Chapter 15
Multi–Sensing Monitoring and Knowledge–Driven Analysis for Dementia Assessment

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ABSTRACT

DemaWare is a Service-Oriented platform that aids in the timely assessment and monitoring of people with dementia in an Ambient Assisted Living context. This work presents in detail the underlying modules integrated in DemaWare, providing both software and hardware services. The system coordinates the retrieval of raw sensor data from a variety of sources, such as ambient and wearable sensors, and their processing into a common knowledge base. The semantic interpretation performed afterwards reasons upon collected knowledge and infers higher level observations. Finally, all knowledge is presented in suitable end-user applications that support various scenarios, e.g. lab assessment trials and monitoring in nursing home environments.

INTRODUCTION

Ambient Intelligence (AmI) (Weiser, 1991) is one of the leading technological paradigms of the future, building upon the visions of Pervasive and Ubiquitous Computing. Facilitated by the portability, accessibility and affordability of both sensors and computing devices, these notions are increasingly penetrating every-day life. AmI further enhances the use of surrounding, non-intrusive computing devices with

Artificial Intelligence techniques. Systems enhanced by AmI have already been investigated and deployed for a variety of application domains, such as smart homes (Friedewald, Costa, Punie, Alahuhta, & Heinonen, 2005), offices (Le Gal, Martin, Lux, & Crowley, 2001), agriculture (Eisenhauer, Rosengren, & Antolin, 2010) and health. Applications of AmI systems in the health domain have grown to contribute to a wider flourishing domain of ICT for health, otherwise known as Ambient Assisted Living (AAL) (Kleinberger, Becker, Ras, Holzinger, & Müller, 2007). AAL specifically targets Quality of Life, eHealth and support for the elderly, disabled or, in general, people in need of medical attention.

The DemaWare system (Dem-entia a-mbient middle-Ware), specifically targets people with dementia, in terms of assisting in their assessment, timely diagnosis and medical care, in an AAL context. The system is deployed as a software implementation of the Dem@Care (Dementia ambient Care) project[1], which investigates novel solutions for the holistic management of dementia, based on both medical knowledge and the latest advances in ICT. To this end, DemaWare capitalizes upon advances in pervasive computing and sensor technologies, promising to deliver a multi-parametric monitoring framework that will sustain context-aware, personalized and adaptive feedback mechanisms for the remote management of people with dementia. These include, among others, sensors for vital signs monitoring, location sensors, lifestyle sensors, such as accelerometers, light and door sensors, as well as wearable and static cameras and microphones. Through the fusion and aggregation of the different types of knowledge, DemaWare provides personalized feedback and care management services coupling clinical and domain knowledge with patients' contextual history and care plans.

The system was previously, briefly introduced in (Stavropoulos, Meditskos, Kontopoulos, & Kompatsiaris, 2014), giving an overview of the underlying modules for sensor and analysis support. This work presents further details on the integration of the underlying modules and applications. At its core, DemaWare provides a Service-Oriented middleware as an integrated solution for remote, universal access to its underlying software components, based on well-defined web standards. It also handles the orchestration of both online (push-based) and offline (pull-based) sensor data retrieval and analysis into semantic knowledge, over a common exchange schema. Its universal API ensures that the applications are built based on the necessary abstractions from low-level and platform dependent actions. Various roles in the context of AAL for dementia are supported through targeted applications, such as lab trials or remote monitoring at nursing homes and patient homes.

Additionally, this work also gives further insight into the semantic interpretation module, responsible for sensor information fusion and higher-level activity deduction. The specific module provides the vocabularies for modelling the application context (e.g. activities, measurements, locations and objects) and encapsulates the inferencing capabilities of the framework for the derivation of complex activities. Additionally, since the incoming data is vastly heterogeneous and inherently noisy, the derivation process is assisted with the incorporation of Defeasible Logics into the semantic interpretation module for handling uncertainty.

The rest of the paper is structured as follows: the next section presents an overview of DemaWare; each subsection presents a layer of the system, ranging from hardware and data layers to the analysis, service, semantic interpretation and application layers. The semantic interpretation subsection further describes the ontologies, fusion and uncertainty handling techniques employed in the system. The next sections provide a survey of related state-of-the-art research, conclusions from this work and directions for future research.

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