Chapter 2.15
Designing Clinical Decision Support Systems in Health Care:
A Systemic View

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ABSTRACT

Clinical decision support systems have historically focused on formal clinical reasoning. Most of the systems are rule-based and very few have become fully functional prototypes or commercially viable systems that can be deployed in real situations. The attempts to build large-scale systems without examining the intrinsic systemic nature of the clinical process have resulted in limited operational success and acceptance. The clinical function, another area of medical activity, has emerged rapidly offering potential for clinical decision support systems. This article discusses the systemic differences between clinical reasoning and clinical function and suggests that different design methodologies be used in the two domains. Clinical reasoning requires a holistic approach, such as an intelligent multiagent, incorporating the properties of softness, openness, complexity, flexibility, and generality of clinical decision support systems, while traditional rule-based approaches are sufficient for clinical function applications.

INTRODUCTION

Clinical decision support applications development in the field of medicine historically has been constrained by two factors. First, the design concept was limited to formal clinical reasoning based on expert physicians' rules of thumb. Second, design appears to have been technology driven, for nearly all of the current systems are rule-based, wherein rules in clinical reasoning (e.g., in diagnosis and treatment) are represented as rules in the clinical system. None of the clinical reasoning applications have yet to become fully functional prototypes or commercially viable (Bates, Kuperman, Wang, Gandhi, Kittler, Volk, & et al., 2003; Kaushal, Shojania, & Bates, 2003; Sim, Gorman, Greens, Haynes, Kaplan, Lehmann, & et al., 2001). The limited operational suc-

cess of these large-scale systems (Kaplan, 2001) is due in large part to the failure to reflect more fully in the design the diverse systemic features of the clinical process. Newer sociotechnical approaches to design, for example, a multiagent approach, and more flexible representational methods are needed to produce viable clinical decision support systems (CDSSs).

A second area of medical activity, which we term here the clinical function, has emerged rapidly as health care participants (e.g., physicians, nurses, HMOs, hospitals, diagnostic labs) increasingly perform their clinical applications work using advanced information technology (IT), such as artificial intelligence-based (AI) systems (Wyatt & Spiegelhalter, 1991) and in-house medical staff. These new AI-based clinical function systems present design issues that differ from those of clinical reasoning systems. For example, these systems typically concern much smaller domains (e.g., alerting to drug interaction, monitoring patient vital signs, reminding to medicate patient) involving structured applications in medicine (Bates et al., 2003; Delaney, Fitzmaurice, Riaz, & Hobbs, 1999; Kaplan, 2001; Kawamoto, Houlihan, Balas, & Lobach, 2005; Ramnarayan & Britto, 2002).

The application of AI (e.g., expert systems) and other computational intelligence techniques (e.g., neural networks) to the field of medicine (Catley, Petriu, & Frize, 2004) has resulted in the attempts to develop CDSSs. Wyatt and Spiegelhalter (1991) have defined medical aids as "active knowledge systems which use two or more items of patient data to generate case-specific advice." CDSSs have the potential to analyze, synthesize and integrate patient-related information to perform complex evaluations and provide that information to clinicians in real time. Over time, as they evolve in sophistication, they offer the prospect of improving the effectiveness and efficiency of patient care by preventing medical errors and enhancing quality (Johnston, Langton, Haynes, & Mathieu, 1994).

Further, the systems can improve preventive care services and help in adhering to recommended care standards (Kawamoto et al., 2005). The overall goal is to improve clinical decision making by focusing on individual patient characteristics and mapping them to a computerized knowledge base of characteristics of similar patients (Garg et al., 2005). They provide a range of levels of decision support, from simple alerts to complex diagnosis. For example, a CDSS can aid a physician in processing complex information to improve prescription writing practices in electronically delivered recommendations (Durieux, Nizard, Ravaud, Mounier, & Lepage, 2000). These types of systems are differentiated from operational decision support systems (DSSs), which are defined as enterprise repositories of clinical and financial information for utilization review, cost evaluation, and performance evaluation (Classen, 1998). In contrast, CDSSs focus on medical decisions (both on making decisions and assisting in making decisions). The key is to use patient specific information that transforms protocols into customized, real-time clinical advice (Kawamoto et al., 2005; Teich, Osheroff, Pifer, Sittig, & Jenders, 2005).

This paper discusses the clinical decision support applications design issues arising from the systemic differences (Churchman, 1971; Van Gigch, 1978, 1991) between clinical reasoning and clinical function systems, and it proposes that different design methodologies be used in the two domains. The paper is organized as follows. First, design issues in clinical reasoning and clinical function are discussed. Second, knowledge representation issues are highlighted. Third, the systemic properties of softness, openness, complexity, generality and purpose are discussed in the context of the two domains. Fourth, domain issues are identified. Next, operational examples of clinical reasoning and clinical function applications are described. Finally, conclusions are offered.

Drowsiness Detection by the Systems Dynamic Approach of Oculomotor Systems
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