

# IntouchFun, a Pervasive Collaborative System to Cope with Elder's Isolation and Cognitive Decline

**Victoria Meza-Kubo, Alberto L. Morán**  
Facultad de Ciencias, UABC  
Ensenada, México  
{mmeza, alberto.moran}@uabc.edu.mx

**Marcela Rodríguez**  
Facultad de Ingeniería, UABC  
Ensenada, México  
marcerod@uabc.edu.mx

## ABSTRACT

Cognitive decline diseases, such as dementia, could be prevented through Cognitive Stimulation (CS). The integration of the members of the elder's social family network (SFN) in CS sessions can encourage the elder to perform CS activities. We designed *InTouchFun*, a pervasive CS collaborative system which eases interaction through natural interfaces and enables SFN members to interact with elders during their CS activities regardless of their physical location. An evaluation of our system provides evidence of a more accessible interaction of the elders with technology and of the importance and benefits of integrating SFN members as informal caregivers.

## Author Keywords

Cognitive Decline, Elder's Social Family Network, Cognitive Stimulation, Multimodal interfaces, Pervasive and Collaborative System.

## INTRODUCTION

The global ageing of population has made more obvious the increase of age-related diseases, some of which are accompanied by a patient's Cognitive Decline (CD), such as dementia. In addition to aging, the lack of social contact, contributes to accelerate this CD [1]. It is estimated that currently one out of ten elders lives alone, the main reasons for this are children moving out to their own houses or widowhood [1]. So, it is important to develop strategies to favorably modify the conditions of the elderly in order to prevent the apparition or delay the onset of CD. The literature provides evidence regarding that a person who participates often in Cognitive Stimulation (CS) activities reduces the risk of suffering a CD related disease, or improves his/her cognitive functioning and behavior (e.g. [2]). 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 CD, ii) the elder's needs of immediate help and feedback, and iii) the specialist's need to know the elder's performance during CS activities, 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 elder's CS activities. It is highly recommended that the elder maintains different relationships with others across a wide array of ages [3], such as his/her 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 the grandchildren miss the opportunity to get to know their grandparents.

To address the inter-generational gap among younger and older members of a SFN, several research projects propose technological solutions, e.g. using Light-weight Technology to communicate elders and their young relatives [4]. However, there exists a concern that elders are not receptive towards technology which is due to the challenging experience of learning and using it. In addition, an older person tends to show a poor performance in controlling their movements [5], which would mean a greater difficulty in using the interaction devices (e.g. mouse) to work with traditional (point & click) interfaces.

We consider that ubiquitous computing systems may enable to create accessible computer-based CS activities for the elderly. Our assumptions are that i) technology allows elders to perform CS activities by themselves; ii) The use of entertainment activities may engage elders to perform these activities more frequently; iii) Integrating the members of an elder's SFN to participate in CS activities could act as motivators for the elder; iv) That multimodal interfaces may adapt computer applications to the capabilities, needs and preferences of elders to facilitate and motivate their participation in CS activities; and v) Monitoring the elders performance in their CS activities would help to detect CD early.

## UNDERSTANDING THE PROBLEM SPACE

With the aim of designing technologies to support CS activities, we performed several studies to understand the

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process of providing CS assistance; to identify the main participants in this process and their interactions; to understand the elders' interaction with the CS materials; the latter aimed at identifying further details of the elder's SFN, such as number of contacts, interaction frequency, and interaction tools, among others; This will enable us to understand how ubiquitous computing technology may support these interactions.

### Study 1: Interactions between actors in the CS session

To identify those involved in the CS activity, what are their roles and how they interact, we conducted an observational study of a CS session [6]. The participants were 10 elders and 3 caregivers, from a local elder's nursing home. We identified different interactions, with functions such as: (i) patients request for help to caregivers, (ii) caregivers provide directions to patients, encourage them to develop the CS activity, (iii) caregivers provide feedback to patients and promote demonstration or help among patients, (iv) caregivers give directions to other caregivers, seek help from or delegate tasks to other caregivers, or request information regarding a patient, (v) caregivers choose material for patients, deliver material to patients or remove material from the table. Some identified areas of opportunity for providing computer-based support include: i) facilitating communication and collaboration between caregiver and elder; ii) facilitating communication and coordination among caregivers, iii) selecting materials and activities according to the needs and preferences of each elder, iv) monitoring the elder performance to provide to caregivers with awareness of the status of each individual within the group, and early detection of some cognitive problem; v) integrating remote SFN members to the elders activities in order for them to provide assistance and motivation to elders.

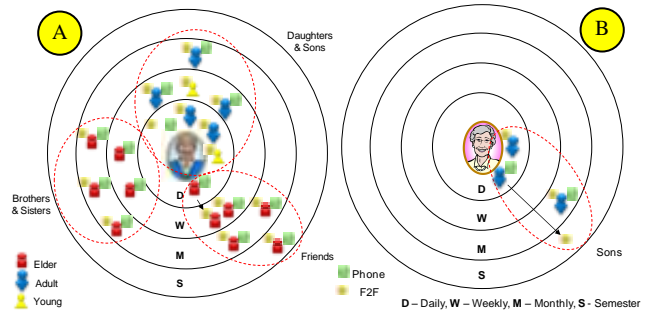
### Study 2: Interaction with materials

In order to understand the elders' capabilities and preferences regarding the use of traditional physical objects vs. digital objects, for the execution of CS activities [6, 7], we performed an empirical study, with the participation of thirty elders from a support group from the local municipality. The main results indicate that older adults complete more exercises (5:1), and in less time (1:14), using the physical objects than when using the digital objects. A surprising result from the on-exit survey was that almost all participants (92.5%) indicated that they would rather continue performing their CS activities using the computer. These results provide evidence regarding the importance of introducing alternative interaction mechanisms for executing CS activities that combine physical objects and computers, like Tangibles Interfaces.

### Study 3: Identifying the elder's SFN and its evolution

Aiming at identifying and understanding the characteristics and the evolution of elders' SFN, we performed a SFN mapping exercise. The participants were a group of 11 elders with ages ranging from 65 to 87 years. We studied three groups in the following conditions: i) seven healthy

(worried-well) elders living at their own home, ii) one elder living at home with his wife suffering from mild cognitive decline, and iii) three elders living at a nursing home suffering from moderate cognitive decline. Figure 1 shows the representation of an elder's SFN which represents the frequency with which members of a household maintain communication and awareness of their social contacts.



**Figure 1. (A) Representation of the SFN of a healthy elder with independent living. (B) Representation of the SFN of an elder suffering from CD and living at a geriatric residence.**

As can be seen, the SFN of an independent living healthy elder is large, both in the number of members and groups, and his level of interaction ranges from frequent or very frequent; by interacting with 5 members of his SFN daily, with another 5 weekly, with 3 members monthly, and with 1 more every six months or more (on average). In contrast, for the elder living at home suffering from CD, her SFN slightly decreases both in the number of members and groups, and her level of interaction is somewhat less frequent; on average she maintains daily contact with 3 people, with 4 more people weekly, with 3 more people monthly, and with 1 more person every six months or more. Finally, for the elder suffering from CD living at a nursing home, these numbers decrease drastically to 0.66 people daily, 0.66 more weekly, 1 person monthly and 0.66 more people every six months or more.

### INTOUCHFUN

Informed by the findings of our initial understanding studies, we present our proposal for a system that allows elders to interact with technology to perform their CS activities, and the integration of SFN members into these activities. We envisioned a usage scenario of *InTouchFun*, a Pervasive CS collaborative System to illustrate how to integrate SFN members into elder's CS activities, and how these 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 (a Chinese puzzle), which is a recommended activity for coping with cognitive decline:

*After breakfast, Carlos moves to the entertainment room, and goes to the multi-touch table (Fig 2a). The system detects his presence and displays a welcome message on the table. Then, the system asks him to choose one of the scheduled exercises proposed by the specialist. He chooses the Tangram game and takes the required materials. As*

Carlos starts the activity and interacts with the tangible pieces of the Tangram, this is reported to his son Cruz, who has subscribed to this service to be notified via his Smartphone (Fig. 2b). After solving two puzzles, Carlos starts to have problems as the third one is slightly more complicated than the two previous. Thus, Cruz, who has been receiving reports about the progress of the activity on his Smartphone, 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 (Fig. 2c). In the Collaboration Client, he can see his father's movements and provides feedback during the assembly of the puzzle through the audio channel that has been initiated between the two applications. In this way, Carlos is able to complete the whole set of exercises of the CS activity and achieves 20 minutes of interaction (feedback, support, socialization) with his son. A record of the activity has been saved in order for the specialist to track Carlos' performance evolution.



**Figure 2.** A) An elder interacting with the Tangible Interface, directly manipulating the physical tangram pieces over the GUI projected on the tabletop. B) An elder's relative interacting with the notification system through his Smartphone. C) An elder's relative interacting with the traditional interface to participate in the CS activity.

From the previous scenario, we notice that Carlos didn't have any problem to perform the CS activity by using the tangible and touch interfaces. However, he had problems due to the difficulty of the task. In order to assist Carlos with this problem, his son Cruz was notified and allowed to participate in his father's CS activities. On the one hand, Cruz acted as a caregiver providing instructions, feedback and motivation to Carlos. Cruz participation was essential to achieving Carlos completion of the activity, as he represented an additional motivator.

### System prototype

We proposed the development of a pervasive collaborative system that provides support for CS sessions, which is accessible to elders and that allows the integration of remote SFN members. Figure 3 shows the two main interfaces of this system: The elder client and the SFN member client interfaces.

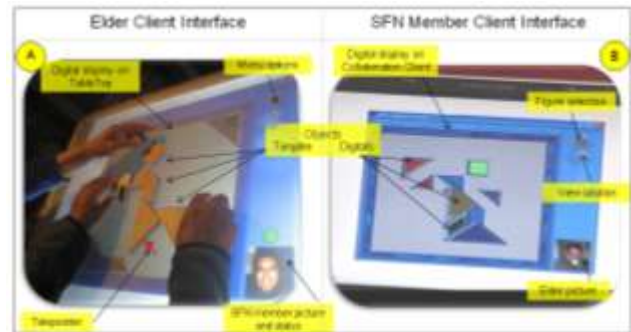
#### Elder Client Interface.

This client interface introduces the use of tangible objects and a multi-touch tabletop surface computer as alternative means of interaction for the elder. The main elements of the interface include (see Figure 3.A): the shared digital board

or work area that is projected on the tabletop, the tangible objects and their digital representation, an exercise selection and solution menu, the SFN member picture and status, and a tele-pointer for the remote relative user.

#### SFN members Client Interface

This client presents a traditional GUI-based interface that is used through a mouse and keyboard. This interface basically replicates the Elder client interface and gathers gesture and audio information to be sent to the elder's client side. It includes (see Figure 3.B), the shared digital board or work area, the digital representation of the objects, the exercise selection and solution menu, and a picture of the remote elder user.



**Figure 3.** System Prototype: A) TUI-based Elder Client Interface on a tabletop multi-touch surface computer. B) GUI-based SFN Member Client Interface on a laptop computer.

### EVALUATION

In order to determine the ease of use of the proposed system and its utility by allowing the members of the elder's SFN to participate during the CS activities as informal caregivers, we carried out an evaluation session of the system. Participants in this evaluation were six elders with no apparent CD, and one of their closest relatives, such as a child or grandchild.

The evaluation consisted of three steps: 1) *Video Projection*. Elders and their relatives observed a video clip showing a scenario of use of the proposed system; 2) *CS Activity*. Elders and their relatives participated in a CS activity exercise. The aim of this exercise was to let them know and to use the proposed system. They were located at different contiguous rooms to simulate a remote collaboration situation. They performed two different activities: i) *A Cognitive Activity*, which consisted on carrying out the assembly of four figures using the Tangram puzzle. In this case the elder performed the activity while his relative observed and provided help and motivation; and ii) *An Entertainment Activity*, which consisted on playing during 10 minutes with one of the available games (Tic-tac-toe, Checkers, and Connect-4). Each elder choose the game they preferred and in this case the elder and his relative competed against each other. 3) *On-exit questionnaire*. Finally, an On-exit (TAM-based) questionnaire was applied. We inquired the participants about their general perception of ease of use and usefulness by using standard

questionnaires [8]. We also included questions regarding the perceived anxiety and perceived enjoyment while using the system. Questionnaire items were mostly measured on a 7-point Likert scale, ranging from 1 (“completely disagree”) to 7 (“completely agree”).

### Results and discussion

The results relating to factors depending on the actual perception of use (ease of use, usefulness, enjoyment and anxiety) and related to a projected use (intention of use and expected use) are presented below.

#### *Participants' actual perception of use*

Evaluation results provide evidence that the system was perceived as useful by all participants (6.40). Participants agreed that both the cognitive activity (6.55) and the entertaining activity (6.26) were useful to cognitively stimulate the elder. The entertaining activity is perceived as more useful for socialization and having fun (e.g. “[Game] is a common game, already known to both of us, and thus familiar”, “The [Game] fosters elder and grandchildren’s interaction”).

Overall, perceived enjoyment for the system was high both for elders and their relatives. The results of evaluating perceived system enjoyment for elders (6.92) and relatives (6.33), show that the entertainment activity was graded slightly higher (elders 6.81, relatives 6.43) than the cognitive activity (elders 6.21, relatives 6.24). The entertainment activity was more engaging to both of them as it represented a competition challenge between the elder and her relative (“I got you”, “I will let you win next time”), while the cognitive activity represented a challenge mainly to the elder, who have even expressed that this activity made her feel under evaluation.

The data gathered through the TAM-based questionnaire provides evidence that the perceived anxiety regarding system use was low for participants (2.33). Particularly, elders perceived suffering from anxiety slightly higher (2.85) than their relatives (1.81). Further, the results showed that elders felt more anxious during the cognitive activity (3.59) than during the entertainment activity (2.11).

#### *Participants' projected use*

The results from the evaluation provide evidence of high intention of use (6.06) by participants. Elders stated to have a higher intention to use the system (6.33) than their relatives (5.79). That could be due to the difference in time availability for this type of activities, elders stated to have plenty of time available, while SFN members were conscious about the time limitations they have due to their main activities (e.g. work or school).

Finally, participants were also asked to state the expected use they would give to the system if they have it available. The average expected use in days per week is slightly higher for elders (3.6) than for their relatives (3.08). As discussed for the intention of use, a possible explanation for this could be also related to the difference in time available to perform the activity.

### CONCLUSION

The case studies and the evaluation carried out in this work provide evidence towards: i) CS can be reached by elders in their own home through the technology; ii) We consider the concept of play as an appropriate approach to enable elders to receive therapy and encourage them to spend time using the system; iii) Facilitate the interaction between elders and the members of their SFN, allows them to collaborate (e.g. the cognitive activity), compete (e.g. the entertainment activity), and socialize (e.g. aspects of social communication related to the actual gaming experience, or about the social or family context of the SFN that involves them), and these in a fun and entertaining environment that motivate elders and their relatives; iv) Using pervasive interaction devices appropriate to the age and computer skills of the SFN members is paramount; v) Monitoring of elder performance in his CS activities could be registered to applied specialized algorithms to evaluate his progress and early detect some CD problem.

This way, the evidence obtained in the evaluation, reported in the evaluation section, concerning the high perceived levels of ease of use, usefulness and enjoyment, along with the low levels of anxiety, suggests that systems like the proposed one represent a good opportunity not only to assist in CS activities of elders in a fun way, but also to allow them to keep in touch with members of their SFN and reduce their isolation.

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