Medical Imaging Informatics and Medical Informatics: Opportunities and Constraints

Findings from the IMIA Yearbook of Medical Informatics 2002

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Summary

Objectives: The Yearbook of Medical Informatics is published annually by the International Medical Informatics Association (IMIA) and contains a selection of recent excellent papers on medical informatics research (http://www.yearbook.uni-hd.de). The 2002 Yearbook of Medical Informatics took as its theme the topic of Medical Imaging Informatics. In this paper, we will summarize the contributions of medical informatics researchers to the development of medical imaging informatics, discuss challenges and opportunities of imaging informatics, and present the lessons learned from the IMIA Yearbook 2002.

Results and Conclusions: Medical informatics researchers have contributed to the development of medical imaging methods and systems since the inception of this field approximately 40 years ago. The Yearbook presents selected papers and reviews on this important topic. In addition, as usual, the Yearbook 2002 also contains a variety of papers and reviews on other subjects relevant to medical informatics, such as Bioinformatics, Computer-supported education, Health and clinical management, Health information systems, Knowledge processing and decision support, Patient records, and Signal processing.

Keywords
Medical informatics, International Medical Informatics Association, Medical imaging informatics, Yearbook

Introduction

The Significance of Medical Imaging Informatics

The 2002 Yearbook of Medical Informatics takes as its theme the topic of Medical Imaging Informatics. The visual nature of so much critical information in the practice, research, and education of medicine and health care would suggest that computer-based imaging and its related fields of graphics and visualization should be central to the practice of medical informatics. Yet, historically, this has not usually been the case. The need for technological sub-specialization on the part of imaging researchers and the frequently opposite tendency towards generality of information systems studied and developed by informatics researchers may have contributed to an increasing separation between the fields in the period from the 1970’s to the 1990’s.

A trend towards re-convergence, however, began in the early 1990’s as important new image database, mapping, registration, and segmentation issues arose in the context of neuroimaging with the Human Brain Project (1, 2), and multimodal, whole body imaging with the Visible Human Project (3, 4). There was early recognition of the need for computer-based knowledge representations, not only of anatomy at the tissue level, but also at the multiple underlying biological levels (cellular, molecular, atomic) leading to the definition of structural informatics (5), and the development of a Foundational Model of Anatomy (6).

Meanwhile, knowledge representations for integrating multimodal image interpretations (7), methods for modeling elastically deformable anatomical objects (8), integrated segmentation and visualization systems (9), knowledge-based methods (10), and model-driven systems for surgery and education (11) have been gradually helping renew connections between imaging and mainstream informatics work. Encouraging further productive collaborations between researchers in imaging and informatics was one of our motivations in the choice of Medical Imaging Informatics as the theme for the 2002 Yearbook.

Imaging Informatics and Medical/Health Care Informatics

The Opportunities and Constraints of Interdisciplinarity

Medical informatics researchers have contributed to the development of medical imaging methods and systems since the inception of this field approximately 40 years ago. Starting in the mid-1970’s rapid progress in computer-based imaging research and practice came from the increasingly specialized, highly mathematical, biophysical, and engineering models of different imaging modalities (CT, MRI, digital angiography, ultrasound, nuclear
medicine imaging, etc.). Various specialties such as radiology, cardiology, and nuclear medicine distinguished themselves by concentrating their efforts on the technologies most effective for their own diagnostic and therapeutic goals. Hospital or enterprise-wide storage and retrieval of large numbers of patient image studies led to the development of PACS systems, but, technological, organizational, and economic constraints tended to divorce them from novel imaging research, and they frequently became just another part of the IT infrastructure for hospitals and clinics. Meanwhile, professional societies and conferences devoted exclusively to biomedical imaging and its subdisciplines proliferated. The number of researchers in the mainstream of medical informatics who remained professionally active in medical imaging began to shrink, and this trend continued until recently.

The combination of more advanced and user-friendly medical image data bases, coupled with improved 2D and 3D reconstruction, visualization and navigation algorithms, is making medical imaging results more accessible to physicians at the point of care. Starting in the early 1990’s the Visible Human Project produced a widely available reference set of multimodal images of the whole body. Its wide dissemination has led to much anatomically-detailed education software, but more importantly, it has raised important informatics issues of knowledge representation, modeling, and information retrieval for dealing with large-scale repositories of such multimodal digital image sets. The Human Brain Project initiated at around the same time led to a very large number of projects in brain data mapping, registration and segmentation, all of which made clear the new informatics, biometrics, and computational imaging challenges inherent in integrating massive visual datasets of subject-specific data which needed to be abstracted and summarized into atlases and retrievable maps of the brain. Possibly as result, there has been a re-awakened interest of medical informatics researchers in imaging problems, and the development of what can be identified as a medical imaging informatics subspeciality (13). This is centered around the problems of image data representation and abstraction, where ontologies for describing the underlying medical knowledge needed to interpret images are now being developed in computationally explicit form (14). This will not only assist in standardization and interoperability, but will be crucial in making image data more usable for data mining, decision support, and visual modeling and simulation.

Fundamental issues in imaging that are well-known to medical informatics researchers include: standards for image information exchange, communication protocols, underlying computer data and knowledge representations, coding, nomenclature and vocabulary for including imaging information in the electronic medical record, relation to computerized guidelines for health care, information compression, efficient indexing of image databases, security and confidentiality of imaging records, etc.

There are also many informatics challenges that require deeper scientific, technical, and medical expertise as imaging information becomes more integrated and pervasive to the practice of medicine. These include:

- the development of better human-computer interaction models for healthcare that rely not only on the increasing power of graphics and visualization but also on good psychophysical and cognitive science studies, given the multiresolution nature of many medical imaging studies, and how this affects perception and interpretation of data;
- developing better techniques for automatic segmentation and registration of medical images in 3D as well as 2D;
- data abstraction, summarization, and graphical (iconic) representation involved in atlas construction;
- representation of biological variability across repositories of bioimaging data to interpret imaging data across populations, and the linking of phenotype to genotype data;
- improving ways of integrating results from automatic image segmentation with expertly derived manual segmentations and annotations – and methods for evaluating the outcomes;
- developing annotation languages for extracting key patient findings found within the massive quantity and great level of detail inherent in medical imaging data;
- creating underlying computer-based representations of knowledge (ontologies, atlases, etc.) to help formalize such communication, while also preserving the flexibility needed for capturing novelty and enabling discovery;
- embedding advanced imaging systems in more general healthcare delivery software and evaluating their results within healthcare environments with effective feedback for learning how to modify and update the imaging methods in different clinical contexts.

As researchers in medical imaging informatics begin to address these and other topics, we hope that the 2002 IMIA Yearbook’s theme will stimulate greater interaction among imaging and informatics researchers in the development of working systems for the practice of health care, and the improvement of education.

The IMIA Yearbook of Medical Informatics 2002

The IMIA Yearbook of Medical Informatics (14) has been published annually since 1992, by the International Medical Informatics Association (IMIA). It contains a selection of recent, excellent and original research papers in the area of medical informatics. It includes papers selected from the literature for the period from April 2000 to March 2001. The selection criteria include topic significance, representativeness and coverage of research in a given subfield, subject to appropriately high levels of quality in presentation and results.

Traditionally, the selected papers are structured according to main sections: Bioinformatics, Computer-supported Education, Health and Clinical Management, Health Information Systems, Knowledge Processing and Decision Support, Patient Records, and Signal Processing. In addition, papers such as reviews covering medical
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Brossete SE, Sprague AP, Jones WT, Moser SA. A data mining system for infection control |
### Table 1 Continued

imaging informatics as well as other topics, synopsis by guest editors, and papers presenting international research and education programs, are included. In the following, we will give a short outline of the content. The detailed table of contents of the IMIA Yearbook 2002 can be found in Table 1.

**Table 1**


**Preface**

This year’s preface to the Yearbook »From Digital Anatomy to Virtual Scapels and Image Guided Therapy« has been prepared by Nicholas Ayache, Research Director for the Epidaure Project, Medical Imaging and Robotics of INRIA (The French National Institute for Research in Computer Science and Control), Sophia Antipolis, France.

**Reviews**

As is customary, the 2002 Yearbook includes a number of original review articles, which focus primarily on this year’s theme. An article by Michael Ackerman on »Visible Human Project: From Data to Knowledge« updates the status of this seminal project for the field. »Imaging Informatics and the Human Brain Project: The Role of Structure« by Jim Brinkley and Cornelius Rosse, provides a comprehensive review of how imaging informatics approaches were essential for the Human Brain Project and the development of structural informatics, and have led to the development of a computer-based foundational model of anatomical structure. Wieslaw Nowinski gives a systematic review of the application of different modeling methods for enhancing neuroimaging results. Two papers address other important topics to medical informatics: Bonnie Kaplan and Nicola T. Shaw use evaluation processes to review how people, organizations, and social issues impact medical informatics concerns; and Gunnar Klein reviews advances in standards-setting activities in the field.

**Education and Research in Medical Informatics**

The Yearbook provides an opportunity for highlighting an international selection of current education, training, and research programs in Medical Informatics. This year Russ B. Altman describes the program in Biomedical Computation at Stanford University which increasingly introduces biomolecular as well as clinical applications.
Challenges in Medical Informatics

In this section, three papers can be found dealing with the future of Medical Informatics. Incoming IMIA President KC Lun (Singapore) describes important future tasks of IMIA. Mark Musen (Stanford) reports on the outcomes of an IMIA satellite conference on this topic. Finally, the result of a panel discussion on the future impact of information and communication technology on health care, addressed by clinicians, researchers and industrial representatives, is presented.

Selected Papers and Synopses

This year, overall 37 original papers, obtained from 27 international journals, were selected to be included in the Yearbook. After the selection had been completed, guest editors were asked to write Synopses reviewing the papers in the different sections.

The section on Health and Clinical Management, which contains 4 papers dealing with search and retrieval techniques, intelligent information presentation, and information retrieval and delivery on the Internet, was edited by Steven Chu of the University of Auckland. He concluded that a challenge is to further improve these technologies and to build them into integrated software applications to support automated knowledge retrieval.

The section on Patient Records was edited by Michio Kimura of Hamamatsu University. It contains 6 papers on data mining, information retrieval by semantic terminological models, concepts indexing by UMLS, diagnostic coding, and patient holding their own records. The guest editor remarked that medical informatics professionals can prepare healthcare information systems which help to manage data in an intelligent and standardized way, and which provide a good working environment for future users.

Sedick Isaacs of Groote Schuur Hospital Observatory edited the section on Health Information Systems which contains 5 papers on human communication, using the internet to improve patient care, patient satisfaction with telemedicine, effects of compression in telepathology, and measurement of the quality of nursing documentation. The guest editor points to the necessity to prove the cost-effectiveness and acceptability of new information technology in health care.

Signal Processing, with 5 papers, was edited by Pablo Laguna of Zaragoza University. The papers deal with three types of biomedical signals: Electrocardiogram, otoacoustic emissions, and electroencephalogram. The guest editor concluded that signal processing is a very useful technique in many biomedical applications, especially as it offers low cost and non-invasive techniques compared to more elaborate techniques such as imaging.

The section on Knowledge Processing and Decision Support, containing 4 papers, was edited by Greg Cooper of the University of Pittsburgh. The papers discuss methodological issues in developing and evaluating predictive clinical models, novel methods for converting decision models into guidelines, and evaluation of guidelines integrated into the physicians’ workflow. In the opinion of the guest editor, finding a bridge between the development of diagnostic, predictive, and therapeutic models and the presentation of such models to clinical users will remain an important issue for medical informatics research.

Computer-supported education, with 4 papers, was edited by guest editor Jens Dørup of Aarhus University. The papers deal with web-based clinical guidelines, the design and programming of a computer-aided educational system, a virtual-reality based telerehabilitation system, and a patient education program. The guest editor discussed success criteria for educational software and expressed his hope that more top-quality medical educational software is made available via the Internet.

Information on IMIA

The Yearbook contains detailed information about IMIA, its Member Societies, Working Groups, and Special Interest Groups. Preparation of the general pages describing IMIA activities received considerable assistance from Steve Huesing, the Executive Director. The section on IMIA Working Groups and Special Interest Groups was greatly aided by contributions from Nancy Lorenzi.

For the first time in this Yearbook, a more detailed report on the activities of IMIA regions is included with the help of Regional Editors: Arie Hasman (for EFMI), Sedick Isaacs (for Helina), Jochen Moehr and Charles Safran (for the North American IMIA Member Societies), and Chun Por Wong (for APAMI).

The IMIA representatives from the individual countries provided the material for their own national societies.

Outlook

The next IMIA Yearbook, 2003, will appear in March, 2003. The theme of the 2003 Year-
The 2003 Yearbook will continue its coverage of all topics in medical informatics, including the one newly added this year, that of bioinformatics, which, due to its long-term implications for the development of molecular medicine and its methodological connections to medical informatics, will now become a permanent section of the Yearbook.

Up-to-date information about the current and future issues of the IMIA Yearbook is available at http://www.yearbook.uni-hd.de.

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References


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