Intergenerational Communication Systems in Support for Elder Adults with Cognitive Decline

Victoria Meza-Kubo, Alberto L. Morán
Facultad de Ciencias
Universidad Autónoma de Baja California
Ensenada, México
{mmeza, alberto_moran}@uabc.mx

Marcela D. Rodríguez
Facultad de Ingeniería
Universidad Autónoma de Baja California
Mexicali, México
marcerod@uabc.mx

Abstract— **Cognitive decline diseases, such as dementia, could be prevented through Cognitive Stimulation (CS) activities in which elders' relatives participate as informal caregivers. We carried out case studies for understanding the role of technology in the evolution of the relationships among older adults and their children, and the practices, roles and responsibilities of the elders' relatives in a CS session. Based on the results for these case studies we are proposing a pervasive system that incorporates mechanisms for facilitating elders' relatives to provide elders with instructions, help and feedback. In this paper we are presenting the design of a pervasive system that enables the diversity of the members of the elders' social family network to participate in CS sessions. This system consists of multimodal interfaces and distributed software components that enable the members of the elders' family to motivate them to carry out their CS activities.**

Keywords: Multimodal interfaces, cognitive stimulation, intergenerational gap.

I. Introduction

The global ageing of the population has made the increase of age-related diseases, some of which are accompanied by a patient's cognitive decline (e.g. dementia), more obvious. Currently, there is no cure for these diseases, thus a multidimensional therapeutic approach that includes both pharmacological and non-pharmacological interventions is proposed. One of these non-pharmacological interventions is Cognitive Stimulation (CS). Recent published research work provides evidence of the fact that a person who participates often in CS activities reduces the risk of suffering a cognitive decline related disease, or improves his/her cognitive functioning and behavior (e.g. [1]). However, some important limitations for the implementation of CS are related to i) the lack of specialized personnel to handle the increasing number of prone and ill adults suffering some kind of cognitive decline, ii) the need to take the elderly out of their homes to a specialized facility (e.g. elders daycare residence or clinic), which has the specialized personnel and materials to perform CS, and iii) the elder's progressive loss of attention in the CS activity as cognitive impairment progresses, among others.

One way to address these limitations is through the involvement of members of the elder's social family network (SFN) as participants of elders CS activities. It is highly recommended that elders maintain relationships with others across a wide array of ages [2], such as his SFN. However, when children grow up, these relationships are affected in different ways, for instance: children who live far away from their parents do not maintain frequent contact with them, and grandchildren miss the opportunity to get to know their grandparents. These situations may restrict the active participation of members of the elder's SFN in CS activities.

To address the inter-generational gap among younger and older members of a SFN, several research projects propose technological solutions (e.g. [3] [4]). However, there exists a concern that elders are not receptive toward technology which is due to the challenging experience of learning and using it. In addition, the elderly tend to show poor performance in controlling their movements [5], which would mean a greater difficulty in using interaction devices (e.g. mouse) to work with traditional (point & click) graphical interfaces. This is one of the main impediments for older adults to use a computer.

Our hypotheses are that i) technology allows integrating the elder's SFN members to participate in CS activities, while providing informal caregivers that act as motivators for the elder; and that ii) multimodal interfaces may adapt computer applications to the capabilities, needs and preferences of elders, and of SFN members, to facilitate and motivate their participation in CS activities.

II. Understanding the Evolution of the Elders' Social Family Network

The results of our previous work enabled us not only to obtain an understanding of the evolution of the relationships among elders and their children, but also an initial understanding of how current communication technology is used to preserve these relationships [6]. Through semi-structured interviews conducted with six elders between 65 and 75 years old and their children, we obtained that:

a) The focus of their relationships changes over the years: when children were younger, one of the objects of communication was frequently and mainly about arguments dealing with the children's needs.

b) Older parents become the focal point for family gatherings and news distribution, since children receive recent family news through them.

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c) Female children tend to have a closer relationship with their old parents, which can be more intense when parents become sick.

d) Children encourage their parents to carry out different activities to cope with their loneliness, especially to carry out activities in which they can interact with other senior citizens, such as knitting classes.

e) Children do not consider the current cognitive decline of their parents as a problem, similarly, the parents stated that they forgot some things, but considered that this was normal.

f) The adoption of new communication technologies has positively affected the parent-children relationships, since now they use technology, such as cell phones and the Internet, to stay in touch more frequently. We found that technology, such as appliances, had been adopted by elders since it was considered easy to use. In some cases, the elders' relatives have encouraged them to use some of these devices.

These findings enabled us to identify some roles that technology should play in order to facilitate the involvement of the elders' intergenerational SFN in their CS activities. Technology should facilitate not only the active participation of those who already maintain a strong relation or interact frequently with the elder (such as the daughters), but also those that may face restrictions to interact with him/her (e.g. due to distance or when they don't have enough time to visit the elder frequently). Younger members of the elders' family can help to reduce the generational gap by using technology, since they encourage and teach older members to start using it, which will enable them to discover the affordances of these new means of communication.

III. Understanding Cognitive Stimulation Activities

In order to envision how to integrate the participation of an elder's SFN members in his/her CS activities, we had to first understand the actors' practices, roles and responsibilities in a CS activity. For this, we performed data acquisition using conventional unstructured techniques, and semi-structured interviews with patients and caregivers at a geriatric residence for patients with cognitive decline [7].

We identified different interactions, with functions such as: (i) patients request help to caregivers or request to leave the activity; (ii) caregivers provide instructions to patients and encourage them to perform the CS activity; (iii) caregivers provide feedback to patients and promote help or demonstration among patients; (iv) caregivers give instructions, seek help from or delegate a task to other caregivers, or request information regarding a patient; (v) caregivers choose material for patients, deliver material to patients or remove material from the work area. These findings provide evidence on the preponderant role of caregivers at CS sessions. Even at early stages of patients' cognitive decline, caregivers, following therapist's instructions, establish which activities are performed, in which order, and using which materials. As cognitive decline progresses, patients depend on caregivers not only for instructions, help, feedback and motivation, but also to keep them focused on the stimulation activities to be performed.

IV. Towards the Integration of the Elder's Social Family Network in CS Activities

Based on results of previous studies, we envisioned a usage scenario of an Intergenerational Communication (IC) System to illustrate how CS activities can be mediated by multimodal interfaces adequate for each SFN member. In this scenario, our system includes a digital version of a tangram game, which is a recommended activity for coping with cognitive decline:

Juan is an elder suffering from mild cognitive impairment. He lives in Colima with Maria, his wife and primary caregiver. Jose and Isabel are their grandchildren whom moved to California a year ago. They participate (at a distance through the IC system) in their grandfather's CS activities. It is 11:00 a.m., and Juan is about to perform a CS exercise. Maria prepares the tangible version of the Digital Tangram application. The IC System detects the start of the CS session, and sends notification of this to Jose and Isabel, who are members of Juan's SFN. Jose is at home watching TV when he receives the notification, and decides to be present in the activity (as an observer), which enables him to receive text notifications regarding the status of Juan's activity. Maria notices her grandson's presence. Isabel is leaving home to do some shopping when she receives the notification on her Smartphone. Today she won't be able to participate.

Juan starts with the CS activity, and as he performs it, the IC system estimates the activity's completeness and correctness, and sends notifications about it to Jose, through the TV. In this way, Jose realizes that his grandfather Juan is not particularly motivated and attentive in the activity, even though Maria is trying to motivate him. Thus, Jose decides to help his grandfather. He goes to his computer and starts the Digital Tangram remote interface (GUI + mouse + keyboard), which presents the current status of the activity and enables him to participate in the CS activity. After some informal voice chat discussion, Jose proposes to his grandfather to continue with the Tangram Game, and to play with him like when he was a child. So, Juan restarts the activity. After a while, Jose notices that his grandfather has incorrectly placed one of the pieces. He asks (through the voice channel) his grandfather about the incorrectly positioned piece, while he gestures (with a telepointer) over the area where the correct piece is placed. Juan takes this piece and correctly places it.

From the previous scenario, we notice that Jose (grandchildren) and Maria (grandmother) were playing a very significant role during Juan's CS activities. They were acting as caregivers providing materials, instructions, feedback and motivation to Juan (grandfather). Further, although Maria could have performed this role in a collocated manner, Jose's participation was essential to achieving Juan's participation, as it represented an additional motivator.

V. Design Insights

We describe the two types of design insights for a system that aims to provide support for the integration of SFN members into the CS activities of elders. The first type deals with

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providing support for the creation and evolution of the SFN including: i) Enabling synchronous interaction and communication among co-located and distributed members of the SFN; ii) Providing context-aware notification mechanisms that let elders know when their SFN members are available for interaction, and vice versa; iii) Providing appropriate interfaces that can be accessed from different devices, allowing users to select an adequate interaction device according to their ages, preferences and computer skills.

The second type of design insight deals with the integration of SFN members into actual CS activities including: i) Allowing SFN members to assume the caregiver role, so that they can monitor the level and correctness of the activity, and be able to motivate and provide feedback; ii) Enabling the therapist, through collaborative synchronous and asynchronous systems, to monitor the elder's performance, to specify the activities to be performed, to evaluate progress and to plan the activities for a later session.

VI. Proposed System

Based on the results of previous studies and the insights presented above, we propose the development of a pervasive system that provides support for CS sessions, which allows the integration of remote SFN members (see Fig. 1).

A. System's Architecture

As shown in Figure 2, the architecture is based on a client-server model. On the client side, the components include:

a) Elder's Client. It consists of four components. *Activity Assessment* and *Digital Model* support the elder's interaction with the tangible objects. The *Activity Assessment component* manages CS activities, estimates the completeness and correctness of the CS activity from the physical objects using a vision-based algorithm that correlates the image obtained by a camera in real-time with a reference image, and then maps the recognized objects into digital objects, and updates the *Digital Model*. This model contains a digital representation of the current state of the physical activity, which is displayed by the *Digital Display*. This latter component provides elders with a digital view of the progress of the activity, displays other digital items such as pictures and instructions, and retransmits the state of digital elements to/from the elder's SFN member clients during a remote CS session. The *Communication* component provides synchronous communication (text, audio or video) between the elder and his/her SFN members.

b) SFN Member's Client. It includes the *Digital Display* and *Digital Model* components. The former maintains a local copy of the elder's Digital Display based on the Digital Model. The latter maintains a copy of the elder's Digital Model (which is updated as the elder interacts with the materials), and displays the progress (e.g. completion and correctness) of elder's remote CS activity. There is also the *Communication* component, which supports synchronous communication between the elder and the SFN members.

c) SFN Member Communication Client. It receives and sends notifications through mobile (e.g. smartphones) and fixed (e.g. Digital TV set) devices to inform of the elder's activity status, and presence and availability of SFN members.

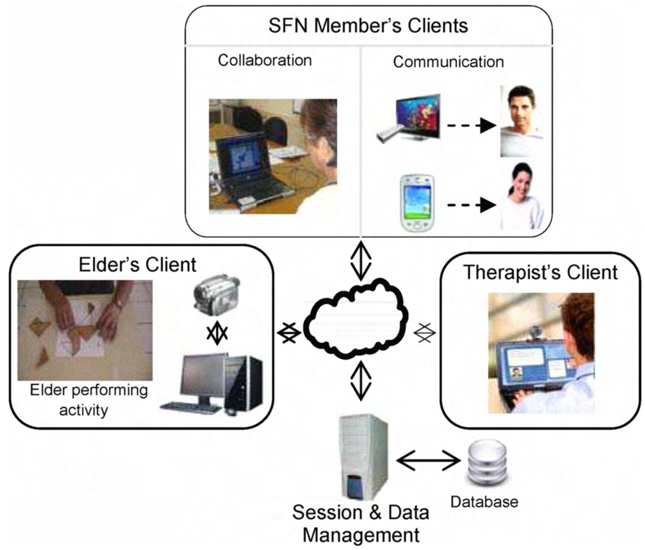

Figure 1. Main elements of the proposed system.

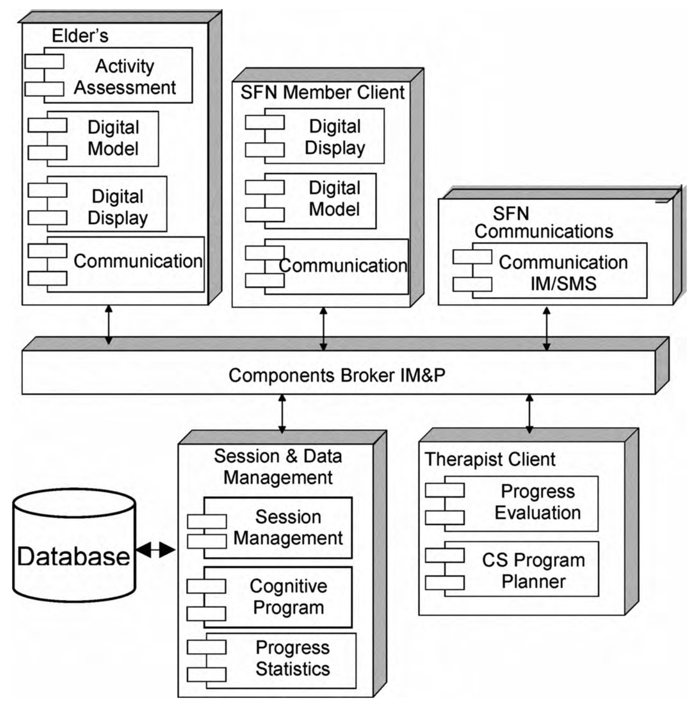

Figure 2. Architecture of the proposed system.

d) Therapist's Client. Its main components are the *Progress Evaluation* and *CS Program Planner*. Through the former the therapist gains access to the information regarding the elder's performance in the CS activities. Through the latter, the therapist is allowed to establish the plan for the activities of a future session.

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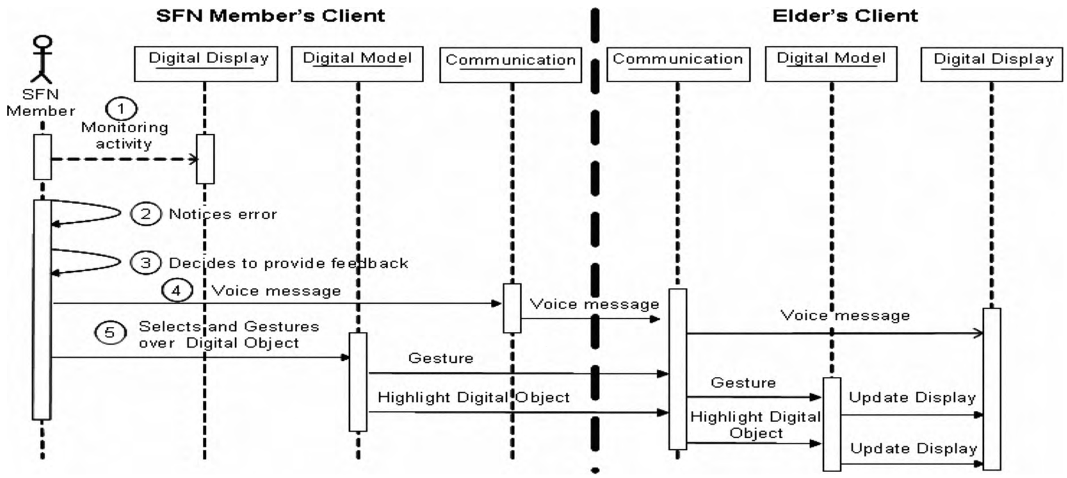

Figure 3. Sequence diagram showing the interactions that occur when a SFN member provides feedback to the elder during a CS session.

On the Server side, the components include:

e) IM and Presence (IM&P) Broker. It is a broker component that manages the communication between the multiple components of the architecture by means of XML (eXtensible Markup Language) messages.

f) Session and Data Management. This component manages multiple sessions (elder and SFN member clients), maintains the activity plan for each CS session, and keeps a log of the elder's activity performance. The recorded information is mainly used to aid the therapist in determining the evolution of the elder's disease.

B. Sample interactions among components

To illustrate the IC system functionality, we revisit the scenario presented in Section IV. Figure 3 shows the interactions that occur among the system components in order to allow Jose to help his grandfather to conclude his CS activity. A brief description of it follows.

1 While Juan is moving the tangram pieces, the Digital Display enables Jose to monitor Juan's activity.
2 Jose notices that his grandfather has incorrectly placed one of the tangram pieces.
3 Then Jose decides to provide feedback to his grandfather.
4 Thus, Jose asks his grandfather (through the voice channel) about the incorrectly positioned piece.
5 At the same time, Jose gestures with a telepointer on the incorrectly placed piece and then highlights its correct position. Jose's actions are communicated to Juan's Digital Model and shown by his Digital Display.

When Juan hears his grandson's comments and observes his gestures he proceeds to correctly place the tangram piece following Jose's feedback directions.

VII. Conclusions

In this work, through the understanding of the evolution of the elder's SFN, and of the practices of CS activities, we identified a set of design insights that enabled us to envision how to integrate the members of the elder's SFN as informal caregivers in CS activities, as well as to integrate them to act as additional motivators for the participation of elders in executing those activities.

Additionally, these insights allowed us to introduce multimodal interfaces (e.g. tangible interfaces) as elements to break some of the barriers that hinder the active participation of the Elders' SFN members. These barriers include age differences, computer literacy, and different skills and preferences regarding the use of computing and communication technologies. Finally, with the implementation, evaluation and use of these technologies we hope to contribute to maintain and improve intergenerational relationships over long distances, while contributing to improve the quality of life of elders with cognitive decline.

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