Project Topic: Developing a software for analyzing data from online learning quizzes

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Traditional Bayesian Knowledge Tracing

Model student knowledge with a directed model with hidden states. This topic is a perfect example of a HMM.

- We only observe the performance of the students through test, exams, etc. **observed nodes**
- The true knowledge or skill is unknown **hidden nodes**
- Intuitive idea: model the true knowledge through a HMM $\rightarrow$ BKT
- Student knowledge is represented as a set of binary variables (one per skill)
- Observation of BKT also binary: gets a problem right or wrong

Hidden Markov Model (HMM)

Traditional Hidden Markov Models are a directed graphical model with unobserved nodes (hidden) and observable nodes.

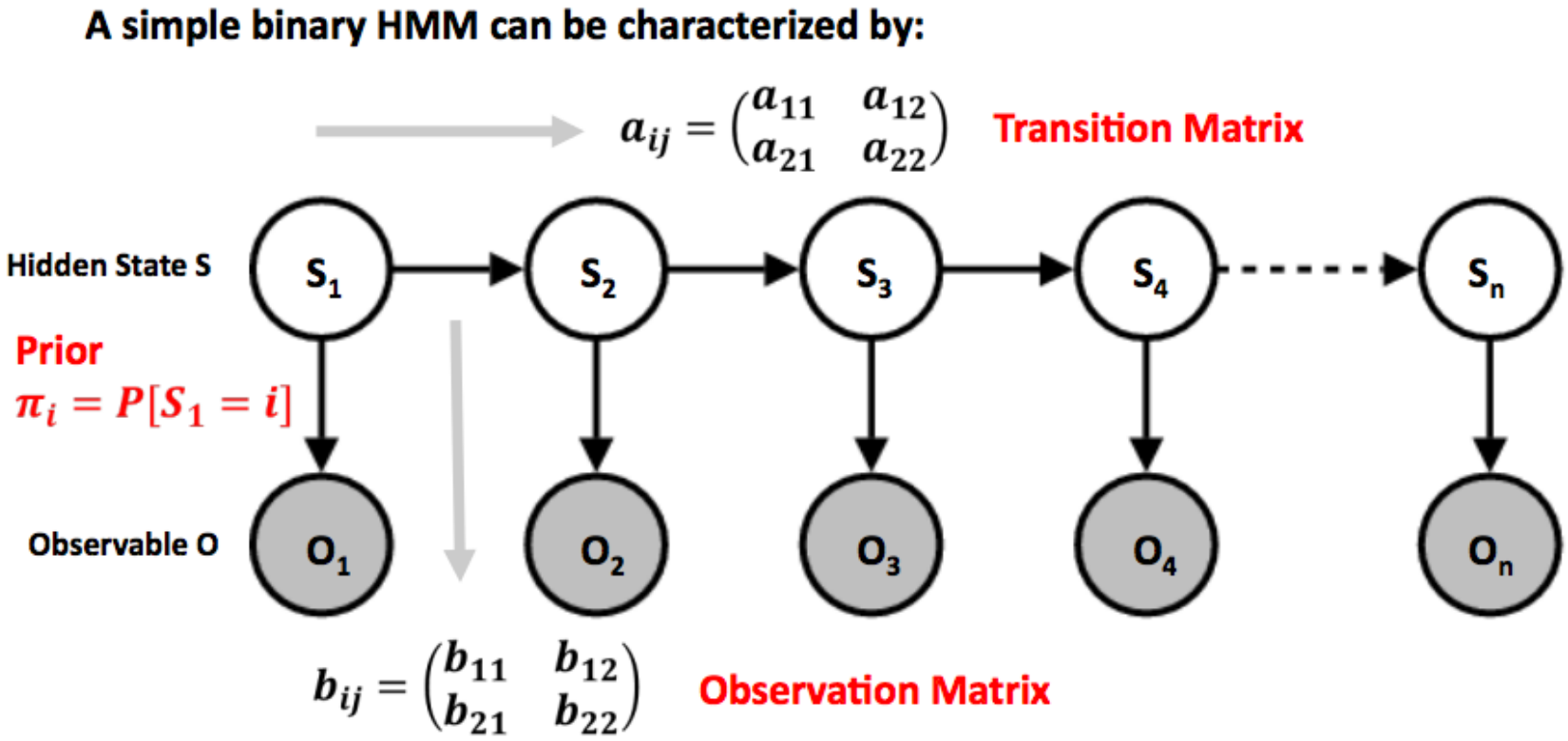

Figure: Hidden Markov Model

Traditional Bayesian Knowledge Tracing

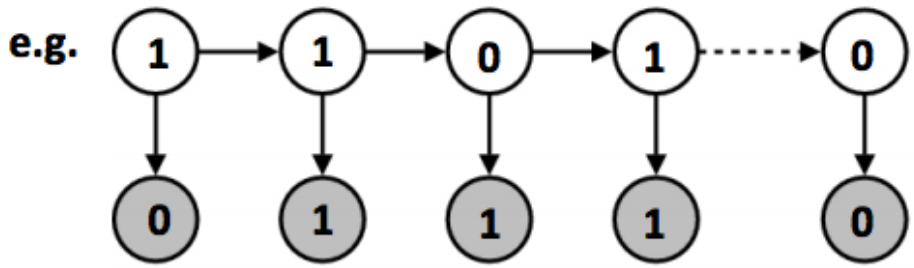

Figure: Bayesian Knowledge Tracing

Parameters of the BKT

The BKTs are caracterized with the Prior distribution, the Transition Matrix and The Emission (Observation) matrix. In this project, are equivalent to:

- **P-init**: Initial a priori of knowing the skill $p(L_0)$
- **P-transit**: Probability of each student to transition from *not known* to *known* $p(T)$
- **P-slip**: Probability to make a mistake when applying a known skill $p(S)$
- **P-guess**: Probability of correctly applying a not-known skill $p(G)$

Equivalence with HMM

The P-slip and P-guess are components of the Emission matrix and P-transit of the Transition matrix.

known	$p(L_0)$
unknown	1-$p(L_0)$

	to known	to unknown
from known	1	0
from unknown	$p(T)$	$1 - p(T)$

	right	wrong
known	1-$p(S)$	$p(S)$
unknown	$p(G)$	1-$p(G)$

Figure: Transition and Emission matrix of BKT

Individualized Bayesian Knowledge Tracing

Idea:

- All data for the students practicing skill k would be used to fit four BKT parameters for that skill: P^k
- All data for student u will be used to fit four parameters for that student P_u
- Build a function to yield a value p_u^k

Problems and fitting

How to update the parameters?
First attemps: Expectation maximization method (EM),
Conjugate gradient methods, but EM doesnt optimize a likelihood of the observations given BKT parameters.
Other approaches:
Bayesian approaches (HMC, MCMC)