6 Evaluation and Conclusion

6.1 Evaluation

6.1.1 Characterization of Localisation Accuracy

Experiments Inside the Energy Lab

To reliably evaluate the accuracy of the proposed indoor localisation algorithm, a walking model for the robot was designed, its measured track was collected through static UWB tag (frequency = 10 Hz) and corresponding X and Y coordinates are in 6.1:

Listing 6.1: Measured Ground Truth From UWB

```
xs: [5.799013605442178, 5.677136752136748, 5.703061068702290, 5.09885606060606,
    5.120082644628101, 4.572519379844961, 4.478495575221241, 2.03554054054054]
ys: [4.865020408163268, 4.234247863247866, 3.7864122137404563, 3.554515151515152,
     3.1047024793388442, 2.931767441860464, 2.4959646017699106,
    2.353558558558559]
```

It's a series of command of *move* and *rotate*:

From the commands we can know, the robot has moved 5.8m in total in each single experiment. We sample 50 data in each experiment, which is about every 0.116m a point, and calculate *mean error* and *variance* based on the ten experiments and the result is:

```
mean = 0.24249670463171374 m, variance = 0.033868014433167205 m²
```

Assuming the initial pose [5.799013605442178, 4.865020408163268] is correct, based on the given commands we can also derive a theoretical track as bias correction, as shown in Figure 6.1.

By remote control, the filter result is shown in Figure 6.2.

Algorithm 1 Commands

procedure CONTROL
  move forward 0.7m
  rotate counter-clockwise 30°
  move forward 0.5m
  rotate counter-clockwise 30°
  move forward 0.5m
  rotate clockwise 150°
  move forward 0.5m
  rotate counter-clockwise 90°
  move forward 0.5m
  rotate clockwise 90°
  move forward 0.6m
  rotate counter-clockwise 90°
  move forward 2.5m

Experiments In the Corridor

In order to further evaluate the effect of kalman filter, experiments were also conducted in the around $30m \times 2.293m$ corridor. Considering that the maximum working distance of UWB is approximately 30 m, five UWB units were configured as anchors and the fusion result is in Figure 6.3.

Experiments In the Hall of APB

In order to further evaluate the effect of kalman filter, experiments were also conducted in the around $18.573m \times 13.657m$ hall of APB. Four UWB units were configured as anchors and the fusion result is in Figure 6.4 .

A random walk in the hall was also conducted, in which the robots stopped at where it started, as shown in Figure 6.5.

6.1.2 Observation

Compare different experiment results we can know, smoothing filter result heavily depends on the fluent remote control process, which is not always the case. It would always be harder to control the robot to follow a straight line rather to move randomly and smoothly.

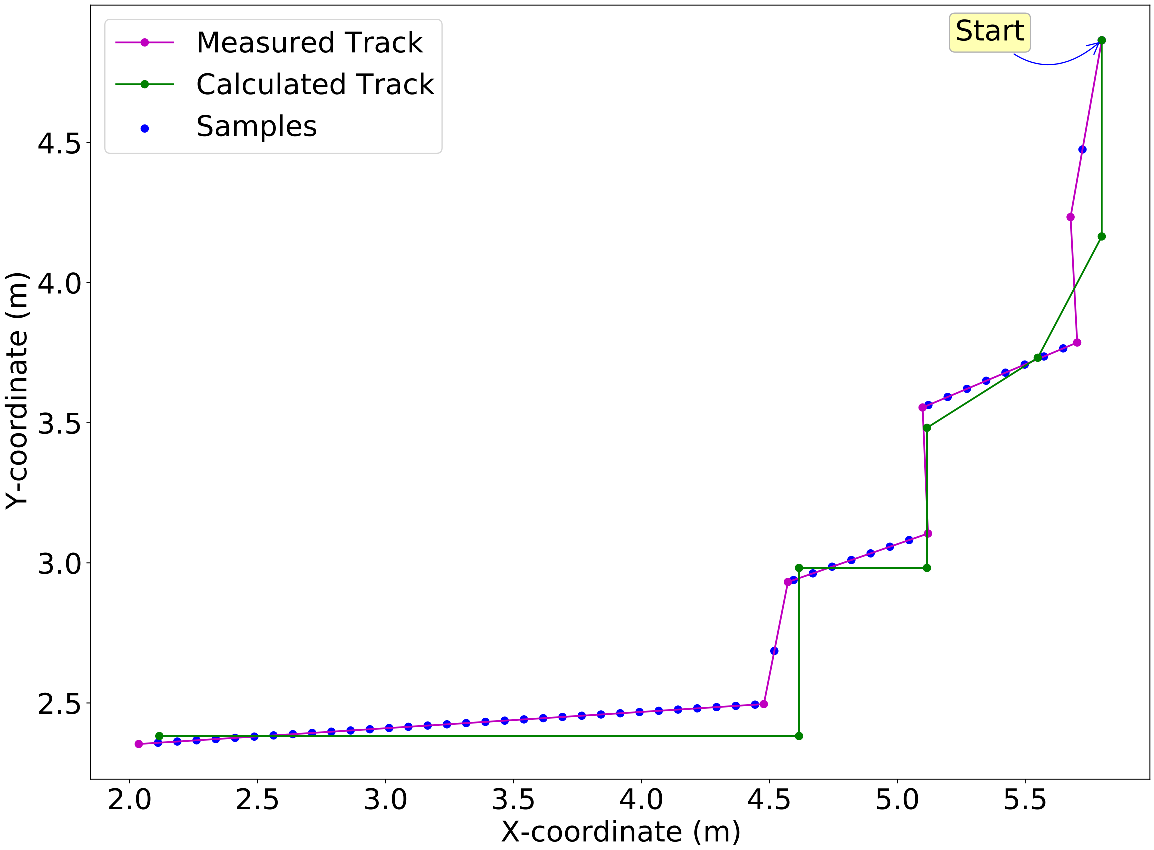

Figure 6.1: Measured vs. Calculated Ground Truth and sample points for measured track

6.2 Conclusion

The model of sensors and model of the system can never be perfect and errors are always unavoidable, what we can do is just localising the mobile robot as accurate as possible. No doubt, robotics programming is a process which often involves a great deal of plain old trial-and-error. Sometimes in order to tune a single parameter it takes a few hours or even days.

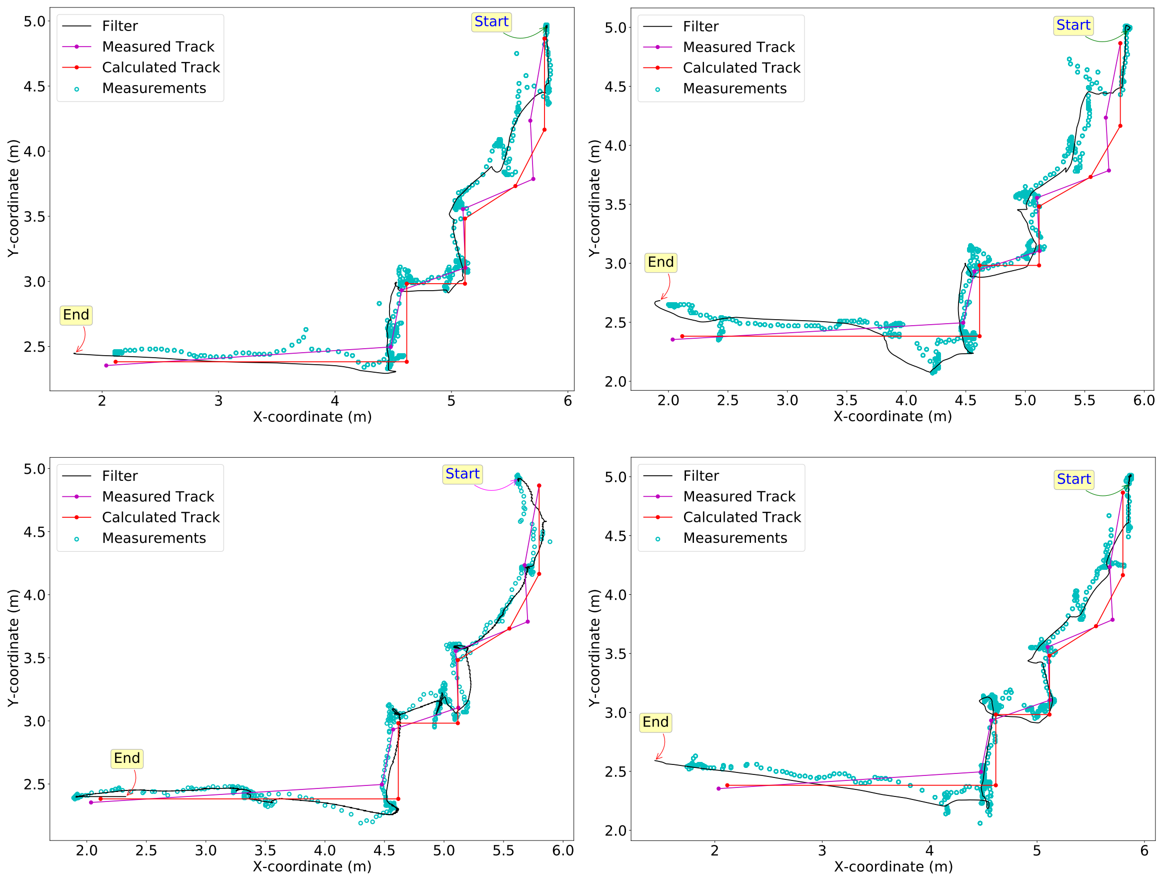

Figure 6.2: Plots of four repetitive experiments inside the energy lab

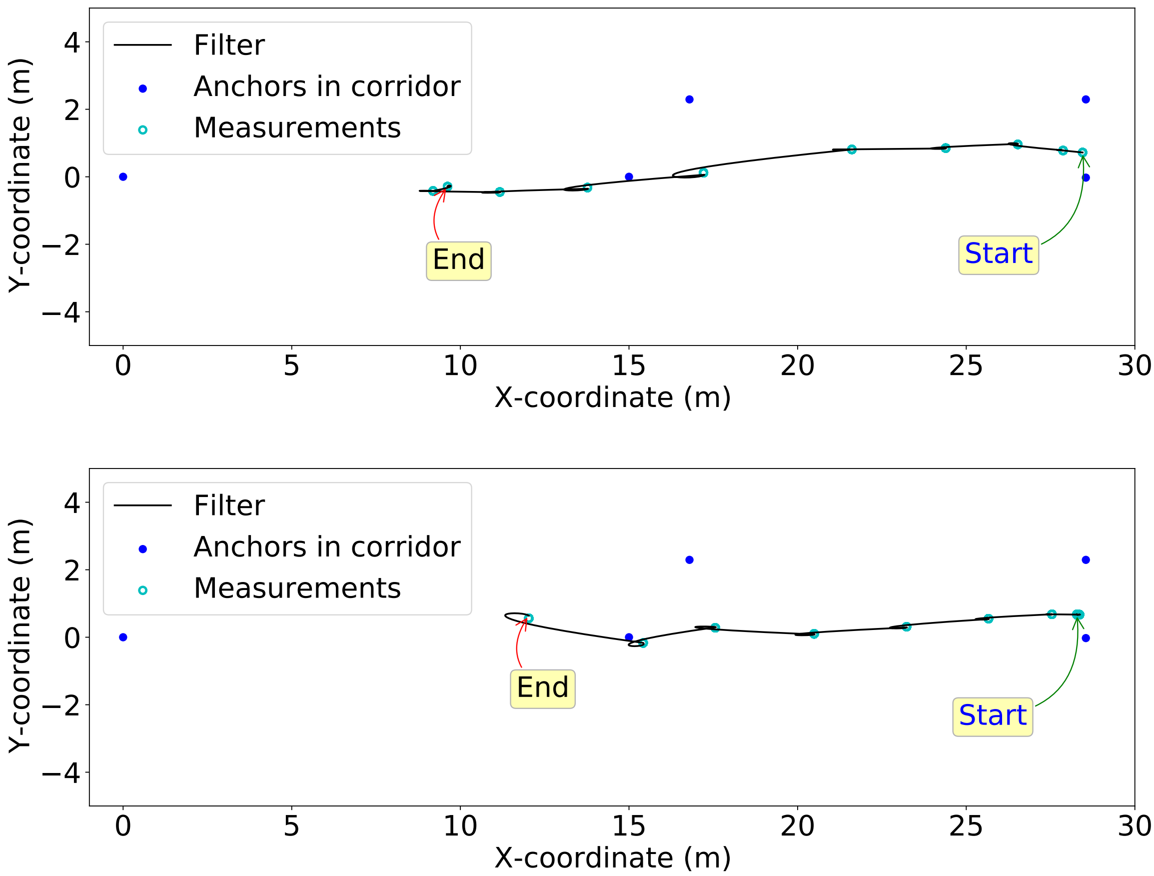

Figure 6.3: Plots of Kalman Filter In Corridor

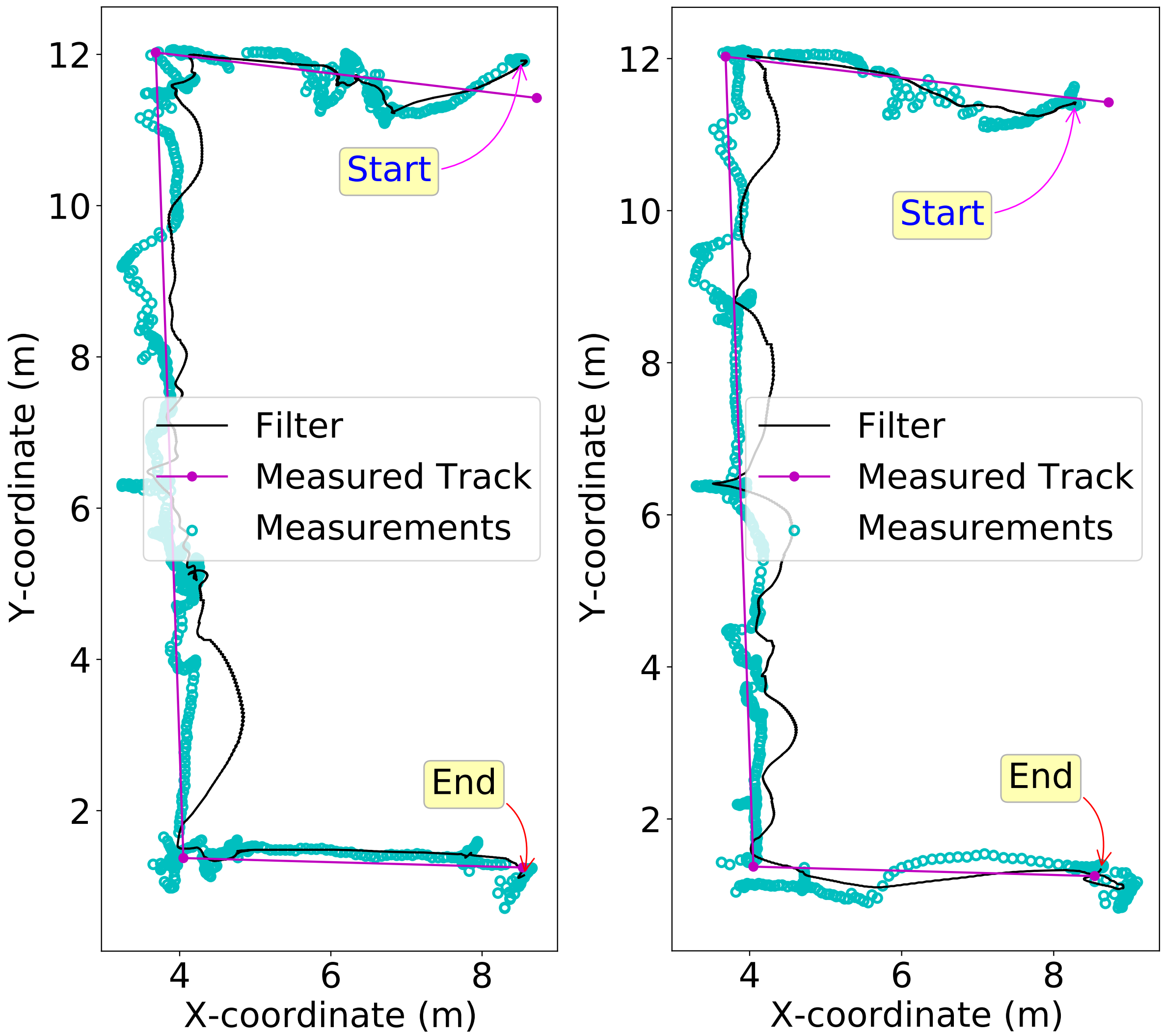

Figure 6.4: Running process inside the hall of APB

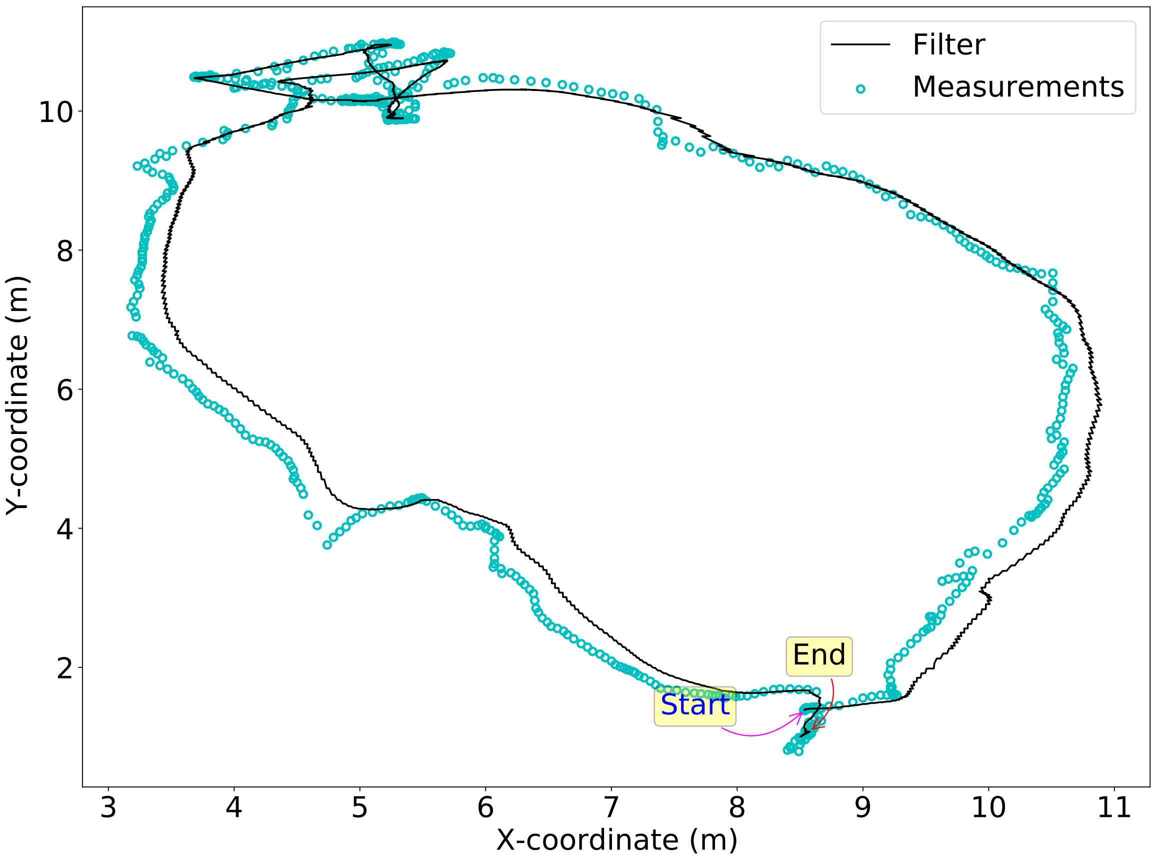

Figure 6.5: Random control inside the hall of APB