AUGMENTED OBJECTS TO SUPPORT PEOPLE WITH MILD COGNITIVE DEFICIENCIES IN EVERYDAY ACTIVITIES

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Abstract: The cognitive deficiencies are the spectrum of deficiencies related to the reduction of brain cognitive capability. They mainly affect decision-making, reasoning, planning and solving capabilities of daily activities. The consequence is cognitively impaired people become dependent by families, caregivers or Health Institutes. Not-intrusive information technology applications can be applied onto augment the house of mild cognitive impaired people to maintain their autonomy and facilitate their daily activities. At the same time, the applications combat the deficiency effects and are a good mean to promote self-esteem and increase the independent time living at home. In this paper, we propose an approach to use everyday objects as input and output devices for a processing system supporting people affected by mild cognitive deficiencies in successfully complete activities of daily living.

1 INTRODUCTION

Cognitive is an adjective related to the abstract human faculty of information process and knowledge applying closely related to concepts as reasoning, comprehension, inference, decision-making, planning and others capabilities of the human mind.

Example of such diseases are traumatic brain injury, dementia, Alzheimer's disease, mental retardation, schizophrenia and autism. That fundamental abilities are necessaries to successfully complete the common daily activities so related deficiencies have the effect to compromise any action with the consequence people becomes dependent by families, caregivers and National Health Institutes.

This dependence raises a set of problems for all involved actors. Families should face with the time required to assist the impaired relative and the cost for personal caregivers.

The National Health Institutes support the families and patient providing appliances, ad-hoc public structures and specialized medical staffs. Elements drawing on national economies and state budgets. Last and more important, it is the patients acceptance of her disease and of the helps from relatives and institutes. They often are angry, do not accept the disease, refuse to use medical appliances installed in their house, consider an intrusion the continuous presence of caregivers and hate the lost of independence.

A solution able to satisfy all of them consists on augmenting the patient's house with not-intrusive Information Technology (IT) applications. Where the whole house becomes the computing environment actively supporting people in daily living activities either serving their needs, providing their safety and monitoring their actions.

Each object, household appliance, furniture and any other element becomes an input source, contributing to compose the user interface for interacting with the digital processing system. The outputs are indications or helps exposed on or by the same elements providing input.

In this paper, we propose an approach to use everyday objects as input and output devices for a processing system supporting people affected by

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mild cognitive deficiencies in successfully complete Activities of Daily Living (ADLs). Next sections will introduce to the tangible user interfaces defining such a type of object-based interaction and the IT architecture of the processing system. The attention is focused on the daily activities performed in the kitchen and the ingredients/utensils collection is the activity analyzed as example.

2 TANGIBLE USER INTERFACES

To support people with mild cognitive deficiencies in everyday activities, traditional input-output interaction system based on graphical user interfaces (GUIs) looks to be not adequate because rely on input devices keyboard, mouse or touch-screen and do not explore the natural ability to interact manipulating physical objects. Such a gap is filled by the tangible user interfaces (TUIs).

They “provide physical form to digital information and computation, facilitating the direct manipulation of bits” (Ishii, 2008). Physical, touchable, concrete objects are used as representations of digital information and computational operations. User executes physical, real and direct manipulations of these objects to interact with processing systems.

In everyday live, humans interact with the physical world processing an associating of symbolic functions and relationships with physical artifacts. Boards games like draughts, mahjong and Nine Men Morris are some examples where distinctive physical tokens represent people, physical entities or actions.

The abacus, the oldest human developed tool (some hypothesis date it back to 8000 BC, before written language and even the wheel) (Schmandt-Besserat, 1997), is a TUI where tokens changes their values according the position on the board.

2.1 Augmenting Everyday Objects

Objects are fundamental parts of the everyday life of everybody independently by his religion, country, gender, age or ability. We actively surround ourselves with objects, helping to establish our identities and to find arrangement of those objects such as to constitute an autotopography (a physical map of memory, history and belief) (Gonzalez, 1995).

TUIs put the everyday objects to the centre of the attention to interact with digital systems reducing or cancelling the entering barrier of the manual dexterity of the digital input devices. The connection between the physical objects and the digital processing is fundamental.

It is realized coupling the objects with a reader. The reader is able to recognize the object, read its information and forward it to processing system. Objects could be augmented inserting microelectronic circuits or Auto-ID technologies (e.g. RFID or visual tag). We prefer to pursuit the “augmentation” in the simplest and no-intrusive way, so visual tags are the ideal choice because it is sufficient to paste a little draw on the object surface.

In particular, Quick Response (QR) (Denso, 2010) and Amoeba, from ReacTIVision framework (Kaltenbrunner and Bencina, 2007), are kinds of visual tags that can fast recognized by video streams using an accompanying detection algorithm.

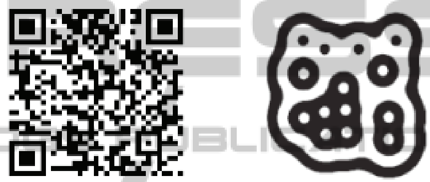

Figure 1: Example of QR (on the left) and Amoeba visual tags.

3 ARCHITECTURE

According to the pipes run-time architecture (Pintus et al, 2010), to design the architecture we make the assumption that each augmented object is coupled to a Web service. It describes the object features, what actions it can perform (if able to be an effector or actuator) and what data it provides according user manipulation (if able to be a sensor). The set of available augmented objects defines the sensor network.

The visual tag placed on the object contains a reference to the Web address of the related Web Services Description Language - WSDL (WSDL, 2007) instance. To add one augmented object to the sensor network, we adopt the point-click interaction.

When technicians sets the system, he points the visual tag with a mobile device and by clicking the visual tag is decoded and the sensor network is commanded to acquires the related Web service.

The task manager uses the set of Web services registered in the sensor network to compose the task related to the ADL, including the actions to perform in case of wrong or missing action by the patient. It can modify, deploy and remove tasks.

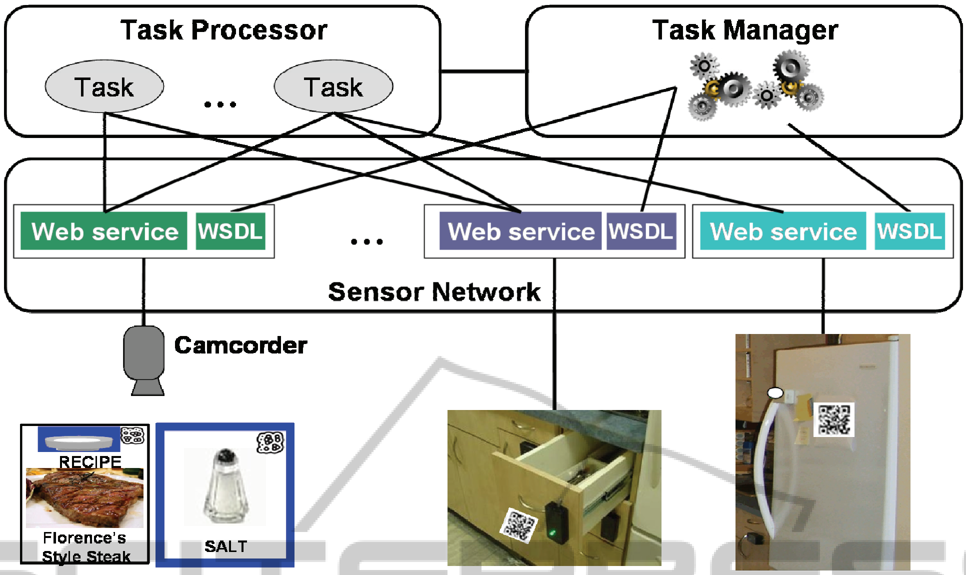

Figure 2: Schema of the processing system using the augmented objects.

The deployed tasks are performed by the task processor. It is a WS-BPEL engine able to compose, dynamically deploy and execute the WS-BPEL process (Oasis, 2007) based on the defined task and the WSDL URLs of the involved objects. The tasks idle waiting for input by augmented objects and forwarded by the sensor network.

According to such input, the task processor performs the next step activating selected effectors and actuators by the invocation of methods on their Web services.

4 A CASE STUDY: THE AUGMENTED KITCHEN

The kitchen is the room of the house where people spend a lot of time performing actions and interacting with others and it is ideal to test TUI solutions on account of the tools and utensils used for cooking. The successful completion of meal preparation is not only a need for a healthy eating but also an important step toward the independence and increase self-esteem for mild cognitive impaired people.

To augment the kitchen, we need to register the sensors and effectors composing the sensor network. Firsts are the input elements of the task processor and any everyday object with a visual tag becomes a sensor able to provide input. Effectors are electronic objects able to show or play an output.

After sensor network setting, we can count on it and a smart task processor, but we must remember to let people to interact in the most simple possible way defining the TUI with high attention in order to be as intuitive as possible and accepted by people. LEDs and lights are our privileged outputs, leaving on traditional screen eventually alerts on wrong or missing user actions and the video indications to address them.

4.1 An Example of Task: The Meal Preparation

Picture cards and card games are related to fun time of the life of any one since we were children. With the Virtual Kitchen cards – VKards (Piras et al, 2009), we want to reuse that experiences and the pleasure to play with such games in order to help and train the mild cognitive impaired people on recipe selection and ingredient/utensil search. The user interaction with VKards becomes input for the task processor.

We define two kinds of VKards: recipe and ingredient/utensil. Each card is structured according to the visual supports defined by Picture Exchange Communication System (PECS) (Bondy and Frost, 2001). Such a system is a unique augmentative/alternative training package that teaches children and adults with autism and other communication deficits to initiate communication using simple pictures exposing one image and its related text.

Each VKard depicts one image, the name of its subject, plus eventually the quantity, and one Amoeba visual tag on the top right corner. The recipe VKard is recognizable by the empty dish and the text “RECIPE” on its top. The dish background has the same colour of the borders of ingredients/utensils VKards used in that recipe. The same colour fills the cards back.

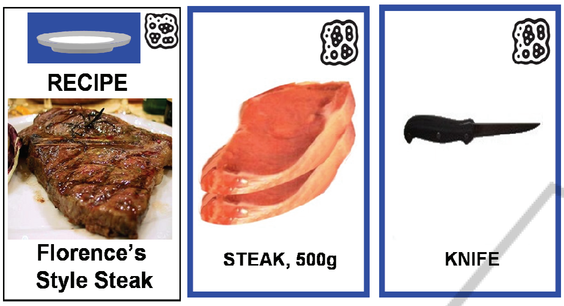

Figure 3: Example of VKards. From left to right: the recipe, one ingredient and one utensil.

The interaction model is the Token+Constraint (Ullmer at al, 2005). The VKard is the token and the constraints are areas where place the cards: the recipe area where placing the recipe card, the search area for the object that person is searching in the kitchen, the missing items area for items not available and the found items area.

5 RELATED WORKS

Around the world, several smart homes has been realized. Casattenta (T3Lab, 2010) and House n/PlaceLab (House_n, 2010) investigate how fabrication and sensing tools can be used to create responsive, adaptable environments helping in everyday life, integrating safety, comfort and energy saving where everything is under control but no more restrictions in everyday actions.

eKoti (DE, 2010) are smart home projects to design and construct electronic devices that user could not perceive, until he would actually use them.

Gator Tech Smart House (Gator Tech, 2010) is a laboratory-house designed to assist older and disabled people in maximizing independence and maintaining a high quality of life (Helal et al., 2008). In Canada, the DOMUS laboratory (DOMUS, 2010) of the University of Sherbrooke studies and develop solutions for cognitive assistance conjugating an intelligent home with mobile applications. The Ambient Kitchen (Olivier et al, 2009), placed in Newcastle, is a laboratory based on a real kitchen with a wide set of sensors and digital equipment in order to evaluate pervasive computing prototypes able to support people with cognitive impairments

Other works focused their attention on meal preparation. Counteractive (Ju et al., 2001) teaches cooking through a fixed multimedia projection of recipe steps and contextual information is neither used nor available. The Virtual Recipe of the Chameleon Kitchen (Lee, 2005) uses numerous invasive projectors and camcorders raising several occlusion problems to expose the predefined sequence of steps.

Other kinds of technologies can be used to enhance objects:

- Bluetooth emitters (Salminen, Hosio, and Riekki, 2006);
- Infra-Red tags (Ailisto et al., 2006);
- barcodes, like AURA (Bernheim Brush et al., 2005) and WebStickers (Holmquist et al., 1999);
- and RFID.

The last one is the major competitor of visual tags. Even if the RFID theory has been published in the 60’s, only since 90’s it started to be widely used on packages, blood sacks (Sandler et al., 2006), and so on. Passive RFID tags and visual tags are both so cheap. RFID requires specific readers while for visual tags a camcorder is sufficient. Both of them have occlusion problems but in favor of visual tags there is the fact they do not get interferences by metals and liquids.

6 CONCLUSIONS

The number of people affected by cognitive deficiencies is predicted to increase a cause of the population aging. The World Health Organization (WHO) provided an estimation of approximately 24.5 millions of people affected with dementia in 2005, which was going to increase to 30 million in 2015, reach 45 millions by 2030 (WHO, 2006) and 81 million by 2040 (ADI, 2008). Another study provided a worldwide estimation of AD in 2006 of 26.6 million which would multiply by four in 2050 (Brookmeyer et al., 2007).

Regarding economic problems, family caregivers often give up time from work to spend 47 hours per week on average with the person with AD. Old assessments, (Ernst and Hay, 1994), (Meek et al., 1998) evaluated the direct and indirect annual costs of caring for people with dementia is at least $100 billion per year in the United States.

Such numbers justify the great effort performed by Governments, industries and researchers to find solution to reduce the impact of cognitive deficiencies allowing individuals to best live in their homes, mixing and merging interdisciplinary technologies and studies, as architecture, design, electricity, ergonomics, electronics, computer science and psychology.

On our opinion, augmenting objects with not-intrusive technologies and defining TUI that relies on common activities are fundamental elements to design tasks able to enhance autonomy, to combat the deficiency effects and a good mean to promote self-esteem.

With respect to the interaction with traditional GUI, the TUI lets people to take advantage of the human haptic interaction skills for manipulating physical objects. For people aged or with mild cognitive deficiencies the use of common input devices may represent another difficult tasks, and TUI represents a more suitable alternative. Furthermore, it has the not secondary effects to stimulate the manual interaction with everyday objects and to push them to perform action and instead to stay passive.

Specifically on the use of VKard, the advantages are:

- its extreme cheapness (it is sufficient to print them);
- the ingredients and utensils can be searched any time and with the user preferred order;
- the cognitive deficient person focuses attention on the card, its picture and its text without striving to associate recipe and ingredients, names with mental images or pictures.

Some drawbacks are:

- the need to one constraint area;
- occlusions can not let the camcorder to see the visual tag and so to detect the VKard.

The proposed approach is an on-going work that will require several experimentations considering the particular the end-user category and the number of different disciplines involved. Before to formulate it, we have studied what could let to realize it and we lend TUI and visual tags from IT world, the PECS visual supports from alternative communication and VKards from card games. After the development phase, we plan to perform test sessions with normal and deficient cognitive people.

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