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New interaction paradigms to fight the digital divide: a pilot case study regarding multi-touch technology

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Abstract

Information and Communication Technologies (ICTs) are considered a powerful tool for economic development and the growth of societies. However, instead of helping overcome society's inequalities caused by the digital era, they have instigated an increase of the people that rested aside of the information age. The digital divide refers to the difficulty info-excluded people have in keeping up with technological advances. This phenomenon was triggered by the rapid growth and dissemination of technological equipment, as a portion of society did not have the proper time or knowledge to adjust. This paper sets forth a new approach to help fight the Portuguese digital divide by presenting new ways of interaction. Resorting to multi-touch technology, we examine how this new natural interaction paradigm can have a positive influence in the struggle against info-exclusion. For this purpose, we present a multi-touch game envisioned to encourage and teach digitally excluded people on how to use an important and needed everyday equipment – the ATM (Automated Teller Machine) – as it is still avoided by some. We believe that our pilot case study can show preliminary results on how natural user interfaces may be beneficial to help overcome some difficulties enforced by the digital divide. We consider that our findings may be valuable to show a possible path of how the new natural user interfaces can help bring technology and people closer. After being asked about their user experience, the participants of this exploratory study agreed that the game encouraged them to explore more about new technologies.

Keywords: digital divide; HCI; natural user interfaces; interaction paradigms; multi-touch; ATM

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1. Introduction

The increase of the digital divide worldwide currently presents itself as one of the biggest challenges of the digital era, with repercussions, both direct and indirect, over several contexts of the Information Society. Indeed, knowledge is presently considered a fundamental driver to enhance global competitiveness and productivity, as well as innovation and wealth generation [1]. However, the existing gap between those who could keep up with the technological advances, and those that did not, represents a barrier for all communities. Indeed, this problem prevents the populations to be given a fair dissemination of knowledge and equipment, and thus the improvement of their quality of life and cultural enlightenment.

Info-exclusion, or digital exclusion, reflects the deprivation of the access to ICTs, whether it is due to political, socio-economic, cultural or even environmental reasons [2]. This worldwide phenomenon cannot be generalized or even measured according to the same parameters: different contexts and social backgrounds can be presented as defining influences for the society to embrace ICTs [3]. In fact, in order to give the "information have-nots" [4] the opportunity to embrace new technological advances in this information age, numerous determinants must be acknowledge, such as: their social features (age, gender, ethnicity); historical background and cultural access; their average educational levels; global geographical position; or even proximity to urban populations and their size, infra-structure availability and technological costs [5–7]. In an effort to close the gap between individuals with different socio-economic levels, regarding both their opportunities to access the ICTs and the ability to use them, it is first necessary to understand the primary cause in each specific context [8].

According to several studies, the main contributing factor for the digital divide to occur is the educational level of the community [9–12]. This is, indeed, the fundamental cause for the Portuguese digital divide [13], as the community avoids using useful everyday equipment such as the computer, mobile phone or even the ATM (Automated Teller Machine), because they do not feel confortable handling them. While these situations were aggravated by the appearance of the traditional ICTs, as communities did not have the knowledge to use them, they could presently be improved due to the interaction paradigm's shifts emerging.

The new era of natural user interfaces takes advantage of the knowledge society already haves (human natural interaction based on gestures or voice), instead of making them learn new concepts. Therefore, it becomes important to recognize if these user interfaces can really help fight the digital divide when the main determinant for that phenomenon in a community derives from an educational scope.

For this exploratory investigation, a multi-touch and gesture-based natural user interface simulating the ATM was created. We chose the ATM as the focus of our investigation because of its importance in our daily lives, despite its deficient use by digitally excluded people: only 70% of the Portuguese population uses it [11].

In this paper, we want to understand to what extent multi-touch technology can encourage the use of technological equipment by info-excluded people and help overcome the barriers imposed by the previous user interfaces. After presenting a brief outline of the related work and the importance of Natural User Interfaces (NUI) in the Portuguese digital divide, we believe it is important to also clarify the foundations for the game created for this preliminary investigation and its features. Furthermore, we describe the methodology used for this pilot case study and discuss its results. By reporting our observations and conclusions of the interaction with the multi-touch surface, we believe that we can provide insights on how excluded people approach, perceive and interact with a new natural interface.

2. Scientific Background

In this section, we briefly outline related work concerning info-exclusion and what efforts have been carried out to overcome this worldwide phenomenon. Moreover, we attempt to understand the importance of NUI in the struggle against the digital divide and why these new interaction paradigms may be considered a positive

choice.

2.1. The digital divide as a worldwide phenomenon

There have been several attempts at trying to bridge the digital divide, as this is a worldwide phenomenon with global consequences [14]. However, the spreading of movements [15] to increase awareness on this problem and the mass production and distribution of technological equipment [16] and infra-structures is not sufficient [17].

Indeed, there are other strategies to endorse the fight against the digital divide at different geographical locations, supporting all of them the importance of promoting digital literacy in the communities [18–20]. Peña-López [21] approached this phenomenon in the higher education, as most universities leave digital competences unattended, and proposed that various stages of digital literacy should be taken into account: from the simplest needs to the most thorough understandings.

However, other than studying the impact of the spread of infra-structures and strategies to include info-excluded people, there has not been a study yet of what paths to follow in order to enhance this learning process. In fact, it is very important to analyze if, and how, the new natural user interfaces and the new interaction paradigms can help overcome the difficulties imposed by the digital divide.

2.2. The importance of natural user interfaces in the Portuguese digital divide

In Portugal, the main determinant for the digital divide is not due to economical or technical factors, but because of the low levels of literacy in the community [13]. It is not enough to control the spread of the technological devices and infra-structures as we must also understand if the community has the ability to use them or not. And if not, what can be done to minimize the problem. One of the main reasons for the Portuguese info-excluded people to avoid embracing technological advances is their fear to deal with the devices and damaging them.

One of the solutions to overcome this fear might be the emerging human-computer interaction paradigms, namely multi-touch interfaces. This new era focuses on a more intuitive and direct manipulation of the technological devices. Instead of having a technology-centered context, we now turn to a human-centered one, where technology can “understand” the user and his/her context of use [22]. According to Buxton [23], the only innate behavior is to eat, breathe, touch, hear. Knowledge is something expensive to acquire. That is why, when it comes to technology, people should not be obligated to learn the machine’s language and waste their own abilities, but it is technology who should learn the user’s language, allowing them to use their cognitive, motor, tactile or even social abilities.

The main goal of a natural user interface is to remove other intermediary devices, like the computer mouse, to support information input [24]. In this regard, technology is focusing on the users and their needs and adopting a user-oriented and task-oriented approach [25]. Presently, we witness a user interface paradigm that is contextual and enables the user to interact with it physically, with no need for previously acquaintance with the device or obligatory preparation [26]. Moreover, the multi-touch interface’s capacity to detect multiple points of input has raised new challenges for multi-user interaction. Multi-touch surfaces enable multiple users’ input simultaneously, stimulating collaborative work and social cooperation, thus also emphasizing how it is more common for people to try to use a system if another one is already using it [27]: people tend to observe others interacting before trying it themselves.

In short, if the problem of the digital divide is the low level of literacy in the community, these novel standards of interaction can help solve unnecessary learning practices and thus improve the human-computer relationship.

3. The multi-touch interface

The main goal of this preliminary study was to understand if a multi-touch interface could be considered an incentive for the participants to explore technological equipment's features and stimulate their learning skills. Thus, the game created for this investigation was intended to teach how to perform the most popular operations permitted by a Portuguese ATM through an intuitive interface that allowed multi-touch and gestures. We chose to simulate the ATM because of its importance to the Portuguese community. Even so, digitally excluded people prefer to wait for attendance at the bank's counter than quickly complete the transactions allowed by the device.

The game was envisioned to gain the attention of the participants without making them fearful of the device and thus observe if they responded positively to a new kind of natural interaction with no need for previous learning. It was of the utmost importance that the interface allowed the participants to embrace the contents being taught, as well as trigger their curiosity and motivation to explore other technological equipment.

3.1. Game prerequisites

The game had two major prerequisites: the ability to detect various users simultaneously; and enable interaction with no time limit. As asserted by Peltonen et al. [27], and also endorsed by our own personal experience with our target-audience, the participants should not be confronted with the technological equipment individually. In order to embrace the learning process of this case study, they had to be taught in a group. Therefore, the game's ability to enable multiple touches and different users simultaneously was a prerequisite. This feature was recommended while the participants were still becoming accustomed to the interface and the type of interaction and would also warrant us the possibility to analyze their behavior concerning teamwork and collaboration. Moreover, there was no time limit for the participants to complete each level. Given our target-audience, we made a decision to not restrict the time for the tasks being concluded as there was a possibility that the participants could develop a sense of apprehension and anxiety about finishing the level on time, thus affect their performance.

3.2. Level's description

The game created was a multi-touch and gesture-based natural user interface, allowing a multi-user collaboration in the first and second ones. Each level supported different types of interaction based on touch and gestures, and its goal was explained by small introductory digital clues, as well as, when needed, a quick clarification by the investigator. The game had four levels:

- Level one's goal was to place broken modules of the ATM back to the right place;
- Level two instructed the user to rotate the banking card to the right position and insert it in the ATM slot;
- Level three's goal was to successfully introduce the PIN (Personal Identification Number) given to the user;
- Level four instructed the user to check the account balance and withdraw cash.

3.3. Overview of the physical prototype

Apart from the multi-touch game, the physical surface required for this preliminary study was also significant. For this purpose, we built a physical prototype to meet our needs and implemented a "Laser Light Plane" surface because of its efficiency at detecting finger's touches. The 42'' touchable surface supported interaction with up to 3 people simultaneously. This feature was vital to analyze the level of collaboration of the participants. Furthermore, in order to facilitate its transportation, the structure was built with the purpose of retracting when not in use.

4. Case study

This pilot case study attempts to understand if the digitally excluded people were able to interact with NUI-based technological equipment and thus reveal a possible path to fight the digital divide.

When ICTs emerged, there were people scattered over different age groups that fell behind and did not keep up with the digital era. Having considered that, we came to the conclusion that all age groups were relevant for our case study. For this preliminary investigation we considered individuals ranging from 30 to 80 years old. Their shared characteristic is their difficulty to participate in the technological era and thus being a part of a digitally excluded community. Individuals younger than 30 years old were left out of the study, essentially due to their easier adaptation to new technological equipment.

4.1. Procedure

We considered two rural Parishes of Vila Real, Portugal, for this pilot study: Andrães and Constantim. Although being located close to the main city, they present low literacy rates: most of its inhabitants only completed the 4th grade of primary education. Moreover, their main occupation is agriculture and, in spite of being more isolated communities, are diversified populations in terms of age groups, holding an average age of 45 years old. The intervention was divided in three different phases and implemented in the main facilities of the Parish Councils, in order to accommodate the participants in an area where they could feel comfortable and at ease and thus facilitating the interaction process. The first tests were carried out at Constantim, having participated 6 individuals: 4 of them on the first day and 2 of them on the second. Andrães hosted the other set of tests, having participated 3 individuals during one day of tests.

Due to the complex approach of this investigation concerning the impact of a new interaction paradigm to teach how to use the ATM, it was important to resort to several strategies for data collection: questionnaires, participant observation and a field diary.

In order to comprehend the participants' characteristics, behaviors and difficulties, we enquired them during two phases: 1) prior to the tests; and 2) after the levels had been completed. The first questionnaires were meant to understand the individuals' previous experience with technological equipment, more specifically the ATM and the computer. Indeed, we wanted to understand:

- The receptiveness of the inhabitants to new technologies, more specifically the computer and the ATM;
- If the community uses the ATM and how frequently;
- If the mouse and keyboard on a computer constituted an obstacle to using the equipment;
- If a new type of interaction paradigm could simplify the usage of a device and contribute as an incentive to a better user experience.

There was also a set of questions to be asked after the test was concluded. Subsequently, we wanted to gather opinions on the quality of the interaction, their positive or negative user experience and to discover if they had, or had not, learned the contents that were expected.

This intervention study was monitored at all times by the investigators resorting to direct and participant observation. Our main goal was to be able to apprehend the participants' behaviors, reactions, feelings and even commentaries or opinions. Moreover, there were some aspects of our investigation about the new interaction paradigm that we tried to perceive more carefully:

- Interaction difficulties the participants expressed during the tests and the amount of help they needed to complete the tasks from either the other game partners or the investigator himself;
- The amount of time the individuals spent to get comfortable with the interface and their level of satisfaction;
- How many levels they successfully completed and how much effort they put into it.

Aside from the annotations made during the study, the whole session was documented through photography and video recording, with the express statement of consent of all of the participants.

4.2. Participants' characteristics

Nine individuals with ages comprised between 32 and 78 years old participated in this pilot case study. Table 1 presents the main characteristics of the individuals, having all of them consented to disclose this information. We found, indeed, that the participants had different levels of digital literacy, thus helping the learning process and stimulating teamwork.

Table 1. Participant's characteristics

Age	Experience with the ATM	Experience with the interaction paradigm
67	Had unsuccessfully tried the equipment	Had never experienced multi-touch interaction
78	Had never tried the equipment	Had never experienced multi-touch interaction
46	Had never tried the equipment	Had never experienced multi-touch interaction
52	Had unsuccessfully tried the equipment	Had never experienced multi-touch interaction
35	Had unsuccessfully tried the equipment	Had never experienced multi-touch interaction
32	Had never tried the equipment	Had never experienced multi-touch interaction
41	Had never tried the equipment	Had never experienced multi-touch interaction
57	Had never tried the equipment	Had never experienced multi-touch interaction
62	Had never tried the equipment	Had never experienced multi-touch interaction

Before the tests, the questionnaires answered by the participants revealed their unfamiliarity with technological equipment. We learned that the most feared technologies there were the computer and the ATM machine. In fact, 80% of the participants had at least one debit card at home, but would simply not use it. The participants recognized what the computer and the ATM were capable of doing, but they had never tried to use them because: 1) they could not make use of the mouse in a computer as it was too confusing to operate; 2) they were afraid of doing something wrong and either damage the equipment or, in the case of the ATM machine, losing the money they owned by pressing the wrong button. Also, 3 participants acknowledge to have used a computer before. However, they did not actually use the computer alone, as a relative always accompanied them, and the most popular activity was watching photographs of their relatives. Furthermore, when we mentioned the possibility to remove a computer's interference – the mouse – they all agreed that the device would be much more accepted.

5. Results and Discussion

In this section, we present the preliminary results of this pilot case study. We believe that we may be able to throw some light on how info-excluded people approach the new interaction paradigms, and if there is a possible path to be explored concerning the fight against the digital divide.

5.1. Initial impact of the interface

Most of the individuals were hesitant to touch the surface with their fingers, mainly because they were afraid to touch in the wrong place. Such concern diminished when we explained that the true purpose of the test was for the users to interact directly with the game using their hand and nothing wrong would happen because, in the first and second levels, there were no wrong places to touch. The participants only had to manipulate virtual objects and place them in the right positions. Also worth highlighting is the fact that, at the beginning of the experience, the investigators accidently left a computer mouse on top of the multi-touch prototype. Curiously, three participants were reluctant to play the game merely because they saw the computer mouse, affirming they would cease their participation in case they had to work with it. We thus guaranteed they would not require the

computer mouse to interact with the device, but only their fingers. Shortly after this notice they embraced another posture and felt more at ease with the equipment. This may be an indicator that this portion of society has a negative pre-conceived idea of technology and their anxiety is even more aggravated when facing iconic objects, like the computer mouse.

As the participants played the first level of the game, we observed a quick change in behavior regarding the "machine", as they called the equipment. We noticed there was truly a sense of fear of what could happen if they touched the surface. In this first phase, the investigator played an important role, as he encouraged the participants to just try to touch a digital object with the finger and dragging it to see what happened. Indeed, the individuals attempted to follow the instructions of the investigator (Fig. 1a), but curiously they would not try it alone, as the first individuals to play the game would always call their colleagues to support them. After overcoming that apprehension, the game itself started to stimulate the curiosity of the participants, who explored what type of gestures they could perform and what effects they caused in the digital objects. This situation proved to be invigorating throughout the tests, as the users felt an instant feedback depending on where they touched. Moreover, as the tests proceeded, they began to feel more at ease and comfortable with the equipment. Undeniably, every participant successfully managed to complete the level in less than 10 minutes, only being needed an incentive for interaction with an explanation on the type of possible gestures.

5.2. Change in behavior regarding interaction

Throughout the experience, all of the participants revealed a constant progress in terms of a quicker and smoother interaction: their initial fear towards the device was gradually diminishing. A popular behavior adjustment was revealed within all of the participants: instead of only using one or two fingers to manipulate the digital objects of the game, they began using their entire hands on the surface at a certain point. Indeed, this situation confirmed that the individuals were feeling more comfortable with the prototype as time went by, as seen on Fig. 1b.

Another point to note was the fact that three participants seemed so eager to start another level that they would not even read the introduction to understand the level's goal, and would immediately touch the start button, forcing the investigator to restart the level.

One of the biggest surprises in this study was the progress made by the 78-year-old participant. She was also reluctant to interact with the interface, such as her colleagues, but after a quick demonstration by the investigator of the acceptable gestures – moving or rotating the digital object – she felt more confident and tried it herself. After one simple gesture of dragging the image and resizing it, she realized how effortlessly it was and, without further help, she was able to complete the task at hand. This was truly a big accomplishment for a woman of this age that had never used any technological equipment before. Afterwards, she changed her posture and started to encourage her colleagues, who were also distrustful at the beginning, to do the same, claiming "This is easy!".

The individuals exhibited great satisfaction during the game, having fun when the results being triggered were not the ones expected. This behavior could not be more different than the one exhibited in the beginning

Fig 1. (a) First impact of the interface; (b) Change in behaviour; (c) Teamwork

of the tests.

5.3. Teamwork and collaboration

When the participants were playing side by side, they would often try to assist their colleagues promptly if they had any trouble deciding where to touch or what gestures to make (Fig. 1c). Occasionally, the participants would even try to manipulate the information simultaneously. We consider that, because they were already at ease with the game and the equipment, they did not feel anxious when the game would not react the way it was supposed to, and just removed their hands from the surface for a second and immediately tried again.

We also observed a manifestation of a specific social role during the game: participants would act as the "teacher" explaining what should be done; and some even acted as leaders, encouraging others to solve the tasks.

The participants managed to get passed by their initial fear as a group, and not alone. Thus, they did not feel an abrupt change when they were asked to complete the last two levels individually. At this point, the participants did not even realize their progress, but the fact is they did not feel uncomfortable or fearful completing the tasks alone. For someone who avoided any technological devices, this was an impressive advance.

5.4. Participants' difficulties

It is important to highlight two main difficulties regarding the interaction detected during the tests. First, the participants had a problem at identifying what type of gestures to do in different contexts of the game and when to perform them. They often tried to scale a digital object, even though the only purpose of the level was to drag it to the right position. On the other hand, they also could not distinguish which areas allowed touching and which did not. In fact, the individuals tried to touch every element in the game expecting a feedback, but not all the areas reacted to a finger's touch. Some were just decorative and thus not vital to the interaction. Indeed, it was confusing for them to understand that different levels supported different kinds of interaction.

5.5. Setbacks

The major obstacle of this investigation was the literacy level of the participants. We noticed that some of the individuals did not understand what to do during the game because they did not recognize specific labels, such as "account balance". They had heard the name, but did not know its meaning. Only after the investigators had explained what they meant they were able to execute the tasks and finish the level. This was the worst setback detected during the tests, as the lack of general knowledge constantly interrupted the interaction process.

6. Conclusions

This preliminary study was intended to understand if a new type of interaction could help digitally excluded people to better relate to technology and facilitate the learning process of an existing electronic equipment that was mostly feared by the chosen community – the ATM. Indeed, we came to the conclusion that this initiative was positive and it was possible for the participants to embrace emergent technologies and surpass some of their fears, as most subjects affirmed to try to change their attitude regarding the specific electronic equipment inherent to the test.

All the information presented was selected regarding a distinct procedure and all the tests were concluded according to what was anticipated. We believe that the type of interaction used to conduct the test was even

easier to apprehend that we had estimated, as is the case of the older subject that, in a few moments, understood the interaction paradigm and was able to quickly manipulate the information displayed. In fact, all of the participants exhibited enthusiasm during the tests and completed the tasks proposed through a type of interaction unknown to all. Even though this approach is completely exploratory and far from complete, the emerging natural interaction technologies show a lot of potential concerning the digital divide, mainly due to its small learning curve.

We observed a positive response from the participants of the test regarding the type of interaction and their innate attitude towards collaboration and sense of teamwork. Future investigations will be scheduled to validate these preliminary results and compare them against different geographical areas and even other technological devices feared by the Portuguese info-excluded society.

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