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Covariance Matrices

1) State Covariance matrix (P)
If initial state is not very close, the P_0 value should be large, whereas if the initialization is good (x_0 matrix) then we can assume smaller P_0 value.

* Don't initialise P_0 to zero (zero matrix).

* Recommended to initialise state covariance matrix to unity (diagonally) (identity matrix).

Many times P_0 matrix is diagonal, with diagonal elements corresponds to the expected variance of the corresponding state (initial state vector)

If number of elements in state vector is 'n', then dimension of P matrix is $n \times n$.

The values of P matrix goes on decreasing at each iteration.

* If sensor co-variance matrix 'R' (values given based on the data sheet of sensor) is ~~larger~~ smaller, hence 'K_k' (Kalman Gain) is large enough to reduce the value of state co-variance matrix 'p' in update state.

we can also say value of P matrix is small from initial stage itself.

~~* If the sensor is less noisy, K_K~~

2) Process noise Covariance matrix (Q)

'Q' matrix corresponds to the errors that we expect in the state transition equation (Newton equations).

✓ This could include mathematical modeling errors also (while designing equations)

✓ In most of times we consider control inputs which introduce process noise matrix (u)

Eg: In case of RADAR & LiDAR we consider acceleration in x-y & timestamp as control inputs.

* Both of 'P' matrix & 'Q' matrix predictions occur based on the previous states, & then they are used for the update state.

* In a constant velocity model, the 'Q' matrix represents accelerations that allows the tracked object to deviate from constant velocity.

This will expand the predicted 'P' matrix to allow for slight deviations in the track when the object moves.

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✓ Q matrix can never be filled with zeroes, if we do this the filter will use the noise free model to predict the state vector & will ignore the control inputs.

✓ Generally we would set the diagonals of Q matrix to be proportional to twice the expected moment in acceleration (in case of constant velocity model).

✓ If the diamension of state vector is $n \times 1$, then dia^{m} of Q matrix is $n \times n$

* The diagonals of any covariance matrix must be positive, since they represent the squared errors.