AmICog – mobile technologies to assist people with cognitive disabilities in the work place

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ABSTRACT

This paper presents the system AmICog, designed specifically to assist people with cognitive disabilities in their workplaces. To do that we employ mobile devices for two different purposes: on the one hand, to show interactive guides adapted to the user, the task and the user's context. On the other hand, to locate and provide directions in indoors environments.

1 Introduction

Personal autonomy is one of the main problems that people with cognitive disabilities have to face. Even those whose disability is not very severe, and they could be as independent as people without disabilities, the difficulty to find and keep on a job prevent them from real independence since. As de Urries stated in [DE URRIES, F.J. 2010], full autonomy of people with cognitive disabilities depends directly on the job placement possibilities.

Productivity, execution or planning capabilities are some of the issues around this problem, but some can be addressed thanks to the use of Assistive Technologies (AT in forward). As the ISO 9999 standard defines in [INTERNATIONAL 2011], *"Assistive Technologies are any device, equipment, instrument, technology or software produce to anticipate, compensate, monitor, mitigate or neutralize any dysfunction in the structures or body functionalities, restrictions in activities or problems in social participation"*.

The system presented in this paper, AmICog, can be considered as an Assistive Technology (AT) resource since its intention is to provide support to people with intellectual disabilities so that they can do their work more efficiently and effectively, promoting the independence and autonomy of these people.

To do that, mobile devices are employed as assistive systems to locate the user, guide her indoors and provide instructions about how to use resources or do tasks. Specifically, these tools were designed to be used in the work place, primarily during the training period that takes part during the first weeks and whenever a new task has to be taught.

An added-value of the system is the promotion of the assistance-training duality pursuing the user to not need the system anymore. Therefore, the virtual assistance could be adapted to the user's abilities. This way, it would be gradually reduced as long as the user gets confidence and experience in the task.

The system can be divided into two different, but narrowly related, modules. On the one hand, AssisT-Task provides adapted and interactive guides to help the user to handle resources or to do tasks. On the other hand, AssisT-In guides the user in her movements in the work place (offices, buildings, etc.) Therefore, we present a built-in system to make the job placement of people with cognitive disabilities easier, saving human and time resources.

This paper is organized as follows: after a review of the state-of-the-art, the whole system is described in detail: architecture, modules, data management, algorithms employed, etc. Finally, after concluding the most important ideas of the work, some future work lines are enumerated.

2 Related work

Nowadays, technology is part of our daily lives. Almost everything we do is supported by technology. Even in activities where Information and Communication Technologies (ICT) did not take part in the past.

One of these new areas is the assistance of people with disabilities or special needs. As it was said before, this research area is also known as Assistive Technology (AT in forward). Moreover, the increasing interest of the Community in this topic and the necessity of standardization made the International Standard Organization (ISO) to put forward the ISO9999 [INTERNATIONAL 2011] that defines and describes ATs in detail. According to Carmien et al. [CARMIEN, S. 2004b], this standardization helped to increase more the interest of the Scientific Community in the topic.

Furthermore, one of the most interesting aspects of the area is the relation between cognitive disabilities and human computer interaction. In particular, LoPresti et al. [LOPRESTI, E. 2004] listed a set of requisites that these technologies should fulfil to meet the necessities of users with cognitive disabilities. Among them, we find multimodality of information (graphical, video, audio), presenting the information as simple as possible and in sequence. Besides, the authors pointed that, in general, cognitive disabled people usually present some kind of physical or sensory disability as well. Therefore, they suggested introducing the user in the design process and the employment of user models.

Literature reviews offer many collections and classifications of ATs for daily live activities. One of the most complete and updated survey is [TSUI, K. 2010]. In this paper, the authors presented an up-to-date review of the literature focused on mobile devices to do sequential tasks. This revision provides a wide view of the state of the art thanks in part to the classification proposed, and to the comparative evaluation of some of the studied works.

The classification divided the works into two different groups: the ones that used technologies and the ones that did not.

If we consider only the ones that used technologies, the authors classified them regarding the system's capabilities. On the one hand, some systems could only present linear sequences. These projects (some specifically designed for mobile devices) showed a set of images and texts to help the users doing activities. In other words, a step-by-step guide was shown, representing the different actions to do to complete the task. Among them, we find iPrompts [HANDHOLD 2010] or The Jogger [INDEPENDENT 1998]. On the other hand, the authors suggested another group of systems that could present non-linear sequences. This is, the set of actions to follow to complete the task could be different depending on the user's context. Therefore, the sequences could be adapted to the specific user needs at any moment. Some relevant works of this type are Visual Assistant [DAVIES, D. 2002], Planning and Execution AssisTant (PEAT) [LEVINSON, R. 1997] VICAID [FURNISS, F. 2001] and Memory Aiding Prompting System (MAPS) [CARMIEN, S. 2004a].

Finally, the authors highlighted a special section for intelligent systems, this is, the ones that were able to detect user's progression and presented the next step automatically. Two examples are General User Interface for Disorders of Execution (GUIDE) [O'NEILL, B. 2008] and COACH [MIHAILIDIS, A. 2000].

Regarding indoor way finding, as Benson concluded in his study on the effects on landmark instructions for people with Down Syndrome [BENSON, M. J. 2010], they usually make more mistakes and need more time to carry out these navigational tasks in a virtual

environment, than other people with similar spatial development skills (i.e., people with another type of cognitive disability or kids). Besides, these worse outcomes may remain despite of previous training. According to his research, the main cause of this deficit is due to a dysfunction in the hippocampus associated to Down syndrome.
On the other hand, Lemoncello et al. [LEMONCELLO, R. 2010] evaluated three different orientation prompts: landmarks, cardinals and left/right arrows. After collecting the results from the field trial, they concluded that the best method was using landmarks, this is, using visual elements that could be identified easily along their names.
Another interesting work is [FICKAS , S. 2008] In this paper, the authors ran an evaluation with two groups of people (with and without disabilities), and asked them to follow some intentionally wrong directions. From the results they concluded that people with cognitive disabilities presented more difficulties to express their position (to a caregiver, for example). Besides, they needed more instructions to go back to the correct path, almost constant verification and more frequent interventions.
Regarding the information modality methods, Liu et al. [LIU, A. 2008] and Chang and Wang [CHANG, Y. 2010] were the first studies focused on the development of functional interfaces for people with cognitive disabilities. According to their studies, each user has her own preferences on the modality (images, audio or text) when receiving instructions. Another interesting work by Liu et al. is [LIU, A. 2009] This paper dealt with navigational systems and the utility of including additional information, such as landmarks, names or compound directions. Additionally, they addressed the route personalization. This is, adapting the route calculation to the user and, therefore, the instructions given (e.g. avoid stairs if the user has reduced mobility)
Another interesting work is WADER (Wayfinding System with Deviation Recovery), by Tsai [TSAI, S.-K. 2007]. This is an indoors navigation system for PDA that uses QR codes to provide directions for people with special needs.
The last work we want to stand out is Hidalgo et al. [HIDALGO, E. 2011] They suggested that result analysis should be considered as an important part of the developments as the customization or adaptation of the tools. In this paper the authors set out a system that studied the registries from a planning and evaluation tool to suggest recommendations for future tasks.

3 AmICog

The AmICog Project arises with the aim of providing assistance and resources to interact with the social and physical environment for people with cognitive disabilities. Specifically, it was first designed to assist these people in the workplace, making them more independent and autonomous. However, it can be extended to any other daily life activity. Therefore, AmICog can be considered as a mobile assistive technology resource [BOISVERT, A. 2009]
As we stated in the introduction, AmICog is composed of two modules: AssisT-Task and AssisT-In.

AssisT-Task

Getting and keeping a job is a key to be independent. However, people with cognitive disabilities present some limitations that may hamper them from being independent. Although the legal framework in Spain supports companies to hire people with functional diversity, in the case of cognitive disabilities there are some obstacles that limit these contracts, i.e. lack of autonomy, time to learn work labours and necessity of continuous supervision.
In order to make up for some of these obstacles, we designed AssisT-Task, a system that uses smart phones in combination to QR codes[1] to present interactive guides to help them doing job tasks. Moreover, the set of instructions is

[1] QR Code is a registered trademark of DENSO WAVE INCORPORATED.

adapted to the user needs and context as well as the task.

This work is based on the previous project "aQRdate" [GÓMEZ, J. 2013] but it has been improved in order to perform a better adaptation to the user's context. Formerly, the adaptation capabilities of aQRdate project were restricted to: on the one hand, the caregiver could reduce the amount of assistance given to the user as she learnt how to do the task. On the other hand, both the interface and the interaction were specifically designed for people with cognitive disabilities, considering their special needs.

As a result from the evaluation carried out, we concluded that the system helped learning how to do daily life activities (e.g. preparing a breakfast) and, therefore promoted the autonomy of the user. Furthermore, according to the data extracted from the personal interviews with the relatives and caregivers, the system also made the user more motivated and self-confident. In contrast, a limitation on the context adaptation was detected and that is one of the points that AssisT-Task tries to solve, how to provide a more accurate adaptation to the user context and the needs related to the task particularities. Therefore, a context collector mechanism has been developed so the sequence of steps can be adapted. Thus, tasks do not have to be strictly linear. This is, the set of steps may be different depending on the specific needs of the user in execution time. To do that we differentiate two mechanisms: repetitions and branches.

On the one hand, under certain circumstances, the user may be asked to repeat an action (a step of the whole sequence) a number of times. But two different situations may arise: in some cases the caregiver may know the number of times that the user should repeat the action while she designs the task but, in some others, this number may be unknown until the user performs the task, so she should be asked and the sequence should be adapted in real and execution time. An example of this state is making photocopies. This is an actual job task that many people with disabilities do as a work assignment. Despite of the more advanced user that may configure the copy machine to do a certain number of copies, for users with more restricted capabilities may be easier to repeat the action "press the copy button" as many times as they need to complete the task. In this case, the user would be asked "how many copies do you want to do?" and then the action "press the copy button" and the number of remaining copies would be showed until she finishes the task.

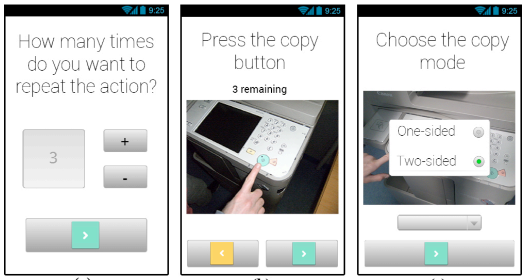
On the other hand, some tasks may not consist on the same set of steps depending on the specific context of the user. Coming back to the photocopies example, the specific steps to follow may depend on the copy format or mode, i.e. one or two-sided, automatic or manual input, colour or B&W, etc. The task "photocopies" is always the same but, as we have seen, the set of steps may vary depending on the specific user needs and context at that moment. Therefore, the caregiver has the capability of set branches when designing the task, so the user may be asked about her context in execution time. These questions consist on a list of options, where she can choose only one of them. After that, the sequence will be adapted to fulfil these requirements.

In order to describe and model the manuals, caregivers or tutors have to describe the different steps or actions that will compose the manuals. To do that, an ontology-based middleware for Ambient Intelligence environments is used [GÓMEZ, J. 2011]. This middle layer meets the modelling capabilities required:

- Modelling different tasks
- Each task can be composed of other tasks and actions
- Moreover, every part (task or action) could be reused if needed
- User adaptation has to be included in the model
- The model should be flexible enough to hold context adaptation by means of repetitions and branches

To fulfil these requisites, we took advantage of the modelling tools provided by the middleware, namely: classes, which represent the different categories of elements that can exist in the model; entities, which are the realizations of these classes; properties, which represent intrinsic properties of the elements; capabilities, that model functional properties; and relations,

which establish links between the different elements.
Particularly, two classes have been created: "*Task*", to model a manual or, in other words, a collection of steps. And "*Action*", to model each step that composes a manual. This also has two important properties: the title, which is the action itself and it would be showed to the user; and the image URL. Apart from that, some other properties are included in both classes, such as an identifier, name, etc. Additionally, Actions also include two capabilities in order to model the repetitions and branches, namely "*hasToBeRepeated*" and "*isMultipleChoice*". Regarding the repetitions mechanism, the capability contains the number of times that the action has to be repeated. As it was said before, in some situations the task designer may not know the accurate number of repetitions, so the user has to be asked. To model that, the designer has to set the value -1 to the corresponding property of this capability. This way, the mobile application may ask the user about the number of times that the action has to be done. On the other hand, modelling branches involves a more complex mechanism that implies relations. In this project, different relations are used to set links between Tasks and Actions: composition and next/previous position. Every position relation has been tagged with the user identifier, so the user adaptation is perfectly integrated in the model. Additionally, to model branches, another tag is added to the relation to identify the corresponding option.
Once the task and its actions are modelled, and the images are uploaded to the proper server, a QR code (with the task id) can be printed. Any user can scan it with her mobile phone and the AssisT-Task application will show the designed manual.
Coming back to the photocopies example, imagine that the task designer (caregiver, relative or tutor) decides that the number of copies has to be asked to the user, so the manual may be adapted to the current necessities of the user and the task. Besides, the sequence to make the photocopies might depend on the copy mode (e.g. one or two-sided). In this case, branches have to be included and, therefore, the user will be asked to choose one of the possible options.
These situations have been illustrated in Figure 1. As can be seen, there are three different screenshots that will be shown to the user to acquire the contextual information: (a), the screen to select the number of copies; (b), a step repeated three times (as can be seen, there is a counter that decrements as the user press the button next); and (c), screen asking the user for information. The user has to provide context information, selecting one or two-sided copies.



(a) (b) (c)

Figure 1: AssisT-Task screenshots. (a) Repetitions selection screen. (b) Action to be repeated. (c) Branch selection screen

AssisT-In

The AssisT-In module provides assistance to users with cognitive disabilities in their indoors movements. This help may result particularly interesting in unknown environments, such as a new workplace.
Global Positioning System (GPS) signal is often used to locate people. Thanks to the integration of GPS sensors in smartphones and the accuracy provided, around 5m. in theory, many applications have arisen taking advantage of these features to provide new services. However, GPS signals only work in outdoor and clear environments. Therefore, indoor environments require new location mechanisms and procedures.
Our proposal is based, again, on QR Codes in combination with smartphones. This way, an environment (office, floor, building, etc.) can be tagged and modelled so that the user may be able to scan any of these QR codes to get the automatically locate and guide her to the destination.
Before providing the directions, the system has to identify the user first, so the instructions can be adapted to her. To do that, due to the possible

limited capabilities of the target users, instead of asking for a user name and password, we decided to show a list of names with pictures so that the user could identify herself. After that, a list of the possible destinations is shown and the user is asked to choose one of them. These destinations have to be previously set up by the caregiver or the person in charge in the work place. Finally, the user is located by scanning the closest QR code. This way, the system is in position to calculate and show the different directions to guide the user to the selected destination.

On giving directions, instead of using "turn left/right", "go upstairs" or "go straight" instructions, we decided to follow the general recommendations we found on the state of the art review [LEMONCELLO, R. 2010] and show actual photographs showing the position and view of the next QR code, similar to the identification of landmarks. This decision involves one deployment requisite: there has to be direct vision between the different QR Codes.

At every point of the route, three instructions are given to the user: first, the actual view to find the next QR is showed and the user is asked to go there. After that, the user has to press the scan button and finally, a feedback interface is provided (correct code, code out of the route or unsorted code). Then the next QR view is showed and the whole process is repeated unless it is the end of the route. In that case, the user is informed that she has reached her destination and the application is closed.

Both the interface and the interaction have been adapted to meet the user needs, presenting clean and simple interfaces and clear texts. In addition to that, a virtual assistant (a dog) has been included. According to Schroeder and Axelsson [SCHOROEDER, R. 2008] the use of virtual assistants contributes to the user's motivation. Besides, the assistant is in charge of giving the feedback and its expression changes according to the information provided.

Finally, one of the advantages of the presentation mechanism (real views) is to make the user more aware of the environment, promoting the location and learning of reference points. On the other hand, from the user point of view, the instructions are simpler and the process is always the same (find the view, go to the QR, scan and retrieve the feedback)

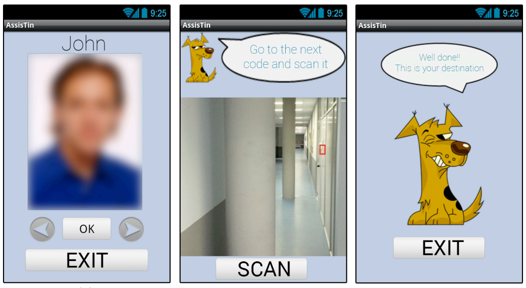
The system's architecture is based on the client-server approach. The server stores all the information in a database and processes it, while the client is used to present the appropriate information and locate the user.

The deployment of the system requires some previous steps to be in position to guide the user. The first task is tag the environment. To do that, several QRs has to be printed representing different IDs (numbers) so every QR is unique. Once all the places or resources are tagged, they have to be modelled in the database. It is composed of three files to model: blueprints, nodes and edges. Blueprints are abstract elements that represent a map, composed of several nodes linked by edges. In other words, a graph. Modelling floors, offices or buildings as graphs offers the advantage of ease of analysis and calculus. There are several algorithms to study graphs and, in this project, can be used to calculate the best route.

Therefore, the atomic elements of the maps are nodes, which represent different places or resources. Moreover, not all the nodes are possible destinations; some are auxiliary points (or QRs) to make easier the guidance (e.g. QRs in corridors or turns). Every node can be connected with one or more nodes by edges. And, every edge involves two photographs that will be shown, one from each node "looking at" the other.

Once the environment is tagged with QRs, modelled and the photographs are available, the user is in position to ask for guidance. To do that, as we saw, she has to log in the system, select the destination and scan the closest QR. All this information is sent to the server and the information of the next QR code is returned. To do that, the Breadth First Search algorithm has been used since it is a non-directed graph without weights.

In Figure 2 three screenshots are provided. Image (a) corresponds to the user selection screen. As can be seen, the user only has to press left/right arrows to find herself and then press OK. Image (b) shows the real view to find the next QR code. In this case, the QR has been highlighted with a red square since it was difficult to identify due to the perspective distortion. Finally, image (c) shows the feedback screen corresponding to the last step of the route, informing the user that he has finished. Note the friendly face of the virtual assistant.



(a) (b) (c)

Figure 2: AssisT-In screenshots. (a) user selection screen; (b) next QR view; (c) destination reached screen

4 Conclusions

Thanks to the combination of QR Codes and smartphones we are in position of presenting a built-in system, AmICog, which aims to assist people with cognitive disabilities in their daily life activities. The use of smart phones in combination to QR Codes provides information of the user's context and a communication channel with her.

AmICog is composed of two modules, AssisT-Task and AssisT-In. The first one provides adapted manuals to guide the user to do daily life activities. QR codes allow encoding the minimum information to identify the task and, once scanned with the smart phone, the system presents the task manual adapted to the task itself, the user and her context. This module is based on a previous development, but it has been drastically improved thanks to the inclusion of repetitions and branches so sequences do not have to be strictly linear. Depending on the user context, the set of steps that has to be followed to complete the task may vary, offering a more flexible and adapted system. This mechanism is based on two new capabilities: the possibility to specify that a step has to be repeated for a number of times (fixed or asking the user) or asking direct, choice and closed questions to the user to get her specific needs in execution time.

On the other hand, AssisT-In provides directions to locate resources indoors. In this case QR Codes are employed to locate the user, since GPS signal does not work in indoor environments. Therefore, the environment has to be modelled and tagged with these codes so the user can be located after scanning any of them and directions can be given precisely to assist her to arrive at her destination. Furthermore, the assistance-training duality is stressed thanks to the presentation mechanism, which makes the user to be aware of the environment.

5 Future Work

Considering the development state of the system, the main line to work in is the evaluation of the different modules with real users. This way, we would obtain a certain measurement about the suitability of these tools, as well as detecting possible conflicts y make a deeper study on the gradual assistance adaptation.

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