

Pervasive Healthcare: From Orange Alerts to Mindcare

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ABSTRACT

This purpose of this article is to help the reader understand the research area of *pervasive healthcare* and pervasive healthcare computing. It defines the term, and discusses the 2011 conference on Pervasive Computing Technologies for Healthcare, held in Dublin, Ireland. In particular, it examines the workshops proposed for the conference, highlighting the current exploratory research on the fringe of the area of pervasive computing, before discussing the implications for mainstream healthcare.

1. INTRODUCTION

Healthcare technologies nowadays are increasingly pervasive. They are moving into the working environment of healthcare professionals and the homes of those receiving care. The field of Pervasive Healthcare is concerned with the development and application of pervasive computing to the healthcare domain. More specifically, it “addresses a set of related technologies and concepts that help integrate healthcare more seamlessly into everyday life, regardless of space and time.” [1]

The complexity and scope of pervasive healthcare has brought together practitioners from a wide range of disciplines. From technologists to designers, to health and social care practitioners and healthcare policy makers, the stakeholders in healthcare are varied and wide. A shared challenge however, is to design appropriate and usable pervasive healthcare systems, and to evaluate them fairly and systematically in order to increase their uptake and use. This community is brought together yearly in the Pervasive Healthcare conference. This article gives a brief overview of the field of pervasive health and provides a preview of the conference to be held in Dublin, Ireland in May 2011 in order to present a checkpoint for where we are in state of the art in pervasive healthcare research.

2. WHAT IS PERVASIVE HEALTHCARE?

Before going into details about Pervasive Healthcare, we must first clarify what is meant by the term. Pervasive Computing refers to distributed and embedded sensor networks and computing technologies. The most commonly cited motivation and driving vision for the field is Weiser’s vision of invisible computing [5]:

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

Technology was envisioned that could respond to the context of a user in such a way that using the technology becomes effortless. In order to respond, technology would first have to be able to detect the context of the user. Through networks of sensors distributed around an environment or worn on a body such ability has, in part, transpired. For more thorough discussions on the current state of ubiquitous computing please see [2,3].

Varshney [4], provides useful definitions of Pervasive Healthcare and Pervasive Healthcare Computing:

Pervasive healthcare is the conceptual system of providing healthcare to anyone, at anytime, and anywhere by removing restraints of time and location while increasing both the coverage and the quality of healthcare. Pervasive Healthcare Computing is at the forefront of this research, and presents the ways in which mobile and wireless technologies can be used to implement the vision of pervasive healthcare.

Sensors, sensor networks, mobile, and wireless technologies can therefore be considered the technological foundation of Pervasive Healthcare Computing. However, to apply such technology successfully to the healthcare domain and to help to realize the vision of seamless integration of healthcare into everyday life, it is necessary to take a multidisciplinary approach. As such, the Pervasive Healthcare community has a broad scope of research topics and concerns including:

- identifying and understanding problems from a technological, social, and medical perspective (with a particular emphasis on understanding and supporting the needs of all people using the systems directly (end users) or indirectly (friends, family, health and social care professionals);
- design, implementation, and evaluation of supporting hardware and software infrastructures, algorithms, and applications; and
- organisational strategies that facilitate integration of Pervasive Healthcare Technology into the healthcare enterprise.

Since 2006, the ICST Conference on Pervasive Computing Technologies for Healthcare has been the premier forum for researchers, practitioners, industry and international authorities contributing towards the assessment, development and deployment of pervasive health technologies, standards and procedures. In 2011, Pervasive Health features a special theme of Coping with the Challenges and Opportunities within Pervasive E-Healthcare (COPE), with a special focus on pervasive healthcare management and its ability to deliver timely, quality based information to medical practitioners in providing high levels of patient care. Also in 2011, the conference features a record number of workshop proposals, all with topics at the forefront of Pervasive Health research. Here we examine the themes of the workshops held in conjunction with the conference in order to present a flavor of the state of the art in Pervasive Health research in 2011.

3. The Pervasive Health ‘Fringe’

The workshops proposals for 2011 reflect the aforementioned scope of research topics and concerns, and illustrate some of the

health and wellbeing domains that may benefit from innovations in this field. They are, in effect, the research ‘fringe’ of the main conference and can reveal trends and other insights on the evolution of pervasive healthcare. The workshops cover three main areas of pervasive healthcare, including theory and practice, applications and application areas, and sensor technologies. The workshops relating to theory and practice include *integration within health services of assisted-living, telemedicine & tele-healthcare systems* and *user-centered design*. A large number of the workshops cover application areas, including *mental health, Dementia and carers, serious games* and several specifically on care at home including *home rehabilitation, older adults in the home* and *assisting care in the home*. Finally two workshops address sensor technologies; these are *activity inference and data visualization* and *cognitive sensor networks*. The following sections highlight each of these main themes of Pervasive Healthcare.

3.1 Sensor technologies

As was discussed earlier, sensor technologies form the very core of the technological research and development in Pervasive Healthcare. Example applications of sensor technologies range from activity and physiological monitoring (instrumenting the person) to smart homes (instrumenting our environment).

Situation recognition and medical data analysis in Pervasive Health environments reflects on the state of the art in situation recognition, medical data analysis, and behavior monitoring. This includes considering technological aspects such as data fusion in pervasive healthcare environments and decision support algorithms, as well as social implications and acceptance of the resulting technologies. In contrast, *Cognitive Sensor Networks for Pervasive Health* focuses on one particular approach to supporting the vision of Pervasive Health. Key aspects of this vision are the correct monitoring and understanding of how people interact with their environment; how they can actually benefit from the added intelligence; and finally how future services can be improved or better personalized to enhance human environment interaction as a whole. One aim of this research is to define a framework for cognitive sensor networks.

3.2 Applications and application areas

The workshops in Pervasive Health 2011 represent both established and emerging Pervasive Health application domains: condition management, serious games, and homecare.

The development of technologies and applications that assist in the detection, management, and prevention of specific conditions has been an active area of research since the first Pervasive Health conference. Traditionally, physiological conditions have been the primary focus of such research efforts. More recently, the scope of such applications has expanded to include cognitive and behavioural conditions.

Focusing on preventative mental health interventions and applications, *MindCare* is concerned with the exploitation of technology in favor of cognitive and emotional wellbeing. *Pervasive Care for People with Dementia and their Carers* aims to provide a forum for discussion on challenges and opportunities in bringing technology to support people with dementia.

In addition to more traditional forms of intervention, Serious Games are also an emerging genre of condition management and prevention technology. *Therapeutic Serious Games and Pervasive Computing* explores the use of Serious Games for

telerehabilitation. More specifically, it aims to consider the technological, medical and ethical challenges of developing *theragames* and integrating them into clinical practice.

Many researchers are currently investigating ways to deliver health care and assistance in the home. The *Envisaging the Future of Home Rehabilitation* workshop focuses on how to design systems for rehabilitation in the home and investigate how technology can encourage adherence and health and wellbeing management in a myriad of ways from visualizations to games. Paying particular attention to systems that encourage independence and boost the confidence of the users in the home or other care settings, this research focuses on home-based systems that support for home-based activities in such a way that the need for direct supervision by allied health and social care professionals is eliminated.

Existing commercial homecare systems for elders tend to focus on the emergency scenarios, or red alerts, when a person has fallen or is otherwise incapacitated. To truly care for people in their homes more has to be done to take action based on ‘orange alerts’ scenarios such as depression cognitive decline or physical decline. *Behavior Modeling and Health of older people in their homes* reflects on what has been done to date on behavior modeling and health decline detection of older people in their homes, what is missing from the research and what is required for industry to be able to provide this technology to older people.

Advances in Techniques and Technologies Assisting Care at Home - This workshop brings together researchers, developers and practitioners with an active interest in technologies that specifically support delivery of care in the home. Discussions in this area focus on: architectures and platforms for home care systems; sensor and actuator networks for the home, including novel devices for telecare/telehealth; automated collection, analysis and interpretation of home care data; design and assessment of novel interfaces for home care systems; specific solutions to help with activities of daily living, prompting, reminding, guidance; communication and community-building; policy, economic, psychological and social factors in home care technology; privacy, confidentiality, security and ethical issues in computer-supported home care.

3.3 Theory and practice

The theory and practice workshops at Pervasive Health seek to address the issue of how to ensure that the technological advances made by Pervasive Health research materialize into real world artifacts, practices, and outcomes. One commonality between these workshops is the call for multidisciplinary academic-industry-practitioner collaboration and coordination needed to design and implement successful pervasive healthcare technology.

The organizers of *User-Centered Design of Pervasive Healthcare Applications* argue that significant improvements in pervasive healthcare systems are only possible if academics and practitioners from various disciplines collaborate in order to develop new strategies for conceptualizing, designing, and implementing new applications. They advocate taking a holistic approach to the design of pervasive healthcare applications, suggesting underlying strategies must be harmonized and balanced in two ways: first, within the technological areas, and second, regarding the integration of technologies into the medical, cognitive, and social context. This also includes the way technology acts within the life courses of individuals and

societies, and the balance of the benefits that technology brings against perceived or actual medical, social as well as ethical risks.

In contrast to considering the challenges inherent in the effective design of Pervasive Health systems, *Designing and Interating Independent Living Technology* considers the challenges involved in the large-scale deployment of tele-medicine and tele-healthcare systems. Example barriers include, complexity of needs, fragmentation of the e-health industry, lack of standards and issues of interoperability of systems, a lack of underlying clinical evidence-based of successful outcomes and entrenched resistance to innovation from some certain sections of the health services or services users.

4. CONCLUSION

Governments are spending significant and increasing amounts of their tax incomes on health and social care for ill, frail, disabled and older people. An examination of our population demographics reveals that the ageing of the post-WWII 'baby-boomers' around the world will result in many more older people requiring health and social care and support. One way to continue to provide care with reduced budgets and increased numbers of people requiring care is to use technology to support and extend the care provision.

Pervasive Healthcare is a broad framework in which technology-supported care can be positioned, examined and developed by the many stakeholders involved in the provision of care. It offers care for people in their own homes, so-called 'aging-in-place' or 'independent living'. People using pervasive healthcare can self-manage their care, or interact with a health and/or social care team electronically, e.g., monitoring diabetic patients at home. This move to self-care aligns with changes in the political landscape, where personal health budgets or 'personalized healthcare packages' are seen as a way of devolving costs and cost decisions to the individual. Some chronic conditions require sophisticated analysis and support of data relating to people's disease and pervasive healthcare can address this, offering automated or technology-enhanced care for day-to-day management of conditions and rapid interventions when appropriate using knowledge-rich decision making.

Pervasive healthcare services are becoming more common around the world with many countries seeking to transition from large-scale pilots to everyday usage. This brings with it a new wave of research issues, ranging from user issues including usability, accessibility, privacy, stigma and abandonment of technology, to service and commissioning issues such as service evolution management, incorporation of technology into everyday services, evolution of business models for self-care, etc.

As pervasive healthcare technologies mature, the focus now inevitably and justifiably shifts towards identifying appropriate application areas. The identification of such application areas depends on both advancement of the technology and a thorough understanding of the proposed clinical and social context of use. It also requires a systematic approach to design, development, evaluation and large-scale deployment, and collaboration between all stakeholders. These are the very things that are being addressed by at the Pervasive Health conference series and the Pervasive Health community.

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This article has used the 2011 Pervasive Health workshops to frame our discussion of the current state of the Pervasive Health research 'fringe'. As such, we have abridged the words of the

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6. REFERENCES

- [1] Bardram, J.E., Mihailidis, A., and Wan, D.: 'Pervasive Computing in Healthcare' (CRC Press, 2006)
- [2] Bell, G., and Dourish, P.: 'Yesterday's tomorrows: notes on ubiquitous computing's dominant vision', *Personal Ubiquitous Computing*, 2006, 11, (2), pp. 133-143
- [3] Rogers, Y.: 'Moving on from Weiser's Vision of Calm Computing: Engaging UbiComp Experiences'. *Proc. 8th International Conference on Ubiquitous Computing*, 2006, Springer, pp. 404-421
- [4] Varshney, U.: 'Pervasive Healthcare Computing' (Springer, 2009)
- [5] Weiser, M.: 'The Computer for the Twenty-First Century', *Scientific American*, 1991

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