

Lecture 24

Uncertain Reasoning Presentation (3 of 4): Decision Support Systems and Bayesian User Modeling

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Readings:
"The Lumière Project: Bayesian User Modeling for Inferring the Goals and Needs of Software Users"
- Horvitz, Breese, Heckerman, Hovel and Rommelse

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Presentation Outline

- Goal
 - Bayesian User Model used in reasoning under uncertainty to capture the relationships among user needs, user actions, and user query
- Structure
 - Background knowledge of Bayesian User Model
 - Some difficulties in Lumière project implementation
 - Introduction of Lumière/Excel prototype
 - Office assistant- Lumière/Excel prototype in real world
- References:
 - Machine Learning, T. M. Mitchell
 - Artificial Intelligence: A Modern Approach, S. J. Russell, and P. Norvig
 - Trouble Shooting under Uncertainty, David Heckerman, John S. Breese, and Koos Rommelse
 - A Tutorial on Learning With Bayesian Networks, David Heckerman
 - Lecture Notes in CIS 798, William Hsu

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Presentation Outline

- Outline
 - Background: Bayesian User Models
 - Lumière Project Implementation
 - Structuring Bayesian User Models
 - Temporal Reasoning about User Action
 - Bridging the System Events and Users Actions
 - Lumière/Excel System Prototype
 - Lumière in Real World-Microsoft Office Assistant
 - Future Work and Summary
- Issues
 - How to build an appropriate Bayesian User Model?
 - How to fulfill temporal reasoning?
 - How to connect system event to user actions?
 - Is Lumière/Excel prototype applicable to real world software application?

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Background: Bayesian User Model

- A Graphical probabilistic model combining Bayesian Network and influence diagrams makes inference about the goals of users
- Features
 - Express uncertainty
 - Incorporate prior knowledge
 - Support decision making
 - Be able to reason over time
 - Provide a decision theoretic model and provide utility values for the decision nodes with influence diagram
- General Product Rule in this model:

$$P(X_1, X_2, X_3, \dots, X_n) = \prod_{i=1}^n P(X_i | \text{parents}(X_i))$$

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Bayesian Network

• Example 1:

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Bayesian Network

• Example 2:

$P(a < 30) = 0.25$
 $P(a = 30-50) = 0.40$
 $P(f \Rightarrow cs) = 0.00001$
 $P(g \Rightarrow cs | f \Rightarrow cs) = 0.2$
 $P(g \Rightarrow cs | f \Rightarrow no) = 0.01$
 $P(s = male) = 0.5$
 $P(j \Rightarrow cs | f \Rightarrow cs, a = *, s = *) = 0.05$
 $P(j \Rightarrow cs | f \Rightarrow no, a = 30-50, s = male) = 0.0004$
 $P(j \Rightarrow cs | f \Rightarrow no, a = > 50, s = male) = 0.0002$
 $P(j \Rightarrow cs | f \Rightarrow no, a = < 30, s = female) = 0.0005$
 $P(j \Rightarrow cs | f \Rightarrow no, a = 30-50, s = female) = 0.002$
 $P(j \Rightarrow cs | f \Rightarrow no, a = > 50, s = female) = 0.001$

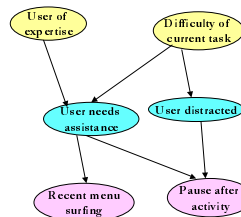
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Framing, Constructing and Assessing Bayesian Model

- Several important evidential distinctions
 - Search
 - Focus of attention
 - Intr inspection
 - Undesired effects
 - Inefficient command sequences
 - Domain-specific syntactic and semantic content

- A Small Bayesian Network in Lumière project



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Temporal reasoning about user actions

- Markov Model

- Dependencies among variables at adjacent time periods.



- Time-Dependent Probability Approach

- Alternative goals at the present moment
- Temporal model-construction methodology
- Less relevance of earlier observation to the current goals
- Definition of evidential horizon and decay parameters

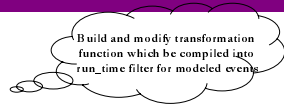


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System events and Users actions

Lumière events architecture:



Example primitives:

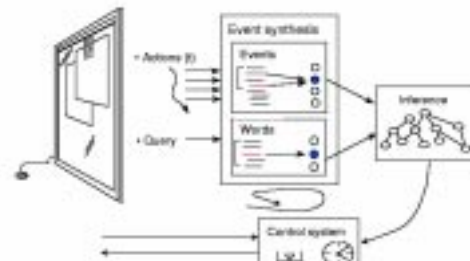
Rate(x_i, t), Oneof($\{x_1, \dots, x_n\}, t$), All($\{x_1, \dots, x_n\}, t$), Seq(x_1, \dots, x_n, t), TightSeq(x_1, \dots, x_n, t), Dwell(t)

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Lumière/Excel Project

- Overall Lumière/Excel Architecture



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Lumière/Excel Project

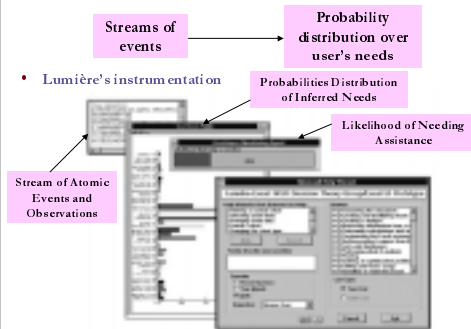
- Control policies of timing for assistance
 - Pulsed strategy
 - Event-driven control policy
 - Augmented pulsed approach
 - Deferred analysis
- User profile
 - Tailor Lumière/Excel performance according to user's expertise.
 - Update the probability distribution over the user's needs.
 - Determine special competency variable which can be used to estimate the expertise in Bayesian user model

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Lumière /Excel in Operation

- Lumière's instrumentation




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Lumière/Excel in Operation


X Without User Query ✓ With User Query



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Lumière /Excel in Operation

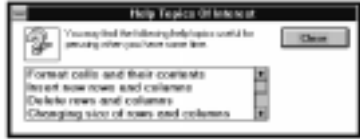
- Lumière autonomous assistance mode: when the probability distribution is over a threshold, the autonomous assistance window will pop up




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Beyond Real-Time Assistance



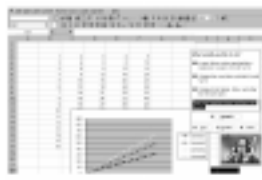
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    graph LR
      A[Patterns of Weakness] --> C[Customer-Tailored Offline Tutorial]
      B[Likelihood of User Problems] --> C
  
```



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Lumière in Real World




- Services included
 - Apply character to display Bayesian inference results
 - Apply broader but shallower model reasoning user goals
 - Capture current view and documentation with rich set of variables
 - Consider only a small set of relatively atomic user actions
 - Consider a small event queue and the most recent event
 - Separate the analysis of word and of events
- Services not included
 - Maintain a persistent user profile
 - Reason about competency
 - Combine events over time.


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Ongoing Work and Summary


- Ongoing work
 - Learning Bayesian models from user log data
 - Integrating vision and gaze-tracking into user modeling system
 - Employing automated new sources of events
 - Using value of information computations to engage users in dialog about goals and needs
- Summary
 - Investigation with human subject helps to elucidate sets of distinctions when user needs help and helps to construct an application Bayesian Model.
 - Temporal reasoning method is presented to make inference from a stream of user actions over time.
 - Event definition language is used to describe the architecture for detecting and making use of events.
 - Evidence from actions and words in user's query is integrated to support decision making.
 - The autonomous decision making about user assistance controlled by a user-specified probability threshold is presented.
 - Customer-tailoring tutorial materials is supported by Real-time inference.


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Summary

- Strength
 - The paper presents a good example using Bayesian user model to infer user's need by user's background, actions and queries.
 - Several problems, Bayesian user model construction, temporal reasoning, event language, user profiles are tackled in this paper.
 - Construction of key components of the Lumière/Excel prototype is provided.
 - Properly using the information provided in this paper can help enhance legacy software applications and provide an infrastructure for building new kinds of services and applications in software.
 - Paper presentation is clear and easy to understand
- Weakness
 - The example in real world did not maintain a user profile that can distinguish expert level.
 - Office assistant in real world is annoying because of the incorrect inference or too many options in which only a few or none is relevant to the needs.


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