HMM - Hidden Markov Models

- Problems
  - No time dependence of state holding time
  - Only DTMC as hidden Model
- Applications
  - Gene decoding
  - Pattern recognition
  - Speech recognition
- Training
  - problems
    - local optimization!
    - expensive
    - choosing model size
  - Baum-Welch
    - Expectation Maximization
    - = Forward-Backward Alg
    - General Idea
      - iterative adjustment of initial guess model parameters
  - Problem
    - $\lambda = \arg\max\{P(O/\lambda)\}$
    - Find lambda given O for given structure
    - How do we get the model parameters?
- Decoding
  - Viterbi Algorithm
    - General Idea
      - for most likely end state retrace path
      - Find partial probabilities delta for each timestep and state
      - Greedy - find most likely sequence so far (recursive by time step)
  - Naive Approach - Total enumeration
  - Applications
    - Recognizing sentence structure / word tagging
  - Problem
    - "$Q = \arg\max\{P(Q/O, \lambda)\}$"
    - Find most likely Q of given O and λ
- Motivation
  - Weather/Freetime (Rainy-Sunny)/(walk-shop-clean)
  - Urn/Ball Model with Genie
  - Speech Recognition Phoneme/Sound
- Basics
  - Signal Models
    - "hidden source, observable signal"
    - can be time dependent or independent
  - Graphical Representation
  - "Formal (S, V, A, B, Π)"
    - "Hidden States $S=\{s_1, s_2, \ldots s_N\}$"
    - "Output Symbols $V=\{v_1, v_2, \ldots v_M\}$"
    - Transition Probabilities $A=\{a_{ij}\}$
    - Output Probabilities $B=\{b_i(v_k)\}$
    - Π Initial Probabilities
  - Notation
    - "$\lambda=(A,B,\Pi)$"
    - Q=state sequence
    - O=output sequence
  - How to generate a Symbol Sequence
  - Three Basic Problems/Questions
- Evaluation
  - Problem
    - Find probability of given O for λ
    - $P(O/\lambda)$
  - Application
    - Find word (model) that generated the sound (observation)
    - Find meaning behind pattern
  - Naive Approach - Total enumeration
  - Forward Algorithm
    - General Idea - recursive by time step
    - find partial probabilities alpha for each timestep and state