INFSCI 2480: Adaptive Information Systems

User Models for Adaptive Hypermedia and Adaptive Educational Systems

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Adaptive systems

Classic loop user modeling - adaptation in adaptive systems
Intelligent vs. Adaptive

1. Intelligent but not adaptive (no user model!)
2. Adaptive but not really intelligent
3. Intelligent and adaptive

3 Dimensions of User Models

- What is being modeled (nature)
- How this information is represented (structure)
- How the models are constructed and maintained

What is Being Modeled?

- User knowledge of the subject
- User interests
- User goals
- User background
- User individual traits

How to Model User Knowledge

- Scalar model
  - The user knowledge level is modeled as one value
  - Example: MetaDoc, CAT
- Structural model
  - What kind of knowledge?
    - Declarative, procedural, episodic
  - How it relates to expert knowledge?
    - Overlay model -> Bug mode -> Genetic model
Overlay Model of Knowledge

- Domain model
  - The whole body of domain knowledge is decomposed into set of smaller knowledge units
  - A set of concepts, topics, etc
- User knowledge model (aka student model)
  - Overlay of the Domain model
  - Student knowledge is measured independently for each knowledge unit

Vector vs. Network Domain Models

- Vector - no relationships
- Precedence (prerequisite) relationship
  - is-a, part-of, analogy
  - Wescourt et al, 1977
- Genetic relationships
  - Goldstein, 1979
Vector model

Network model
Simple overlay model

Concept 1
yes

Concept 2
yes

Concept 3
yes

Concept 4
no

Concept 5
no

Concept N
no

yes

yes

Simple overlay model

Concept 1
yes

Concept 2
yes

Concept 3
yes

Concept 4
no

Concept 5
no

Concept N
no

yes
Weighted overlay model

Student Modeling Approaches

- Ad Hoc (1-100)
- Heuristic and rule-based (qualitative)
- Simple statistical (Bush, Atkinson)
- Probabilistic and Bayesian (BN, D-S…)
- Fuzzy
- Neural networks
- Combine approaches and layered models
How to do Course Sequencing

- Needs a Domain Model
- Uses classic or weighted overlay model
- Needs indexing of learning material with domain model
- May also need a learning goal (also based on domain model)

Indexing teaching material

- Types of indexing
  - One concept per ULM
  - Indexing of ULMs with concepts
- How to get the ULMs indexed?
  - Manual indexing (closed corpus)
  - Computer indexing (open corpus)
Simple case: one concept per learning activity

- Random selection if there are no links - Scholar
- Links can be used to restrict the order

Indexing content with concepts
Simple goal model

- Learning goal as a set of topics

More complicated models

- Sequence, stack, tree
Sequencing with models

• Given the state of UM and the current goal pick up the best topic or ULM within a subset of relevant ones (defined by links)
• Special cases with multi-topic indexing and several kinds of ULM
• Applying explicit pedagogical strategy to sequencing

Maintaining Overlay Models

• Adaptive educational systems use problems, questions, and other evaluation activities to model student knowledge
• If a page is read, an example is browsed, or a problem is solved, knowledge of all involved concepts increases (example: jWADEIn)
  – Links could be used to propagate knowledge
• If problem is not solved, the system needs to allocate “blame” for involved concepts
  – Links could be helpful to avoid noise
Models in SIETTE

Models for interactive problem-solving support and diagnosis

- Domain model
  - Concept model (same as for sequencing)
  - Bug model
  - Constraint model
- Student model
  - Generalized overlay model (works with bug model and constraint model too)
- Teaching material - feedback messages for bugs/constraints
Bug models

- Each concept/skill has a set of associated bugs/misconceptions and sub-optimal skills
- There are help/hint/remediation messages for bugs

Do we need bug models?

- Lots of works on bug models in the between 1974-1985
- Bugs has limited applicability
  - Problem solving feedback only. Sequencing does not take bugs into account: whatever misconceptions the student has - effectively we only can re-teach the same material
  - Short-term model: once corrected should disappear, so not necessary to keep
Constraint Model: SQL-Tutor

- Domain model: Set of constraints (procedural, evaluation knowledge); Student model: Bug model

Models for example-based problem solving support

- Need to represent problem-solving cases
- Episodic learner model
  - Every solution is decomposed on smaller components, but not concepts!
  - Keeping track what components were used and when - not an overlay!
- ELM-PE and ELM-ART - only systems that use this model
Multi-Aspect Models in ADAPTS - an adaptive IETM

What’s in adaptive content?

ADAPTS dynamically assembles custom-selected content.

Troubleshooting step plus hypermedia support information, custom-selected for a specific technician within a specific work context.
## Domain model example

<table>
<thead>
<tr>
<th>CONCEPT</th>
<th>Principles of Operation</th>
<th>Removal Instructions</th>
<th>Testing Instructions</th>
<th>Illustrated Parts Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reeling Machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonar Data Computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonar System</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Domain content

- **SUMMARY**
  - Reeling Machine
  - Sonar System
- **DETAILS**
  - Principles of Operation
  - General Component Location
  - Parts List
- **TUTORIAL**
  - Power Distribution
  - System Description Details
  - Testing Instructions
  - Removal Instructions
User model

- Characterizes user ability at each element of the domain model
  - Size of model is bounded by domain
  - Weights on different types of elements account for learning styles and preferences
  - Can be time sensitive
- Constrains the diagnostic strategy

User model example
Adaptive content selection

• Information is custom-selected for a user
  – Level of detail offered depends upon who the user is (i.e., his level of expertise)
  – Selected at a highly granular level, e.g., for each step within a procedure
• Performance-oriented training is presented as part of content

Interest Modeling

• User interests are typically modeled by overlay models as well
• Keyword model of user interests (profile)
  – Keyword overlay
• Concept model of user interests
  – Concept overlay
Domain Models

- A domain model is required for interest modeling
  - Traditional domain model for interest modeling in educational context
  - A taxonomy of interest areas for non-educational areas

Example: Domain model for adaptive News system

Overlay Model of Interests

- For each domain concept or taxon an overlay model stores estimated level of interest
Ontological Interest Modeling

- Interests are deduced from the content of “interesting documents”


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Spreading Activation

- Spreading activation over the model may be used for more reliable modeling and to deal with sparsity

Overlay model + indexing

• Indexing nodes with concepts
  – InterBook, ELM-ART, ISIS-Tutor, AHA
• Indexing anchors with concepts
  – StrathTutor
• Indexing fragments with concepts
  – MetaDoc, AHA, PT
• Nodes are concepts
  – InterBook, ELM-ART, ISIS-Tutor
Generalized overlay model

- Knowledge
  - overlay for set of concepts, network of concepts
- Goals
  - overlay for set of possible goals, tree of goals
- Stereotypes
  - overlay for set of stereotypes

Indexing with generalized model

- fragments are indexed with goals
  - PUSH
- nodes are indexed with user’s tasks
  - HYNECOSUM:
- nodes are indexed with stereotypes
  - EPIAIM, Anatom-Tutor, C-Book
- goals are nodes
  - HYPERFLEX