Editorial

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interests lie in the areas of depth perception; virtual environments; 3D simulations for training; multimedia training applications; usability evaluations, human factors and mobile displays. She has been a guest editor for special issues of *Virtual Reality Journal* and *Journal of Intelligent Systems*. Her most recent work explored the usability issues of game-play on mobile devices.

Joseph Tan, PhD, serves on various journal editorial review boards and is Editor-in-Chief of the *International Journal of Healthcare Information Systems and Informatics*. He has been tenured at the University of British Columbia, Canada for 14 years and has served as Professor and Head of Information System and Manufacturing Department, School of Business Administration, Wayne State University in the last three years. Currently, he is leading an interdisciplinary e-health research team across the WSU campus. His most recent work, *E-Health Care Information Systems*, published by Jossey-Bass, July 2005, touches on the cutting-edge theories, methods and practices in e-healthcare.

Ray Paul, PhD, is Emeritus Professor in the School of Information Systems, Computing and Mathematics at Brunel University, and Visiting Professor in the Department of Information Systems at the London School of Economics. Paul taught Operational Research and Information Systems at LSE for 21 years, then joined Brunel for 12 years. Paul has over 400 refereed publications and three books. He is coeditor of the *European Journal of Information Systems*, which he co-founded in 1990. He is one of the editors of the *Journal of Computing and Information Technology*. Paul's research interests are in business modelling, particularly simulation, and information systems development.

The use of mobile technologies in the healthcare sector is on the increase across the globe. This phenomenon is describe by a variety of terms such as mobile health, pervasive health, or wireless health. All these terms relate to the use of mobile computing, medical sensor, and communications technologies for improving healthcare. This editorial uses the term m-health, which encapsulating various types of healthcare systems such as telemedicine (Istepanian and Zhang, 2004), telehealth (Istepanian and Lacal, 2003) and biomedical sensing.

The rapid advances in Information Communication Technology (ICT) nanotechnology, biomonitoring, mobile networks pervasive computing, wearable systems, and drug delivery approaches are transforming the healthcare sector. These developments have not only had a significant impact on current e-health and telemedical systems, but they are also leading to the creation of a new generation of m-health systems with convergence of devices, technologies and networks at the forefront of the innovation. The ubiquitous deployments of mobile networks have the potential to enhance communication between patients, physicians, and healthcare practitioners. The use of mobile networks also facilitates the delivery of accurate health information anytime anywhere, thereby reducing errors and improving access pertinent knowledge.

There has been a gradual increase in the implementation of applications that use wireless technology in the healthcare environment. These applications rely on the use of small unobtrusive medical devices to capture and manipulate data over wireless

networks. These medical mobility solutions have the potential to deliver enormous benefits to the industry by reducing costs, improving patient safety, and improving response times.

There are a variety of commercially available mobile technologies used in the healthcare domain. These mobile technologies have limitations which are constraining the use of Mobile technology in the healthcare sector (Istepanian and Lacal, 2003; Istepanian and Zhang, 2004). Some of the challenges that are affecting the adoption of m-health applications include:

- Lack of clarity and commonly accepted terminology, standards or technology across the domain.
- Integrating the mobile devices platforms with legacy systems is complicated and costly.
- The lack of linkage and compatibility between telemedical services due to the difficulty of achieving operational compatibility between the telecommunication services, m-health protocols, terminals and device standards.
- Expensive communication links between network types. This is apparent between satellites and global mobile devices and is also apparent with the same network type such as GSM, but when roaming with a different network provider.
- There are some limitation of existing wireless data rates especially for the globally available 2.5G and third-generation (3G) services for some e-health services.
- There are concerns about the integrity and security of mobile internet connectivity and information access especially for e-health systems.
- Organisational changes may be required for healthcare institutions to benefit from e-health and m-health services.
- Economic consequences (both short-term and long-term) and working conditions for physicians and healthcare experts are not fully understood for m-health technologies
- The business models along with methods of payment and reimbursement issues for e-health and m-health services are not yet fully developed and standardised.
- There are integration challenges between legacy systems, existing e-health services and other information systems, *e.g.*, referral and ordering systems, medical records, *etc.*
- The implemented pilot projects so far have failed to show that m-health services result in real savings and have cost effective potential.

Overcoming these challenges is a slow process but it is gradually being achieved across the globe. The implementation of a m-health application in the healthcare environment leads to the creation of a Mobile Healthcare Delivery System (MHDS); an MHDS can be defined as the carrying out of healthcare related activities using mobile devices such as a wireless tablet computer, Personal Digital Assistant (PDA), or a wireless enabled computer. An activity occurs when an authorised healthcare personnel accesses the clinical or administrative systems of a healthcare institution using a mobile device (Wickramasinghe and Misra, 2004). The transaction is said to be complete when medical personnel decide to access medical records (patient or administrative) via a mobile

network to either browse or update the record. The range of Mobile applications in operation are constantly increasing Field (1996) has categorised applications into two main groups clinical and non-clinical. Clinical applications are grouped into eight categories (Committee, 1996):

1 initial urgent evaluation

2 supervision of primary care

3 provision of specialty care

4 consultation

5 monitoring

6 use of remote information and decision analysis resources to support or guide care for specific patients

7 diagnostic

8 treatment (surgical and non-surgical).

In addition to these groups above two new categories have been identified to reflect future trends

9 drug delivery

10 patient identification.

Non-clinical purpose includes medical education, administrative meetings and does not involve decisions about care for particular patients. Some examples of m-health non-clinical applications include:

1 mobile access to the latest drug reference database

2 bedside access to patient records – increase efficiency by reducing demand for paper records

3 ePrescribing – mobile prescription writing and verification of drug interactions

4 prescription formulary reference – electronically identify most economic pharmaceuticals for a patient

5 electronic billing for in-home healthcare workers

6 patient/drug verification – scan patient and drug bar codes to help ensure the appropriate medicine is being administered to the correct patient

7 delivery applications – healthcare supply delivery, tracking and billing

8 patient encounter data capture.

This special issue consists of eight papers describing the latest research findings from institutions around the world. The papers broadly look at the design and development of mobile technologies and applications to support the provision and management of healthcare services within the hospital and home environments as well as exploring the possibilities for these technologies to provide healthcare ubiquitously. Through wireless, integrated networks, medical knowledge can be shared almost instantly enabling the provision and management of healthcare outside traditional working hours and beyond the traditional physical constraints.

Nugent *et al.* look at outpatient care and describe the development of an internet based system for the management of medication and the development of a novel mobile home based medication management device. The MEDICATE system was developed and aimed at collectively addressing and satisfying the needs of all stakeholders (such as the patient, the general practitioner, the pharmacist) in the supply to intake chain for medication and evaluated positively by the stakeholders. The authors also describe a second case study which exploits the potential and the synergies of different technologies capable of supporting disabled and elderly people through home automation, wearable devices, assistive technologies and telemedicine. They conclude emphasising the challenges of developing these systems so that they integrate effectively with the existing healthcare infrastructures and the roles and daily activities of the stakeholders; and also to support the diverse requirements of patients which might result in the need for a number of technologically differing solutions.

Sneha and Varshney discuss how a wireless ECG monitoring system can continuously monitor a patient even as they move around freely. They describe an architectural framework of a system that utilises mobile technologies to enable continuous, wireless, electrocardiogram (ECG) monitoring of patients anytime anywhere. The intelligent agents residing in the system detect any anomalous ECG readings and trigger an alarm that would be sent to the healthcare centre in case of an emergency. The propose that this system would not only improve the quality of life for a patient but also, save healthcare costs that are associated with extensive hospitalisation of cardiac patients.

Belsis *et al.* discuss the security, integrity and privacy issues of medical data used across health information systems which are generally distributed and interoperable. They describe a pilot system called HERMES, which allows secure mobile access in geographically distributed medical databases. This system enables mobile medical personnel to perform secure registration and acquisition of medical information and it can used as an overall medical communication system on which diverse medical applications could interoperate and securely exchange data. After presenting an overview about security issues, they describe the systems architecture and schematics and show how a combination of Digital Certificates, the TLS and the IPSec protocols provide security at two different levels:

1 the transport level

2 the communication level.

Moran *et al.* report the findings of an observational workplace study conducted in a hospital to understand how hospital workers interact with information while moving around. They found that hospital workers spent a quarter of their time performing information management tasks followed by coordination, then clinical case assessment and finally direct patient care. They discuss how handheld computers can provide the basis for a pervasive computing hospital environment, providing designers can use empirical information to understand how hospital workers conduct their work.

Baldwin *et al.* reflect on the current interactions between technology and clinicians in a hospital setting. They observe a static information/dynamic clinicians model whereby, the clinicians have to go to the computer terminals in order to access information about the patients. Through a case study, they present evidence to show that this existing model is relatively inefficient with respect to, for example, time delays in accessing information. Based upon this, they propose a dynamic information/static clinicians model suggesting

that technologies could be employed to provide information to clinicians as they need it, whilst they are by a patient's bedside or as the patient is being transported within areas of the hospital.

Gaynor *et al.* describes a next generation patient care system for pre-hospital airmedical transport. The system described in this article is called iRevive, The systems was developed by a collaborations between 10Blade, Inc., the University, The system and its infrastructure are built using emerging technologies such as mote-based sensors, mobile wireless devices, next generation Wide Area Networks (WANs), the Data Elements for Emergency Department Systems (DEEDS) data standard, web services, HL7v3 messaging, and rule-based data capture. Inexpensive wireless vital sign sensors. The system can support the continuous and real-time capture of vital signs as they are entered into the iRevive application running on a mobile tablet PC with wireless capabilities.

Bratan *et al.* examine the organisational and human aspects of introducing a remote patient monitoring system that uses wireless and broadband networks into three residential care homes in the UK. The articles used semi-structured one-to-one interviews to identify issues deemed most important to each group. This article provides an interesting examination of the issues of communication between healthcare workers in several primary and secondary care organisations.

Reeves *et al.* describe on an empirical study which evaluated SoundHelper, a multimedia application to demonstrate how to pronounce target speech sounds. Two prototypes were developed: one based on video and the other on rotoscoped, motion captured animation of lip and facial movements. Twenty Speech and Language Therapists evaluating the prototypes responded positively to both, with the video being preferred because of the perceived extra information provided. Most evaluators (85%) said that they would use the SoundHelper if it was available.

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