Week 7 Video 7
Knowledge Inference:
Other Structures
How do we get a skill-item mapping?

- Hand-development and refinement
- Automatic model discovery
- Hybrid approaches
Hybrid Approaches

- The most popular hybrid approach is called Learning Factors Analysis

Learning Factors Analysis (LFA)

- Uses a mathematical model similar to Performance Factors Analysis
- Adds a student parameter, has only one learning parameter per skill
Learning Factors Analysis (LFA)

- Take an existing skill-item mapping
- Add a set of potential candidate “learning factors”

- Repeatedly tries to split skills based on learning factors
  - Using A* space search algorithm

- For Skill A, Learning Factor B
- Test new skills (A and B), (A and not B)
Three Ways to Improve Skill-Item Mappings

- Hand-development and refinement
- Automatic model discovery
- Hybrid approaches
Why is this important?

- A good skill-item mapping is a prerequisite to using algorithms like BKT, PFA
- If you consider irrelevant evidence (student performance at hockey when predicting math)
- You’ll have ineffective prediction
A limitation of Q-Matrices

- Assumes no relationship between skills
- Except that a specific item can involve multiple skills
A definite limitation

- Several ways that skills can interconnect
Partial Order Knowledge Spaces


Postulate relationships between items

Mastery of one item is *prerequisite* to mastery of another item
Example
(Desmarais et al., 2006)

If student succeeds at C, they will succeed at D; D is prerequisite to C

\[
\frac{2}{12} + \frac{5}{8} = \frac{31}{24}
\]

B does not inform us about C

\[
\frac{2}{12} = \frac{4 \times 2}{12} = \frac{2}{3}
\]

\[
\frac{2}{3} + \frac{5}{8} = \frac{31}{24}
\]

If student succeeds at C, they will succeed at D; D is prerequisite to C

\[
2 \times \frac{1}{2} = 1
\]
POKS can be extended rather easily to use skills (interchangeable items) rather than items.
Bayesian Networks

- Less restricted set of models that also infer relationships between skills and items, and between skills

- Can infer more complicated relationships between material than the very restricted set of relationships modeled in POKS
  - Can infer \{skill-skill, item-item, skill-item\} relationships at the same time
  - Can model hierarchies of skills and meta-skills
  - Can integrate very diverse types of information

- That extra flexibility can lead to over-fitting (cf. Desmarais et al., 2006)
Martin & VanLehn (1995)

- Kinematics eqn 1
- Kinematics eqn 2
- Kinematics eqn 3
- Kinematics eqn 4

Kinematic mastery → Chapter 2 mastery

- First law
- Second law
- Third law

Laws of motion → Chapter 5 mastery

- Normal force
- Tension force

Force mastery
Conati et al., 2009
Shute et al., 2009

Success in Oblivion

Cognitive
- Attention
- Domain Knowledge
  - Working Memory
  - Reading Comp
  - Listening Comp
  - Speaking Skill

Noncognitive
- Creative Problem Solving
- Problem Solving
  - Efficiency
- Creativity
  - Novelty
- Persistance
  - Reflection
  - Exploratory Behavior
Propagation of Information

- Several algorithms are used for propagating information around a Bayes Net
- If we know that a student has skill A
  - Then this provides us with information about all of that skill’s prerequisite skills
  - And some information for skills for which skill A is a prerequisite
  - And some information about relevant meta-skills
Bayes Net or Simpler Model?

- How much do the interconnections between your skills matter in the context of your learning system?

- How much do you care about hierarchy in skills?

- The cost of a Bayes Net is complexity, over-fitting, and over-propagation of information
Tools for creating Bayes Nets

- **Netica**
  - [http://www.norsys.com/netica.html](http://www.norsys.com/netica.html)

- **SamIam**
Next Up

- Week 8: Advanced Topics