Systems That Adapt to Their Users

Description of an IJCAI 01 tutorial*

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1 Brief Description

Interactive systems that adapt to their users have been gaining rapidly in practical importance, for example in the areas of e-commerce and web-based information access. Relevant terms include *personalization*, *personal assistants*, *adaptive hypermedia*, *adaptive interfaces*, *user profiling*, and *student modeling*.

The AI techniques used in these systems include machine learning techniques, probabilistic and decision-theoretic approaches, logic-based methods, and a variety of more or less application-specific techniques.

Although user-adaptive systems can serve many different functions, there are a number of questions that must be addressed in the design of any such system. This tutorial will look at these questions from an AI perspective, integrating the results of previous experience in many different domains.

The six most general questions are the following ones:

1. What functions are to be served by the adaptation?
2. What properties of the user should be modeled?
3. What input data about the user should be obtained?
4. What techniques should be employed to make inferences about the user?
5. How should decisions about appropriate adaptive system behavior be made?
6. What empirical studies should be conducted?

For each question, we compare the main answers that have been worked out so far in research and practice concerning user-adaptive systems, discussing their strengths and limitations. The discussion will be illustrated throughout with reference to concrete system examples.

2 Detailed Outline

2.0 Introduction and Motivation

Goals

- Define terms and clarify the scope of the tutorial
- Stimulate the interest of the participants

Questions Addressed

- What are "user-adaptive systems"?
- Why are such systems both theoretically and practically important?
- What can be expected in the rest of this tutorial?

2.1 Functions of User-Adaptive Systems

Goals

- Make participants aware of all important types of user-adaptive systems
- Introduce example systems that can be referred back to later in the tutorial

Functions Discussed

(For each function, at least one example system will be presented briefly. $\mathcal{U}$ = user.)

- Help $\mathcal{U}$ to find information
- Recommend products to $\mathcal{U}$
- Tailor information presentation to $\mathcal{U}$
- Help $\mathcal{U}$ to learn about a topic
- Help $\mathcal{U}$ to use a system
- Adapt an interface to $\mathcal{U}$
- Perform routine tasks on behalf of $\mathcal{U}$
- Support collaboration between $\mathcal{U}$ and other persons

2.2 Properties of Users Represented

Properties Discussed

- Personal characteristics
- General interests and preferences
- Proficiencies
- Noncognitive abilities
- Current goals and plans
- Specific beliefs and knowledge
- Behavioral regularities
- Psychological states
- Context of the interaction

Criteria for Comparison

- Ease of assessment
- Directness of decision-relevance
- Breadth of implications

2.3 Input for User Model Construction

Types of Input Considered

- Self-reports on personal characteristics

*This description was written in October 2000 for submission to the IJCAI 01Tutorial Chair. Because of rapid developments in the field, the final structure of the tutorial may differ in some details from the structure described here.

- Self-reports on proficiencies and interests
- Evaluations of specific objects
- Responses to test items
- Naturally occurring actions
- Low-level measures of psychological states
- Low-level measures of context

Criteria for Comparison

- Frequency of acquisition
- Additional activity by $\mathcal{U}$
- Cognitive effort by $\mathcal{U}$
- Motor effort by $\mathcal{U}$
- Reliability of assessment

2.4 Inference Methods

Goal

The aim is not to provide a tutorial on the AI techniques involved (which would be impossible in the time available) but

- to illustrate how each one can be applied within a user-adaptive system and
- to compare the techniques in terms of their suitability for the typical inference problems that arise with user-adaptive systems.

Types of Methods Considered

- Bayesian methods
- Machine learning, various paradigms:
  - rule learning
  - neural networks
  - probability learning
  - instance-based learning
  - approaches to collaborative filtering
- Logic-based methods
- Stereotypes (of mainly historical interest)

Criteria for Comparison

1. Knowledge acquisition effort
2. Computational complexity
3. Amount of input data required
4. Handling of noise and uncertainty
5. Validity and justifiability

2.5 Decision-Making Methods

Approaches Considered

- Apprenticeship (i.e., the system does what $\mathcal{U}$ would be most likely to do)
- Rating of attributes of objects (e.g., the relevance of recommended web pages)
- Explicit prediction and evaluation of consequences of system actions (the decision-theoretic approach, including decision-theoretic planning)
- Use of hand-coded adaptation rules

Questions About Each Approach

- To what types of adaptation is the approach applicable?
- How valid and justifiable can the decisions be?

2.6 Empirical Foundations

Note: User-adaptive systems require more empirical, user-oriented research than most other types of AI-based systems, because their success is more strongly dependent on assumptions involving users. This section therefore deserves about 30 minutes of the tutorial, even though the methods discussed are mostly not AI methods.

Types of Empirical Foundations Considered

- Use of results of previous empirical research
- Knowledge acquisition from domain experts
- Evaluations with synthetic or already available data
- Controlled evaluations with users
- Experience with real-world use

Empirical Questions That Are Relatively Specific to User-Adaptive Systems

- Correctness of assumptions about users relied on by inference techniques
- Appropriateness of the inference techniques used
- Adequacy of available data
- Adequacy of coverage
- Appropriateness of adaptation decisions

2.7 Concluding Discussion

In this final portion of the tutorial, participants can raise any issues that they believe warrant further discussion.

3 Necessary Background and Potential Target Audience

The target audience encompasses three groups:

1. Researchers who do not yet know much about user-adaptive systems but who would like to get a systematic overview of this area.

2. Researchers who may already be experts with respect to some type of user-adaptive system but who would like to be able to make better use of relevant research that has been conducted in other research communities.

3. Representatives of industry who are interested in currently important applications of user-adaptive systems (e.g., personalization in e-commerce) and who would like to gain a firmer grasp of issues and methods than is offered by company brochures.

Accordingly, no particular knowledge beyond a general acquaintance with AI will be presupposed. Where technical topics are touched on, the central ideas will be introduced briefly in an accessible way, and references to more technical expositions will be provided.

4 Interest for IJCAI Audience

Whereas in the 1980's research on user-adaptive systems was initially focused on a rather limited spectrum of application types and techniques, in recent years such systems have been appearing in more and more sub-areas of AI.

The practical importance of user-adaptive systems has been increasing even more rapidly than its representation in research. One reason is that research advances have made usefully accurate adaptation more feasible. Another reason

is that application areas (such as e-commerce) have opened up in which the added value of user-adaptation is especially clear.

Issues concerning user-adaptive systems have typically been represented in several different sessions at past IJCAI conferences. For example, at IJCAI99 they could be found in part of the invited talk by David Heckerman on learning Bayesian networks; in sessions on *Cognitive Modeling* ([1]), *Multi-Agent Systems* ([3]), *Challenge Papers* ([4]), *Learning for Information Retrieval* ([2]), and *Probabilistic Reasoning and Learning* ([5]); and in workshops, including the one devoted to *Learning About Users* (http://www.sics.se/humle/ijcai99-ws/). This distribution of relevant contributions at IJCAI conferences shows (a) the general relevance of this class of systems for IJCAI participants and (b) the need for efforts to support integration and cross-fertilization.

References

[1] A. Fiedler. Using a cognitive architecture to plan dialogs for the adaptive explanation of proofs. In T. Dean, editor, *Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence*, pages 358–363. Morgan Kaufmann, San Francisco, CA, 1999.

[2] T. Hofmann and J. Puzicha. Latent class models for collaborative filtering. In T. Dean, editor, *Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence*. Morgan Kaufmann, San Francisco, CA, 1999.

[3] S. Noh and P. J. Gmytrasiewicz. Towards flexible multiagent decision-making under time pressure. In T. Dean, editor, *Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence*, pages 492–498. Morgan Kaufmann, San Francisco, CA, 1999.

[4] M. Perkowitz and O. Etzioni. Adaptive web sites: Conceptual cluster mining. In T. Dean, editor, *Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence*. Morgan Kaufmann, San Francisco, CA, 1999.

[5] I. Zukerman, R. McConachy, K. B. Korb, and D. Pickett. Exploratory interaction with a Bayesian argumentation system. In T. Dean, editor, *Proceedings of the Sixteenth International Joint Conference on Artificial Intelligence*. Morgan Kaufmann, San Francisco, CA, 1999.