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Using a contextualized sensemaking model for interaction design: A case study of tumor contouring

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ABSTRACT

Sensemaking theories help designers understand the cognitive processes of a user when he/she performs a complicated task. This paper introduces a two-step approach of incorporating sensemaking support within the design of health information systems by: (1) modeling the sensemaking process of physicians while performing a task, and (2) identifying software interaction design requirements that support sensemaking based on this model. The two-step approach is presented based on a case study of the tumor contouring clinical task for radiotherapy planning. In the first step of the approach, a contextualized sensemaking model was developed to describe the sensemaking process based on the goal, the workflow and the context of the task. In the second step, based on a research software prototype, an experiment was conducted where three contouring tasks were performed by eight physicians respectively. Four types of navigation interactions and five types of interaction sequence patterns were identified by analyzing the gathered interaction log data from those twenty-four cases. Further in-depth study on each of the navigation interactions and interaction sequence patterns in relation to the contextualized sensemaking model revealed five main areas for design improvements to increase sensemaking support. Outcomes of the case study indicate that the proposed two-step approach was beneficial for gaining a deeper understanding of the sensemaking process during the task, as well as for identifying design requirements for better sensemaking support.

1. Introduction

Health information systems (HIS) refer to computer based information systems (i.e., software and hardware) used in healthcare settings [1]. HIS were initially developed for patient care and administrative purposes, but are now being gradually extended to different areas of healthcare planning [2]. With the continuously growing amount of digital data, treatment planning relies more and more on software solutions. At the same time, the effectiveness and efficiency of those software solutions depend on whether they can successfully combine the physicians' expertise with the computing power, and whether they fit well into the clinical workflow. Among the ongoing research activities for improving HIS, there is an increased interest in supporting physicians' cognition while they are performing clinical tasks. This indicates the growing role and the importance of cognitive science within HIS design [3]. However, many of current solutions only offer limited support to typical cognitive tasks in the clinical domain, such as decision making and prevention of medical errors [4].

1.1. Background

Sensemaking is the process of creating an understanding of a concept, knowledge, situation, problem or work task, often to inform an action. It is a prerequisite for problem solving and decision making [5] as such: *"better understanding of human sensemaking processes is critical for understanding how information processed through information systems is appropriated by human users and converted into knowledge and resulting action and performance"* [6]. In general, sensemaking can be seen as the

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process of searching for a frame (also referred to as knowledge, a mental model, a representation, or a structure) and encoding data into that frame to answer task specific questions [7]. Throughout a task, one is *"facing gaps, building bridges across those gaps, evaluating outcomes and moving on"* [8]. Furthermore, the interplay between frames and data is bidirectional as *"frames shape and define the relevant data, and data mandate that frames change in non-trivial ways"* [9].

Most sensemaking models consist of loops or cycles, which indicates that sensemaking is generally seen as an *iterative* process. This process usually starts from a *goal*, and takes place through the use of *data*, to build and update the *frames* iteratively until one has reached a satisfactory outcome. Furthermore, *gaps* (i.e., discrepancies between *data* and *frame*, or between *frames*) are typically seen as the triggers behind the sensemaking activities. The driving force for the sensemaking activities is to explain the *gaps*, resulting in updating the *frames* or *data*. As such, in a broad understanding, sensemaking connects the *data* and *frame* through a series of sensemaking activities (i.e., sensemaking loops) to build and update the *frame* according to a specific task goal as illustrated in Fig. 1.

Sensemaking theories have been developed for having a better understanding of the cognitive process mainly in four fields [10]: Human-Computer Interaction [7]; Cognitive Systems Engineering [9,11]; Organizational Communication [12] and Library and Information Science [8]. In the past decade, research activities regarding understanding sensemaking process and applying sensemaking theory in different fields has been increasing. For instance, Russel et al. held two workshops on sensemaking at two consecutive Conference on Human Factors in Computing Systems (CHI 2008 [13] and CHI 2009 [14]). Such an increase of interest can be accredited to multiple factors: the explosion of information in the Web; the increased number of projects in library and information sciences; the needs to help people make sense of the multitude information resources available and in response to the growing interests from various funding agencies in improving homeland security, emergency response, and intelligence analysis [15].

The concept of information foraging, consisting of information seeking, gathering, and consumption [16], is closely associated to sensemaking. For instance, Pirolli and Card [17] developed a notional sensemaking model that described intelligence analysis process. This model consisted of both foraging loops and sensemaking loops. Depending on the sensemaking theory, information seeking can be seen as a part of or strongly coupled to sensemaking. As such, research on information seeking behavior can bring relevant insights for comprehending sensemaking. For instance, Kannampallil et al. [18] observed that the information seeking process was exploratory and iterative, and it was driven by the maximized information gain from information sources. Such a view of information seeking is very similar to sensemaking, which can be seen as an iterative information processing task, during which one attempts to reduce the cost of operations [7].

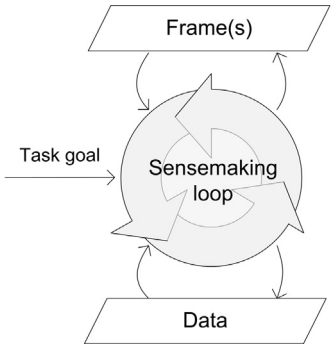

Fig. 1. A generalized sensemaking model. The frame represents a cognitive structure of a concept, knowledge, etc. Data is being iteratively fitted to the frame through the sensemaking until the task goal is achieved to a satisfactory level.

In the research area of applying sensemaking in the healthcare context, Mamykina et al. [19] developed a theoretical sensemaking framework in a study of chronic disease (diabetes) management. Such a sensemaking based framework can be used as a new analytical lens that could enrich the existing scholarship and suggest new directions for research and for the design of technological interventions. Sensemaking approaches can also be beneficial in shaping and framing research about HIS [20]. Besides, collaborative sensemaking had been applied in hospital emergency department setting [21], nursing [22], and online health forums [23]. Other specific areas of collaborative sensemaking that have been investigated are: team collaboration [24,25], handoffs [26], etc.

Although there is a range of sensemaking models available in different domains and contexts, most of them focus on describing and explaining the sensemaking process. Literature review indicates that few studies systematically used sensemaking models to identify requirements for HIS, or more specifically to describe how to support the design of software for HIS from the sensemaking perspective. In many cases, HIS designers have to use their intuition and experience to interpret and apply the theoretical sensemaking in the HIS software design, thus it is difficult to keep a holistic view of sensemaking process of a given task as well as to extract detailed design requirements from sensemaking for each step of the task.

1.2. Research approach

The aim of this paper is to introduce an approach that uses a (contextualized) sensemaking model to support interaction design of HIS software. Using a case study of tumor contouring task for radiotherapy treatment planning, we formulate the proposed approach in two steps (Fig. 2): (1) using sensemaking theory and contextual knowledge to develop a contextualized sensemaking (C-SM) model. This model gives designers a holistic view of sensemaking process as well as a deeper understanding of different moments that sensemaking takes place while the user uses a software solution for a given task; (2) analyzing the software interactions (patterns) using this C-SM model in order to generate detailed insights of the sensemaking process and to identify requirements for the design.

The remainder of this paper is structured as follows: In Section 2, based on observational research studies of the complicated tumor contouring task, the context of this task and the generalized sensemaking model from the literature, we developed the C-SM model. In Section 3, we present a case study where different navigation interactions and interaction sequence patterns were mapped to the developed C-SM model. The sensemaking and design insights obtained by incorporating the C-SM model into the analysis of navigation interactions and interaction sequence

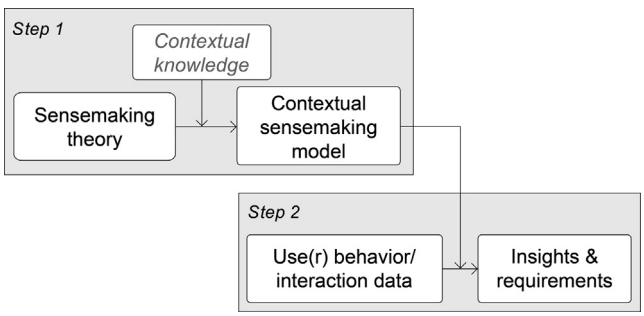

Fig. 2. The proposed two-step approach.