Software Visualization

A Task Oriented View

The Papers

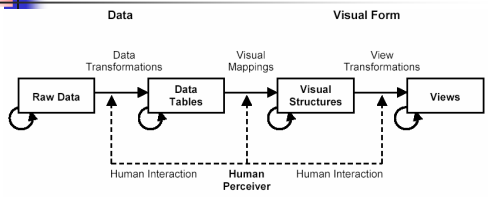
- A Task Oriented View of Software Visualization
  - Maletic J., Marcus A., Collard M. (2002)
- Strata-Various: Multi-Layer Visualization of Dynamics in Software System Behavior
  - Kimelman D., Rosenburg B., Roth, T. (1994)
- 3D Representations for Software Visualization
  - Marcus A., Feng L., Maletic J. (2003)

Match the Method to the Task

- The Domain: Understanding and analysis during development and maintenance of large-scale software systems.
- The Argument: No single software visualization tool can address all tasks simultaneously.
- The Proposal: A framework for identifying the most appropriate visualization mechanism for the given task.

A Reference Model

adapted from Card et al. "Readings in Information Visualization: Using Vision to Think"



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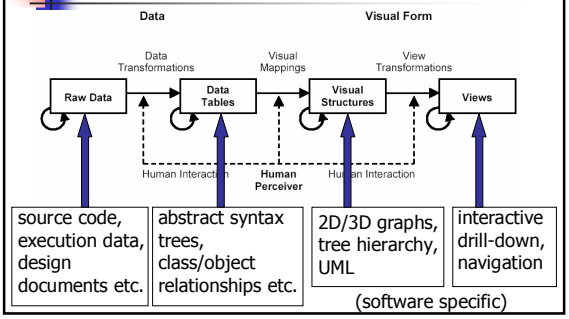


A Taxonomy of Software Visualization Systems

- Dimensions of Software Visualization
  - Tasks – **why** is the visualization needed?
  - Audience – **who** will use the visualization?
  - Target – **what** is the data source to represent?
  - Representation – **how** to represent it?
  - Medium – **where** to represent the visualization

How does this relate to previous work?

Dimension	Roman [Roman '93]	Price et all. [Price '93,'98]
Task	***	Purpose
Audience	***	Purpose
Target	Scope, Abstraction	Scope, Content
Representation	Specification method, Interface, Presentation	Form, Method, Interaction, Effectiveness
Medium	***	Form

Why is a new taxonomy needed now?

- Task dimension not covered in Roman's taxonomy and only marginally by Price et al.
  - Why? Largely due to the state of the art of the field nearly a decade ago.
  - Importance: The task requires visualizations with characteristics that can later be defined along the remaining dimensions.
  - Ultimate Goal: Identify key tasks for maintenance/development -> determine sets of dimensional values that are most appropriate

Mapping Software Visualization Systems

Dimension / SV System	Task	Audience	Target	Representation	Medium
SHriMP	Reverse engineering, maintenance	Expert developer	Source code, documentation, static design-level information, medium Java systems	2D graphs, interactive, drill-down	Color monitor
Tarantula	Testing, defect location	Expert developer	Source code, test suite data, error location	Line oriented representation, color, interactive, filtering, selection	Color monitor
IMSOvison	Development, reverse engineering, management	Expert developer, team manager	Source code, static design information, metrics, large OO systems	Specialized visual language, 3D color objects, spatial relationships, drill-down, interactive, abstraction mechanism	Immersive virtual environment
SeeSoft	Fault location, maintenance, reengineering	Expert developer	Source code, execution data, historical data	Line oriented representation, color, interactive, filtering, selection	Color monitor

Critique

- What is a Task?
  - Granularities of 'task' result in overlapping and imprecision
  - Is it what you are using the visualization for?
  - Is it what the designers of the tool had in mind when they created it?
- Not convinced that we can organize all software visualization tools by this...

PV: Visualizing Dynamics in Software System Behavior

- Domain: Visualization tool for debugging or tuning
- Argument: Current (1994) tools provide only static structure or dynamics from only a few of the many layers of a program and its underlying system.
- Proposal: Multiple views present synchronized view of behavior from all levels as the programs behavior unfolds over time.

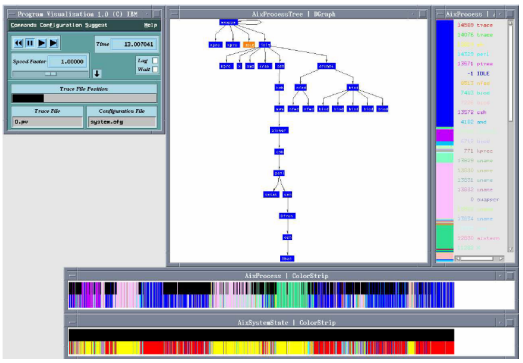
How does it work?

- Low Level:
  - PV is trace driven
  - Displays are produced as PV reads through a trace containing an execution history.
  - System is Extensible. Views may be written as plug-ins.
  - The prototype reads trace formats generated by the AIX system

How does it work?

- High Level:
  - The user continually replays the execution history and rearranges the display to discard unnecessary information or to incorporate more relevant information.
  - During a replay, (although live delivery is possible) the user watches for trends, anomalies and interesting correlations.
    - If an interesting discovery is made, the user may zoom in on a view for greater detail. Views are linked – so context is preserved.
  - Behavioral phenomena (perhaps unexpected) may be revealed.

The User Interface



Mapping PV

Task	Audience	Target	Representation	Medium
debugging tuning	expert developer	program, user-level libraries, operating-system, hardware	multiple 2D interactive views – color, zoom, animation	color monitor

Critique

- This tool clearly had great potential – many of the ideas exist in today's IDE's
- something close to case studies were presented –these acted mainly as a description of possible features/uses.
- the user interface was barely described – and appeared to be accessible only to expert users.
  - This was identified as a limitation in the 'future work' section – where, coincidentally, 3D views were discussed...

3D Representations for Software Visualization

- Domain: Visualizing large scale software to assist in comprehension and analysis tasks associated with maintenance and reengineering.
- Motivation: To explore new mediums and representations to address particular software engineering tasks.
- Proposal: A 3D metaphor for software visualizations.

Mapping Data to a Visual Metaphor

- A Criteria [MacKinlay 1986]
  - **Expressiveness**
    - capability of the metaphor to represent all the information we desire to visualize
  - **Effectiveness**
    - efficiency of the metaphor as a means of representing the information

Related Works

- SeeSoft [Ball and Eick 1996]
  - **Expressiveness**: 2D pixel bars limits the number of attributes that can be visualized as well as the types of relationships.
  - **Effectiveness**: natural and direct mapping from the visual metaphor to the source code and back.
- Tarantula [Jones et al 2001]
  - **Expressiveness**: built on SeeSoft – uses brightness to represent an extra attribute.
  - **Effectiveness**: As noted by authors – brightness is confusing and poorly perceived by users.

Related Works

- Bee/Hive [Reiss 2001]
  - **Expressiveness**
    - introduces file maps, which make use of texture and third dimension.
    - supports multiple views of the data and multiple data sources.
  - **Effectiveness**
    - supported user interactions are somewhat limited for 3D renderings.. thus problems such as occlusion may occur.

The sv3D Framework

- Builds on the SeeSoft and Bee/Hive metaphors while making a number of enhancements:
  - **Expressiveness**:
    - various artifacts of the software system and their attributes can be mapped to 3D metaphors, at different abstraction levels
    - currently – container is a file.
    - use of height, depth, color, position
    - design and implementation are extensible

The sv3D Framework

- **Effectiveness**:
  - displaying data in 3 dimensions instead of 2 can make it easier for the user to understand
    - [Ware, Frank 1994]
  - user understanding of 3D structure improves when they can manipulate structure
    - [Hubona et al. 1997]
  - 3D representations have been shown to better support spcial memory tasks than 2D
    - [Tavanti, Lind 2001]

The User Interface [Shneiderman '96]

- **Filtering**:
  - transparency, elevation
- **Details on demand**:
  - interaction: track ball, handle box; information panel for data values
- **Relate**:
  - height, depth, color, position - arrange in 3D space
- **History**:
  - snapshots (sequences of snapshots for a path)
- **Extract**: future (currently focused on visual)

Mapping sv3D

Task	Audience	Target	Representation	Mdm
maintenence, reengineering	expert developer	source code, independent	interactive 3D view. uses color, depth, texture, position	color mntr.

Critique

- Currently file based, which may not be that helpful – it's difficult to relate files to each other in a meaningful way.
- Examples used height dimension to indicate nesting level of control structures.. A better variety of uses would have been interesting.