

# Information visualization of software source code evolution to manage technical debt

Axel Ekwall

axelekw@kth.se

KTH Royal Institute of Technology  
Stockholm, Sweden

## ABSTRACT

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## KEYWORDS

information visualization, technical debt, software evolution

## 1 INTRODUCTION

In recent years society has undergone a digital transformation and our everyday life depends on digital technology more than ever before. This development relies on an ever-growing collection of software systems and services that span our society and connect our lives. With the increasing size and scope of these software projects, and the growing numbers of software developers working in the same project simultaneously, development planning and collaboration becomes harder. //SOURCE A common method to handle these challenges is for software development teams to work according to an agile methodology [7] where requirements and solutions in a project are evolving over time in collaboration between developers, project managers and users. This

process is conducted in an iterative cycle with continuous reflections and improvements on previous work.

In order to handle these iterative and fast paced change to the source code in a project, development teams are using version control systems to keep track of changes. This allows developers to work on different versions of the software in parallel and *commit* their changes to the project in batches when new features are completed or bugs are fixed. All these small incremental changes are recorded and make up a rich source of information into the evolution of the code. However, this information is cumbersome to grasp and oversee and therefore often not used in an effective way, partly because it is not aggregated and presented as relevant metrics, but also because it is hidden from non-technical stakeholders who might not be able to retrieve the information from the VCS system. //SOURCE This makes it hard for stakeholders to get an overview of how the project in general, and more specifically the source code, evolves over time. In this context, where rapid continuous decision making and reflection is important, insights into the evolution of the source code and a shared understanding of the current state of the code can be valuable. [1]

## Information visualization

One method to gain knowledge from a large set of complex information is to visualize it, or in other words, form a mental model of the information in order to understand it better. [10] This practice has been conducted since long before modern technology was available to help and it is thus not necessarily required to use technology to aid in this process. [6] However, the trend in recent years of collecting increasingly larger amounts of data creates new challenges in visualization and manual processing of data might not be an option. In this scenario, the capability of modern technology is a useful tool to help process, filter and map large data sets to visual representations in order to help the user to understand the data and form a mental model of the information. [2] Digital visualization tools can also enable rich interaction and allow a user to explore the data step by step rather than getting overwhelmed by too much information at once. //SOURCE

## Technical debt

When exploring source code evolution, and problems that commonly occur in long term software projects, a useful concept to utilize is *technical debt*. First described by Cunningham in 1992 [5], technical debt (TB) is a metaphor to financial debt and describes the common situation with increased development costs over time in software projects caused by poor software engineering practices. [12] In some cases, taking on TB can be a strategic short term decision in order to reach a critical deadline in time. However, if not properly managed the debt can be costly by decreasing development velocity and increasing maintenance costs. [9]

## Research question

The goal of this paper is to design a visualization tool to explore the source code evolution in a software project in order to provide an overview and understanding of technical debt and how it is changing over time with the evolution of the software and source code.

In doing that, his thesis aims to investigate whether information visualization can be used to empower software development teams to make better informed decisions about software architecture and source code maintenance in order to manage technical debt. Based on this goal, a prototype of such an information visualization tool will be created to answer the following research question.

**Does a visualization of the evolution of software source code help software development teams manage technical debt by informing decision regarding maintenance and refactoring?**

In order to answer the research question, the prototype will be evaluated with the following sub-questions:

- Does the prototype present enough information for developers to make decisions about whether to refactor and/or break up specific parts of the source code in order to pay off technical debt?
- Does the prototype present the information required in order to identify technical debt by highlighting “hotspots patterns” [8] in the source code?

## Delimitations

The main objective of this study is to evaluate a design concept, not developing a fully functioning visualization tool. Only the features and interactions necessary to properly evaluate the concept and generate design guidelines will be implemented in the prototype. Further, the visualizations included in the design concept will be based on the data available from commits to a git repository with source code. In order to keep the scope focused, the source code itself will not be analyzed in this project, even though this would be an interesting topic for a complementary study.

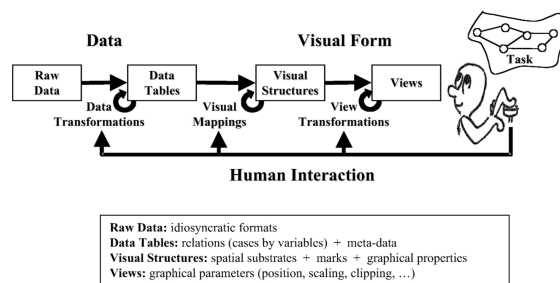


Figure 1: Reference model for visualization by Card et al. 1999. [3]

## 2 RELATED RESEARCH

The core of information visualizations are the mapping of data and intent to visual representations. Although there are many different techniques used in the field, this central process of visualizations can be described by the *Reference model for visualization* by Card et al. presented in figure 1. [3] This common reference model is helpful in order to analyze and compare the different techniques as seen in the taxonomy proposed by Chi based on model by Card et al. [4]

The raw data can take many forms which can be classified into three main categories based on its properties, *nominal data* is simple data with some sort of label but no quantitative value, *ordinal data* can be ranked according to some attribute and *quantitative data* which support arithmetic operations. [2]

Previous research has been published investigating software evolution through different visualization techniques.

Bayer and Hassan developed “Evolution Storyboards”, examples include code-swarm, CVSscan and Software evolution storylines. However, during the last decade tools and workflows used by software development teams have evolved and more information is recorded with every change, allowing for rich analyses of the history and evolution of software source code.

The previous work mentioned contributed with valuable knowledge and in doing that also created new questions to be answered. In comparison to CVSscan which focuses on single files, this thesis will investigate a whole repository of source code to give a better overview and richer understanding about how the whole projects evolves. code-swarm and Software evolution storylines presented intuitive visual mappings for data points but targeted casual users and did not allow for interaction and deeper exploration of the data. In contrast, this study targets advanced users with domain knowledge and information about the context of the software project, allowing for a more advanced interactive visualization tool that presents complex information.

### 3 METHOD

In order to investigate the research question, a methodology informed by Stoltermans Concept-Driven Design Research was used. [11] Two design iterations was conducted in 6 steps listed below over a period of 10 weeks.

#### First iteration:

- (1) Generate concept.
- (2) Explore design space and generate low-fi sketches.
- (3) First critique session, focus group.

#### Second iteration:

- (1) Develop design artefact, an interactive prototype of the concept.
- (2) Second critique session, user study with prepared tasks and interview.
- (3) Concept contextualization and design refinement.

The critique sessions was conducted with participants from the target group; developers, designers and project managers at Mentimeter AB. The critique session during the first iteration will be a focus group workshop where the participants will be presented with the concept idea and low-fi prototypes and sketches created during the first two steps. This session will be structured like group interview and workshop where the goal is to get early feedback on the overall concept design and help in choosing a direction for the second integration.

Based on the gathered feedback in the first critique session, an interactive high-fi prototype was developed as a second iteration on the concept idea and design. When the defined concept and features were implemented in the prototype, a second critique session was conducted. This session aimed to gather more specific critique and was structured as task-based user tests in a one-on-one setting where participants were asked to complete a set of tasks with the interactive prototype, followed by a semi-structured interview.

The data collected during the user tests includes both qualitative data gathered during the interviews and quantitative data from screen recordings in the form of time measurements from tasks and quantitative results from structured parts of the interview.

### 4 RESULTS

### 5 DISCUSSION

### 6 CONCLUSION

### ACKNOWLEDGMENTS

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