Feedback Particle Filter

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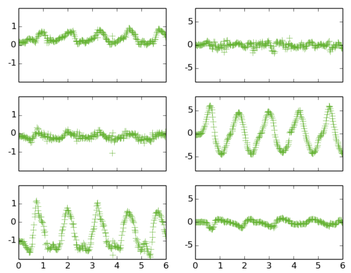
Gesture recognition

Gesture

Sensor measurements



Hidden state: Motion of hand

Measurements: Motion sensors, accelerometer and gyroscope

Problem: Detection of a gesture in real-time

Navigation

Quad rotor

Measurements (Camera)

Hidden state: Position and orientation of quadrotor

Measurements: Camera and motion sensor

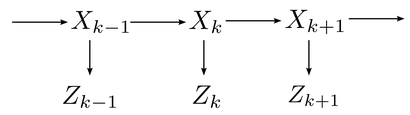
Problem: Estimate the state based on measurements

Challenges

1. Nonlinear dynamics
2. Model uncertainties
3. Sensor noise
4. Real-time and reliable solution

Approach: Probabilistic, Nonlinear filtering

Nonlinear filtering, Bayesian inference



State of the system: X_k

Model for state dynamics: $X_k \to X_{k+1}$

Model for measurements: $X_k \to Z_k$

Objective: Compute probability distribution of state given measurements

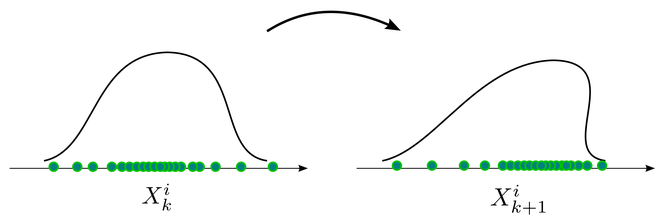
$\mathrm{P}(X_k|Z_1, \ldots, Z_k)$

Filtering algorithms

Linear and Gaussian: Kalman filter

Nonlinear and non-Gaussian: Extended Kalman filter, particle filter

Feedback Particle Filter



- Approximate $\mathrm{P}(X_k|Z_1, \ldots, Z_k)$ with particles, $\{X_k^1, X_k^2, \ldots, X_k^N\}$
- Move particles with a control law s.t

$$X_{k+1}^i \sim \mathrm{P}(X_{k+1}|Z_1, \ldots, Z_{k+1})$$

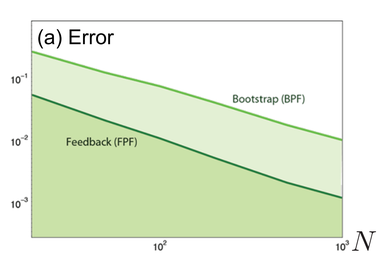
- The control law has a feedback structure

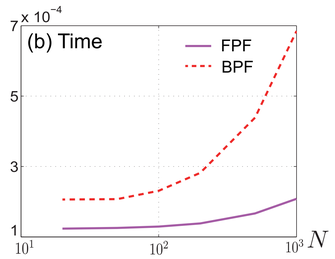
$$\text{Gain} * \text{Error}$$

- *Gain* is solution to a BVP $\to$ hard to solve!

FPF vs particle filter

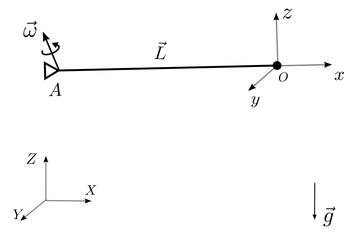
- Variance reduction

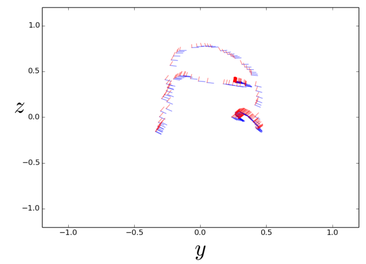




Estimating gesture trajectory

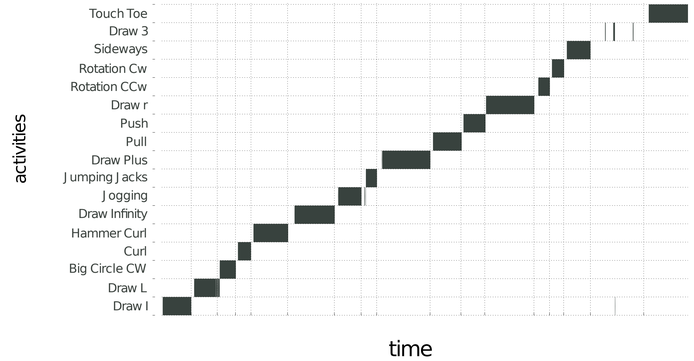
- The hand is modeled as a rigid link
- State is the attitude of body frame
- FPF is implemented to estimate the attitude





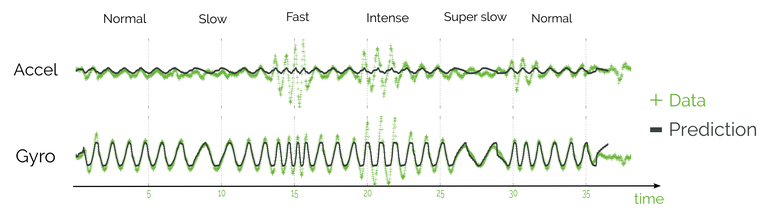
Activity recognition

- Models for 17 activities are learned
- FPF is used to classify activities in real time



Robustness

- Filter is robust to changes in speed and intensity



Recent publications

- An optimal transport formulation of linear FPF, ACC, (2016)
- FPF on matrix Lie groups, ACC, (2016)

Acknowledgement

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