Distributed Tracking System for Patients with Cognitive Impairments

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Abstract. The increase of life expectancy has arisen new challenges related with the amount of resources required to attend elderly people with cognitive disabilities. These requirements, such as medical staff and financial resources, have been multiplied in the last years, and this tendency will continue in the forthcoming ones. In order to reduce these requirements, the introduction of new technologies will be a key aspect. In this paper we propose a test-question-based memory game that collects the answers given by patients and facilitates access to this information to caregivers and relatives.

Keywords: cognitive impairments, memory game, elderly, triple space.

1 Introduction

The ageing of the population during the last decades has caused a substantial growth of cognitive limitations cases in people, such as Alzheimer and dementia. Moreover, the expected raise of the life expectancy suggests that the amount of people affected by this kind of disabilities will be significantly increased [12]. Thus, hospitals' and residences' staff requirements will become economically unsustainable. In other to tackle this problem, the use of new technologies which ease caregivers' duties will be a key aspect.

In this paper, we propose a distributed system which is formed by two kinds of nodes. The first node type is a memory game application used by patients with cognitive disabilities. Therefore, to ease the interaction the game has been designed taking into account the impairments of the users. This game is going to

J. Bravo, R. Hervás, and V. Villarreal (Eds.): IWAAL 2011, LNCS 6693, pp. 49–56, 2011.

be deployed in several nodes. The second one is a Web application that gathers the results obtained by the patients. This application can be used by patients' therapists and relatives.

Although the use of distributed architectures offers several benefits, it also raises new drawbacks. When facing this system the most relevant ones were: a) how to manage the information's flow (mainly the results of the patients), b) where to store the information, c) how to react to node crashes and d) how to add a new node without reconfiguring the whole system. In order to solve these issues, an architecture based on the Triple Space (TS) paradigm [4] has been used, which offers seamless solutions to these conflicts.

The rest of the paper is organized as follows. In Section 2 we discuss the related work. Section 3 explains the use case of the system. Section 4 describes the technical aspects of the proposed solution. Finally, Section 5 concludes this paper.

2 Related Work

With ageing of Europe [14], the infrastructures used for treating the elderly will gain relevance, and the costs of these infrastructures will increase notably. In order to optimize the costs of these infrastructures, the development of new technical solutions is required. In fact, the European Union is working in the promotion of programmes to develop applications and frameworks that enable the reduction of related costs and the increasing of factors that ease the quality of life of the elderly. Within this context, Ambient Assisted Living [1] solutions are arising across Europe to tackle these costs.

It has been proved that the use of videogames and new technologies ("serious games") can be useful as a support for the psychotherapy [3], as a tool in the physical rehabilitation after a stroke [10], and as a instrument of cognitive stimulation in Alzheimer patients [2,13]. In the case of dementia patients, the use of psychosocial programs of non-pharmacological intervention (cognitive behavioural therapy, elderly caregiver training, context adaptation, occupational therapy, activities and physical exercise programs, cognitive stimulation) have demonstrated to improve one or more aspects of the quality of life [8].

The use case presented in this paper is formed by several independent nodes which share their information. In order to share it in a very decoupled but expressive way TS paradigm is used. TS comes from tuplespace-based coordination languages where the interaction between processes is performed sharing information in a common space. Although, several approaches in the field of semantic tuplespaces exist [7,9], to the best of our knowledge this kind of solution has never been specifically designed and implemented to capture the dynamic and heterogeneous nature of future hospitals' network [6].

3 Use Case

As we detail in the system architecture section we have developed two different applications. The first one is a questionnaire game that patients will have to fill out. These questions are developed by therapists and the results are added to a historic. The other allows therapists to see and analyse patients' results. Next we describe the stakeholders' interactions with the presented system:

- Firstly, patients will have to login into the system in order to avoid results inconsistency. This task will be able to be made either by patients or caregivers, since we know that those patients may be elders or people with cognitive problems, which usually have interaction difficulties. A list of patients names will be presented, so just clicking on a name will allow the system to register them. We realized it became relevant to have multiple instances of the game running independently. With the given solution more than one patient can complete exercises in different nodes at the same time.

  Since there are some studies and previous works in face recognition and gestures capturing areas which can ease the login task [3,5], it is not the goal of our system.
- Thus, each patient will have to answer a few number of customized questions, as shown in Fig. 1, with different difficulty levels. These answers will allow therapists to analyse and manage their memory or cognitive progressions.

Fig. 1. Questionnaire window

- When the patient finishes the exercise, her answers are added to the historic stored in the space with additional data (e.g. username, current date, questions difficulty levels, correct answers taking into account these levels, etc.).
- On the other hand, therapists can analyse patients historical results. To that end, they will have to log into the system, and then they will be able to see the desired results. The developed web application displays patients' results and today's results. It also allows therapists to search for patients. Once a therapist selects one option the system generates a query which consults in the space for the desired information.
- As therapists can see patients results in their desktop application, patients' families will be able to do the same in their mobile devices (Fig. 2(a)).

It is expected that the usage of the presented technological solution, which enables therapists to remotely track results of users in the exercises will benefit the different actors at the following three levels:

(a) (b)

Fig. 2. Adapted interfaces to (a) mobile devices and (b) common desktop screens

- For the patients, the programs can be automatically adapted to their particular requirements at any moment. It generates ecological validity of the platform, improves the user satisfaction and increases the use of non-pharmacological treatments avoiding program abandonment.
- For the professionals, they can easily track patients online without requiring to wait for the results at the end of the program. This tracking will enable to perform customized adjustments of the exercises program taking into account the performance of the individual, adjusting the tasks with different levels of difficulty. It generates an efficiency improvement in the cognitive intervention programs, increases the use satisfaction of professionals and improves the cost-effectiveness relationship of these interventions.
- Finally, integrating caregivers and relatives to use these technologies improves the validity and trust of the data. Their implication makes them co-participants in the patient intervention plan, facilitates the communication among patients and professionals, and prevents burn-out effects on caregivers, which mostly results in the renunciation of the proper care.

This solution is built within the ACROSS project[1] (TSI-020301-2009-27), funded by the Spanish Ministerio de Industria, Turismo y Comercio. The project aims to incorporate robotic services into social scenarios allowing them to anticipate to user needs by improving communication and empathy between people and embodied agents. Although this is a first approach, more efforts are being placed for this solution to work out and to adapt to a robot in the Hospital de Sant Antoni Abat in Barcelona.

4 System Architecture

Due to the presented use case we have developed two different applications:

[1] http://www.acrosspse.com

- A desktop application was required in order to capture the patients' results. We called it Memory Game (Fig. 1) and its only purpose is to help patients to train their memory by a questionnaire. It has been developed in JavaSE using the SWT library[2], which is an open source widget toolkit for Java, providing a native look and feel to the applications. Designed user interfaces have been developed taking into account that patients may have some interaction difficulties or problems.
- A web application for therapists to consult all patients' results. This application has been developed using the Google Web Toolkit[3] (GWT) open source development toolkit, which basically allows developers to build and optimize complex web applications using the Java language. Thanks to GWT we can adapt its user interface in the browser to adapt itself for procuring the best suitability for mobile devices. This way, not only therapist would study patients results but their relatives could do it from their homes.

Both applications communicate each other by publishing and querying the TS. Memory Game will write on it every result for each patient. On the other hand, the GWT web application will launch some requests or queries to the space for receiving patients results.

Fig. 3 shows the information flow among the nodes connected to the TS.

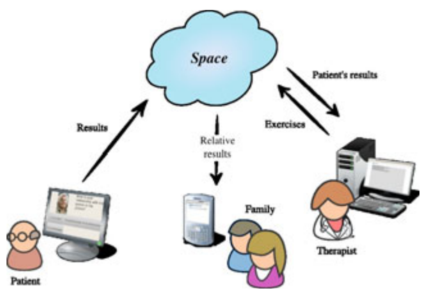

Fig. 3. System architecture and data sharing

4.1 Memory Game

The Memory Game is a desktop application for asking test questions to the patients. The asked questions can be private, such as "What is your relationship with the person in the picture?", or general knowledge questions, such as "Which is the animal of the photograph?". This questions are selected depending on a difficulty level preconfigured for each patient.

Because the patients of the game are elderly people, the user-friendliness is the application's main objective. In order to achieve it, the game has taken into account: a) designed to run in a touch screen to minimize the input/output devices to use, b) a reduced set of possible actions (choose user and answer) and c) a simple user interface that only uses text labels, big buttons and images.

[2] http://www.eclipse.org/swt/

[3] http://code.google.com/webtoolkit/

4.2 Results Web

The Results Web is the component responsible for listing patients and displaying the results of each one to therapists or to their relatives.

Therapists will probably use the application from the hospital's office desktop. However, familiars would very likely run the application in their mobile devices. In fact, nowadays it is claimed that around 40% of iPhone users browse the Web more frequently from their mobile device than from a desktop [11]. This can probably be applied to users of other smartphones (i.e. Android or Windows Phone devices) and this trend will probably increase in the near future.

By contrast, the Web is supported by most mobile devices. Some adaptation is required but only in the user interface, providing a proper layout, only the required contents, and avoiding plug-ins such as Adobe Flash or Java Applets.

Therefore, the technology selected to display results was the Web. The Results Web component is compounded by a servlet and a web client which communicates with the servlet through AJAX. The web client provides two different user interfaces (Fig. 2(b)), one adapted for the desktop, and the other adapted for mobile devices (Fig. 2(a)). Users will use any of these web interfaces and call methods provided by the servlet, which will act as a gateway to the TSs infrastructure.

Both the web client and the web server have been implemented in GWT, which is an open source technology developed by Google that provides an API to be used from the Java programming language. The toolkit is capable of translating that Java code to JavaScript. This way, a developer can use a Java IDE like Eclipse[4], and there write and test Java code, finally compiled into JavaScript.

4.3 Triple Spaces

The TS middleware used in the proposed solution allows the coordination between different processes writing and reading semantic information through a shared space easing the information's flow management. In the described use case, both the computers used by the patient and the web server which serves pages to mobile and normal clients are nodes from the same space.

Due to the decoupling nature of the middleware, the patients' computers or the web server do not depend on each other. Furthermore, no matter how many computers are used across the hospital by patients, the solution's behaviour will remain the same and additional configuration will not be required. As result of this capabilities and to the fact that TS allows to the developer to select where the information have to be stored, it facilitates the development of a error prone system which fulfils the challenges described in the introduction.

Moreover, the used middleware can be deployed on heterogeneous devices, so it could be possible to create a native mobile peer which does not act as a simple client of the web server. In this way, a central element or bottleneck such as the web server could be easily avoided or new applications could be easily developed to satisfy previously unidentified requirements.

[4] http://www.eclipse.org

4.4 Ontology

The ontology, which is dumped in the TS, is depicted in the Fig. 4. The most relevant concepts described by the ontology are:

User represents the user that can login in the system. The users can be therapists and patient's relatives.
Patient represents a patient of the hospital. The difficulty of the questions asked to a patient is defined by "min_level" and "max_level".
GameResult represents the questions done to a patient in a game play and the obtained results.

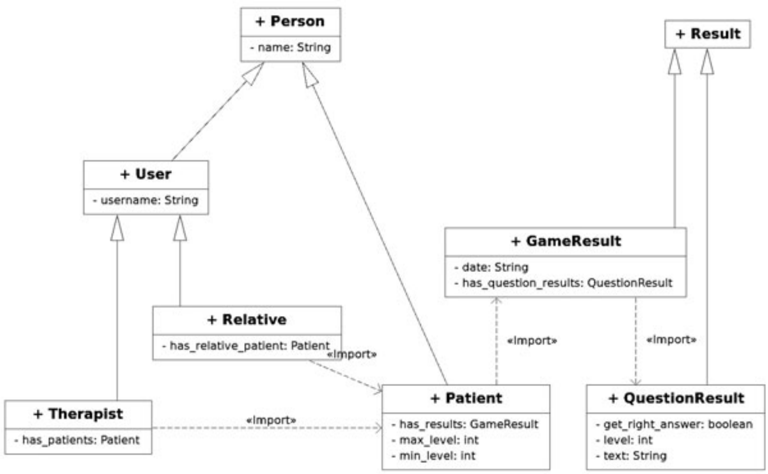

Fig. 4. System ontology

5 Conclusions and Further Work

In this paper, we presented a system that collects the patients' results of multiple nodes of the memory game application and offers these results to the patients' caregivers and relatives. To that end, we proposed a user-friendly solution which facilitates a) the interaction of elderly people and b) the caregivers' information gathering.

Our future plans include the deployment of the detailed system, as part of the ACROSS project, on a robotic platform. Once this deployment is finished, the proposed solution is going to be tested in a real environment by the research unit of the Sant Antoni Abat foundation. The target of this evaluation is to measure the impact on cognitive disability patients of these technologies.

Acknowledgments. This work has been supported by project grant TSI-020301-2009-27 (ACROSS), funded by the Spanish Ministerio de Industria, Turismo y Comercio.

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