ASSIGNMENT-4
EKF SLAM
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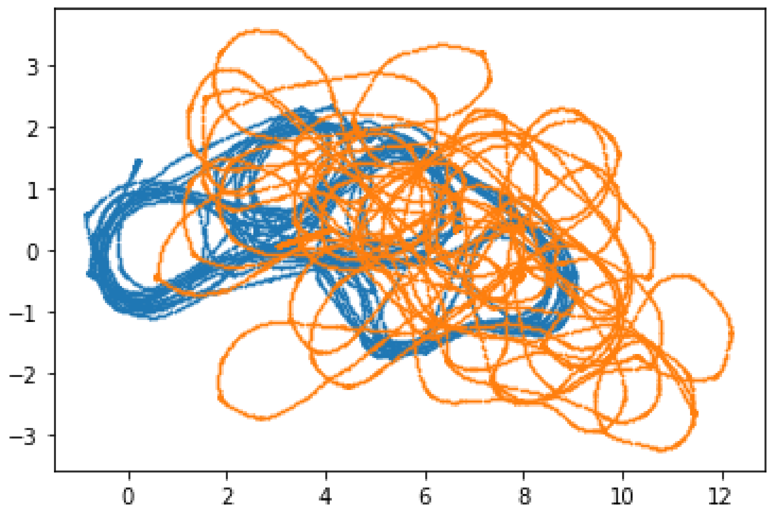
This assignment is an application of sensor fusion using EKF Slam. We need to estimate the trajecory of the robot using a set of landmarks given in the dataset. EKF Slam is used when we need to find the motion from the sensors which have non linearities.

We have assumed that the noise is gaussian in this assignment. The algorithm is given in the image below. We initialize the mean, variance to the first groundtruth values given to us (can be seen in the code).

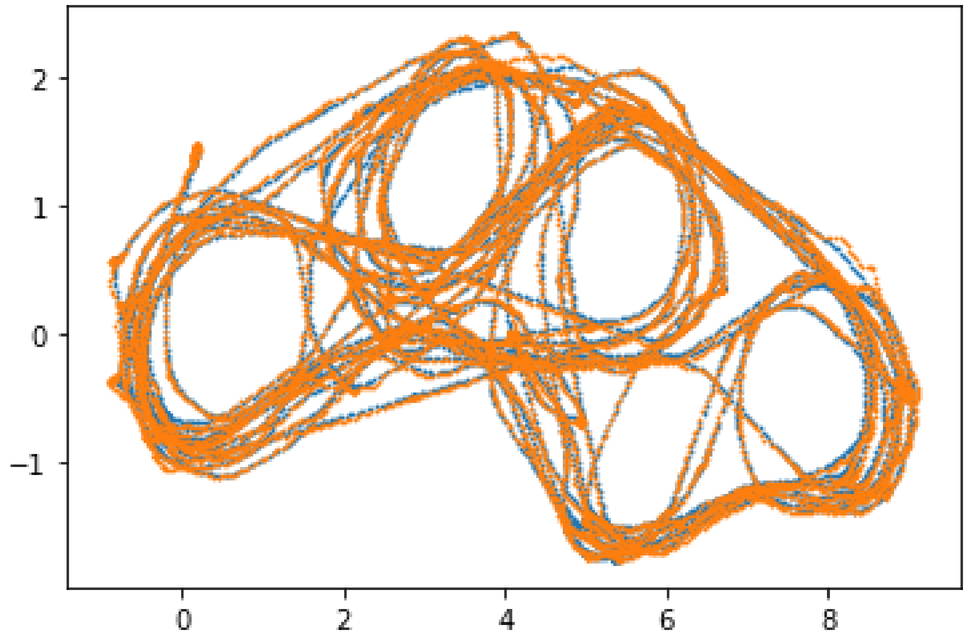
$$
\begin{array}{ll}
2: & \bar{\mu}_t = g(u_t, \mu_{t-1}) \\
3: & \bar{\Sigma}_t = G_t\, \Sigma_{t-1}\, G_t^T + R_t \\
 & \\
4: & K_t = \bar{\Sigma}_t\, H_t^T (H_t\, \bar{\Sigma}_t\, H_t^T + Q_t)^{-1} \\
5: & \mu_t = \bar{\mu}_t + K_t(z_t - h(\bar{\mu}_t)) \\
6: & \Sigma_t = (I - K_t\, H_t)\, \bar{\Sigma}_t \\
7: & return\ \mu_t, \Sigma_t
\end{array}
$$

The expressions for both H and G is attached below. The first step is to form the prediction, after which we have an update step in order to find the final mean and variance values that we desire. In the prediction step, we use G to calculate the covariance matrix after we estimate the position. In the update step, we calculate the Jacobian for the observation using the given values of orientation, calculate the Kalman gain and correct the values.

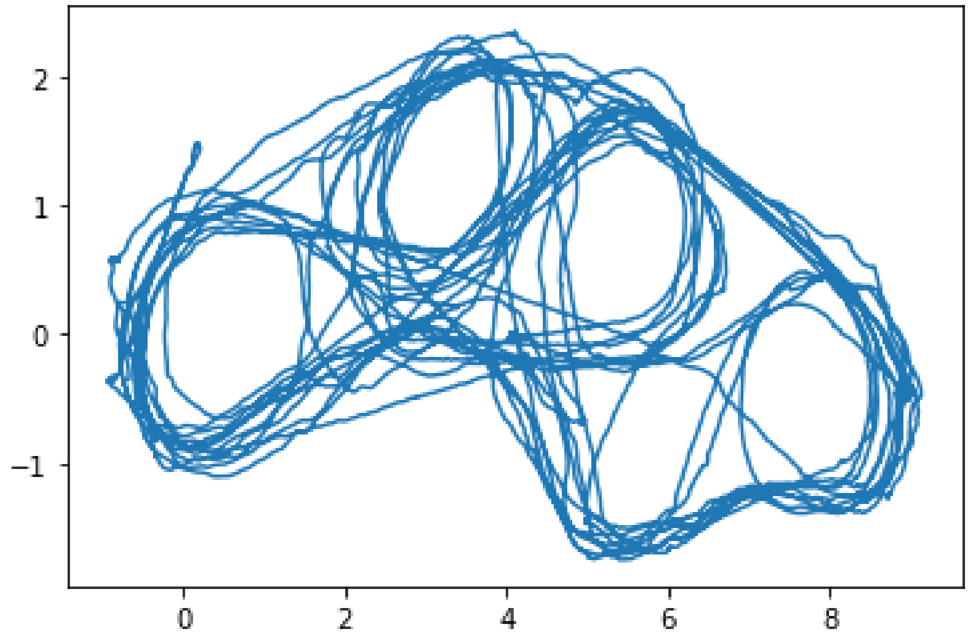
OUTPUTS: Prediction step



Update step: Both the groundruth and correction match with each other.



Output from the correction step:



This is in line with the desired results.

~~For H~~ ~~This~~ For H:

Motion model needs to be derived for EKF Slam.

The final ~~and~~ equations for calculating the Jacobian are as follows:

$$\frac{\partial r_k}{\partial y_k} = \frac{-(y_L - y_k - d\sin\theta)}{\sqrt{(x_L - x_k - d\cos\theta_k)^2 + (y_L - y_k - d\sin\theta)^2}}$$

$$\frac{\partial r_k}{\partial x_k} = \frac{-(x_L - x_k - d\cos\theta_k)}{\sqrt{(x_L - x_k - d\cos\theta_k)^2 + (y_L - y_k - d\sin\theta)^2}}$$

$$\frac{\partial r_k}{\partial \theta_k} = \frac{2(x_L - x_k - d\cos\theta_k)\, d\sin\theta_k + 2(y_L - y_k - d\sin\theta)\cos\theta_k}{\sqrt{(x_L - x_k - d\cos\theta_k)^2 + (y_L - y_k - d\sin\theta)^2}}$$

$$\frac{\partial \varphi_k}{\partial x_k} = \frac{y_k - d\sin\theta - y_L}{(-x_k - d\cos\theta + x_L)^2 + (y_k + d\sin(\theta) - y_L)^2}$$

$$\frac{\partial \varphi_k}{\partial y_k} = \frac{-x_k - d\cos\theta + x_L}{(y_L + d\sin(\theta) - y_L)^2 + (-x_k - d\cos\theta)}$$

This can be written as a $2l \times 3$ matrix

no. of landmarks

$$\frac{\partial \varphi_k}{\partial \theta} = \frac{d\sin\theta(d\sin\theta + y_k - y_L)}{(d\sin\theta + y_k - y_L)^2 + (-d\cos\theta - x_k + x_L)^2}$$

$$= \cancel{(d\cos\theta - x_k + x_L)} \frac{(-d\cos\theta - x_k + x_L) - d\cos\theta}{(d\sin\theta + y_k - y_L)^2 + -d\cos\theta_k - x_k + x_L)}$$

$$= -1$$

For 4) we get

$$dt \begin{bmatrix} 0 & 0 & -v_k \sin\theta_{k-1} \\ 0 & 0 & v_k \cos\theta_{k-1} \\ 0 & 0 & 0 \end{bmatrix} + [I]_{3\times 3}$$

$$= \begin{bmatrix} 1 & 0 & -dt.v_k \sin\theta_{k-1} \\ 0 & 1 & dt.v_k.\cos\theta_{k-1} \\ 0 & 0 & 1 \end{bmatrix}$$