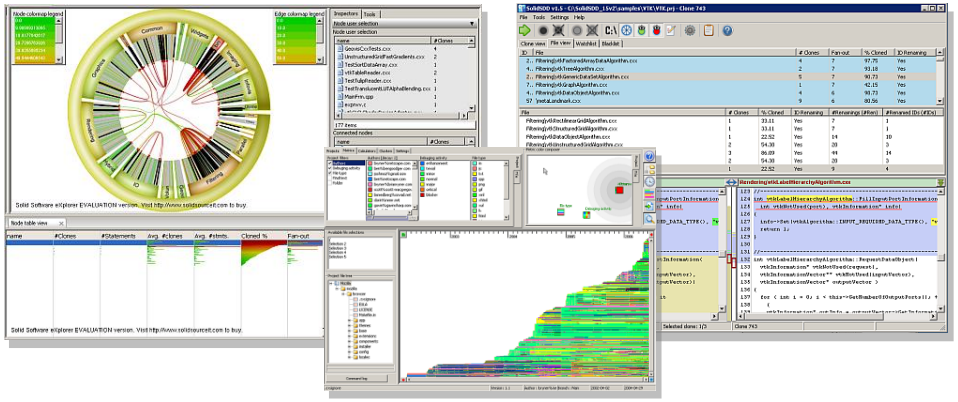
A Visual Analytics Toolset for Program Structure, Metrics, and Evolution Comprehension



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Software Visual Analytics

- integrates data mining, analysis, and interactive visualization for sense-making from large software systems

- data: structure, dependencies, metric, behavior, evolution
- tools: static analysis, fact extraction, repository mining
  graph, table, matrix, timeline visualizations
- tasks: sensemaking by iterative hypothesis creation, refinement, (in)validation

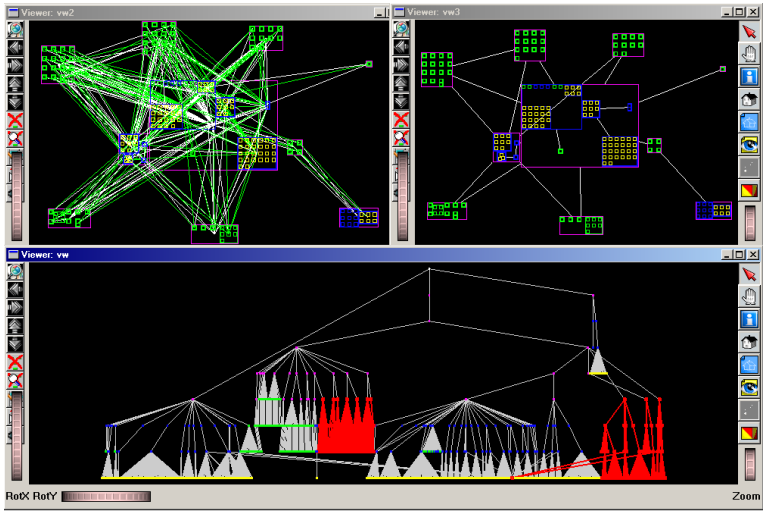
Visual analytics

✓ proven added value in many contexts (including software)

✗ hard to develop efficient and effective tools

- wide range of technologies
- scalability, usability, robustness, integration issues
- visualization is still not widely accepted in software engineering

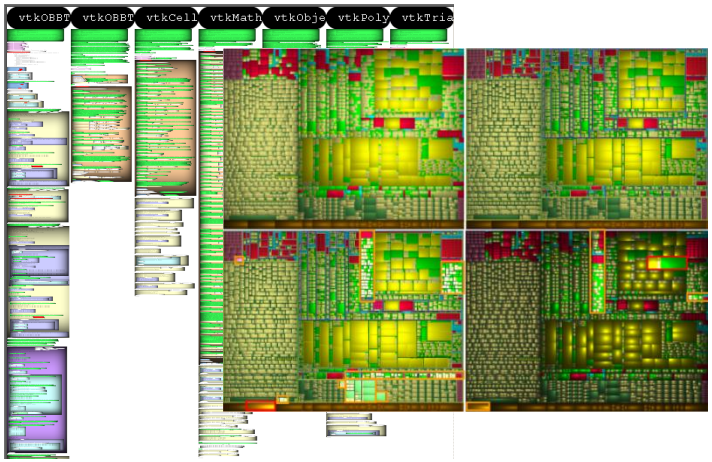
Visual Analytics Tooling



2002 SoftVision

SoftVision
- software architectures
- node-link 2D/3D layouts

Visual Analytics Tooling

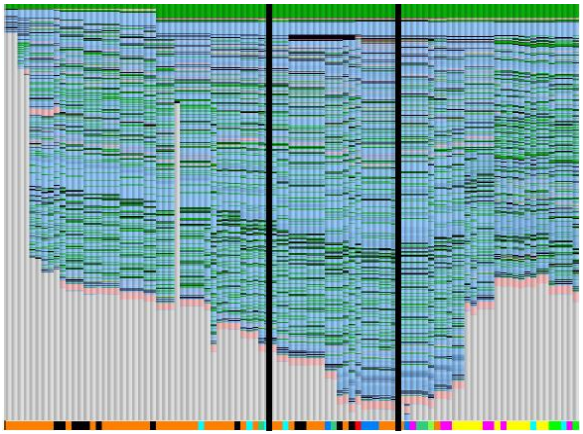


2004 VCN

VCN (Visual Code Navigator)

- code syntax structure
- dense pixel layouts
- gcc-based static analysis

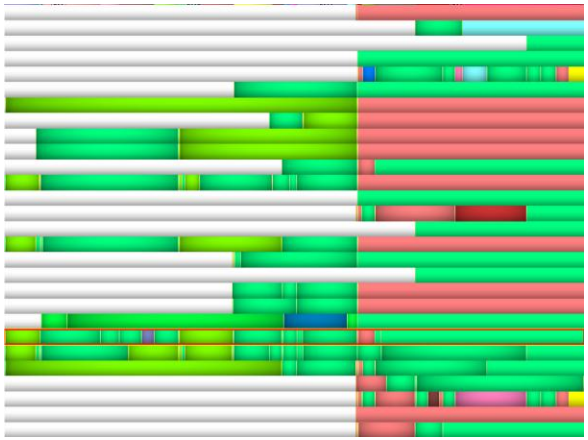
Visual Analytics Tooling



2005 CVSscan

CVSscan
- line-level code evolution
- dense pixel layouts
- CVS repositories

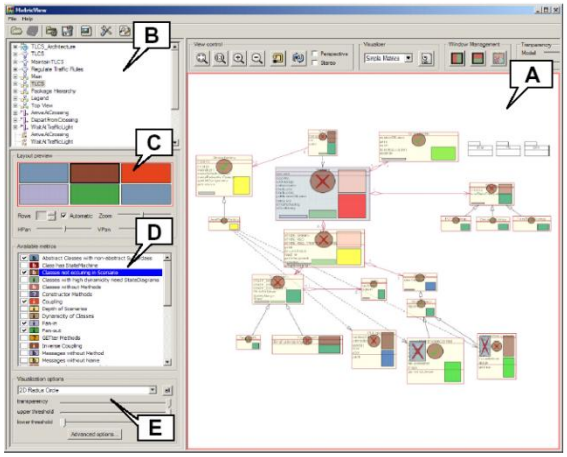
Visual Analytics Tooling



2006 CVSgrab

CVSgrab
- file-level code evolution
- dense pixel layouts
- CVS, SVN repositories

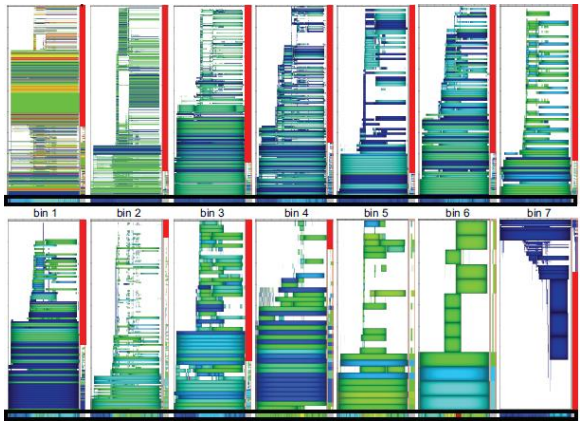
Visual Analytics Tooling



2006 MetricView

MetricView
- architectures and metrics
- UML layouts and glyphs
- XMI diagrams

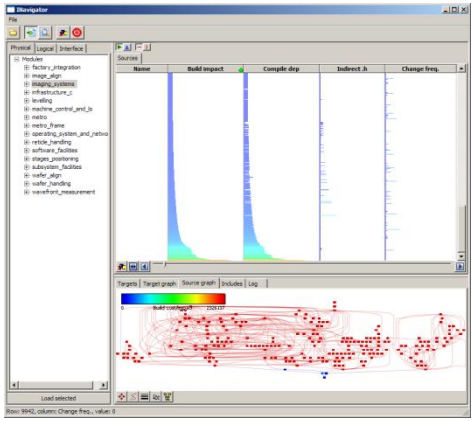
Visual Analytics Tooling



2007 MemoView

MemoView
- dynamic memory allocations
- dense pixel layouts
- third-party traces/logs

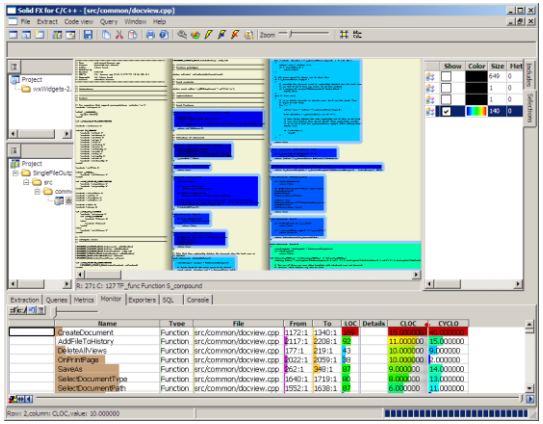
Visual Analytics Tooling



2007 SolidBA

SolidBA
- build dependencies
- table lenses, graphs
- C/C++ lightweight static analysis

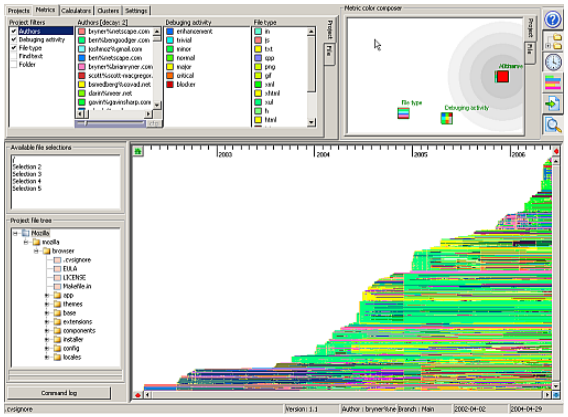
Visual Analytics Tooling



SolidFX
- code structure, metrics, dependencies
- dense pixel layouts, table lenses, UML diagrams
- C/C++ heavyweight static analysis

2008 SolidFX

Visual Analytics Tooling

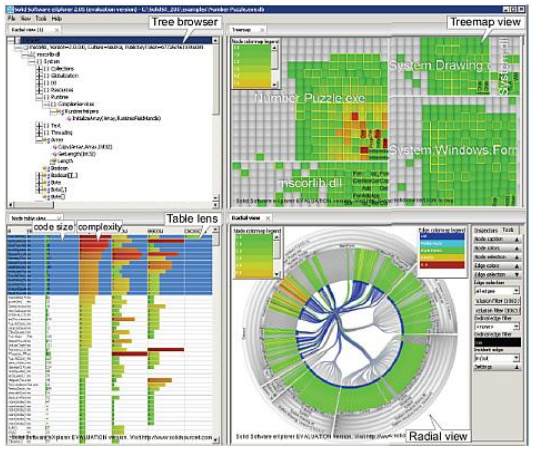


SolidSTA (Software Trend Analyzer)

- code evolution (line, file, project level)
- dense pixel layouts, table lenses, timelines
- CVS, SVN, Git, CM/Synergy repositories
- metric plug-ins

2008 SolidSTA

Visual Analytics Tooling

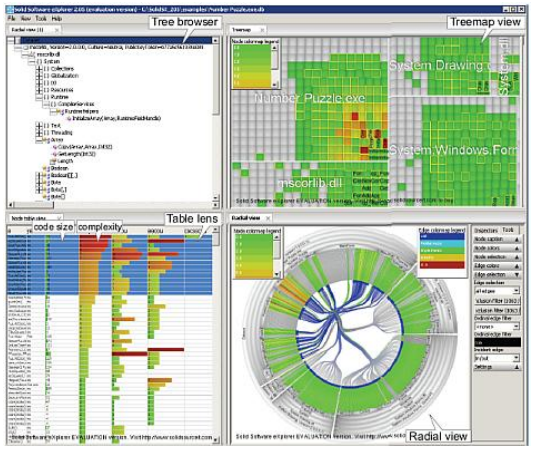


SolidSX (Software Explorer)

- code structure, dependencies, metrics
- bundled layouts, treemaps, table lenses
- C/C++, Java, .NET built-in analyzers
- Visual Studio integration

2009 SolidSX

Visual Analytics Tooling



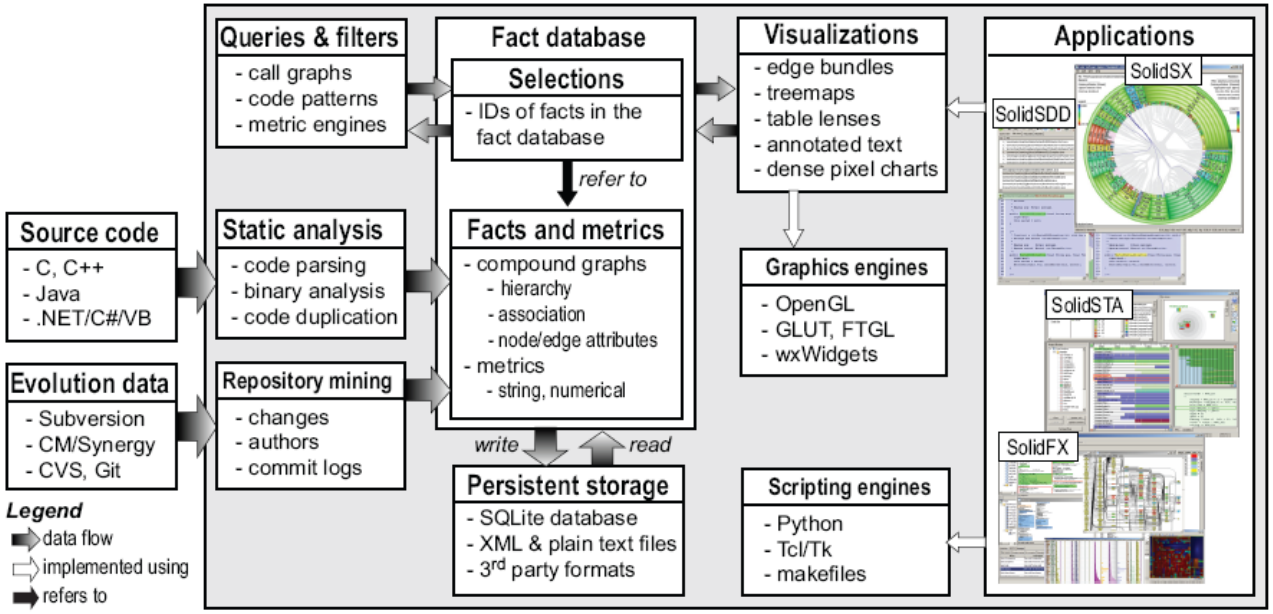
SolidSDD (Software Duplication Detector)

- code clones
- C/C++, Java, C#
- integrated visualization

2010 SolidDD

Common Design

- multiple 'fact databases'
  - custom format: ASTs
  - SQLite: anything else (metrics, call graphs, evolution data, ...)
- selections:
  - sets of ID's in the fact databases
  - inputs and outputs for all operations
- operations:
  - connected in a dataflow model via selections



Common Visualizations

- small set of choice

annotated text

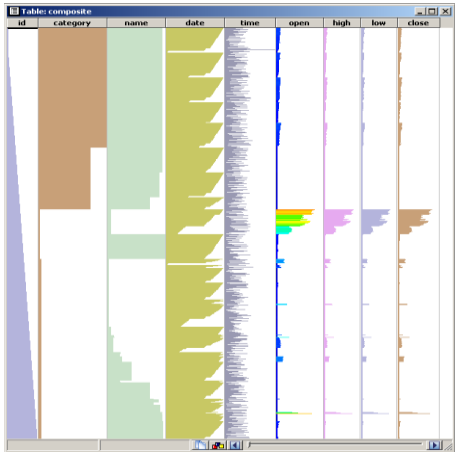
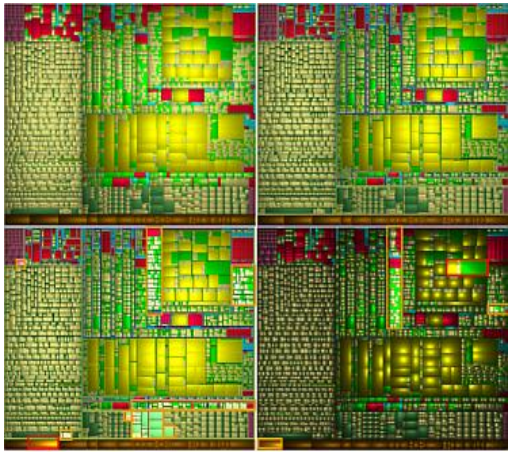
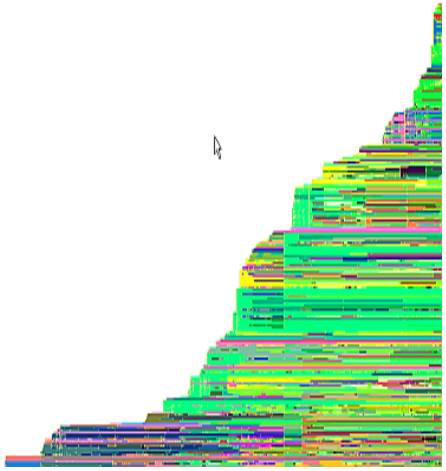


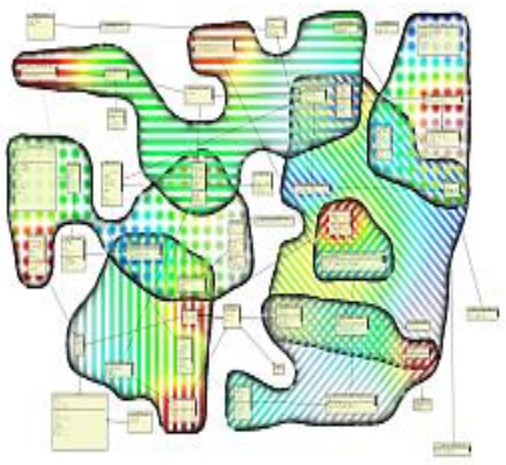
table lens



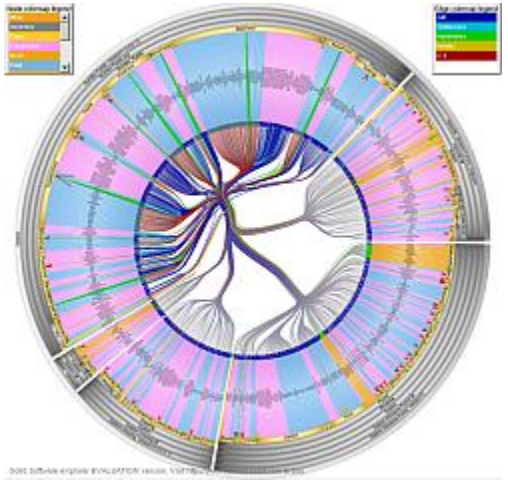
treemaps



timelines



UML diagrams



bundled layouts

Demonstration

SolidSX

- visual exploration of software structure, dependencies, metrics
- integrated static analyzers for C/C++, .NET/C#, Java
- open SQL/XML data formats
- pluggable metric engines
- Visual Studio integration

SolidSDD

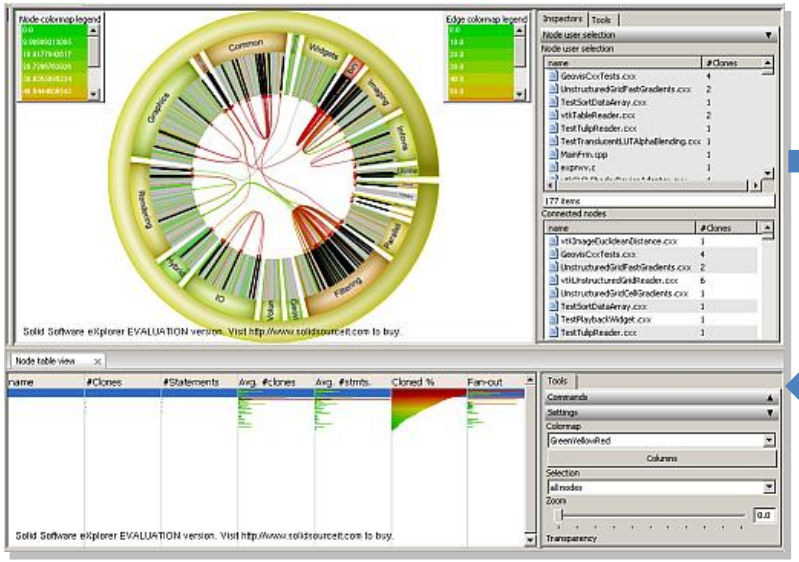
- visual exploration of code duplication (clones)
- integrated clone detector for C/C++, C#, Java
- open SQL data formats
- integrated with SolidSX

Demo

- VTK code base (3500 C/C++ files, 2.5 MLOC)
- clone detection: 5 minutes

Demonstration

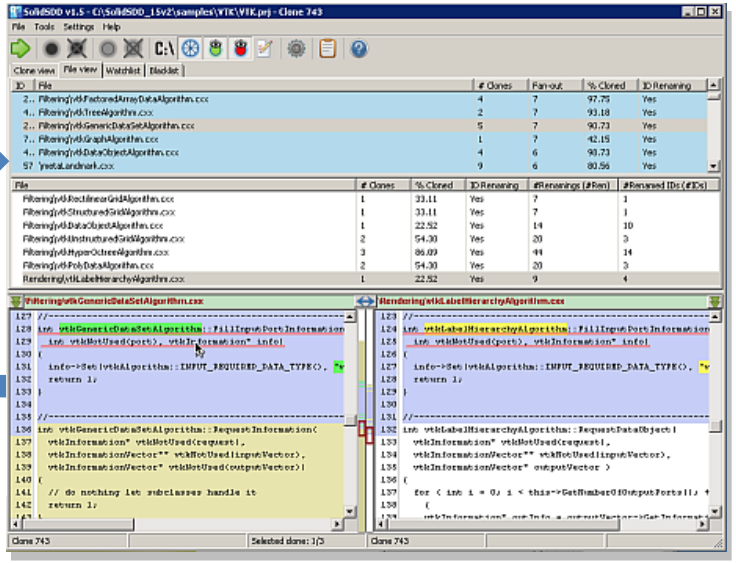
SolidSX visualization tool



selected code

clone database

SolidSDD clone extractor



data: SQLite
events: sockets

Implementation

Efficiency

- required to handle code bases of MLOC-size
- all core visualization/analyses implemented in C/C++ with OpenGL 1.1

Uniformity

- single GUI toolkit / look-and-feel: wxWidgets (Qt: equally good alternative)

Flexibility

- scripting layer: Python (smooth integration with C/C++)

Genericity

- use simple attribute-entity-relationship (AER) data model – wherever possible
- persistent storage and queries: SQLite – wherever possible
- XML: thanks but no thanks (does not scale for MLOC-size AER graphs!)

Toolchain integration

- data: shared on-disk SQLite databases
- events: socket-based communication
- very flexible: integrate with no programming (!)

Discussion

1. Should academic tools be of commercial quality?

- tool = carrier for testing new method? Polished implementation = waste
- tool = proof-point for a method's effectiveness? Good implementation = vital!

2. How to integrate and combine independently developed tools?

- several levels
  - dataflow: read/write databases in common formats (SQL, XMI, FAMIX, ...)
  - shared database: single format (Eclipse CDT, Intellisense)
  - common APIs: best but hardest (Mondrian, CodeCrawler, SolidSX)

3. What are lessons learned and pitfalls building tools?

- 2D vs 3D: software engineers do *not* (yet) accept 3D visualizations!
- interaction: minimalist design = best (hide rest under advanced options)
- scalability: vital for acceptance; dense pixel visualizations are best
- integration: **most crucial acceptance factor**

4. Are there any useful tool building patterns for tools?

- architecture: dataflow + shared database = most useful composition pattern
- visualizations: dense-pixel layouts are **best** since **scalable**
- heavyweight-vs-lightweight analysis:
  - both are useful and arguably required
  - simple database model favors their integration

5. What are effective techniques to improve the quality of academic tools?

- **usability** is the single most important factor to optimize
- problem: ‘value model‘ for academic work does not match the one of end-users!

6. How to compare/benchmark tools?

- lab studies: good for **technically** testing a new visualization/interaction method
- class studies: **biased**, as indicated by literature (see paper references)
- field studies: best, but **hardest**; extra effort often not compensated in academic model!
- ‘insight‘ is hard to quantify – the value is in the eyes of the beholder
- side-by-side tool comparisons: **good compromise**

7. What languages are best suited for building tools?

- core: C/C++ for absolute performance
- database: SQLite (fast, small, simple, portable)
- graphics: OpenGL 1.1 only
- scripting: Python (Tcl/Tk or Smalltalk possible, but harder)

Conclusions

Visual software analytics

- **effective:** added-value in solving real problems
- **hard:** lots of implementation/optimization effort
- **challenging:** the only way forward for software visualization (we believe)

See it yourself

www.cs.rug.nl/SoftVis: Free academic software visual analytics tools!
www.solidsourceit.com: Free-trial commercial-grade visual analytics tools!

Thank you!