Ball Tracking Example

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Ball Tracking with Kalman Filter

Ball physical model:

Position: \( \vec{p}_t = (\text{col}_t, \text{row}_t)' \)
Velocity: \( \vec{v}_t = (\text{velcol}_t, \text{velrow}_t)' \)
Position update: \( \vec{p}_t = \vec{p}_{t-1} + \vec{v}_{t-1} \Delta t \)
Velocity update: \( \vec{v}_t = \vec{v}_{t-1} + \vec{a}_{t-1} \Delta t \)
Acceleration (gravity down): \( \vec{a}_t = (0, g)' \)
State vector: \( \vec{x}_t = (\text{col}_t, \text{row}_t, \text{velcol}_t, \text{velrow}_t)' \)
Initial state vector: random

Ball physics update

Prediction: \( \hat{y}_t = A \hat{x}_{t-1} + Bu_t \)

\[
A = \begin{bmatrix}
1 & 0 & \Delta t & 0 \\
0 & 1 & 0 & \Delta t \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 \\
\end{bmatrix}
\]

\[
Bu_t = \begin{bmatrix}
0 \\
0 \\
0 \\
g \Delta t \\
\end{bmatrix}
\]

Use \( \Delta t = 1 \)

Rest of model

Observation process:

\[
H = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
\end{bmatrix}
\]

Measurement noise:

\[
R = \begin{bmatrix}
0.285 & 0.005 \\
0.005 & 0.046 \\
\end{bmatrix}
\]

System noise: \( Q = 0.01 \times I \)
Ball Tracking with Kalman Filter

KALMAN FILTER SUCCESSES
SEE: homepages.inf.ed.ac.uk/rbf/...AVINVERTED/DEMOS/TRACK/demo.html 8:

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KALMAN FILTER FAILURES
14: BOUNCE OVERSHEEP 16: SLOW CATCH UP
59: GRAVITY PULLS DOWN AT REST

Ball tracking analysis

- KF smooths noisy observations (not so noisy here) to give better estimates
- Could also estimate ball radius
- Could also plot boundary of 95% likelihood of ball position - grows when fit is bad
- Dynamic model doesn’t work at bounce & stop

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