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PILOT STUDY OF SMART HOME "CASA SATELLITE": FIRST RESULTS OF THE MONITORING

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ABSTRACT

Nowadays, using of automation technologies is a solution implemented in different contexts (e.g. private homes, sheltered apartments, and health care facilities) in order to help users with special needs and even persons with Cognitive Impairments (CIs). A training apartment called "Casa Satellite" was realized in Trento (Italy). It is a Smart Home (SH) with an automation system and assistive devices for people with CIs. First residents of the "Casa Satellite" project are sixteen young adults with Down Syndrome (DS) aged between 21 and 31 years who live with their families. They are individuals with mild or moderate mental retardation. They stayed in this apartment in groups of four and for four consecutive days per month for about three years. Some of these participants have been monitored as a case study. This paper describes the analysis of five Activities of Daily Living (ADLs), selected from nine monitored, but for only one user. Goal of the pilot study is to measure the improvement margin of the independence in ADLs carried out without and with home automation and Assistive Aids (AA). A Supports Intensity Scale (SIS) has been used for a standardized assessment of the intensity of support needs. Data processing showed different trends of improvement for the monitored activities in both absence and presence of AAs although more marked in the second case. The first results of this pilot study suggest a potential training value of the "Casa Satellite".

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Key words: Smart Home, Cognitive Impairments, Down Syndrome, Independent Living, Assistive Aids

Introduction

Smart Home (SH) technology is used to obtain a home environment that proactively monitors and reports undesirable events [1] and that responds and modifies itself continuously according to its different occupants and their changeable needs [2].

The term SH has been used for a long time to introduce the concept of home networking devices and equipment. A SH definition states [3]that "a dwelling that incorporates a communications network connecting key electrical appliances and services in order to provide the inhabitants the control of the building functions" (e.g. lighting, temperature and multi-media control, safety and security, window and door operations, as well as many other functions). Nowadays, a better definition of SH is "the integration of technology and services through home networking for a better quality of living [2]" including assistive technology in order to help people with special needs.

SHs are a good alternative for the independent life of disabled and elderly people. Several SHs with special architecture solutions and technological innovations have been developed to satisfy the needs of people with movement and physical limitations such as automation and control of home environment, movement assistance and physical rehabilitation, health monitoring, information exchange [4]. However, the range of available different technologies allows us to design SHs to help people with low vision or blind and hearing-impaired people. In addition, some solutions of technological opportunities have been developed for supporting people with Cognitive Impairments (CIs) who are living at home. The main goal of these solutions is to increase the independence in Activities of Daily Living (ADLs) and well-being.

Defining CI is not easy. CI is a general term "to describe any characteristic that acts as a barrier to the cognition process" [5]. CIs include deficits in global intellectual performance (mental retardation), specific deficits in cognitive abilities (learning disorders, dyslexia, etc.), drug-induced memory impairment, etc.. CIs may be congenital or caused by environmental factors such as brain injuries, neurological disorders, and genetic causes such as Down Syndrome (DS), autism, or mental illness. CIs are different and different technological solutions may be installed in the SHs to improve the quality of life of these users. For this reason, the design of SHs for people with CIs requires bigger efforts. It is necessary to understand the daily lives of people with CIs, the difficulties they have, and the possible implications for their ability to live autonomously [6]. Developing targeted research in order to discover acceptable and effectiveness solutions is an important question.

Another important question is the analysis of the improvement trend that can be achieved using smart technology and/or specific solutions not only at home but also in nursing homes. An example is the use of high colour temperature lighting for institutionalized older people with dementia. The Van Hoof's work refers about the effect, for people with dementia, of using this technology, measuring the behavior conditions of the residents by Behavior Observation Scale for Intramural Psychogeriatrics (GIP) [7, 8]. The effects of a set of electronic memory aids for patients with cognitive problems has been investigated [9], by using a computer system to register activities that were not performed, in order to act upon with reminders or alarms. In previous research, interviews with occupational therapists and with other professional caregivers have been used in order to identify the ADLs, for people with CIs living at home, that might most usefully be supported [6]. Another approach, used by Colombo et al., was the analysis of domiciliary settings to identify the most frequently occurring specific problems [10].

A literature review revealed that the use of smart technology specifically for people with DS, has not yet been deeply investigated until now.

"Casa Satellite" is a SH, a pilot training apartment for young adults with DS. This work is part of a research started in 2007. "Casa Satellite" project has already been presented in the paper entitled "Smart Devices in a Training Home for People with Down's Syndrome: Case Study of Casa Satellite" in XXXV IAHS World Congress on Housing Science 2007, where the authors described the project goals and the design of the apartment in terms of furniture and smart devices [11,12]. From then on, the training apartment has been furnished, fully equipped and inhabited by the first users. This paper reports on the use of the apartment and the first results of the monitoring activity.

Training Apartment

Aim of this pilot study was to explore the possibilities of a home automation system as support in everyday activities in the home environment for people with DS. For this, the research team has identified both the scenarios of home automation system in order to satisfy the specific needs of the users and the improvements to facilitate the work of the "Casa Satellite" operators.

The home automation system of "Casa Satellite" includes solutions for safety, security, indoor environmental control, communication, entertainment, and some customized solutions. It is possible to supervise and control the system locally using a video touch screen installed inside the home or using a PC, an iPad or a smartphone (Figure 1).

The communication system among the home automation components is a bus cable installed in channels mounted on the walls without invasive building works because the apartment is for rent. All malfunctioning alarms and dangerous situations detected by input devices of the home automation system activate a warning signal on the video touch screen and a call to operators of expertise. A database records all events detected by the system. This is useful for monitoring all alarms and answers of the users.

Users can interface with the home automation system through a video touch screen located in the living area with command buttons. Design and implementation of the adopted technological solutions have been widely described in previous papers [11, 12]. During construction, almost all design requirements have been met except for small discrepancies such as the choice to differentiate the TV screen from the video touch screen. The reasons of this choice are two. The first reason is that the current location of the video touch screen (embedded in a furniture of the living room) compared to the position of the TV is better for making it visible from the kitchen. In this way, it is possible to use the video touch screen for viewing educational videos for household activities such as cleaning the kitchen and preparing meals. The second reason are the high and not sustainable costs for installing a video touch screen with the same dimensions of the TV screen.

This paper describes the analysis of five Activities of Daily Living (ADLs), selected from nine monitored, but for only one user. In particular, we reports on the following ADLs: "Organizing and managing the daily schedule", "Planning and preparing meals", "Grocery shopping", "Tidying up and cleaning the kitchen", and "Cleaning the bathroom".

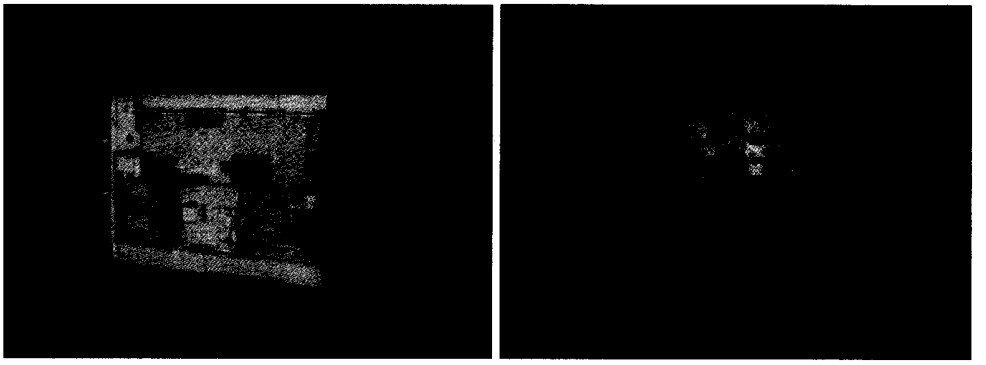

Figure 1 : Local and remote supervision for the home automation system of "Casa Satellite".

Organizing and Managing the Daily Schedule

The video touch screen reminds the daily schedule of the "Casa Satellite" occupants. In particular, it displays all tasks that each user must perform inside the home and appointments. An adequate iconography specifies the ADLs to be performed on a daily basis (Figure 2). When an ADL has been completed (e.g. cleaning, tidying, washing of linens) each user can confirm it by touching the screen.

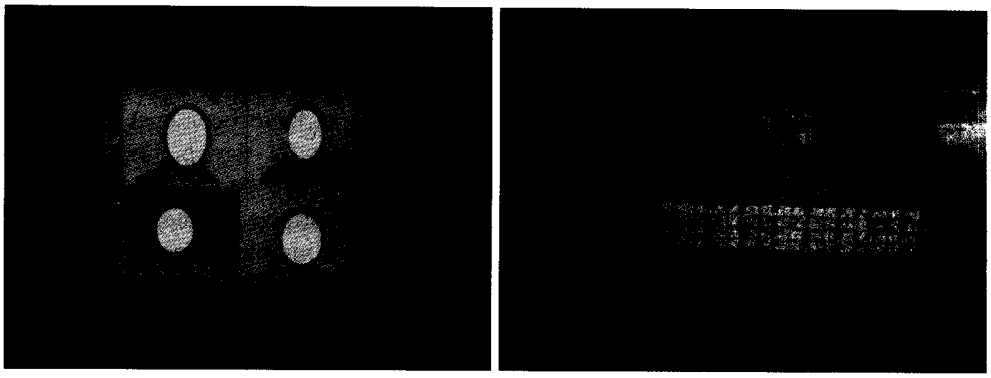

Figure 2 : Different daily schedules for each user and report of the carried out tasks.

Recording all completed ADLs is important in order to obtain a report of the experience of each user in this apartment. On the one hand, this is of educational value for the users because they can knowledge how many planned ADLs have performed. On the other hand, the "Casa Satellite" operators can verify the progressive improvement or worsening of the user performance in this apartment.
The recording includes the carried out ADLs, the malfunctioning alarms and the dangerous situations. From an analysis of collected data, both in progress and at the end of the study, we observed that almost all ADLs have been carried out although with different level of needed support. Furthermore, the level of alarms/dangers is minimal compared to the time of use of the apartment. For this reason, even in the early months of monitoring, the research team decided to use tools for measuring the level of difficulty in the carrying out tasks.

Planning Meals and Grocery Shopping

The grocery shopping begins with the choice of meals to prepare during the four-day stay. A dedicated software supports the users to organize the daily menu. This application displays a set of pictures of foods such as first and second courses, side dishes, and desserts. Task of the occupants is to select the foods for lunch and dinner by clicking on the pictures of the video touch screen. The software has been developed to properly combine the different courses to avoid choices that could jeopardize the health of the occupants. On the basis of the selected menu, the software

provides a shopping list with products and quantities. With the printed list, the users can check the ingredients that are in "Casa Satellite" to obtain the real list of the products to buy. Afterward, the residents can walk to the supermarket not far from "Casa Satellite" for grocery shopping. For preparing the different foods, the users are supported by explanatory videos.

Tidying Up and Cleaning the Kitchen and Bathroom

Other explanatory videos have been introduced in "Casa Satellite" for cleaning the bathroom and the kitchen.

Pilot Study

The first participant selected for our preliminary study is a young woman (about 30 years old) suffering from DS with a moderate mental retardation and with a high level of support needs in several daily activities. She lives with her family and works. Before "Casa Satellite" project, she was involved in other educational projects organized by ANFFAS Trentino Onlus Association (the association of parents of people with mental and relational disabilities of Trentino region). In particular, the project called "We group up together" is aimed at developing a strong identity and independence for the daily life. This project created the cognitive prerequisites, such as autonomy and good interpersonal relations, necessary to participate in "Casa Satellite" project.

The participant stayed in the apartment with other people for four consecutive days per month, and for a total period of twenty-two months in three years. Her typical day is as follows: she wakes up and has breakfast; she dresses and goes to work (part time job); she comes back to "Casa Satellite" for lunch. In the afternoon, she performs domestic activities according to the daily schedule, recreational activities and then she prepares the dinner. A volunteer or parent spends the night in "Casa Satellite".

For this pilot study, the research team investigated five ADLs in home environment. They are listed in Table 1 with the relative Assistive Aids (AAs) introduced in the apartment. Aim of the study is to discover whether the user of "Casa Satellite" changes his/her performance without and with AAs, and to confirm the training value of this apartment. In particular, the research team applied an analysis method to measure the improvements of the independence level in performing ADLs both with and without AAs.

Method and Data Collection

Data were collected by monitoring of the support needs using an assessment grid based on an observational analysis. This grid is divided into separate five sections, which correspond to the five ADLs selected for the pilot study.

Table 1 : ADLs and AAs of the "Casa Satellite" project.

Activity of Daily Living (ADL)	Assistive Aid (AA)
ADL n.1 "Daily Schedule"	"Daily schedule" software
ADL n.2 "Grocery shopping"	"Meals" software
ADL n.3 "Planning meals"	"Meals" software + videos
ADL n.4 "Tidying up and cleaning the kitchen"	Video
ADL n.5 "Cleaning the bathroom"	Video

Applying a task analysis process, each ADL has been divided into tasks to which it is possible to assign a score called Difficulty Index (DI). DIs are the measures of the support need based on the Supports Intensity Scale (SIS) model. SIS is an assessment tool specifically developed to measure the level of supports required by people with intellectual disabilities to have independent and normal life in society [13].

The SIS scale used for the assessment is a 5-point scale ranging from 0 (no support needed) to 4 (full physical assistance). The assessment grid calculates the Average Difficulty Index (ADI) for each ADL. Throughout the pilot study, the grid has been applied, without and with AAs to the participant always by the same investigators.

Data were processed on the basis of: i) an analysis of the annual average ADIs in order to highlight the improving trend in the investigated ADLs both without and with AAs; ii) a monthly analysis of the actual values of DIs in order to quantify the reduction of the support need in the investigated ADLs.

First Results and Discussion

Collected data were processed into three consecutive time series: "homogeneous years", representative of the same number of months analyzed excluding the summer months and the absences of disease.

The graph of Figure 3 represents the annual average ADIs of the five investigated ADLs for the first, second and third year, both without and with AAs. In this graph, it is possible to observe the following:

- the annual average ADIs for the ADLs performed without AAs are higher than those performed with AAs in all three years;
- there is a gradual improvement from the first to the third year both in the absence and the presence of AAs;
- the levels of improvement are not homogeneous for the monitored ADLs.

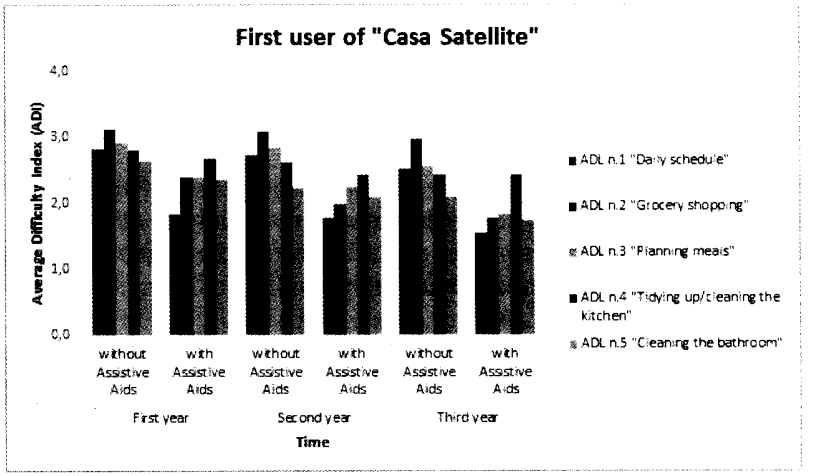

Figure 3 : Annual Average ADIs of five ADLs performed by the first user of "Casa Satellite" with and without AAs.

The graph of Figure 4 depicts the differences of the annual average ADIs without and with AAs. In particular, we can observe the following:

- the average level of improvement for the ADL n.1, n.2, n.3 is greater than for the ADL n.4 and n.5 (e.g. from 0.14 for ADL n.4 to 0.99 for ADL n.1 in the first year);
- the improvement trend is different in the investigated ADL (e.g. for ADL n.2 we can observe an improvement increasing from 0.74 to 1.20, while for ADL n.1 the difference stabilizes around 0.97).

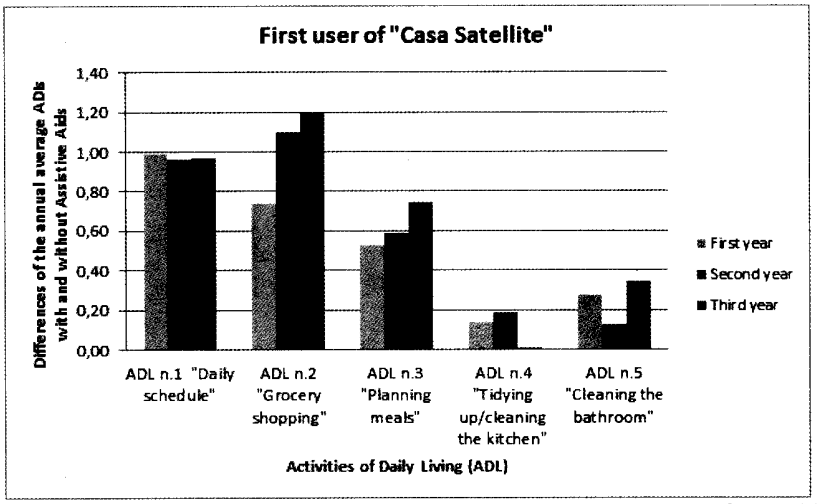

Figure 4 : Differences of the annual average ADIs of five ADLs performed by the first user of "Casa Satellite" with and without AAs.

The results show an average improvement around the unit in two ADLs (ADL n.1 and ADL n.2) where the presence of AAs was more significant. Since the unit is to indicate the change of scale in accordance with SIS scale, we have investigated in more detail the significance of this value.

We have calculated for each month the percentage frequency of the DIs assigned to the tasks of each ADL investigates. After an accurate analysis of the total range of time, we have identified two months significant for the comparison one at the beginning and one at the end of the monitoring period.

The graphs of Figure 5 are an example of this analysis and they show the percentage frequencies of the scores (from 0 to 4) of the ADL n. 2 "Grocery shopping" for the first user. The comparison relates the same ADL without AA and with AA.

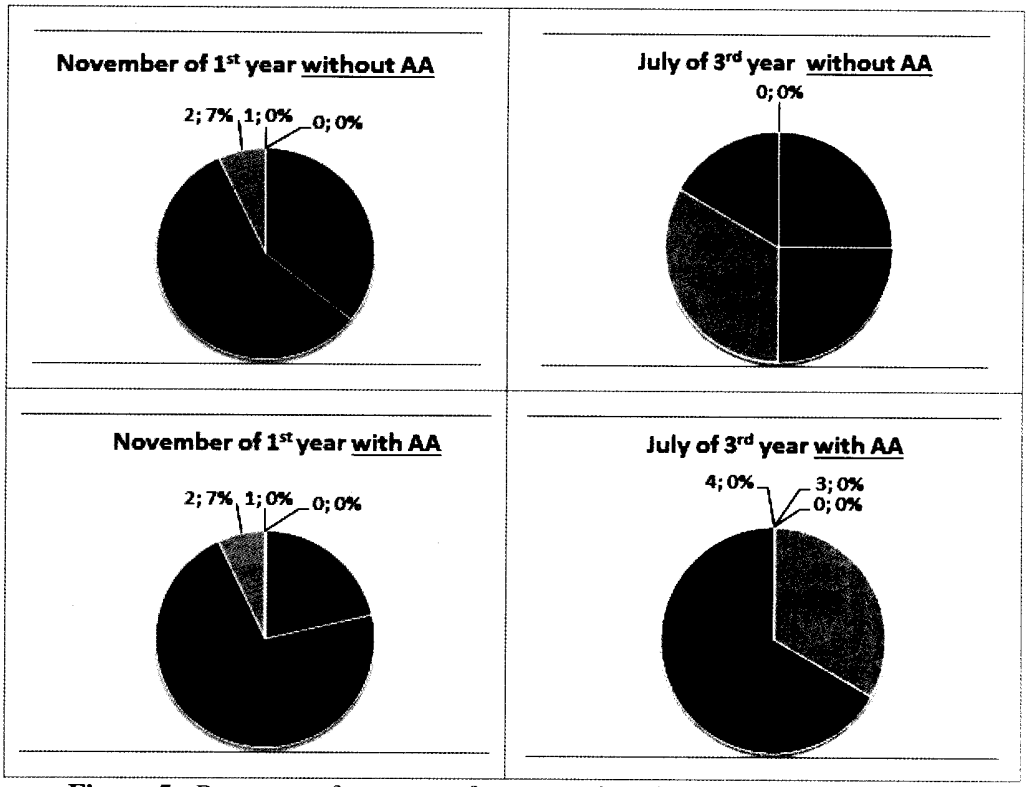

Figure 5 : Percentage frequency of scores assigned to the ADL n.2 "Grocery shopping" for the first user. (0 = no support need, 1= support need with one verbal intervention, 2 = support need that requires an articulated verbal intervention, 3 = support need that requires an operational action, 4 = full physical assistance)

The graphs of November of the first year (see the first column) show that at the beginning of the pilot study the percentages of the scores change. We can observe that the percentage of level 4 decreases (from 36% to 21%) while the percentage of level 3 increases (from 57% to 71%).

The graphs of July of the third year (see the second column) show that at the end of the pilot study there is an improvement in the performance of this user without and with AA. Without AA we can observe the percentage frequencies of the scores 3 and 4 are decreased compared to values of November of the first year. In addition, the user obtains at the end of the pilot study the score of 1 for 17% of tasks. With AA we can observe that the scores of 3 and 4 disappear and the percentage are 67% (score 1) and 33 % (score 2).

The monthly analysis showed a trend of positive improvement for periods of at least three months with negative peaks and reversal situations in specific months. For example, the first month after the summer break (three months) showed a worsening of skills acquired by this user with DIs almost equal to the initial values of the first months of the first year. However, with the second month of activities in "Casa Satellite", the user recovered the knowledge of previous experience and the scores recorded by the monitoring showed a significant improvement in the long term.

Processing data concerning the ADL n.1 "Daily schedule" "and the ADL n.3 "Planning meals" provides results and considerations similar to those of the ADL n.2.

Conclusion

"Casa Satellite" helps and supports people with CIs to live independently. *It is a SH* with a dual purpose: educating to live independently and ensuring safety and security. Casa Satellite" is a training apartment where young people with specific AAs learn in small groups to perform ADLs.

The first monitoring activity of this project, and presented in this paper, shows that the home automation and the AAs helps to generate in these people the will and the inclination to get closer to live at home independently.

The motivation of the first participant was high. In conclusion, her abilities are augmented from month to month, even if in different way in the five investigated ADLs. It was important to instill the message that "Casa Satellite" was her home. To the question "What is for you the "Casa Satellite"?, she answered: "Casa Satellite is a home where it is possible to do yourself; it is an apartment to help us not only to live alone and separated from the , but also to stay with friends"; it is a home where we learn to cook and to clean, etc."

In order to confirm these initial encouraging results and the training value of this project, data of the others and of new occupants will be analyzed and processed. Currently, the experience of "Casa Satellite" has been replicated in Pavia, where a similar SH for people with mild intellectual disabilities has been realized.

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