Developing Digital Support for Learning and Diagnostic Reasoning in Clinical Practice

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Dissertation

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Abstract
The two main purposes of clinical decision-support systems (CDSSs) are to provide healthcare professionals decision-making support based on evidence-based medical knowledge, and a continuing medical education. This thesis focuses on both purposes and shows how fundamental theory in the field of artificial intelligence can be developed, adapted and implemented in a CDSS for supporting learning and diagnostic reasoning in clinical practice. The main research problems addressed in this thesis are how to represent and manage uncertain, incomplete, inconsistent and distributed knowledge in automated reasoning and decision-making with the clinicians in the loop, how to facilitate the knowledge engineering and maintenance process, and how to detect and support learning and skill development in CDSS users.

Research contributions include theories, methods, and algorithms based on possibilistic logic and formal argumentation for representing and managing uncertain, incomplete, inconsistent and distributed medical knowledge, and for supporting reasoning and decision-making when using a CDSS. The clinician is provided potentially conflicting arguments and their strength based on different diagnostic criteria and the available patient information in order to make an informed decision. The theoretical results were implemented in the Dementia Diagnosis and Management Support System - Web version (DMSS-W), in a multi-agent hypothesis-driven inquiry dialogue system, and in an inference engine serving as a module of ACKTUS.

CDSS maintenance is challenging since new knowledge about diseases and treatments are continuously developed. Typically, knowledge and software engineers are needed to bridge medical experts and CDSSs, leading to time-consuming system development. ACKTUS (Activity-Centered Knowledge and Interaction Tailored to Users) was, as part of this research, further developed as a generic web-based platform for knowledge management and end-user development of CDSSs. It includes the inference engine and a content management system that the medical expert can use to manage knowledge, design and evaluate CDSSs. A graphical user interface generator synchronizes the interface to the ontology serving as the knowledge base. ACKTUS was used for developing DMSS-W, and facilitated the system development and maintenance.

To offer person-tailored support for the clinician’s learning, reasoning and decision-making, the CDSS design was based on theories of how novices and experts reason and make decisions. Pilot case studies involving physicians with different levels of expertise who applied DMSS-W in patient cases were conducted in clinical practice to explore methods for detecting skill levels and whether learning is taking place. The results indicated that the skill levels can be detected using the method. The novice was seen to develop reasoning strategies similar to an expert's, indicating that learning was taking place. In future work, tailored educational support will be developed, and evaluated using the methods.

Keywords
Clinical decision-support systems, knowledge representation, possibilistic logic, multi-agent systems, formal argumentation, ontology, automated decision making, inquiry dialogue, end-user development, continuing medical education, dementia