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A LODE OF INSIGHTS FOR PERSONS INTERESTED IN CLINICAL INFORMATION FOR PATIENT CARE

CLINICAL INFORMATION SYSTEMS
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While computer science is a young discipline, medical computer science or—more generally speaking—medical informatics is even younger. Medicine has been fast to adopt new technologies, but, to date, only very few physicians have acquired the necessary skills to do primary technological development of computer systems for clinical care. This situation has been recognized by several major groups with influence in medical education.

Medical informatics has been adopted as the generic term for the discipline whose principal research interests are in the fields of information management, decision support, artificial intelligence in medicine, or forms of physiological modeling. This multidisciplinary field is still not well recognized within schools of medicine. The National Library of Medicine has a current national initiative called the Integrated Academic Information Management Systems, which has led to the solidification and, in some cases, the creation of departments of medical informatics in six schools of medicine. Five other schools are in the process of building similar divisions or departments.

A recent meeting at the Institute of Medicine was devoted to issues involving the role of technology and its relationship to the medical record. For each of the past two years, the American Association of Medical Colleges has made strong recommendations to the deans of American medical schools recommending the development of institutionalized approaches for teaching fundamental computer skills to all students of medicine and of pathways for advanced training of students who would like to make a career of medical informatics research. This year's report is in the form of a multiauthored state-of-the-art review supported by a number of position papers by prominent figures who have strong credentials in both medicine and informatics.

Why this long preamble to the current Springer-Verlag book, *Clinical Information Systems,* by Bruce I. Blum?

There was a great need in this area for a high-quality publication that could be used for an introductory course in informatics. I say "was" because with Blum's work, this important void has in most, if not all, ways been filled. There are a variety of texts related to the use of computers and artificial intelligence in medicine. Most of them have been multiauthored collections of papers or chapters. Never before has there been a book that not only covers the area from the ground up but also shares the continuity provided by a single author. I might add that not only is it singly authored, but the quality of the writing is superb. I found the book not merely informative but, in many ways, entertaining.

The book complements several others; in particular, two other Springer-Verlag publications: *Computer-Assisted Medical Decision Making* (Volumes 1 and 2)[1] and *Information Systems for Patient Care.*[2] From the artificial intelligence standpoint, *Artificial Intelligence in Medicine*[3] and *Readings in Medical Artificial Intelligence*[4] are excellent reading. Nonetheless, they may be too advanced for the newcomer. This is where *Clinical Information Systems* comes to the fore. In fact, while the discussion of the issues related to computer-based instrumentation and signal processing is brief, they are covered. This leads me to my only possible, but mild, criticism. It seems to me the book might well have been titled *An Introduction to Medical Informatics* or *An Introduction to Computing Sciences in Medicine.*

The book's 373 pages are broken into 10 chapters that are divided into three sections: (I) Background and Introduction, (II) Computer Systems, and (III) Clinical Applications. A 14-page glossary of technical terms is also provided that is worth the price of the book for many who are starting out with an interest in informatics or for those who would like to acquaint themselves with the subject. I have often been asked to supply such a list for any number of purposes and now have an excellent source. Each subject and title within the book is self-contained; therefore, the book does not have to be read in sequence.

The first section is not the standard introduction to computing machinery. While the usual assemblage of early works and devices is mentioned and pictured, Blum goes a step farther. For example, there is a clear and concise description of Napier's Bones. Because the author is a faculty member of both The Johns Hopkins

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School of Medicine and the Applied Physics Laboratory, he was able to trace the history of computing machinery from Herman Hollerith to John Shaw Billings. Billings, besides designing the Johns Hopkins Hospital, also founded the National Library of Medicine and invented (if that is the proper word) the *Index Medicus*. Hence, it may be that the roots of medical informatics can be traced to the very institution where Bruce Blum has made his own contributions to the field!

The second part of Section I reaffirms a theme that can be found in other writings by Blum. The notion that medical information systems are a time-varying, maturing technology helps both the novice and the expert to place in perspective the work of the past 15 to 20 years. This is true both from a technologic and a medical vantage point. Blum's model of early research leading first to data processing, then to information processing, and finally to knowledge processing really captures the current state and trends in the field. That not all are in synchrony also becomes clear with further reading. The notion of medical information being separable into data-oriented, information-oriented, and knowledge-oriented applications is a very concise and useful mental model for the field of informatics.

Section II, Computer Systems, is the strongest part of the book, in my opinion. It is well-written and covers important information in a clear and very readable manner. Certainly, if a primarily medical audience was intended, the four chapters are excellent. They cover the areas of hardware and software, programming languages, databases, and system implementations. A brief introduction with good examples is provided for each area. While presented at an introductory level, the chapters offer a good working knowledge without being too simplistic. They also seem to entice the reader into wanting to know more about the areas in question, something an introductory text often does not do.

The chapter on programming languages is excellent. I have often been admonished personally by Blum that knowing a programming language does not make one a computer scientist. Reading Chapter 4 of *Clinical Information Systems* will forever make that point to the initiate and the veteran alike. Blum produces several simple (yet always medically related) examples and shows partial implementations in a number of languages. Along the way, the historical genealogy of the languages is brought out. He also introduces the notion of "folk," "structured," and "functional" languages. With these subtypes, the idea of languages as tools for different tasks is developed. Rather than the usual, somewhat religious, approach to language selection, the chapter teaches the reader to begin to recognize that a particular tool might suit a particular problem, and that one tool may not be well-suited to all problems.

The database portion of Section II is clear; I would expect it to be useful to people who have never formally considered the issues associated with the database management systems. All too often in medicine, one hears of a collection of data being referred to as a database. Unfortunately, the content of a database and the control systems to maintain it have become obscured in common medical discourse. This chapter goes a long way toward clearing up the errors resulting from the double meaning of database. The chapter begins with a description of file-structure issues and proceeds to a definition of the hierarchical, network, and relational models. It also includes a segment on high-level design tools and formalisms used to describe data. While those ideas are readily found in full textbooks on database management systems, they are not as easily found in the literature of medical informatics.

The final portion of Section II is devoted to system implementation. Here, the issue is design, not hardware or particular software. Rather, the process of developing a system's specifications, tracing its actual data flow, defining its data sources and sinks, and validating and verifying its data are the subjects discussed. The chapter concludes, after talking about somewhat more ill-defined subjects such as high-level design, with a discussion of the notion and meaning of the term "algorithm." The idea of measuring the order of algorithm is discussed, and the ideas of refinement and divide and conquer are introduced. Finally, the issue of modularity is presented. All in all, this is a solid introduction to the issues surrounding programming projects.

The final four chapters, which make up Section III, "Clinical Applications," could be considered the case-studies portion of the book. They could be used as an excellent primer before one proceeds to the four other texts referenced earlier in this review. Blum takes care to mention all the participants in this arena: inpatient systems, ambulatory care systems, and decision-support systems. Many important medical systems are covered, including the American Rheumatology Association Medical Information System (Palo Alto), the COSTAR ambulatory care system (Boston), HELP (Salt Lake City), the Regenstrief Medical Record System (Indianapolis), and the CORE record system (Baltimore). Several important systems in decision support are also mentioned and reviewed, including the Bayesian model and artificial intelligence models such as Caduceus and MYCIN. The discussion is balanced and a good first lesson. With the section in hand, the reader is prepared for the two-volume set edited by Reggia and Thurim mentioned earlier.

The final chapter is an in-depth study of the Oncology Center Information System (OCIS) at the Johns Hopkins Hospital. Blum played a major role in the design and implementation of OCIS, so it seems fitting that this chapter is a case study of that system.

All in all, the book fills an important void in medical informatics. It provides a well-written starting point for a more detailed and in-depth study of the field. The balance and breadth are excellent. It is matter-of-fact and nonjudgmental. It is intriguing enough to stimulate the curiosity of the reader and is readable by more than just the beginner. For both the computer scientist and the physician, who may not appreciate what the other does, the book is recommended. I hope that it gets into the hands of enough medical students so that it will have a positive influence on their interests and on their comprehension of medical informatics.