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Synopsis

Education

Informatics in medical education encompasses two very different topics: one is the use of computers and information technology in the teaching of medicine (computer-assisted instruction or CAI) and the other is the teaching of the use of information technology (informatics) in medicine. In this Education section, we present both topics. Four separate papers present research and design in computer-assisted instruction, a fifth paper is a report of a panel discussion on Health Informatics as a unique discipline.

Early computer-assisted instruction used repetitive and systematic presentation and checking of basic knowledge. Such software helps students to rehearse knowledge. However, they typically use predefined tutorial structures, usually prescribe a single problem-solving method, and fixed explanations. More recently, CAI has been augmented by rich multimedia resources, but the pedagogical structure of programs that use these resources remains simple and rigid.

The article "*An Intelligent Computer-Assisted Instruction System for Clinical Case Teaching*", by Fontaine et al.[1], describes the design of a rule-based system for construction and presentation of clinical simulations for teaching. The cases themselves are derived from a knowledge base. A knowledge-acquisition module allows new production rules to be added to the knowledge base, and a diagnostic module controls the activation of rules in the knowledge base. Three additional modules have been developed to allow this knowledge base to be used in computer-assisted instruction: An Author module allows the teacher to use the knowledge base to construct cases for the student; the Pedagogical module actually simulates and presents the case to the student and interacts with the student; and a Student module evaluates the student's responses, giving guidance where necessary.

The knowledge base uses a classical production-rule model. If a set of premises is true, an action or consequence occurs. The consequence may be a premise for another production rule. Thus the knowledge base is an And/Or network of premises. No Bayesian logic is used. Besides the networks that contains expert knowledge, an additional common sense network is used to represent knowledge such as normal temperature and consequences of gender.

The author constructs a case for simulation by selecting one or more objectives, where an objective is a result or consequence of rules but is never the premise of a rule. Selection of an objective activates a backward-chaining process which determines any necessary premise. Those premises for which the system cannot assign a value are then set by the case author. Random assignation of values by the system for these premises may result in an unnatural case.

The Pedagogical module, which controls interaction with the student, and the Student module, which provides continuous student evaluation, have the potential to make this program a rich learning environment for students. No data are given about the actual usage of the program or about the clinical domains that have been simulated.

In the second paper [2], the process of medical diagnosis as a categorization task is examined. Two early theories of this categorization process are considered - exemplar and independent cue (or prototype). The exemplar theory claims that subjects store accurate memories of encounters in given categories and that new encounters are compared against stored encounters for diagnostic category selection. The independent cue theory claims that experience with encounters is abstracted and that the abstraction for each category represents the key features associated with the encounters in that category.

"*Agreement among Medical Experts about the Structure of Concepts in Pulmonary Physiology*" by McGaghie et al.[2], is an application of the Pathfinder technique to the study of concept organization in medicine. The organization of concepts in memory is assumed to mediate their recall and use. This paper uses the Pathfinder algorithm to deduce the linkages or configuration of a preselected set of concepts in three different expert populations. The goal of the study is to ascertain whether there is agreement between experts on their cognitive structure of concepts.

In the Pathfinder algorithm, a similarity judgment is made between every pair of concepts, and a network or graph is generated. The configural similarity between two networks with a common set of nodes is measured by the number of links between concept pairs that they have in common. Two networks with four links each have a similarity of 0.5 if two of those links are the same for both networks.

Thirteen concepts were selected in pulmonary physiology as concepts that students were expected to master. Examples of these concepts include alveolar ventilation, diffusion and gas exchange. All pairs of these concepts were presented for similarity judgement, with both presentation order and sequence randomized. From these judgments, a concept network was created for each user.

Networks were created for three physiologists who teach the pulmonary concepts course, 17 board-certified anesthesiologists and 11 board-certified general internists. Similarity measures were constructed for each pair of experts. Between-group similarity measures were constructed by averaging the data within each group. The coherence of group data was also assessed.

Qualitative inspection of the 31 networks showed marked discrepancies in concept organization both within and between groups. Similarity measures (the ratio of common links to all links) ranged from 0.22 to 0.34. The similarity was greater within a group than between groups. The internists' networks showed the greatest coherence, with alveolar ventilation and lung perfusion as the central concepts. The central concept for physiologists was gas exchange.

The lack of similarity between experts indicates that setting normative standards for student achievement may be more difficult than expected.

In the third paper, the cognitive structure of medical concepts is investigated further. "*The Effects of Various Knowledge Formats on Diagnostic Performance*", by Elieson and Papa [3], investigates the hypothesis that there is a link between knowledge formats and subsequent performance. The form in which knowledge is presented may affect performance. In particular, for the novice, the organization of the knowledge base is more likely to be influenced by the knowledge presentation. If this is true, it may suggest how to structure knowledge for effective presentation by instructors and efficient acquisition by students. Conclusions could be drawn about the most effective presentation and the nature of diagnostic category representation for clinical reasoning.

The subjects were 64 third and fourth-year medical students. They were divided into five study groups and one control group. Each study group received a different diagnostic aid, representing different structuring of the key diagnostic information. The aids ranged from a quantitative matrix of probabilities of each symptom or a textual description of key symptom occurrence to lengthy narratives of symptoms. The clinical reasoning topic was in neurology, specifically a complaint of "muscle weakness". The cases represented four distinct anatomical causes for the weakness. Sixteen cases were presented with a spectrum of difficulties. A total of 18 relevant features or symptoms were identified.

Each case was presented on the computer. The subject could select any of the 18 possible symptoms and find out if it was present. Up to 9 symptoms could be queried. When the subject was ready to make a diagnosis, or when 9 symptoms had been queried, the list of four possible diagnoses was displayed, and the subject was asked to select one. The subjects were then told the correct diagnosis. By limiting the number of features (symptoms) available, and forcing sequential selection of features, the authors believed that the subject's reasoning process would be made visible.

The study demonstrated that groups using diagnostic aids with a structured presentation that highlighted key symptoms performed significantly better than groups with aids in which information was presented as a narrative with no highlighting of key symptoms. Textual or quantitative (probabilities of symptom occurrence) highlighting of symptoms seemed to be equally effective.

The fourth paper presents a solution to some of the technical problems in the creation of software for computer-assisted instruction. Many concepts central to medical education can be communicated best through visual examples. Bergeron et al, in "Morphing as a Means of Generating Variation in Visual Medical Teaching Materials"[4], demonstrate a method of increasing the range of available visual material by increasing its variability. They use the relatively new technique of morphing between images representing two disease states to create intermediate images representing intermediate disease states.

The morphing process uses corresponding points in the two source images to direct the process of geometric interpolation between the two images. In general the two images have objects that differ in shape, orientation, color and texture. When the images differ only in color and texture, the morph effect is that of one image dissolving into the other. However, most images include geometric differences. In such cases, the quality of the intermediate morphed images depends on the number and location of the selected corresponding points in the two images. The intermediate images may require touch-up to remove rough or false edges.

The authors demonstrate the results of morphing in a variety of situations. Brain tumors of varying degrees of severity were created by morphing magnetic resonance images and computed tomography images. Varying degrees of hypertrophy in cardiac ventricles were created using echocardiograms and computed tomography images. Dermatologic presentations that involve skin color variation or a variety of skin lesions were also created by intermediate morphed images.

The fifth paper, by Protti et al, moves from computer-assisted instruction to a panel discussion on the question "Can Health/Medical Informatics be Regarded as a Separate Discipline?". As a separate discipline, do its students require a specialized curriculum? Is the methodology of medical informatics sufficiently different from that of informatics in general so as to require specialized training?

Protti, the panel chair, opened the discussion by talking about the evolution of informatics and information technology. In information technology, the computer is only one element in a complex infrastructure to communicate and record information. Each new level of computer technology significantly alters what can be done with information. The change is qualitative and not just quantitative.

As more information becomes available, more informed decisions can be made, and they are likely to produce better results. This is particularly true in medicine. Tests that once required analysis by physicians were structured and defined such that they could be carried out by trained technicians, and now can be conducted by machines. Diagnoses that were only possible in large hospitals can now be performed in doctor's offices. Further, as the emphasis shifts from cure to prevention, from institutional care to home care, from medicine to health, the need for information for better decisions keeps increasing.

Thus Protti defines two areas of informatics: Medical Informatics, which is rooted in clinical medicine and uses information to support clinical decision making; and Health Informatics, which deals with the methodology for introducing information systems in organizational settings and includes both the technical and the social and psychological effects of such systems.

Haux argues that to be a separate discipline, medical informatics must be characterized by an application field, a methodology, and objectives. The application is clearly medicine and the objective is to provide quality health care, but these are common to all fields of medicine. The question he then addresses is whether medical informatics has a distinct methodology or is simply informatics and medicine. Educating a student in medical subjects (anatomy, surgery) and informatics subjects (programming, compilers, databases) does not prepare a student to tackle the unique problems of medical informatics. Knowledge representation and inference mechanisms for clinical knowledge base systems have required significant redefinition of knowledge systems for efficiency and robustness. Methods for building clinical registers and classifying medical texts had to be developed before useful databases of medical knowledge could be developed. Therefore, acknowledging medical informatics as an unique discipline has significant effect on both the teaching of the subject and on the research that is needed. Haux concludes that medical informatics is a separate discipline and that it is a specialization of medicine with its own methodology based on informatics.

Van Bemmel takes a pragmatic approach asking whether there is a need for medical informatics and whether it offers a scientific methodology. That the need is present is obvious from the examples he cites. Clinical departments are very willing to invest in people and infrastructure to solve problems such as computer-based patient records or telemedicine that are essentially informatics problems. Further, medical informatics offers insights into the structuring of such problems based on knowledge learned in other clinical fields. Thus, the knowledge is generalizable and this is a hallmark of a science.

All five papers present thoughtful insights in leading problems areas for medical education. Each defines a vein of research and thinking that is rich and should be fruitful for many years.

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