Applications of Kalman Filters Report

Group members: Tai Nguyen (Computer Engineering), Johnathan Palko (Mechanical Engineering)

Professor: Thomas Chmielewski

ECEC-T580

Drexel University, College of Engineering

June 06, 2020

Table of Content

Section I: Introduction/Background

1. Management summary
2. Objective
3. Data gathering summary

Section II: Alpha Filter

1. Objective
2. Statistics and KF parameters
3. Data analysis and presentation

Section III: Alpha-Beta Filter

1. Objective
2. Statistics and KF parameters
3. Data analysis and presentation

Section IV: Summary and Conclusions

Section V: Appendix

Section III: Alpha-Beta Filter

1. Objective

This section features the implementation of the Alpha-Beta filter (ABF), a related cousin to the Kalman filter (KF), and its application on an object-tracking model described below.

An Alpha-Beta filter assumes that a system can be approximated with 2 internal states, one state is an integral of the other (i.e. position and velocity). This filter works by calculating a tracking index, T, which is used to calculate the value of alpha and beta. These 2 values are very good estimates of the stead-state Kalman gain, K. It is shown by Kalata[1] that the covariance matrix resulted from the Alpha-Beta filter converges to the one from Kalman filter. The principal advantage of ABF is that alpha and beta can be calculated a head of time with limited knowledge about the applied system:

where T is the time period in between each measurement, is the process noise, and is the measurement noise.

The object-tracking model demonstrated in this paper is similar to the train-on-track model, where a moving train is tracked knowing the distribution of the initial conditions and its position-velocity constraints. While the train is running on the track, an onboard radio signal is communicated to a far away station every T seconds about the current position of the train. Assume that the train is traveling with a constant velocity, , with some unknown acceleration. Hence, the train’s velocity is described by a Gaussian distribution with mean = , and standard deviation = . Using the Alpha-Beta filter, the objective is to predict the train movement and evaluate the prediction based on ground-truth.

1. Statistics and KF Parameters

The process noise is chosen to be , which assumes a displacement variation of inch. The measurement noise is taken from the class’s variance, and is set to be 0.0764. The average velocity for the “train” is 1.11 inches per second over a distance of 30 inches, yielding a time period T of 1.7850 seconds.

Hence, using the equations in the above section, the value for alpha and beta are:

Hence, the ABF gain K is:

We initialized P(k|k) to be .

After running our filter, P(k|k) is:

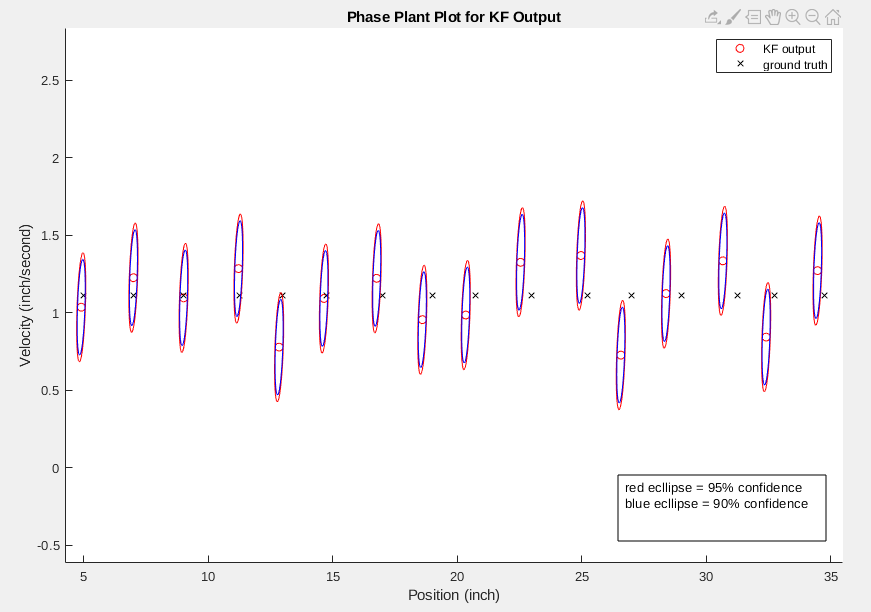
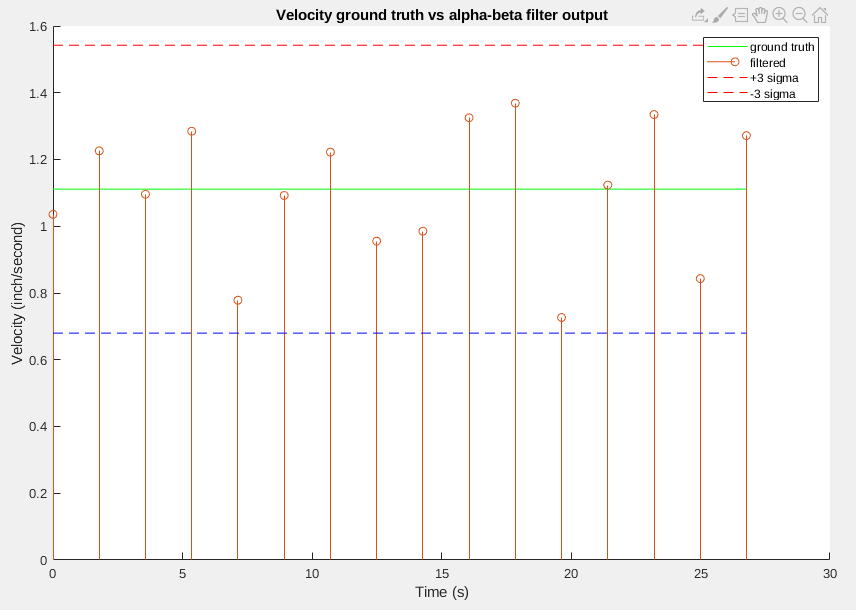
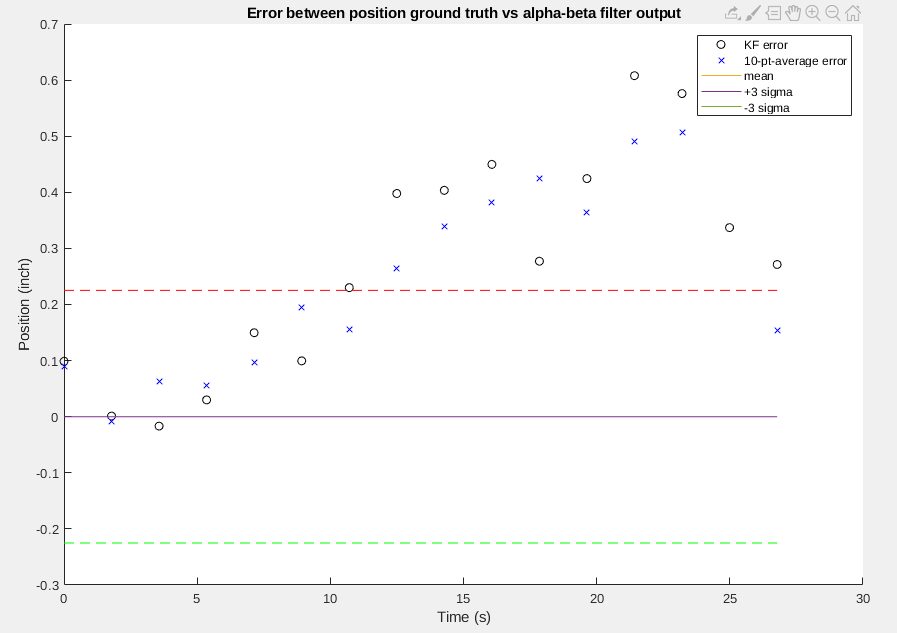
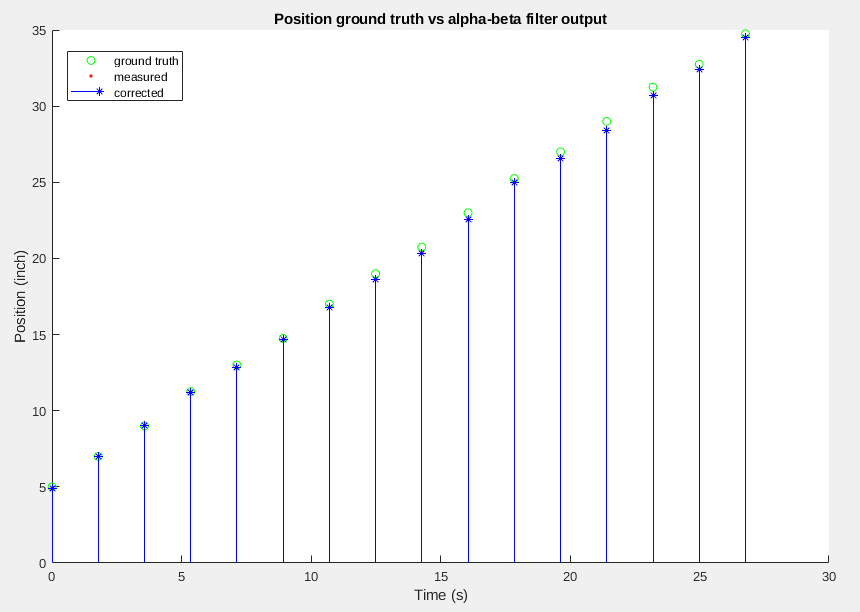
Our results are summarized in the table below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | T  (second) | Alpha | Beta | Steady state eror covariance   Matrix | IC | IC |
| **0.0058411** | **1.7850** | **0.9642** | **1.3147** | **0.0056 0.0043**  **0.0043 0.0207** | **5.0000**  **1.1111** | **1000 0**  **0 1000** |

1. Data analysis and presentation

In this section, we present our analysis on the result and performance of the filter on our dataset.

First, here are the figures for set #1:



And below are the figures for set #2

