Editors' Foreword: Intelligent Temporal Information Systems in Medicine

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Abstract. In this foreword, we first introduce the topics relevant to intelligent temporal information systems in medicine in general, and to the papers of this special issue in particular. We then provide a brief description of each paper. Finally, we describe the selection process for this special issue and thank the people who helped us put together the issue. We conclude with the list of the dedicated reviewers.

Keywords: intelligent information systems, time, medicine.

1. Time, medicine, and information systems

Time plays a major role in medical information systems. Representing, maintaining, querying, and reasoning about time-oriented clinical data is a major theoretical and practical research area. Temporal reasoning is important to medical decision making (e.g., in clinical diagnosis and therapy planning) and in medical data modeling and managing (e.g., for representation of the patient’s medical record).

It is sometimes useful to distinguish two research directions, distinct with respect to their focus and the research communities pursuing them, that can be easily identified in the literature: (1) temporal reasoning, which supports various inference tasks involving time-oriented data, such as planning and execution, and traditionally has been linked with the artificial-intelligence community, and (2) temporal data maintenance, which deals with storage and retrieval of data that have heterogeneous temporal dimensions, and typically is associated with the (temporal) database community. Tasks such as abstraction of higher-level concepts from time-stamped data and management of temporal granularity create an intersection between these two research efforts. Furthermore, both research directions necessarily involve temporal data modeling, since otherwise data can be neither maintained nor reasoned with. Additional common research areas can be identified, and further collaboration between these two research communities holds much promise.

A third scientific community, the medical-informatics one, has been greatly stimulated by the results obtained in the areas of temporal databases and in temporal reasoning. Since the
members of this community often belong also to the computer science/computer engineering area, researchers in medical informatics have often investigated the issues of temporal data modeling, temporal data maintenance, and temporal reasoning, especially in the context of the different tasks relevant to medical information systems.

Intelligent temporal information systems in medicine, are information systems that are able to store, manage, query, and support different inference tasks on time-oriented clinical data. These systems can be effectively studied, defined, and implemented only through a multidisciplinary combination of the database, artificial intelligence, and medical informatics research areas and their associated communities.

The subject of time-oriented systems in medicine covers a wide variety of specific subtopics, both theoretical and practical; among them, in this special issue the following specific research issues are faced:

- modeling and reasoning with vague and imprecise temporal information. Clinical data (e.g., symptoms, onset of a pathology) is often given with vagueness and imprecision. Two papers of this special issue, i.e., that of Wainer and Sadri and that of Lowe et al., deal with this topic, adopting fuzzy set theory as the methodological basis.
- summarizing and querying large amounts of clinical data. Detection of temporal trends in raw data is a common task in clinical medicine (e.g., gradually decreasing hemoglobin for three months, increasing left-ventricular end-diastolic diameter). Deriving temporal trends in clinical data is the focus of two papers, i.e., that of Lowe et al. and that of Salatian and Hunter. The paper of Nguyen et al. focuses on a related question: how to merge temporal database and temporal-abstraction systems, to provide users with a system able to answer a wide range of queries, at multiple levels of abstraction, about time-oriented clinical data and its derived abstractions (such as trends and patterns).
- modeling and managing granularity in medical knowledge-based systems. Granularity (i.e., the presence of different time units) must be considered both in modeling temporal data and in performing reasoning tasks: the paper by Keravnou addresses the definition of a time model allowing different granularities and different temporal contexts. The use of different time units, for queries about raw data and its temporal abstractions, is also proposed by Nguyen et al.

Besides being an important application area for advanced research on intelligent information systems, clinical information systems provide an excellent motivation for research on multiple theoretical and methodological aspects of dealing with the management of and reasoning about complex time-oriented data. We hope that this special issue will show how deep and multidisciplinary are the research and application issues related to intelligent temporal information systems in medicine. It is our profound belief that this special issue is only a first step in merging database theories/methodologies and reasoning methods to solve complex application problems. Medicine provides database and artificial intelligence researchers with fertile ground and vast amounts of available data and knowledge, as well as excellent reasons for integrating the two areas. The case of handling and reasoning about large numbers of time-oriented data is a good example.
2. Content of the special issue

In this special issue we present five research papers.

The paper “Fuzzy Temporal/Categorical Information in Diagnosis,” by Wainer and Sadri, deals with the problem of integrating diagnostic reasoning with fuzzy temporal reasoning. Fuzzy sets are used to model both vagueness in times of manifestation of disorders and intensity of the manifestation. The paper addresses problems related to consistency between the patient's data and the disorder model.

The paper “Temporal Pattern Matching Using Fuzzy Templates,” by Lowe, Jones, and Harrison, proposes a fuzzy template system to manage uncertainty in the existence of events, as well as vagueness in their starting instants and durations; the paper describes an application of the system to trend detection in anaesthesia monitoring.

The paper “Deriving Trends in Historical and Real-Time Continuously Sampled Medical Data,” by Salatin and Hunter, addresses the problem of abstracting and summarizing large volumes of continuous data acquired in Intensive Care Units (ICU). Trends such as increasing, decreasing, steady are thus detected by the system, after evaluating time series of historical or real time ICU data. The authors propose an intriguing combination of general filtering techniques and knowledge-based abstraction.

The paper “A Multidimensional and Multigranular Model of Time for Medical Knowledge-Based Systems,” by Keravou, deals with conceptual and design aspects of a time model for knowledge-based medical system. In particular, the author addresses both the problem of modeling time with multiple granularities in different clinical contexts and the issue of representing temporal entities in different clinical contexts, characterized by different time granularities.

Finally, the paper “Integration of Temporal Reasoning and Temporal Data-Maintenance into a Reusable Database Mediator to Answer Abstract, Time-Oriented Queries: the Tzolkin System,” by Nguyen, Shahar, Tu, Das, and Musen, proposes a system that integrates a temporal database system and a temporal abstraction system, to provide physicians with a “temporal database mediator” allowing them to perform queries on raw and derived data by using an SQL-like interface.

3. Putting together this special issue

Putting together this special issue proved to be a very interesting but also a very intensive project. After the call for papers appeared (disseminated since January 1998 through internet announcements and through specific mailing lists for people working in the areas of artificial intelligence, databases, and medical informatics) we received 12 papers. For each submitted manuscript, at least two or three reviewers, and sometime four, have been used. A second revision and review phase followed for potentially accepted papers. (The two guest editors also were involved in the review and revision of each of the submitted or accepted papers.) More than 200 electronic mail messages were exchanged between the guest editors, the JIIS editors in chief, the publisher, and the authors of the submitted papers. Eventually, we selected five research papers from the original 12. We selected the papers
according to several interdisciplinary criteria: in particular, reviewers evaluated papers with respect to both their methodological content and their significance to a real clinical setting. Thus, researchers from areas such as computer science, engineering, and medical informatics were required to demonstrate that their research contains both a technically sound approach, merging artificial intelligence and database technologies/methodologies, and a demonstrable medically relevant aspect. The existence and the innovative integration of these two components were the major criteria in the evaluation process. We are indebted to many people for bringing this project to a successful conclusion. We thank Dr. Maria Zemankova, Editor-in-Chief of the Journal of Intelligent Information Systems, for providing the first spark that started this special issue. We thank Prof. Larry Kerschberg, Editor-in-Chief of the Journal of Intelligent Information Systems, for his assistance and his suggestions during the final phases of the preparation of this issue. We thank also Mr. Alexander Greene, from Kluwer Academic Publishers, for his assistance in preparing the final format of this issue. We thank all of the dedicated reviewers (a complete list of these follows) for their invaluable assistance in the production of this issue. Finally, we thank the authors of all of the 12 papers submitted for this special issue.

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