Mobile Robots and Autonomous Vehicles

Week 5: Behavior Modeling and Learning

- Bayesian Filter inference: filtering, smoothing, prediction and recognition

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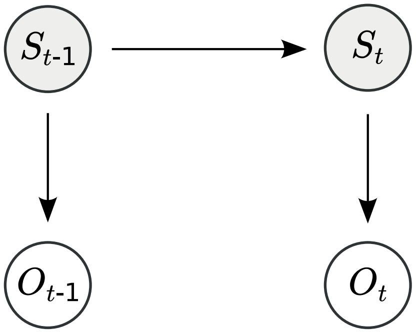
Hidden Markov Modes: discrete Bayes filters



- Variables
  - $S_{t-1} \in \{1, \cdots, N\}$: Previous state
  - $S_t \in \{1, \cdots, N\}$: Current state
  - $O_t \in \mathbb{R}^2$: Observation

- Joint probability distribution

$$P(S_{t-1}, S_t, O_t) = P(S_{t-1})P(S_t|S_{t-1})P(O_t|S_t)$$

HMM: Parametric Forms

- State prior $P(S_{t-1})$: multinomial
- Transition probability $P(S_t|S_{t-1})$: NxN matrix
- Observation probabilities $P(O_t|S_t)$: Gaussians

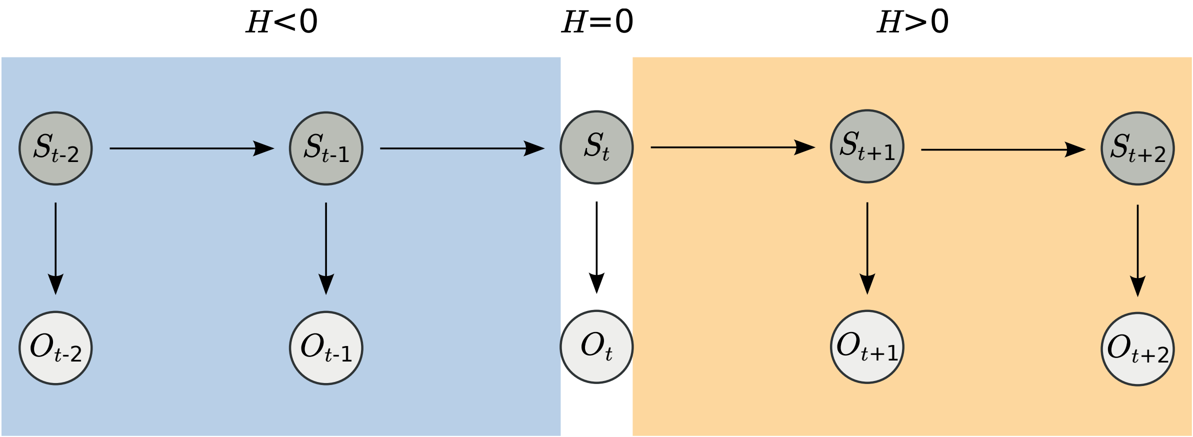
$$\mathcal{N}(\Sigma, \mu_i) \forall i \in 1, \cdots, N)$$

HMM: Probabilistic Questions

- Question:

$$P(S_{t+H}|O_{1:t})$$

  - $H = 0$: Filtering
  - $H < 0$: Smoothing
  - $H > 0$: Prediction



HMM: Filtering

- Recursive formulation:

$$P([S_t = i] | O_{1:T}) = \frac{1}{Z} P(O_t | (S_t = i)) \sum_{j=1}^{N} P([S_t = 1] | [S_{t-1} = j]) P([S_{t-1} = j] | O_{1:t-1})$$

- Can be computed on-line, once O_t is available.

HMM: Prediction

- Computed after filtering

$$P([S_{t+H} = i] | O_{1:t}) = \sum_{j=1}^{N} P([S_{t+H} = i] | [S_{t+H-1} = j]) P([S_{t+H-1} = j] | O_{1:t})$$

- On-line update also possible
- We will not cover smoothing