Estimating A Vehicle Speed using State Estimation Kalman Filter

Solomon Gugsa

Abstract—This paper evaluates the performance of the cruise control of a car (how good it keeps a constant vehicle speed) using sensor data recorded by a mobile phone. The mobile phone was placed inside the car while driving on a road when the cruise control was set to 70 km/h. The log file from the mobile phone consists of data from a GPS sensor and an IMU. I used state estimation kalman filter to estimate the speed of a car using collected sensor data.

Index Terms—Kalman Filter, State Estimation, Sensor

1 System Model

In this project, A simple constant velocity model is used by where px(t)is the position x-coordinate, py(t) is the position y-coordinate, vx is the velocity in x-direction and vy is the velocity in y-direction, thus the discrete time model for the system is given by:

x(t) = $\begin{pmatrix} 1 & T & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & T \\ 0 & 0 & 0 & 1 \end{pmatrix}$ x(t-1) + $\begin{pmatrix} 0 \\ T^2/2 \\ 0 \\ T \end{pmatrix}$ where T is sampling interval and G is zero mean Gaussian and assumed in the second matrices. This is only because the state transition which involves moving from one state to another and it should be linear with Gaussian noise. Therefore, the state vector x(t) becomes:-

x(t) $\begin{pmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \\ x_4(t) \end{pmatrix} = \begin{pmatrix} p_x(t) \\ p_y(t) \\ v_x(t) \\ v_y(t) \end{pmatrix}$

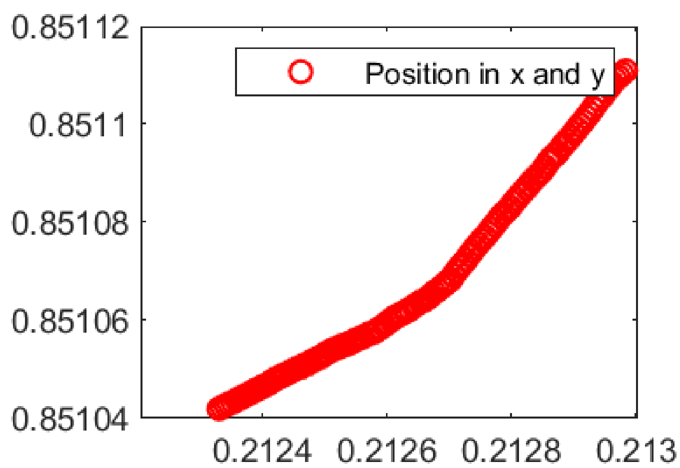
where px (t) position x coordinate, px (t) position y coordinate, vx (t)he velocity in x direction and vy (t) the velocity in y-direction.

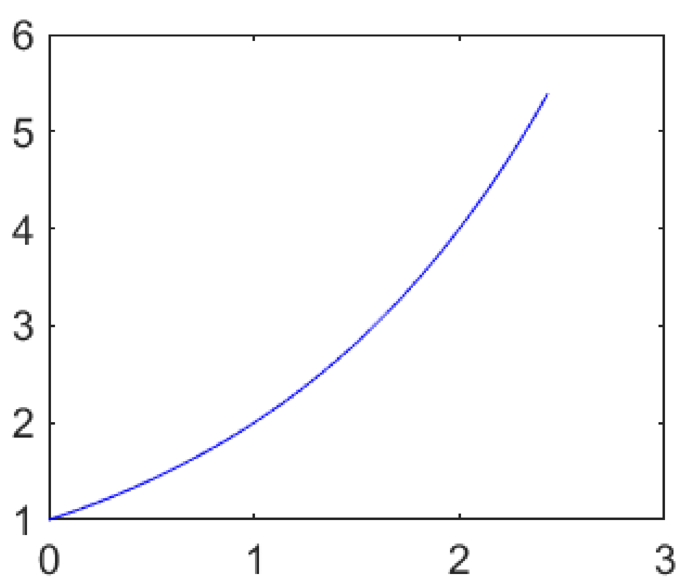
2 Simulation

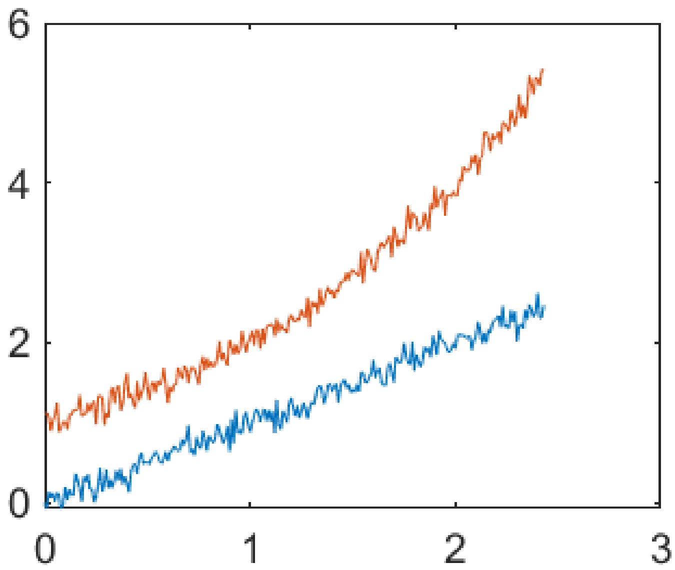
Rigorous simulated experiments are performed mainly applying the Kalman estimation filter based on a constant velocity model and sensor measurement presented in this project and the result present in fig 1, and 2.

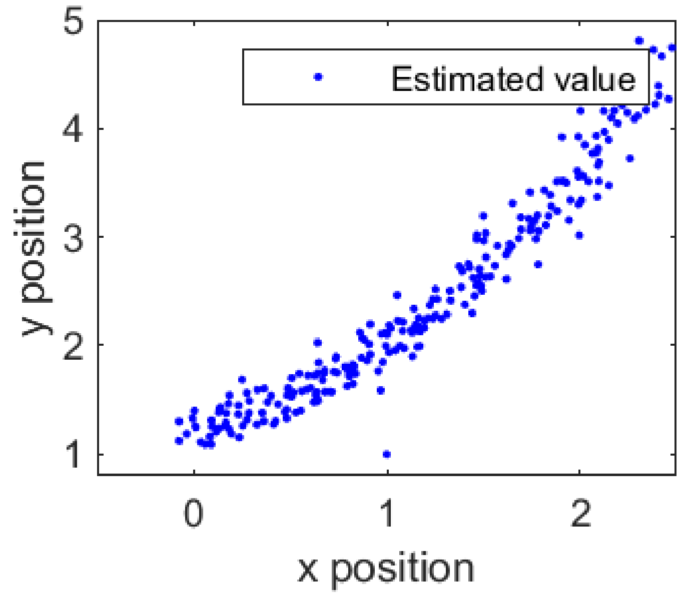
3 Discussion and conclusion

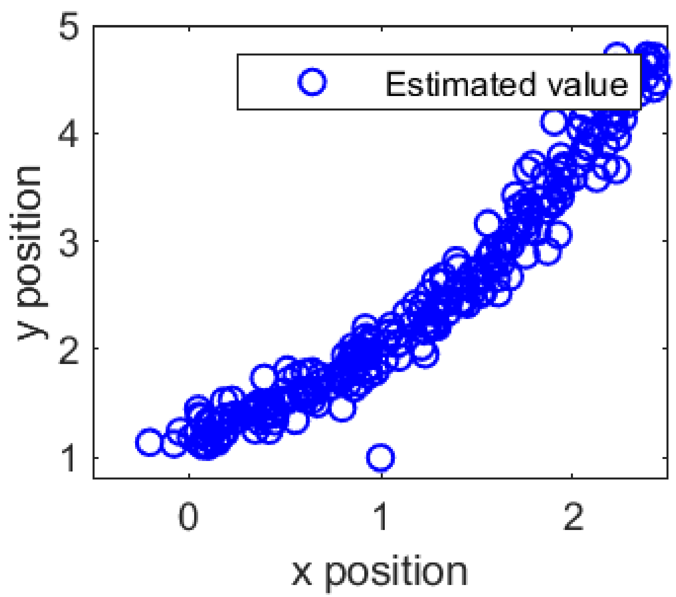
Generally, the model of Cruise control system is relatively simple to implement and to follow the car movement and speed. The result show that the filter seems to work correctly. However, "tuning" the parameters Q yields different filter performance. In last figure below we can see what happens when Q is increased or decreased by a factor of 10 respectively. By lowering or increasing this variable, we're able to see the filter quickly response or believe the noisy measurement, While the estimation of a constant is relatively straight-forward.The error plot shows that the

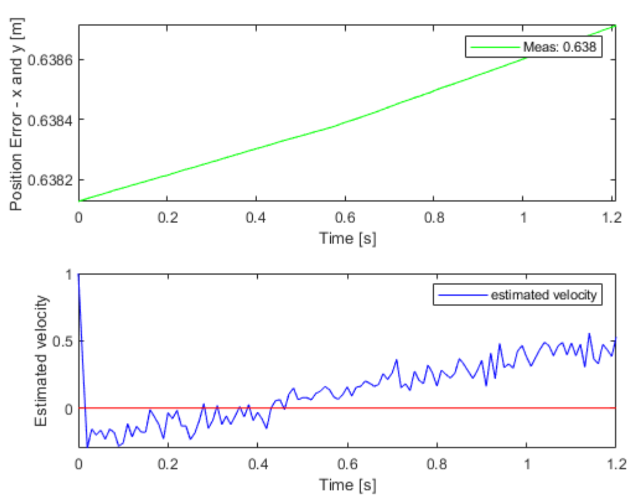












position measurement and estimation error normalized by the number of sensor data points and it shows about 0.638 percent less error than the original sensor data. The filter velocity estimate also trends somehow similar to the true value except change of direction at half point and traveling at higher velocity, ultimately making estimation harder for the filter and struggle to converge at the end. Overall, we see how to estimate a position and velocity for a vehicle using one of state estimation kalman filter. We also see that the noise process dynamics of the system model are time varying and discrete.Finally,we have also validated the filtering performance by tuning R, and Q co-variance parameters and also by simulating vehicle maneuvers by randomly generating noise.

4 References

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