

Support Sense-Making with Tools for Structuring a Conceptual Space

1. Introduction

This abstract describes the design of a sense-making tool that assists users to structure their conceptual space and create a task report from the conceptual structure. Sense-making involves the

- recognition of a knowledge gap,
- seeking for information,
- analyzing and synthesizing information to create an understanding, and possibly
- producing a task output: a report, decision, or other type of output.

A typical sense-making task is for an intelligence analyst to gather, analyze, and synthesize information related to some political figure or event, and to make recommendations for action. Everyday sense-making tasks, although less complex, share certain characteristics with the example.

Many people use information systems as sense-making tools. Standard information retrieval systems can support reasonably well the search for pieces of relevant information when the user can identify her information need or knowledge gap to certain extent. However, in order to make sense of the information they found, users need to understand the pieces of interrelated information, identify patterns, and build on their previous knowledge to create an updated understanding.

Most sense-making tasks are characterized by the interplay of searching for information and creating a structured representation of the situation, problem, or domain. In difficult sense-making tasks, sense makers often use external more or less structured representations to store the information for repeated manipulation and visualization (Stefik et al., 1999). Users need sense-making tools that facilitate the creation of such conceptual structures.

Research in the areas of education (especially learning theories), cognitive psychology, and information extraction all bring useful insights into sense-making research. This study aims to integrate findings from these areas and build on that basis to design a sense-making tool that assists users in creating and using external representations for sense-making. Some questions to be explored are:

1. How do users build the concepts and relationships in their conceptual models?
2. How can the tool support the co-existence and transformation of different formats in which users represent their mental models of concepts and relationships?
3. How can automatic or computer-assisted extraction of entities and relationships assist users in building a representation?
4. Does the framework of topical relevance types assist users in making connections between retrieved information and conclusions to be reached and in identifying types of information to search for?

2. Related Research

2.1 Sense-making

Sense-making is characterized as a series of continuing gap-bridging activities (Dervin, 1998; Savolainen, 2006). Through cognitive task analysis, (Pirolli & Card, 2005) proposed a notional model of sense-making, with two loops of activities:

- (1) a foraging loop that involves seeking and extracting information, and
- (2) a sense-making loop that involves iterative development of a conceptualization.

For the information foraging loop, researchers identified the important role of exploratory search and developed systems to support it (Qu & Furnas, 2007). The sense-making loop, on the other hand, including activities such as skimming, examining details, summarizing, organizing, and identifying patterns, is not as well supported. A key task in sense-making is to identify patterns of concepts and relationships to build on. Structured representations play an important role in this task.

Tools have been developed to support sense-making in various ways, mostly to capture intermediate products of sense-making such as insights (Gersh, Lewis, Montemayor, Piatko, & Turner, 2006) and analytical thoughts (Lowrance, Harrison, & Rodriguez, 2001), and to provide a workspace of the intermediate representations. (Hsieh & Shipman, 2002; Wang & Haake, 1997; Wright, Schroh, Proulx, Skaburskis, & Cort, 2006) However, there is less support for connecting intermediate products to the conceptual structure that users develop. This research aims to develop a workspace that supports users' structuring a conceptual space using and consisting of various sources, including search results and intermediate structured representations such as concept maps, templates, and outlines.

2.2 Information Extraction

Automated extraction of concepts and relationships helps users with pieces of useful information from various sources. It may suggest preliminary formal statements for users to examine and filter, saving users the time reading the documents and extracting relationships manually. A flexible sense-making tool should support the co-existence and transformation (Wang & Haake, 1997) of information structures in different degrees of formality. How to organize and integrate extracted results into the emerging conceptual structure of users remains a question to be investigated.

2.3 Task-based Information Seeking and Relevance Research

Sense-making is often embedded in tasks. Task-based information seeking research (Vakkari, 2000; White, 1975) found that different types of information are sought at different task stages, for example, background information are sought at the beginning (e.g. pre-focus) stage of the task. Research in relevance (Huang & Soergel, 2006) reveals different ways in which a piece of information may be useful to a task. This paper aims to build on the finding to investigate how the different relationships between a piece of information and a task may be used in a sense-making tool to help users throughout the different stages of sense-making, especially how to organize

different sources and formats of information based on these relationships in the visual workspace for creating a conceptual structure.

3. Design of a Sense-making Tool

This section describes the design of a sense-making tool to assist users in building their conceptual model of a task situation by organizing their search results, identifying and recording concepts and relationships, and outlining a task report for further use. It is to be integrated with a standard IR system. We envision the following major functions:

1. Searching

- Users can use the regular search box to issue a query or they can initiate a search from the workspace on a particular part of the conceptual structure.
- Users can search for entities and relationships extracted by the system with different levels of manual involvement (shown in Figure 1).

Search	Workspace
Al-Bashir	Type in your query or right click on a concept to start a search
Source text	Extracted Relationships related to Al-Bashir
President of the Republic, Field Marshal Omar Al-Bashir has affirmed that Sudan is considered.. <i>Suna News Agency – July 20, 2006</i>	<is president of> Sudan
... Back in Sudan Al-Bashir led a series of successful assaults on the SPLA in ... <i>BBC news - Oct 1, 2001</i>	<fights against> Sudan People's Liberian Army (SPLA)
President Al-Bashir has lauded the efforts of sister Chad for boosting the security and stability in Darfur states... <i>BBC news - Sep 11, 2003</i>	<is supported by> Chad
Egyptian Prime Minister held talks in Cairo late Sunday ... At the beginning of the Egyptian-Sudanese higher committee meeting ... <i>BBC news - Jul 28, 2002</i>	<met with> Egyptian Prime Minister

Figure 1: Search results in formats of source text and extracted relationships

2. Recording and manipulation of interim representations of concepts and relationships in concept maps, templates, and outlines:

- Users can create, modify, and delete concepts or relationships based on useful search results or previous knowledge, shown in Figure 2.
- Users can attach a piece of evidence found in any text segment and its citation information to the relevant parts of their conceptual model, and specify the relevance type.

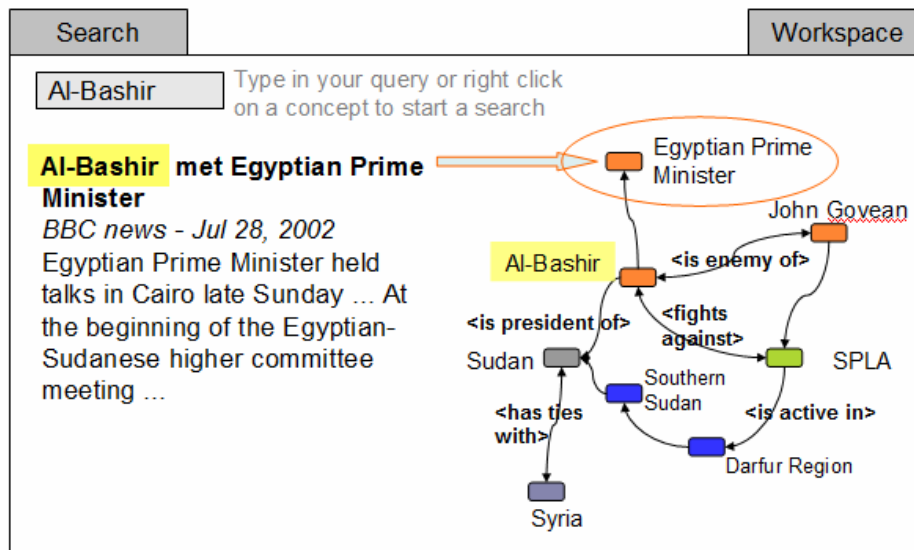


Figure 2: Creating an entity from search results into an existing concept map

3. Supporting co-existence and transformation of structures in different degrees of formality: users can switch between graphic, template-based, and outline displays of concepts and relationships.
4. Organization of search results and creation of task reports: users can annotate useful search results and categorize them by subject or task component and connect them according to the relevance types identified by (Huang & Soergel, 2006). Such categories may be quite useful to users throughout the sense-making. At the beginning stage, background information is needed. When creating a task report, comparison of similar situations and how they were handled may be especially useful. The relevance types may provide guidance in what to search for next (for example, information on similar situations for comparison). The display and organization of search results and of the information in the work space can also differentiate what is direct evidence to an argument and what are inferred by the user based on indirect evidence based on user input from an earlier stage.

4. Iterative Design and Evaluation

The research design involves iterative design and evaluation of the sense-making tool for structuring a concept space. Participants will be 16-20 journalism and political science students. They will work on two assigned tasks and one task of their own. Each task session takes about 90 minutes, 30 minutes for a brief introduction of the tool and a training task, 60 minutes for the main task.

Data collection will involve:

- Two pre-session questionnaires/interviews to learn about user background and background knowledge about the task;
- A post-session Questionnaire for User Interaction Satisfaction (QUIS) (Harper & Norman, 1993) (modified) to learn about how users think about the tool;

- Think-aloud protocols to learn about users' evolving progress of the sense-making process;
- Intermediate representations and final documents produced by the tasks;
- Search and use activity logs automatically recorded by the system.

Results from the user studies will be used to refine and improve the functions of the tool until the delivery of the final system.

5. Conclusions and Implications

Sense-making tools are useful in many settings. They can be used for knowledge management by individuals or the sharing of knowledge in small groups for collective sense-making. Different formats allow differences in representation and may allow users with a range of cognitive styles to share knowledge that is otherwise hard to share.

Helping users retrieve the right information is only half the battle; assisting users with making sense of what they found is the next frontier in information system design. This study will contribute to our understanding of sense-making processes, and thereby give a better foundation for system design.

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