Introduction to the ACM TIST Special Issue on Intelligent Healthcare Informatics

Healthcare Informatics is a research area dealing with the study and application of computer science and information and communication technology to face both theoretical/methodological and practical issues in healthcare, public health, and everyday wellness. Intelligent Healthcare Informatics may be defined as the specific area focusing on the use of artificial intelligence (AI) theories and techniques to offer important services (such as a component of complex systems) to allow integrated systems to perceive, reason, learn, and act intelligently in the healthcare arena. One of the many peculiarities of healthcare is that decision support systems need to be integrated with several heterogeneous systems supporting both collaborative work and process coordination and the management and analysis of a huge amount of clinical and health data, to compose intelligent, process-aware health information systems.

After some pioneering work focusing explicitly on specific medical aspects and providing some efficient, even ad hoc, solutions, in recent years, AI in healthcare has been faced by researchers with different backgrounds and interests, taking into consideration the main results obtained in the more general and theoretical/methodological area of intelligent systems. Moreover, from a focus on reasoning strategies and deep knowledge representation, research in healthcare intelligent systems moved to data-intensive clinical tasks, where there is the need for supporting healthcare decision making in the presence of overwhelming amounts of clinical data. Significant solutions have been provided through a multidisciplinary combination of the results from the different research areas and their associated cultures, ranging from algorithms, to information systems and databases, to human–computer interaction, to medical informatics. To this regard, it is interesting to observe that, from one side, medical informaticians benefited 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.

This *ACM Transactions on Intelligent Systems and Technology* (ACM TIST) special issue contains articles discussing fundamental principles, algorithms, or applications for process-aware health information systems. Such articles are a sound answer to the research challenges for novel techniques, combinations of tools, and so forth to build effective ways to manage and deal in an integrated way with healthcare processes and data.

1. THE ARTICLES OF THIS SPECIAL ISSUE

The current special issue is composed by eight research articles. The first two articles deal with smart homes, as they are of high interest in the next (and current) healthcare scenario, where the right specific care services are provided at home as much as possible.

The first article, entitled "Analyzing Activity Recognition Uncertainties in Smart Home Environments," deals with an emerging important topic in the area of healthcare informatics. Indeed, activity recognition (AR) for intelligent human–computer interaction is a critical aspect in many smart home applications supporting elderly patients with chronic diseases or people with special needs. However, state-of-the-art

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AR technology is not ready or adequate for real-world deployments due to its insufficient accuracy. Here, the authors propose an approach that can account for multiple uncertainty sources and assess their impact on AR systems.

The article entitled "Design of a Predictive Scheduling System to Improve Assisted Living Services for Elders" describes a system assisting caregivers to work in geriatric residences. From this study, the authors obtained relevant requirements and insights of design that were used to design, implement, and evaluate two prototypes for supporting caregivers' tasks (e.g., electronic recording and automatic notifications). PRESENCE, the predictive schedule system proposed, triggers real-time alerts of risky situations from sensors (e.g., falls, entering off-limits areas such as the infirmary or the kitchen) and informs caregivers of routine tasks that need to be performed (e.g., medication administration, diaper change, etc.).

The web is nowadays an extremely powerful way of accessing healthcare information and recommendations. However, the overwhelming amount of data at disposal may generate frustration and/or use of low-quality sources. In this direction, the article entitled "Empowering Patients and Caregivers to Manage Healthcare via Streamlined Presentation of Web Objects Selected by Modeling Learning Benefits Obtained by Similar Peers" introduces a framework for selecting web objects (texts, videos, and simulations) from a large online repository to present to patients and caregivers in order to assist in their healthcare. The authors are motivated by the paradigm of peer-based intelligent tutoring and model the learning gains achieved by users when exposed to specific web objects. They show that streamlined presentations lead to effective knowledge gains for the specific application of caring for children with autism.

Data and text mining in healthcare and medicine are attracting several research efforts in the direction of (1) supporting decisions in the clinical domain, such as diagnosis, therapy, and patient monitoring; (2) extending and deriving new medical knowledge; and (3) supporting healthcare activities as drug safety surveillance and pandemic monitoring. In the healthcare domain, the authors of the article entitled "Using Health Consumer Contributed Data to Detect Adverse Drug Reactions by Association Mining with Temporal Analysis" propose to use association mining to identify relations between a drug and an adverse drug reaction and temporal analysis to detect drug safety signals at the early stage. Web-based data sources are in this case health-related social media and the proposed techniques are effective to identify early adverse reaction signals.

The huge amount of clinical and health data available makes extremely interesting the issue of providing physicians with data-centric decision-support tools in diagnosis, therapy, and patient monitoring. The proposal of suitable data mining techniques is the focus of the article entitled "Estimating a Ranked List of Human Genetic Diseases by Associating Phenotype-Gene with Gene-Disease Bipartite Graphs." Here, the authors propose a method for ranking genetic diseases for a set of clinical phenotypes through weighted bipartite graphs.

In the article entitled "MeTA: Characterization of Medical Treatments at Different Abstraction Levels," the authors deal with the extraction of association rules at different levels of abstraction by considering taxonomies for drugs and examinations from patient datasets. Considered data are prescribed examinations, drugs, and patient profiles. The effectiveness of the proposed approach has been experimented on a real diabetic patient dataset.

Finally, in the article entitled "Smart Colonography for Distributed Medical Databases with Group Kernel Feature Analysis," the authors face the problem of computer-aided detection (CAD) of polyps in computed tomographic (CT) colonography. As currently single databases at each hospital/institution do not provide enough

data for training the classification algorithm, the use of multiple distributed databases is proposed, together with a scalable and efficient algorithm, which can be applied to multiple cancer databases to improve the overall performance of CAD.

Moving to the sound topic of natural language processing for healthcare applications, in the article "Recognition of Patient-Related Named Entities in Noisy Tele-Health Texts," the authors investigate the application of state-of-the-art natural language processing and machine learning to clinical narratives to extract meaningful information. The considered (noisy) data consists of dialogues transcribed by nurses while consulting patients by phone. The authors propose then ad hoc techniques to filter different kinds of noise in the data. The result of this denoising task is the extraction of normalized patient information, visualized as a graph made of linked named entities, where term associations and trends of patients' symptoms and concerns are highlighted.

2. CONCLUDING REMARKS

Building a special issue is always an interesting and intensive activity. After the approval by the editor in chief of the journal in October 2012, the call for articles appeared (disseminated since the autumn of 2012, through Internet announcements, and through specific mailing lists for people working in the areas of artificial intelligence and healthcare informatics), and by the end of November 2013, we received 31 submitted articles. Two further regular articles submitted for publication in ACM TIST have been managed by the guest editors to evaluate their inclusion in this special issue. Each submitted manuscript has been refereed usually by three reviewers, chosen to have both medical and technical expertise on the topic of the manuscript. Further revisions and review phases followed for potentially accepted articles. Eventually, we selected eight research articles from 33 submissions (with an acceptance rate of about 24%). Articles were selected according to several interdisciplinary criteria. In particular, reviewers evaluated articles with respect to both the methodological and theoretical contents and the relevance to the considered clinical domains. Thus, authors were required to demonstrate that their research results are both technically sound in methodology and relevant in the healthcare arena.

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