A Model to Develop Videogames for Orientation and Mobility

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Abstract. There is a real need to have systems for people with visual disabilities to be able to improve their orientation and mobility skills, and especially for children to be able to improve their autonomy into the future. However, these systems must be designed according to available objectives, methodologies and resources, as well as by taking the interests and ways of interacting of the end users into account. This work presents a model for the development of videogame-based applications, which includes differing levels of abstraction and different stages in the design and development of systems that allow for the improvement of orientation and mobility skills for people with visual disability. The feasibility of the model was studied by modeling two videogames for children with visual disabilities.

Keywords: Software engineering model, serious videogames, orientation and mobility, audiogames.

1 Introduction

Spatial relations during the first years of life are established through the ability to situate oneself in space, using different sensory channels and strategies that allow one to assimilate and integrate the information intake from the environment. This information is transformed into meaningful knowledge that we use throughout our lives [2].

In the case of a blind child, in the sensory-motor period of his/her development, aspects such as the permanence of an object is a difficult concept to acquire, given that vision is the main sense that provides information on the presence of objects or people in a certain location [2]. For a child with visual disability to be able to develop this ability, it is necessary to be accompanied verbally during all the movements that he/she makes.

Unlike a sighted child, for whom movement emerges as a result of visual curiosity, a blind child lacks visual experience, such as seeing oneself in the mirror, seeing other people and relating with them, or feeling a visual attraction towards an object [10]. As a child with visual disability does not have the chance to be "attracted" to things, his/her mobility will be diminished, as initially sound is not able to transmit the existence of things that can be touched; although in time and with the positive

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development of auditory perception, this can change [10]. As a consequence, the experiences of a child with visual disability as compared to a sighted child regarding the initial stages of life, do not allow the visually disabled child to integrate tactile, auditory and kinesthetic experiences in the same way as a sighted child [7].

As far as orientation, children with visual disability should learn and understand from an early age that to be oriented is to know where one is, and to know the relationship between one's position and other locations in space. They must learn to establish and utilize reference points that allow them to know where they are located at any given time in their navigation [17].

There are several ways to help users with visual disabilities to achieve autonomous navigation with the support of technology. Such technologies can be defined as any item, equipment or system that is commercially acquired, and is modified or adapted in such a way that it can be used to increase, maintain or improve the functional abilities of blind users [13]. Some projects provide different means of interaction for blind users through the use of mobile devices, implementing ways of entry through the use of tactile or voice commands, the output of which is provided through verbal and/or iconic sounds [5][15].

Bradley and Dunlop [3] consider the contextual differences in which the blind user moves about, differentiating between indoor and outdoor systems. The main result includes the fact that with location systems for legally blind people, both technical aspects of the technology and the different ways in which the users codify spatial information according to the context in which they are immersed must be taken into account. Other mobile aid solutions for the orientation and mobility of legally blind users take advantage of the logic of the environments with which these users relate. Sánchez and Maureira [15] present mBN, a system of navigation to be used in a subway station. Without the need of any other device besides a handheld PocketPC, the user can obtain information from the various subway stations and certain aids that allow him/her to enjoy autonomous navigation. Another way to help them to be more autonomous is to train them virtually, to then apply the knowledge attained in the real world [1]. In the studies carried out by Lahav and Mioduser [6] the user's achievement regarding their cognitive representation of the virtually navigated space that they attain, and their ability to apply this representation in carrying out tasks in a real space are examined. The results show the success of the experience, in which the users are able to construct a mental map and then apply it to the real world.

In general, videogames are seen only as tools for entertainment. They can also be used as powerful learning tools [12]. However, although the majority of successful studies and projects in this area refer to sighted children, there is a clear niche for research on the application of videogames in support teaching new skills to blind children.

In this way, for the purpose of this study it is necessary to evolve from a traditional software development process, and adapt it to these new needs (blind children, serious videogames, orientation and mobility learning), thus creating a new development model. Therefore, the objective of our study is to propose a model for the development of videogame-based applications designed to assist the navigation of blind people, based on the adaptation, widening and integration of existing software engineering models and the design and evaluation of mobile applications that support the orientation and mobility of blind people [16][11] to this new field within software engineering, related to the design and creation of videogames for the education and learning of blind children.

2 Methodology

To design this innovative and specific model for the development of video game-based applications for the navigation of blind people, other models that have already been designed, developed and validated by the authors of this study were used as a reference. These models, however, do not consider the video game factor and the multi-disciplinary nature of the focus for the current study. The first model taken for reuse is related to the design, development and evaluation of mobile applications to support the development of orientation and mobility (O&M) skills in blind people [16]. The second model is related to software engineering, and is used to support in the development of conventional mobile applications for learning. This model allows the developers to consider aspects that are critical to the development of a functional application [11].

3 Model

In order to develop video game-based applications for the improvement of O&M skills in blind users, it is necessary to consider three processes (see Fig.1): (1) Definition of Cognitive Skills Navigation, (2) Software Engineering, and (3) Impact Testing. These processes must be executed cyclically and iteratively. This creates a global process that incrementally adjusts the technological tool that is being developed to the cognitive objective regarding the navigation of blind users.

Definition of Cognitive Skills Navigation: During this stage all of the O&M skills that are required to support the following are determined: perceptual development, spatial orientation, motricity, communication, basic concepts and protection techniques [17]. These skills are represented by behaviors and knowledge that the users must exhibit in order to carry out autonomous navigation.

This stage is fundamental to be able to begin the process for the development of technological tools. Here the most significant problems are identified, which are to be dealt with in the following software engineering process. The main objective of this stage is to determine the feasibility of the solution, as well as its restrictions (technical and methodological). The proposed solution will depend on the balance between the technological context and the orientation and mobility skills that are to be supported.

Impact Evaluation: We were interested in knowing the gains in terms of learning (O&M skills) between the pretest and posttest scores, which are the result of having used the application. The dependent variable corresponds to the O&M skills studied. Basically, this design responds to three steps: (1) Application of a pretest that measures the behavior of the dependent variable prior to the intervention; (2) Application of the intervention, which imply use of the video game for O&M skills; and (3) Application of a posttest that measures the behavior of the dependent variable after the intervention.

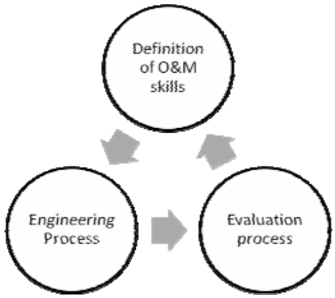

Fig. 1. Global iterative process for software development to improve the O&M skills in blind people

Software Engineering Process: In this stage of the model, efforts are mainly concentrated on the process of software engineering for the design and development of applications that can be used to improve the orientation and mobility skills of blind people. To these ends, it is proposed to work using the 5 traditional phases of systems development: Initial Phase, Analysis Phase, Design Phase, Implementation Phase and Evaluation Phase (see Fig. 2).

3.1 Initial Phase

During this phase, the feasibility for the development of the application is determined. An analysis of the technological context in which the video games will be developed is performed, and the O&M skills to be developed in users with visual disabilities are defined (see Fig. 2). **Technological Context:** Refers to the technology available in the market that can provide support for possible technological solutions for the development of orientation and mobility skills. In particular, the problem to be dealt with must be clear (defined by Orientation and Mobility Skills), and based on this one can define the most pertinent technology to be used. **O&M Skills:** The objective of this stage is to clearly define which specific O&M skills we will be able to support with the system to be developed.

3.2 Analysis Phase

In this phase an analysis of the end-users of the video game to be developed is analyzed, as well as the internal and external restrictions to the project. This is a stage to consider the most significant variables that will interfere in the design and development process. **Real Situations Analysis:** The real contexts in which the users would be able to carry out their activities, given the specific orientation and mobility skills that it is desired to support, must be analyzed. This analysis must include the problems that are presented within the environment, which could impede the navigational tasks from being completed, and considering a complete profile of the user that will utilize the system. **End-User:** The users' characteristics on a cognitive level (O&M), mental model, degree of vision and their most significant descriptive variables are specified. **Restrictions:** All of the restrictions that must be considered for the user to

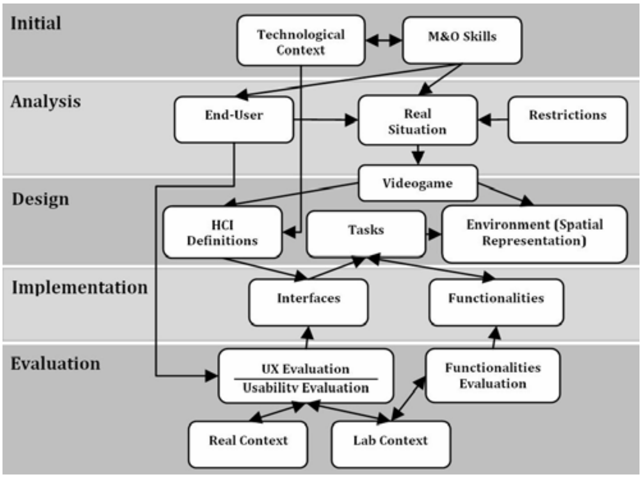

Fig. 2. Model to develop videogame applications to develop O&M skills in blind users

be able to correctly develop the desired O&M skills are defined. Both the rules of conduct for the user while using the technology and the social behaviors involved in the activity are specified. **Videogame:** This component, developed between the analysis stage and the design stage, allows us to define how to design the support system for O&M as a videogame.

3.3 Design Phase

HCI Definition: In this component the specific guidelines for how the interfaces and the interaction with the system to be developed must be designed. To do this, it is necessary to take the characteristics of the end users, their habitual ways of interacting and their interests into account. This also includes the specific characteristics of the system so that it has a recreational, "educational videogame" type orientation [12], and so that it is used to develop O&M skills. The end users' considerations are provided during Analysis of the Real Situation stage, in which the users and their needs are defined (see Fig. 2). Due to this information, which can be considered within different technological contexts, it is necessary to include the way in which a blind user interacts with different kinds of technology [9]. **Environment:** Component responsible for defining where the system to be developed will be used. This is based on an abstract representation of the real world in the system. The computational representation of the real environment must be in accordance with the tasks that the videogame users have to perform. **Tasks:** For the correct development of the skills to be analyzed, it is necessary for the tasks, defined both on the level of the real environment (if the system is mobile, for example) and on the level of the software, to allow for the child to use the orientation and navigation tools through the videogame itself. This is essential for the kind of skills that it is sought to develop. These tasks must include elements from the real environment to be represented in the virtual world. General guidelines for how this environment should be represented will also be provided.

3.4 Implementation Phase

After the design phase the problem to be solved is clear, as well as the best way to achieve this. The task assigned to this phase consists of developing the solution that has been designed in the previous phase. **Interfaces:** In this stage of the model, the different interfaces that the blind user will use to develop the previously defined tasks are implemented. These interfaces can be of different sorts: Audio [14], haptic [8] and multimodal [4]. These interfaces must include the users' characteristics (from the Definition of HCI component), and the elements that make the orientation and mobility tasks possible. **Functionalities:** During this process, the data structures and the specific functionalities for the system being developed are defined. This component includes the activities within the tasks to be performed and implements the necessary functionalities, always making sure that it is possible to complete all the specific tasks assigned.

3.5 Evaluation Phase

By the end of the previous phase, the videogame has already been implemented. During this testing phase, the video game is tested in order to solve possible errors and defects (corrective maintenance), and to modify or improve the videogame (adaptive maintenance). During this stage, the following tasks must be considered. **Usability Testing:** In order to evaluate the interfaces used by the system developed, specific usability evaluations must be applied [9] (quantitative and/or qualitative), in order to assure that the users' interactions with the system are adequate and pertinent. These evaluations must be performed with end users, and involve the previously designed interfaces. **Real Context:** During the design of the interfaces for the system to be developed, it is necessary to consider evaluations based on the real environment. These evaluations can be either quantitative and/or qualitative. The main idea is that from these evaluations, relevant considerations regarding how the user interacts in the real environment emerge in such a way that the system adjusts to this kind of interaction. **Laboratory Context:** In order to make a more controlled and precise evaluation, it is necessary to perform experiments in a laboratory in order to evaluate usability. These evaluations would be of a more focused nature, and would define the specific redesigns for the interfaces being developed. **Functionalities Evaluation:** This stage of the development will validate if the functionalities of the system developed do what they have to do. Exhaustive tests must be taken within a laboratory setting regarding the system's behavior under various simulated conditions of use.

4 Conclusions

In this work, a model for the design, development and evaluation of video game-based applications is presented and described, so that users with visual disabilities can improve their O&M skills. A theoretical review of the concepts related to mobility and digital technology, the use of technology for O&M sills, and the use of video games to support learning was performed. Afterwards, the proposed model was presented, as well as its different stages and the impact that it has had on the development process.

Our previous experience with the design of educational software development models for the blind [39] has taught us how important it is to provide design and development tools for such systems. These tools can considerably improve the pertinence, acceptance and use of these systems by the end users.

The early development of orientation and mobility skills in blind children is fundamental for their performance in navigating unknown environments autonomously. At the same time, a higher understanding of space and the development of orientation and mobility skills does not only allow them to develop psychomotor activities at their age level, but also allows them to have a higher level of learning with regards to their perception and understanding of the environment. It is for this reason that the model presented in this work can be an essential contribution to generating videogames in support of the development of orientation and mobility skills, thus creating innovative ways of improving such abilities.

As it has been presented in the model, the end user takes on a leading role in the design of the systems, thus constituting an end user-based design. The participation of the end user in the main stages of development favors acceptance of the final product, an adequate and pertinent use in accordance with the user's mental model, and reduces the costs associated with redesigns due to problems with the interaction.

In future work, this model will be used as a basis for the design of mobile systems so that blind users can improve their navigational methods, making them more efficient and thus helping them to improve their autonomy in different, everyday-life environments. All in all, the systems based on this model will help to improve the navigation of blind users, and with this will aid in their integration and inclusion in society.

References

1. Amandine, A., Katz, B., Blum, A., Jacquemin, C., Denis, M.: A Study of Spatial Cognition in an Immersive Virtual Audio Environment: Comparing Blind and Blindfolded Individuals. In: Proc. of 11th ICAD, pp. 228–235 (2005)
2. Arnáiz, P.: Deficiencias visuales y psicomotricidad: teoría y práctica. Madrid: ONCE. Departamento de Servicios Sociales para Afiliados (1994)
3. Bradley, N., Dunlop, M.: Investigating design issues of context aware mobile guides for people with visual impairments. In: Proceedings of workshop on HCI in Mobile Guides Workshop at International Symposium, Mobile HCI 2004, Glasgow, UK, September 13, 2004, pp. 1–6 (2004)
4. Crossan, A., Brewster, S.: Multimodal Trajectory Playback for Teaching Shape Information and Trajectories to Visually Impaired Computer Users. ACM Trans. Access. Comput 1(2), 1–34 (2008)
5. Dowling, J., Maeder, A., Boldes, W.: A PDA based artificial human vision simulator. In: Proceedings of the WDIC 2005, APRS Workshop on Digital Image Computing, pp. 109–114, Griffith University (2005)
6. Lahav, O., Mioduser, D.: Construction of cognitive maps of unknown spaces using a multi-sensory virtual environment for people who are blind. Computers in Human Behavior 24(3), 1139–1155 (2008)
7. López, M.: Aspectos evolutivos y educativos de la deficiencia visual, 1a Edición. Netbiblo, Sl, ACoruña (2004)

8. McGookin, D., Brewster, S., Jiang, W.: Investigating touchscreen accessibility for people with visual impairments. In: Proceedings of the 5th Nordic Conference on Human-Computer interaction: Building Bridges, NordiCHI 2008, Lund, Sweden, October 20-22, vol. 358, pp. 298–307. ACM, New York (2008)
9. Nielsen, J.: Usability engineering. Academic Press Professional, New York (1993)
10. Nielsen, L.: Oportunidades para el niño. Relaciones espaciales en niños ciegos congénitos. In: International Council for Education of the Visually Handicapped, vol. 66, pp. 3–15. Christoffel Blinden Mission (1989)
11. Ochoa, S., Alarcón, R., Guerrero, L.A.: Understanding the Relationship between Requirements and Context Elements in Mobile Collaboration. In: Jacko, J.A. (ed.) HCII 2009. LNCS, vol. 5612, pp. 67–76. Springer, Heidelberg (2009)
12. Prensky, M.: Computer games and learning: Digital game-based learning. In: Raessens, J., Goldstein Raessens, J. (eds.) Handbook of Computer Game Studies, pp. 97–122. The MIT Press, Cambridge (2005)
13. Rodrigues, C.: Um Dispositivo Háptico de Auxílio À Navegacao para Deficientes Visuais. Trabalho de Graduacao ao Centro de Infromática da Universidade Federal de Pernambuco para a obtencao do grau de Bacharel em Ciência da Computacao (2006)
14. Sánchez, J.: User-Centered Technologies for Blind Children. Human Technology Journal 45(2), 96–122 (2008)
15. Sánchez, J., Maureira, E.: Subway Mobility Assistance Tools for Blind Users. In: Stephanidis, C., Pieper, M. (eds.) ERCIM Ws UI4ALL 2006. LNCS, vol. 4397, pp. 386–404. Springer, Heidelberg (2007)
16. Sánchez, J., Sáenz, M., Baloian, N.: Mobile Application Model for the Blind. In: Stephanidis, C. (ed.) HCI 2007. LNCS, vol. 4554, pp. 527–536. Springer, Heidelberg (2007)
17. Schultz, P.: Movilidad e independencia para el discapacitado visual. Dinámicas Psicológicas del proceso de Enseñanza. Córdoba (Argentina): ICEVH. vol. 69 (1990)