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Editorial: Pervasive Healthcare

Environment is the basis for the design and development of any product. The environment of a product includes technologies and human beings involved with the product. Since the expansion of mobile and wireless technologies, health care services, as a kind of product, are heavily influenced by the rising expectations from patients and healthcare professionals. The pervasiveness of healthcare environments is becoming a trend to provide personalized healthcare services, which can be delivered to a plethora of users including medical professionals, healthcare practitioners, individual patients, their families and communities. Such pervasive healthcare should be developed based on transdisciplinary efforts through the contributions from and collaborations among software, communications and network engineers, social and cognitive science specialists, public servants and entrepreneurs on one side and clinicians, patients and regulatory/government bodies involved in healthcare delivery on the other. Future healthcare systems may be characterized by the integration of numerous gadgets, sensors, devices of variable communication and computational power, software technologies and people into cyber-physical spaces.

This special issue consists of three papers, which illustrate the role and impact of pervasiveness on various healthcare domains. The papers differ in their specific domain of interest and in proposed software technologies to address their respective problems. All three papers are interdisciplinary in that knowledge is synthesized across disciplines of software engineering, social and cognitive sciences, multimedia and healthcare.

The first paper, titled “Towards the Development of a Virtual Counselor to Tackle Students’ Exam Stress”, presents the development of an embodied conversational agent ESCAP. The ESCAP is a virtual counselor whose role is to support undergraduate students in their stress management during exams, by giving advice of a professional psychologist. The objective of the paper is twofold: to generate tailored exam management advice, to suit each individual student, and to make sure that a virtual counselor has the appearance of a human psychologist. In order to achieve both objectives the authors exploit the power of immersion in virtual environments, because ESCAP must give effective counseling to students and relieve their anxieties through media mediated virtual doctors. Highly personalized virtual characters such as avatars enable verbal interactions with students. It is expected that such environments require pervasiveness of devices which could capture students’ stress, problems and possibly facial expression on one side and extensive use of virtual world tools and environments, which could mimic the role of real life psychologists, on the other. The authors illustrate their proposal through ESCAP system architecture, which uses various technologies for deploying its modules. At the conversational interface level they use natural language processing, natural language interfaces and conversational processors, with the automation of sentence parsing. The decision support system for ESCAP is responsible for the creation of a comprehensive knowledge base, which involves a complex level of verbal interactions, processed by its expert system and ESCAP inference engine. The result of inference is an advice to a student on techniques to cope with their exam stress. The contribution of this research is threefold. Firstly, it shows a

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good synthesis of well known artificial intelligence and natural language processing techniques for manipulating the semantics of counseling environments. Secondly, it uses virtual world tools in order to create immersions, but virtual environments are based solely on authors' specific way of exploiting semantics of a counseling environment, which is a novelty in creating immersive spaces. Finally, their research might have an impact on other numerous disciplines. Their agent based behavioral modeling of avatars in ESCAP may have implications in the field of machine learning for human computer interaction. Similarly, their self-learning expert system for detecting symptoms and diagnosis of student stress might make a contribution in areas of social science and psychology. Furthermore, ESCAP should be very beneficial in some other healthcare domains as a support to people who are victims of violence, who have domestic and post-traumatic stress disorders, and who suffer from depression.

The second paper, titled "A Multinode Mechanism to Verify Interoperability Issue in Healthcare", shows how pervasiveness of healthcare environments directly affects the interoperability of software applications which run within them. This is because pervasiveness in healthcare very often assumes the co-existence of heterogeneous devices, sensors, data models, repositories and software applications built around them. This is exactly what motivated the authors to focus on interoperability in environments where we exchange clinical data and images between heterogeneous patient electronic folders and hospitals. We have been aware that the issue of heterogeneity triggers the interoperability problem at various levels in computing environments. Most of the interoperability solutions advocate integrations and federation of data repositories and applications and recommend standards which address heterogeneities of software and platforms. However the authors point out that interoperability in healthcare is not purely a software engineering problem for two reasons. Pervasiveness of sensors, and various gadgets used in modern healthcare severely affect the interoperability of environments where these devices are used. Furthermore, the choice of devices in healthcare is dictated by their potential adoption by patients and healthcare professionals. This means that end users of such devices should be able to use them efficiently and adopt them instantly in their everyday tasks. Software, which accompanies such pervasive devices, should also be user friendly and learned quickly. Therefore in pervasive healthcare, hardware and device manufacturers, software developers and end users have to collaborate in the development process. Their role is also to address the problem of constant technological advances which affect their healthcare delivery, medical workflows and clinical decision making. The proposal in this paper is a multi-mode mechanism for verification of interoperability of healthcare software applications. The authors' aim is to ensure that the proposed mechanism uses ETICS services, which detect the lack of compatibility of healthcare software applications. In other words, it detects a possible interoperability problem, while building and testing software applications for quality and management purposes. Their proposal is illustrated through an example of medical imaging, because they have been able to use ETICS with the DICOM interoperability standard in terms of checking and testing automatically whether DICOM implementations, i.e. DCMTK and dgate can interoperate with each other. It can also use methods defined in DICOM and check if two programs can interoperate with each other through these methods. The impact of this research is significant for two reasons. Firstly, medical imaging and exchange of images between heterogeneous healthcare environments have become essential in the delivery of modern healthcare and show one of the best examples of sharing of information generated in pervasive environments. Secondly, the outcome of the integration of the multi-nodal mechanism for software testing and ETICS is a potential web service, which can be used in an ad-hoc verification of the interoperability of medical imaging standards.

The third paper, titled "Computationally Significant Semantics in Pervasive Healthcare", is a sharp contrast to the first two in that it focuses on a particular computational model, dependent on OWL/SWRL enabled ontologies, which automates the delivery of services in self-care homes (SeCH). In order to address the pervasiveness of such environments, in terms of integrating devices, software and people involved in various locations and situations in SeCH, the authors propose OWL/SWRL computations embedded within a particular process, which uses SWRL reasoning for the purpose of delivering correct health services. The rationale behind creating OWL/SWRL enabled computations is to secure the definition and manipulation of semantics of pervasive environments in care homes, which results in decision making based on inference created through the computational model. There are two important outcomes from this research. Firstly, the proposed model and its reasoning process are not performed upon knowledge-bases, using artificial intelligence techniques. The authors propose a software engineering solution which could be implemented as a mobile and android/iPhone application, personalized for SeCH residents. Secondly, their OWL/SWRL enabled computational model does not favor any formal healthcare ontology and it should not be confused with known OWL ontologies which store formal health and medical knowledge. This solution hosts relatively small and portable OWL/SWRL computations, i.e. OWL concepts, its hierarchies and reasoning upon them. They are dynamically created according to the semantics grasped form each situation we detect in SeCH. Services delivered are very often in the form of various automations, advices and warnings. They always result from inference created in the reasoning process. Both of these outcomes can be seen as a step forward towards delivering mobile e-health services in wireless environments, personalized on an ad-hoc basis and according to various situations we may encounter in pervasive healthcare environments such as care homes.

Although the papers in this special issue cover just a few concerns when addressing healthcare services, as a final product in the delivery of modern healthcare, it clearly shows transdisciplinary efforts in solving a range of problems triggered by pervasiveness in current healthcare environments. In one of the papers the pervasiveness is an explicit and inseparable part of the computational model which automates the delivery of healthcare in care homes. In the other two, the pervasiveness is built-in and assumed in their problem domains with a range of technologies, devices and software applications interwoven within them. Furthermore, the papers on ESCAP virtual counsellor and care home services based on OWL/SWRL computations may resemble each other because of their internal decision making processes, which issue recommendations and warnings, as a part of healthcare delivery within their respective environments. However, the software technology and type of software applications which support these two disparate healthcare sub-domains are completely different. ESCAP is an expert system with a rich combination of techniques and technologies deployed within it and SeCH, with its OWL/SWRL enabled computations, is not! It does not need a knowledge-base for performing reasoning and decision making. It is a component based Java application, dependent on ontological repositories, which automates the delivery of healthcare services according to a particular situation we encounter in care homes. Both papers show viable solutions when looking at the automation of processes and workflows in healthcare environments. By juxtaposing them in this special issue, I hope to trigger discussion on future research directions when automating the delivery of products in pervasive healthcare and pervasive environments in general. I would like to think that crossing boundaries between research and creating new knowledge and discoveries in healthcare, accompanied with standards, workflows and procedures, will open the healthcare research towards other disciplines and help us to define new processes, products and services, regardless of the level of pervasiveness we encounter. Furthermore, all three papers highlight the power of software engineering concepts, techniques and technologies. They are in the core of the solutions these papers advocate and probably provide new types of software engineering ideas as solutions, compared to traditional healthcare applications, focused on either the manipulation of patient records or clinical decision making. However, they all must be synchronised and interwoven with social, technological and cognitive aspects of modern healthcare, if we wish to claim that we create functional cyber-physical spaces in healthcare.

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