INFSCI 2955
Adaptive Web Systems
Session 1-2: Adaptive E-Learning Systems
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Overview

• The Context

• Technologies

• Adaptive E-Learning Systems vs. Learning Management Systems (LMS)

Why Adaptive E-Learning?

• Adaptation was always an issue in education - what is special about the Web?
• greater diversity of users
  – “user centered” systems may not work
• new “unprepared” users
  – traditional systems are too complicated
• users are “alone”
  – limited help from a peer or a teacher
Technologies

• Origins of AEL technologies
• ITS Technologies
• AH Technologies
• Native Web Technologies

Origins of AEL Technologies

Intelligent Tutoring Systems
Adaptive Hypermedia Systems
Adaptive Web-based Educational Systems
Origins of AEL Technologies (1)

Technology inheritance examples

- Intelligent Tutoring Systems (since 1970)
  - CALAT (CAIRNE, NTT)
  - PAT-ONLINE (PAT, Carnegie Mellon)
- Adaptive Hypermedia Systems (since 1990)
  - AHA (Adaptive Hypertext Course, Eindhoven)
  - KBS-HyperBook (KB Hypertext, Hannover)
- ITS and AHS
  - ELM-ART (ELM-PE, Trier, ISIS-Tutor, MSU)
Technology Fusion

Adaptive Web

Adaptive Educational Systems

Adaptive E-Learning

Origins of AEL Technologies (2)

Adaptive Hypermedia Systems

Information Retrieval

Machine Learning, Data Mining

CSCL

Intelligent Tutoring Systems

Adaptive Hypermedia

Adaptive Information Filtering

Intelligent Monitoring

Intelligent Collaborative Learning

Intelligent Tutoring
Inherited Technologies

• Intelligent Tutoring Systems
  – course sequencing
  – intelligent analysis of problem solutions
  – interactive problem solving support
  – example-based problem solving

• Adaptive Hypermedia Systems
  – adaptive presentation
  – adaptive navigation support

How to Model User Knowledge

• Domain model
  – The whole body of domain knowledge is decomposed into set of smaller knowledge units
  – A set of concepts, topics, etc

• Student model
  – Overlay model
  – Student knowledge is measured independently for each knowledge unit
Simple overlay model

Course Sequencing

- Oldest ITS technology
  - SCHOLAR, BIP, GCAI...
- Goal: individualized “best” sequence of educational activities
  - information to read
  - examples to explore
  - problems to solve ...
- Curriculum sequencing, instructional planning, ...
Course Sequencing

• What is modeled?
  – User knowledge of the subject
  – User individual traits

• What is adapted?
  – Order of educational activities
  – Presentation of hypertext links
  – Presented content
  – Problem solving feedback

Active vs. passive sequencing

• Active sequencing
  – goal-driven expansion of knowledge/skills
  – achieve an educational goal
    • predefined (whole course)
    • flexible (set by a teacher or a student)

• Passive sequencing (remediation)
  – sequence of actions to repair misunderstanding or lack of knowledge
Levels of sequencing

- High level and low level sequencing

Sequencing options

- On each level sequencing decisions can be made differently
  - Which item to choose?
  - When to stop?
- Options
  - predefined
  - random
  - adaptive
  - student decides
Simple cases of sequencing

- No topics
- One task type
  - Problem sequencing and mastery learning
  - Question sequencing
  - Page sequencing

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
ELM-ART: question sequencing

SIETTE: Adaptive Quizzes

Combination of CAT and concept Based adaptation
Models in SIETTE

Beyond Sequencing: Generation
Adaptive Problem Solving Support

- The “main duty” of ITS
- From diagnosis to problem solving support
- Highly-interactive support
  - interactive problem solving support
- Low-interactive support
  - intelligent analysis of problem solutions

Adaptive Problem Solving Support

- What is modeled?
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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

Example: ELM-ART
Example: SQL-Tutor

Interactive Problem Solving Support

- Classic System: Lisp-Tutor
- The “ultimate goal” of many ITS developers
- Several kinds of adaptive feedback on every step of problem solving
  - Coach-style intervention
  - Highlight wrong step
  - What is wrong
  - What is the correct step
  - Several levels of help by request
Example: PAT-Online

You have just been promoted at PAT-E-Gift Furniture Inc. and have received a raise to $5.50 per hour.

1. How much would you get paid if you worked 5 hours?
2. How much would you get paid if you worked 25 hours?
3. How much would you get paid if you worked 10 1/2 hours?
4. How much would you get paid if you worked 80 hours?
5. How much would you get paid if you worked 280 hours?
6. If you plan on working 10 hours a week during a forty week school year, what would be your total earnings be for the entire year?

For the formula, define a variable for the time worked and use this variable to write a rule for your total pay.

<table>
<thead>
<tr>
<th>Heading</th>
<th>Time worked</th>
<th>Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>[hours]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Formula</td>
<td></td>
<td>[ ]</td>
</tr>
<tr>
<td>Question 1</td>
<td></td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Example: WADEIn

http://adapt2.sis.pitt.edu/cbun/
Problem-solving support

• Important for WBE
  – problem solving is a key to understanding
  – lack of problem solving help
• Hardest technology to implement
  – research issue
  – implementation issue
• Excellent student modeling capability!

Adaptive hypermedia

• Hypermedia systems = Pages + Links
• Adaptive presentation
  – content adaptation
• Adaptive navigation support
  – link adaptation
• Could be considered as “soft” sequencing
  – Helping the user to get to the right content
Adaptive problem solving support

- What is modeled?
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- What is adapted?
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Adaptive Annotation: Icons

1. Concept role
2. Current concept state
3. Current section state
4. Linked sections state

InterBook system

In ACT-R, elements of declarative knowledge are called chunks, or WMEs (working memory elements).
Demo: QuizGuide

Demo: NavEx
Adaptive Presentation

• What is modeled?
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• What is adapted?
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Example: SASY

Scrubtable adaptive presentation

Adapting to User Knowledge: Other Ideas

• Adaptive interface
  – Presence of menus and widgets in an educational applet can be adapted to user knowledge
• Educational animation and simulation
  – Adaptive explanations
  – Adaptive visualization

Demo: Improve
Adapting to Individual Traits

- Source of knowledge
  - educational psychology research on individual differences

- Known as cognitive or learning styles
  - Field dependence, wholist/serialist (Pask)
  - Kolb, VARK, Felder-Silverman classifiers

Style-Adaptive Hypermedia

- What is modeled?
  - User knowledge of the subject
  - User individual traits

- What is adapted?
  - Order of educational activities
  - Presentation of hypertext links
  - Presented content
  - Problem solving feedback
Style-Adaptive Hypermedia

- Different content for different style
  - Recommended/ordered links
  - Generated on a page
  - Mixed evidences in favor
- Different navigation tools for different styles
  - Adding/removing maps, advanced organizers, etc.
- Good review:

Example: AES-CS

Interface for field-independent learners
Example: AES-CS

Interface for field-dependent learners

Style-Adaptive Feedback

- What is modeled?
  - User knowledge of the subject
  - User individual traits

- What is adapted?
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  - Presentation of hypertext links
  - Presented content
  - Problem solving feedback
Overview: Classic Technologies

<table>
<thead>
<tr>
<th>What?</th>
<th>Knowledge</th>
<th>Styles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order of activities</td>
<td>Sequencing</td>
<td>?</td>
</tr>
<tr>
<td>Feedback</td>
<td>Adaptive diagnosis</td>
<td>Style-adaptive feedback</td>
</tr>
<tr>
<td>Content</td>
<td>Adaptive presentation</td>
<td>Adaptive presentation</td>
</tr>
<tr>
<td>Links</td>
<td>Adaptive navigation support</td>
<td>Adaptive navigation support</td>
</tr>
</tbody>
</table>

Origins of AEL Technologies (2)
Native Web Technologies

- Availability of logs - helping the teacher!
  - Log-mining
  - Intelligent class monitoring - class progress is available!
- One system, many users - group adaptation!
  - Adaptive collaboration support
- Web is a large information resource - helping to find relevant open corpus information
  - Adaptive content recommendation
- Possible combinations of the above
  - Collaborative recommendation
  - Social navigation

What You Can Get from Logs?

- Log processing and presentation
  - Presenting student progress on topic and concept level: making sense of class
- Course/site improvements
- Grouping users by learning styles
- Intelligent class monitoring
  - Comparing progress, identifying students way ahead and behind
Adaptive Collaboration Support

- Peer help
- Collaborative group formation
- Group collaboration support
  - Collaborative work support
  - Forum discussion support
- Mutual awareness support
- More information

Personalized Access to Educational Resources

- A lot of resources are available on the Web and in educational DL/Repositories
- A new direction of adaptation - provide personalized access to these resources
  - Content based recommender
- Adding advantage of community wisdom
  - Collaborative recommender systems
  - Social navigation systems
Modeling User Interests

• Concept-level modeling
  – Same domain models as in knowledge modeling, but the overlay models level of interests, not level of knowledge

• Keyword-level modeling
  – Uses a long list of keywords (terms) in place of domain model
  – User interests are modeled as weighted vector or terms
  – Originated from adaptive filtering/search area

Keyword User Profiles

<table>
<thead>
<tr>
<th>Art</th>
<th>Portrait 0.60</th>
<th>Sculpture 0.72</th>
<th>Watercolor 0.45</th>
<th>Painting 0.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports</td>
<td>Soccer 0.88</td>
<td>Bat 0.27</td>
<td>Touchdown 0.79</td>
<td>Score 0.13</td>
</tr>
<tr>
<td>Music</td>
<td>Rock 0.15</td>
<td>Symphony 0.87</td>
<td>Score 0.31</td>
<td>Orchestra 0.63</td>
</tr>
</tbody>
</table>
Use of Profiles in AES: ML Tutor

Overview

- The Context
- Technologies
- Adaptive E-Learning Systems vs. Learning Management Systems (LMS)
What LMS Can Do

- For students
  - Course information and content delivery
  - Assessment and grades
  - Communication and collaboration
- For teachers
  - Authoring
  - Learning control
  - Student monitoring
  - Communication

What AES Can Do for Students

- Presentation
  - Adaptive presentation, adaptive navigation support, adaptive sequencing
- Assessment
  - Adaptive testing
- Communication and collaboration
  - Peer help and collaborative group formation
  - Collaboration coach
- Learning by doing
  - Problem solving support
What AES Can Do for Teachers

• Student monitoring
  – Identifying students in trouble
• Control
  – Sequencing
  – Adaptive navigation support
• Authoring
  – Concept-based authoring and courseware engineering

AES vs. LMS

• Adaptive E-Learning systems can provide a more advanced support for most functions
  – Course material presentation - InterBook, AHA
  – Assessment with quizzes - SIETTE
  – Threaded discussions - collaboration agents
  – Student management - intelligent monitoring
• Why LMS are not really adaptive?
  – Except simple control and learning design
Challenges

• How to make it working in practice?
  – AES systems use advanced techniques - hard to develop
  – AWBES content is based on knowledge - hard to create
  – AES require login and user modeling - hard to integrate
• Possible solutions - (watch, PhD students!)
  – Component-based architectures for AWBES
  – Authoring support
  – Open Corpus adaptive systems

Component-based Architectures

• Research systems can provide a better support of almost each function of E-Learning process
• Adaptive systems show how to implement nearly each component adaptively
• We need the ability to assemble from components
  – Course authors can choose best components and best content for their needs
  – Components providers and content providers have a chance to compete in developing better products
Current State

• Several component-based frameworks
  – ADAPT², ActiveMath, MEDEA,…
• Attempts to develop systems with internal components
• Reusable user/student model servers
• Some matching work in the standardization movement

Re-use/Standards Movement

• Learning Object Re-use supported by coming standards is another major research direction in E-Learning
• The re-use movement joins many existing streams of work driven by similar ideas
  – Create content once, use many times
  – Content independent from the “host” system
  – Content and interfaces with the host system are based on standards (metadata, CMI, etc)
• Let content providers be players in E-Learning
• The future is components and re-use
ADAPT² Architecture

Knowledge Tree II Portal