Administeration of Medical Contexts with Denotational Mathematics in Ubiquitous Computing Home Environments


Aristides Vagelatos, CTI “Diophantus”, Athens, Greece

Isaac Lagaris, Computer Science and Computer Engineering Department, University of Ioannina, Ioannina, Greece

ABSTRACT

Home healthcare promises significant advantages over the traditional hospitalization, provided the support of the contemporary scientific and technological achievements. The ubiquitous computing paradigm suits the home healthcare provided that the dispersed computing devices in the home environment can actively participate in the interpretation of the developed, each time, medical context. Large numbers of disseminated sensors and computing devices, wirelessly and ad-hoc connected, present problems related to energy limitations and the patients’ mobility introduce systemic complexity, uncertainty, and ambiguity. The formal description of such systems requires the inclusion of extensive details becoming tedious, if not impractical. Denotational Mathematics provides an alternative formal methodology framework capable to formally describe the constituting components, the performed operations, and the static and dynamic behaviors of complex system. Employing the expressive power of Denotational Mathematics, it is attempted to design a system that develops medically valid contextual contents adequate to support patients hospitalized at home. The formally described design provides the contents of the medical context enriched by the rules of the current state of medical knowledge. Denotational Mathematics provides the means to formally present the conceptual comparison between technically obtained medical contexts against predetermined medical contexts to obtain valid interpretations. The presented design has the ambition to formally describe the required cooperation of discrete ubiquitous computing applications to achieve the development of a commonly interpreted medical context at home.

Keywords: Denotational Mathematics, Fuzzification, Home Care, Medical Environment, Ubiquitous Computing

DOI: 10.4018/IJSSCI.2015040101
1. INTRODUCTION

According to the ubiquitous computing paradigm, the term introduced by Mark Weiser (1991), many networked and closely cooperating sensors and computing devices which are implanted, worn, or carried by the user synthesize a dynamic computing system. Such a system (Friedemann, 2001) is required to present the characteristics of transparency, adaptability, availability, awareness, reliability, scalability, connectability, and reusability. The end-user is supported unobtrusively, the way someone is using eyeglasses, available everywhere and at any time. The supporting software is always aware of the evolving situational context, the feature of context-awareness.

In the ubiquitous computing environment, independently operating sensors measure physical magnitudes. The values of the sensors measuring the same magnitudes must be fused in order to obtain the dominating value for each measured magnitude. The operation of the measuring sensors can be cooperative, competitive, or complementary. Moreover, the sensors can be classified as either physical, directly measuring devices, or virtual, resulting from the physical sensors’ data correlation without succeeding, so far, to find a generalized fusion model (Zhang, Cao, Zhou, & Guo, 2009) for home healthcare.

The disseminated physical sensors at home are characterized by practical limitations caused by user’s mobility or energy availability and thus introducing uncertainty. There are two types of uncertainty, the objective uncertainty, caused by random events and situations at home, and the subjective uncertainty, caused by missed information and by the holding state of knowledge. Uncertainty develops when sensors contribute incomplete, imprecise, or conflicting measurements. The determination of uncertainty requires precise hypotheses probability values from mutually exclusive sensors which is hard to obtain in real-time conditions. Instead, intervals of probabilities of sensors’ readings can be considered, expressing the confidence about the sensors’ reliability applying the Dempster-Shafer evidence theory -DSET- (Zhang et al, 2009) (a generalization of the Bayesian probability theory) referring to discrete and finite readings from single or multiple sensors applied on sets of events. The DSET method presents problems related with the emblematic Zadeh’s paradox (1986) and the excessive computational overhead which is partially reduced applying DSET’s extensions such as those proposed by Yger (1987), Boujelben et al. (2009), and Zhang et al. (2009).

Home healthcare is an alternative paradigm provided that the necessary infrastructure is in place supporting the inhabitants’ health status. The provision of health services at home presents advantages over the experienced conventional ways with respect to financial savings, the quality level of the provisional health services, and the avoidance of hospital infections. Healthcare faces three categories of patients, first, the healthy population, second, the people experiencing a health crisis, and third, the chronic patients. The provision of healthcare services at home can be based on a ubiquitous computing system which is capable of supporting the dynamic development of consecutive contexts on which the decision making relies on. However, the available analytic mathematics has limited practical expressive power to describe dynamic abstractions of context in home healthcare. The developing context at home evolves in time and it is tedious or impractical to analyze and examine with analytical mathematics due to the unavoidable large number of details.

The complexity developed by the interrelationships among the sensing and the computing devices supporting healthcare at home obliges to look for alternative mathematical tools. Denotational mathematics propose an alternative way of handling complex data structures beyond the conventional use of sets and calculus functions which find difficulties in representing relationships, behaviors, concepts, and knowledge. The complexity of the analytic mathematics for the formal description of medical contexts at home leads to the adoption of denotational mathematics.
Related Content

Toward Automatic Answers in User-Interactive Question Answering Systems
Tianyong Hao, Feifei Xu, Jingsheng Lei, Liu Wenyin and Qing Li (2011). International Journal of Software Science and Computational Intelligence (pp. 52-66).
www.igi-global.com/article/toward-automatic-answers-user-interactive/64179?camid=4v1a

Quantum Backpropagation Neural Network Approach for Modeling of Phenol Adsorption from Aqueous Solution by Orange Peel Ash
www.igi-global.com/chapter/quantum-backpropagation-neural-network-approach/72511?camid=4v1a

Evaluating the Security Level of a Cryptosystem based on Chaos
Jesus D. Terrazas Gonzalez and Witold Kinsner (2012). International Journal of Software Science and Computational Intelligence (pp. 80-120).
www.igi-global.com/article/evaluating-security-level-cryptosystem-based/76271?camid=4v1a
A Two-Stage Zone Regression Method for Global Characterization of a Project Database
J. J. Dolado, D. Rodríguez, J. Riquelme, F. Ferrer-Troyano and J. J. Cuadrado
(2007). Advances in Machine Learning Applications in Software Engineering (pp. 1-13).
www.igi-global.com/chapter/two-stage-zone-regression-method/4854?camid=4v1a