Preface

There is an ever increasing thrust to automate a range of activities in every discipline including healthcare, engineering, science, business and management. Computational intelligence paradigms have offered some advantages in automating and creating the human-like capability in healthcare sector. The primary goal of this book is to present some of the most recent research results of the applications of computational intelligence in healthcare. This book consists of ten chapters.

Chapter 1 by Sordo et al. present an Order Set Schema developed by the Clinical Knowledge Management and Decision Support Group at Partners HealthCare and the Decision Systems Group at Harvard Medical School. It provides a brief introduction to key issues involved in its implementation. The Order Set Schema is the result of a broader enterprise-wide knowledge management effort to identify and leverage current clinical knowledge across Partners institutions. The chapter includes a brief introduction to knowledge representation and management including ontologies. It includes description of the clinical content identified and presents a summary of accomplishments.

Chapter 2 by Sordo et al. is on a state-based model for management of type II diabetes. This model encompasses strategies for prevention, early diagnosis, and treatment of type II diabetes and associated complications. This effort is part of an on-going, enterprise-wide strategy to improve the quality, safety and efficiency of provided care, by maximizing the use of new clinical information technology in key issues such as complex clinical workflows, usability, controlled terminology, knowledge management and clinical decision support carried out by Partners HealthCare System. The proposed model is a disease state management system for the continuum of diabetes care that synergistically integrates patient care and education protocols at all levels of disease management, and supports the integration of evidence-based personalized care. This approach could be easily adapted to managing other chronic conditions e.g. hypertension, asthma, and coronary artery disease.

Chapter 3 by Schmidt is on case-based reasoning in medicine especially an obituary on Lothar Gierl. The research work undertaken by Gierl on

Base-Based Reasoning in Medicine (CBR-M) is discussed. A good review of the research work undertaken in the area of CBR-M is also presented. A number of case studies are included in the chapter.

Chapter 4 by Montani et al. is on assessing the quality of care in artificial intelligence environment for end stage renal failure patients. End Stage Renal Disease (ESRD) is a severe chronic condition that corresponds to the final stage of kidney failure. Hemodialysis (HD) is the widely used treatment for ESRD. This paper reports the progress made in the development of an auditing system for assessing the performance of HD centres. The authors have demonstrated that their approach is suitable for knowledge discovery and critical patterns similarity assessment on real patients' data.

Chapter 5 by Cerrito is on mining the electronic medical record to examine physician decisions. When there is a lack of accountability, there is variability in practice. Physicians typically are not held accountable for their costs in a hospital environment, nor are their patient outcomes compared to those of other physicians, with the exception of mortality rates. Therefore, there is little information available on how to examine variability in practice. With the availability of the electronic medical record, it is now possible to investigate how the variability in physician decision making impacts patient outcomes and hospital costs. This chapter examines the medical record in a hospital emergency department. Medications, charges, length of stay, and patient disposition will be analyzed using data mining techniques, including text analysis. Data were collected on approximately 14,000 patients over a six month period from a hospital emergency department. The electronic medical record (EMR) was used for all orders and charges while the patient was in the emergency department. However, medications were recorded on a separate pharmacy database that was merged into the EMR. The objective was to find ways to decrease costs while improving the quality of patient care. Payment to the hospital from Medicare, Medicaid, and private insurers is based upon an assignment of Level 1 to Level 6 care, with Level 6 generating the highest payment. Level is assignment based upon a series of points. Each item of care generates a specific number of points. However, the point-system is self-generated by the hospital, and the points assigned a particular item can vary from one hospital to another. Emergency Department care is expensive, and the longer a patient remains in the ED, the higher the cost of that care. Therefore, variability in the length of stay and reasons for that variability are also of concern.

Three fields in the data are of concern as well: charges, medications, and diagnosis. Each of the three fields has thousands of potential levels. In addition, physicians are free to insert their own information in non-standardized language. While it is possible to analyze each different diagnosis separately, the number of different diagnoses is so large that there are very few patients to be considered. Text analysis was used to reduce the number of levels, using the fact that similar words and phrases indicate similar medical issues. Then association rules were used to examine differences in physician orders for similar medical diagnoses. Once the categorical levels are reduced to manageable levels, kernel density estimation is used to investigate the relationship of levels to outcomes, in addition to predictive modelling. Once completed, the analysis showed that some physicians routinely treat patients with similar diagnoses at a higher cost compared to other physicians. Some nursing costs are routinely added as patient charges by some RNs compared to others within the same hospital setting.

This chapter demonstrates each of the techniques in the context of analyzing the EMR from the hospital emergency department. It will show that it is possible to make physicians and hospitals more accountable for their actual treatment of patients, and for the costs incurred.

Chapter 6 by Hill is on capturing and specifying multi-agent systems for the management of community healthcare. The deployment of multi-agent systems remains immature and many agent healthcare applications are developed ad hoc, with little reference to design methodologies or compliance with rigorous design requirements. It is therefore necessary to be able to model and specify, at an acceptable level of abstraction, the required characteristics of an agent-based solution to the management of community healthcare. The required characteristics should reflect the real-world view, and it follows that such specifications should also mirror the requirements of the target domain environment.

As each element of community healthcare is often delivered by independent agencies, the number of autonomous command and control systems is often considerably large, leaving the overall managers of the care (the UK Local Authority) to protect the individual bodies from disclosing sensitive and irrelevant information. Although information technology is established in community care management, it is clear that in many instances the vast quantities of disparate heterogeneous information repositories can lead to the undermining of effective system operations. Thus, using collaborative intelligent agents that overcome the difficulties of integrating disparate hardware and software platforms, queries can be mediated to the most appropriate information source. Accordingly, agent technologies have the potential to build effective co-ordinated healthcare management systems. Groups of agents such as private care providers, routine care services, nursing and medical staff, local authority manager, private care manager, and health trust agents, need to undertake considerable autonomy in order to manage the horde of messages exchanged within the community.

Contractual agreements with community healthcare agencies create a complex economic environment that must be described in a robust way if agent managed services are to be accepted commercially. Typically auction models are utilised by agent applications as they are widely understood, established, and cheap to implement, but they are too simple to capture the nuances of community care payment transactions. The author considers the 'Event Accounting' model in relation to the myriad of payment transactions within the community care environment, and proposes a robust transaction based framework for the deployment of agent-managed community care systems, to address the gulf between abstract concept and low-level, undisciplined agent system implementation.

Chapter 7 by Cortés et al. is on assistive wheelchair navigation. The world elderly population is currently increasing in a steady way, and, hence, the costs of health care are also increasing dramatically. Consequently, significant effort is being focused on technology to help individuals to remain independent in their preferred environment. Specifically, a key issue in assistance to achieve autonomy is mobility, as mobility impairment has proven to cause a downward trend in quality of life.

Mobility can be provided by different devices, ranging from walkers to traditional wheelchairs. There are several important issues to design a control system for such devices, namely the user interface, the sensory-motor hardware, and the control algorithms required to produce an output. Regarding interfaces, most works focus on user modelling. Naturally, the interface must be easy to use and accepted by the user and diverse types of interaction suited to users with different capabilities, needs and preferences. This personalization is usually achieved through activity, cognitive and affective profiles. A fundamental feature of adaptation that must be considered is the degree of autonomy that the interface provides, to check who is ultimately in control. Even though very different approaches exist as joysticks, touch screens and voice interfaces are the most common choices. The sensory motor hardware is mostly subjected to safety and health regulations and, hence, the usual choice is to employ commercial homologated wheelchairs equipped with *safe* sensors. Even though sonar has been widely used for autonomous navigation, wheelchair assisted navigation requires more precision and may rely on laser sensors instead. If localization is required, GPS may be used outdoors, whereas active beacons are feasible indoors. In most cases, wheel encoders with different precisions are used as well. The wheelchair control algorithms range from reactive to deliberative control. Reactive control maps input patterns to outputs in a straight way and it is mostly used in the field to implement emergency responses, removing control from the user only when immediate danger is detected. Deliberative control follows the sense-plan-act (SPA) paradigm and it is used to take more complex decisions like *how to reach a goa*l given a location and a model of the working environment. In this case, the wheelchair is mostly controlled by the system and the user only provides high level guidelines. Hybrid solutions where control is given sometimes to the system and sometimes to the user are also feasible, but require some ranking on the user's performance or the situation at hand.

Whereas user interfaces are highly dependent on the user condition and sensory-motor hardware mostly depends on the system environment, the same control algorithms can be applied to a wide range of problems. Hence, much research has been done to this respect. It must be noted, though, that most work in the area has focused either on emergency mechanisms, curvature integration to remove shaky motion or autonomous control whenever the user can not drive the wheelchair himself/herself.

This chapter reviews current approaches to assisted wheelchair navigation control. Its main contribution is real experimental evaluation of the performance of different users presenting different pathologies depending on *how much* control they exert over their wheelchair. Results are correlated with users' pathologies to extract conclusions about the benefits of assistive navigation and how existing approaches could be improved through adaptation. It is expected that adaptive shared control would avoid loss of residual capabilities and also provide a better sense of self control to the user.

Chapter 8 by Kaiser and Miksch is on modelling treatment processes using information extraction. Clinical Practice Guidelines (CPGs) are important means to improve the quality of care by supporting medical staff. Modeling CPGs in a computer interpretable form is a prerequisite for various computer applications to support their application. However, transforming guidelines in a formal guideline representation is a difficult task. Existing methods and tools demand detailed medical knowledge, knowledge about the formal representations, and a manual modelling. In this chapter the authors have introduced methods and tools for formalizing CPGs and have proposed a methodology to reduce the human effort needed in the translation from original textual guidelines to formalized processable knowledge bases. The idea of this methodology is to use Information Extraction methods to help in the semi-automation of guideline content formalization of treatment processes. Thereby, the human modeller will be supported by both automating parts of the modelling process and making the modelling process traceable and comprehensible. The methodology, called LASSIE, represents a novel method applying a stepwise procedure. The general idea is to use this method to formalize guidelines in any guideline representation language by applying both general steps (i.e., language independent) and language-specific steps. In order to evaluate both the methodology and the Information Extraction system, a framework was implemented and applied to several guidelines from the medical subject of otolaryngology.

Chapter 9 by Brahnam et al. is on neonatal pain detection using face classification techniques. Detecting pain in neonates is a difficult problem for health care professionals yet it is very crucial since pain is a major indicator of medical conditions and untreated pain in infants results in central nervous system changes that slow development and impede child-parent bonding. This chapter presents the Infant COPE (Classification of Pain Expressions) project and the groups' research work using face classification to detect pain in a neonate's facial displays.

Aside from discussing the neonatal pain detection problem, this chapter provides a tutorial on state-of-the-art face classification techniques that is suitable for those unfamiliar with the subject. The chapter also notes other medical problems that could benefit from the application of face recognition technology.

Chapter 10 by Simo and Cavazza is on medical education interfaces through virtual patients. Virtual Patients have been used widely in simulation and medical education related to the fusion of AI Theory and Applications with knowledge in the medical field.

The authors have successfully built a system where virtual humans (virtual patients) are used for training applications in the field of cardiac emergencies. Different versions of the system integrate AI techniques for simulating medical conditions (cardiac shock states) with a realistic visual simulation of the patient in a 3D environment representing an ER room. It uses qualitative simulation of the cardio-vascular system to generate clinical syndromes and simulate the consequences of the trainee's therapeutic interventions. The use of knowledge-based simulation provides a strong basis to integrate the behavioural aspects with the graphical appearance of the patient in the virtual ER. This also supports the creation of an emotional atmosphere increasing the realism of this training.

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Editors

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