



GUEST EDITORIAL

Temporal representation and reasoning in medicine

1. Introduction

Temporal representation and reasoning is a very challenging research topic in several areas of computer science: among them, we mention here databases, artificial intelligence, theoretical computer science, computational linguistics, real time systems, and medical informatics [1–6]. The scientific interest for temporal representation and reasoning is confirmed by a solid tradition of international events, as conferences and workshops, hosting new research on these arguments. Moreover, in the last decade there have been several specific events on the topic, which attracted specialized people sharing their results. Among these events, the TIME Symposium is emerging as the annual event where people from different areas of computer science discuss on time-related issues; since 1996 TIME proceedings have been published by IEEE Computer Society—see for example [7–10]. Several special issues of well known scientific journals in the last decade confirm that the interest of the scientific community for the considered topic is stable and sound, even though time and related issues are not a topic suddenly attracting huge quantities of research scientists [11–18].

Temporal representation and reasoning in medicine is related to several relevant medical tasks [2,6]: medical decision making (clinical diagnosis, therapy planning); medical data management (e.g., summarization of the patient's data, mining clinical follow-up data). Even in the specific area of medical applications, temporal aspects of health information have been the focus of a well established and internationally acknowledged scientific community, as it can be recognized by several special issues of scientific journals [19–22], which have been regularly published in the last years.

After some pioneering work focusing explicitly on specific medical aspects and providing some

efficient, even ad hoc, solutions, in recent years, temporal reasoning and representation in medicine have been faced by researchers with different backgrounds and interests, taking into consideration the main results obtained in the more general and theoretical area of temporal representation and reasoning. Significant solutions have been provided through a multidisciplinary combination of the results from these different research areas and their associated cultures. To this regard, it is interesting to observe that, from one side, medical informaticians benefitted by the general solutions coming from the generic computer science area, tailoring them to specific medical domains, while, from the other side, computer scientists found several (still open) challenges in the medical and, more generally, health domains regarding the treatment of time-related information.

2. The papers of this special issue

As the current special issue of the International Journal Artificial Intelligence in Medicine considers the tightly coupled issues of temporal representation and of temporal reasoning on information in medicine, the following papers consider both the aspects, possibly paying a slightly prevalent attention to one of them. The current special issue is composed by one position paper and five research papers.

The special issue is opened by a position paper, authored by Klaus-Peter Adlassnig, from the Medical University of Vienna, by Amar K. Das, from Stanford University, by Elpida Keravnou, from the University of Cyprus, and by the guest editors of the special issue, Carlo Combi, from the University of Verona, and Giuseppe Pozzi, from the Polytechnic of Milan. By this paper, the authors outline some possible

interesting research directions about temporal representation and reasoning in medicine over the next years [23].

The first research paper is by Yuval Shahar et al., and it is mainly focused on representation. In the paper entitled *Distributed, intelligent, interactive visualization and exploration of time-oriented clinical data and their abstractions*, the authors present the KNAVE-II system, which is an intelligent interface to interpret, summarize, and visualize time-oriented clinical data from a distributed architecture [24]. The system was developed according to 12 requirements that were defined by meetings with clinical users and it was applied to some 1000 patients who underwent a bone-marrow transplantation. The evaluation of the system proved that the users were capable of performing medium to hard queries in a faster and more accurate way.

Extending the event calculus for tracking epidemic spread by Hervé Chaudet is the second research paper and it considers the problem of representing and reasoning on spatiotemporal information [25]. The paper describes a formal language, namely SpatioTemporal Extended Event Language, STEEL, to build an event-centered representation of outbreak histories used to track the spread of epidemics over a given area in a given temporal interval. The formal language was implemented in Prolog. As a proof of concept, a trial corpus of 35 reports including spatiotemporal data has been used: the resulting representation was very close to the one obtained by human experts over the same data.

The next paper is by Peter Revesz and Shasha Wu. The title of the paper is *Spatiotemporal reasoning about epidemiological data*. The authors suitably mix the aspects of representation with those of reasoning, and present a method to store epidemiological data in constraint databases, to handle recursive epidemiological definitions, and to efficiently reason about epidemiological data both by recursive and non-recursive structured query language (SQL) queries [26]. As a practical example, the authors consider a system storing information about the diffusion of the West Nile Virus in Pennsylvania: the system is named WeNiVIS.

Luca Anselma et al. present the fourth research paper, which is entitled *Towards a comprehensive treatment of repetitions, periodicity and temporal constraints in clinical guidelines*. As the previous one, this paper considers both the topic of representation and of reasoning, and it focuses on temporal constraints in clinical guidelines [27]. Special attention is paid to composite and periodic or repeated actions, on top of which the authors

propose different types of temporal functionalities and consistency checking. The authors also compare the expressiveness of the introduced formalism and the related computational complexity.

The last paper is by José Palma et al. and its is entitled *Fuzzy theory approach for temporal model-based diagnosis: an application to medical domains*. The paper focuses on reasoning about the temporal evolution of diseases and proposes a temporal behavioral model (TBM) to capture their dynamics [28]. The temporal component is modelled by fuzzy temporal constraint networks (FTCN), which can successfully capture the intrinsic imprecision in the description of the temporal evolution of the diseases. Repeated instances of the same disease through time are detected. To validate the approach, a prototype has been implemented and applied to blood pressure data from patients admitted to an Intensive Care Unit.

3. Concluding remarks

Building a special issue is always an interesting and intensive activity. After the invitation by the editor in chief of the journal in January 2004, the call for papers appeared (disseminated in the autumn of 2004, through Internet announcements, and through specific mailing lists for people working in the areas of artificial intelligence and databases), and by the end of 2004 we received 11 expressions of interest and, finally, 7 submitted papers. Each submitted manuscript has been refereed by three reviewers, chosen to have both medical and technical expertise on the topic of the manuscript. A second revision and review phase followed for potentially accepted papers.

We selected the papers according to several interdisciplinary criteria. In particular, reviewers evaluated papers with respect to both the methodological and/or theoretical contents and the relevance to the clinical domain. Thus, authors were required to demonstrate that their research is both technically sound in methodology and medically relevant. More than 300 electronic mail messages were exchanged between the guest editors, the editorial office of the journal Artificial Intelligence in Medicine (AIIM), and the authors of the submitted papers. Eventually, we selected three research papers from the original seven. Two additional papers have been selected for inclusion in the special issue among those already accepted for regular issues of the journal, following the suggestion of the editor in chief and in agreement with the authors:

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