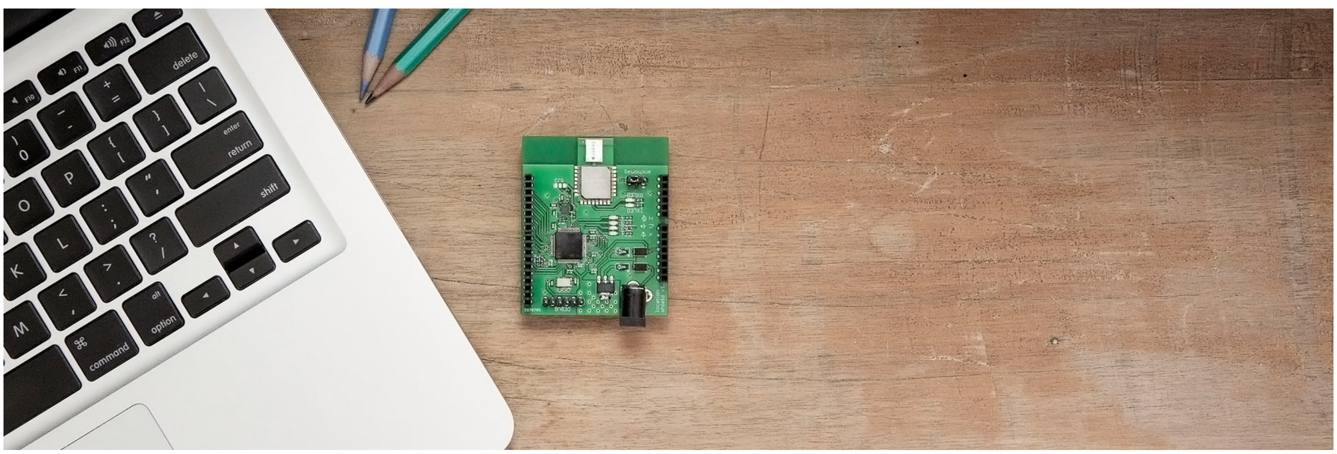
Pozyx Documentation

Rohitkumar Arasanipalai

September 2018

1 Introduction

Pozyx is an affordable and easy-to-use hardware solution that provides accurate indoor positioning and motion information for Arduino. In order to achieve a positioning accuracy of a few centimeters, the pozyx system relies on a novel wireless radio technology called ultra-wideband (UWB). The accuracy achieved with this ultra-wideband technology is several times better than traditional positioning systems based on WiFi, bluetooth, RFID or GPS signals. Furthermore, the signals can penetrate walls and make it suitable for indoor environments.



One or more pozyx devices are localized using pozyx anchors. Minimum 3 anchors are required to localize a pozyx device, but ideally 4 or more should be placed surrounding the area in which localization should take place.

2 Setting up the anchors and the pozyx device

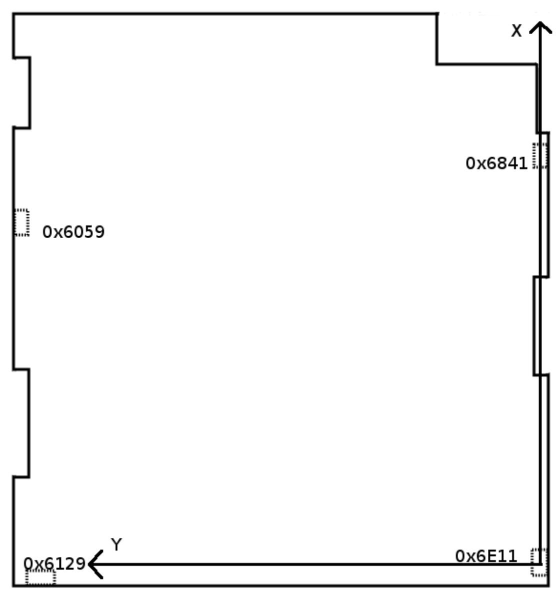
2.1 Setting up anchors for 2D positioning

For 2D positioning, the anchors should be placed at the same height, surrounding the area. Each anchor has its own unique hexadecimal ID. Keeping one anchor as the origin, select the coordinate axes such that, the X or Y coordinate of another anchor is 0.

The anchors for the INSPIRE Lab have the following hexadecimal IDs and (X,Y) coordinates:

Anchor ID	0x6E11	0x6841	0x6059	0x6129
Coordinates	(0,0)	(6300,0)	(5400,7770)	(-300,7670)
Height	2380	2380	2320	2130

The location of the anchors in the lab are as shown in the figure:



The official Pozyx documentation also contains sample code for pozyx localization using Arduino IDE and Processing. It also has comprehensive tutorials on getting set up. Since processing is written in Java and ROS integration would require either C++ or Python, the code for reading the data from serial buffer was re-written in C++ (GitHub Repository).

2.2 Setting up anchors for 3D positioning

For 3D positioning, the anchors have to be set up at various heights and the pozyx devices should ideally be between the these various heights at which the anchors have been placed. (*NOTE: This has not been done in the INSPIRE Lab*).

3 Kalman filter for noise reduction

Since the Pozyx device is prone to a lot of high frequency noise,

3.1 Kalman filter introduction

Kalman filtering, also known as linear quadratic estimation (LQE), is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more accurate than those based on a single measurement alone, by estimating a joint probability distribution over the variables for each time-frame.

3.2 Kalman Parameters

3.2.1 State Transition Model

$$F_k = \begin{bmatrix} 1.0 & 0.0 & dt & 0.0 \\ 0.0 & 1.0 & 0.0 & dt \\ 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 \end{bmatrix} \tag{1}$$

3.2.2 Control Input Model

$$B_k = \begin{bmatrix} dt^2/2 & 0.0 \\ 0.0 & dt^2/2 \\ dt & 0.0 \\ 0.0 & dt \end{bmatrix} \tag{2}$$

3.2.3 Control Vector

$$u_k = \begin{bmatrix} X'' \\ Y'' \end{bmatrix} \tag{3}$$

We get the accelerations (i.e., "control") from the pozyx device.

3.2.4 Observation Model

It maps the true state space into the observed state space. Since we do not have any information about the velocity, our observation model is:

$$H_k = \begin{bmatrix} 1.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 1.0 & 0.0 & 0.0 \end{bmatrix} \tag{4}$$

3.2.5 Covariance of Observation Noise

Since our observations are only position we will have 2x2 matrix.

$$R_k = \begin{bmatrix} 10.0 & 0.0 \\ 0.0 & 10.0 \end{bmatrix} \tag{5}$$

The covariance matrix have to be tuned. These tuned parameters were taken from [3].

3.2.6 Covariance of Process Noise

$$Q_k = \begin{bmatrix} 0.1 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.1 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.3 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.3 \end{bmatrix} \tag{6}$$

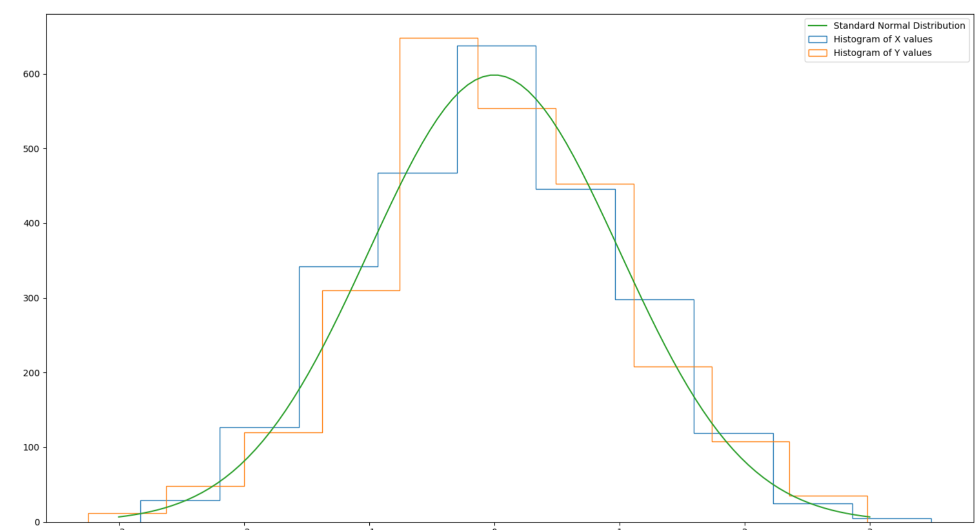
This matrix also has to be tuned. These tuned parameters were taken from [3].

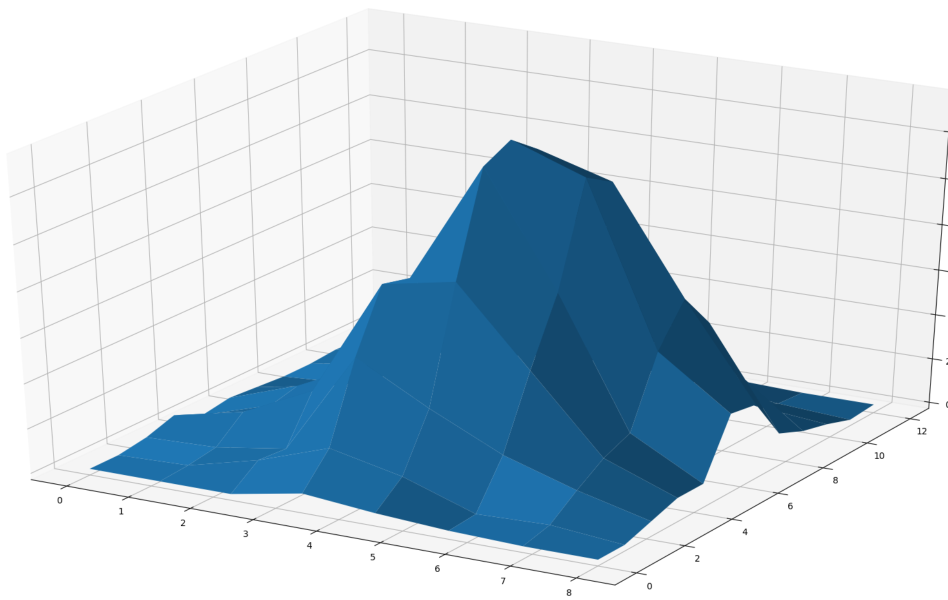
4 Results of testing the Pozyx device under different conditions

The stationary tests were conducted by taking readings over a period of 25 secs while keeping the pozyx device stationary.
The locomotion tests were conducted by connecting the pozyx device to the Firebird VI robot and running it at various speeds for different amounts of time. It was run the X direction of the pozyx coordinate system but due to slight deviations the bot did not follow a straight path. All the these and further external factors cause the distance to not be 3 meters as discussed later.
All tests were conducted 5 times and the worst results were taken for consideration.

4.1 Stationary test

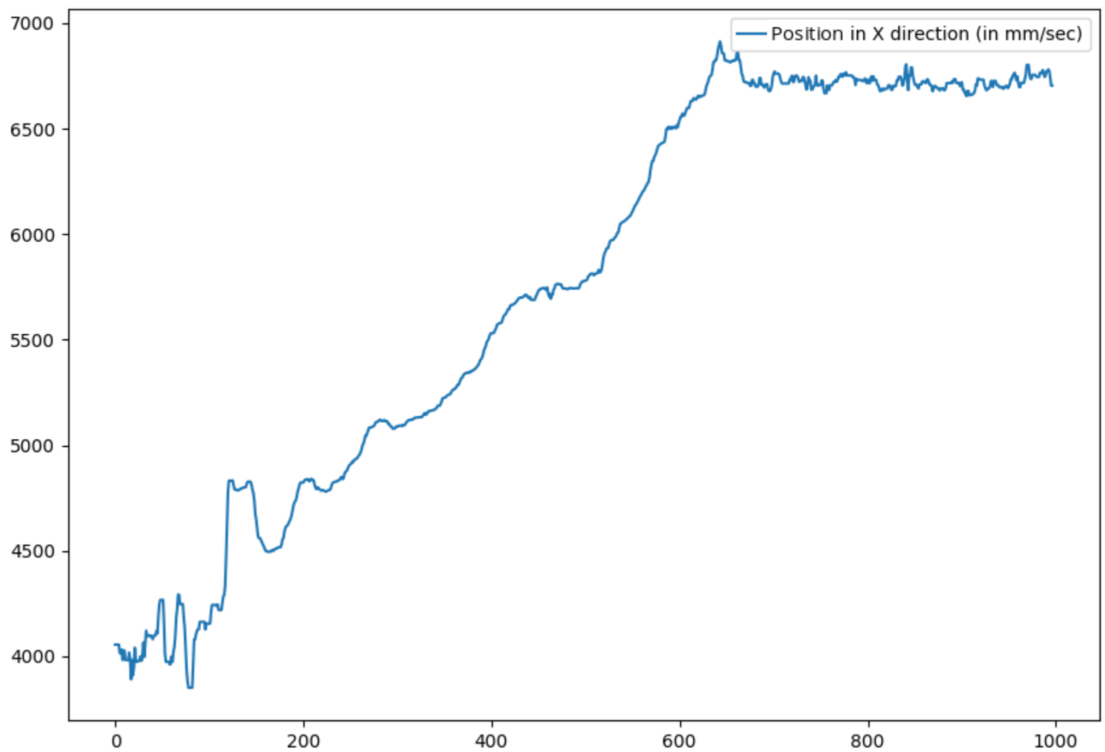
From the graphs, we can see that the stationary position data has a Gaussian distribution format with 95% confidence the error is ± 11.76 mm in X-axis and ± 15.68 mm in Y-axis.



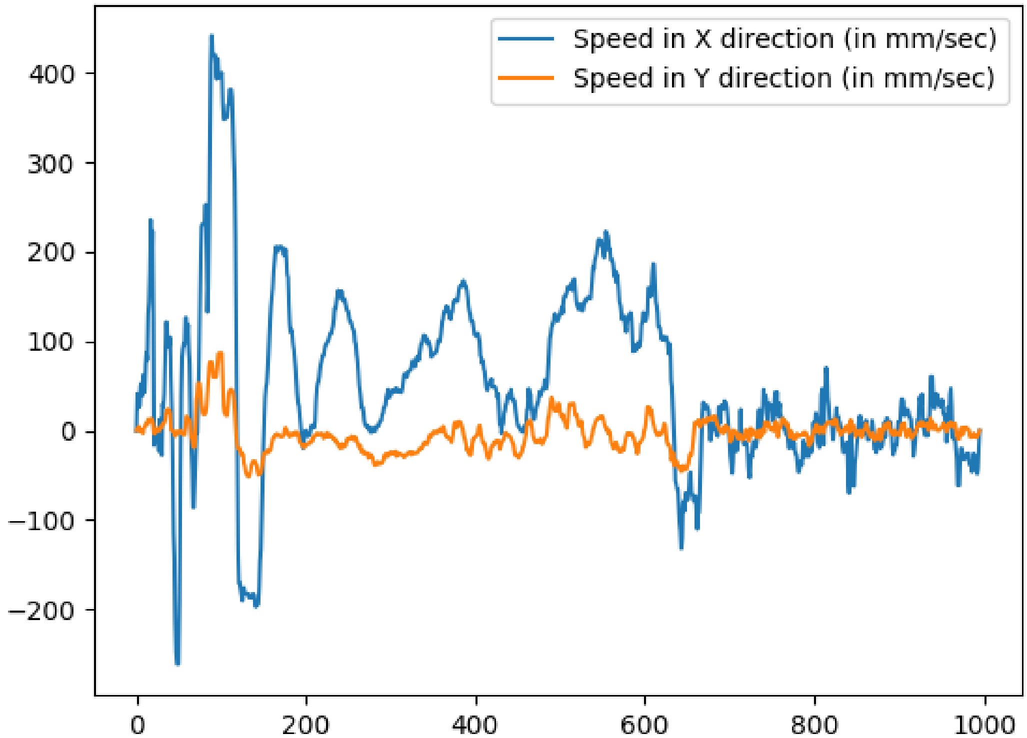


4.2 Low constant speed

In this test, the Firebird VI robot was run at 0.1 m/s. It was run for 30 secs and ideally it should have covered 3 meters, but due to initial acceleration, final deceleration and frictional causes the total distance covered will be less than 3 meters.
As seen from the graph, initially the reading is X and from approximately constant slope we can see that the robot is moving with a constant velocity and is finally stabilizing at Y after the robot has stopped.

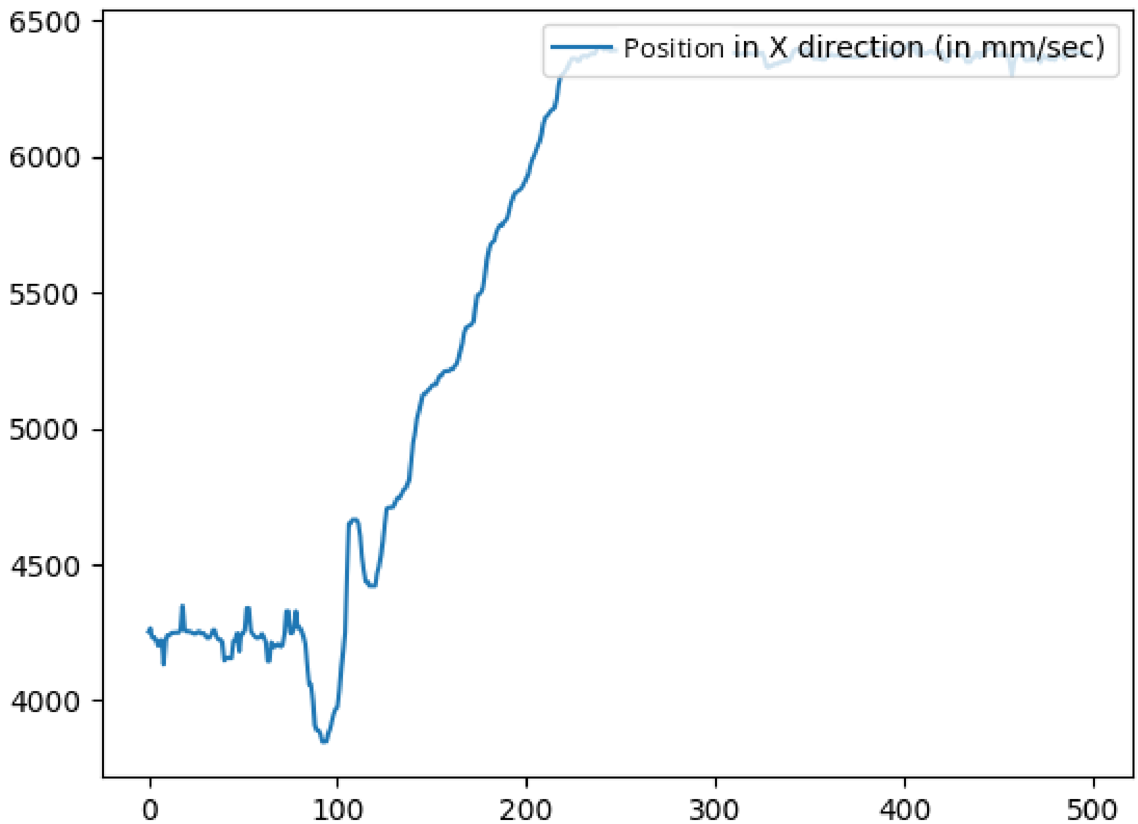


When the velocity was calculated, it was quite prone to noise as the sample time was very small and so even small changes in position due to noise were reflected as a large amount in velocity.



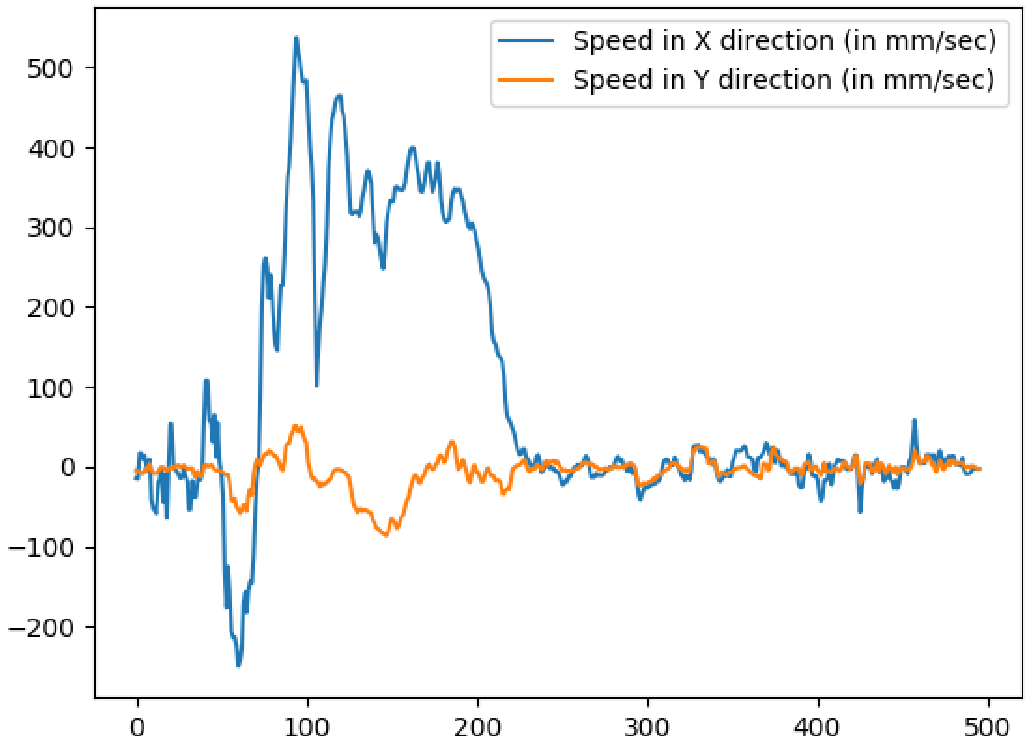
4.3 Moderate constant speed

In this test, the Firebird VI robot was run at 0.5 m/s. In this scenario, the initial acceleration from 0 m/s to 0.5 m/s cannot be neglected. It was run for 6 secs and ideally it should have covered 3 meters, but due to initial acceleration, final deceleration and frictional causes the total distance covered will be less than 3 meters.



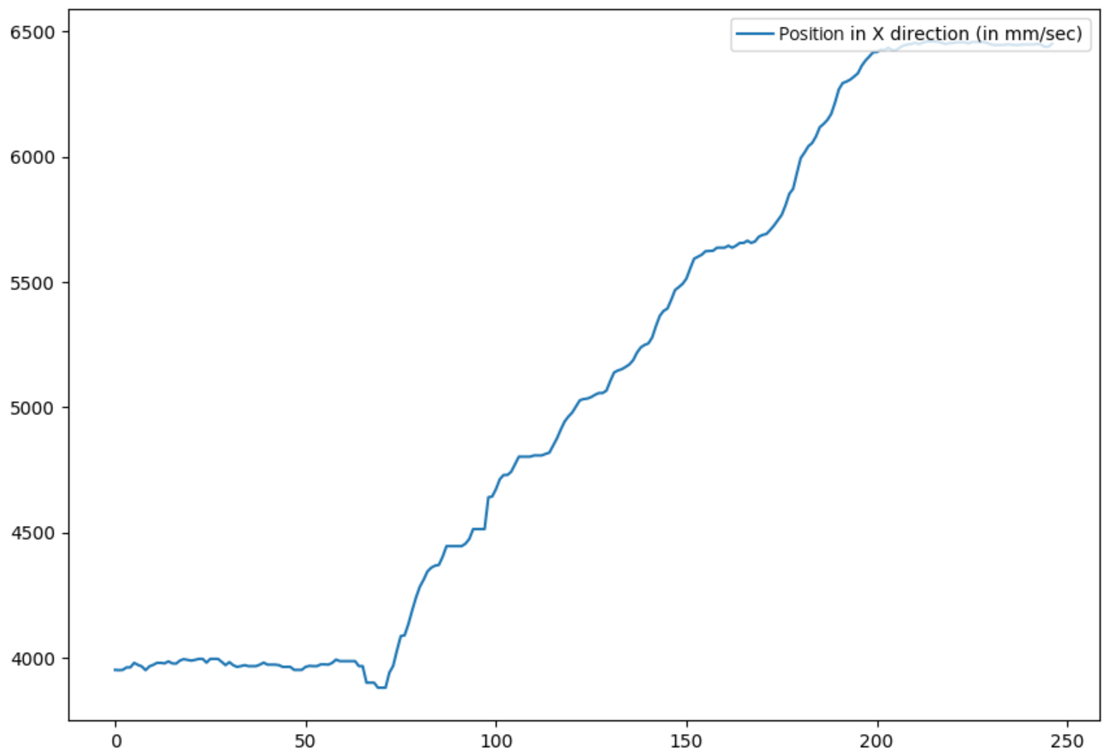
As seen from the graph, initially the reading is X but when the robot starts accelerating there is a slight dip. This is due to the sudden acceleration and since Kalman filter takes acceleration as control input it affects its output. Once the initial acceleration has subsided the position returns to the accurate value and is constantly increasing which corresponds to a constant velocity.

When the velocity was calculated, the same scenario as the one for low constant velocity occured.

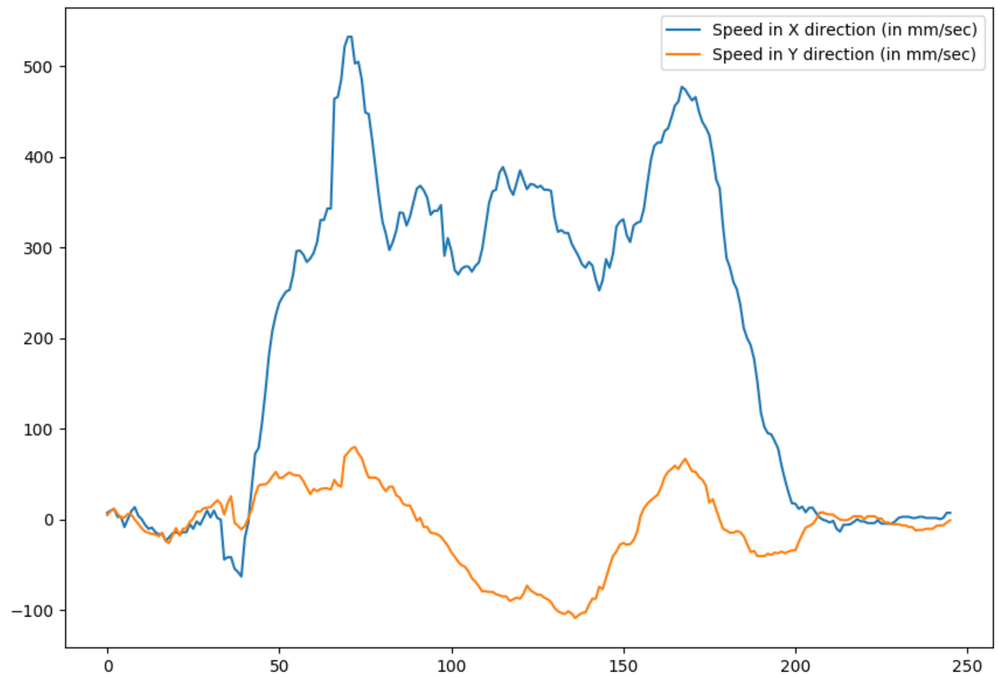


4.4 High constant speed

In this test, the Firebird VI robot was run at 1 m/s. In this scenario, the initial acceleration from 0 m/s to 1 m/s is quite large. It was run for 6 secs as it could not cover even 2 meters in 3 seconds due the time taken to reach that velocity. Even then it could not cover 6 meters in the x direction as it deviated and followed a slight parabolic path causing the X distance to be less than the calculated value.
As seen from the graph, initially the reading is X but when the robot starts accelerating there is a large dip. This is again due to the sudden large acceleration and since Kalman filter takes acceleration as control input it affects its output drastically in this case. Once the initial acceleration has subsided the position returns to the accurate value and is constantly increasing which corresponds to a constant velocity.



When the velocity was calculated, the same scenario as the one for low constant velocity occured.



5 Final conclusions

The Pozyx device is quite an accurate indoor positioning system with a 95% confidence the error is ±11.76 mm in X-axis and ±15.68 mm in Y-axis when the device is stationary.
The device accuracy in the locomotory scenario is decent with the error being within the bot dimensions and thus can be neglected. On the other hand, it cannot be used to calculate velocity as the the high frequency noise in position data affects the velocity data drastically as it is a derivative. The ideal locomotory use case would be in scenarios where the velocity is constant and there is no sudden acceleration or deceleration.

References

[1] Pozyx-centimeter positioning system for arduino.

[2] Reduce GPS data error on Android with Kalman filter and accelerometer

[3] Mac Thi, T. (2018). Autonomous navigation strategies for UGVs/UAVs.