Introduction to the Special Section on Intelligent Systems for Health Informatics

The field of health informatics has revolutionized the face of healthcare in the past decade. Informatics-based solutions have not only changed the way in which information is collected and stored but also played a crucial role in the management and delivery of healthcare. Intelligent and automated processing of healthcare data has never been more important than it is today. In recent years, intelligent systems have emerged as a promising tool for solving problems in various healthcare-related domains. With the advent of various swift data acquisition systems and recent developments in healthcare information technology, huge amounts of data have been amassed in different forms. One of the key challenges in this domain is to build intelligent systems for effectively modeling, organizing, and interpreting the available healthcare data.

This *ACM Transactions on Intelligent Systems and Technology* special Section on Intelligent Systems for Health Informatics presents some of the exciting and challenging applications of intelligent systems to the field of healthcare. For this special Section, our aim was to provide a forum for interdisciplinary researchers to discuss fundamental principles, algorithms, or applications of intelligent data acquisition, processing, and analysis of healthcare data. Our call for papers elicited a tremendous response with a total of 47 submissions. After a rigorous reviewing process, we selected nine articles that showcase the wide spectrum of applications of building intelligent systems in healthcare informatics.

Batal et al. in their article "A Temporal Pattern Mining Approach for Classifying Electronic Health Record Data" study the problem of learning classification models from complex multivariate temporal data encountered in electronic health-record systems. They extract useful classification features using temporal abstractions and temporal pattern mining to extract the classification features. They present a minimal predictive temporal patterns framework to generate a small set of predictive and nonspurious patterns and apply this approach to the real-world clinical task of predicting patients who are at risk of developing heparin-induced thrombocytopenia.

In "COM: A Method for Mining and Monitoring Human Activity Patterns in Home-Based Health Monitoring Systems", Rashidi and Cook develop a fully automated approach for discovering and monitoring patterns of daily activities. This work can provide unprecedented opportunities for health monitoring and assisted living applications, especially for older adults and individuals with mental disabilities. As opposed to relying on a set of preselected activities as done in previous works, their approach automatically discovers natural activity patterns and their variations in real-life data.

Processes in the healthcare domain are characterized by coarsely predefined recurring procedures that are flexibly adapted by personnel to suite specific situations. A workflow management system that provides guidance and documents the personnel's actions can lead to a higher quality of care. In "Dealing with Uncertainty – Robust Workflow Navigation in the HealthCare Domain", Wolf, Herrmann, and Rothermel develop a framework for activity recognition systems that use sensor data (e.g. audio and acceleration data) to infer the current activities by personnel and provide input to a workflow (e.g. informing it when a certain activity is finished). They describe a

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comprehensive approach tailored for flexible human-centric healthcare processes that improves the reliability of activity recognition data.

In healthcare-related studies, individual patient or hospital data are often not publicly available due to privacy restrictions, legal issues, or reporting norms. However, such measures may be provided at a higher or more aggregated level, such as state-level, county-level summaries or averages over health zones. In "CUDIA: Probabilistic Cross-Level Imputation using Individual Auxiliary Information", Park and Ghosh tackle the problem of running data mining procedures on health surveillance data where different variables are available at different levels of aggregation or granularity. They provide a better utilization of variably aggregated datasets using a Bayesian-directed graphical model-based "cross-level" imputation technique.

In "Reliable Medical Recommendation Systems with Patient Privacy", Hoens et al. provide a solution to the problem of recommending the physicians for patients using sensitive medical information collected by the system. They develop a privacy-friendly framework and present two architectures that realize it: the Secure Processing Architecture (SPA) and the Anonymous Contributions Architecture (ACA). They discuss various aspects of both architectures including techniques for ensuring the reliability of computed recommendations and system performance, and they provide a comparison of the two.

In "Validation of an Ontological Medical Decision Support System for Patient Treatment Using a Repository of Patient Data: Insights into the Value of Machine Learning", Khan, Doucette, and Cohen present a hybrid ontological and learning medical system which provides medical decision-making for patient treatment under time-critical decision scenarios. Their design of medical recommendation systems can provide personalized patient treatment under diverse considerations such as coping with misinformation provided by patients, performing effectively in time-critical environments where real-time decisions are necessary, and potential applications facilitating patient information gathering.

In "Customized Prediction of Respiratory Motion with Clustering from Multiple Patient Interaction", Lee et al. propose a respiratory motion predictor which performs customized prediction with multiple patient interactions using a neural network (CNN). The prediction accuracy of this work was investigated with a variety of prediction time horizons using normalized root mean-squared error values in comparison with the alternate recurrent neural network (RNN). Their experimental results showed that the proposed CNN can outperform RNN with respect to the prediction accuracy with an improvement of 50%.

Incremental tests are widely used in cardiopulmonary exercise testing both in the clinical domain and in sport sciences. The highest workload reached in the test is key information to assess the individual body response to the test and to analyze possible cardiac failures, plan rehabilitation, and training sessions. In "Early Prediction of the Highest Workload in Incremental Cardiopulmonary Tests", Baralis et al. present a new approach to cardiopulmonary tests by analyzing the individual body response to the exercise and predicting the highest workload value using a k-nearest neighbor-based classifier and an ANN-based classifier. They introduce a new index, the CardioPulmonary Efficiency Index (CPE), for summarizing the cardiopulmonary response of the individual to the test.

In their article titled "A Semantic Framework for Intelligent Matchmaking for Clinical Trial Eligibility Criteria", authors Lee, Krishnamoorthy, and Dinakarpandian tackle the problem of characterizing and matching clinical trials with potential subjects. They provide a semantic framework that facilitates intelligent matchmaking through a minimal set of eligibility criteria with maximum coverage of clinical trials. They propose a bottom-up data-driven approach that finds a nonredundant representation

of an arbitrary collection of clinical trial criteria and their prototype illustrates the effectiveness of the proposed methodology.

We would like to thank all the people who contributed to this special section. This includes all the authors who submitted articles and also the reviewers for providing careful reviews and constructive comments in a short timeframe. We hope that this special Section will provide readers with a sample of advances in the research of building intelligent systems for healthcare problems including the research challenges in developing novel techniques for effective ways of handling, retrieving, and making use of healthcare data. We believe that the research in the field of health informatics will continue to grow in the years to come.

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Guest Editors