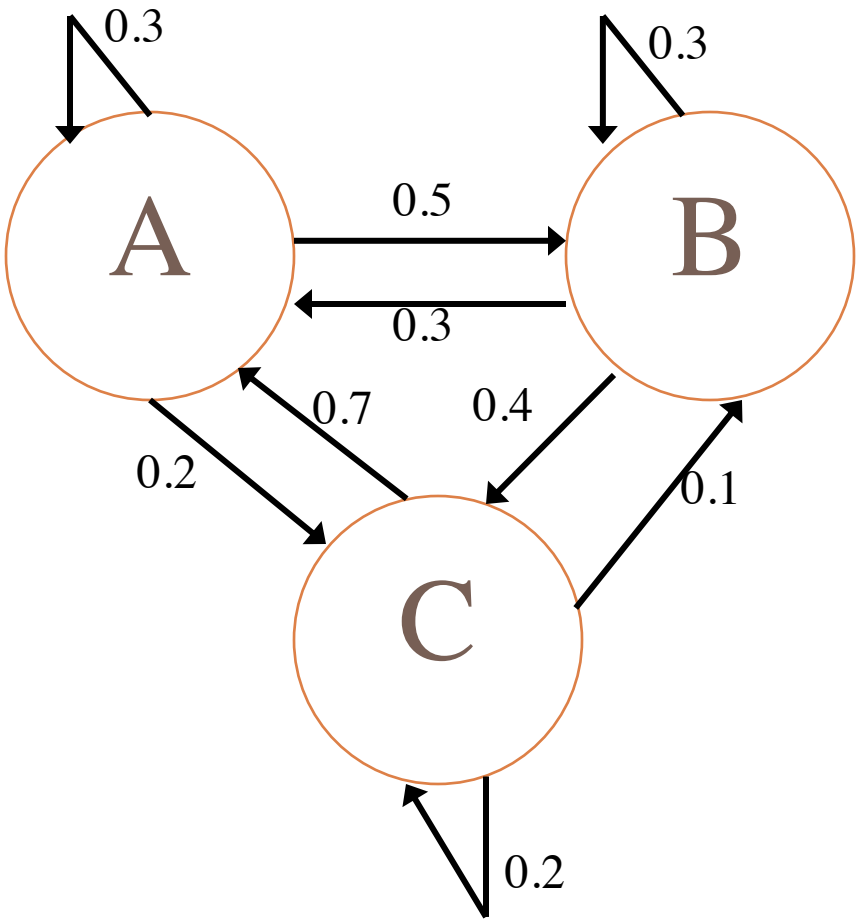
Week 8 Video 4

Hidden Markov Models

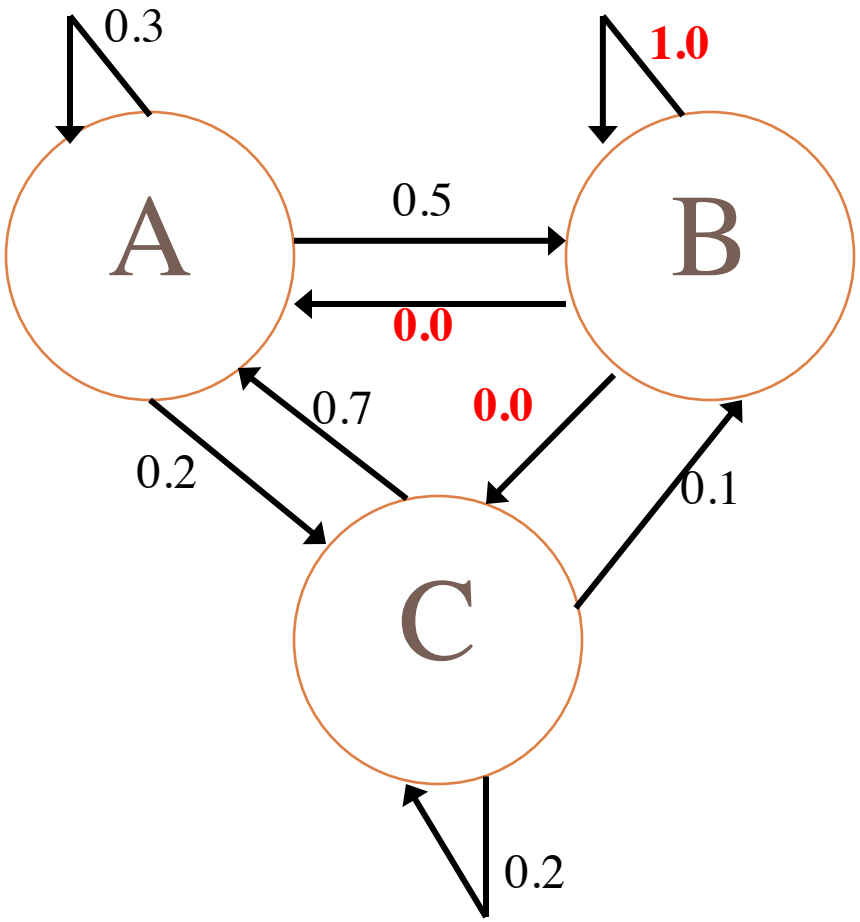
Markov Model

- There are N states
- The agent or world (example: the learner) is in only one state at a time
- At each change in time, the system can change state
- Based on the current state, there is a different probability for each next state

Markov Model Example



Markov Model Example



Markov Assumption

- For predicting the next state, only the current state matters
- Often a wrong assumption
- But a nice way to simplify the math and reduce overfitting!

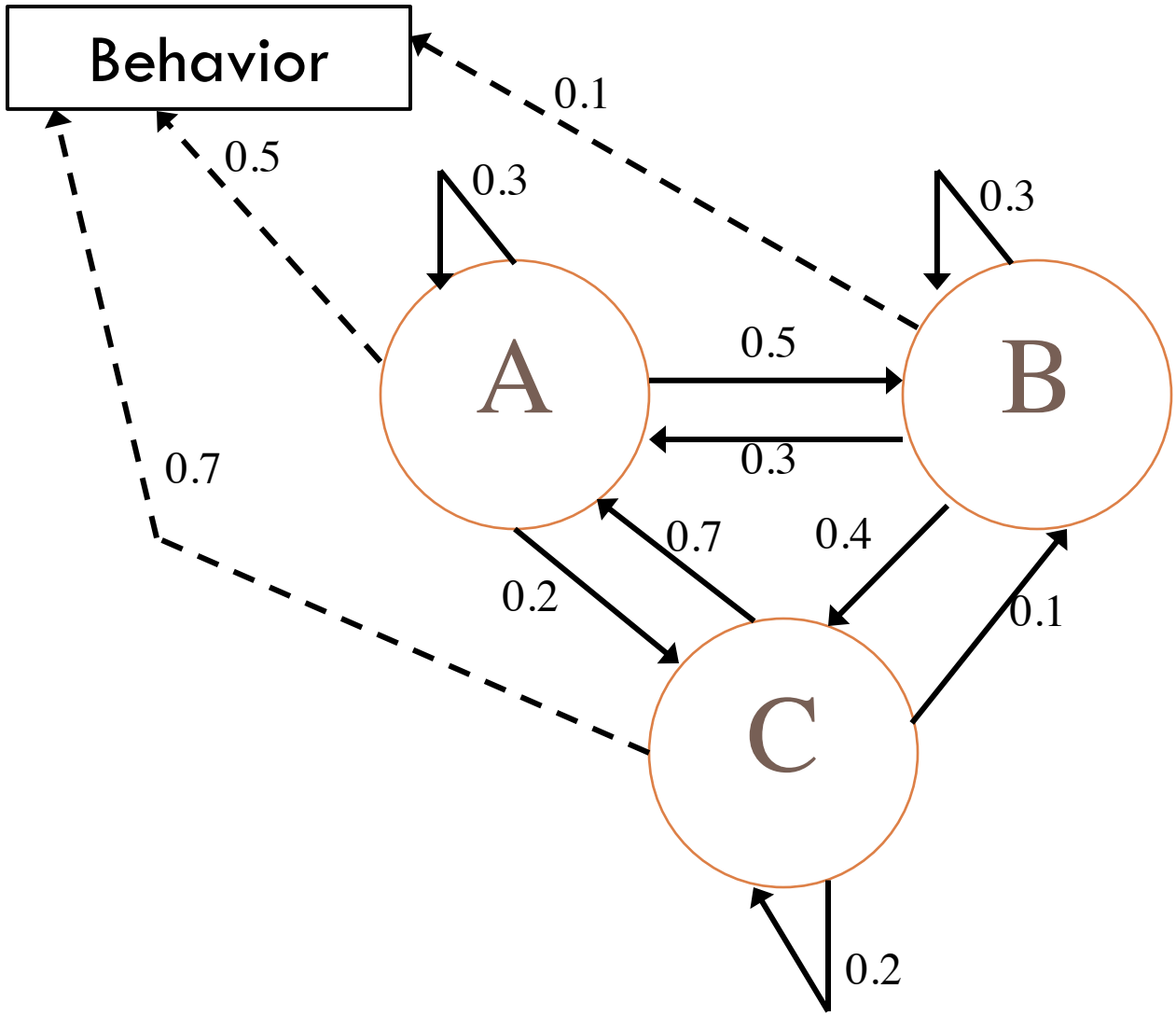
Hidden Markov Model (HMM)

- There are N states

- The world (or learner) is in only one state at a time
- We don't know the state for sure, we can only infer it from behavior(s) and our estimation of the previous state

- At each change in time, the system can change state
- Based on the current state, there is a different probability for each next state

Hidden Markov Model Example

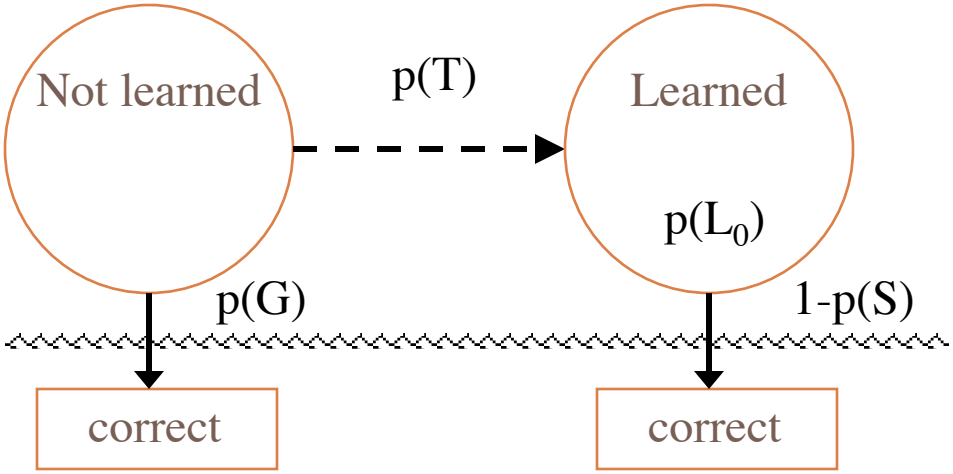


We can estimate the state

- Based on the behaviors we see
- Based on our estimation of the previous state

- What is the probability that the state is X, given
  - the probability of the behavior seen
  - the probability of each possible prior state
  - the probability of the transition to X from each possible prior state

A Simple Hidden Markov Model: Bayesian Knowledge Tracing



Hidden Markov Model: BKT

- There are 2 states

- The world (or learner) is in only one state at a time: KNOWN OR UNKNOWN
- We don't know the state for sure, we can only infer it from CORRECTNESS and our estimation of the previous probability of KNOWN versus UNKNOWN

- At each change in time, the system can LEARN
- Based on the current state, there is a different probability for each next state
  - P(T) of going KNOWN from UNKNOWN
  - KNOWN from KNOWN

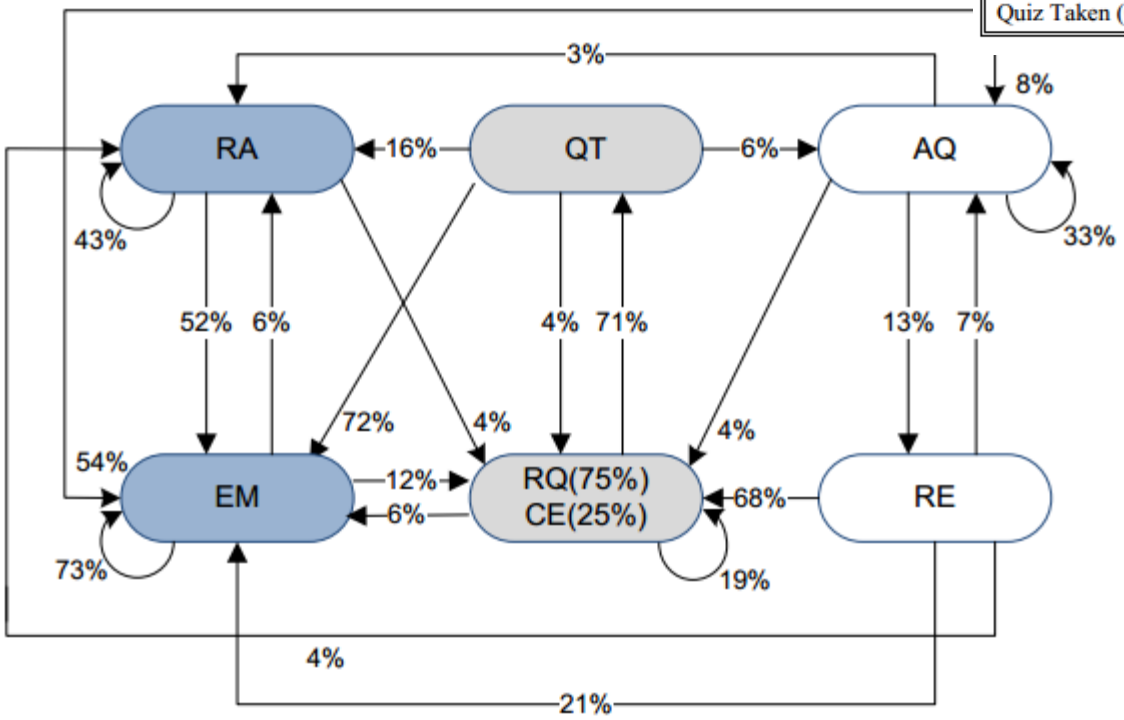
Fitting BKT is hard…

- Fitting HMMs is no easier
  - Often local minima
- Several algorithms are used to fit parameters, including EM, Baum-Welch, and segmental k-Means
- Our old friends BiC and AIC are typically used to choose number of nodes

Other examples of HMM in education

Predicting Transitions Between Student Activities (Jeong & Biswas, 2008)

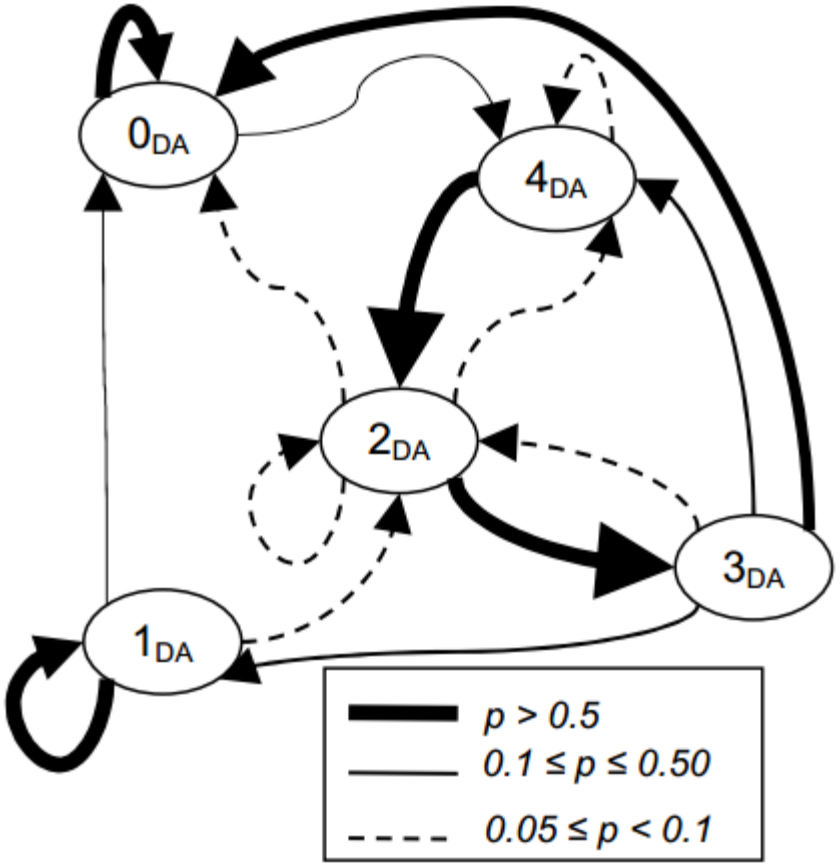
Activity	Student Actions
Edit Map (EM)	adding, modifying, or deleting concepts and links
Ask Query (AQ)	asking Betty queries
Request Quiz (RQ)	asking Betty to take the quiz
Resource Access (RA)	accessing the resources
Request Explanation (RE)	asking Betty for an explanation to her query answer
Continue Explanation (CE)	asking Betty to provide a more detailed explanation
Quiz Denied (QD)	asking Betty to take the quiz without adequate preparation
Quiz Taken (QT)	asking Betty to take the quiz with adequate preparation



Studying patterns in dialogue acts between students and (human) tutors

- (Boyer et al., 2009)

- 5 states
  - 0: Tutor Lecture
  - 4: Tutor Lecture and Probing
  - 3: Tutor Feedback
  - 1: Student Reflection
  - 2: Grounding



A powerful tool

- For studying the transitions between states and/or behaviors
- And for estimating what state a learner (or other agent) is in

Next lecture

- Conclusions and Future Directions