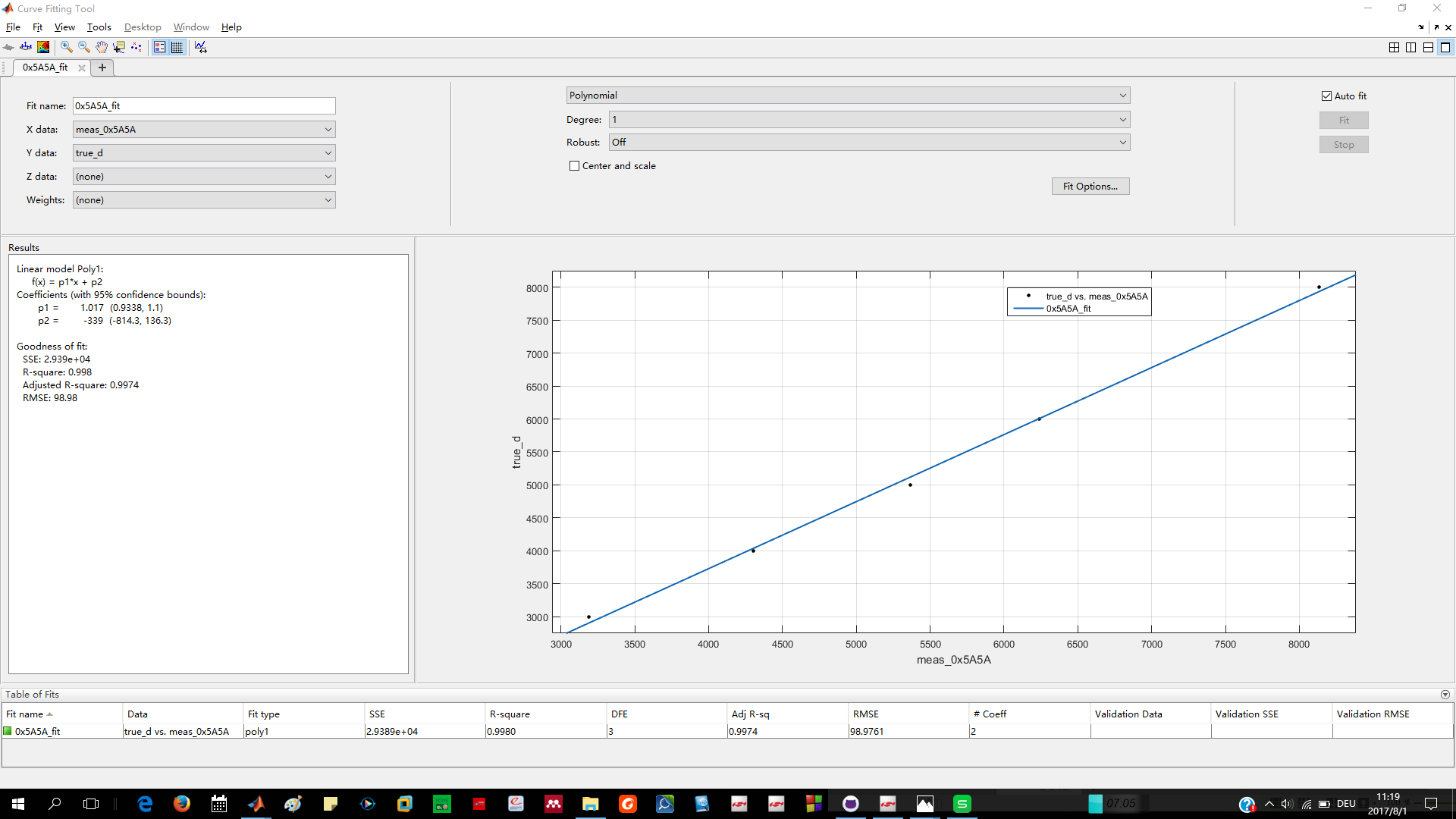
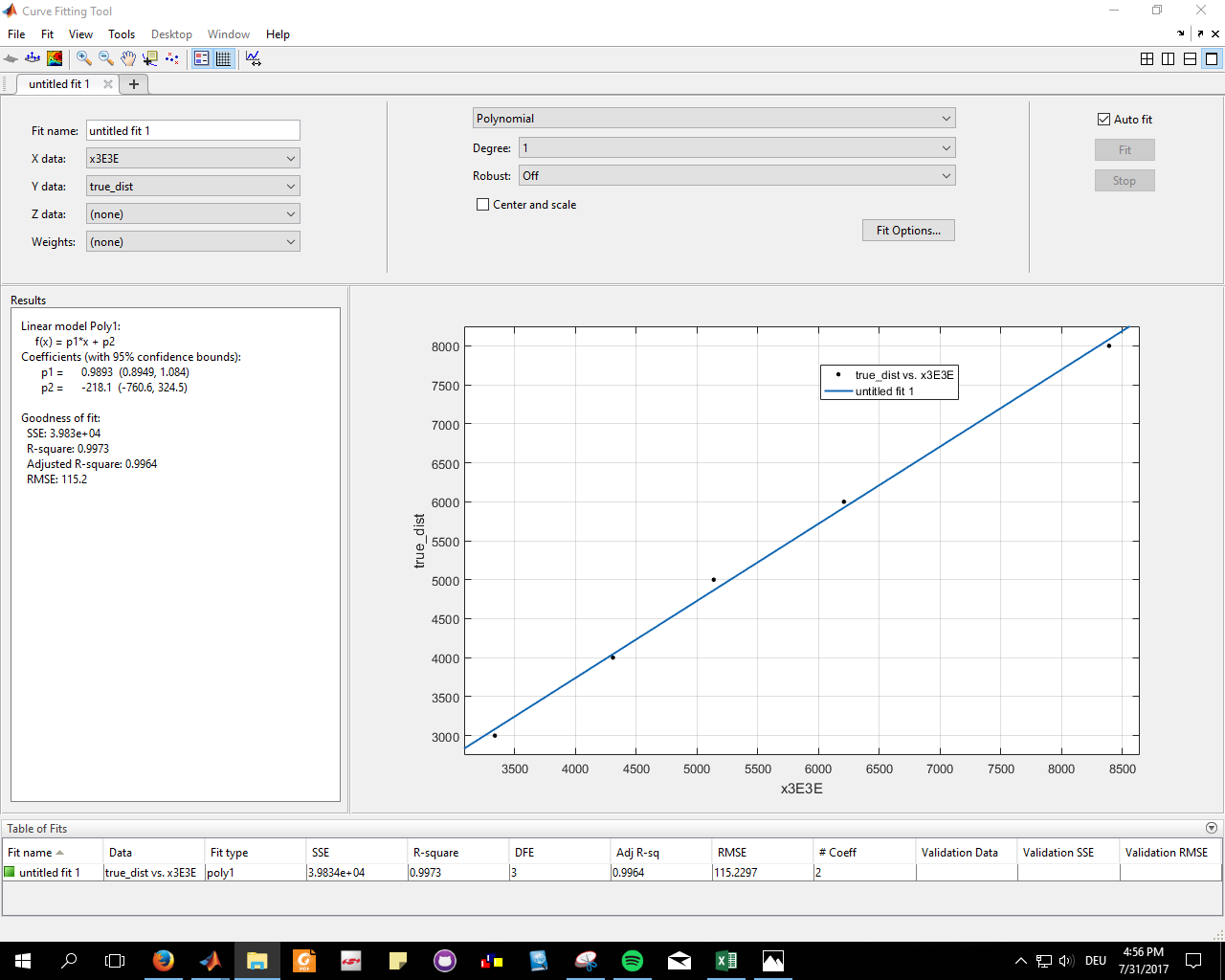
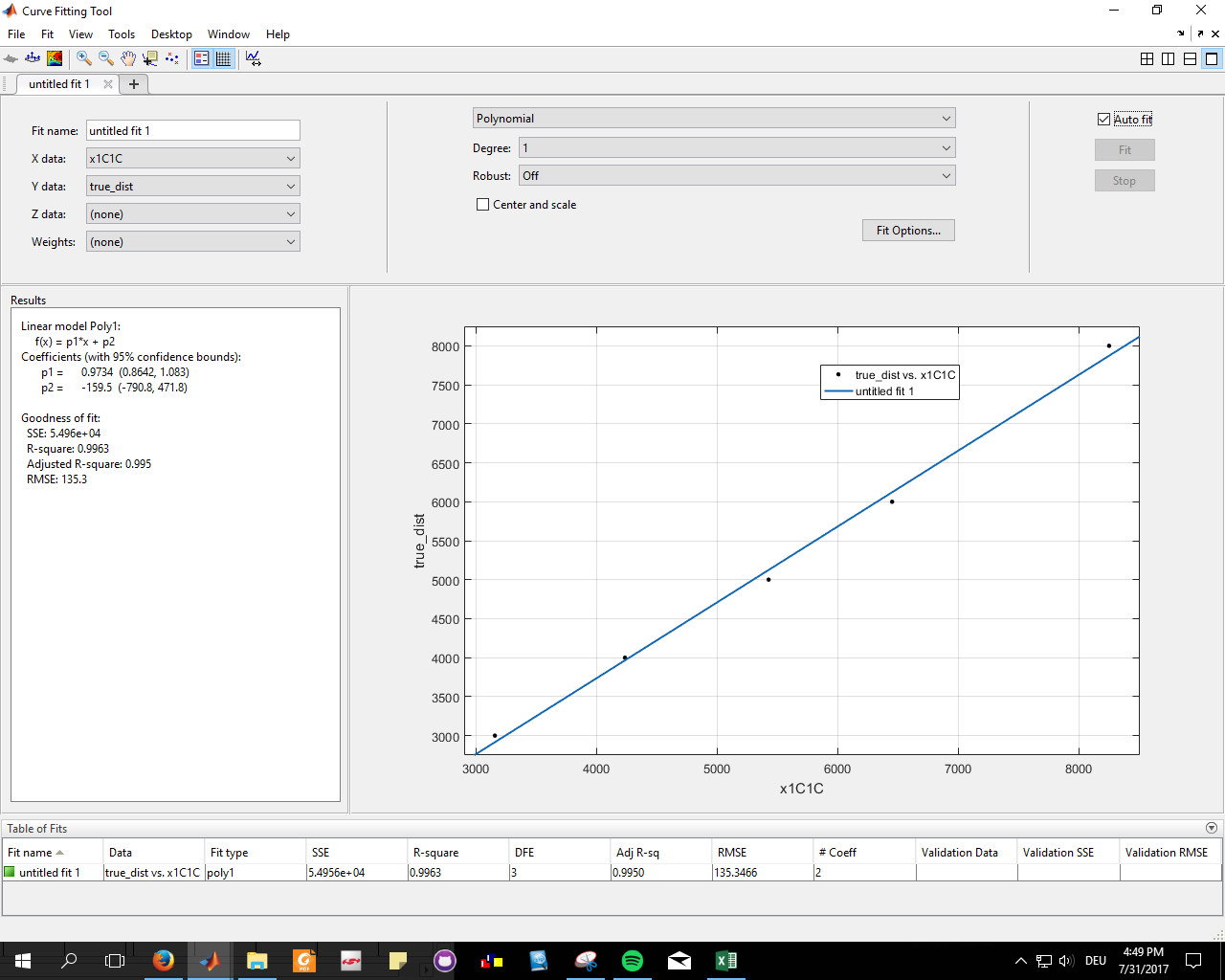
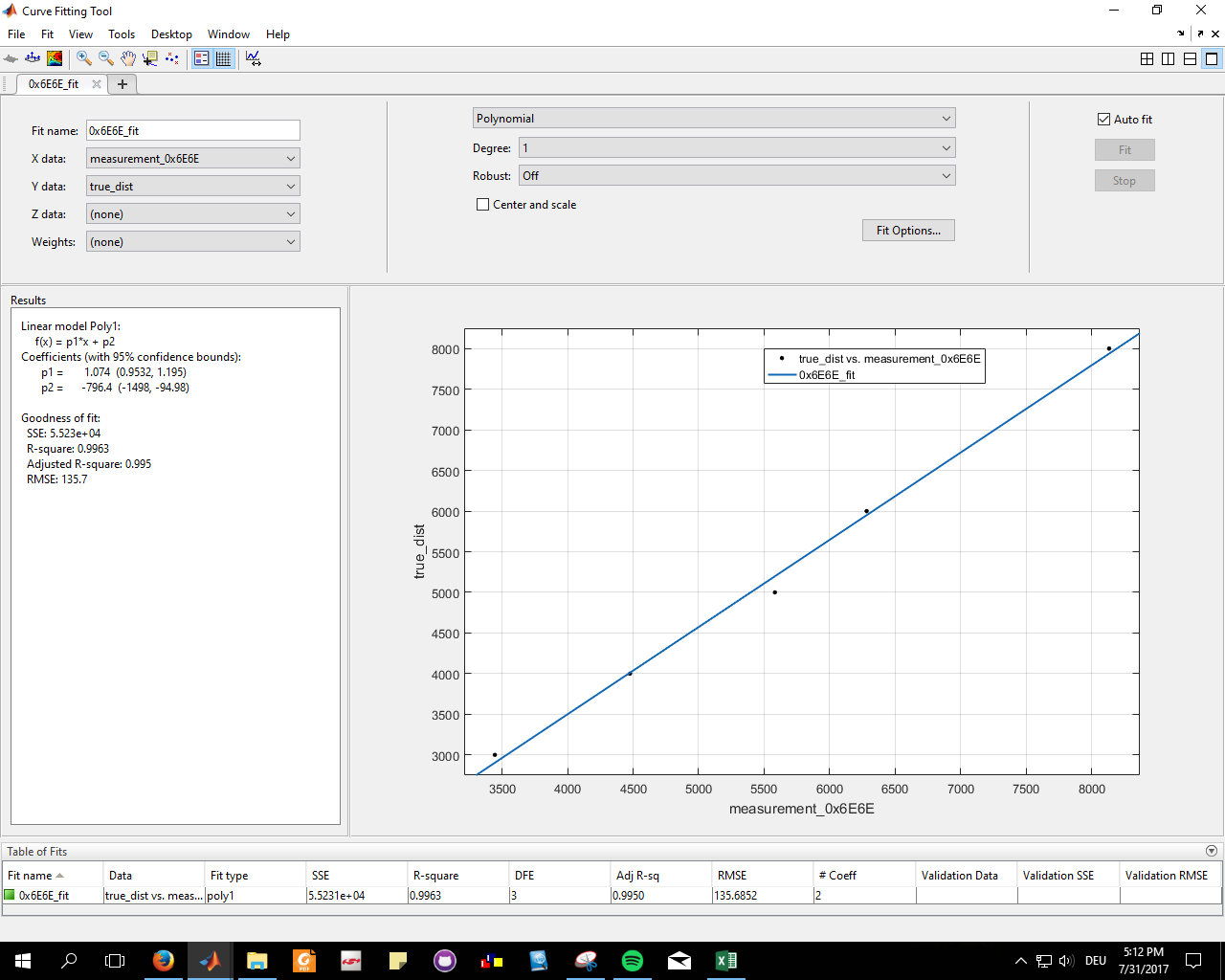
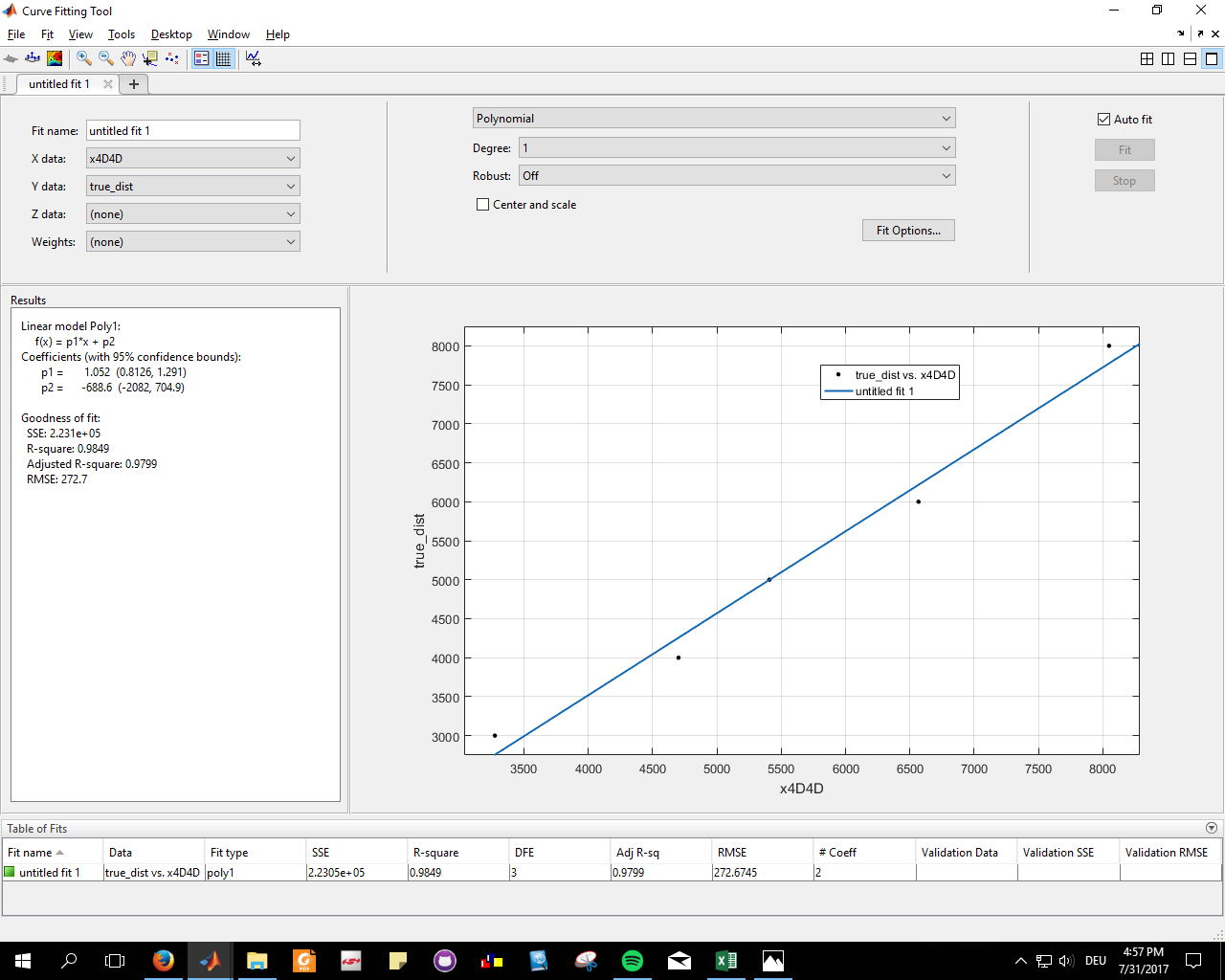
‘thesis\_indoorLocalization\communicate\_with\_basis\_station\_in\_matlab\calibrations\outdoor\OUTDOOR\_MEASUREMENT\_07\_27\_2017\histogram’

Trimmean and mad useage.

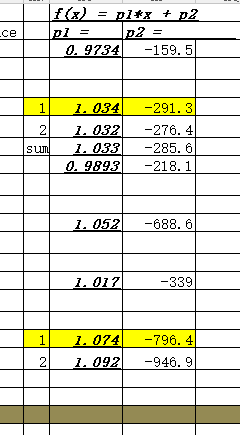
Trimmean for calibration

Mad for R

Calibration results



‘thesis\_indoorLocalization\communicate\_with\_basis\_station\_in\_matlab\calibrations\outdoor\OUTDOOR\_MEASUREMENT\_07\_27\_2017\fitting\_0x1C1C.PNG’



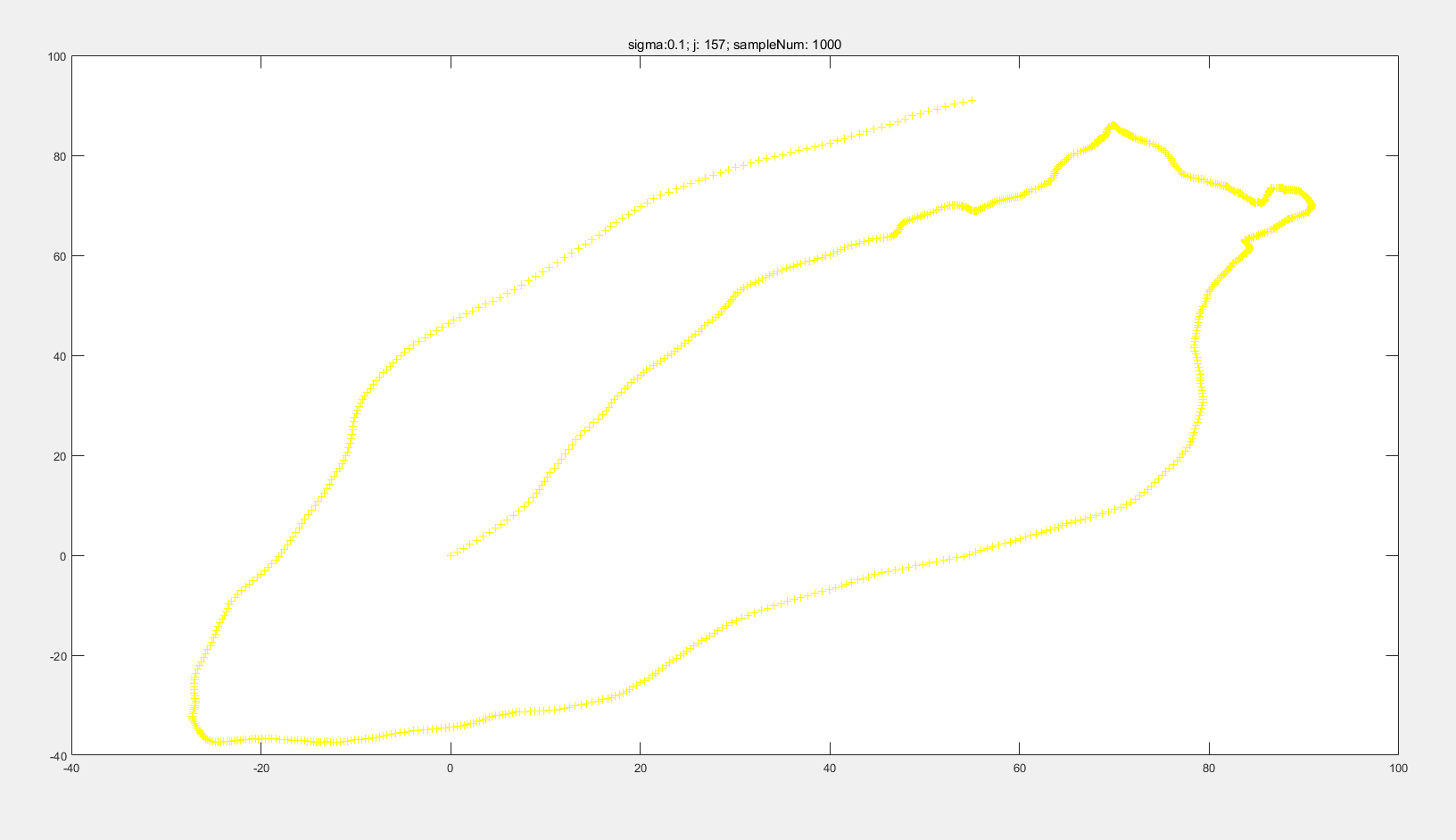
**(mad, trimmean)**

‘thesis\_indoorLocalization\communicate\_with\_basis\_station\_in\_matlab\calibrations\outdoor\OUTDOOR\_MEASUREMENT\_07\_27\_2017\outdoor\_calibration\_results.xlsx’

4.1.2 Data Collections

5 Experiments Base on Simulations data

5.1 generating moving trajectories

(unit m)

(‘\thesis\_indoorLocalization\trajectory\goodTraj01’)

Algo::Code:(\thesis\_indoorLocalization\trajectory\TrajectoryGenerator\_plot\_onlyONE\_qualified\_with\_changing\_Sigma.m)

5.2 choosing Positions of Anchor-Nodes

>2m

Cover the traj in the acceptable range, which the signal still can be reached to most of the nodes

5.3 EKF without noisy distance data

5.3.1 choosing the right parameter for EKF

Q/R big trusts more on measurements, vercise wise...the motion model is randon, not so well simlated , so try to make the Q big.

Q/R big or small results

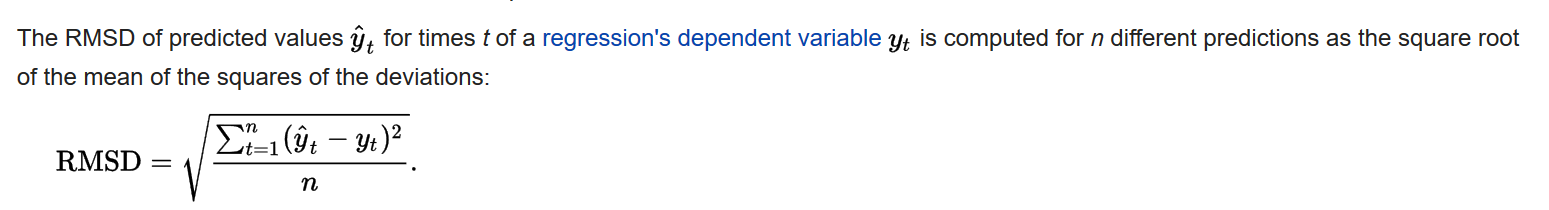
5.3.2 different strategies of processing incoming data

5.3.2.1 evenly distributed sampling in time domain

5.3.2.2 uneven distributed sampling in time domain

5.3.3 Results

**root-mean-square error (RMSE)** is a frequently used measure of the differences between values (sample and population values) predicted by a model or an estimator and the values actually observed.(wikipedia)

(wiki)

**RMSE v.s. ratio of Q/R**

(C:\Users\Yitong\Documents\GitHub\thesis\_indoorLocalization\KalmanFilter\KF\_traj\results\same R to generate noise\data not missing) (results are not calculated by RMSE, but this way[*mis\_match = sum(mis\_pos(1,:).^2 + mis\_pos(2,:).^2) / size(X,2) / area\_of\_map;*]) convert back to RMSE

RMSE = sqrt( *mis\_match\*area\_of\_map ) =* sqrt( *mis\_match\*140\*140). (PS 140 unit m)*

*When data is not enough , this set can be use ’differ R to generate noise’*

(C:\Users\Yitong\Documents\GitHub\thesis\_indoorLocalization\KalmanFilter\KF\_traj\results\differ R to generate noise\fig\_goodTraj01)



5.4 EKF with noisy distance data

5.4.1 noisy data generatation(add noise / delete data)

(add noise according to the R from mad)

delete data (randon delete; in a specific order to reproduce the cinario of 25ms40Hz case)

5.4.1 choosing the right parameter for EKF (XXX)

5.4.2 Results

25ms40Hz case

‘C:\Users\Yitong\Documents\GitHub\thesis\_indoorLocalization\KalmanFilter\KF\_traj\EKF\_25ms40Hz\25ms\_40HzSamplingRate’

**RMSE v.s. ratio of Q/R**

**RMSE v.s. number of missing meas**

**RMSE (noisy free vs noisy)**

5.5 Self-Calibrations for Anchor-Nodes

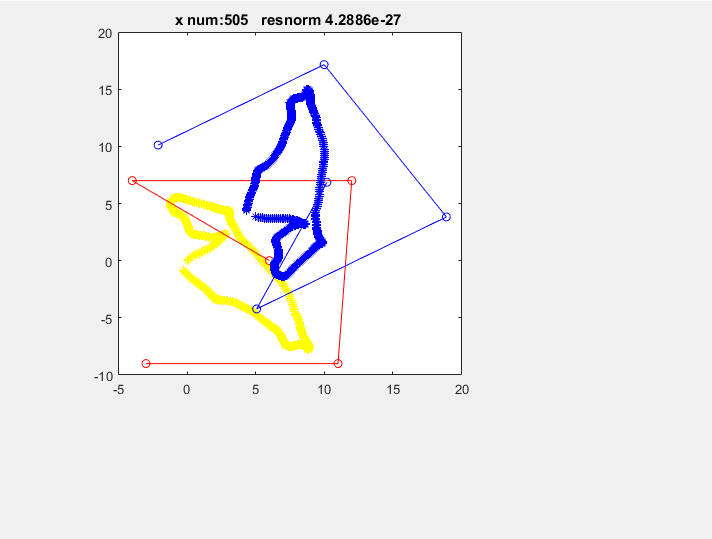
550 principle and method(optimization)

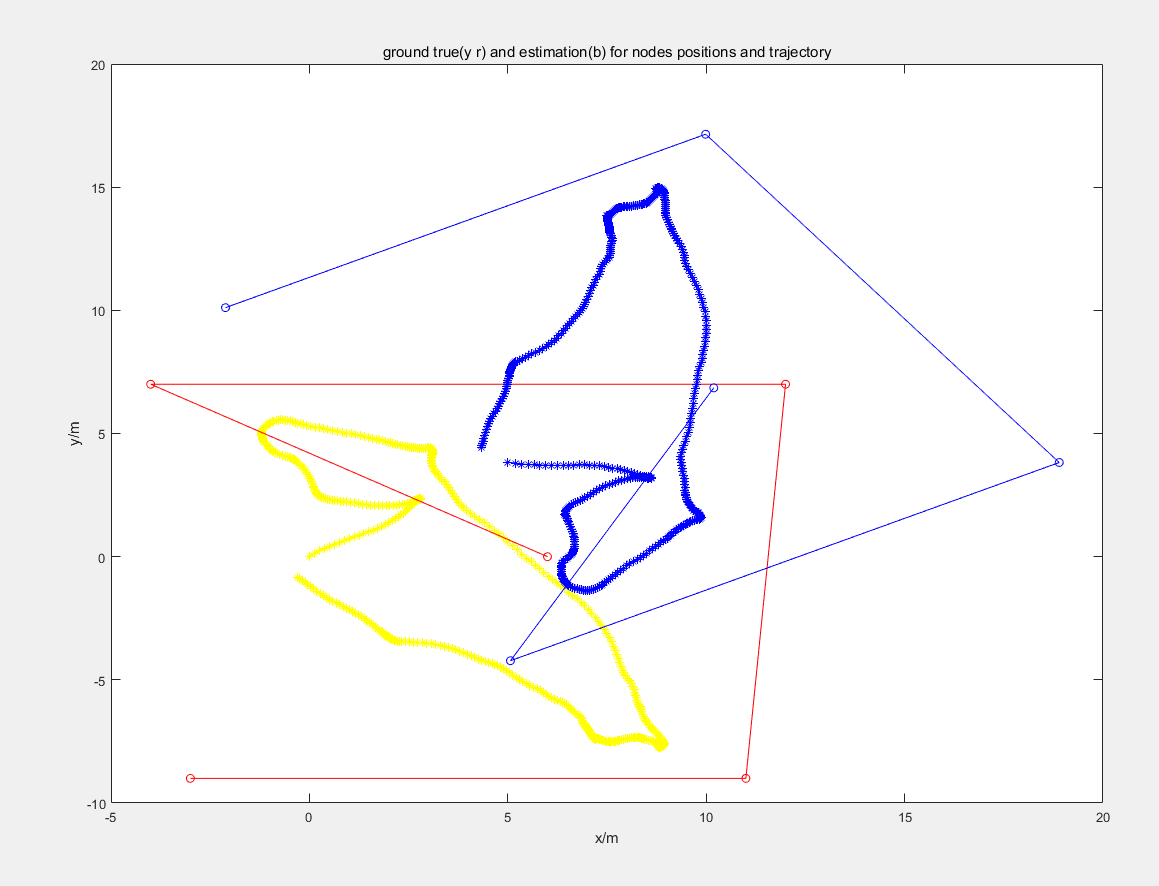
5.5.1 performance effected factors

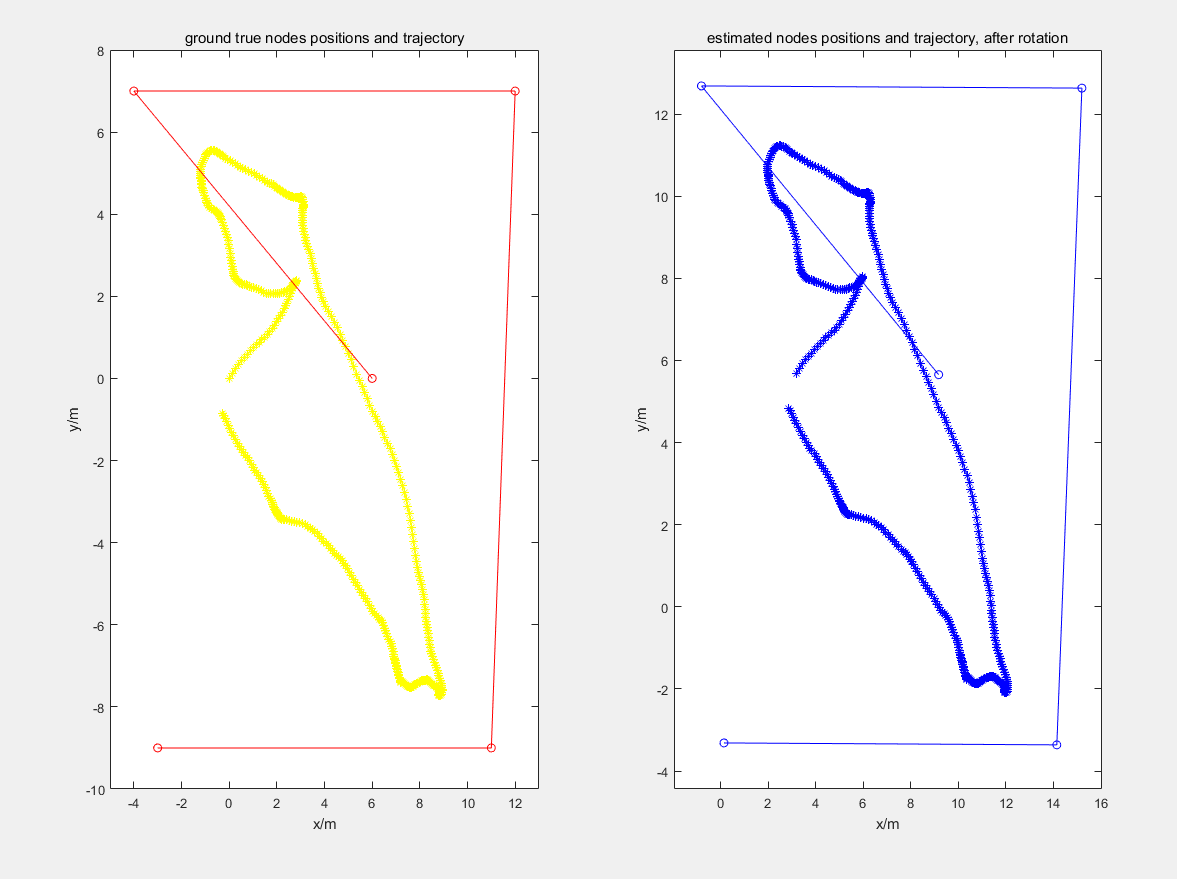
5.5.1.1 number of trajectory points and Anchor-Nodes

5.5.1.2 distributions of the Anchor-Nodes and the trajectory

5.5.2 results







(TODO: apply transform to it)

‘C:\Users\Yitong\Documents\GitHub\thesis\_indoorLocalization\Calibration-Free Localization\simulation\_results’

7-- 6.Experiments based on measurement data

6.0 environment set up

Hangar set up

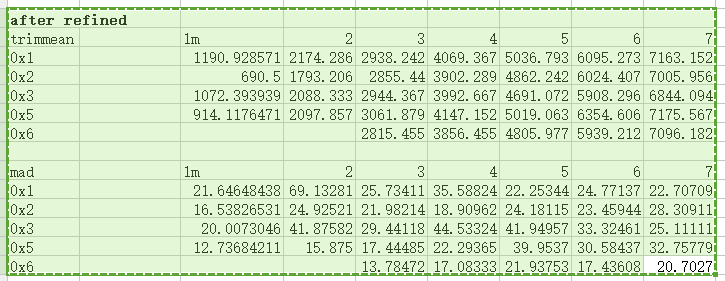
§(size of room,

§ position of nodes : range & other unmovable facility

§ position of ASSIST anchor-nodes

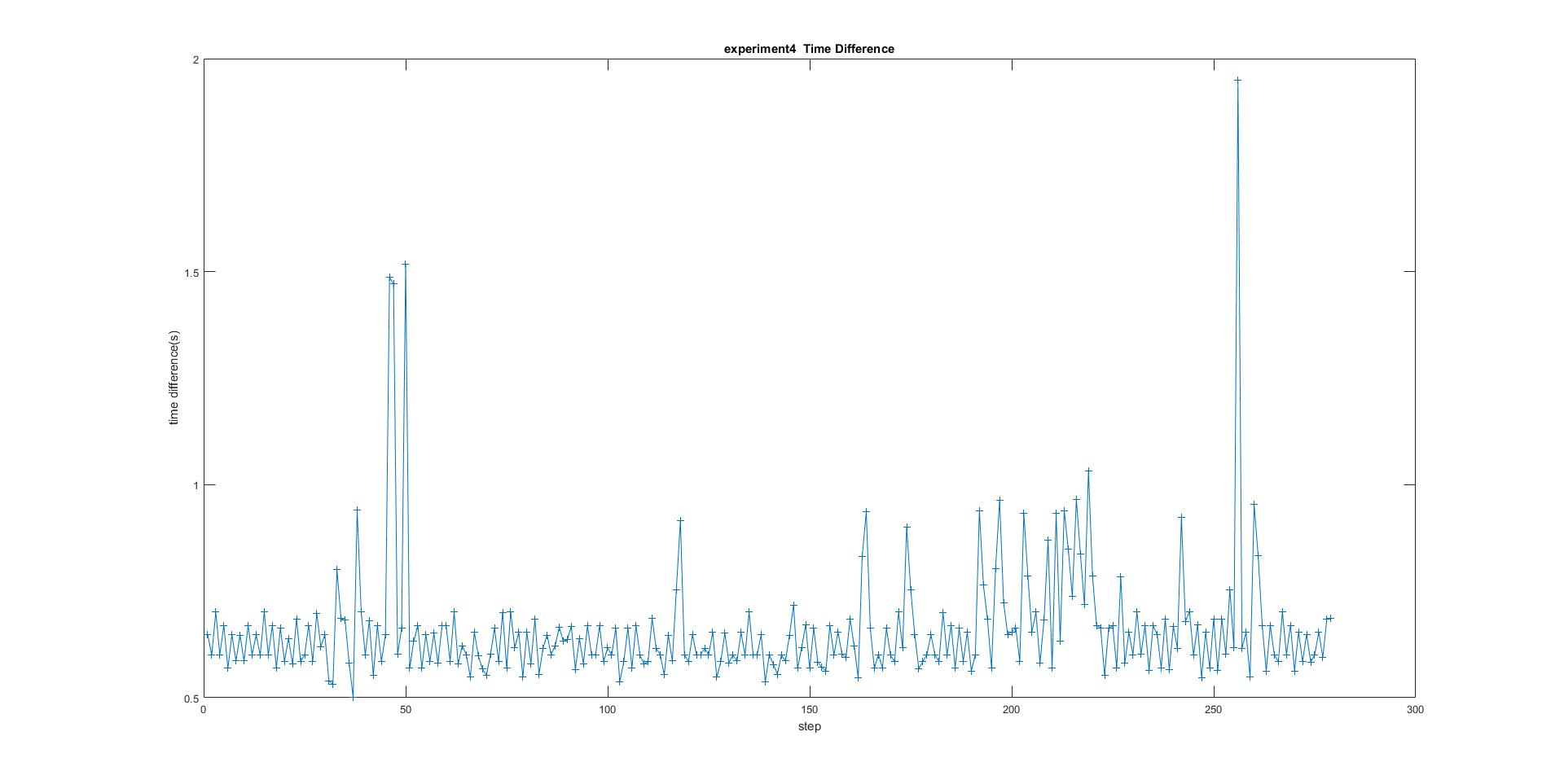
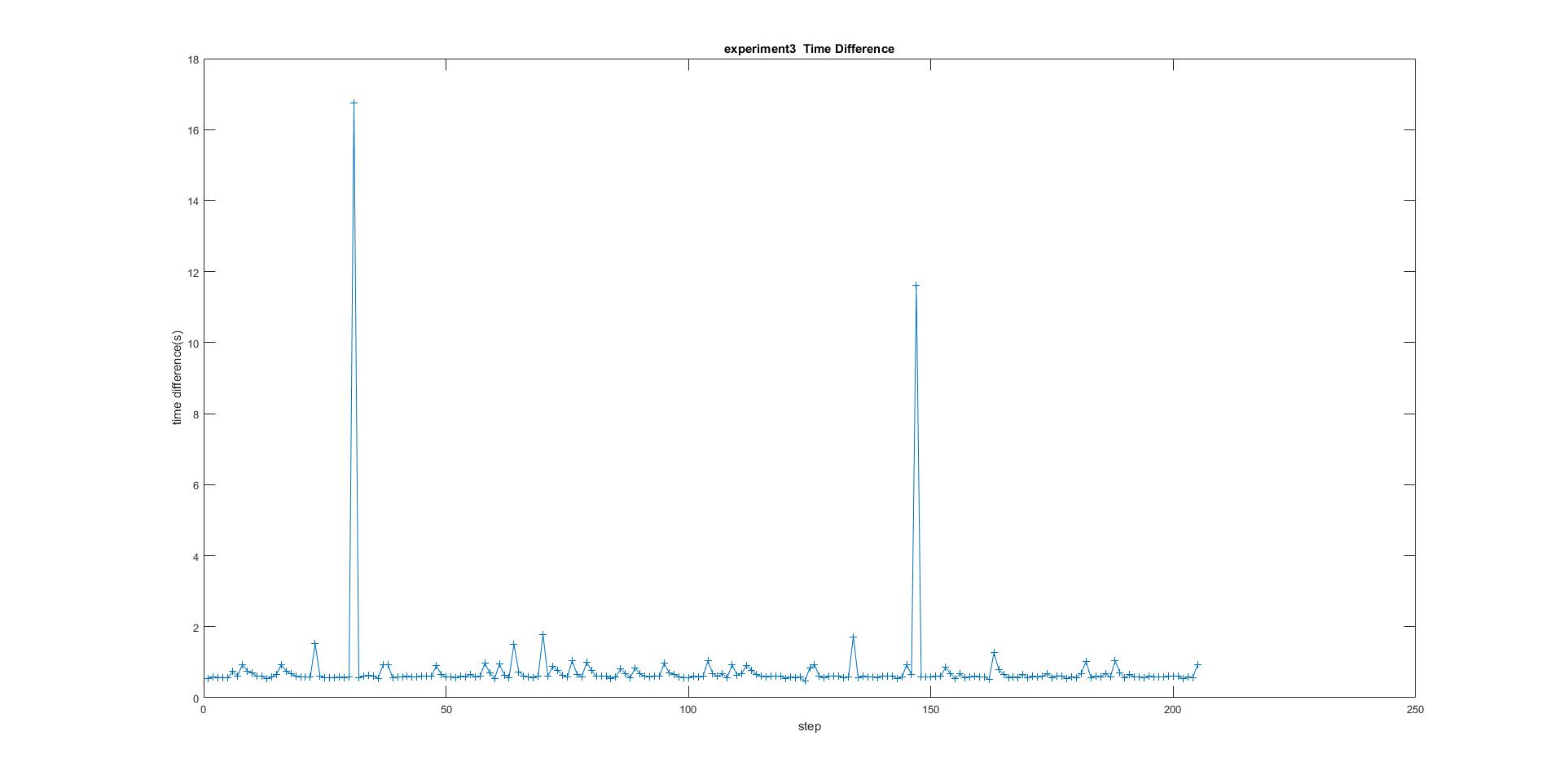
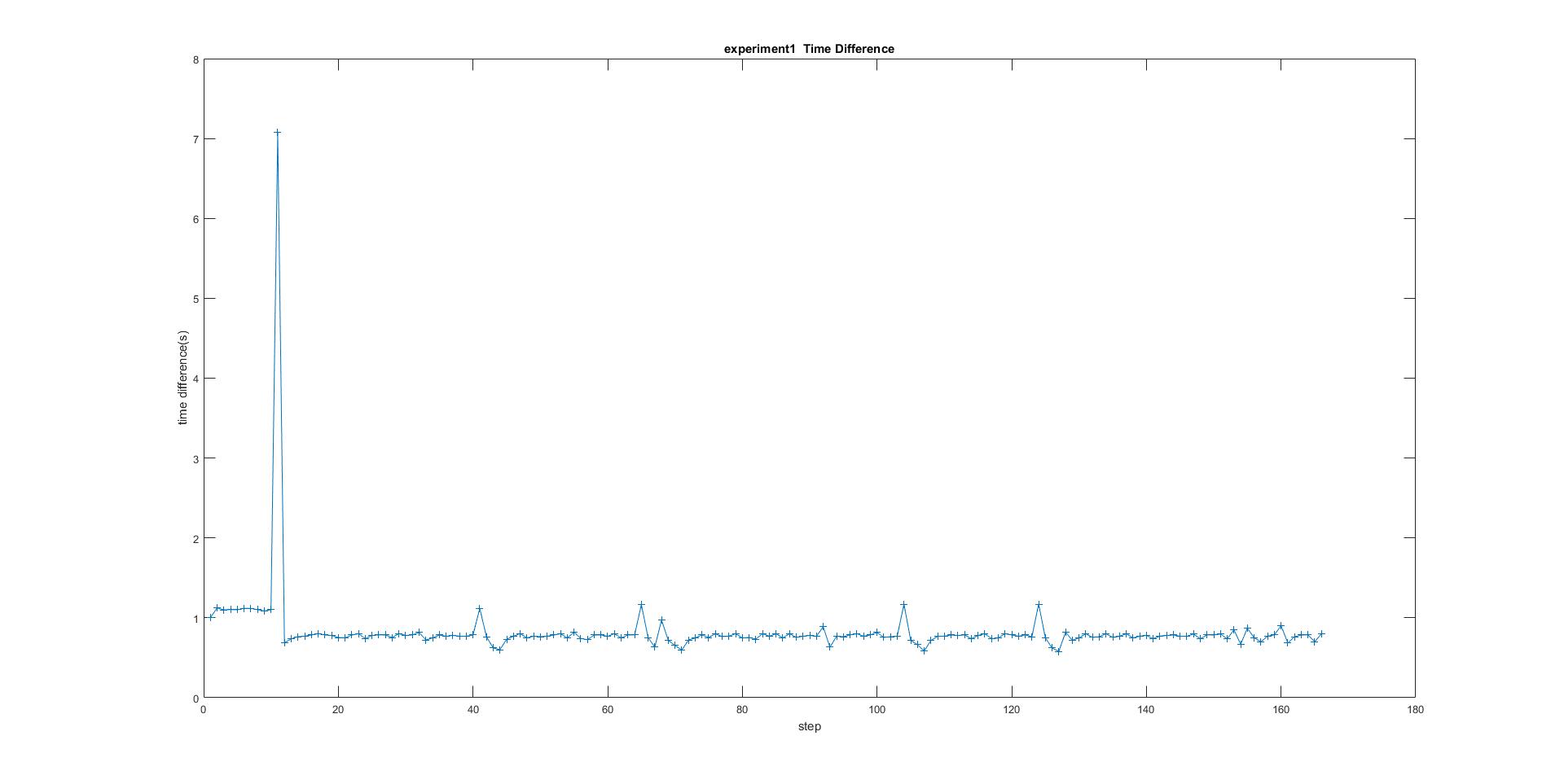
6.1 -- data analysis

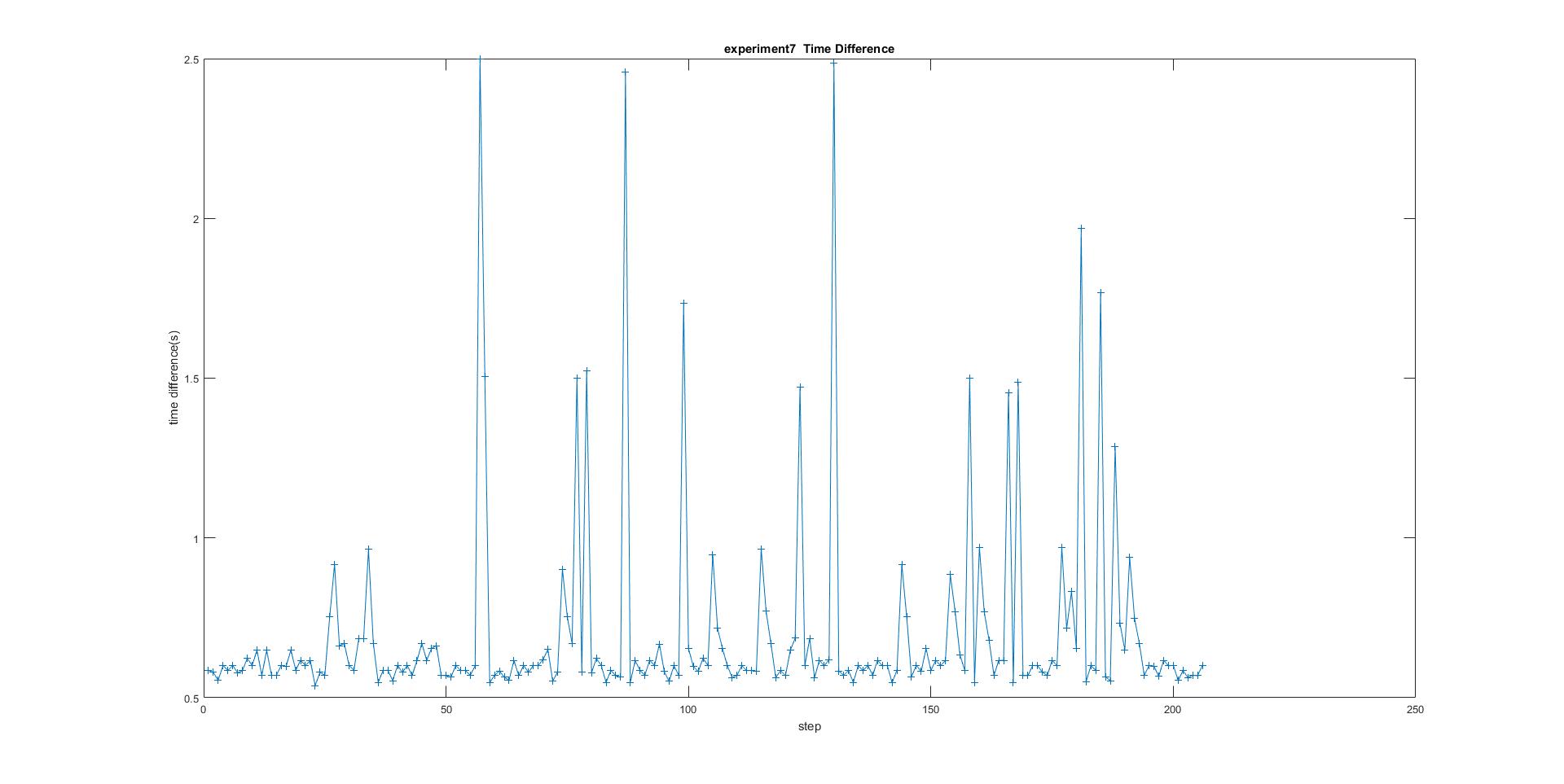
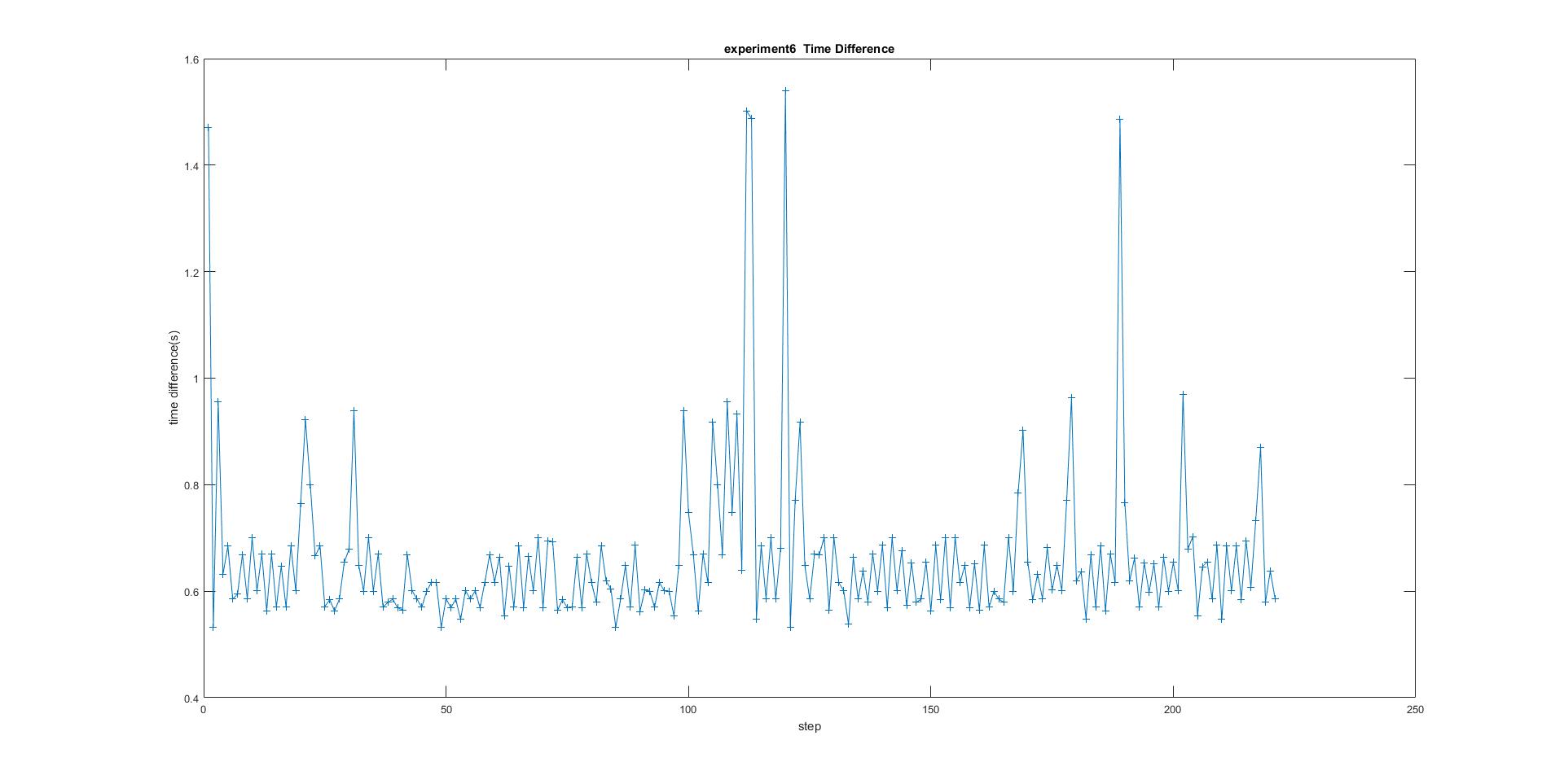
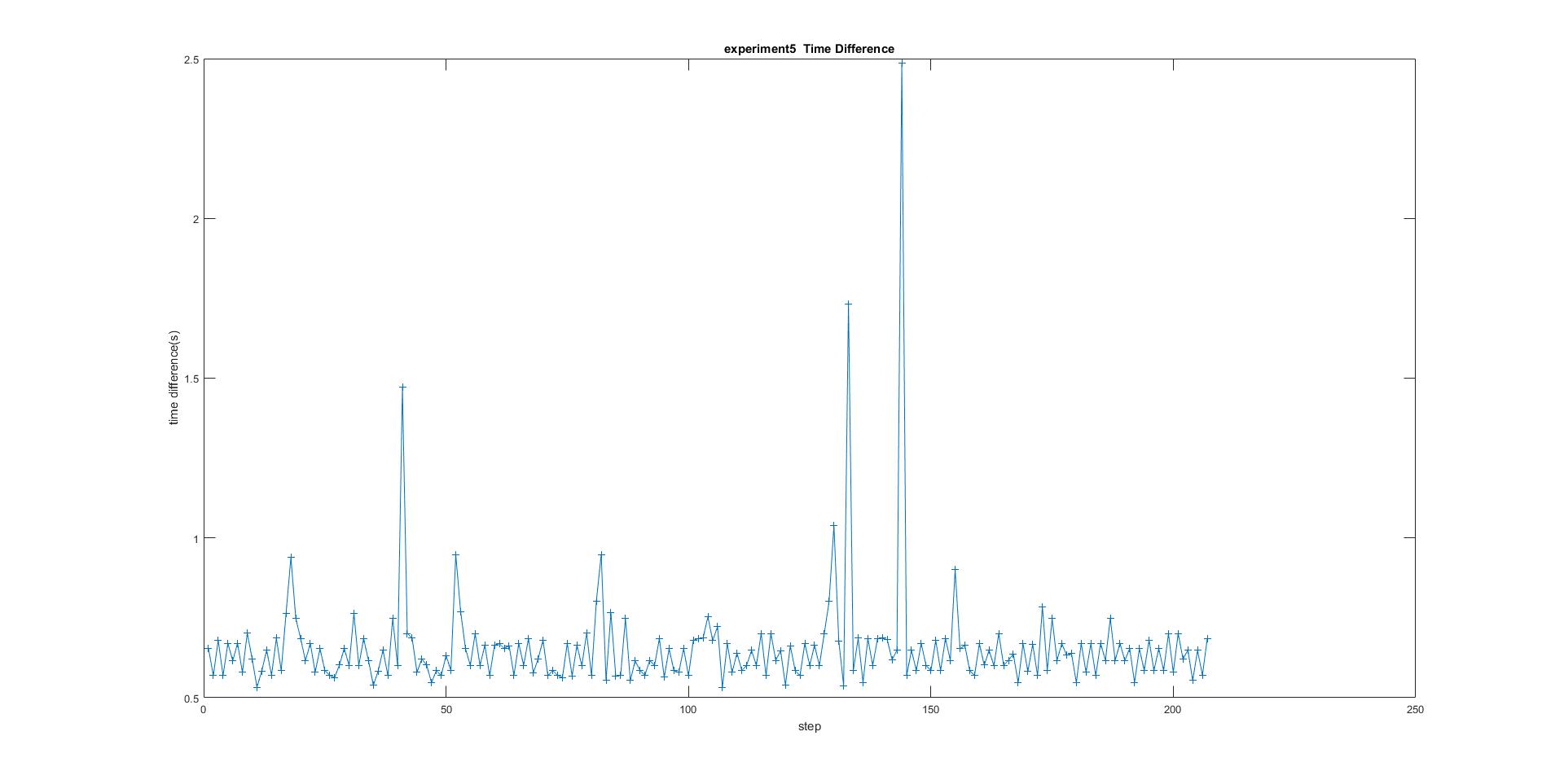
Calibration results in the same environment as the experiments run

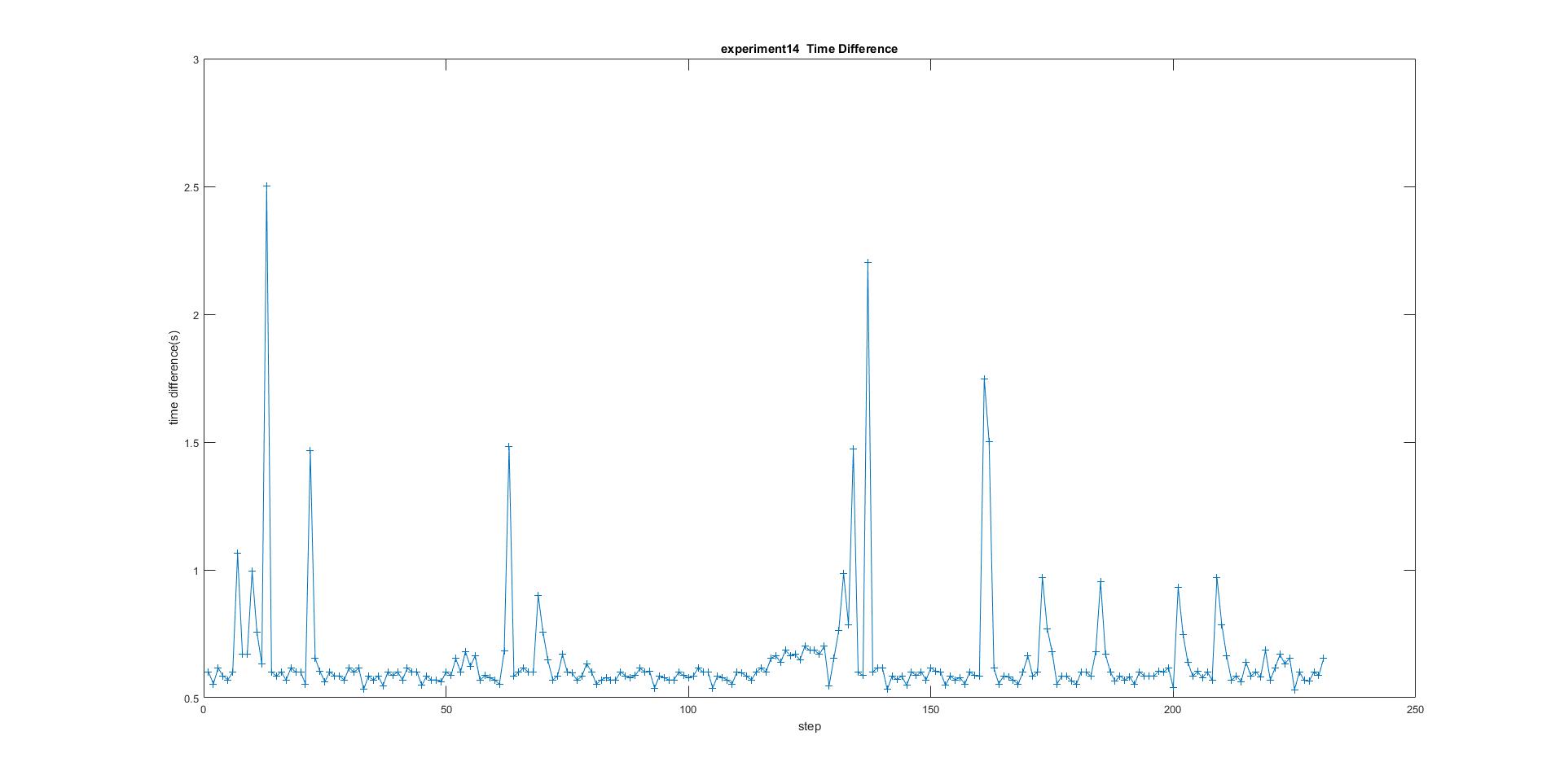
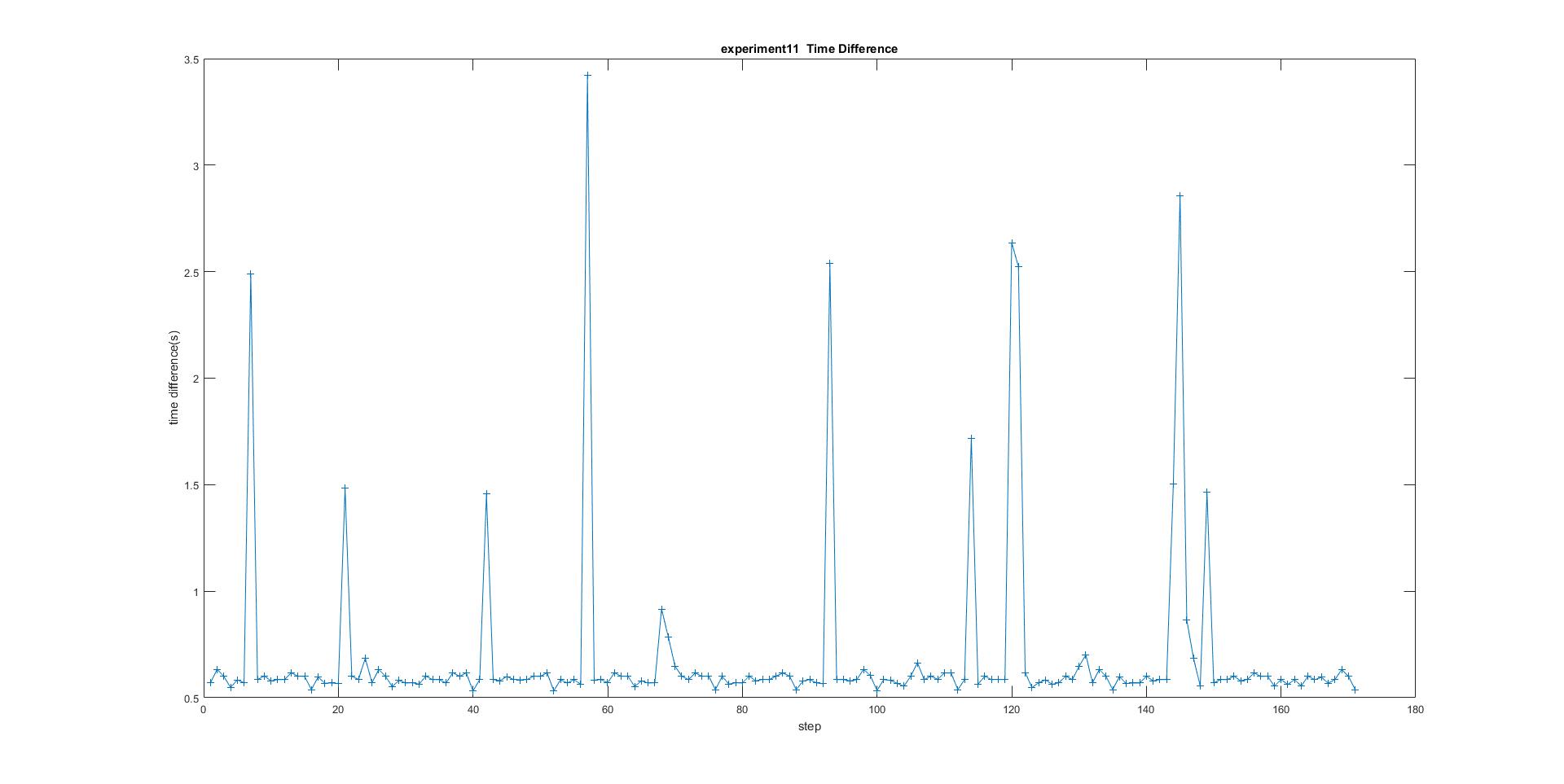
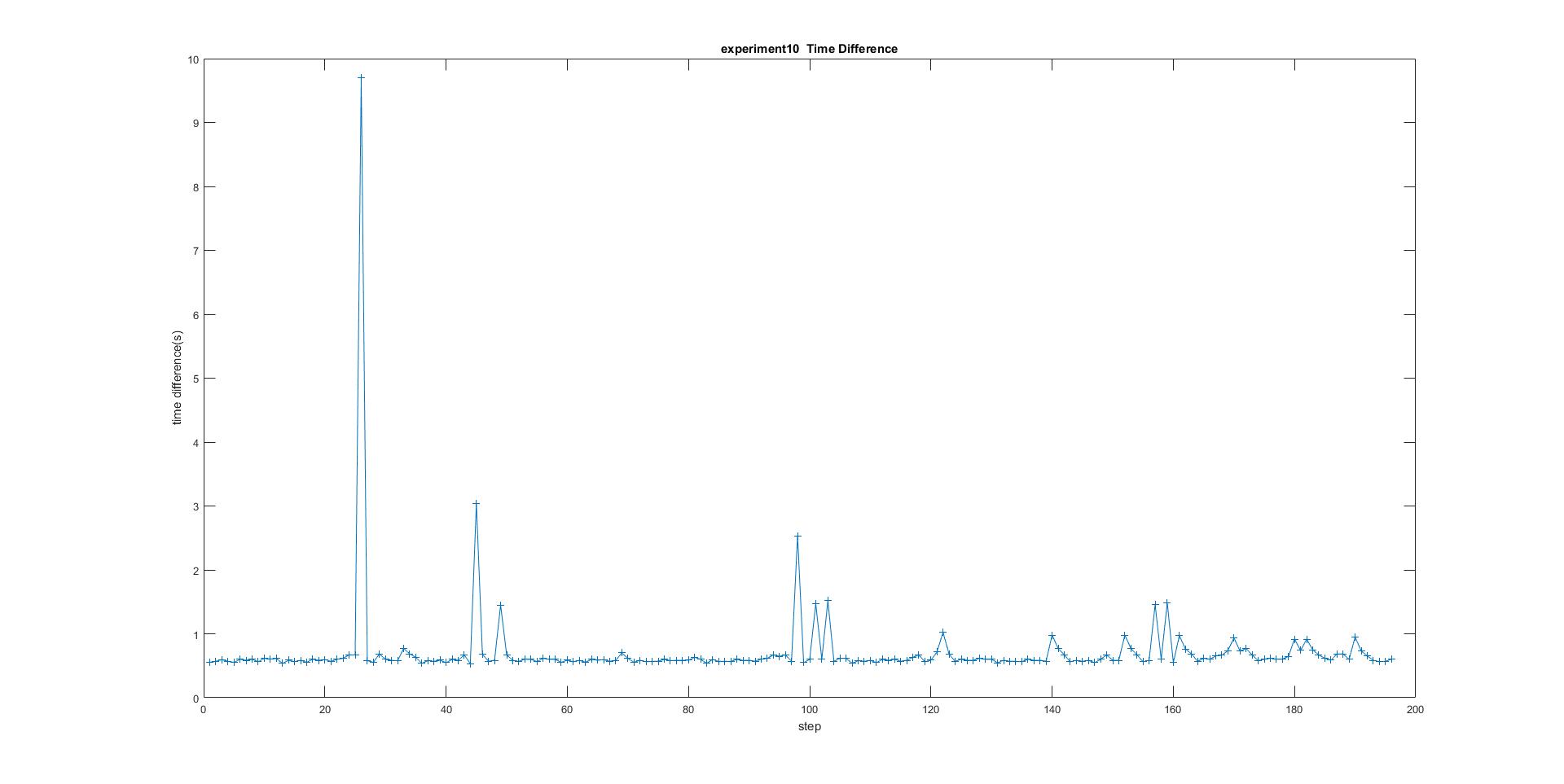
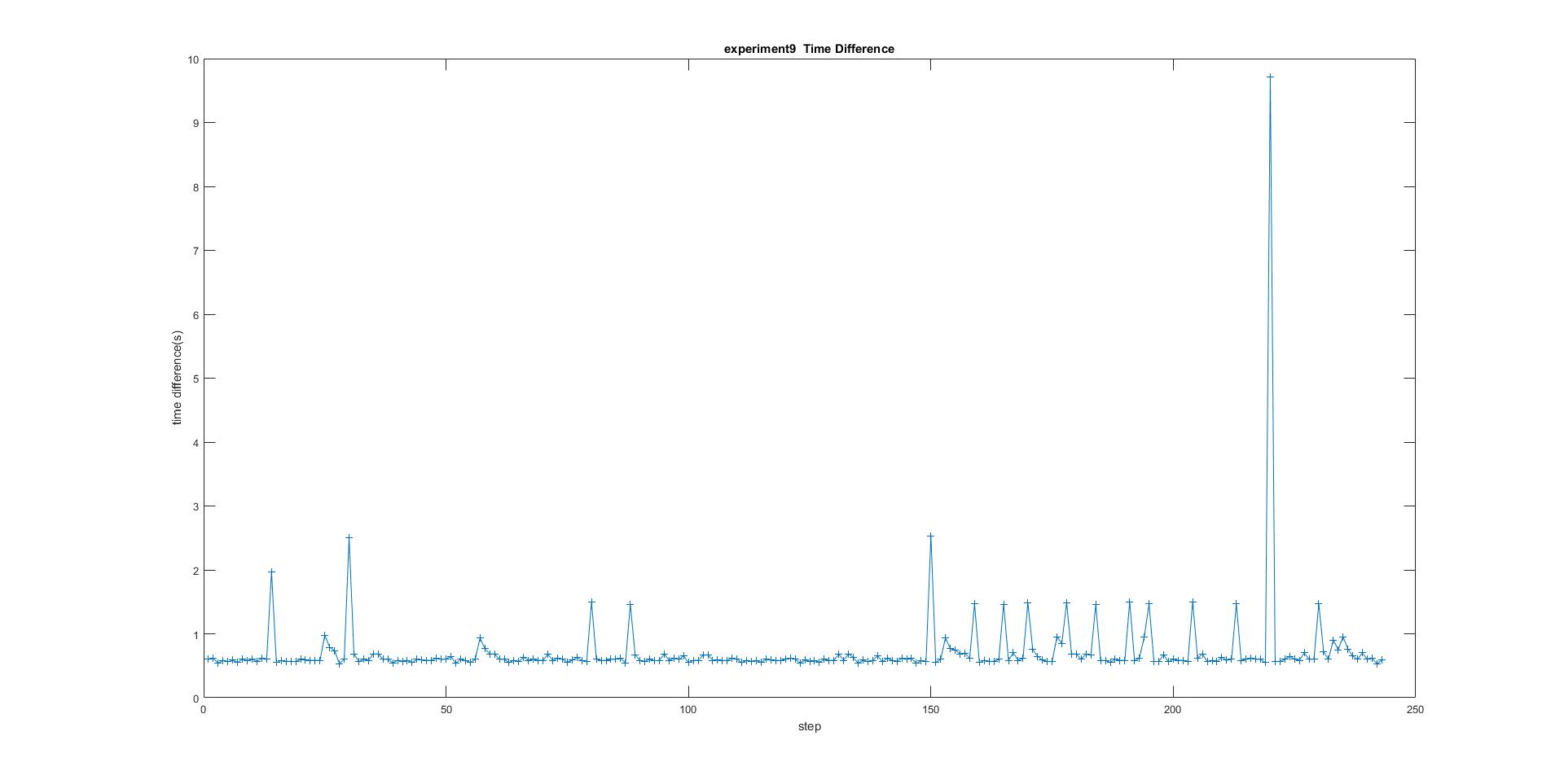
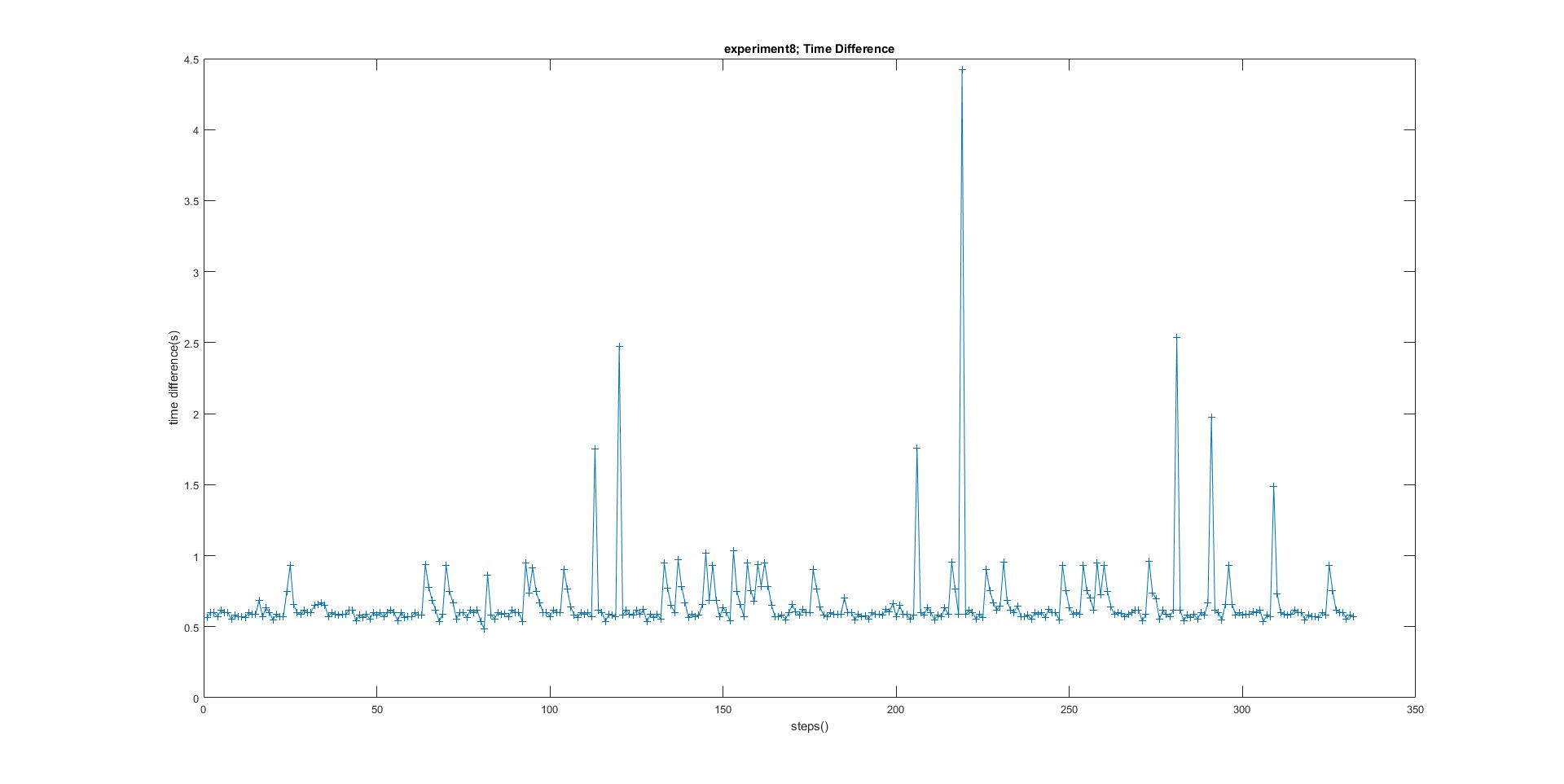


‘D:\Yitong\GitHub\thesis\_indoorLocalization\data-from-experiments\experiment\_12.Oct.2017.Hangar\CALIB\calib\_statistic.xls’

Time diff in exper

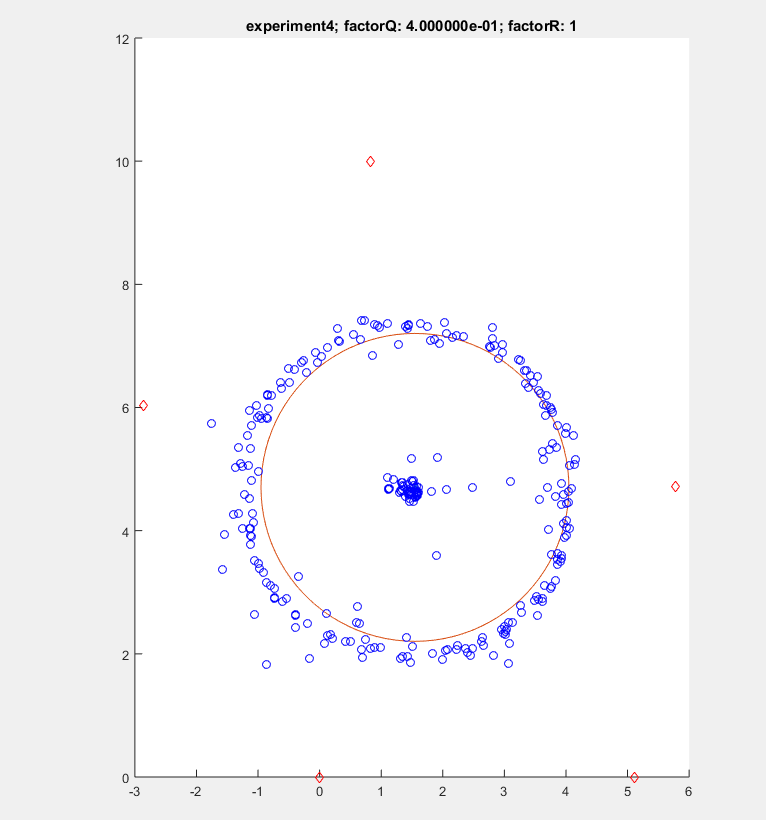






6.1 EKF with Measurement data

6.1.1 choosing the right parameter for EKF



‘D:\Yitong\GitHub\thesis\_indoorLocalization\data-from-experiments\experiment\_12.Oct.2017.Hangar\record\_of\_HTerm\traj\_recovered\_ekf\_experiment\_other’

Remove outliars with methods data mitigation

All kinds of fig(hist, std-mad, time-diff, exper4\_posiVSnumbMeasurements\_2\_1. etc)

‘D:\Yitong\GitHub\thesis\_indoorLocalization\data-from-experiments\experiment\_12.Oct.2017.Hangar\record\_of\_HTerm\outlier\_removement\exper4’

6.1.2 Results Compare with other system

Rotation algo base on the points with closest time stamp (due to diff sampling rate in diff system)

^^Compare with assist

ASSIST results

’D:\Yitong\GitHub\thesis\_indoorLocalization\data-from-experiments\experiment\_12.Oct.2017.Hangar\record\_of\_ultra\_sound\_system’

^^Compare with MOCAP

6.2 Self-Calibrations for Anchor-Nodes

6.2.1 Results

6.3 25ms40Hz

6.3.1 data mitigation

6.4 first self calibration then EKF

RMSE (VS hand meas resultingEKF)