Conceptual Issues in Mastery Criteria: Differentiating Uncertainty and Degrees of Knowledge

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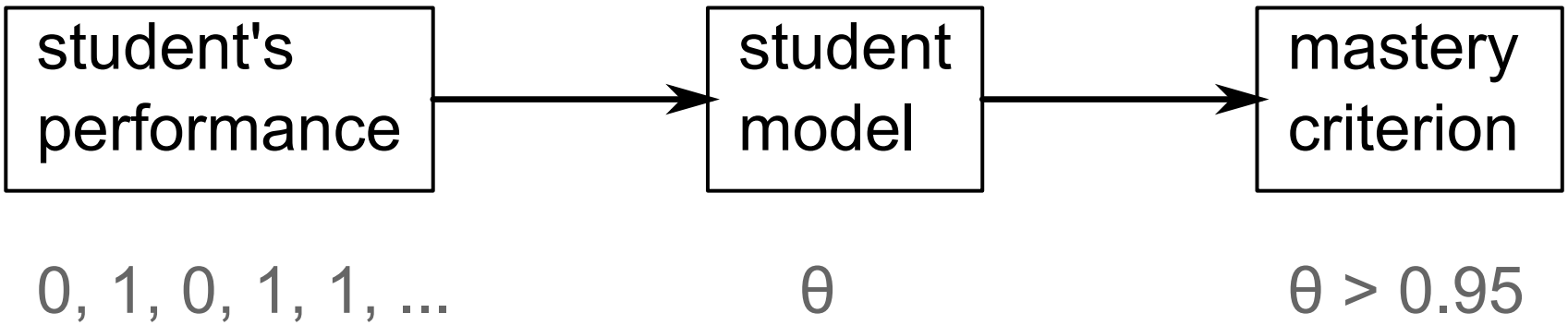
Mastery Learning



Threshold Criterion

$$\theta > 0.95$$

What does it mean?

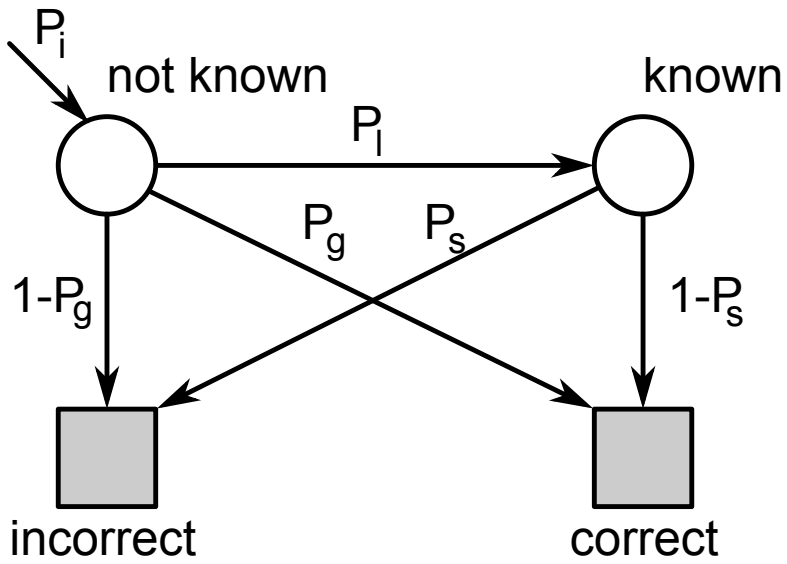
Threshold Criterion

$$\theta > 0.95$$

What does it mean?

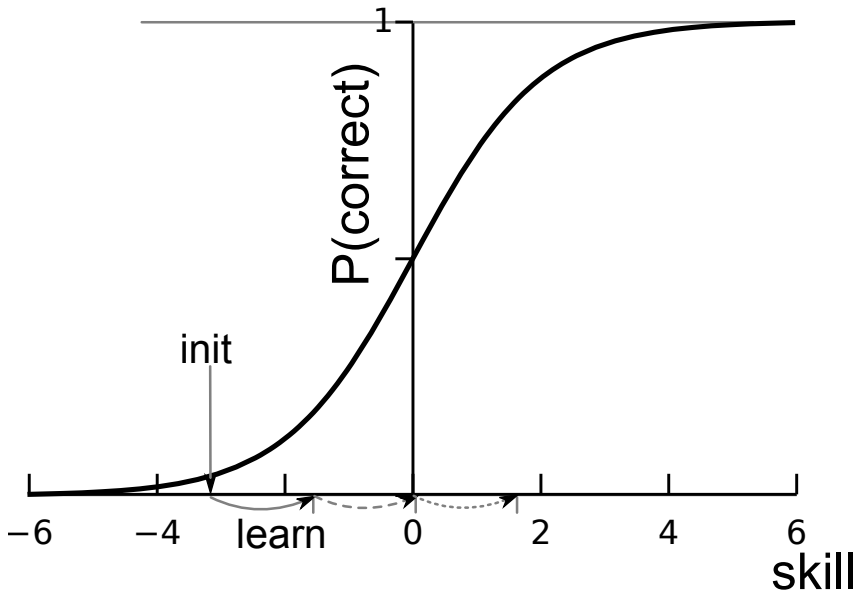
- portion of the topic that the learner mastered?
- uncertainty of the estimate?

Bayesian Knowledge Tracing



- threshold on uncertainty
- binary knowledge assumption

Logistic Models

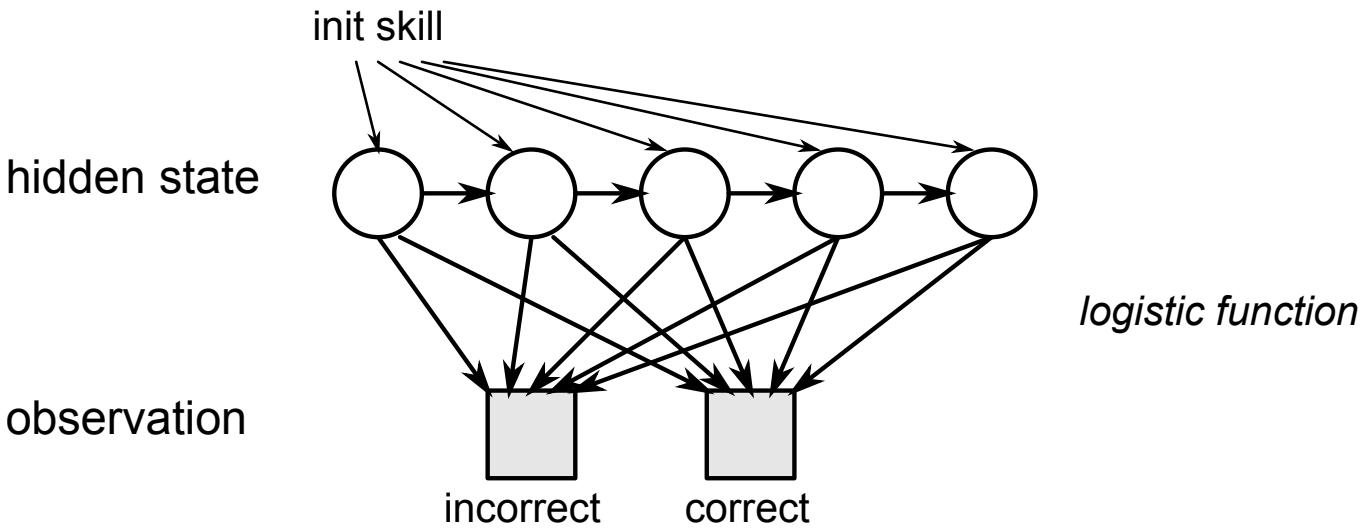


- degrees of knowledge
- uncertainty of estimate not explicitly quantified

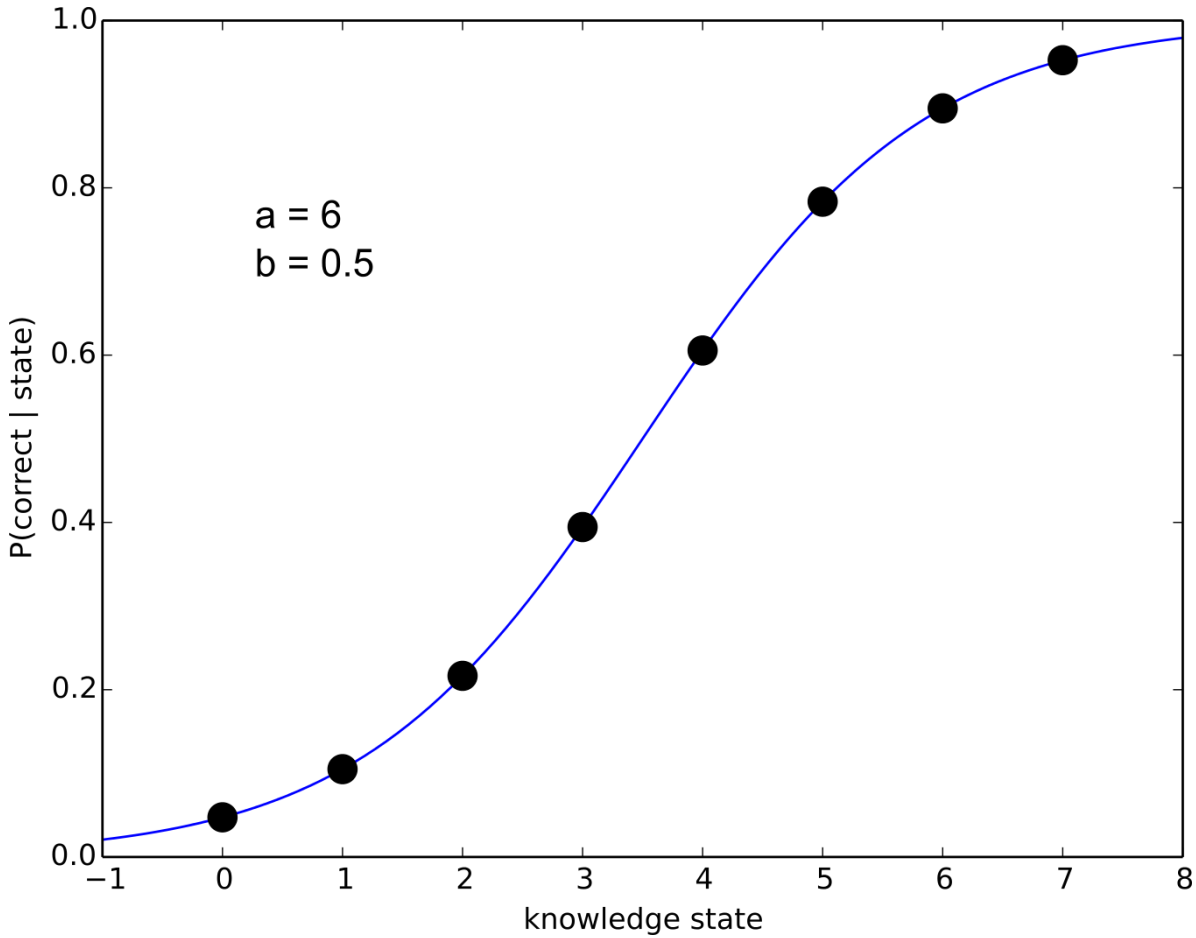
LogisticHMM

- generalization of BKT and logistic models
- goal of the model:
  - clarification of conceptual issues: uncertainty vs degrees of knowledge
  - not practical modeling (fitting real life data)

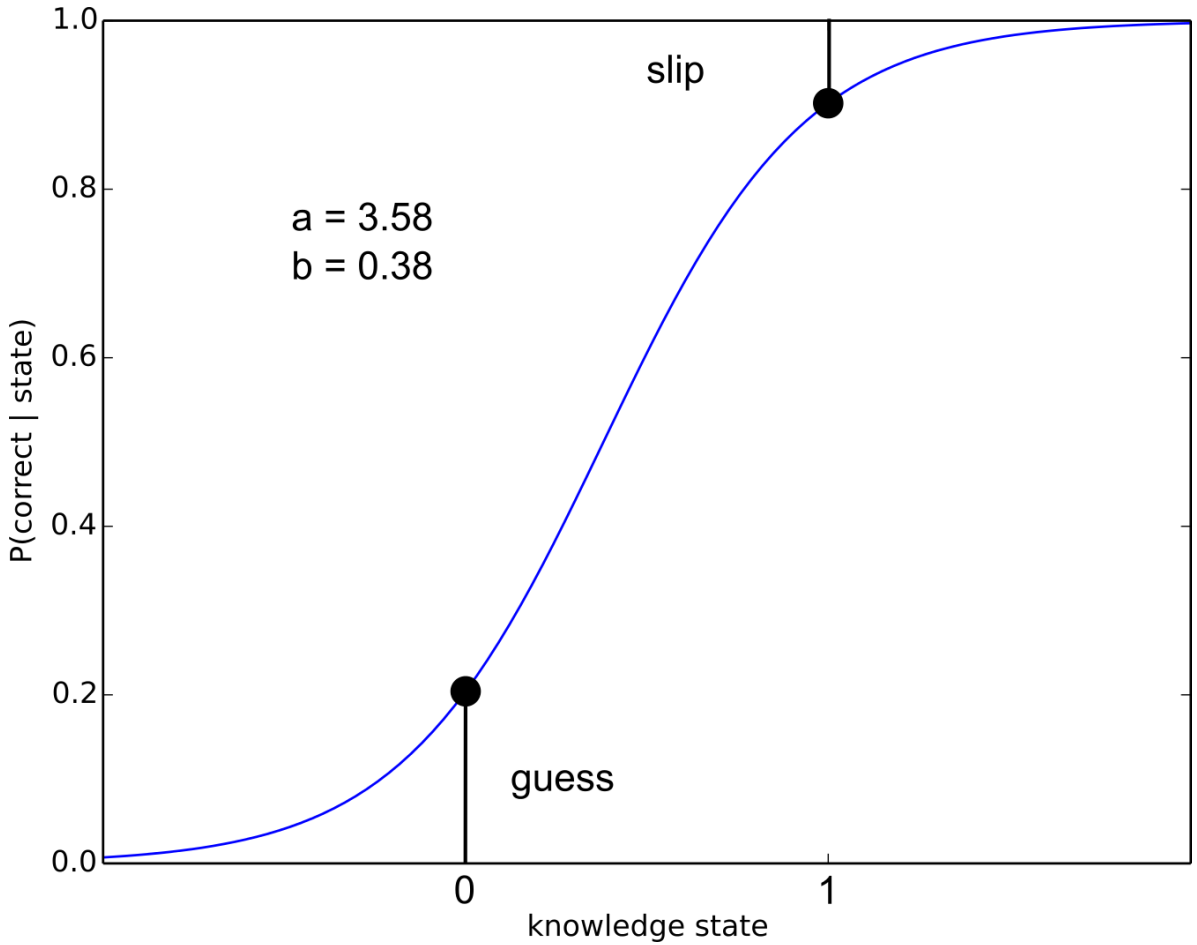
LogisticHMM



Emmision Probabilities



LogisticHMM and BKT

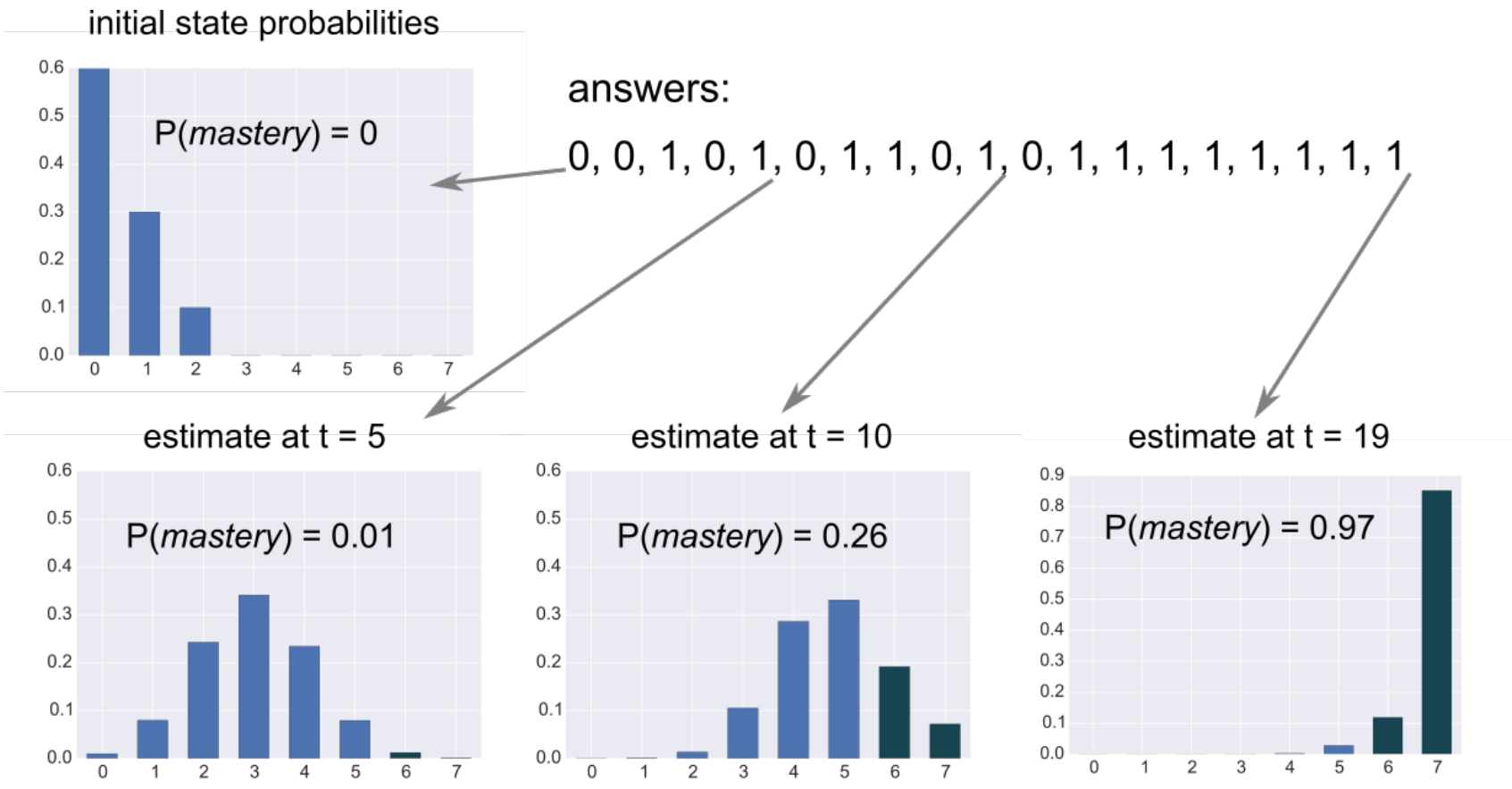


Uncertainty and Degrees of Knowledge

multiple knowledge states
$\rightarrow$ multiple degrees of knowledge

student state estimate = probability distribution over states
$\rightarrow$ uncertainty

Using the Model



Experiments

setting: simulated data, generated by the LogisticHMM

Comparision with other mastery criteria:

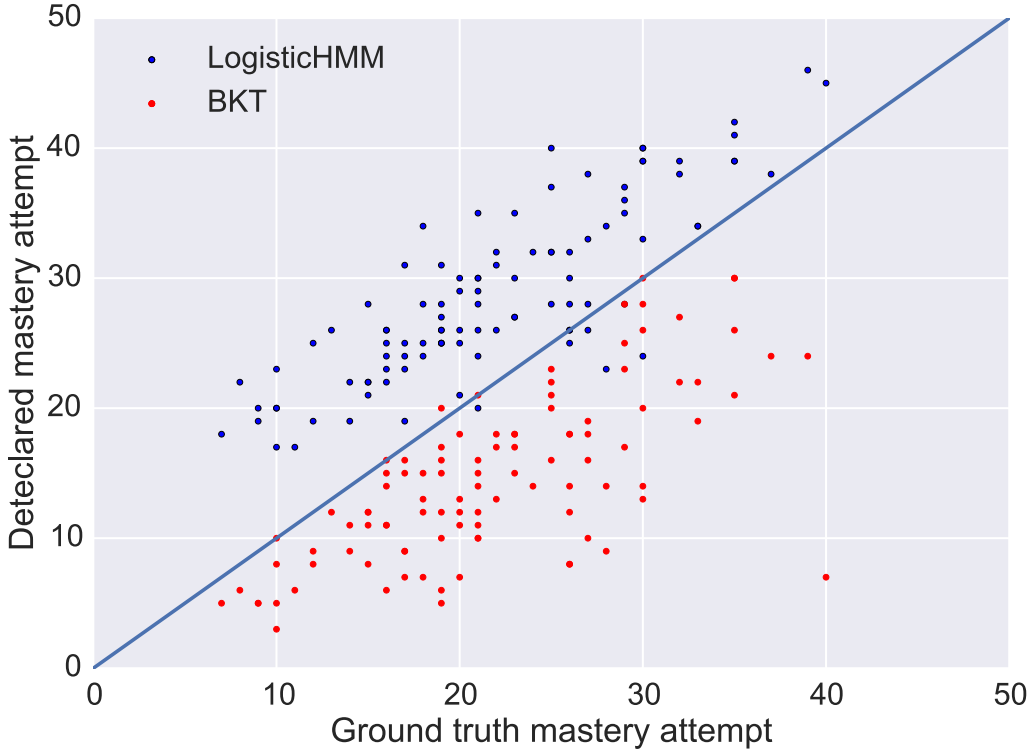
- N consecutive correct
- Exponential moving average
- Bayesian knowledge tracing

Comparison with Simple Criteria

- N consecutive correct
  - low noise in observations – similar decisions
  - high noise in observations – better decisions by LogisticHMM
- Exponential moving average
  - parameters: weight of exponential smoothing, threshold
  - similar decisions achievable by suitable choice of parameters
  - setting of parameters difficult

Comparison with BKT

BKT: parameters fitted to data, threshold 0.95



$\Rightarrow$ BKT leads to serious under-practice

Consequences for Practice

- ~~LogisticHMM for student modeling~~
- differentiate uncertainty and degrees of knowledge
- simple criteria may be sufficient: number of attempts, average of recent performance
- LogisticHMM as tool for setting parameters, thresholds

Other Issues and Future Work

- wheel-spinning students – unable to master a topic
- relation to more complex student models
- multiple skills, forgetting, ...

Mastery criteria are important and underexplored.