# Hidden Markov Model (HMM)

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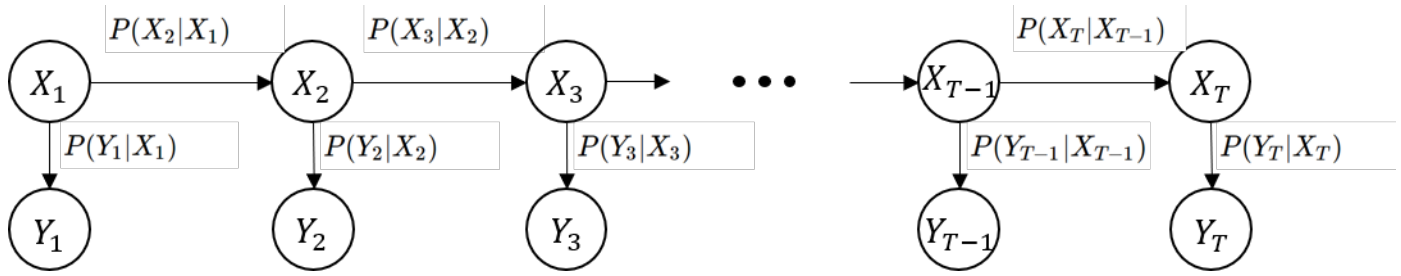
# Hidden Markov Models

- Discrete state-space model
  - Used in speech recognition
  - State representation is simple
  - Hard to scale-up the training



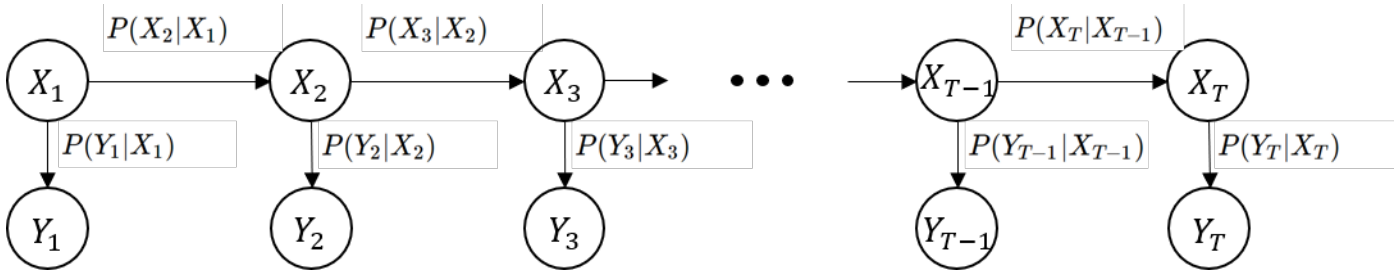

- Assumption
  - We can observe something that's affected by the true state
  - Natural way of thinking

- Limited sensors (incomplete state information)
  - But still partially related

- Noisy sensors
  - Unreliable

# Hidden Markov Model (HMM)

- True state (or hidden variable) follows Markov chain
- Observation emitted from state
  - $Y_t$ is noisily determined depending on the current state $X_t$




- Forward: sequence of observations can be generated
- Question: state estimation

$$P(X_T = s_i \mid Y_1 Y_2 \cdots Y_T)$$

- HMM can do this, but with many difficulties

# Hidden Markov Models

- Question 1: State Estimation

  What is $P(q_t = Si|O_1O_2 \cdots O_T)$

Interested for us
- Current state estimation given sequence of observations

- Question 2: Most Probable Path

  Given $O_1O_2 \cdots O_T$, what is the most probable path that I took? And what is that probability?

- Question 3: Learning HMMs

  Given $O_1O_2 \ldots O_T$, what is the maximum likelihood HMM that could have produced this string of observations?