Developing a multi-touch Serious Game to fight the digital divide

The Portuguese ATM: a pilot case study

Diana Carvalho, Maximino Bessa, Emanuel Peres, Luís Magalhães
USIG and ECT
INESC TEC and UTAD
Vila Real, Portugal
dianac@utad.pt, maxbessa@utad.pt, eperes@utad.pt, lmagalha@utad.pt

Carlos Guedes
DEEC
INESC TEC and FEUP
Porto, Portugal
cguedes@fe.up.pt

Lia Oliveira
Institute of Education and Psychology
University of Minho
Braga, Portugal
lia@ie.uminho.pt

Abstract—**The use of Information and Communication Technologies (ICTs) has grown substantially over the past few years. However, a portion of the world's society has not been able to keep up with these technological advances. For this purpose, we present a serious game with a multi-touch interface envisioned to encourage and teach digitally excluded people on how to use the Portuguese Automated Teller Machine (ATM): a commodity much needed by society, but still avoided by some, mainly due to their fear of the digital world. An exploratory study was conducted to investigate if a serious game based on a new interaction paradigm can have a positive influence in the struggle against the Portuguese digital divide. We believe that the findings of our pilot case study can be useful to determine if a multi-touch serious game, due to its intuitiveness and ease of use, can stimulate the digitally excluded people to handle the ATM on a regular basis. The results that were obtained suggest that this approach may indeed produce a positive impact in the attempt to bridge the Portuguese digital divide.**

Keywords-Serious Games, Digital Divide, Natural User Interfaces, Multi-touch, HCI, ATM

I. INTRODUCTION

The Information and Communication Technologies (ICTs) are shaping the way we communicate, live, work and learn. They can even be considered a tool for the economical growth and social development of societies, transforming how we create, store, and distribute information [1]. Nevertheless, some people still have not embraced ICTs: this happens due to economic, demographic or environmental factors [2]. Numerous determinants may come as defining factors for the society to acknowledge ICTs: size and geographical position of the urban population, its historical context, adaptation easiness, technological costs, infrastructure availability, social characteristics (age, gender, ethnicity, status), cultural access or average education level of the communities [3][4].

In Portugal, a portion of the digitally excluded society does not use ICTs mainly due to educational factors, i.e. low levels of literacy in the community: they do not know how to use an electronic equipment, and they have never tried to use one out of fear of damaging it [5]. According to the statistics, there was an increase on the number of ATM (Automated Teller Machine) terminals existent per 100 000 inhabitants in Portugal, arising from 8,2 terminals in the year of 1990 to 134,6 in 2010 [6]. However, only 70% of the Portuguese population uses this equipment. Furthermore, the areas that registered a worse usage percentage were the ones in Northern Portugal, with just 64% of the population using the device [7].

In an effort to familiarize the excluded community with what seems to be one of the most feared technological services [5] – the ATM – we created a multi-touch serious game named "Multi-touch ATM". Its main goal was to help people with low levels of digital literacy, so they could learn how to use the ATM and perform its key operations. In this context, we wanted to: (1) make the participants understand how the device works, how to interact with it and its functionalities; and (2) gain their attention through a serious game that is based on a new kind of interaction and, therefore, observe if they respond positively to it without making them fearful of the technology.

In this paper, we explore the impact of a multi-touch serious game within Portuguese digitally excluded participants. After briefly presenting the related work and discussing the importance of serious games, we describe the methodology used for this case study and its results. By reporting our observations, we throw some light on how excluded people

approach and perceive information through a serious game that attempts to teach them how to use a feared equipment. This, together with the acknowledgment on whether the new interface paradigm can stimulate users to handle technological equipment on a regular basis, is the main goal of our study.

II. Related Work

In this section, we briefly outline scientific background related to serious games and their importance in the struggle against the digital divide. Furthermore, in order to clarify our choice of a game based on a natural user interface (NUI) as a catalyst to an easier interaction, we also lay out the impact of multi-touch technology and why it can represent a possible path to overcome digital exclusion.

A. *The importance of serious games for the digital divide*

The digital divide cannot be generalized nor can it be measured with the same parameters on different contexts [8]. In order to involve the "information have-nots" [3] in the digital era, we must first learn the main cause on each community for that phenomenon to occur. Studies have indicated that the main determinant is the educational level of the community [9][10][11]. The fact that technology plays an important role in our daily lives makes us realize that as the world evolves, so does our need for new literacies and ways to learn [4]. It is no longer appropriate to use traditional methods to teach, but to use other means to engage people in the learning process instead.

Serious games have the ability to successfully develop and enhance people's skills and expertise, making them feel motivated and offering direct and continuous feedback [12]. This approach has shown to be effective and has a positive impact on learners [13], and can be implemented to instruct large sectors of the population, even with different motivations and social backgrounds [14]. As these games are proving to be important assets in the learning process, there has been an increase regarding their scopes: simulations [15], training [16], health care [17], therapy [18], among others.

This is an active research area with a lot of potential, as serious games are absorbing features of our daily lives and presenting more realism than ever before [19]. In fact, they may play a very important role in the struggle against digital exclusion due to their ability to engage users and allow them to explore the interface at their own pace, without feeling they have a strict obligation to learn the contents.

B. *The importance of a NUI-based serious game in the Portuguese digital divide*

There were several attempts at bridging the digital divide, whether it was through a mass production and distribution of personal computers [20] or by the implementation of movements to raise awareness on this problem [21].

In 2008, Portugal presented one of the highest values of the European Union concerning the Internet penetration and infrastructures availability, with 95% of the territory covered [22]. Moreover, an economical approach also revealed that the financial access to the equipment was not the problem either, since the country held the 3th lowest price of the Internet connection of all the European countries [23]. However, low education levels prevented a portion of society from using ICTs, as they did not have the knowledge on how to use them. In 2005, 74% of the Portuguese population between 16 and 74 years old had not completed the secondary education [24]. This circumstance explains why Portugal faces one of the lowest literacy levels in the European Union.

With this in mind, it is not enough to control the spread of the technological equipment and infrastructures, but also understand if the community has the ability to use them or not. The dissemination of technological equipment alone cannot solve this problem, as there is a priority to improve computer skills and interaction easiness rather than providing more computers [25]. Multi-touch technology can act as a solution for this situation due to its small learning curve [26]. This technology is a part of the new Natural User Interfaces' era that focuses on a more intuitive and direct manipulation of the technological devices, allowing the users to take advantage of their cognitive, motor, tactile or even social abilities [27], and improving the human-computer interaction by being able to perceive gestures or speech. Furthermore, it enables the user an interaction with no need for prior acquaintance with the device. The absence of a required user's manual or obligatory training is noteworthy [26].

Apple iPhone and Microsoft Surface were a breakthrough in terms of bringing technology and people closer: Banes presents a series of results about the impact of the latter on people with disabilities [28]. The existing solutions regarding the educational scope [29] and health care support [30] also reveal its advantages. Other studies have been made regarding gestural interfaces and games for elderly [31][32], people with motor disabilities [33], and children with special intellectual needs [34].

However, there has not yet been a study of how this interaction paradigm can help overcome the difficulties imposed by the digital divide: more specifically, when it comes to interacting with equipment such as the ATM. If the problem of the digital divide is the low levels of literacy in the community, these novel standards of interaction may improve the human-computer relationship.

III. "Multi-Touch ATM"

Our multi-touch serious game was named "Multi-touch ATM" and it was envisioned to teach users how to perform the most popular operations executed on the ATM: introduce the PIN number, check the account balance and withdraw cash. We chose this equipment because of its importance to society, being vital as a way to manage a bank account on a regular basis. Even so, digitally excluded people avoid it, mainly because of their fear of technology, and prefer to wait for attendance at the bank's counter than quickly execute the key transactions allowed by the device (as we concluded through the initial questionnaires given to the participants).

From our personal experience with our target-audience, they could not be taught individually, as they would avoid the process of learning if confronted alone with the ATM. Therefore, it was a requisite to propose a serious game that, at a

first stage, could enable more than one user, thus making the participants feel comfortable and at ease to communicate and interact with each other and the game. Moreover, this would allow us to observe their behavior concerning teamwork and collaboration, although this was not our main concern. We believe that the game could also be an incentive to motivate and acclimatize digitally excluded people to properly explore technological equipment, as well as stimulate their abilities. Here, the advantage of the multi-touch's natural interaction through gestures was of the utmost importance.

A. *Technical overview*

We used the programming language Python to develop the serious game. In order to trace individuals' touches on the surface we resorted to the Community Core Vision, an open source/cross-platform solution for computer vision.

B. *Game description*

The most basic operations to perform on an ATM were divided in levels. The application's graphical environment is constant throughout its four different levels: they all begin with an introduction of the level's main goal explaining the task at hand, how to complete it successfully, and some points that should be considered during the interaction. The graphical interface of the game was designed to be as similar as possible to the real ATM. The screens corresponding to the different possible operations responded in the same way the real ones would if the user inserted wrong data. This was meant to avoid a discrepancy between the real screens and the simulation that could induce misapprehension of the contents. Worth noticing is also the fact that all buttons presented in the application had the same function of the real ones and responded exactly the same way. Our main concern was to be able to familiarize the participants with the graphical interface of the equipment and not cause confusion when facing a real ATM. At the end of each level successfully completed, a "Congratulations" message was shown in order to emphasize the accomplishment and encourage them to explore more levels (Fig.1). Moreover, there was a decision made concerning the time limit for the user to complete each level: given our target-audience, we avoided to restrict the time for the tasks being concluded, as the participants could develop a sense of anxiety and thus affect their performance.

The first level (Fig. 1) tried to seize the natural interaction advantage, allowing gestures to resize, rotate and move different parts of an ATM. Here, the goal was to place the broken modules of the equipment back to the right position. The user was always given the possibility to try to surpass the different obstacles and interact with the game independently, or being helped by colleagues, thus highlighting the multi-user feature of the game.

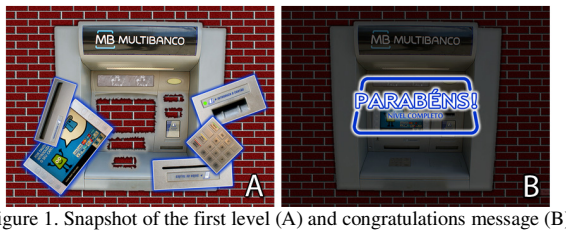

Figure 1. Snapshot of the first level (A) and congratulations message (B)

In the second level (Fig. 2), the user was asked to rotate the banking card to the right position and insert it in the ATM slot. The user was presented with two cards and could only advance if both of them were placed correctly. Here, we intentionally restricted the number of participants to only two for behavioral analysis purposes, even though there was always an option of only having one participant playing.

The third level (Fig. 2) forbade multi-user collaboration, encouraging the user to interact alone with the equipment and thus developing a notion of independency. Here, the user was asked to memorize a PIN number that was given to him through the game and insert it correctly. The level was prepared for every action that could happen in a real device: introduce the wrong code, choose the wrong button or interrupt the operation. The fourth and last level (Fig. 2) challenges the participants to withdraw some cash, but not without first compelling them to consult the account balance.

Figure 2. Snapshot of the second level (A), snapshot of the third level (B) and snapshot of the fourth level (C)

These levels cover the more basic operations that could be performed in an ATM, and the game responds exactly the same way the real equipment would. In fact, the learner can only go further in the game by following the same options a real ATM would require.

IV. CASE STUDY

During this study it was necessary to identify the target-audience that could benefit from this approach. We came to the conclusion that all age groups were relevant in this situation, but with more emphasis on the eldest due to their harder adaptation to new technologies. Therefore, for this case study we considered people ranging from 30 to 80 years old. The common characteristic among them is their difficulty to use the ATM. We did not cover people younger than 30 years old mainly because of their apparently easier adaptation to new technological devices.

Apart from trying to teach people who had never tried the ATM, despite their will, we also hoped to understand if the people who had already tried it, even unsuccessfully, could also respond to the new type of interaction offered by the game and even become a partner that could help others during the tests. Our purpose was to give learners the opportunity to interact more naturally with a machine and also analyze, during this process, their level of satisfaction.

A. *Apparatus*

Two Parishes of Vila Real were considered for this intervention study: Constantim and Andrães. These are closely located to the main city, but present low literacy rates, as the majority of its community only concluded the 4th grade of primary education, and their main occupation is agriculture. In

spite of being rural and more isolated communities, they have a diversified population in terms of age groups, holding an average age of 45 years old.

The intervention was divided in different phases and performed at specific places granted by the respective chairmen within the facilities of the parish councils. The tests were conducted within their own facilities in order to accommodate the participants in an area where they could feel comfortable and at ease, which would facilitate the interaction process. The first set of tests was carried out at Constantim, where 6 individuals participated: 4 of them on the first day and 2 of them on the second. Andrães hosted the other intervention, where 3 individuals participated during one day of tests.

The physical surface required for the intervention was also vital. Therefore, we built a specific physical prototype according to our needs and defined its configuration. We chose to implement the "Laser Light Plane" technique on the surface, not only because of its swiftness to build and low cost, but also due to its efficiency at detecting human touches. The table had a 42'' touchable surface and was able to support interaction with up to 3 people simultaneously, thus permitting some level of teamwork. In order to be able to transport it more easily, the structure was built with the goal of retracting when not in use.

B. *Participants*

The group of participants of the investigation consisted in nine individuals with ages comprised between 32 and 78 years old. Table 1 presents the characteristics that are relevant for this pilot case study.

TABLE I. PARTICIPANTS' CHARACTERISTICS

Age	***Experience with the ATM***
67	Had unsuccessfully tried the equipment
78	Had never tried the equipment
46	Had never tried the equipment
52	Had unsuccessfully tried the equipment
35	Had unsuccessfully tried the equipment
32	Had never tried the equipment
41	Had never tried the equipment
57	Had never tried the equipment
62	Had never tried the equipment

a. All of the participants consented to disclose this information.

According to the initial questionnaires, 67% of the individuals had never used an ATM before. They justified that answer by responding that they were afraid to press the wrong button and, in several cases, they did not need it because they usually asked someone to do it instead. The other participants had already tried to use the ATM, but unsuccessfully. We thus found that the individuals had different levels of knowledge in terms of technology. This was a good thing, as we could join people with different levels of digital literacy interacting with the same equipment and helping each other.

C. *Procedure*

In light of the complex approaches on the social scope of the investigation, there was a necessity not to limit it to an elementary strategy. In order to comprehend the communities' characteristics, behaviors and difficulties, we conducted a controlled interview made to the Chairmen of the two selected parishes. These interviews were essential to collect sincere opinions and observations needed to justify the interaction design of the game.

Furthermore, before the tests the participants were asked to answer a quick questionnaire in order to understand their previous experience with technological equipment, more specifically the ATM. We monitored the test during the entire experience, resorting to direct and participant observation. Even more, every session was documented through photography and video recording, with the express statement of consent of all of the participants. After the tests were concluded, another enquiry was made to gather opinions on the quality of the interaction and their user experience, and to discover if they had learned the contents that were expected.

D. *Limitations of the study*

There were two limitations in this study:

- The game that was created was not complex enough to explain and teach every functionality of an ATM. However, it was only intended to teach this type of population the use of its most popular operations.
- As the tests were conducted on specific days, a portion of the active population could not attend them due to their working schedule, even after the experiment had been announced to the community. This left a part of the target population out of the experiment.

V. ANALYSIS AND DISCUSSION OF THE RESULTS

Regarding the interaction of the participants with the virtual application, there were some aspects we tried to cover and observe more carefully: (1) interaction problems the users had during the tests; (2) how much time they spent to get familiarized with the multi-touch technology; (3) how many levels they managed to complete and how much effort they put into it; and (4) how much help they needed from either the other colleagues or the investigators.

A. *First impact of the application on the participants*

Initially, most participants feared to touch the surface of the equipment with their bare hands. In fact, three participants were reluctant to interact with the game merely because they saw a computer mouse on top of the physical prototype and refused to use it. After being told that they would not use the mouse but their hands instead, they positively embraced another posture and immediately felt more at ease. The 78 year old participant was also reluctant to interact with the interface, but after a quick demonstration by the investigator moving and rotating one digital image, she felt more confident and tried it herself (Fig. 3). After one single attempt to manipulate the images, she realized how effortless it was and, without help, managed to quickly rotate and scale the digital content. This is

a big accomplishment for a woman of this age that had never used any technological equipment before. In fact, she even claimed "This is easy!" and encouraged her colleague, who was also distrustful to do the same. Even without any experience on any technological devices and despite her age, this participant did not perform worse than the others, as she completed this level in only a few minutes.

Figure 2. First gestures of interaction

The first level proved to be stimulating, as the participants felt the instant feedback depending on where they touched. It was proven that every participant successfully managed to complete the task in less than 10 minutes, only being needed an explanation on the type of possible gestures. It was also an advantage that the level's introduction displayed a complete ATM, so the users could understand the correct position of the different modules.

B. Teamwork

The participants often tried to immediately help the colleague if they had any difficulty on where to touch or what gestures to make. In fact, we observed that when the participants were side by side, they were ready to act promptly if the other one was having any doubt on what to do. At times, they would even try to manipulate the content together.

We also noticed that there was an emergence of a social role during this process: some participants acted as the "teacher" showing what should be done, while others tried to encourage each other to solve the tasks. During the test, as soon as one participant finished their task at hand, they would immediately try to encourage the others to do the same, thus creating a sense of collaboration. In fact, the participants exhibited great satisfaction during the interaction for being able to help their colleagues to complete the levels.

C. Behavioral changes

All of the participants revealed a fast evolution in terms of a smoother interaction throughout the test: the initial fear demonstrated by most of the individuals gradually disappeared. In Fig. 4, we can see that instead of only using one or two fingers to manipulate the digital information, at one point the participants began to use the entire hands on the surface, so it seemed that they felt more at ease with the prototype over time.

Moreover, they managed to overcome their initial fear as a group, and not alone. When asked to complete the last two levels individually, they felt confident because they had already surpassed their apprehension regarding technology. For someone who promptly avoided technological devices, this was an impressive progress.

Figure 1. Behavioral changes and readiness to collaborate

D. Setbacks

1) The literacy level of the participants: some of them did not recognize what to do because they did not understand some expressions, like "account balance", so the researchers had to explain it. This was a problem during the tests, as the lack of general knowledge interrupted the interaction process.

2) The enthusiasm of the participants: some participants did not understand when to perform, or not, certain gestures because they wanted to show off the new skills and constantly tried to repeat the gestures previously learned, regardless of the context. Additionally, three participants were so eager to start another level that they would not even read the instructions to understand the level's goal and would immediately select the start button. This situation forced the researcher to restart the level.

E. Final questionnaires

At the end of the experience, when asked about their satisfaction regarding the game, 60% of the participants answered that they "liked a lot", and the rest that they "liked". Positively, all the participants were sure that they had learned new useful information. In fact, all of the individuals asserted that this type of interaction to teach contents – in this case how to use the ATM – was very compelling: 70% of the participants expressed a will to start using the technological equipment more often and learn more about it.

We questioned the participants again 15 days after the experience in order to validate the results and verify if the experience really did have an effect on their daily lives. According to the new questionnaire, 2 participants out of the first 9 actually changed their behavior and began to use the ATM. Other 3 participants used the equipment again after the experience but they could not be considered frequent users. The remaining subjects did not use the ATM again.

VI. CONCLUSIONS

This exploratory investigation was intended to understand if a serious game supporting an easier interaction could facilitate the learning process regarding the use of the Portuguese ATM by the digitally excluded people. Results obtained suggest that serious games have a lot of potential as a driving force in the struggle against the Portuguese digital divide. Our choice to create a serious game based on a natural interface presented itself to be the most appropriate, as we observed a positive response from the participants regarding the intuitiveness of the game. We recognize that this approach may represent an important step in bridging the digital divide

and helping people to better relate to technology. In fact, 2 of the participants started to frequently use the Portuguese ATM.

Regarding the game's interface we noted that, for some participants, the contents that were taught were even easier to apprehend than we had estimated. We believe that this happened due to the interaction paradigm used. Although the participants were reluctant to touch the surface at first, they got comfortable with the game after realizing that they could manipulate the objects with just a natural hand gesture: the fact that they did not need another device to assist them with the interaction (e.g. mouse), highly encouraged the individuals to get engaged with the game. Their enthusiasm was visible while discovering the ATM interface, not noticing they were actually learning how to use the electronic device that they were so afraid of using before, as they were focusing on completing the different levels as quickly as they could.

This pilot case study presents preliminary perceptions that may be vital to understand the problem locally and close to the population. In the future, we intend to perform more tests and expand them to other geographical areas. In order to support our findings and acknowledge to what extent the serious games can help fight the digital divide, other feared technological equipment may also be considered.

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