INFORMATION VISUALIZATION

- RESEARCH PERSPECTIVE 😊

Zilina, May 14, 2009

JO UNI HUOTARI
PRINCIPAL LECTURER, PH.D.
SCHOOL OF TECHNOLOGY
MY PERSONAL BACKGROUND

• Born in Kuusamo, Finland
• M.Sc. 1991 (University of Oulu; Department of Information Processing Science)
• Ph.D. (econ.) 2005 (University of Jyväskylä; Department of Computer Science and Information Systems)
• Work experience: developing applications and teaching in a company of my own + other companies
CURRENT POSITION

• Currently working as a principal lecturer in [Jyväskylä University of Applied Sciences](https://jyu.fi) (School of Information Technology)

• Main teaching topics:
  – Database design and management
  – Project management

• Main research interests:
  – Information visualization
  – Graphical information systems models
  – Electronic portfolios

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RESEARCH PROCESS (FOR PH.D.)

- **Field studies and surveys**
- **Participant observation**
- **Video recording and interviews**
- **Lab experiment**
- **Pilot studies**

**Theory building**:
- Development of new ideas, conceptual frameworks, and models

**Observation**:
- Analysis of secondary data sources

**Experimentation**:
- Research prototype 1
- Research prototype 2

**Systems development**

<table>
<thead>
<tr>
<th>Year</th>
<th>1997</th>
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<th>1999</th>
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<td>Paper published</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
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</table>

Jouni Huotari

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Improving Graphical Information System Model Use with Elision and Connecting Lines

Jouni Huotari, Kalle Lyytinen, and Marketta Niemelä

ACM Transactions on Computer-Human Interaction (TOCHI)
Volume 10, Issue 4 (December 2003)

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Enhancing Graphical Information System Model

WITH VRML

IV CONFERENCE IN LONDON 2002

JOUNI HUOTARI AND MARKETTA NIEMELÄ
BACKGROUND FOR THE RESEARCH

- Information system (IS) specifications consist of a collection of design documents and diagrams.
- When the size and number of these documents increase, understanding relationships between them becomes difficult.
- During IS development, it is very important to find inconsistencies and other errors as early as possible.
- Designers, reviewers, and testers need to understand how design information relates in a larger context.
- Currently available CASE tools do not provide efficient techniques to visualise the design documents and graphical IS models in them.
EXAMPLE: TYPICAL ERD AND DFD

Entity-Relationship Diagram

Dataflow Diagram

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### PROBLEMS IN CASE AND POTENTIAL VISUALISATION SOLUTIONS

<table>
<thead>
<tr>
<th>Problem type in CASE</th>
<th>Examples of problems in CASE</th>
<th>Examples of potential visualisation solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representational</td>
<td>Use of (hyper-) text, tables, matrices, or graphics; semi-structure → how to preserve object's position</td>
<td>Colour, size, position, shape</td>
</tr>
<tr>
<td>Conceptual</td>
<td>Storing and processing recursive structures; decomposition, explosion</td>
<td>Distortion, elision, intelligent zoom</td>
</tr>
<tr>
<td>Methodological</td>
<td>Horisontal and vertical consistency; traceability</td>
<td>Explicit cues, highlighting (brushing-and-linking)</td>
</tr>
<tr>
<td>Implementation</td>
<td>Repository support; versioning and configuration</td>
<td>Layers, rotation, stereo, 3D</td>
</tr>
</tbody>
</table>
EXAMPLE OF ERD AND DFD WITH COLORS AND INTEGRATING CUES
VRML IMPLEMENTATION

• **Visible lines** between different types of diagrams (to enable horizontal consistency checking)

• **LOD** and **scripting** for elision: parts of the hierarchical structure are hidden by collapsing them into icons
  – click symbol (JavaScript, ROUTE, and TouchSensor),
  – by choosing a predefined viewpoint that is inside a LOD, or
  – "flying" inside a LOD's effective area

• **PROTO**: efficient way to reduce the length of the code

• **Billboard**: text is always facing the reader
• 3D v.
2D VS. 3D DIAGRAMS, AN EXPERIMENT
HUOTARI, LYYTINEN & NIEMELÄ (2004)
EXPERIMENT

• Case: university student register system
• 102 visual symbols and their inter-relationships indicated by arrows
• One-wall CAVE (Cave Automatic Virtual Environment)
• 105 subjects randomly assigned to the five conditions, 21 participants per condition
• 11 information search tasks
## CONDITIONS

<table>
<thead>
<tr>
<th>Traditional: multiple separate diagrams on uncolored paper sheets</th>
<th>Large-screen: like traditional but diagrams are colored and shown on a large screen</th>
<th>2D visual cues: like “Large-screen” but visual connecting cues (lines and elision) are added</th>
<th>3D visual cues: like “2D visual cues” but with 3D objects and layout</th>
<th>3D visual cues with stereo: like “3D visual cues” but with stereo effect</th>
</tr>
</thead>
</table>

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# RESULTS

<table>
<thead>
<tr>
<th>Information search tasks</th>
<th>CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paper – no visual cues</td>
</tr>
<tr>
<td></td>
<td>LS – no visual cues</td>
</tr>
<tr>
<td></td>
<td>LS 2D – visual cues</td>
</tr>
<tr>
<td></td>
<td>LS 3D – visual cues</td>
</tr>
<tr>
<td></td>
<td>LS 3D stereo – visual cues</td>
</tr>
<tr>
<td>Response time (s)</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>57</td>
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<tr>
<td></td>
<td>48</td>
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<tr>
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<td>52</td>
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<td></td>
<td>54</td>
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<tr>
<td>Error rate (%)</td>
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<td>9.6</td>
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<tr>
<td></td>
<td>4.8</td>
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<td>6.4</td>
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<td>7.6</td>
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<td>Horizontal search tasks</td>
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<td>3.6</td>
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<td>2.0</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
</tr>
<tr>
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<td>NA</td>
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<tr>
<td>Vertical search tasks</td>
<td>3.6</td>
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<tr>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Perfect answers (avg)</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
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</tbody>
</table>
CONCLUSION AND FUTURE DIRECTIONS

- Two things improve search accuracy when compared to a traditional visualisation with multiple separate diagrams:
  - Displaying diagrams in a large screen with colour
  - Visual connecting cues (elision and connecting lines)
- 3D visualisation did not affect search accuracy in the diagrams
- Problems in the CAVE environment (text and stereo effect) will be solved in the future, e.g. computers with real 3D screen are emerging
INTEGRATING UML VIEWS WITH VISUAL CUES

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OUTLINE

• Introduction: problems and needs
• Conventional and potential solutions
• Examples and a demo
• A pilot study and results
• Conclusions
• Information system (IS) models are complex
  – Many views (UML: 4+1), phases, and abstraction levels
  – Graphical representation: e.g. set of UML diagrams
• When the size and number of these diagrams increase, understanding relationships between them becomes difficult
• During IS development, it is very important to find inconsistencies, omissions, and other errors as early as possible
• Designers and reviewers need to understand how design information relates in a larger context
• Current CASE tools do not provide efficient techniques to integrate views and visualize the interconnections in graphical IS models (diagrams in separate windows)
POTENTIAL DEFICIENCIES: INCONSISTENCIES, OMISSIONS, AND OTHER ERRORS

Deficiencies might exist between:

a) external representations,
b) external and internal representations,
c) views (internal representations),
d) views and real world, and
e) external representations and real world

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**Diagram:**

- **Real world**
  - **Observation**
  - **Creation**
    - **Designer’s view**
    - **User’s view**
  - External representations (IS model)
    - **Level 0**
    - **Level 1**
EXAMPLE OF 3 VIEWS; USE CASE, PROCESS, AND LOGICAL VIEW

- Which use cases have detailed descriptions?
- Which use case is the sequence diagram made for?

• Where are the classes or actors used?

=> Separate diagrams; no cues about possible connections
POTENTIAL SOLUTION: VISUALIZATION TOOL

• Utilises appropriate visualisation techniques and cues
  – Coupling and coordination is addressed from an integration point of view
  – Coupling techniques in use are connecting lines and brushing
  – Elision: parts of the hierarchical structure are hidden by collapsing them into icons

• Show complexly interlinked information
  – Overview first, zoom and filter, details-on-demand
  – Enables exploration (new knowledge about relationships can be discovered or existing information can be validated)

• Our first research prototype
  – Student register; hard-coded with VRML
  – Laboratory experiment in Holvi (CAVE)

• Our second research prototype
  – Reads UML model file created with a CASE tool (IBM Rational Rose)
  – Imports use case, sequence, and class diagrams
EXAMPLE OF INTEGRATING DIAGRAMS WITH VISUAL CUES (DEMO)
A PILOT STUDY

• Two conditions (randomly assigned): ISVIS research prototype and IBM Rational Rose
• Six subjects interviewed; three of them participated in the pilot (no previous experience from the tools)
• The reviewing situation was videotaped (thinking aloud was encouraged)
• 12 information search tasks (questions)
  – Question 6: Is there a sequence diagram where both the class “Order” and “Order Line” are specified?
  – Question 10: Estimate how complete the model is. How many of the requirements are currently specified?
• The main dependent variable was search accuracy (time was also recorded)
• Evaluation about the usability of the tools (1=bad, 5=excellent)
RESULTS OF THE PILOT STUDY

• Subject 1: one error with ISVIS tool, 45 min.
  – The error was due to the difficulty in positioning the mouse and selecting the objects

• Subject 2: two errors with Rose, 52 min.
  – Errors mainly due to the difficulty of maintaining control of separate windows

• Subject 3: no errors with ISVIS tool, 45 min.

• Usefulness: average score: ISVIS: 3.4; Rose: 2.4
THE ACTUAL EXPERIMENT TOOK PLACE IN 2005

- N=50, With-in subjects
- No major differences between Rose and ISVIS
- Error rate was the same between the tools
- Usability slightly better with Rose (3.1 vs. 2.9), usefulness better with ISVIS (3.2 vs. 2.8)
- More in-depth analysis is needed
CONCLUSION AND FUTURE DIRECTIONS

• Our tool helps
  – Three different reviewer roles: designers, external reviewers, and teachers
  – People with different skill levels: novices, new designers in a SW project team, and experts in reviewing or decision making (e.g. reusing a component)
  – The actual modelling tool is not needed in order to review the graphical IS models
  – Integrate behavior (processes) and static structures

• Potential solution to a typical integration problem, which exists e.g. in representing organizational structures and functions)

• The benefits of using 3D are not clear

• Usability problems should be solved and more functionality added
OTHER RESEARCH (ON INFORMATION VISUALIZATION)

JOUNI HUOTARI
SOME PLACES TO START

• The Human-Computer Interaction Lab (HCIL) at the University of Maryland:
  – http://www.cs.umd.edu/hcil/

• Laboratory for Information Visualization and Evaluation @ Virginia Tech: http://infovis.cs.vt.edu/

• Visualization ToolKit (VTK): http://www.vtk.org/

• IV conferences, e.g. http://www.graphicslink.co.uk/
JOINT RESEARCH / PROJECT COOPERATION?

• What are your interests?
• How could visualization tools and techniques help you to accomplish your goals?
• We are starting cooperation on topic “Research on Usage of Visualization Techniques for Large Databases Exploration”
• Potential project: “Open Solutions in Higher Education”:  
  – Building reusable learning packages based on open source software, open standards, open solutions, and open course material
  – Information Visualization course could be one Case