Visualization, Cognition and Requirements Modeling

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Outline

- Information visualization: what is it?
- Ontologies and structured data
- Jambalaya: demo
- NCI and the role of customization
- Cognitive support
- Requirements and visualization
Information Visualization

"Clutter and confusion are failures of design, not attributes of information”
- Edward R. Tufte
People have used external aids for centuries to amplify cognition (e.g. paper, slide rule, diagrams, charts)

- Visualize
  - To form a mental image or vision

- Visualization is done by humans, it is not done by a computer
  - But the use of computer supported, interactive, visual representations of abstract data can amplify cognition

- Visualizations can help us gain insight into data
Why are visualization tools important?
An outbreak of cholera
by Dr. John Snow, 1850’s
Interactive Visualizations that make us smart...

Hyperbolic Trees

http://www.smartmoney.com/maps

Attribute Explorer

SHriMP Views

The Brain

Early RE talk – June 22, 2005
Scenario
Scenario

Time

$853.00

$745.00

7:45am
11:45am
12:45pm
2:00pm
2:45pm
11:00am
12:15

Boston
Montreal

Vancouver
Victoria

Early RE talk – June 22, 2005
• An ontology is an explicit specification of a conceptualization
• Ontologies answer the question:
  “What is there that I need to know about?”
• They help us classify things through the enumeration of concepts, attributes of concepts, and relationships among concepts, thus defining a structure for the application area
• Ontologies may be used to maintain controlled terminologies and define constraints on relationships among concepts
Will ontologies become pervasive?
Reasons for interacting with a knowledge-based system

• Creating, using, debugging, maintaining, communicating knowledge….

• Different users:
  – Authoring an ontology
  – Evolving an ontology
  – Using an ontology to add new knowledge
  – Using an ontology to infer knowledge

\[\begin{align*}
\text{Knowledge Engineer/} \\
\text{Domain Expert} \\
\text{Expert user} \\
\text{End user}
\end{align*}\]
• Indented lists
• Collapsible direct manipulation tree (Protégé)
• Hypertext links (Ontolingua)
• Graph representation (Ontoviz)
• SemNET – powerful techniques (3D graphics, fisheye perspective views, clustering, animation), was not widely adopted (1988)
• A prototype environment for integrating various visualization techniques
• Integrated as a Protégé plugin
• Improves use of limited screen area
• Integrates text browsing using hypertext (HTML objects) embedded in a graphical view
• Allows for nested, hierarchical views of knowledge
• Supports navigation and exploration of diverse perspectives of the information space
• Domain independent
Demonstration of Protégé and Jambalaya
The Case of the NCI

- National Cancer Institute
- Vocabulary team is a group of 5-8 knowledge modelers
- Model contains 40,000 complex concepts from disparate areas (diseases, genes, drugs…)
- Editors often unsure how model should be structured and where concepts should go
- As model grows, the NCI has trouble understanding what is changing, why it changes, and how it changes
- Need to answer these questions for stakeholders and management

Potential solution: tool for better understanding this model
Motivation

• Knowledge modeling is complex and challenging
• Perceived usefulness requires addressing tasks important to the user
• Customization will allow those with the knowledge to decide what features are necessary
Approach

• Identify the tasks requiring support
• Identify non-functional design goals
• Evaluate existing tools
• Implement, validate, and analyze a customization approach in one application
• Reflect on the work and place in wider context
“[A tool’s] usefulness is ultimately dependent upon [its] utility relating to cognition: i.e., to thinking, reasoning, and creating [Walenstein02].”

- Identifying cognitive support examines
  - How the tool will be useful (to a given user)
  - Why it will be useful
  - What factors prevent that support from being realized

(derived from [Norman86])
Customization

- **Customization enhances cognitive support**
- Customization: non-source changes by users to presentation, data, or functionality
- (at least) 3 roles are involved
  - tool Designer, who incorporates the customization at design-time
  - Customizer, who possesses domain knowledge and tool knowledge
  - End User
Assessing KE Tasks

• Created an explicit, provenanced list of modeling tasks
• Based on
  – literature review
  – web survey
  – contextual inquiries
• Used these tasks and design goals to evaluate 5 visual interfaces for Protégé
## Task Taxonomy

<table>
<thead>
<tr>
<th>Category</th>
<th>Task #</th>
<th>Program Compr.</th>
<th>Contextual Inq.</th>
<th>Readings</th>
<th>Survey</th>
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<tbody>
<tr>
<td>Navigation</td>
<td>1</td>
<td>x</td>
<td>x (NCI, FMA)</td>
<td>([19], [76], [12], [56])</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-</td>
<td>x (NCI, FMA)</td>
<td>([76],[12], [56])</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>x</td>
<td>x (FMA)</td>
<td>([12])</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>([19], [56])</td>
<td>x</td>
</tr>
<tr>
<td>Modeling</td>
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<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>-</td>
<td>x (FMA)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>x</td>
<td>x (NCI, FMA)</td>
<td>([19], [12])</td>
<td>-</td>
</tr>
<tr>
<td>Verification</td>
<td>8</td>
<td>x</td>
<td>x (NCI, FMA)</td>
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<td>-</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>-</td>
<td>x (FMA)</td>
<td>([56])</td>
<td>-</td>
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<tr>
<td></td>
<td>10</td>
<td>-</td>
<td>x (FMA)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 3.1. Research methods used to derive tasks requiring cognitive support.

1 – overview and top-down exploration, 2 – slot-based browsing,
3 – view query results, 4 – save and annotate views, 5 – graphical editing,
6 – editing navigation, 7 – ontology reuse, 8 – identify incoming relationships,
9 – incremental navigation, 10 – browse complex relationships
### Task support in tools

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<tr>
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<td>1. Overviews</td>
<td>x</td>
<td>p</td>
<td>x</td>
<td>p</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>2. Slot-based browsing</td>
<td>p</td>
<td>p</td>
<td>-</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>3. Show queries</td>
<td>p</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>p</td>
</tr>
<tr>
<td></td>
<td>4. Save views</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>p</td>
<td>x</td>
</tr>
<tr>
<td>Editing</td>
<td>5. Graphical editing</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>6. Editing navigation</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7. Ontology reuse</td>
<td>p</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Verification</td>
<td>8. Incoming relations</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>9. Incremental navigation</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10. Multiple relations</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>p</td>
</tr>
</tbody>
</table>

**Table 3.2.** List of Protégé and its extensions evaluated against knowledge engineering tasks. An **x** indicates the support was provided in that tool, a **p** that there was partial support, and a dash that there was no support.
• Non-functional requirements are tradeoffs designers must keep in mind
• Five key soft goals are usability, learnability, expressivity, scalability, and customizability
• Customizability focuses on making a tool’s features user-centric, allowing people with the needs to make decisions about what is useful.
• Although tasks may be common, details about how to address them are not.
• Theory: customizable tools are more likely to be perceived as useful by end-users.
Conclusions of the Validation

- Customization may not work well for Jambalaya in its current form
- Model-based customization may have too much cognitive overhead
- Prototype effect: some small bugs and inconsistencies played larger role than necessary
- Success in other tools and enthusiasm suggest customization is an important design goal
Research Loop (derived from [Hollan00])

D.C. derived theories

- tasks req. support
- design goals
- customization
- cognitive support
- adoption

Cognitive Ethnography

- Contextual inquiry
- Participant observation
- Observational study

Workplaces

- NCI
- Stanford
- UWash
- CHISEL

Experiment

- Heuristic walkthroughs
- NCI/FMA studies
- Literature reviews

Work Materials

- Jambalaya
- CVF
- Apelone
- Protégé
- paper + pencil

Early RE talk – June 22, 2005
What does this suggest for requirements modeling?

- Both requirements and visualization influence each other (cf. Hollan)
- RE tools should be positioned to a target audience: users, modelers, engineers, etc.
- RE tools should leverage RE techniques for design (e.g. OME)
- Need smarter visualizations: AI techniques, views that answer user queries and give cognitive leverage
Fin


