Personalisation of Intelligent Homecare Services Adapted to Children with Motor Impairments

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Abstract. Ambient Intelligence could support innovative application domains like motor impairments´ detection at the home environment. This research aims to prevent neurodevelopmental disorders through the natural interaction of the children with embedded intelligence daily life objects, like home furniture and toys. Designed system uses an interoperable platform to provide two intelligent interrelated home healthcare services: monitoring of children´s abilities and completion of early stimulation activities. A set of sensors, which are embedded within the rooms, toys and furniture, allows private data gathering about the child´s interaction with the environment. This information feeds a reasoning subsystem, which encloses an ontology of neurodevelopment items, and adapts the service to the age and acquisition of expected abilities. Next, the platform proposes customized stimulation services by taking advantage of the existing facilities at the child´s environment. The result integrates Embedded Sensor Systems for Health at Mälardalen University with UPM Smart Home, for adapted services delivery.

1 Introduction and State of the Art

Ubiquitous Computing and Ambient Intelligence (AmI) bring forwards innovative opportunities to provide key health services at the Point of Care [1]. The availability of smart monitoring solutions at home can provide medical doctors, physiotherapists and carers with reliable data about people´s health status when required. This facility could trigger secondary and tertiary prevention activities to reduce disease related complications for children with musculoskeletal impairment, as stated by the World Health Organization and the World Bank [2]. This paper details EDUCERE, a set of child adaptable smart care services that use AmI paradigm for early attention of motor impairments in children who are often not diagnosed or treated by health care entities.

The Council of Children With Disabilities of the American Academy of Pediatrics pointed out in 2006 the possibility to identify infants with developmental disorders at

the home scenario [3]. Thus, the personalised analysis of children's interaction with the daily life objects, such as toys or home furniture, could help to find out potential disorders on their neurodevelopment in a natural way. This new smart environment for the child needs data acquisition from embedded intelligence sensor systems in order to provide an adaptable reasoning subsystem with real time data that supports decision taking according to scientific knowledge about the children´s evolution. The service must take into account that usability, reliability and privacy of such systems are critical to guarantee a natural and safe interaction of the child, and this requires a user-centred development approach [4].

Embedded Sensor Systems can support the use of smart-objects based interaction to acquire and process physiological and environmental parameters at home. Example of interesting parameters to monitor is motion parameters, as activity levels and deviations from normal behavior, position, acceleration, and motion patterns for daily interaction. Multiple innovations demonstrate the feasibility to manage the interaction with the environment of people with movement disorders for homecare [5, 6].

The aim of this research paper is to show the design and integration of EDUCERE adaptable home healthcare services, which use the potential of embedding sensors in toys and pieces of furniture, in order to carry out smart prevention and early attention of motor impairments by monitoring and stimulating children´s physical activities.

2 System Design for Adaptive Home Healthcare Services

This research requested to design a set of children centred adaptable home healthcare services that rely on the personalisation capabilities of the system according to the expected human interaction procedures. Thus, the system functionality was defined by starting from the user characterization at the home environment. Further to the modelling of users´ needs or wants, published by Skillen et al. in 2012 [7], the system should have scientific knowledge about the children's neurodevelopment and motor impairments. Orlin et al. validated the age and Gross Motor Function Classification System (GMFCS) to test the participation of children with physical disabilities in home and community activities [8]. In this way, the service could monitor children´s interaction at the home through their participation, defined as 'involvement in life situations' by the International Classification of Functioning, Disability and Health.

UML 2.0 communication diagrams facilitated the modelling of the interactions of the embedded intelligence daily life objects (home´s furniture and toys) with the child, the family and healthcare staff. Thus, involved experts got a clearer view of the system by describing its static structure and behaviour. Fig 1. shows the interaction process between the child (C), the ambient sensors (AS), the local reasoner (R), the health professionals (P), the smart toys (S) and the furniture (F). E.g.: AS detect the presence of C and report R which initiates S; S records how C plays with it and AS record other interactions between C and F; R gets data from S and AS and reports P who is able to readapt the behaviour of S related to some development items (i).

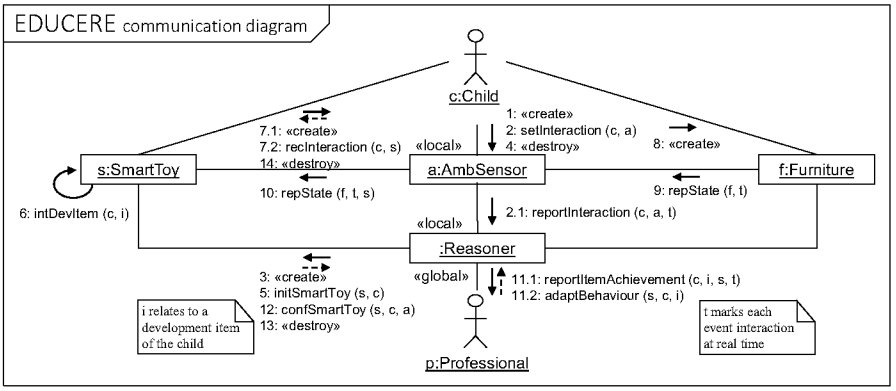

Fig. 1. Child-centred adaptable system and service behaviour

3 Service Integration and Testing

The service testing requires integrating devices and Embedded Sensor Systems for Health, developed at Mälardalen University, with the customisable reasoning platform deployed at UPM Smart Home. This living lab provides a real bedroom, living room, kitchen and bathroom to test the child´s interaction with daily life objects. Full system can provide feedback from available motion sensors, connected home appliances and three prototyped smart toys, which are natural for children to play with: a carpet, a teddy bear and a ball. The home gateway is in charge of suggesting stimulation tasks by activating lights and sounds though open X.10 commercial devices.

The smart toys are connected to the local reasoning subsystem that manages the data acquired by embedded sensors. The absence of neurodevelopment ontologies led to develop one from scratch starting from scientific knowledge about children´s growth. Thus, the subsystem takes into account the children´s development items to adapt its follow-up services to their specific age and acquired abilities. In this way, the solution supports personalized intelligent health services at home that utilize ad hoc smart toys and ambient sensors to infer potential disorders, suggest stimulation activities and securely provide health care experts with valuable real time feedback.

EDUCERE defines three categories to group the children according to their lower and upper limbs skills acquisition: a) zero to one, b) one to three and c) three to six years old. The smart carpet addresses to group a) whose aim is to use motion and pressure sensors to test how the children start to move, lay on the carpet and crawl. Next, the smart teddy bear allows to identifying and stimulating the use of upper limbs at group b) by using touch and pressure detectors. Finally, the smart ball can support in category c) the follow-up of advanced lower and upper limb activities and its interaction with the home environment. The experiments will be carried out with 10 children per group who assist to a nursing school and a school for children with specific needs. Two groups of experts (teacher, physiotherapist and psychologist) will analyze how the children interact with the smart toys, the benefits of acquiring this real time data, and the ability of the system to adapt its behavior to the child´s needs.

4 Conclusions

This system goes one-step forward on existing AmI works as it takes into account the development skills of children with motor impairments to create daily life based markers that push home health services by acquiring data from the so-called "Smart Toys". The integration at the UPM Smart Home of the Embedded Sensor Systems for Health of Mälardalen University, paves the way to make research about the feasibility to take advantage of daily life objects, like home´s furniture and toys enriched with sensing capabilities, to monitor the skills´ acquisitions of children with disabilities.

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