Editorial Comments JAMIA

Medical Imaging Informatics: Challenges of Definition and Integration

Drawing on biophysics and engineering for primary methodology, medical imaging traditionally has had little overlap with medical informatics. This, however, is beginning to change. As new imaging modalities have proliferated, general-purpose image analysis software has been developed to incorporate not only low-level processing but also increasingly sophisticated functions that extract, transform, and combine the medical content from sets of related images. All require expert physician interaction to determine and interpret the content that is of interest for a specific patient. However, with the rapid and seemingly endless rise in computational power coinciding with unprecedented constraints on health costs, the potential and pressure for automating all but the most routine functions increase apace. This raises important issues for medical informatics, since any automation, however gradual, requires us to improve our understanding of the underlying image data and knowledge and its explicit definition, representation, and use on the computer.

This special issue of JAMIA contains a section of three papers addressing some of the major problems and opportunities in medical informatics that arise in imaging. The paper by Brinkley and Rosse[1] discusses the problems of developing knowledge-based image representations and methods in the context of their Digital Anatomist framework. They emphasize the need for symbolic anatomical reasoning so that whatever the image annotations made by the expert, a computer model can be developed to capture their medical content or semantics. They also highlight the importance of introducing knowledge-bases for supporting image segmentation and the technological value of network-based integration of multimodality imaging. Examples of research in functional brain imaging and mapping demonstrate the power of these approaches and techniques. Increases in computational power and storage capacity have also spurred dramatic improvements in the science and technology of graphics and databases. These in turn have enabled rapid visualization of large amounts of graphic information (generated by models that may well be parametrized from image data) and growing research on the unique characteristics and requirements of image databases. The paper by Tagare, Jaffe and Duncan[2] addresses some of these issues from the perspective of the medical user of such databases, emphasizing the problems of defining the semantics of image knowledge bases and the implications of the imprecision inherent in medical datasets. They discuss the problems of indexing by feature content and supporting spatial queries that will distinguish changes in shape, size, and topological arrangement of anatomical structures, emphasizing the importance of developments in object-oriented schemas for defining anatomical reference structures.

There is increasing urgency to standardize the exchange of medical image data because of the needs of practice, research, and education. These needs include shared access to and utilization of medical image databases by multiple interacting specialists working on different computer platforms and with different software systems, the development of massive reference digital image datasets like that of the Visible Human Project, and sharing data in large clinical studies. The paper by Bidgood[3] provides a comprehensive introduction to the evolving DICOM (formerly ACR-NEMA) standard of image data description and interchange. It discusses the many difficult issues involved in standardizing the definition of image information content for an electronic medical record in a way that preserves the flexibility of reporting structure and content. The interpretation data interchange (IDI) model of DICOM incorporates an object-oriented analysis of image interpretation reporting, semantic meta-analysis of the message components of prevailing health care data interchange standards, informal analysis of real-world scenarios, and trial encodings with iterative rounds of expert review. It has led to the specification of a Structured Interpretation (SI) Information Object Description (IOD), which provides the basis for an evolving description standard for medical image data interchange. Once it has reached a suitable level of stability, the next step would involve proposing equivalent extensions to the Health Level Seven (HL7) Standard, in order to integrate medical imaging information with other patient health care data in a platform- and software-transparent manner.

As can be seen from the above, it is still early days for medical imaging informatics. The structuring of medical information and knowledge described in the above articles is only the beginning of a challenging scientific, technological, and empirical process that will have to draw on a multitude of disciplines. Besides the central computer vision, graphics and visualization, database, software engineering, artificial intelligence, distributed processing, networking, and interface research, basic work is needed in the underlying psychophysics, cognitive science, and mathematical/statistical modeling of the imaging modalities and their interpretation by synergistic human–machine methods. Considerable efforts will be needed to connect existing text-based semantic models with visual/graphical models of medical information and knowledge so that practitioners, researchers, educators, students, and patients can not only navigate but also understand the results of querying and interacting with our evolving multimedia databases.

The medical informatics community has many challenges ahead if it is to seize the opportunity for serving as the integrative catalyst in this process.

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Received for publication: 1/13/97; accepted for publication: 1/17/97.

■ **J Am Med Inform Assoc.** 1997;4:252–253.