Probabilistic Robotics
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Lab Sessions:

- Filtering a single variable (3 hours)
- SLAM with a 1D mobile robot (3 hours)

- SLAM with a 2D mobile robot (optional)
- SLAM with a 3D mobile robot (optional)

The algorithm in Matlab

for k = 1:NumberTimeStamps - 1

% Prediction

```
xhat(k+1) = Fk * xhat(k) + Uk;
zhat(k+1) = H * xhat(k+1);
Pk(k+1) = Fk * Pk(k) * Fk' + Q;
```

$$\hat{\mathbf{x}}_{k|k-1} = \mathbf{F}_k\hat{\mathbf{x}}_{k-1|k-1} + \mathbf{B}_k\mathbf{u}_k$$

$$\mathbf{H}_k\hat{\mathbf{x}}_{k|k-1}$$

$$\mathbf{P}_{k|k-1} = \mathbf{F}_k\mathbf{P}_{k-1|k-1}\mathbf{F}_k^{\mathrm{T}} + \mathbf{Q}_k$$

% Observation

```
z(k+1) = H * x(k+1) + normrnd(0,sqrt(r));
```

$$\mathbf{z}_k$$

```
vv(k+1) = z(k+1) - zhat(k+1);
S = H * Pk(k+1) * H' + R;
```

$$\tilde{\mathbf{y}}_k = \mathbf{z}_k - \mathbf{H}_k\hat{\mathbf{x}}_{k|k-1}$$

$$\mathbf{S}_k = \mathbf{H}_k\mathbf{P}_{k|k-1}\mathbf{H}_k^{\mathrm{T}} + \mathbf{R}_k$$

% update

```
W = Pk(k+1) * H' * inv(S);
xhat(k+1)  = xhat(k+1) + W * vv(k+1);
Pk(k+1) = Pk(k+1) – W * H * Pk(k+1);
```

$$\mathbf{K}_k = \mathbf{P}_{k|k-1}\mathbf{H}_k^{\mathrm{T}}\mathbf{S}_k^{-1}$$

$$\hat{\mathbf{x}}_{k|k} = \hat{\mathbf{x}}_{k|k-1} + \mathbf{K}_k\tilde{\mathbf{y}}_k$$

$$\mathbf{P}_{k|k} = (I - \mathbf{K}_k\mathbf{H}_k)\mathbf{P}_{k|k-1}$$

end;

Lab Sessions

Lab 1 – Filtering a single variable (3 hours lab)
- Open the Temperature_estimate.m file.
- Program the parts of the code denoted by "…." that are missing.
- Execute and check that runs properly.
- Tune the measuring noise (r) and process noise (pn) and see the effects.
- Change the initial position of the state (xhat(1)) to a different temperature and check that converges to the observation.
- Program the temperature to follow a sin function.
- Tune the measuring noise (r) and process noise (pn) and see the effects.
- Check the values of the state (xhat) and uncertainty (Pk).
- SHOW TO THE TEACHER

Lab Sessions

Lab 2 – SLAM with KF of a 1D mobile robot (3 hours lab)
- Read and Execute the Slam1D1.m file, pay attention to the xhat vector and the H matrix. Vehicle Position and Velocity ARE NOT measured.
- Read and Execute the Slam1D2.m file, pay attention to the xhat vector and the H matrix. Vehicle Position and Velocity ARE measured.
- Modify Slam1D1.m so that landmarks are measured relative to vehicle position, vehicle position and velocity ARE NOT measured.
- Modify Slam1D2.m so that landmarks are measured relative to vehicle position, vehicle position IS NOT measured, but velocity IS.
- Change the vehicle trajectory performing an arbitrary movement (ex sin function).
- Tune the measuring noise (r, rv) and process noise (pn) and see the effects.
- SHOW TO THE TEACHER

Lab Sessions (Optional)

Lab 3 – SLAM with KF of a 2D mobile robot (4 h. home)

- Read and Execute the Slam2D1.m file.
- Modify the code so that only the landmarks are observed. Vehicle position and velocity ARE NOT observed.
- Tune the measuring noise (r) and process noise (pn) and see the effects.
- Read and Execute the Slam2D2.m file.
- Modify the code so that only the landmarks are observed. Vehicle position and velocity ARE NOT observed.
- Increase the range of the sensor so that all the landmarks are always observed, see effects.
- Reduce drastically the range of the sensor to see one landmark from time to time, see effects.
- Modify the code so that the vehicle velocity is observed, vehicle position IS NOT observed.
- Reduce/Increase the range of the sensor and see effects.
- Tune the measuring noise (r, rv) and process noise (pn) and see the effects.
- SHOW TO THE TEACHER

Lab Sessions (Optional)

Lab 4 – SLAM with KF of a 3D underwater robot (Off the lab)
- Read and Execute algorithms Slam3D1.m up to Slam3D4.m.
- Play and enjoy, but also UNDERSTAND the code.