HW 4 State Estimation
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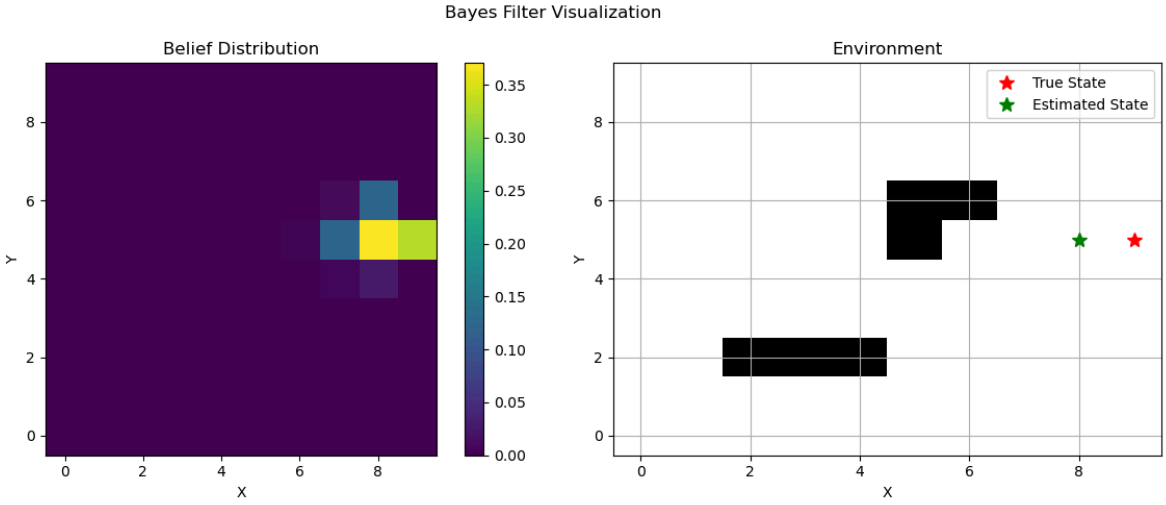
Purpose of the assignment:

This assignment was to have us build our own bayesian filter and EKF functionality. Through mostly hand held instructions (which is greatly appreciated in my opinion) leaving us to do the math ourselves to figure out how to get the final outputs.

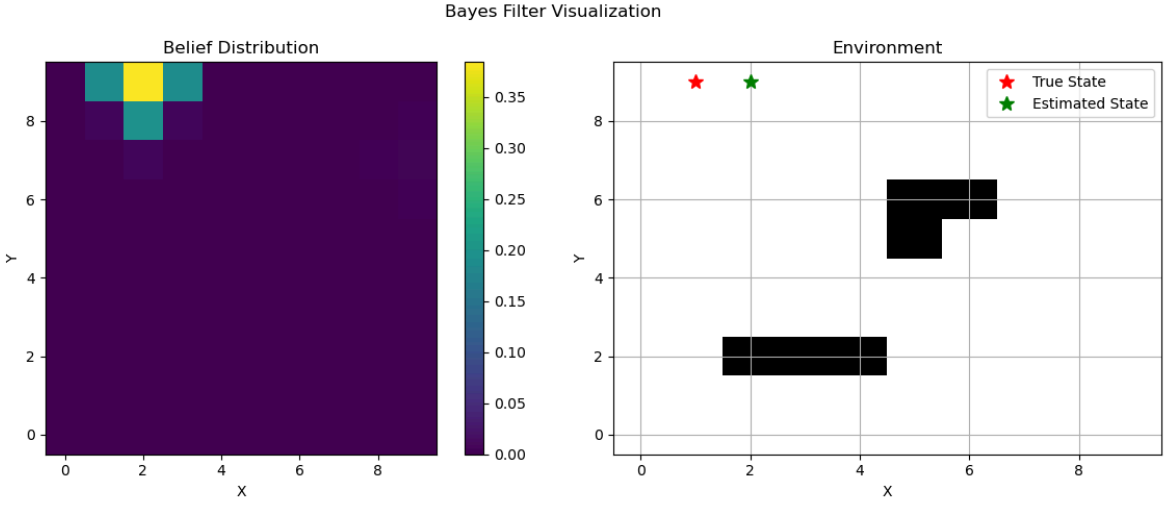
Outputs of the Bayes Filter:

I ran the code a few times to make sure i was getting propper values and that i wasnt getting a one off here and there, i ran it 5 times to get a good spread of data.

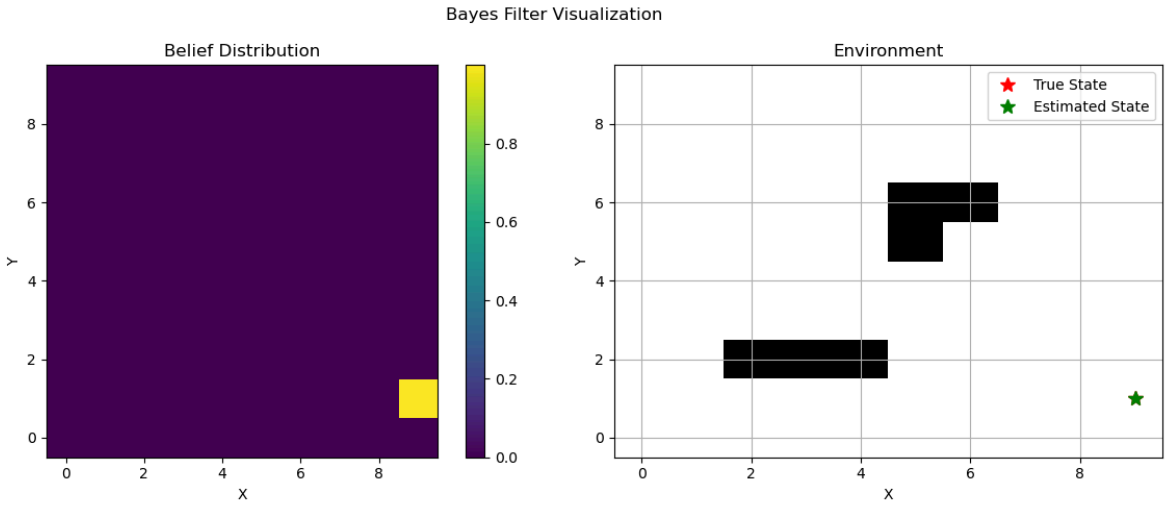
Attempt 1:



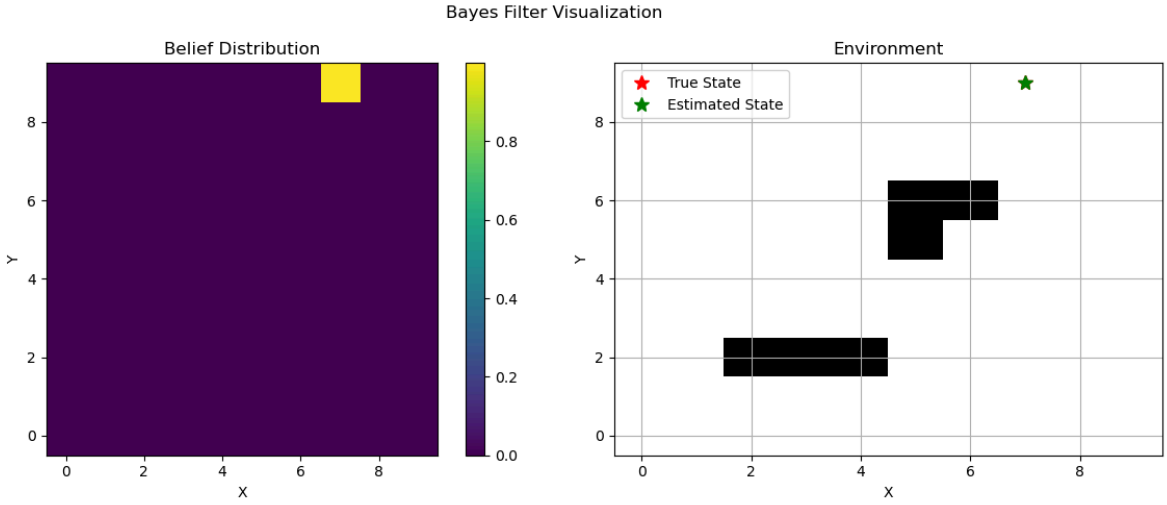
Attempt 2:



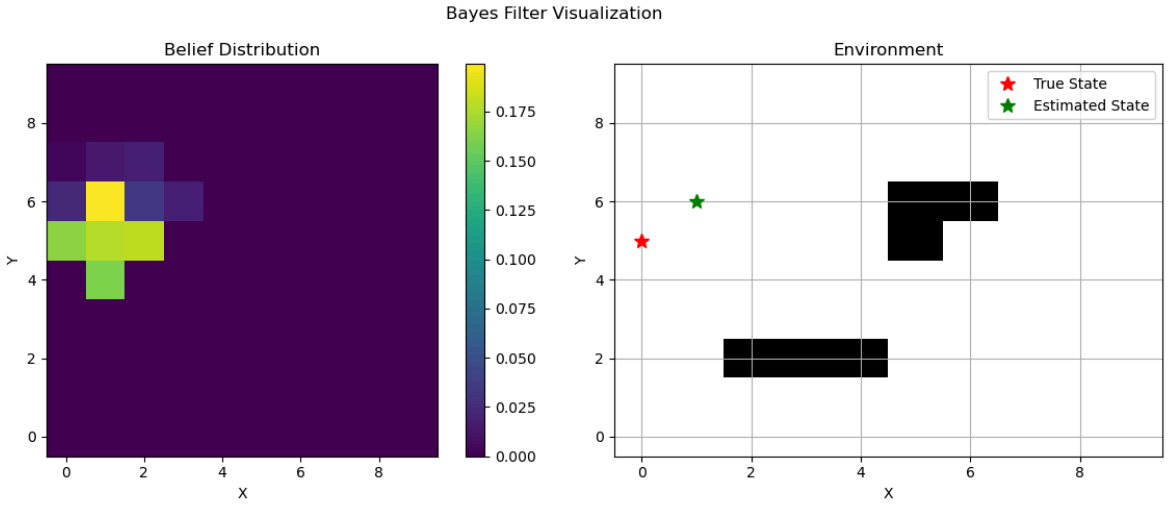
Attempt 3:



Attempt 4:

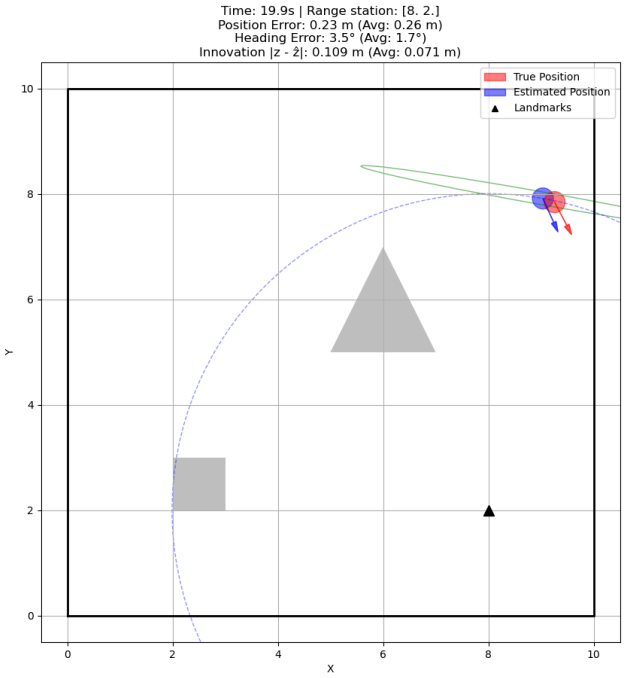


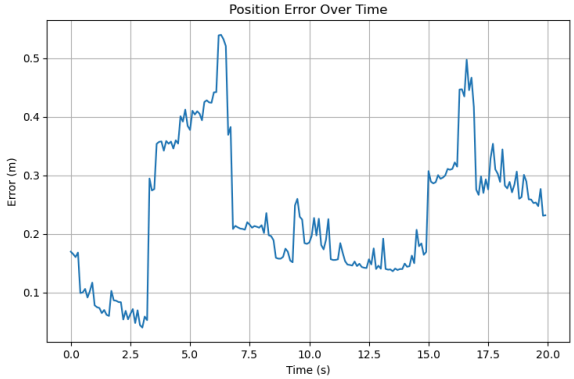
Attempt 5:

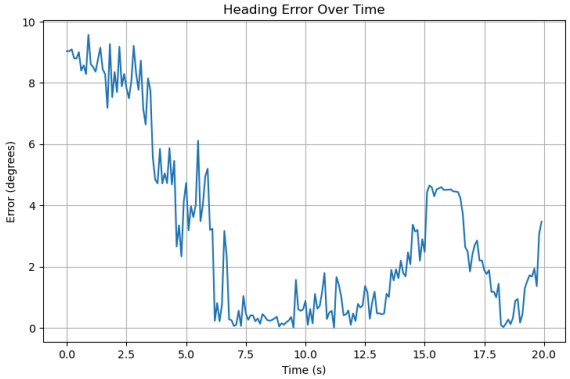


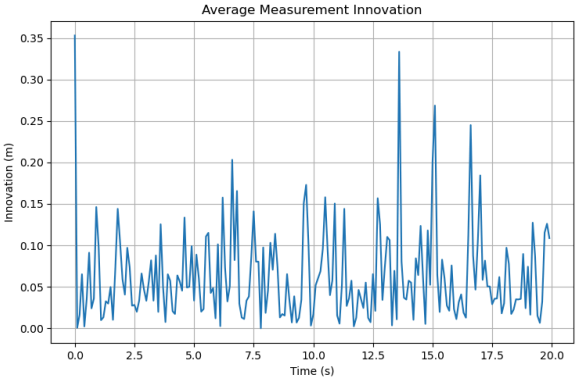
Outputs of the Extended Kallman Filter:

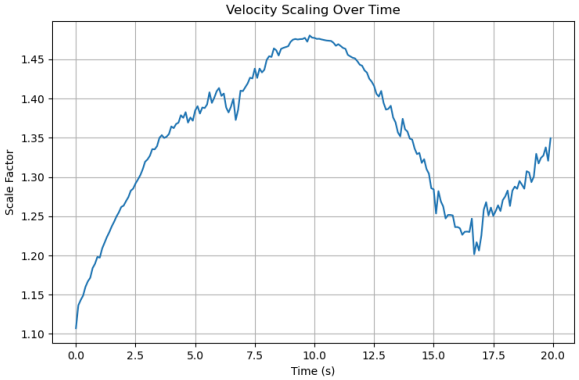
Attempt 1:



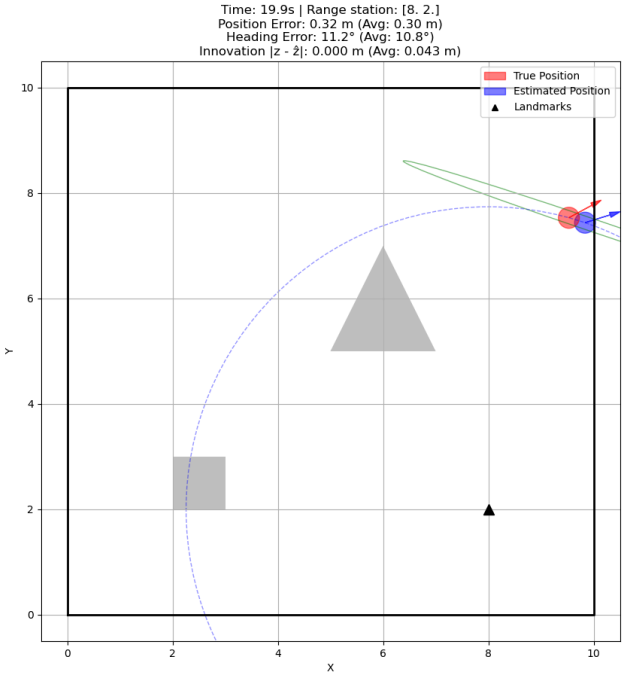


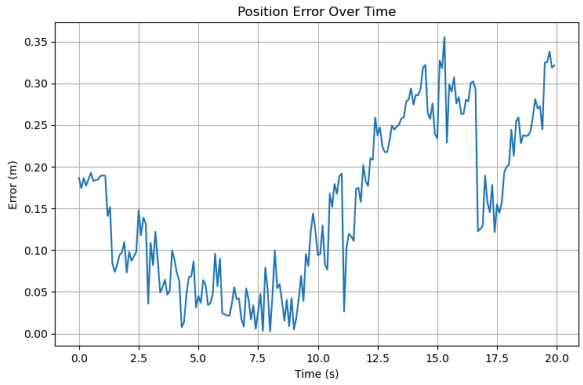


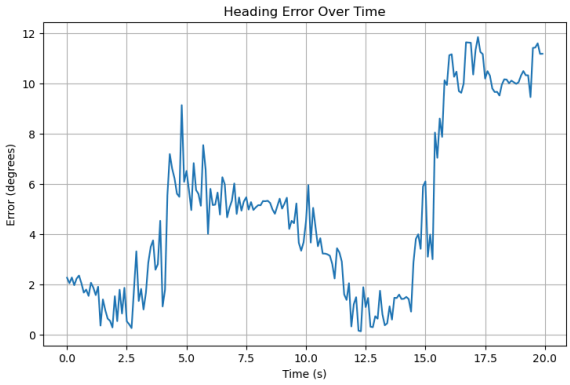


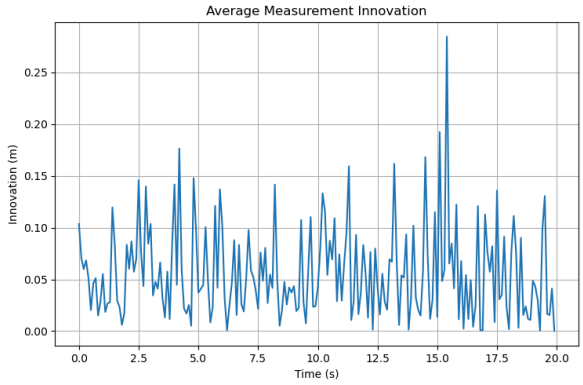


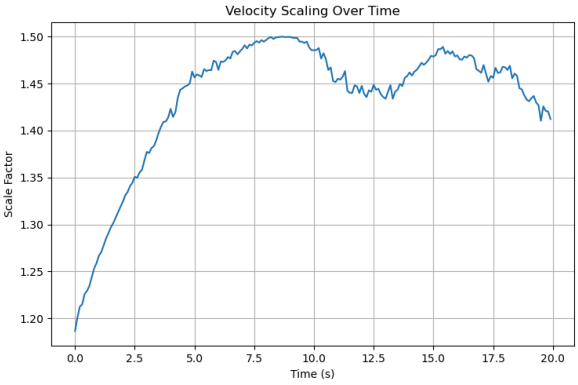
Attempt 2:


Time: 19.9s | Range station: [8. 2.]
Position Error: 0.32 m (Avg: 0.30 m)
Heading Error: 11.2° (Avg: 10.8°)
Innovation |z - ẑ|: 0.000 m (Avg: 0.043 m)
True Position
Estimated Position
Landmarks
X
Y

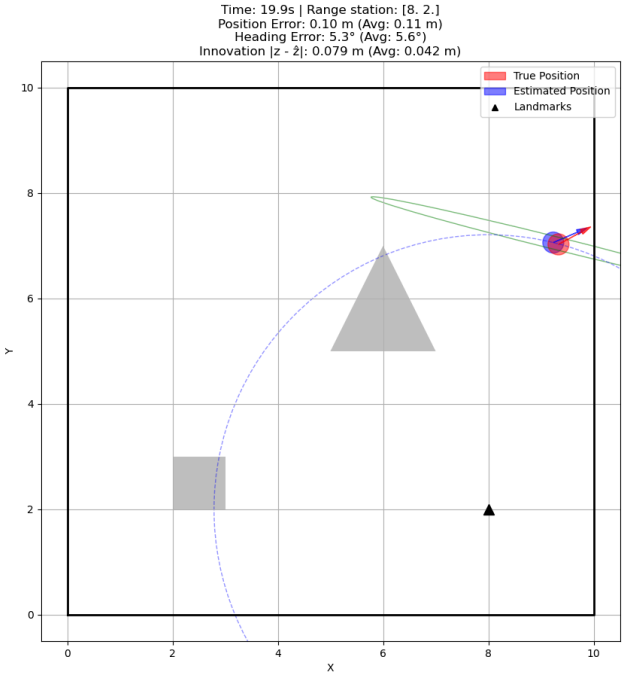

Position Error Over Time
Error (m)
Time (s)

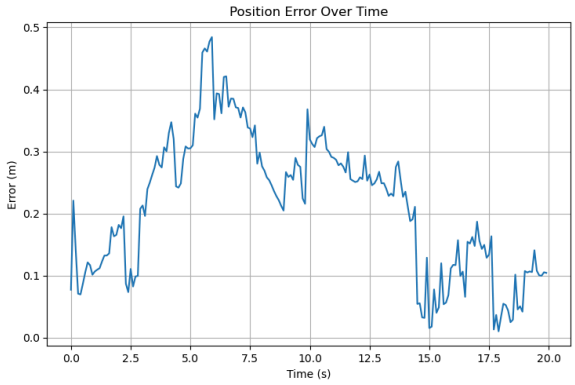

Heading Error Over Time
Error (degrees)
Time (s)

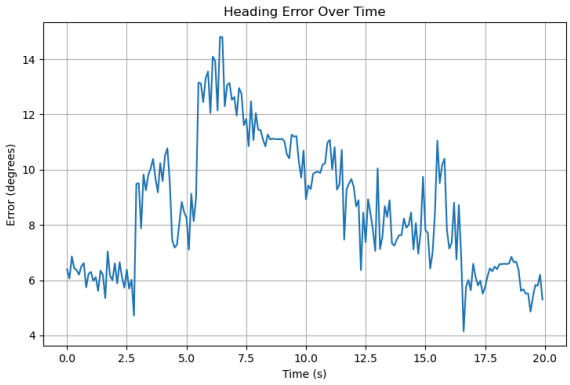

Average Measurement Innovation
Innovation (m)
Time (s)

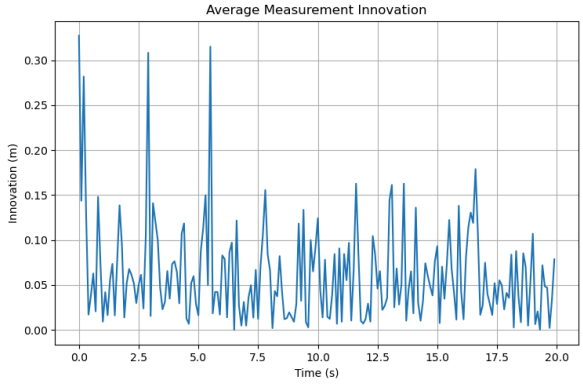

Velocity Scaling Over Time
Scale Factor
Time (s)

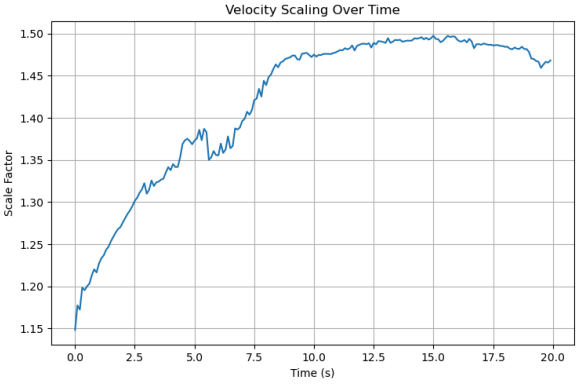
Attempt 3:


Time: 19.9s | Range station: [8. 2.]
Position Error: 0.10 m (Avg: 0.11 m)
Heading Error: 5.3° (Avg: 5.6°)
Innovation |z - ẑ|: 0.079 m (Avg: 0.042 m)
True Position
Estimated Position
Landmarks
X
Y

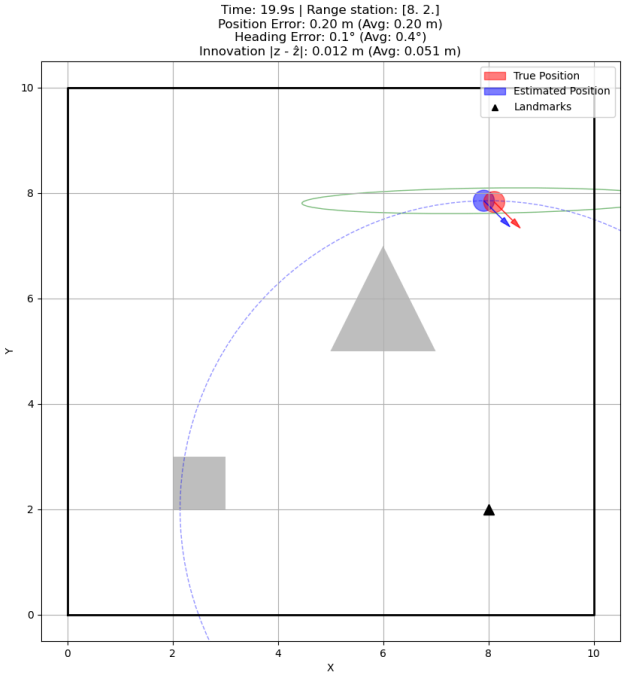

Position Error Over Time
Error (m)
Time (s)

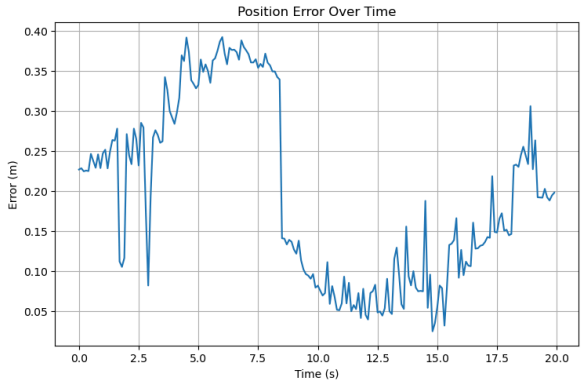

Heading Error Over Time
Error (degrees)
Time (s)

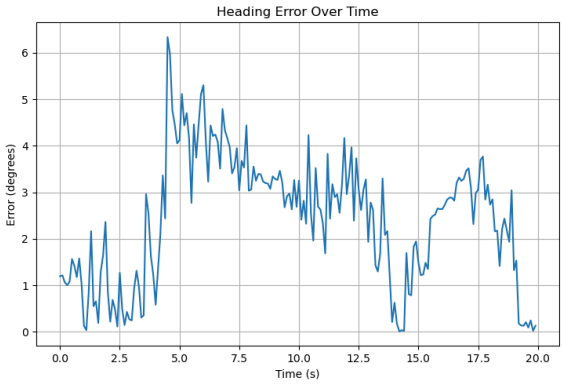

Average Measurement Innovation
Innovation (m)
Time (s)

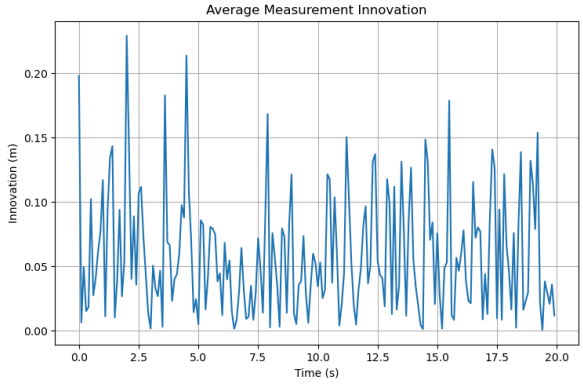

Velocity Scaling Over Time
Scale Factor
Time (s)

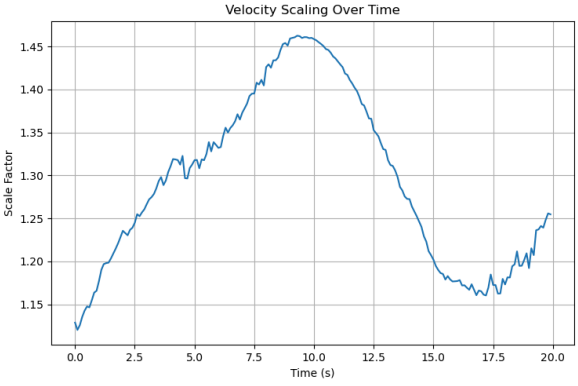
Attempt 4:


Time: 19.9s | Range station: [8. 2.]
Position Error: 0.20 m (Avg: 0.20 m)
Heading Error: 0.1° (Avg: 0.4°)
Innovation |z - ẑ|: 0.012 m (Avg: 0.051 m)
True Position
Estimated Position
Landmarks
X
Y

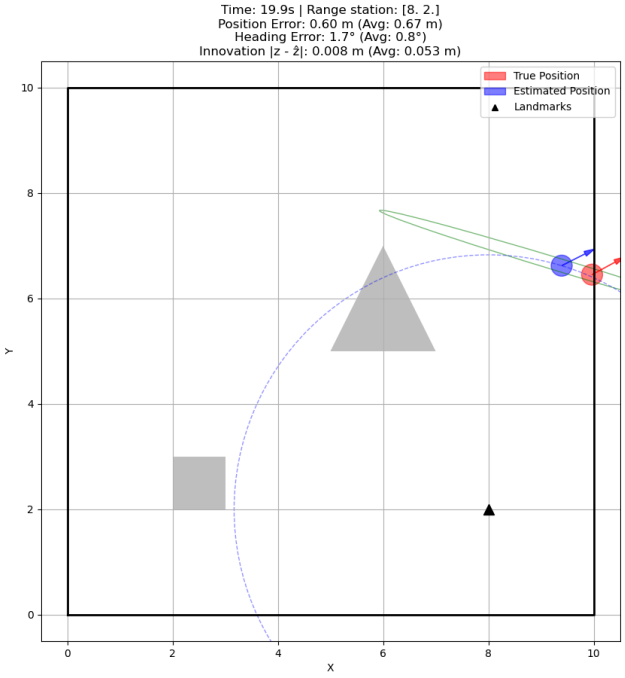

Position Error Over Time
Error (m)
Time (s)

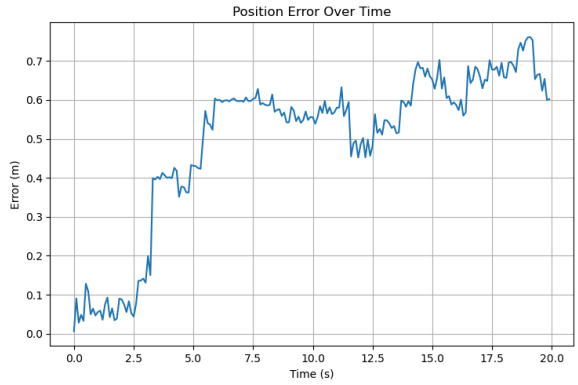

Heading Error Over Time
Error (degrees)
Time (s)

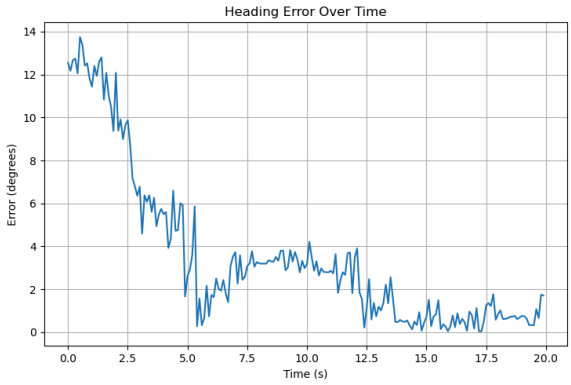

Average Measurement Innovation
Innovation (m)
Time (s)

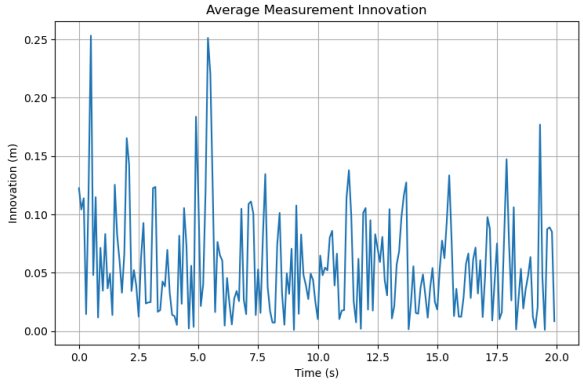

Velocity Scaling Over Time
Scale Factor
Time (s)

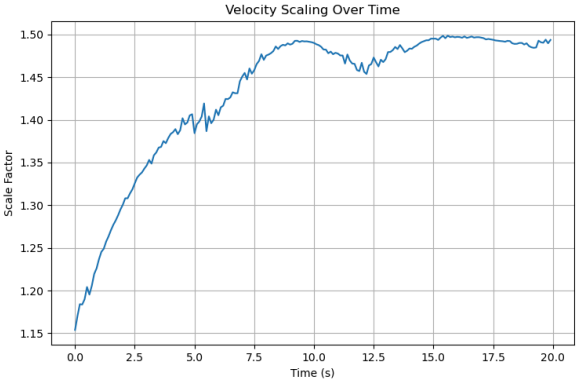
Attempt 5:


Time: 19.9s | Range station: [8. 2.]
Position Error: 0.60 m (Avg: 0.67 m)
Heading Error: 1.7° (Avg: 0.8°)
Innovation |z - ẑ|: 0.008 m (Avg: 0.053 m)
True Position
Estimated Position
Landmarks
X
Y


Position Error Over Time
Error (m)
Time (s)


Heading Error Over Time
Error (degrees)
Time (s)


Average Measurement Innovation
Innovation (m)
Time (s)


Velocity Scaling Over Time
Scale Factor
Time (s)

Math:

```
F[0, 0]  = 1 + forward_vel * dvs_dx * cos_h * dt
F[0, 1]  = forward_vel * dvs_dy * cos_h * dt
F[0, 2]  = -effective_vel * sin_h * dt

F[1, 0]  = forward_vel * dvs_dx * sin_h * dt
F[1, 1]  = 1 + forward_vel * dvs_dy * sin_h * dt
F[1, 2]  = effective_vel * cos_h * dt

denom = speed_factor * max_vel
F[2, 0]  = -(effective_angular_vel * forward_vel * dvs_dx * dt) / denom
F[2, 1]  = -(effective_angular_vel * forward_vel * dvs_dy * dt) / denom
F[2,2]   = 1
```

If we work through it we can get what is essentially the code through derivation. Following the "simple steps" needed we can see that we can derive them as:

$$\delta x_n/\delta x = F[0,0] = \delta/\delta x(x + f_{vel} * v_{scale} * cos(h) * dt) = 1 + f_{vel} * dvs_{dx} * cos(h) * dt$$

$$\delta x_n/\delta y = F[0,1] = \delta/\delta y(x + f_{vel} * v_{scale} * cos(h) * dt) = f_{vel} * dvs_{dy} * cos(h) * dt$$

$$\delta x_n/\delta \Theta = F[0,2] = \delta/\delta \Theta\,(x + f_{vel} * v_{scale} * cos(h) * dt) = -e_{vel} * sin(h) * dt$$

$$\delta y_n/\delta x = F[1,0] = \delta/\delta x(y + f_{vel} * v_{scale} * sin(h) * dt) = f_{vel} * dvs_{dx} * sin(h) * dt$$

$$\delta y_n/\delta y = F[1,1] = \delta/\delta y(y + f_{vel} * v_{scale} * sin(h) * dt) = 1 + f_{vel} * dvs_{dy} * sin(h) * dt$$

$$\delta y_n/\delta \Theta = F[1,2] = \delta/\delta \Theta(y + f_{vel} * v_{scale} * sin(h) * dt) = -e_{vel} * cos(h) * dt$$

$$e_{AngVel} = a_{Vel}/s_{factor}$$

$$\delta \Theta_n/\delta q = F[2,0] = -\delta/\delta q(\Theta + e_{AngVel} * dt) = e_{AngVel} * f_{vel} * dvs_{dx}/denom$$

$$\delta \Theta_n/\delta q = F[2,1] = -\delta/\delta q(\Theta + e_{AngVel} * dt) = e_{AngVel} * f_{vel} * dvs_{dy}/denom$$

$$\delta \Theta_n/\delta \Theta = F[2,2] = 1$$