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 can not 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

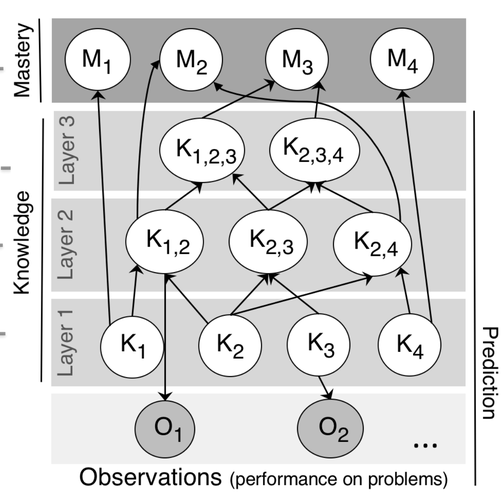
Representing Chunk Units

We use a hierarchical Bayesian network as follows:

individual mastery skills or *difficulty factors*
e.g., MasteredWhileStatement

chunk units
e.g., WhileStatement + StringAddition + *Precede*
WhileStatement + StringAddition + *Append*
StringAddition + *Append*
WhileStatement + StringAddition

individual basic skills or *difficulty factors*
e.g., *Append,* StringAddition, WhileStatement, *Precede*



Extracting and Selecting Chunk Units

We consider the following frameworks:

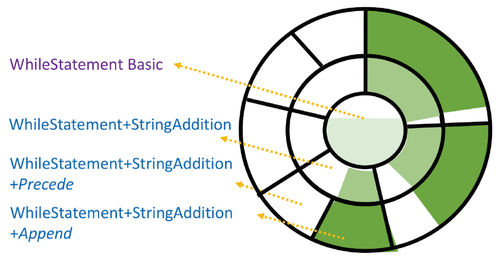
- Regression-based feature selection or structure learning framework.
- **BN-based score-and-search framework** (main): We propose a greedy search procedural that requires a ranked list of candidate chunk units, which can be extracted and ranked based on:
  - Frequency information based on skill to problem 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?

[6] González-Brenes, J. P. and Huang, Y. Your model is predictive but is it useful? theoretical and empirical considerations of a new paradigm for adaptive tutoring evaluation. In EDM , pages 187–194, 2015.
[9] Huang, Y., González-Brenes, J. P., Kumar, R., and Brusilovsky, P. A framework for multifaceted evaluation of student models. In EDM, pages 203–210, 2015.
[10] Huang, Y., Guerra, J., and Brusilovsky, P. Modeling Skill Combination Patterns for Deeper Knowledge Tracing. In Workshop on Personalization Approaches in Learning Environments (PALE) in UMAP, 2016.

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