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

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

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 Lumiere/Excel prototype applicable to real world software application?

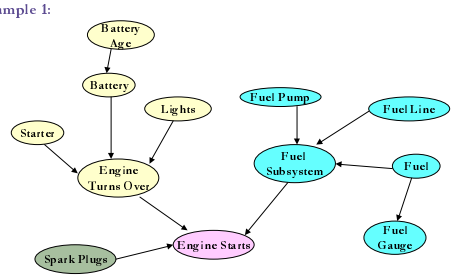
Background: Bayesian User Model

- 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:

$$P(X_1, X_2, X_3, \ldots\ldots X_n) = \prod_{i=1}^{n} P(X_i \mid \textbf{parents}(X_i))$$

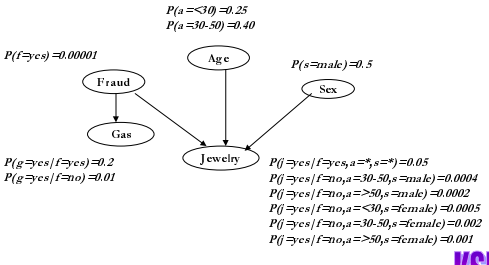
Bayesian Network

- Example 1:



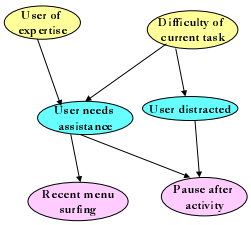
Bayesian Network

- Example 2:



Framing, Constructing and Assessing Bayesian Model

- Several important evidential distinctions
  - Search
  - Focus of attention
  - Introspection
  - Undesired effects
  - Inefficient command sequences
  - Domain-specific syntactic and semantic content
- A Small Bayesian Network in Lumière project



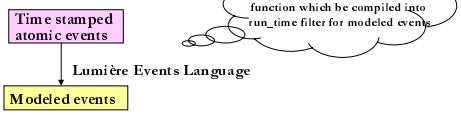
Temporal reasoning about user actions

- 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

System events and Users actions

Lumière events architecture:

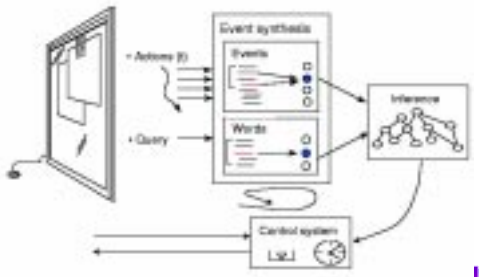


Example primitives:

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

Lumére/Excel Project

- Overall Lumière/Excel Architecture



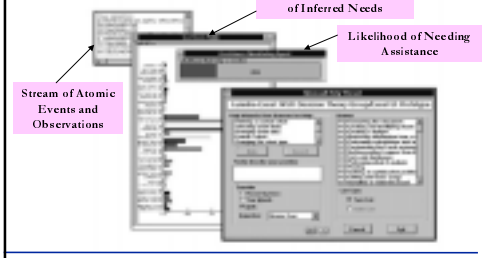
Lumière/Excel Project

- Control policies of timing for assistance
  - Pulsed strategy
  - Event-driven control policy
  - Augmented pulsed approach
  - Deferred analysis
- User profile
  - Tailor Lumiere/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

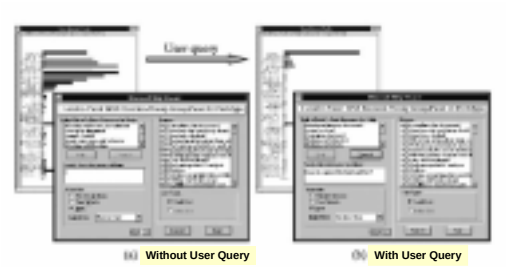
Lumière / Excel in Operation

Streams of events → Probability distribution over user's needs

- Lumière's instrumentation



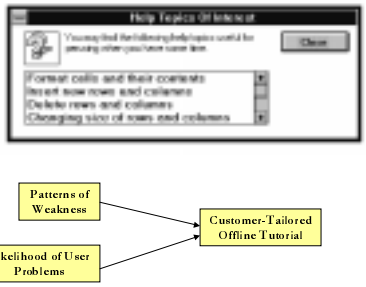
Lumière/Excel in Operation



Lumière /Excel in Operation

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

Beyond Real-Time Assistance



Lumière in Real World

- Services not included
  - Maintain a persistent user profile
  - Reason about competency
  - Combine events over time.

- 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

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.

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 Lumiere/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.