

SketchViz: A Sketching Interface for Domain Comprehension Tasks Illustrated by an Industrial Network Use Case

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ABSTRACT

In this paper a sketch-based prototype for dynamic domain comprehension tasks is presented. It enables knowledge workers to dynamically build up contact based knowledge landscapes and expert management using lightweight pen and paper-like interactions. The proposed prototype is operated on a tablet PC and recognizes objects, text and relations as digital entities for structured editing. The system utilizes sketch based template matching to recognize basic user created items. A flexible data model is used to translate the users' interactions into an ordered composite structure.

Categories and Subject Descriptors

H.5.2. [Information Interfaces and Presentation]: User Interfaces – Graphical User Interfaces (GUI)

General Terms

Documentation, Human Factors, Management

Keywords

Visual Sensemaking, Knowledge Construction, Knowledge Representation, Sketching Interface, Topic Comprehension, Expert Management, Topic Networks, Expert Networks

1. INTRODUCTION

Pen and Paper enable fast and lightweight freehand drawing, which is especially useful in the early stages of knowledge work [1]. Yet, pen and paper face limitations as they do not allow for modifications according to the dynamic processes of reflection, rearrangement of information items and their structure as well as being decoupled from the digital world.

A first attempt to use freehand drawings as input for computational devices was Sketchpad [5]. The initial shortcomings in efficiency have been overcome especially

for graphic manipulation tools used by artists and designers.

The proposed approach uses easy and lightweight creation and manipulation of graphical entities which are sketches of task related knowledge. Treating information like designers treat graphical objects, new and easy to use sketching applications can be built. Via a straight forward approach using paper like affordances and visualization we try to lower the cost of basic operations often being overlooked in current sensemaking systems [2].

This paper first gives an overview about related research. Subsequently, a sketch-based system for domain comprehension tasks is proposed.

2. RELATED WORK

Creating a knowledge sketching application, the challenge is to build a concept for combining humans and computers in the best way to complement one another. Frieder Nake summarized the characteristics of each in the sentence: "Humans Create, Occasionally. Computers Operate, Always. [4]". Ivan Sutherland stated that structure is all important to know for the user to be able to work with such an application. He designed one of the first approaches to implement communication between humans and computers based on graphics named Sketchpad [5]. The experimental assembly enabled the usage of a pen as input device on a screen (see Figure 1).

Ivan Sutherland said about Sketchpad: „The Sketchpad system makes it possible for a man and a computer to converse rapidly through the medium of line drawings. Heretofore, most interaction between man and computer has been slowed down by the need to reduce all communication to written statements that can be typed; in the past, we have been writing letters to rather than conferring with our computers. For many types of communication, such as describing the shape of a mechanical part or the connections of an electrical circuit, typed statements can prove cumbersome. The Sketchpad system, by eliminating typed statements (except for legends) in favor of line drawings, opens up a new area of man-machine communication. [5, page 329]”

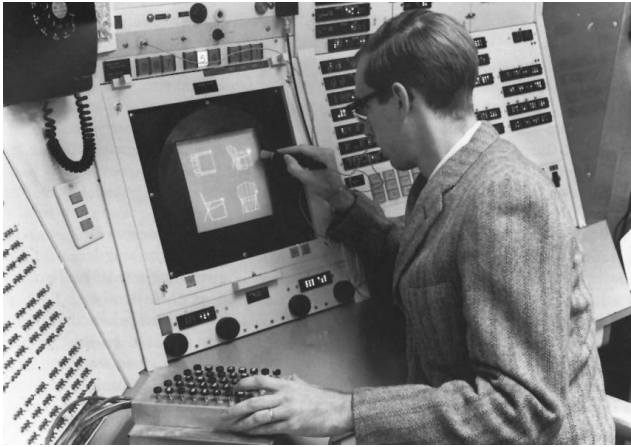


Figure 1: Sketchpad, 1963 [5]

Following this, Moran et al. introduced the notion *freeform interaction* [3], meaning the unconstrained interaction enabled through a freeform representation. “Scribbling is a prime example of freeform interaction: In scribbling, strokes can be created (drawn) anywhere without affecting existing strokes. Any strokes can be changed or erased without affecting any other strokes.” The Authors presented a scheme based on a digital whiteboard system perceiving the “implicit structure” that humans see in the drawn material. Another approach for enhancing a digital whiteboard with gesture input and direct manipulation is Symbik [6]. This tool enables mass data operations through graphical objects on a zoomable interface landscape.

Furthermore, sketching seems to be an appropriate technique for making sense of new information. Furnas and Russel [2] define sensemaking as kinds of tasks involving a process of collecting and organizing data in order to create sense. Thereby knowledge workers often use a fairly simple structure to solve a given problem. The authors state: “the process is sometimes ill-defined, iterative and complex: information retrieval, organization and task re-definition all interact in sometimes subtle ways.”

3. THE SKETCHVIZ SYSTEM

A cost analysis on sensemaking activities showed that paper setting outperforms current sensemaking systems by allowing two-hand lightweight operations, while computer systems have the advantage of more computational power [2]. Digitalization of pen and paper interaction enables new dimensions for sensemaking, including organizational concepts and expert management. A sketch based interface concept implemented on a multi-touch tablet is proposed. By reducing the necessary steps of interaction required for certain tasks, the costs are lowered and an operational feel similar to pen and paper is accomplished.

3.1 Use Case

Although our proposed approach is not limited to certain areas, we address a focused use case to illustrate the basic principles. Building up contact networks and assigning

expertise, responsibilities, areas of engagement, and the like to these contacts is part of daily work in many areas. While today the creation and maintenance of such knowledge landscapes is not only cumbersome but also decoupled between devices as well as the real world, our use case addresses a dynamic and fluid approach. For instance, a consultant for production set-ups needs knowledge on machines throughout their various life-cycles. This includes construction, implementation, operation, service, and decommissioning as well as the associated experts in these areas which, of course, may change over time. SketchViz easily enables the creation as well as the modification of context and relations reflecting the continuous change in enterprise environments. It is further based on mobile devices to adhere to changing work environments.

The process of relation and context building, i.e. sensemaking, constitutes three essential stages [2]:

- learning concepts/facts
- finding relationships
- forming categories and high-level connections

The dynamic and fluid editing of entities furthermore provides insight into and validation of contexts and relations.

3.2 Design Decisions

This subsection describes how the three stages of the process of sensemaking are supported by the SketchViz system. In general every created item on the canvas is treated like a set. The outline of such a set can be used for manipulating the group.

Learning Concepts/Facts

In our use case the consultant learns about facts such as expertise, responsibilities or areas of engagement from fellow workers. SketchViz allows for capturing or creating these new facts with pen or finger (see Figure 2).

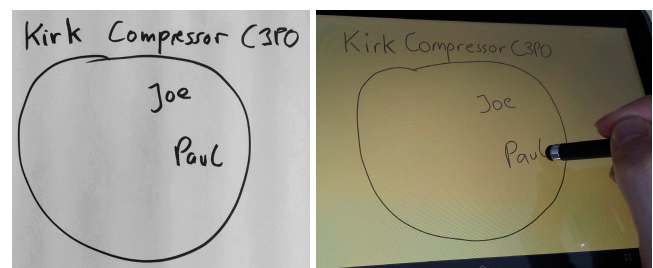


Figure 2: A context is created containing 2 items. Left: using paper setting, right: using SketchViz

Visual items such as freeform shapes, circles, rectangles, triangles, and text can be created. They are not only graphic representations but may also be associated with meaning. For instance, drawing a circle around entities creates a semantic representation of a group.

With respect to the use case the consultant would create an unstructured collection of first contacts related to the machine “Kirk Compressor C350”.

Finding Relationships

Items can be connected via lines or moved close to each other to visualize the strength of their relation. Further they can be scaled and moved into other items using two fingers (see Figure 5) which enables the creation of new relations, reflecting and validating the strength of their connection or hierarchical structure.

Forming categories and high-level connections

By creating outlines around items or moving items into existing ones (see Figure 3) categories or high-level connections can be formed. Once an outline is drawn, a particular category can be assigned to the visual group by selecting a respective icon (Figure 4, left). Predefined icons are T for *topic*, N for *adding a new kind of category* and O for *organization*.



Figure 3: Groups can be formed by drawing a shape around items. Left: The result using paper setting, right: using the SketchViz system

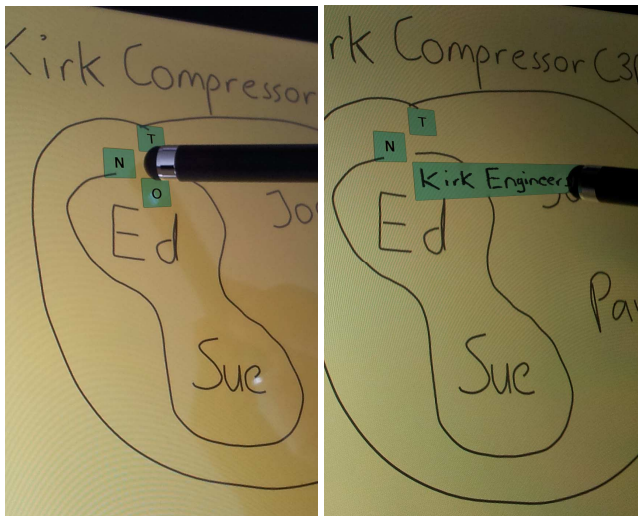


Figure 4: After drawing a shape a particular category can be assigned to the group. Left: Selecting the category, right: writing the respective label

The example of Figure 4 shows the selection of the type “organization” and the creation of the label “Kirk Engineers”. The resulting item is shown in Figure 5 (left).

Regarding the use case the consultant would further structure the contacts, i.e. Ed and Sue are machine experts from Kirk Industries while Joe and Paul are machine experts from third party companies (supplier, services).

Using this interactive visualization, knowledge workers can perform an individual or collaborative visual dialog to make sense of certain topics and their relations via fluid adaption. The strength of free form pen and paper is combined with the dynamics and the scalability of the digital world.

3.3 Interaction

The most important characteristic of the proposed approach is to enable lightweight operations. Therefore drawing is performed with one finger or pen, moving and scaling objects as well as navigation in the zoomable interface landscape by using two fingers. Furthermore, there is the possibility to select and deselect objects by a double tap for exclusive scaling and moving. Detailed Information can be assigned to items in the workspace. After zooming-in on a respective item (e.g. “Sue” in Figure 5), the label is being automatically replaced by a box with the label as title to perpetuate the context on all levels of detail (see Figure 5, right).

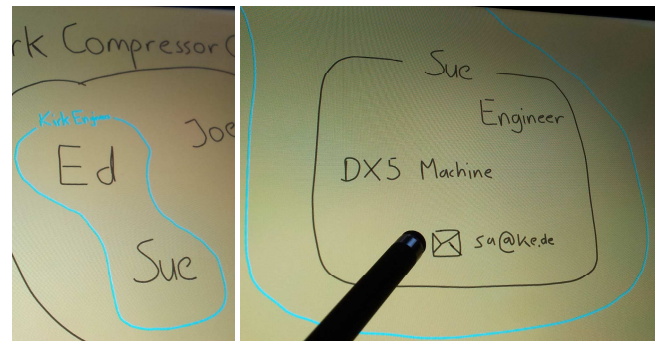


Figure 5: Labeled organization (left) can be zoomed-in to enable editing of detailed information (right)

In our use case the consultant would look up further details of Sue which are stored in the contacts of his mobile device. This enables to access, modify and even create new contacts using the address-book of the mobile device integrated in the SketchViz interface. This provides consistency and re-use of existing data in both ways. For interactions that are likely to be used less often our prototype offers two additional modes:

1) Creating annotations allows for further collection of information in the knowledge landscape. To avoid visual clutter they are only displayed when the annotation-mode is activated.

2) Another mode enables to change metadata of categories, managing their appearance as well as deleting and creating new types of categories. In order to enhance distinction between different modes and awareness about which one is currently activated, each of them appears in different color schemes.

3.4 Data model

Every stroke that has been drawn on the canvas is attached to the composite data structure of the system. There are basically three different data object types a stroke can represent: composites, words, and freeforms. Composites are closed primitives such as circles, rectangles, and triangles that are recognized by the application using the \$1-Recognizer approach [7]. They can encapsulate other closed primitives and any arbitrary user created element. If such a group is selected, every single item in the group is selected as well. Handwritten words are based on a similar model, but the elements they can contain are limited to characters. Finally, freeforms represent arbitrary strokes that do not fit in the aforementioned categories. Furthermore, the data model is immediately updated as soon as its visual representation is manipulated.

4. CONCLUSION

In this paper a system for visual sensemaking based on dynamic relation and context building is proposed supporting the creation and maintenance of knowledge landscapes. The user interface is similar to pen and paper to enable immediate and natural interaction. An illustrative use case of expert management shows the lightweight operations such as drawing and pinching gestures for creating, annotating and manipulating information items and contexts. A powerful and flexible data model allows for capturing the hierarchy and the relations between visual items as well as the integration of existing contacts stored in the address-book of the mobile device.

5. FUTURE WORK

The next step will be an evaluation of the created prototype in a real world scenario. Further information gathering, for example, via a web browser will be enabled. For improving the display of information semantic zooming of objects is considered and a search function shall ease the retrieval of objects.

Furthermore the SketchViz concept relates closely to Linked Data principles regarding object categories and attributes, and thus, a novel user interface for intuitive linking and maintaining contexts is envisioned.

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