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A Visual Approach to Explainable Clinical Decision Support

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Abstract

Clinical Decision Support Systems (CDSS) provide assistance to physicians in decision making. Based on patient-specific evidence and expert-modeled or machine-learned representations of clinical knowledge, these systems provide recommendations in finding the right diagnosis or optimal therapy. The acceptance of and trust in a CDSS are highly dependent on the transparency of the recommendation generation. Physicians must know both the key influences leading to a specific recommendation as well as any contradictory facts. They must be aware of the certainty of a recommendation and its potential alternatives.
We present a glyph-based, coordinated multiple views approach to explainable computerized clinical decision support, inspired by the common decision-making process in clinical routine. Multiple views (1) show the certainty of the computation result, i.e., the recommendation and a set of clinical scores, stagings etc., (2) provide a visual summary of all evidence and their relevance for the computation result, (3) facilitate a guided investigation of the reasoning behind recommendation generation and convey the effect of updated evidence, i.e., due to recent clinical examination results, and (4) present linked textual information, such as clinical guidelines or therapy details. We demonstrate our approach for a CDSS based on a causal Bayesian network representing therapy of laryngeal cancer. Our approach has been developed in close collaboration with physicians and was evaluated by two expert otolaryngologists.

CCS Concepts

• ***Information systems*** → ***Expert systems;*** • ***Human-centered computing*** → ***Information visualization;***

1. Introduction

A crucial prerequisite for acceptance and adoption of a Clinical Decision Support System (CDSS) is the trust of the physicians in a given recommendation [VMW*19]. To gain trust, this recommendation needs to be explained and justified by providing reasons, line(s) of reasoning, and research evidence [MMC*18].

Visualization can assist in elucidating the reasoning and results behind a decision making process, hence supporting cognition in CDSSs [FZ14]. However, most existing works in the context of Bayesian network (BN)-based decision support focus on visualization of the underlying directed acyclic graphical model, neglecting presentation and explanation of the model's computation result and its reasoning. The need for a sophisticated human-computer interface to present and explain this information has been identified as the grand challenge in clinical decision support [SWO*08,OKS17].

2. Method

Within clinical routine, physicians usually are only provided with patient-specific evidence items, e.g., examination results, and apply their own mental model based on clinical guidelines and personal experience for decision-making. Inspired by this process, our approach is designed as a coordinated multiple views system for investigating the relationships between a recommendation, evidence items, reasoning of a BN, and underlying clinical knowledge. We demonstrate our approach for a CDSS based on a BN representing the therapy of laryngeal cancer (Fig. 1). We create two scoring functions for each patient evidence item on which we then perform relevance computations - one scoring function is used to create a recommendation for assigning a variable state, while the other is used for classifying the evidence item as (1) supportive, (2) contradictory, or (3) recommendation-changer. A glyph-based visualization of all evidence items sorted by their relevance for the computed recommendation was developed. For investigation of the causal relationships steering the reasoning, users are provided with a guided network exploration approach. Additionally, users are assisted with evidence modification facilities, both in the advent of new clinical information and for hypothetical reasoning, with a comparative glyph-based visualization of anterior and posterior results.

3. Results and Conclusions

In an evaluation study, two expert otolaryngologists have assessed our proposed visual framework to be trustworthy and justifiable. They have recommended its usage in clinical routine.

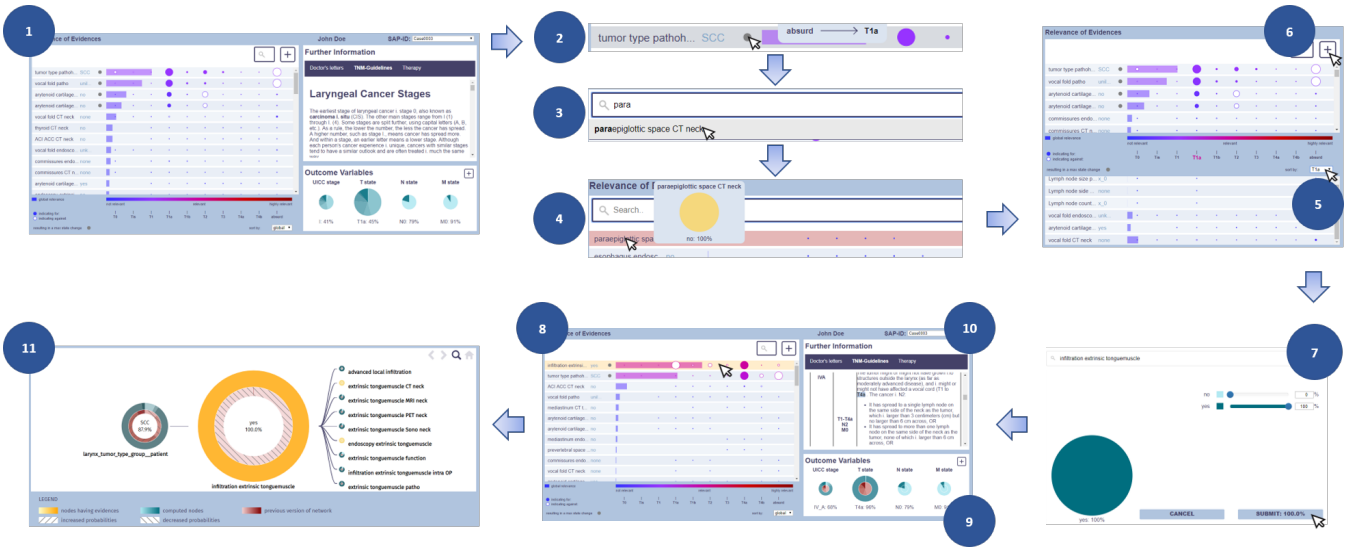

Figure 1: *Workflow of TNM-classification inspired by the decision-making process in clinical routine using our proposed visual approach. Medical domain experts start with an overview of a patient's condition by collecting all patient-specific information (evidence) and investigating predefined outcome variables in the outcome view, as well as key influences of these outcomes in the evidence view (1). Highly important evidence resulting in a recommendation change are highlighted with a gray circle, emphasizing their relevance (2). Since numerous evidence items can be present, a visual auto-complete functionality allows for search of a specific evidence item whose row is then highlighted (3, 4). As physicians must know both the supporting as well as the contradictory evidence for a recommendation, a visual separation of these evidence classes is provided (5). During the investigation process, e.g., in a clinical expert meeting, new evidence items may emerge and can be entered by clicking on the plus icon (6, 7). The related changes are then investigated and justified using the evidence, outcome, and document views (8, 9, 10). Furthermore, additional information regarding the causal relations steering the reasoning of the underlying BN can be inspected in a guided visual exploration of the network (11).*

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