ADAPTIVE LEARNING ENVIRONMENTS:
Unit 1 Intro
L4: Knowledge Representation

February 3rd 2015
Unit 1: Reviewing
Unit 1

Starter papers

Student seminars:
Paper review

Assignment 1:
Literature review
(15% course mark)
Unit 1

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Student seminars: Paper review

Are practice for

Seminar formative feedback: Forestall BIG MISTAKES

Starter papers
SSS1: Before presentation

Individually:
1. Read the paper
2. Write individual review - consider “starter questions”

As a group:
3. Discuss paper and individual reviews.
   - Agree on the contents of “meta-review”
   - Agree on an overall decision:
     • Accept (good paper for communicating to non-experts)
     • Weak accept
     • Neutral (neither good nor bad)
     • Weak reject
     • Reject (dreadful for communicating to non-experts).
4. Write the Meta-review
SSS1: In presentation

5. Prepare a presentation with 1 slide each for:
   1. Key paper content - extra slides for images ONLY
   2. Overall decision (accept/reject) and why
   3. Comments to authors: what done well/what needs improvement

6. When presents to class, explain enough about work to understand your comments or criticisms. BUT spend most time on your review of the paper (why you evaluated it the way you did).

7. Turn in individual reviews, meta-reviews, and slides for formative feedback.
SSS1: Goals

1. What it means to review a paper
2. More depth on core systems
3. Learn how peer reviewing works

Allows you to:

• Getting ahead on the Assignment 1 reading

• Practicing the key skills for Assignment 1 and this whole course, helped by classmates

• Get formative feedback on how you are doing with the reviewing
Unit 1

Student seminars: Paper review

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Assignment 1: Literature review (15% course mark)

Starter papers

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Marking guides: Self-assess or peer-assess to forestall BIG MISTAKES
SSS1: Assignment 1

Write a small-scale review of related literature:
- discuss 3 to 5 papers in some depth;
- in order to answer a particular question, e.g.
  “What is the evidence that Autotutor-emotions impacts
  learners' interactive knowledge construction?”

Your review should include:
- at least 1 paper from the SSS1 papers list
- at least one non-seminar paper.

Not required to use the paper presented in your seminar
May use more than 5 papers if you wish, but not required

See handouts online
Marking guide (rubric)
Your chance to try some metacognition

Weighting: How much items/ tasks are worth
Use as a checklist--make sure you didn’t forget anything

Definitions of poor/good score in each category: e.g.

Referencing and citation use:

“A top score in this category would mean that in-text references (appropriately formatted) are used throughout the assignment to support descriptions of key concepts and information about systems. All in-text references appear on the end references list (and vice versa). The end references provide complete information about each referenced item, and they are appropriately formatted.”

“A low score would mean that some of the following are in evidence: key claims and information are consistently not supported by citations; In-text citations and reference list do not match up with one another; lots of missing references or missing information from listed references. “

→ This is a tool. Assess yourself, assess each other.
Topic unit A: Knowledge representation & User modelling
Today:

Knowledge representation, domain models
The plan: 3-level discussion

1. HIGHEST LEVEL: What types of things are out there that we could represent? *Domains level*

2. MIDDLE LEVEL: What could we/should we represent within our target domain? *Domain level*

3. LOW LEVEL: How could we/should we represent that knowledge? *“Implementation” level*
1: Types of domains

Well-defined versus ill-defined (defined == structured)
Structured domains have right answers. They have theories and rules. Ill-defined domains are the opposite.

• “Domains are ill-defined when essential concepts, relations, or criteria are un- or underspecified, open-textured, or intractable requiring a solver to recharacterize them.” (Lynch, Ashley, Pinkwart, & Aleven, 2009)

• May lack (widely accepted) theories about concepts and relationships in the domain

Problems where “no amount of expertise can provide the indisputable answer.” (Lynch et al p. 261).
See Woolf (2009) textbook, ch 3, for a discussion of these domain “axes”
Many systems

A few systems

Well-structured

Ill-defined

Simple

Complex

Where ALE researchers fear to tread
2: What to represent

We will focus on well-structured “problem-solving” domains for now, as they are a majority of current systems...

Domain model ≠ Domain encyclopaedia

• Generally mixture of declarative domain knowledge (“what”) and procedural domain rules/heuristics (“how”)

• May include general (domain independent) problem-solving strategies and heuristics

• May include incorrect declarative or procedural knowledge (e.g. Common learner mistakes)
2: What to represent

End goal IS NOT to have an amazing, perfect representation of the domain.

End goal IS to have domain knowledge in a form that we can use to help system reason about what students know or don’t know, help inform system tutorial actions, etc.

Domain model = knowledge to reason with
Example: ANDES

Background:
• Elementary physics = law-based
• Problem-solving as induction; answers = proofs

What does it represent?
• Major “textbook” physics principles
• What authors call “minor principles” required to justify key inferences in many problems BUT may not be explicitly taught [by a textbook]
• Mathematical or “common sense” info to justify problem steps.
“...to an AI program, all these pieces of [minor] knowledge act just like the major principles—they justify inferences about physical situations”*

And thus they must be explicitly represented!

BUT Andes authors point out that a system representing principles alone will not do it—experts have OTHER knowledge to constrain their reasoning.

How to do it here? (Long story short, they don’t—after much research, no consensus about how physics experts do it in practice.)

Also must represent **problem-level information** to be able to reason about the correct solution path (and what the student is doing relative to that path)

Most **reasoning work** is happening here!
3: How to represent it

This is the “implementation” level, where systems differ most.

Our task: We have some nice facts and rules—how do we record them in reason-aboutable form suitable for domain, pedagogic goals?

Often have multiple layers here: domain-level model, individual problem-level

Many options, will mention a few examples today.
Example: Production rules

**Remember:** Basic function of a production system is choosing and applying rules from its database

- Rules are domain-specific IF/THEN rules relating conditions to consequent actions

!!! Many domains simply *not reducible* to this format.

**Example systems:** The Cognitive Tutors, based on ACT-R cognitive architecture (discussed earlier)
- Geometry tutor
- LISP tutor
- Pump algebra tutor (PAT)
Pump Algebra Tutor (PAT)

Background:
• Teaches basic algebra problem-solving
• Is one of the Cognitive Tutors: about doing and about acquiring goal-related knowledge

What does it represent?
“"It is important to note that the rules of mathematics (theorems, procedures, algorithms) are not the same as the rules of mathematical thinking, which are represented in PAT by production rules."" (Woolf 2009, ch 3, p 61)
PAT Production rules

Rules of mathematical thinking: This is the issue of constraining, navigating problem space to DO algebra effectively.

Right: Two alternate “correct” rule examples, plus incorrect one (a common novice mistake).

From Woolf (2009) p. 62

(1) Correct:
   IF the goal is to solve $a(bx + c) = d$
   THEN rewrite this equation as $bx + c = d/a$

(2) Correct:
   IF the goal is to solve $a(bx + c) = d$
   THEN rewrite this equation as $abx + ac = d$

(3) Incorrect
   IF the goal is to solve $a(bx + c) = d$
   THEN rewrite this equation as $abx + c = d$
Learning through Model Building

Assumes learner is active and seeking stimulation

Making knowledge explicit:
• get learner to communicate beliefs
• get learner to model theories and test them
• get learner to reflect on learning

Learning through confrontation:
• student has belief of what happens in environment
• tests belief -> consequences in environment
• if consequences don't match belief, then (hope)
• cause student to review belief (=learn)

But, are all confrontations beneficial?
Using Multiple Representations

- Users with a repertoire of representational skills can **describe, reason with** and **build** models of information.

- ‘Constructivist’ learning theory stresses relationship between building **internal mental models** and building **external information models** (Cox & Brna 1995).

- When reaching an impasse (become 'stuck') while solving a problem, **reformulating it using a different representation** can be effective in making progress (Cox & Brna).

- By making thinking visible, the process of constructing an information map can help to understand, refine and communicate ideas.
Information Maps as Classroom Tools (Conlon, 2000)

Used by teachers to communicate information
Used by pupils to learn subject matter.

Building information maps improves generic representational techniques and transferable thinking skills.

eg. 1 creating an argument map about transport policy - learn that argument can be understood as hierarchical structure of claims, justifications and objections.

eg. 2 creating a decision map about the budget – learn that decision-making process can be understood in terms of options, factors and evaluations.
An argument map captures the structure of an argument. Three students to one computer can work well - one to argue for the main claim (green), one to argue against (red), and one to drive the mouse and referee!

**Main claim**
We should use public transport more than we do

**Reason**
Public transport is better for the environment

**Reason**
We should care about the environment

**Reason**
Buses and trains cause less pollution per person than cars

**Reason**
Buses and trains use less fuel per person than cars

**Objection**
Public transport is less convenient than cars

**Reason**
When more people use public transport, the money raised will improve its quality

**Reason**
A car takes you door-to-door and leaves at whatever time you like

**Reason**
A car creates a private space in which nobody bothers you

**Objection**
Cars with clean and efficient engines are becoming available

**Objection**
Some buses create lots of smoke and they leak oil

**Objection**
Many people do not find cars convenient

**Reason**
Many cyclists and pedestrians find cars threatening

**Objection**
Car drivers only care for themselves

**Reason**
Electric cars are now in production

**Reason**
Poor people can't afford cars
Argument mapping

Involves:
• informal discussion
• this involves learners working in twos or threes around a computer,
• debating a main claim while simultaneously constructing an argument map.

Preparation for:
• Formal classroom debates
• Planning an essay
• Reporting on research
This example illustrates the use of the Decision Maker stylesheet. Options are scored from +2 (very good) to -2 (very bad) for each factor.

**Option**
- Take the bus
- Lift in car
- Bicycle
- Walk all the way

**Factor**
- Help the environment
- Personal fitness and health
- Daily cost
- Comfort & convenience

Total scores:
- Bus = +2
- Lift in car = -2
- Bicycle = +4
- Walk = +3

The Bicycle Wins!!
## Map types and applications

<table>
<thead>
<tr>
<th>Map Type</th>
<th>Represents ...</th>
<th>Applications for learners:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept map</td>
<td>A concept framework. Symbols represent concepts, links represent relationships</td>
<td>Creating, completing and correcting summaries of syllabus material and texts — scope for peer critiquing and other forms of collaborative work.</td>
</tr>
<tr>
<td>Web map</td>
<td>As for a concept map, but some or all symbols are hyperlinked to web sites.</td>
<td>Creating a record of internet-based research — organising web findings into a coherent conceptual framework.</td>
</tr>
<tr>
<td>Argument map</td>
<td>An argument framework. Top-level symbol represents a main claim. Lower level symbols represent justifications or objections.</td>
<td>Supporting live informal discussion between two or three pupils seated around a computer. Preparation for formal classroom debate.</td>
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# Map types and applications

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<td><strong>Decision map</strong></td>
<td>A decision-making framework. Symbols represent options or factors. Links represent the evaluation of the options against the factors.</td>
<td>Creating a model of the decision-making process for some aspect of the curriculum — scope for peer critiquing and other forms of collaborative work.</td>
</tr>
<tr>
<td><strong>Mind map</strong></td>
<td>An ideas framework. The central symbol represents the main idea. Ideas that are considered to be associated are linked to the main idea in a star-like network.</td>
<td>Fast and loose’ information gathering tasks such as note-taking and brainstorming.</td>
</tr>
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</table>
Concept mapping by learners

Concept mapping activities by learners can be placed into three categories:

1. **Tabula rasa ('blank slate') mapping** involves the creation of a map from scratch

2. **Scaffolded mapping tasks**: elements of the map are provided by the teacher, leaving the learner to supply the rest.

3. **Buggy map correction tasks** present learners with concept maps containing deliberately introduced bugs (errors). Learners task is to locate and correct them.
This concept map summary of a text on the science of water was created with the 'Concept map large' stylesheet.
This concept map shows some of the uses of Conception. Select the hyperlink tool and click on the linked symbols (italic text) to see an example of each kind. If you try this in Presentation mode you can switch conveniently between windows with the Back/Forward commands.
What does the character do?
He is a captain in the Italian army which occupies Caphallonia in World War 2.

What does the character say or think?
He is a decent man who does his best to have a peaceful war.

Character's name:
Captain Corelli

Other characters:
- Pelagia - daughter of Dr Iannis. Corelli falls in love with her.
- Carlo - soldier serving under Corelli and fellow music-lover. Saves Corelli from a German firing squad.
- Dr Iannis - the island doctor and Greek patriot. After Corelli is shot by the Germans, Dr Iannis takes care of him.

What happens to the character in the end?
Corelli tragically loses touch with Pelagia after the war. He becomes a Greek citizen and a musician.

How does the character's personality change?
As the book develops, Corelli becomes more anti-war, humanistic and sorrowful.
Looking ahead

Talking about domain models is only half the picture.

Next time: From domain models to student models
  - Often, domain model representation type also used in student model, to reason about student’s knowledge and competencies (ex. Betty’s Brain)
  - Generally will be separate modules of system BUT sometimes student model represents totally independent information (i.e. affect)

PS: Do your readings
References


