Requirements Visualization
Purpose

- Attempt to define overlap between SEViz and InfoViz
- Look for where opportunities lie for marriage of ideas
Two Decades of SE Visualization

- Development of visual notations and techniques for defining and communicating the understanding of a problem, its requirements and possible designs
- The demand for shared conventions has ultimately led to the UML
Goals of SEViz

1. Visualization as Artifact
   - Clearly fix and communicate structures to facilitate development.

1. Visualization as Activity
   - Reveal and understand hidden structures
Requirements of SEViz

1. Visualization of Artifacts
   - Communicate structures.

1. Visualization of Activity
   - Reveal states and dynamics of lifecycle processes.
Uses of Visualization

Requirements Engineering

Design

Software Development

Upstream

Downstream
RE - Can We Go from This?

From page 157 of [1]:

**Req #:** 75
**Req Type:** 9 (functional requirement)
**Event/Use Case #:** 6
**Description:** The product shall issue an alert if a weather station fails to transmit readings.
**Rationale:** Failure to transmit readings might indicate that the weather station is faulty and needs maintenance, and that the data fails to transmit readings.
**Source:** Road Engineers
**Fit Criterion:** For each weather station the product shall communicate to the user when the recorded reading per hour is not within the maximum and minimum expected number of readings per hour.
**Customer Satisfaction:** 3
**Customer Dissatisfaction:** 5
**Dependencies:** None
**Conflicts:** None
**Supporting Materials:** Specification of maximum and minimum expected number of readings per hour
**History:** Raised by GBS, 28 July 99

From page 159 of [1]:

**Req #:** 110
**Req Type:** 11 (non-functional requirement - usability)
**Event/Use Case #:** 6, 7, 8, 9, 10
**Description:** The product shall be easy for the road engineers to use.
**Rationale:** To be able to schedule untreated roads and highlight potential danger.
**Source:** Arnold Snow, Chief Engineer
**Fit Criterion:** The recorded treated and untreated roads shall agree with the drivers’ road treatment logs.
**Customer Satisfaction:** 3
**Customer Dissatisfaction:** 5
**Dependencies:** None
**Conflicts:** None
**Supporting Materials:** None
**History:** Created February 29, 2006

From website of [1]:

**Req #:** 74
**Req Type:** 9 (functional requirement)
**Event/Use Case #:** 7, 9
**Description:** The product shall record all the roads that have been treated.
**Rationale:** To be able to schedule untreated roads and highlight potential danger.
**Source:** Arnold Snow, Chief Engineer
**Fit Criterion:** The recorded treated and untreated roads shall agree with the drivers’ road treatment logs.
**Customer Satisfaction:** 3
**Customer Dissatisfaction:** 5
**Dependencies:** None
**Conflicts:** None
**Supporting Materials:** None
**History:** Created February 29, 2006

To This:

Magnus Rembold & Jürgen Späth in *Total Interaction*, Princeton Architectural Press, 2005,
Or This?

Arc Diagram of 63,000 Bible Cross-References,
Chris Harrison (CMU) and Christoph Römhild
Overlapping Concerns

Information Visualization

- Representational techniques to yield structure
- Data yet to be structured
- Metaphors used to yield structure

Software Engineering Visualization

- Complex structured data
- Unstructured data
- Structured data

RE visualization

Visual notations
Questions

- What are we looking for?
- What are the challenges?
- Where are the opportunities?
- How can we jumpstart research?
The Problem

- A meta-problem?
- Where is visualization used in RE?
- What for?
- Who for?
- With what results?

VISUALIZATION: “the act of forming a mental vision, image, or picture of (something not visible or present to the sight, or of an abstraction); to make visible to the mind or imagination.” [OED]
A Problem

- Do we SEE requirements?
- Can we render requirements visible?
- Can we gain some quick or new insight?
  - How do we know if our requirements are any good?
  - Are our requirements healthy? Credible?
- Visualizing the multi-dimensional nature of requirements:
  - Individual requirements
  - Sets of requirements
What’s Been Created?

- 3 ideas:
  - Individual requirement’s footprint
  - Snapshot of health (requirements set) focusing on possible concerns associated with a few important properties
  - Overall big picture (requirements set) focusing on stability / volatility
# Requirement’s Footprint

<table>
<thead>
<tr>
<th>#</th>
<th>attribute name</th>
<th>[type]</th>
<th>(content)</th>
<th>{symbol}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>requirement no</td>
<td>[number]</td>
<td>(000)</td>
<td>{square}</td>
</tr>
<tr>
<td>2</td>
<td>requirement type</td>
<td>[number]</td>
<td>(00)</td>
<td>{square}</td>
</tr>
<tr>
<td>3</td>
<td>events/use cases list</td>
<td>[references]</td>
<td>(000)-(000)-(000)-...</td>
<td>{linked ovals}</td>
</tr>
<tr>
<td>4</td>
<td>description</td>
<td>[text]</td>
<td>(abc...)</td>
<td>{expanding circle}</td>
</tr>
<tr>
<td>5</td>
<td>rationale</td>
<td>[text]</td>
<td>(abc...)</td>
<td>{expanding circle}</td>
</tr>
<tr>
<td>6</td>
<td>originator</td>
<td>[reference or text]</td>
<td>(000)/(abc...)</td>
<td>{square}/{expanding circle}</td>
</tr>
<tr>
<td>7</td>
<td>fit criterion/tests</td>
<td>[text]</td>
<td>(abc...)</td>
<td>{expanding circle}</td>
</tr>
<tr>
<td>8</td>
<td>customer satisfaction</td>
<td>[range]</td>
<td>(1,2,3,4,5)</td>
<td>{upward vertical arrow}</td>
</tr>
<tr>
<td>9</td>
<td>customer dissatisfaction</td>
<td>[range]</td>
<td>(1,2,3,4,5)</td>
<td>{downward vertical arrow}</td>
</tr>
<tr>
<td>10</td>
<td>priority</td>
<td>[range]</td>
<td>(?)</td>
<td>{upward vertical arrow}</td>
</tr>
<tr>
<td>11</td>
<td>conflicts list</td>
<td>[references]</td>
<td>(000)-(000)-(000)-...</td>
<td>{linked squares}</td>
</tr>
<tr>
<td>12</td>
<td>supporting materials</td>
<td>[references]</td>
<td>(000)-(000)-(000)-...</td>
<td>{linked circles}</td>
</tr>
<tr>
<td>13</td>
<td>history</td>
<td>[text or list or references]</td>
<td>(abc...)/(000)-(000)-(000)-...</td>
<td>{expanding circle}/{linked circles}</td>
</tr>
</tbody>
</table>
Empty Requirement
Visual Mapping (i)

From page 159 of [1]:

Req #: 110
Req Type: 11 (non-functional requirement - usability)
Event/Use Case #: 6, 7, 8, 9, 10
Description: The product shall be easy for the road engineers to use.
Rationale: It should not be necessary for the engineers to attend
training classes in order to be able to use the product.
Source: Sonia Henning, Road Engineering Supervisor
Fit Criterion: A road engineer shall be able to use the product to successfully carry out the cited use cases within 1 hour of first encountering the product.
Customer Satisfaction: 3
Customer Dissatisfaction: 5
Dependencies: None
Conflicts: None
Supporting Materials:

History: Raised by AG 25 Aug 99

1 requirement no (110)
2 requirement type (11)
3 events/use cases list (006)-(007)-(008)-(009)-(010)
4 description (11 words)
5 rationale (21 words)
6 source (5 words)
7 fit criterion/tests (26 words)
8 customer satisfaction (3)
9 customer dissatisfaction (5)
10 priority (? not given)
11 conflicts list (000)
12 supporting materials (void)
13 history (6 words)

NB 'Dependencies: None' does not fit shell

Crude to automate; plan to make more of semantics
Visual Mapping (ii)

1. requirement no (110)
2. requirement type (11)
3. events/use cases list (006)-(007)-(008)-(009)-(010)
4. description (11 words)
5. rationale (21 words)
6. source (5 words)
7. fit criterion/tests (26 words)
8. customer satisfaction (3)
9. customer dissatisfaction (5)
10. priority (? not given)
11. conflicts list (000)
12. supporting materials (void)
13. history (6 words)

NB 'Dependencies: None' does not fit shell
Resulting Visualization
<table>
<thead>
<tr>
<th>Requirement no (74)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement type (9)</td>
</tr>
<tr>
<td>Events/Use cases list (007)- (009)</td>
</tr>
<tr>
<td>Description (11 words)</td>
</tr>
<tr>
<td>Rationale (11 words)</td>
</tr>
<tr>
<td>Source (4 words)</td>
</tr>
<tr>
<td>Fit criterion/tests (14 words)</td>
</tr>
<tr>
<td>Customer satisfaction (3)</td>
</tr>
<tr>
<td>Customer dissatisfaction (5)</td>
</tr>
<tr>
<td>Priority (void)</td>
</tr>
<tr>
<td>Conflicts list (000)</td>
</tr>
<tr>
<td>Supporting materials (void)</td>
</tr>
<tr>
<td>History (4 words)</td>
</tr>
</tbody>
</table>

NB 'requirement no' changed to avoid conflict with another example
Resulting Visualization
How Does it Work?

- Lengthy rationale provided
- Attribute values missing
- Supports fewer use cases than #110
- If this is HUGE - there is going to be a lot of history to deal with
- Customer’s going to be peeved if this isn’t implemented
## Requirements Health Check

<table>
<thead>
<tr>
<th>REQ</th>
<th>Value</th>
<th>Source</th>
<th>Rationale</th>
<th>Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td># 74</td>
<td><img src="" alt="Sad Face" /></td>
<td><img src="" alt="Happy Face" /></td>
<td><img src="" alt="Happy Face" /></td>
<td><img src="" alt="Happy Face" /></td>
</tr>
<tr>
<td># 75</td>
<td><img src="" alt="Sad Face" /></td>
<td><img src="" alt="Neutral Face" /></td>
<td><img src="" alt="Happy Face" /></td>
<td><img src="" alt="Happy Face" /></td>
</tr>
<tr>
<td># 110</td>
<td><img src="" alt="Sad Face" /></td>
<td><img src="" alt="Happy Face" /></td>
<td><img src="" alt="Happy Face" /></td>
<td><img src="" alt="Happy Face" /></td>
</tr>
</tbody>
</table>
Requirements Big Picture

Stakeholder groups

Stakeholders

Requirements

Events/use cases
Validation, Critique, Next Steps?

- These are **visions** of visualization possibilities in RE ... there is a lot to do!
- Currently: simple - can be automatically generated and support a small set of questions / tasks
- Future: a collection of visual renderings to support multiple tasks, more use of semantics, user consultation
Scouting Requirements Quality Using Visual Representations

Francis T. Marchese & Orlena C.Z. Gotel
Pace University, New York, USA
ogotel@pace.edu, fmarchese@pace.edu
How to assess quality of this.

From page 157 of [1]:
Req #: 75
Req Type: 9 (functional requirement)
Event/Use Case #: 6
Description: The product shall issue a warning if the recorded number of each type of weather station is faulty and needs maintenance, and that the data fails to transmit readings.
Rationale: Failure to transmit readings might indicate that the weather station is faulty and needs maintenance.
Source: Road Engineers
Fit Criterion: For each weather station the product shall communicate to the user when the recorded reading per hour is not within the manufacturer's specified range of use.
Customer Satisfaction: 3
Customer Dissatisfaction: 5
Dependencies: None
Conflicts: None
Supporting Materials: Specification of Rosa Weather Station
History: Raised by GBS, 28 July 99

From page 159 of [1]:
Req #: 110
Req Type: 11 (non-functional requirement - usability)
Event/Use Case #: 6, 7, 8, 9, 10
Description: For each weather station the product shall successfully carry out the cited use cases within 1 hour of first training classes in order to be able to use the product.
Rationale: To be able to schedule untreated roads and highlight potential danger.
Source: Sonia Henning, Road Engineering Supervisor
Fit Criterion: The product shall record all the roads that have been treated.
Customer Satisfaction: 3
Customer Dissatisfaction: 5
Dependencies: None
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Supporting Materials: None
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Customer Satisfaction: 3
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Dependencies: None
Conflicts: None
Supporting Materials: None
History: Raised by AG 25 Aug 99

[1] Robertson, S. AND Roberson, J. 
Mastering the Requirements Process, 
Requirements Quality Questions

- If you could name the intended software system, what would you call it?
- Who are the main stakeholders for the system?
- What are the main functional requirements of the system?
- What categories of non-functional requirement are important to the system?
- What techniques are used to describe the requirements?
- What are the *general contents* of the requirements document?
- What *requirements* are specified in the requirements document?
Scouting Software Requirements

- A preliminary activity to highlight when and where a more careful inspection of requirements documents, is needed.

- An interactive and collaborative activity centered on a single visual representation of the requirements.
Requirements for Visualization

- Must capture the essence of the system
- Act as a trigger for stakeholder discussion
- Provide an alternative mode of communication
- Be easy to use!
Text/Tag Clouds

Wordle – Top 150 words
All words that appear 5 times or more

TagCrowd - Top 50 words
Wordle

- Created by Jonathan Feinberg
- http://www.wordle.net
- Cut-and-Paste Visualization

Wordle of this paper from the IV’09 Proceedings
Hypothesis

A Wordle of a requirements document provides an effective visualization to help ascertain the quality of a requirements document at a cursory level.

It should:

- Highlight prominent terms
- Emphasize the problem that is being tackled
- Make clear whether the document is written in the language of the domain or populated with design constraints
- Yield a first impression on quality that is comparable with scouting the text of the requirements document itself
Experiment

Part 1: (All 34 Subjects)
A task to assess whether it is possible to differentiate Wordles generated out of requirements documents from those generated out of requirements document templates.
Part 2:

Task to assess the results from scouting a Wordle representation of a requirements document for quality.

**Control group**: Read original requirements documents

**Experiment group**: Viewed Wordles

Three sample requirements documents randomly selected from documents created during a graduate software engineering course.

Each document rated according to 10 Quality Questions
Results: Part 1

Could subjects differentiate requirements documents Wordles from requirements document template Wordles?

**Study Group 1:** 15 graduate computer science students in a 2nd project-based course in software engineering

**Study Group 2:** 18 graduate software design and engineering students
Part 2: Scouting Performance

- The inexperienced group completed the scouting task 25% faster than the experienced group.
- Wordles users completed scouting from 12 to 20% faster than the control groups (inexper. vs. exper.).
- Group 1 performed better with Wordles when ranking quality accurately than Group 2 by 56% to 41%.
- Uncertainty about requirements document exhibiting quality properties
Limitations

- Wordles used to represent documents in their first instance
- Finding ‘ideal’ visual representation beyond the scope of our study
- Experimental studies limited in size and availability of artifacts.
- Font style and color scheme unoptimized
Conclusions and Future Work

- Wordles hold promise for scouting:
  - as the size of a requirements document increases
  - for inclusion of stakeholders who have little prior exposure to writing or reviewing requirements
- Wordles can concurrently act as a shared communicative artifact for conducting a directed requirements quality discussion
- Wordles cannot support all software development tasks - alternative visualizations are being explored.
- Ultimate goal is a dashboard of visual representations that act as triggers for discussions among parties.