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A Classification of Sensemaking Representations

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ABSTRACT

Interest in sensemaking has recently gained prominence in human-computer interaction research. Efforts are being made to better understand sensemaking to help inform the design of appropriate computer-based tools. In this position paper we address the problem of design by presenting a propositional classification of sensemaking situations from a representational perspective. When people engage in sensemaking they organize information into structures which they use as a basis for guiding interpretation and the search for further data. It is these structures that we look at in terms of representations and classify them accordingly. This position paper argues that such a classification can be used as a starting point which would inform the design of sensemaking support tools.

Author Keywords

Sensemaking, classification, design, representation

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Sensemaking has been described in broad terms as the process of finding meaning from information [9]. As such, it is intrinsically linked with information seeking as both an outcome and a driver [5]. How people make sense of information depends on many factors including background, experience, knowledge and task. It is this variation that forms the basis for design challenges. Sensemaking is a process of moving from data to an interpretation (and back again) in a way that helps the person better understand a specific situation. As part of this process people rely on internal and sometimes external representations which they generate and apply to the data. Referred to as frames [4], or schemas [6] these representations are used as aids which guide interaction with the data and influence the ways in which it is understood and accounted for. As integrating devices, these structures have representational relational properties whereby people build, identify and rely on relationships which exist between the various data entities. There may be many different kinds of representation appropriate to different kinds of sensemaking, with implications for how these can be supported by technology. As the research community accrues sensemaking case-studies and tools, we argue that mapping out the scope and variation of sensemaking problems at some appropriate level of abstraction is a significant part of defining a research agenda as well as understanding how particular case-study situations might generalize. So far there has been no systematic attempt to do this.

In this position paper we present initial ideas intended to contribute to a methodology for the design of tools to support interactive sensemaking. We propose a set of generic sensemaking representation types as an appropriate basis for such an endeavor. These are classified into six representational types: spatial, argumentational, faceted, hierarchical, sequential, and networked. Each has an associated set of characteristics which, we argue, can influence the design of the associated sensemaking tools. This is done by presenting examples of tools that support the different representational structures. We discuss the first four in some detail through the exploration of scenarios and tools that support each of these types. Due to space limitations the remainders are discussed in outline. The aim of this position paper is to raise a discussion in relation to the possibility of using sensemaking representational classification as a way of orienting the consideration of variation in the design of supporting tools.

SENSEMAKING: A REPRESENTATION OF THE SITUATION

Sensemaking is an iterative process in which people move between data and an appropriate understanding of a specific situation (Figure 1). Russell et al [6] define sensemaking as the process of searching for a representation and encoding data in that representation in order to answer specific questions. Pirolli and Card [5] reinforce this idea by arguing that sensemaking is not only based on the gathering of data but also on the ability to represent the data into a schema, whether internal or external, which then aids analysis.

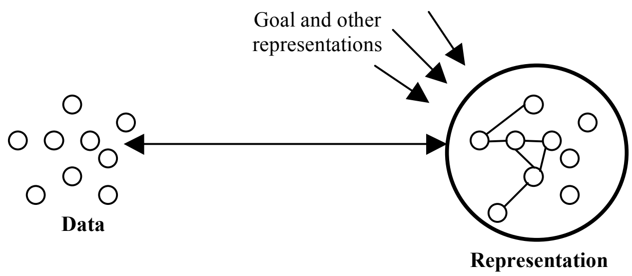

Figure 1. Sensemaking is a process which involves the creation and manipulation of a representation

Similarly, Klein et al's data-frame theory [4] views sensemaking as an iterative process of framing data, with a frame then guiding elaboration which can lead to possible reframing etc. These representations, whether referred to as frames or schemas, can be seen as subjective lenses through which people view, filter and structure data. The type of representation used, however, can be affected by a number of factors, including the data, the goals or tasks, vested interests, and past experiences and knowledge (Figure 1). Depending on the situation at hand, different representations are created and relied on. These are explained next.

REPREENTATION CLASSIFICATIONS

We classify sensemaking representations into six types: spatial, argumentational, faceted, hierarchical, sequential, and networked. For each we give an overview of the properties and associated design constraints.

Spatial

Spatial representations depict objects and their spatial relationships by mapping these to a corresponding representation. In spatial representations elements such as orientation, distance and location are critical components.

Scenario: Planning a Trip

Samantha is planning a trip to South Africa. She has decided to visit Cape Town, Pretoria and Johannesburg. She checks out a travel website and determines that both Cape Town and Pretoria have an international airport. Her task now is to determine a traveling route.

In order to do so she consults a map as she has a vague memory of the layout of South African cities. Based on the map, she sees that Pretoria and Johannesburg are towards the north east whilst Cape Town is more towards the south. She annotates the map with the airport information (Figure 2). From her previous spatial knowledge, she knows that London is far north. By looking at the annotated map she realizes that it will take her longer to travel from London to Cape Town. She decides that she would prefer to make the longer journey on her way to South Africa rather than on her way back to the UK. Therefore, she settles on the following travel route: fly from London to Cape Town and from Cape Town to Johannesburg, drive to Pretoria then back to Johannesburg in order to catch a plane back to London.

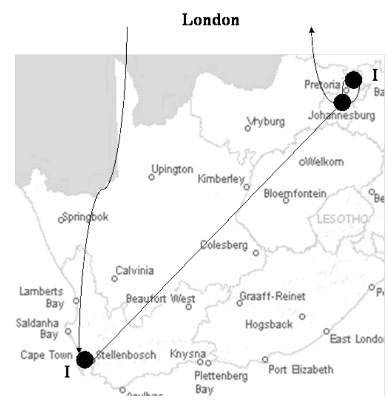

Figure 2. Samantha's trip journey route (saexplorer.co.za)

Design Example – Maps with GPS

A simple design example to demonstrate the spatial representation is the iPhone's Maps application (Figure 3).

Figure 3. iPhone's Maps with GPS (apple.com)

As part of this application users are able to locate themselves in terms of the map's spatial layout, get directions to wherever they want to go and determine areas with high traffic which assists then in planning their journey.

Properties

Two and three dimensional spatial representations are generated in order to make sense of physical layouts. Information such as the relative and absolute locations of different kinds of objects is crucial and so these are generally mapped proportionally within the representation. Spatial representation can also be used to represent a domain metaphorically. For example, our own discussions with a programmer indicate that the way he makes sense of code is by conceptualizing it spatially. What appears to be significant here is that spatial representation offers a means of depicting complex abstract relationships in a simplified way.

Argumentational

Argumentational representations relate multiple propositions or ideas together through argumentation operators in a way that makes inferential relationships explicit.

Scenario: Conducting a literature review

Paul is an HCI researcher. He is reading around the topic of information seeking in order to provide him with ideas for tools and functionalities that might usefully augment digital library systems. He is looking at studies of information behavior in order to gain insights about the things that people naturally do with paper documents in order to trigger ideas about how people might wish to interact with digital documents. Paul notes a study (a) which reports that people use physical piles of paper as a way of informally organizing task related information. This reminds him of a study (b) which reported on the way that paper documents on the desk are sometimes used as reminders for action. He notes that digital libraries don't provide tools that support these kinds of behaviors. Later he reads a paper (c) which describes a spatial hypertext system and how such systems allow users to create informal, visual document arrangements which can persist across sessions. Paul uses these claims to construct an argument which acts as motivation for his new idea of augmenting digital libraries with spatial hypertext functionality. The argument is depicted graphically in Figure 4.

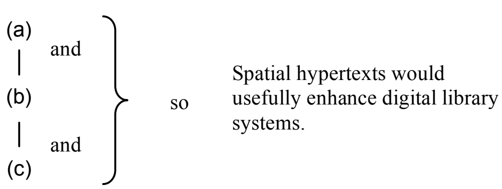

Figure 4. Argumentation representation

Design Example – ClaiMapper

ClaiMapper [8] is an example of an argumentational representation. This application allows users to create concept maps of literature by manually dragging and dropping concepts and building relationships between them. This is done with the aim of creating coherent arguments by sketching out rough structures as informally as required.

Figure 5. ClaiMapper [11]

Properties

Argumentational representations are formed around the integration of a series of claims from which a conclusion is inferred. As a result, the associated tools need to allow users to build dependency connections between different parts of the data, e.g. ClaiMapper [8] (Figure 5), whether these are explicitly expressed by the data or inferred.

Faceted

Faceted representations are representations that show a set of entities within a domain in terms of a set of properties.

Scenario: Choosing a Camera

Claudia and Jeff want to buy a camera. Neither is a professional photographer, and so they want to buy a camera that offers simplicity. They are not really aware of what is available or, beyond simplicity, what they might like. They start browsing online and immediately see that some cameras are more aesthetically appealing than others. This raises their interest and so they add 'good aesthetics' to their list of criteria. Then they see that one of the cameras has an image stabilizer. Previously they didn't know there was such a thing, but it sounds useful, so they add it to their criteria. They identified three cameras that might be of interest as seen in Table 1. By comparing the various cameras to their preferences they decide on camera 3.

Cameras	Simple	Aesthetic Appeal	Image Stabilizer
1	X		
2		X	X
3	X	X	X

Table 1. Comparing the cameras of the generated properties

This scenario involved relating cameras to an evolving set of facets derived from the buyers' changing knowledge of what is available in the camera domain. This is similar to the laptop purchasing case reported by Russell et al [6]. It incorporates the idea of the learning loop complex—that people change the schemas they use to organize data as they discover salient information the current schema fails to accommodate.

Design Example – FilmFinder

The FilmFinder application (Figure 6) is a visualization tool that represents films in terms of (and filtered by) their properties.

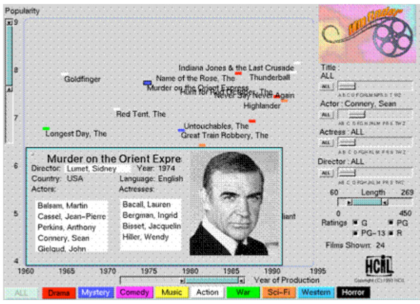

Figure 6. A snapshot of the FilmFinder [1]

In this application films are represented as colored squares, where color encodes genre (e.g. horror, comedy, science fiction, etc). The films are laid out in a scatter plot, in which horizontal position indicates year of production and vertical position indicates popularity. Sliders allow users to filter the database by different properties, e.g. title, actor, etc. The FilmFinder application can be considered as an example that supports the facets representation allowing users to compare objects according to properties that best represent their interests.

Properties

As part of the faceted representation, entities within a domain are shown in terms of a preconceived or generated set of facets. The best possible match will be used to either make a choice or provide an interpretation to a specific situation.

Another example of the faceted representation is used in abductive reasoning (reasoning to the best possible explanation) typical in diagnosis (for example of a system fault or a medical condition). In the medical case, a practitioner recognizes symptoms as facets and hence cues for a possible medical condition. However, a given set of facets may match multiple, competing interpretations. A normative strategy is to look for other symptoms that have discriminating power i.e. facets typical of one diagnosis but not the other. This form of reasoning (and representation) is also apparent in many naturalistic decision making situations such as Klein et al's [4] description of a military analyst forming an explanation for over flight activity around nuclear power plants and weapons facilities shortly after 9/11. The analyst decided that the assumed explanation of surveillance by terrorists didn't fit with Al Qaeda's modus operandi. As a pilot, he knew that student pilots were told that nuclear power stations provide good navigation landmarks. On discovering that the locations in question fell on vectors with airports at each end, the signs indicated a more benign explanation.

Hierarchical

Hierarchical representations model a domain by organizing elements according to asymmetric, one-to-many relations.

Scenario: Categorizing Research Areas

This scenario is based on the first author's experiences. Sarah is working in the area of academic literature visualization and would like to develop a scheme that she can use to structure her literature review. She works with a number of ideas which relate the papers in different ways, but there is no organization that seems to include all the work she wants to include in a neat way that she feels she can structure a narrative around. She considers different facets that seem to distinguish the papers. She realizes that you can describe all of the information visualization tools she has read about as falling into one of two categories: knowledge domain visualizations (KDViz) and Information Retrieval (IR) tools. This strikes her as a candidate for her high level organization. Then, as she looks more closely at the papers that fit into the IR tools' category, she sees that roughly half are concerned with interactivity and half are concerned with usability. She settles on this as her first plan for an organizational scheme (shown in Figure 7).

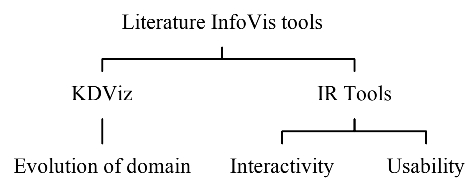

Figure 7. Hierarchical categorization

Design Example – Newsmap

Newsmap (Figure 8) is an application that visually displays the constant changing landscape of GoogleNews. It uses the treemap algorithm [3] where hierarchical data is broken into rectangles, with each rectangle containing its associated hierarchical aggregate. The individual rectangles are color coded to denote some attribute. In Figure 8 colors are used to denote the news category: world, business, sports, etc.

Figure 8. Newsmap [12]

Properties

Hierarchical representations may be represented as trees [7] where each item has a link to a parent item except for the root. The relations used in hierarchical representations are often taxonomic. However, they can also be used to represent non-taxonomic relationships which as *part-whole*, or *parent-child*.

Sequential

Sequential representations depict movement through a series of elements based on a predefined order such as time. Chronologies are a common example of sequential representation, exemplified for example in legal investigation support software such as LexisNexis CaseMap [11], in which elements are events connected within a time-series.

Network

Network structures are relational structures where items may be linked to an arbitrary number of other items in many-to-many relationships [7]. These representations, for example, can support the understanding of complex social structures, e.g. Vizster [2], a visualization that allows for the exploration of online communities.

The scenarios presented here all reflect sensemaking activities, but they are all characteristically different. In the first, Samantha orients her thinking around a spatial layout. In the second, Paul connects ideas in terms of an argument. In the third, Claudia and Jeff make sense of cameras by matching products against properties that they see as valuable and which emerged as part of their explorations. In the fourth, Sarah categorizes papers to provide a structure for her literature review. By classifying these situations based on representational structures we can effectively determine the best visual layout associated with the supporting tool. For example, in the case of Claudia and Jeff the supporting tool must capture and represent the various facets e.g. simplicity, aesthetic appeal, etc, whereas in the case of Sarah the supporting tool needs to assist her in organizing and representing the data hierarchically.

It is important to note that the design examples presented in this paper do not take into account the subjectivity of the experience, except for the ClaiMappr [8] which allows users to add links between the various concepts. We believe that designing for subjectivity is crucial specifically when it comes to sensemaking. However, such a discussion is out of the scope of this paper.

SENSEMAKING: A COMPLEX EXPERIENCE

In the previous discussion we presented two scenarios, argumentational and hierarchical, that address the same sensemaking domain, literature. However, each relying on a different representational structure. In reality sensemaking may make use of several compound representations.

For example, Klein et al [4] describe the way in which an experienced brigadier general was able to identify a number of enemy positions during a desert exercise, where a young sergeant was only able to see a single tank. Knowing that tanks seldom operate alone, the general focussed on likely over watch positions and found further tanks. Seeing the size of the force he then looked for and spotted command and logistics posts. Given the domain in this example, it may be assumed that the only kind of representation in play here is spatial. However, what distinguished the expert from the novice in this case was the capacity to relate an observed property with an abstract representation of a general situation type in which the spatial properties were not necessarily tightly bound. This identification then supported the search for other predicted properties which both confirmed and elaborated the interpretation. Hence the example is also characteristic of the use of a faceted representation.

Another example can be seen in the case study described by Russell et al [6] in which a training course was developed for laser printer technicians. The final course plan might be thought of as a kind of sequential representation. However, as an intermediate step, the need to understand the similarities and differences between various printers is indicative of a faceted representation. Also, included in that case study was the representation of printers in terms of components and sub-systems, which is characteristic of the use of hierarchical representations.

CONCLUSION

This position paper presents early stages of research which has as its goal the development of a design methodology for tools that support interactive sensemaking. In this paper we present a classification of representational types that people create and rely on whilst sensemaking. The scheme has been inductively generated and may not be exhaustive, although we believe that the types that it represents are mutually exclusive. Our motivation is to explore the possibility of using such a categorization as part of a framework for developing a more systematic approach to thinking about the design of sensemaking systems. Additional work needs to be done in order to investigate the generalisability of the categorization, and to address the means of incorporating the compound and subjective nature of such structures into design.

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