Introduction to Kalman Filter

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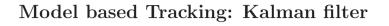
Kalman Filter Introduction

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KALMAN FILTER INTRODUCTION

" A set of mathematical equations that provides an efficient computational (recursive) solution to the least-squares method." [Welch & Bishop]

Most commonly used position estimator used in ? problems



Why? Model can be used to

1. Predict likely position, thus reducing search

2. Integrate ? _____ observations, thus

giving improved estimates

What's in model (here called **state**): position, velocity, shape, ...

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KALMAN FILTER THEORY

Assumes:

1. A changing (with t) ? vector: \vec{x}_t and its

associated covariance \mathbf{P}_t and state transition matrix

 \mathbf{A}

2. A process model that updates the state over time:

$$\vec{x}_t = \mathbf{A}\vec{x}_{t-1} + \mathbf{B}\vec{u}_{t-1} + \vec{w}_{t-1}$$

where:

- A updates the state
- $\mathbf{B}\vec{u}_{t-1}$ some external action on the state at t-1
- \vec{w}_{t-1} process noise: multi-variate normal distribution, mean $\vec{0}$ and covariance \mathbf{Q}

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3. An ?

to the current state:

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that relates measured data \vec{z}_t

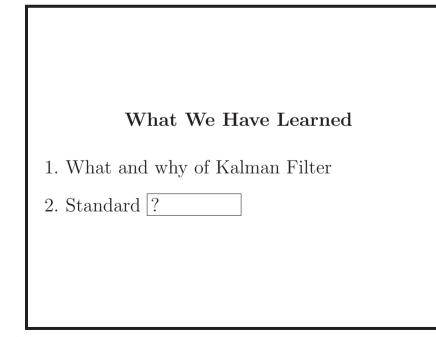
KALMAN FILTER ALGORITHM

- 1. Predict ? given what we already know: $\vec{y}_t = \mathbf{A}\vec{x}_{t-1} + \mathbf{B}\vec{u}_{t-1}$
- 2. Estimate covariance (error) of predicted state: $\mathbf{E}_t = \mathbf{A}\mathbf{P}_{t-1}\mathbf{A}' + \mathbf{Q}$
- 3. Estimate correction gain between actual and predicted observations:

$$\mathbf{K}_t = \mathbf{E}_t \mathbf{H}' (\mathbf{H} \mathbf{E}_t \mathbf{H}' + \mathbf{R})^{-1}$$

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$ec{z}_t = \mathbf{H}ec{x}_t + ec{v}_t$ where: • \mathbf{H} - extracts observations • $ec{v}_t$ - observation noise: multi-variate normal distribution, mean $ec{0}$ and covariance \mathbf{R}

4. Estimate ? given prediction and correction from observations:

$$\vec{x}_t = \vec{y}_t + \mathbf{K}_t (\vec{z}_t - \mathbf{H}\vec{y}_t)$$

5. Estimate error of new state:

$$\mathbf{P}_t = (\mathbf{I} - \mathbf{K}_t \mathbf{H}) \mathbf{E}_t$$

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