Social-aware and context-aware multi-sensor fall detection platform

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Abstract. A social- and context-aware multi-sensor platform is presented, which integrates information of fall detection systems and sensors at the home of the elderly, by using an ontology. This integrated contextual information allows to automatically and continuously assess the fall risk of the elderly, to more accurately detect falls and identify false alarms and to automatically notify the appropriate caregiver.

Keywords: Fall Detection & Risk Assessment, Semantic, Context-aware

1 Introduction

For elderly fall incidents are often life-changing events that might lead to degradation or loss of autonomy. More than half of the elderly living in nursing homes and about one third of the elderly living at home fall at least once a year [4]. 10 to 15% of them suffer severe injuries [6]. Psychological consequences can also not be underestimated. Reliable fall detection and prevention are thus necessities.

The fall risks, e.g., impaired mobility and gait, are assessed by formal caregivers with standardized tests on predefined, long time intervals. As a result, targeted measures and advice are formulated. Attempts to automate this assessment and follow-up through domotic and monitoring systems are limited and not integrated [6]. Several systems exist to detect falls, e.g., Personal Alarm Systems (PAS), accelerometers, video cameras and micro arrays. However, the PAS is often not worn and false alarms and undetected falls regularly occur [1, 3, 6]. When the help desk is notified of a fall, a predefined ordered list is used to assign it. The current context of the (in)formal caregivers, e.g., location or availability, is thus not taken into account, resulting in unnecessary delays and distractions.

The FallRisk project[1] aims to develop a social- and context-aware multi-sensor framework to: 1) automatically assess the potential fall risks and the compliance of the elderly to advice by monitoring his or her behavior, 2) reduce the amount of undetected calls and false alarms by combining the information gathered by the plethora of fall detection systems and sensors installed at the home of the elderly, and 3) automatically select the (in)formal caregivers to

[1] http://www.iminds.be/en/research/overview-projects/p/detail/fallrisk-2

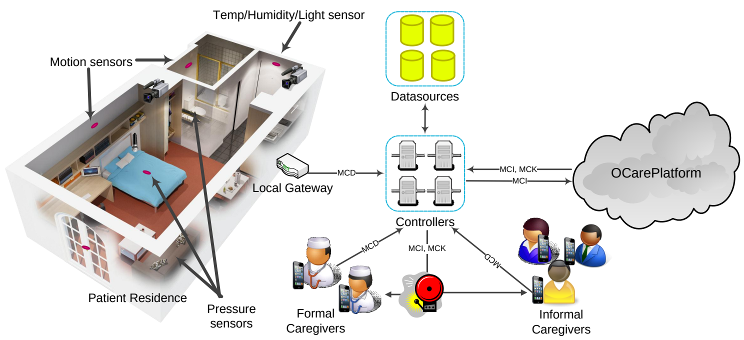

Fig. 1: General architecture of the fall detection platform

whom an alarm or notification should be sent based on the current context. To realize this goal, the framework integrates the heterogeneous and voluminous raw data gathered by all the devices in an ontology. Based on this integrated view of the current context, more intelligent algorithms can be defined.

2 General Architecture of the FallRisk system

To detect falls and assess the fall risk, sensors are installed within the home of the elderly as shown in Figure 1. Three types of context information are captured: 1) the environment, e.g., by temperature, humidity and light sensors, 2) the activity level of the elderly, e.g., by passive infrared motion sensors, and 3) position information, e.g., by pressure sensors. Fall detection and risk assessment systems are also integrated. Finally, data is gathered from the elderly's smartphone. Note that, not all devices should be installed. Depending on the needs and preferences of the elderly, the most appropriate ones should be selected that complement each other and lead to a reliable set-up for continuous monitoring.

The raw Care Data (CD) generated by the devices is gathered on the *Local Gateway* at the residence. To save bandwidth, the gateway already processes some information, e.g., the video images. To provide a back-up plan when the connection to the servers is lost, the *Local Gateway* is able to do some rigorous analysis of the data. Finally, the gateway transforms CD into Meta Care Data (MCD) by enriching it with, e.g., timestamps, identifiers and location.

The *Controllers* manage the connections between the *OCarePlatform* and the clients providing MCD, i.e., *Local Gateways*, caregivers' smartphones and databases of the care organizations. The MCD is back-upped within the *Datasources*. These also store all static information related to the elderly and caregivers. The *Controllers* transform the MCD to Meta Care Information (MCI) by tagging it with one or more Meta Care Concepts (MCC). The *OCarePlatform* uses the MCC to identify the corresponding ontological concept such that the MCI can be correctly integrated into the ontology.

The MCI is sent to the *OCarePlatform*, which infers new Meta Care Knowledge (MCK) by using ontology-based reasoning. Derived knowledge, concerning contextual information and fall estimation and detection, is sent back to the

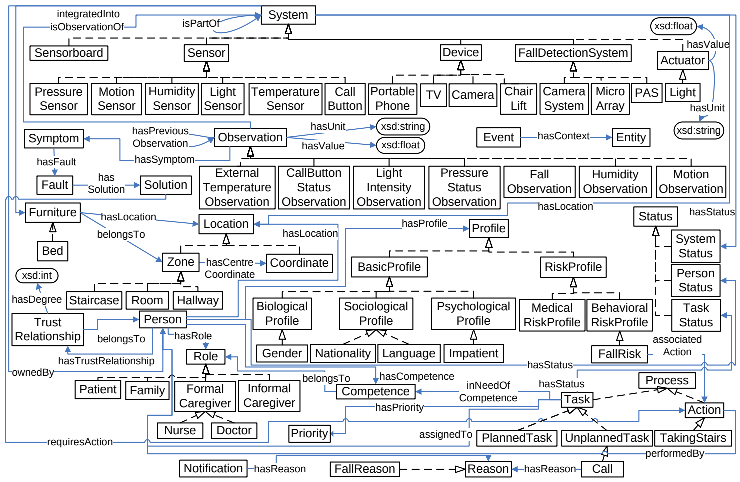

Fig. 2: Prevalent concepts of the ambient-aware continuous care ontology for fall risk estimation and fall detection

Controllers. They are responsible for notifying the correct caregiver(s) or the emergency response center based on the derived knowledge.

3 The OCarePlatform

The OCarePlatform facilitates the intelligent and coordinated integration, analysis, combination and efficient usage of the large amount of MCI sent by the *Controllers* by using ontologies. To model the knowledge pertaining to fall detection and risk assessment, the Ambient-Aware Continuous Care Ontology (ACCIO) [5], was extended as shown in Figure 2.

As shown in Figure 3, MCI enters the OCarePlatform through the *Context Provider Services*, which transform it to ontology individuals by analyzing the associated MCCs. As these map on ontological concepts, the *Context Provider Services* know which type of individuals need to be created and how they should be created by analyzing the axioms defined in the ontologies.

The OCarePlatform is developed as a modular platform, consisting of an extensible set of *MCI Services*. These are the brains of the platform. They process the large amount of data in an efficient and manageable manner. Each service has a specific task, which can be implemented by 1) specifying axioms in the ontology to classify the incoming information and link it to appropriate action, 2) adopting rule engines to perform more complex analyses, and 3) integrating proprietary algorithms. Some example services are shown in Figure 3.

Consequently, there is a need for an intelligent filtering system, capable of sending only that data to the *MCI Services* in which they are interested at that time. For this, the *Semantic Communication Bus SCB* [2] was designed, which uses the extended ACCIO ontology to filter the data based on its semantics, instead of on syntactical text patterns. Ontological data is published onto the *SCB* by *Context Provider Services* by using the *Context Manager*. The *MCI Services* use this *Context Manager* to specify the context they are interested

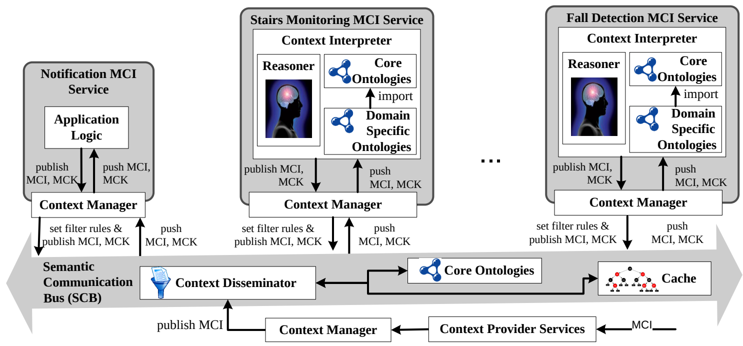

Fig. 3: Architecture of the OCarePlatform

in, by defining ontological *filtering rules* and registering them with the *Context Disseminator*. This allows to reduce the amount of data that is forwarded to the *MCI Services*, which prevents them from being flooded with huge amounts of data. It also facilitates an agile approach, where new services can easily be deployed or duplicated for scalability and redundancy. For example, the *Fall Risk MCI Service* registers the following rule:

Event **and** hasContext **some** ((Action **and** (isPerformedBy **some** (hasRole **some** Patient)))
LichtIntensityObservation)

It is important to note that all conclusions, called MCK, drawn by the *MCI services* are put back on the *SCB*. In this way, conclusions drawn by one *MCI service* can be used by a second *MCI service* as additional situational information. As such, the OCarePlatform supports the composition of complex services from a set of smaller services in a loosely coupled manner. The simple services perform specific reasoning tasks in parallel and notify their conclusions to other services, which have expressed an interest in this kind of information.

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