



Visual Analytics for Software Requirements Engineering

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About Me

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- Requirements Engineering, Requirements Visualization, Visual Analytics, Decision making and Program Comprehension.

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Outline

- Visual Analytics
- Motivation
- Visual Requirements Analytics
- Case Study
- Conclusion & Future Work

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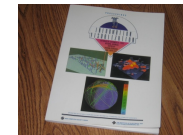
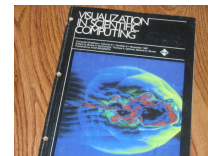


History of Visualization

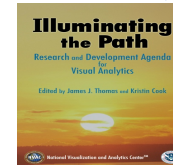
- 70s to 80s
 - CAD/CAM Manufacturing, cars, planes, and chips
 - 3D, education, animation, medicine, etc.
- 90s to 2000s
 - Information visualization
 - Web and Virtual environments



- 80s to 90s
 - Scientific visualization
 - Realism, entertainment



- 2000s to 2010s
 - Visual Analytics
 - Visual/audio appliances



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Visual Analytics

→ Visual Analytics (VA)

- ↳ The science of analytical reasoning facilitated by interactive visual interfaces.
- ↳ Offers a solution to turn the information overload into an opportunity.
- ↳ More than information visualization or visual data mining, it involves technology to support all aspects of the analysis and reasoning processes.

→ Applications

- ↳ Biology, astronomy, geology, forensics etc.

→ VAST (visual analytics science and technology)

- ↳ <http://www.ieeevis.org/>
 - VAST, InfoVis, SciVis

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Successful Story!

→ Mystery:

- ↳ What caused a cholera epidemic in London in 1854?
- ↳ At that time, the data acquisition and visualization tools were severely limited by today's standards.

→ Solved by Dr. John Snow using a map visualization.



http://en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak

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Dr. John Snow's Map

What would Dr. John Snow have done if he had a MacBook Pro and a copy of Processing installed?

http://en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak

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Born again: An Interactive Visualization of the 1854 London Cholera outbreak

Cholera deaths 19-Aug to 8-Sep, 1854
1854 Cholera outbreak in Soho, London. Data collected by John Snow.

Deaths

Gender percentage of deaths

Age class percentage of deaths

Timeline

Clustering

Options

Show victims of gender

<http://www.evl.uic.edu/kredavis/snowcholera/>

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ReCVisu as a VA tool for RE

→ S. Reddivari, Z. Chen, and N. Niu, "ReCVisu: A tool for clustering based visual exploration of requirements," in Requirements Engineering Conference (RE), 2012, pp. 327-328.

→ Results

- ✦ Visualizing requirements enables quick insights that otherwise would be difficult to obtain via textual analysis.
- ✦ Clustering-based visualization effectively raises the level of abstraction.

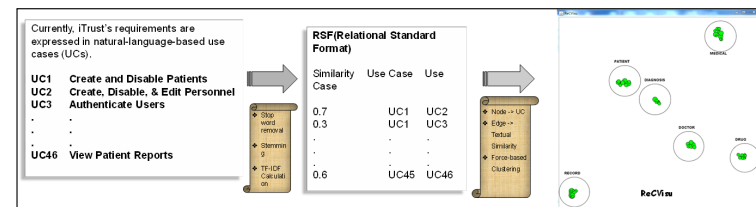
→ Limitations

- ✦ It can't make the visualizations truly interactive.
- ✦ It can't handle anomalies (e.g., locate peculiar requirements, deal with the deviations).
- ✦ It can't handle the heterogeneous data.

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Requirements Clustering Visualization (ReCVisu)



- A node represents a "requirement" and an edge represents the "textual similarity" (i.e., tf-idf cosine values).
- ReCVisu uses the LinLog energy model that most naturally reveals software structures.

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Why Visual Requirements Analytics?

- ↳ VA techniques are still not capable of delivering end-to-end (from data to decision) values.
- ↳ Lack of understanding about how a VA approach efficiently solves the requirements analyst's needs.
- ↳ Visualizations themselves are not sufficient.
- ↳ Need to assess the strengths and weaknesses of the contemporary approaches.

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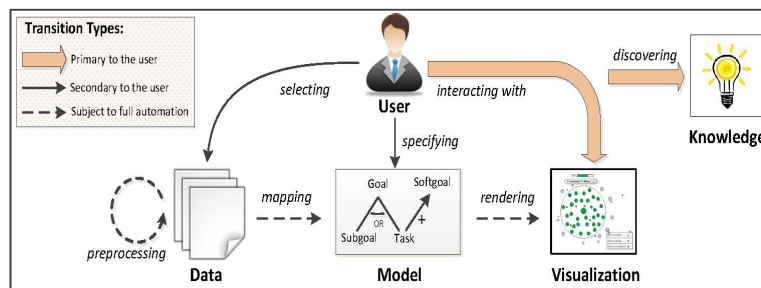
Visual Requirements Analytics

- We developed a framework that provides built-in analytical reasoning capabilities through interactive requirements visualizations.
- Our main objectives are:
 - ↳ 1) development of an RE-oriented framework.
 - ↳ 2) evaluation of existing VA approaches by applying the framework.
 - ↳ 3) advancement of the literature through building VA capabilities that can produce end-to-end values to the RE practitioners.

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Visual Requirements Analytics Framework



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Goal

- In GQM, a goal needs a purpose, issue, object, and viewpoint [Basili *et al.* 1994].
 - “user” goal as an example; here the need is to assess (the purpose) the adequacy (the issue) of user satisfaction (the object) from the VA tool provider's perspective (the viewpoint).
 - “Visualization” goal as an example; here the need is to evaluate (the purpose) the usability (the issue) of the visualization (the object) from the requirements analyst perspective (the viewpoint).

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Conceptual Goals & Operational Questions

User		Data		Model		Visualization		Knowledge	
U1	Multiple stakeholders roles	D1	Large-scale inputs	M1	Explicit model representation	V1	Multiple views	K1	Anomaly Detection
U2	Usage without heavy training	D2	Heterogeneous input types	M2	Automatic model construction	V2	Inter-view navigation	K2	Detailed explanation
U3	Real-time performance	D3	Automatic preprocessing	M3	Model extension and customization	V3	Browsing	K3	Hypothesis-based reasoning
U4	Integration into existing software development environment			M4	Model traceability	V4	Searching	K4	Scenario-based reasoning
						V5	Query-drilling		
U5	Practitioner-oriented guidelines					V6	Filtering	K5	Actionable decision
						V7	Annotation		

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Questions

- Q1: "Is the current visualization satisfactory?"
- Q2: "Does the visualization support multiple views?"
- Q3: "Does the visualization add value to the decision making process?"
- Q4: "Does the visualization support inter-view navigation?"
- Q5: "Does the visualization provide searching facility?"
- Q6: "Does the visualization provide filtering?"
- Q7: "Does the visualization provide query-drilling?"

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Starplots of Assessed VA Approaches



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Case Study

→ Goal

↳ To gain operational insights into how a VA tool can help keep requirements on track in practice.

→ We set out to answer the following questions

- ↳ What RE tasks are in need of VA support?
- ↳ How VA supports these tasks?
- ↳ What benefits can be expected?

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Joint Application Development of ReCVisu+ Tool

Preparation by the research team	Meeting date & duration	Participants	Main activities
Demo ReCVisu on iTrust	Aug 8, 2012 & 1 hour	PM, SA, RA	<ul style="list-style-type: none"> •Present ReCVisu •Collect feedback •Gather requirements
Launch ReCVisu+ & improve "overview"	Sept 21, 2012 & 2.5 hours	RA	<ul style="list-style-type: none"> •Detect & act on extremity •Elicit RE tasks
Implement "anomaly" handling	Nov 30, 2012 & 1.5 hours	PM, RA	<ul style="list-style-type: none"> •Diagnose & handle outliers •Elicit RE tasks further
Implement "heterogeneity" utilization	Jan 14, 2013 & 0.5 hour	SA, RA	<ul style="list-style-type: none"> •Relate multiple artifacts •Refine ReCVisu+ design

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Main Results of the Case Study

RE task in need of VA support	Support provided by RecVisu+
Overview -Summarize a large requirements space - Identify regions of interest	<ul style="list-style-type: none"> • Present flexible labels for each cluster • Show a cohesiveness bar to suggest interesting regions
Anomaly -Locate peculiar requirements - Deal with the deviations	<ul style="list-style-type: none"> • Annotate an outlier as a bridge between clusters • Adopt an outlier as an orphan to a cluster
Heterogeneity -Relate requirements to other artifacts - Compare multi-stakeholder concerns	Use an artifact's tags to link requirements in different clusters (partially supported)
Causality -Perform semantic analysis -Multivariate comparison -Exploratory reasoning	Transform a hypothesis into a visual representation and test the hypothesis interactively

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Overview

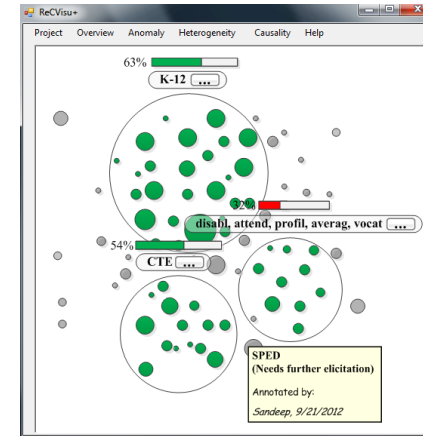


Visual overview leading the action of splitting low-quality requirements clusters into sub-clusters.

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Split sub clusters

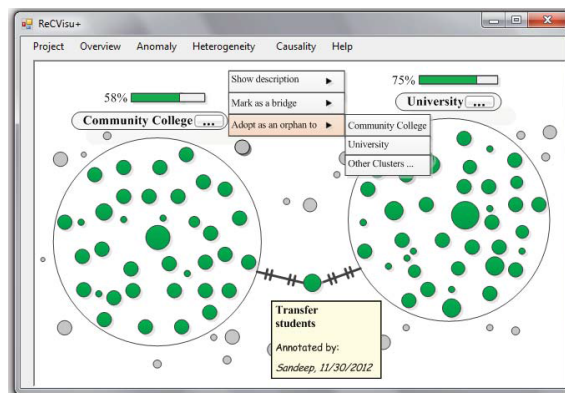


Split sub-clusters leading the actions of further requirements elicitation.

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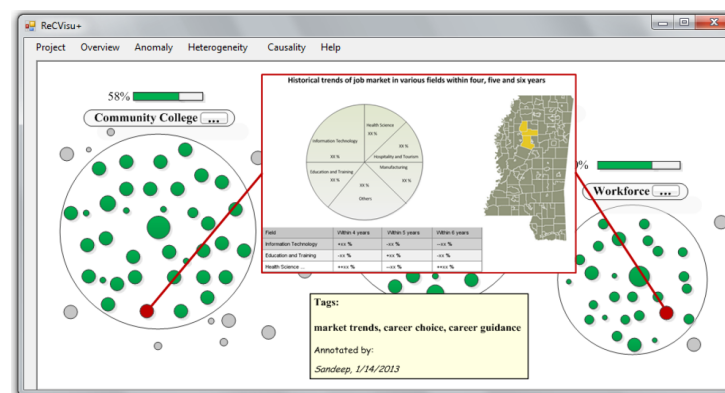
Anomaly Handling



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Using a design mockup to link requirements



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Conclusion & Future Work

→ Conclusion

- ↳ We proposed a visual requirements analytics framework to characterize and improve the state-of-the-art practice.
- ↳ We also applied the framework to assess existing VA techniques for RE.
- ↳ Developed a VA tool 'ReCVisu+'.
- ↳ Conducted case study uncovers four RE tasks
 - Overview
 - Anomaly handling
 - Heterogeneity utilization
 - Causality reasoning

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Conclusion & Future Work

→ Future Work

- ↳ Our future work includes refining the design of ReCVisu+ and implementing advanced features to facilitate causality analysis and exploratory reasoning.
- ↳ We also plan to conduct more empirical studies to quantify the costs and benefits of VA supports for RE.

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Thank you!

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Questions

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