The 6th International Conference on Ambient Systems, Networks and Technologies (ANT 2015)

A Probabilistic Non-Monotonic Activity Qualifier

Juan Carlos Nieves[a,*], Saeed Partonia[a], Esteban Guerrero[a], Helena Lindgren[a]

[a]Department of Computing Science, Umeå University, SE-901 87, Umeå, Sweden

Abstract

The International Classification of Functioning, Disability and Health (ICF) defines Functioning and Disability as the results of the interaction between the health conditions of a person and his/her environment. It considers a set of components and qualifiers to evaluate activity and participation. In this paper, we interpret a *performance quantifier* under a human activity recognition process. To this end, we introduce a novel definition of an activity which is based on ICF guidelines. This definition gives place to *a probabilistic non-monotonic activity qualifier*. In order to recognize an activity according to our novel activity's definition, we explore non-monotonic reasoning technics to capture domain knowledge in terms of action specification languages. By considering an action specification language, called C_{TAID}, and Answer Set Programming, we propose and develop a system called **ActRec** system which takes background information into consideration and recognize activities according to our suggested definition. Moreover, we show that by aggregating our probabilistic non-monotonic activity qualifier, we are able of detecting complex activities, *e.g.*, long-term activities. We illustrate our approach in the context of an ambient assisted living environment called *As-A-Pal*.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license
(http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the Conference Program Chairs

Keywords: Reasoning technology for ambient sensing; Activity Recognition; Non-monotonic Reasoning; Smart-Environments.

1. Introduction

The International Classification of Functioning, Disability and Health (ICF) belongs to the family of international classifications, categorizing functioning and disability associated with health conditions, developed by the World Health Organization (WHO)[23]. *Functioning* is treated in ICF as a generic term for body functions, body structures, activities and participation. By contrast, *Disability*, as defined in ICF, is an umbrella term for impairments, activity limitations and participation restrictions. These two aspects of the interaction between an individual and that individual's contextual factors (environmental and personal factors), require different quantification and qualification tools for measuring the notions of "health" and "disability".

Qualifiers record the presence and severity of a problem in functioning at the body, person and societal levels. The ICF defines two main qualifiers in relation to activity and participation: *Performance* and *Capacity*[14]:

* Corresponding author.
  E-mail address: jcnieves@cs.umu.se; saeed.partonia@gmail.com;esteban@cs.umu.se; helena@cs.umu.se

- The *Performance* qualifier describes what an individual does in his or her current or natural environment. This would be what an individual *really does*, *e.g.*, what purposeful activities an older adult does at home, or in their community.
- The *Capacity* qualifier describes an individual's ability to execute a task or an action in a controlled environment. This qualifier tells us what an individual is *capable* of doing in a structured clinical situation, *e.g.*, measuring the ability of an older adult to stand in a feet tandem position when executing the Short Physical Performance Battery test.

Having access to both Performance and Capacity data enables clinicians and practitioners to determine the *gap* between capacity and performance. If capacity is less than performance, then the person's current environment has enabled him or her to perform better than what data about capacity would predict: the environment has facilitated performance. On the other hand, if capacity is greater than performance, then some aspect of the environment is a barrier to performance [14].

In the literature, quantification measures and evaluation of physical activity based on information obtained by sensors are accepted as valid evidence of a physical phenomena [2,4,18,19,20,21]. In these technological approaches, the evidence is linked to the confidence of the captured observations.

As-A-Pal is a smart environment where the acronym As-A-Pal refers to *Agent-Supported Assessment for Adaptive and Personalized Ambient Assisted Living*. As-A-Pal also refers to *like a friend*, an artificial companion that knows the immediate needs of the human actor, her preferences, priorities and abilities, so that adaptive and personalized services tailored to the current context can be provided. Kitchen As-A-Pal builds on and complements our earlier work on smart homes [11], adaptive systems for older adults [10] and knowledge-based support systems for the medical domain [9]. Kitchen As-A-Pal serves as a living laboratory environment for designing and developing a range of different knowledge-based applications intended to be deployed as part of a holistic approach to ambient assisted living. The objects in Kitchen As-A-Pal are embedded with sensors, actuators, physical interfaces and ambient displays. Kitchen As-A-Pal is augmented with sensors and passively tagged objects. The physical and ambient interfaces provide access to information and services. Some of the mock-up services include recipe provider, medication manager, shopping assistant and self-improvement games.

Understanding and inferring human activities and the context in which they take place is a research challenge. Human activities take place at multiple levels simultaneously: from the level of body and body-part movements, to the interaction with situated objects, to performing goal-directed actions to performing complex activities with clearly defined motives [12]. While there are several approaches to activity recognition in a smart home [22,7] that are of importance, such approaches are not based on a formal definition of an activity and their associated context thereby answering *"what activity was performed?"* but are insufficient in answering *"how the activity was performed?"* and *"how can we be sure that the activity was performed?"* A smart home worthy of its name in providing activity support requires additional knowledge about an activity and better qualitatively describe the activity performed [5].

Against this background, we introduce *a novel definition of an activity* which follows the guidelines of ICF. This definition is introduced in terms of actions and sets of fluents which are called states. Considering this definition, we introduce the so called Δ-*performance qualifier*. In order to capture context information, we model an environment in terms an action specification language called C_{TAID}. To recognize activities according to our suggested definition, we propose and develop a system called **ActRec** system which has been plugged in Kitchen As-A-Pal. The ActRec system infers the Δ-performance qualifier of a given activity. This degree shows evidence about the performance of a given activity; moreover, according to ICF, this degree can be regarded as a performance quantifier. We will show that by considering long terms evaluations of this performance quantifier, we are able to observe an emerging behavior of an observed Persona.

The rest of the paper is divided as follows: Section 2 introduces the theoretical contributions of this paper, namely new definitions of an activity and the definition of the Δ-*performance qualifier*. Section 3 presents a short description of ActRec system. Section 4 illustrates the work flow of ActRec system. Section 5 presents an application of the Δ-performance qualifier. In the last section, we outline our conclusions.