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Glenn D. Rennels

A Computational Model of Reasoning from the Clinical Literature

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Foreword

As research on expert systems has moved well into its second decade, it has become popular to cite the limitations of the phenomenologic or associational approach to knowledge representation that was typical of first generation systems. For example, the Internist-1 knowledge base represents explicitly over 600 diseases, encoding associated disease manifestations (signs, symptoms, physical findings, and lab abnormalities) but failing to deal with the *reasons* that those findings may be present in the disease [Miller, R. A. 82]. In recent years Pople has sought to add detailed causal models to the knowledge base in a revised version of the program known as CADUCEUS [Pople 82]. Similarly, a typical production rule in the MYCIN system states inferences that may be drawn when specific conditions are found to be true [Buchanan 84], but the underlying explanations for such relationships are not encoded. Clancey has argued that MYCIN needs such "supporting knowledge" represented, especially if its knowledge base is to be used for teaching purposes [Clancey 83].

By the late 1970s, artificial intelligence researchers were beginning to experiment with reasoning systems that used detailed mechanistic or causal models of the object being analyzed. Among the best early examples were a program to teach students how to analyze electronic circuits [Brown 82] and a system for diagnosing problems with mechanical devices [Rieger 76]. Such developments were not lost on the medical expert system community, and by the early 1980s we were beginning to see systems that analyzed medical problems based on detailed symbolic models of pathophysiology [Patil 81].

At about this time Glenn Rennels, a physician who had interrupted post-graduate medical training to obtain a degree in Medical Information Sciences at Stanford, was beginning to search for a Ph.D. dissertation topic. Impressed though he was in the exploratory work using medical causal models of pathophysiology, his medical training and experience persuaded him that the approach would be applicable to only a small percentage of the clinical problems that beset physicians in practice. When he observed consultants giving advice in clinics or on the wards, only occasionally did he notice that mechanistic explanations were a key element of the analysis. More typically the experts would cite the literature, mentioning data from clinical trials that were judged pertinent to the question at hand. Even more importantly, it was clear that for many areas of medicine our understanding of pathophysiologic details is so limited that it would be *misleading* to use a mechanistic model, rather than empiric data from well-controlled studies, to guide decision making.

The management of primary breast cancer is a particularly good example of this latter point. Although physicians have a superficial model of disease progression and spread via the blood or lymphatics, those models have proved inappropriate and hence useless for therapeutic decision making. Instead it is a careful analysis of studies reported in the literature, with expertise in statistical interpretation and matching of patient populations, which is the basis for selecting therapy for breast cancer. Even so, there is ample opportunity for disagreement, as the ongoing controversy regarding alternative surgical approaches and the role of adjuvant radiotherapy reveals.

The Roundsman system subsequently developed by Rennels is a novel and clever effort to develop a consultant program that gives advice based on an explicit representation of the content of articles from the clinical literature. Rather than seeking a mechanistic explanation of observed phenomena, Roundsman must select the studies that are relevant to a specific question, isolate the pertinent data for the population of patients best matched to the current case, and then generate advice in the form of free text that is understandable, tactful, and persuasive. Rennels' success in this effort is the subject of the current volume. Although the system is specific to breast cancer management at present (due to the generous collaboration of an eminent oncologist, Dr. Frank Stockdale), the approach is general and should be broadly applicable in other medical domains where empirical data are the cornerstone of expert decision making (for example, the management of hyperlipoproteinemia).

Rennels' work on this project has been a source of considerable excitement for me. Glenn is the first doctoral graduate from a novel interdisciplinary degree program in Medical Information Sciences that we began in 1982. Sitting as it does at the interface between computer science, clinical medicine, biostatistics, and artificial intelligence, Roundsman is in the best tradition of high quality interdisciplinary research. It helps show, by example, the unique confluence of scholarly activities that help define medical informatics as a distinct emerging academic discipline. I will not soon forget the gratifying discussion after Glenn's Ph.D. oral examination when the other members of his examination committee (a computer scientist, biostatistician, and internist) each acknowledged that the work was original and fully worthy of the doctorate although none felt the scope, content, and emphasis would have matched precisely with the advanced degree requirements of their own department.

I accordingly commend to you this excellent book. Roundsman is good computer science, offering an impressive synthesis of recent ideas regarding object centered programming, statistical reasoning, heuristic problem solving, and text generation. It is also good medicine, showing how domain knowledge evolves over time and addressing important issues of how medical experts must integrate new knowledge and data with what they already know. But, perhaps most importantly, it is superb medical informatics and is accordingly a worthy addition to this influential series of research notes.

Edward H. Shortliffe

Palo Alto

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Portions of this work have been published or are in press in the *Encyclopedia of Artificial Intelligence* [Rennels 87a], *Medical Decision Making* [Rennels 87b], *Computer Methods and Programs in Biomedicine* [Rennels 87c], *Proceedings of the Fifth World Congress on Medical Informatics* [Rennels 86a], *Proceedings of the AAMSI Congress 86* [Rennels 86b], *Proceedings of the Tenth Annual Symposium on Computer Applications in Medical Care* [Rennels 86c], and the *Proceedings of the AAMSI Congress 87* [Rennels 86d].

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