From Adaptive Educational Hypermedia to Adaptive Information Access

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From Generation to Generation

UM  HT  ITS
WWW  1G AEH  Classic Adaptive Educational Hypermedia
WBE  2G AEH  Web-based Adaptive Educational Hypermedia
      3G AEH  “Real World” Adaptive Educational Hypermedia

TALE Lab, University of Pittsburgh
Personal View

InterBook, CMU (1996-1998)
QuizPack Pitt (2002-2006)
Adapt2 Pitt (2002-2008)
Knowledge Sea Pitt (2002-2008)
CourseAgent Pitt (2003-2009)
PittCult, ConfNavigator Pitt (2006-2009)

Adaptive systems

Collects information about individual user
User Modeling side
Adaptive System
User Model
Provides adaptation effect
Adaptation side

Classic loop “user modeling - adaptation” in adaptive systems

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Generation 0

UM  HT  ITS

WWW

1G AEH

WBE

2G AEH

3G AEH

Classic Adaptive Educational Hypermedia

Web-based Adaptive Educational Hypermedia

“Real World” Adaptive Educational Hypermedia

Personal View: Generation 0

ITEM/IP, MSU (1986-1994)


ISIS-Tutor, MSU (1992-1994)


ELM-ART, Trier (1994-1997)


InterBook, CMU (1996-1998)

COCOA, CTE (1999-2000)

TALER Lab projects (2000-2004)
ITEM/IP

- ILE for Introductory Programming
- Integrated system
  - Tutorial (presentation of optimal sequence of explanations, examples and problems)
  - Environment (playing with examples, design and debug problem solutions)
  - Manual (a manual for reference-style access to studied information, examples, solved problems)

Knowledge and learning material

![Concepts and Examples Diagram]

Example 1
Example M
Example 2

Problem 1
Problem K
Problem 2
Weighted overlay model

Concept 1
10

Concept 2
7

Concept 3
4

Concept 4
3

Concept N
0

Course Sequencing

- Oldest ITS technology
  - SCHOLAR, BIP, GCAI...

- Goal: individualized “best” sequence of educational activities

- ITEM/IP: multi-type
  - information to read
  - examples to explore
  - problems to solve...
Adaptive presentation

- Goal: make the same “page” suitable for students with different knowledge
  - beginners (in tutorial mode)
  - advanced (in manual mode)
  - smooth transition
- Methods to achieve the goals
  - comparisons of several concepts
  - extra explanations for beginners
  - more complete information for advanced

Conditional text filtering

- Similar to UNIX cpp
- Universal technology
  - Altering fragments
  - Extra explanation
  - Extra details
  - Comparisons
- Low level technology
  - Text programming

<table>
<thead>
<tr>
<th>If switch is known and user_motivation is high</th>
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<tbody>
<tr>
<td>Fragment 1</td>
</tr>
<tr>
<td>Fragment 2</td>
</tr>
<tr>
<td>Fragment K</td>
</tr>
</tbody>
</table>
Problems

- A category of students wanted to make the choice of next thing to do themselves
- Combining guidance and freedom?
- Added menu-based access to new material
- Two information spaces with separate access...
  - Explored material (past)
  - New material (future)
- And in 1991 we have found hypertext...

Generation 1

- UM
- HT
- ITS
- WWW
- 1G AEH
- 2G AEH
- 3G AEH
- Classic Adaptive Educational Hypermedia
- Web-based Adaptive Educational Hypermedia
- “Real World” Adaptive Educational Hypermedia
What can be taken into account?

- Knowledge about the content and the system
- Short-term and long-term goals
- Interests
- Navigation / action history
- User category, background, profession, language, capabilities
- Platform, bandwidth, context...

What Can Be Adapted?

- Hypermedia = Pages + Links
- Adaptive presentation
  - content adaptation
- Adaptive navigation support
  - link adaptation
Adaptive Presentation: Goals

- Provide the different content for users with different knowledge, goals, background
- Provide additional material for some categories of users
  - comparisons
  - extra explanations
  - details
- Remove irrelevant piece of content
- Sort fragments - most relevant first

Adaptive Presentation Techniques

- Conditional text filtering
  - ITEM/IP
- Adaptive *stretchtext*
  - MetaDoc, KN-AHS
- Frame-based adaptation
  - Hypadapter, EPIAIM
- Natural language generation
  - PEBA-II, ILEX
Example: Stretchtext (ADAPTS)

Adaptive Presentation: Evaluation

- MetaDoc: On-line documentation system, adapting to user knowledge on the subject
- Reading comprehension time decreased
- Understanding increased for novices
- No effect for navigation time, number of nodes visited, number of operations
Adaptive Navigation Support: Techniques

- Direct guidance
- Restricting access
  - Removing, disabling, hiding
- Sorting
- Annotation
- Generation
  - Similarity-based, interest-based
- Map adaptation techniques

Personal View: Generation 1

- InterBook, CMU (1996-1998)
- ADAPTS, CMU (1998-1999)
- ITEM/IP, MSU (1986-1994)
- COCOA, CTE (1999-2000)
**ISIS-Tutor: ILE + hypertext**

- An adaptive tutorial for CDS/ISIS/M users
- Domain knowledge: concepts and constructs
- Hypertext - a way to access learning material:
  - Description of concepts and constructs
  - Examples and problems indexed with concepts (could be used in an *exploratory environment*)
- Educational status of explanations, examples and problems is shown with link annotation

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**Knowledge and learning material**

[Diagram showing concepts, examples, and problems with link annotations]

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## Student modeling and adaptation

- **States for concepts:**
  - not ready (may be hidden)
  - ready (red)
  - known (green)
  - learned (green and ‘+’)

- **State for problems/examples:**
  - not ready (may be hidden)
  - ready (red)
  - solved (green and ‘+’)

---

## Sample index page (annotation)

<table>
<thead>
<tr>
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<tr>
<td>1</td>
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<td>2</td>
<td>Арифметические выражения</td>
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</table>

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Sample index page (annotation and hiding)

ISIS-Tutor: Evaluation

- 26 first year CS students of MSU
- 3 groups:
  - control (no adaptation)
  - adaptive annotation
  - adaptive annotation + hiding
- Goal: 10 concepts (of 64), 10 problems, all examples
ISIS-Tutor: Evaluation Results

- The students are able to achieve the same educational goal almost twice as faster
- The number of node visits (navigation overhead) decreased twice
- The number of attempts per problem to be solved decreased almost 4 times (from 7.7 to 1.4-1.8)

Similar works 1991-1994

- γπAdaptερ (Hohl, Böker, Gunzenhauser, 1991)
  - Sorting page fragments and links by relevance
- Manuel Excel (de La Passardiere, Dufresne, 1992)
  - Adaptive link annotation with icons
- ANATOM-Tutor (Beaumont, 1994)
  - Adaptive presentation, hypertext + ITS
- MetaDoc (Boyle, Encarnacion, 1994)
  - Adaptive stretchtext
**Generation 2 vs Generation 1**

- **Generation 1 systems:**
  - Research oriented
  - Traditional hypertext/hypermedia
  - Developed independently

- **Generation 2 systems**
  - Practically oriented
  - Web-based hypermedia
  - Influenced by earlier research
  - Less value on evaluation
Personal View: Generation 2

- ITEM/IP, MSU (1986-1994)
- InterBook, CMU (1996-1998)
- COCOA, CTE (1999-2000)
- TALER Lab projects (2000-2004)

ELM-ART: Lisp ITS on WWW

- ELM-ART:
  - ELM-PE (ILE with problem solving support)
  - Adaptive Hypermedia (all educational material)
- Model: adaptive electronic textbook
  - tests
  - examples
  - problems
Knowledge representation

- Domain knowledge
  - conceptual network for Lisp
  - problem solving plans
  - debugging knowledge

- Student model
  - Overlay model for Lisp concepts
  - Episodic model for problem-solving knowledge

ELM-ART: Adaptive Textbook

- Electronic Textbook
  - Intelligent, adaptive, interactive

- Adaptive navigation support

- Adaptive sequencing (pages and questions)

- Adaptive similarity-based navigation

- Adaptive selection of relevant examples

- Intelligent program diagnosis

- Open student modeling
Adaptive navigation support

Adaptive Diagnostics
ELM-ART: Evaluation Results

- Users with no previous programming and Web experience worked twice as longer if adaptive guidance was provided. No effect of adaptive annotation.
- Users with starting programming and Web experience worked twice as longer if adaptive annotation was provided. No effect of adaptive guidance.

InterBook: a Shell for AET

- “Knowledge behind pages”
- Structured electronic textbook (a tree of “sections”)
- Sections indexed by domain concepts
  - Outcome concepts
  - Background concepts
- Concepts are externalized as glossary entries
- Shows educational status of concepts and pages
Knowledge and hyperspace

Domain model

Textbook

Chapter 1

Chapter 2

Section 1.1

Section 1.2

Section 1.2.1

Section 1.2.2

Concept 1

Concept 2

Concept 3

Concept m

Concept n

Concept 4

3.1.4 The annotated textbook

To make the textbook more intelligent and to connect it to the document, we have to let the system know what about each section of the textbook is. It is done by indexing the textbook sections by domain model concepts. For each unit, a list of concepts related with this unit is provided (we call this list "context" of the unit). For each concept, the spectrum of the unit can represent also the role of the concept in the unit (currently we support two roles each concept can be either an "outcome" concept or a "background" concept). A concept is included in the spectrum as an outcome concept if some part of this page presents the piece of knowledge designated by the concept. A concept is included into the spectrum as a prerequisite concept if a student has to know this concept to understand the content of the page. Indexing is a relatively simple but powerful mechanism, because it provides the system with knowledge about the content of its pages; the system knows which concepts are presented on each page and which concepts have to be learned before starting to learn each page. It opens a way for several adaptation techniques.
Glossary view

Adaptive annotation in InterBook

1. State of concepts (unknown, known, ..., learned)
2. State of current section (ready, not ready, nothing new)
3. States of sections behind the links (as above + visited)

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InterBook Evaluation Results

- No performance difference between groups
- About 90% of clicks were made with sequential navigation buttons
- Adaptive annotation encourages non-sequential navigation
- Adaptive annotation benefits those who use it as expected
Adaptive annotation can:

- Reduce navigation efforts
- Reduce repetitive visits to learning items
- Encourage non-sequential navigation
- Make system more attractive for students
- But we still need to understand better
  - When it is helpful
  - How to match functionality to students

Other Generation 2 AEHS

- ELM-ART stream: Exploring new approaches and techniques
  - AHA!, INSPIRE, MetaLinks, MANIC
- InterBook stream: Creating authoring frameworks and tools
  - Frameworks:
    - KBS-HyperBook, Multibook
  - Authoring Tools:
    - AHA!, NetCoach, MetaLinks
AHA! (De Bra)

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INSPIRE (Grigoriadou, Papanikolaou, Kornilakis, Magoulas)

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Generation 3

UM -> HT -> ITS

WWW -> 1G AEH

WBE -> 2G AEH

3G AEH

Classic Adaptive Educational Hypermedia

Web-based Adaptive Educational Hypermedia

“Real World” Adaptive Educational Hypermedia

Practical E-Learning

- Integrated Course Management Systems
  - Blackboard, WebCT, ...
- Support almost all aspects of E-Learning
  - Course material presentation
  - Assessment with quizzes
  - Threaded discussions
  - Student management and grading
- “MS Word”-style all-in-one tool for WBE
Adaptive E-Learning?

- Adaptive E-Learning systems can provide a more advanced support for most functions
  - Course material presentation - InterBook, AHA
  - Assessment with quizzes - SIETTE
  - Threaded discussions - help agents
  - Student management - intelligent monitoring
- Why they are rarely used in practical E-Learning?

Practical Adaptive E-Learning

- Model 1: Adapting to current E-Learning Paradigm - CMS
- More versatile adaptive systems
- An ability to integrate open corpus content
- Improving CMS content
- Giving more power to the teacher
  - Customize the system to specific course and material
Emerging E-Learning

- Interoperability and standards
  - IEEE CMI, SCORM
- Semantics and metadata
  - LOM
- Component-based architectures
  - OKI, uPortal
- Resource reusability
- Distributed learning content
- Semantic Web

Practical Adaptive E-Learning

- Model 2: Embedding adaptivity into emerging E-Learning
- Use of current interoperability standards (SCORM, LOM)
- Developing new interoperability architectures
- Resource discovery
- The use of Semantic Web
CoCoA - Static Sequencing

- Many contributors for a single course
- Almost impossible to keep the course consistent without special tool
- Courseware engineering: From course authoring in small to course authoring in large
- CoCoA - Static sequencing
  - Prerequisite checking
  - Goal focusing
  - Learning activity balance
Open Corpus Adaptive Hypermedia

- Classic AH - Closed Corpus of pre-processed content
- Integrate Open Corpus content
- Bringing open corpus content in by indexing
  - KBS-HyperBook, SIGUE
- Processing open corpus content without manual indexing
  - Knowledge Sea
QuizGuide: Topic-Based AH

NavEx: Automatic Indexing

Classic “traffic light” prerequisite-based mechanism based on automatic indexing
Concept-Based QuizGuide

Proactive: Metadata for ANS

Recommendation and navigation support based on available metadata indexing
Community-based OCAH

- Footprint-based social navigation
  - Footprints, CoWeb, Knowledge Sea II, ASSIST
- Action-based social navigation
  - (annotation, scheduling...)
  - Knowledge Sea II, Conference Navigator
- Direct feedback for navigation support
  - CourseAgent, PittCult
- Tag-based social navigation
  - Any example???

Knowledge Sea II
Conference Navigator

Considers user visits, scheduling, annotation

Conference Navigator 2.0 Beta

Adaptive Hypermedia 2008

Top Ten Annotated Papers

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<thead>
<tr>
<th>Title</th>
<th>Date</th>
<th>Authors</th>
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<td>Adaptive Navigation Support</td>
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<td>Peter Brusilovsky</td>
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<td>Towards Comprehensive Ac</td>
<td>Aug 1 2009</td>
<td>José V. Reis, Maria Brusilovsky, Maria Brusilovsky</td>
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Top Ten Visited Papers

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Tag Cloud

- Adaptive Navigation Support
- Towards Comprehensive Ac
- Adaptive Link Annotation
- Attracting Attention
- (Web Site)stand-a-Bio
- An Evidence-Based Approach
- BornWeb: A Segmented Web
- A Rule-Based Reasoner
- A Replicating User Model
- Data Mining
- Stylistic Information

Contributors

- Social Web
- Adaptive Web
- User Modeling
- Personalized Web
CourseAgent

**CourseAgent**

- Planned to take (can be registered)
- Already taken (can be evaluated)

Degree of relevance to students’ career goal
- Marginally relevant
- Relevant
- Very Relevant

Difficulty level of the course
- Low
- Medium
- High

**PittCult**

**UNIVERSITY OF PITTSBURGH SCHOOL OF INFORMATION SCIENCES**

**PITTCULT**

Most Recent Events

-CINEMA IN THE PARKS: The Spiderwick Chronicles
  - Dates: 2008-07-30 20:00
  - Venue: Schenley Park (map | Kind: Films/Video Arts)

- Grab a blanket and head out for an unforgettable evening of cinema under the stars. The 2008 "Cinemas in the Parks" schedule will include Spider-Man 2, Ocean's 13...

Social networks for contextual recommendation
Keyword-based OCAH

- Siskill and Webert
  - Link ordering and annotation
- ML-Tutor
  - Link ordering and generation
- ScentTrails
  - Link annotation
- YourNews/TaskSieve
  - Link ordering and generation

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YourNews: Open Keyword-Level User Models

Keyword-level user model is visible and editable
Personalized Information Access 2008

Navigation
- Adaptive Hypermedia

Search
- Adaptive IR

Recommendation
- Web Recommenders

Adaptation Mechanisms
- Metadata-based mechanism
- Keyword-based mechanism
- Community-based mechanism

Personalized Information Access 200X

- With and without domain models
- Keyword- and concept-based UM access
- Use of any AI techniques that fit
- Use a range of adaptation techniques
- Adapt to more than just interests
ASSIST-ACM

Re-ranking result-list based on search and browsing history information

Augmenting the links based on search and browsing history information

More Information

- **Read**

- **Explore**
  - Try our systems at PAWS Community portal: [http://www.sis.pitt.edu/~paWS](http://www.sis.pitt.edu/~paWS)
  - Use PittCult, YourNews, CourseAgent