Towards Modeling Chunks in a Knowledge Tracing Framework for Students’ Deep Learning

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Motivation

- In complex skills, the whole can be greater than the sum of its parts. This cannot be captured by simple decomposition of skills in traditional knowledge tracing models.
- We propose modeling chunks, which encode important patterns or plans in varied application contexts. We also propose a “deep” evaluation framework for student models. We aim to build new skill and student models differentiating between shallow and deep learning.

Proposed Approach

Representing Chunk Units

We use a hierarchical Bayesian network as follows:

- individual mastery skills or difficulty factors:
  - e.g., MasteredWhileStatement
- chunk units:
  - e.g., WhileStatement + StringAddition + Precede

Extracting and Selecting Chunk Units

We consider the following frameworks:

- Regression-based feature selection or structure learning framework.
- BN-based score-and-search framework (main): We propose a greedy search procedural that requires a ranked list of candidate chunk units, which can be extracted and ranked based on:
  - Frequency information based on skill to problem q-matrix.
  - Performance information based on student performance data.
  - Natural language processing on the problem (solution) text.

Data-driven evaluation

Our multifaceted data-driven evaluation framework (extending [9]) includes:

- Knowledge inference quality (extending [6]):
  - Mastery Accuracy: Do students mostly have correct responses on the data after a student model infers mastery?
  - Mastery Effort: How many practices does a student need to reach inferred mastery for all required skills on the data?
- Parameter plausibility: Item Discriminative Index (IDI=1-guess-slip)
- Predictive accuracy of student answers: correct/incorrect/solution content.

Classroom study evaluation

- Do students achieve deeper, or more robust learning?
- Do students agree more with the new knowledge inference?
- Do students’ motivation and engagement for pursuing true mastery increase?
- Is the recommendation more helpful?

Current Work

Proposed model with pairwise skill combinations significantly increases the mastery inference accuracy, and more reasonably distributes students’ efforts (requiring students to focus more on skill combinations by a drill-down analysis), compared to Knowledge Tracing models and its non-hierarchical counterparts. Details are reported in [10].

Advice sought

- Are there datasets or tutoring systems suitable for exploring this idea?
- Are there better representations for chunk units within or beyond BN?
- How should we connect our chunk units with skill definitions in different domains, problem types? Is chunk the right word?

\textsuperscript{[10]} Huang, Y., Guerra, I., and Brusilovsky, P. Modeling Skill Combination Patterns for Deeper Knowledge Tracing. In Workshop on Personalization Approaches in Learning Environments (PALE) in UMAP, 2016.