SIRTET-K3D: A Serious Game for Balance Improvement on Elderly People

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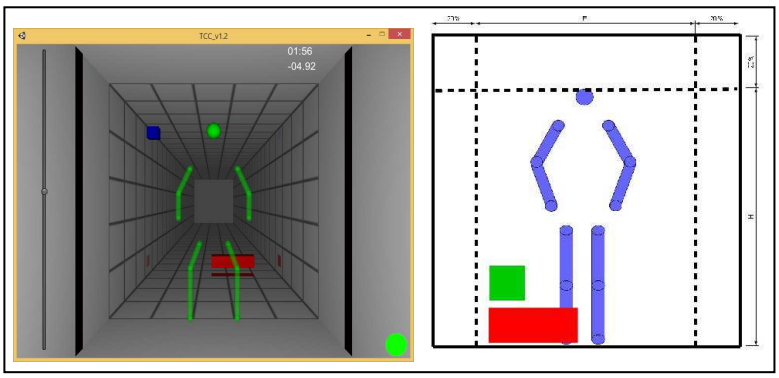

Figure 1: The interface of the game (left) and the template (right) for "challenges" to be presented during the game.

Abstract

Balance difficulty is a condition that affects people as ageing happens and it raises de risk of falling. It is of major concern with elderly people because their overall health makes it difficult for them to recuperate from injuries that are caused by falling around. These injuries not so rarely leads to severe disabilities, long stay in hospitals and, even death. This paper presents a Serious Game (SG) that uses a natural interface based on a RGB-D camera to stimulate balance and reduce the risk of falling in elderly people. The game challenges the player to catch and/or dodge from objects according to their color. The way the challenges were composed gradually works the balance of the player. Game designers have assessed SIRTET-K3D and the data gathered shows that the game fulfills their expectations. SIRTET-K3D is a tool that ultimately improves quality of life of frail elderlies.

Keywords: serious games, natural user interface, balance, elderly

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1. Introduction

Being a natural process and accompanied by the evolution of medicine, the elderly population tends not only to grow but also to become more representative. In fact, health care and adaptations of the society are necessary, if not fundamental, since aging is also followed by a decline of several organs functions and functional and/or structural changes (Zanardini et, al., 2007). In fact, even to daily tasks, health problems can occur and may affect one or several human functions such as walking itself and, a recurring factor in the aging process is the imbalance and adverse potentials that can lead to tipping and falling.

Balance is a key factor and a complex process of the human body to maintain postural control. However, it should be considered that the balance given by the postural control is a skill upheld from the interaction of multiple sensory and motor processes (Horak, 2006).

In recent years, games have raised interest from the scientific community due to its potential to be motivating and, at the same time, being able to deal with more serious issues than just entertainment. Serious Games (SG) then appeared and became a focus of research to a wide variety of applications ranging from education to health issues and behavior changes.

The objective of this paper is to present a SG called SIRTET-K3D. Furthermore, we advocate the use of SGs in motor rehabilitation and treatment of balance disorders, especially to the elderly.

2. SIRTET-K3D

2.1 Presentation

SIRTET-K3D (Rossito, 2013) was inspired by Tetris. Its visual and gameplay were reversed (as its name). The game places the player in a tunnel and objects come from the bottom of the tunnel and goes toward

the player. Some objects needs to be touched (the targets), others need to be avoided (the obstacles). But no particular game console is required (as it runs over a standard personal computer) and no device needs to be held (as a camera-driven gesture-based interface is used). This game requires a Kinect that captures the image of the person and s/he must make moves with her/his body to interact with the game. Thus, K3D was added to the name to highlight the use of Kinect in a three dimensional workspace. For the development of SIRTET-K3D the following technologies were used: Unity3D, NITE and OpenNI.

Figure 1 (left) depicts SIRTET-K3D interface where a player can be seen touching a target object (presented in green/blue) in the middle where his arm becomes the same color as the objet at the time of the collision and some points are assigned to it. At the sides of the tunnel a kind of accompanying shadow (the same color as the object) follows the approaching object to give users a better sense of depth.

2.2 Beginning

At start, the SIRTET-K3D displays some options: the option to Load Player loads the data of a player and what was the last phase and level that he played, that if the given name already exists in the file containing the data of the players, otherwise the game creates a new file for the player starting from the first level of the first stage; when the option Start is clicked, the game loads all player data, identifies its dimensions, and thus creates the appropriate environment at the appropriate stage for him; in Options, one can change general details of the game, such as the volume of audio feedback, kind of avatar, camera position, among others, and ; when the option Quit is clicked, the session ends and the game window closes.

2.3 Level Design

Phases (or missions) were set manually as a loop (sequence) of "challenges" that are composed of targets (green/blue objects to be touched) and obstacles (red objects that one should dodge from). These cannot be created randomly because one should respect the capabilities of the target audience and, a specific sequence has to be incremental in terms of physical demand. To compose the challenges, a template is used that defines positioning for targets and obstacles.

Physiotherapists can control for each Phase: the number of challenges; the composition of each challenge (targets only, obstacles only or a combination of them); the size of each object, and; its type (target or obstacle).

For SIRTET-K3D, the most important programming variables were used for Level mechanics following the MOLDE (Measure-Oriented Level Design methodology (Farias et al, 2014).

2.4 Composing Challenges (Input Data)

The composition of the challenges (obstacles and targets) is given through three editable XML files. The first contains the parameters for each phase. The second XML file contains the targets and obstacles, its position in the tunnel and their size (width and height). The third XML file contains the parameters of the game settings, such as speed of objects and interval between the onset of each challenge, as well as the environment specific details.

2.5 Interface

The collision with target objects occurs only with the extremities (hands, feet and head), this was done to avoid accidental collisions and to encourage correct movement. However, the collision between player and obstacles occurs over the whole body of the avatar, since s/he should deviate completely from the obstacle to score. When the player manages to touch a target correctly, the member used for touching turns greens, the color of the target, indicating the strike.

The same happens when he cannot dodge an obstacle, where the member that crashed turns red to indicate the error. There are other feedbacks, audible and visuals, a side bar that indicates the progress of the levels, and the apparent area behind the avatar, used to indicate when a target or obstacle passes him.

2.6 Scoring

The score was determined to be not only how many points the player acquired in the game, but also an absolute indicator of how he performed at that session. There is a scoring scale from 0 to 100, regardless of how many challenges were specified in the phase file. Otherwise, the player's score will be befitting his progress in the game.

The transition between phases is given through direct verification of the player's score. To advance from one stage to another, it was determined that the player must achieve a minimum of 80% of the possible score for that phase. If, at the end of the phase, the player is below 25% of the total possible score, it will return to previous phase. If he gets in between the two extremes, s/he will remain in the current phase.

2.7 Reports (Output Data)

At the end of each session, SIRTET-K3D generates a CSV (Comma Separated Values) file to monitor the evolution of the player containing relevant information for the analysis of an expert. Such information includes the session ID, date, duration; score the stage and the final level achieved by the player.

3. Tests

A group of students well acquainted with computer games and interested in game design has tested SIRTET just after implementation. This test was performed to assess the potential of the game to fulfill the requirements to be a digital game. The test was based on the test used by Downling et. al. (2013) which analyzes, through a questionnaire, usability and ease of use of the game, which are important points considering that the target audience of the game are elderly. The questionnaire was applied to eight participants who heard a brief explanation about the

game and their role in the evaluation, and watched a live demo of the game. All questions have options that range from 1 to 5, i. e., from the lower level (nothing, too difficult, too weak) to a upper level (a lot, too easy, too strong) accordingly to the question.

First, the characterization of the participants was taken, seeking their qualifications and experience in serious games. The sequence of questions can be seen below and graphics for better visualization of the results are following:

Q1: How much do you know about games? (playing, understanding advantages/disadvantages, studying, researching)
Q2: What do you know about Serious Games?
Q3: What is your knowledge level about game design?
Q4: What is your knowledge level about serious game design?

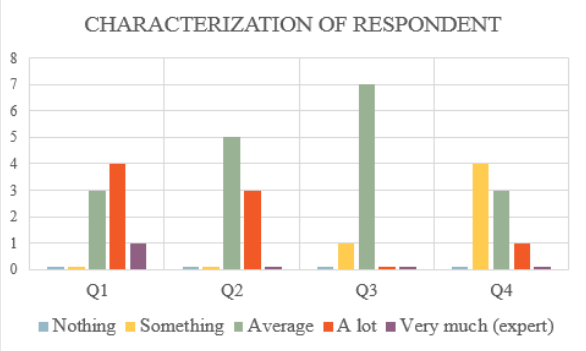

Figure 7: Characterization of respondent

Afterwards, an assessment on how the target population would take the game from the designer's point of view was asked. The sequence of questions as well as a graphic for better visualization can be seen bellow:

Q5: In your opinion, how much will be the difficulty of the elderly in using the Kinect?
Q6: In your opinion, how much will be the difficulty of the elderly in understanding the instructions of the SIRTET-K3D?
Q7: In your opinion, how much will be the difficulty of the elderly in making the movements/challenges (reach and avoid) presented by SIRTET-K3D?

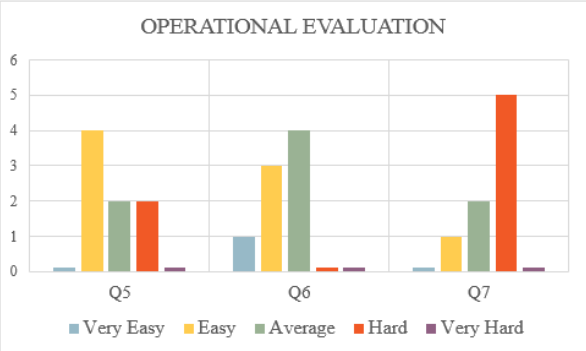

Figure 8: Operational evaluation

There was another question in the operational evaluation, a discursive one, which was:

Q8: Have you any suggestions on some kind of game that could help balance improvement using Kinect/Natural Interface?

The participants described only two problems / suggestions. The first comment was a suggestion to maybe use a different mechanic, replacing the tetraminos by emerging silhouette from the end of the tunnel, with printed positions in them, such as holes, to facilitate understanding of the elderly. This suggestion was discarded because it resembles an existing COTS (Commercial Off-The-Shelf) game. The second comment was just an opinion that COTS games aimed for balance do not meet the requirements that SIRTET-K3D may be capable of meeting.

The following part of this Test of Potential was to seek the opinion of each participant about the game from the target population´s perspective. The sequence of questions can be seen bellow and the graphics for better visualization can be seen in Figure 9:

Q9: In your opinion, how much fun the elderly will have using SIRTET-K3D?
Q10: In your opinion, how much attractive the graphics of the game will be to the elderly?
Q11: In your opinion, how difficult the elderly will feel about the SIRTET-K3D?
Q12: In your opinion, how much the sound given by SIRTET-K3D will assist the elderly?
Q13: In your opinion, how much visual feedback will help using SIRTET-K3D?

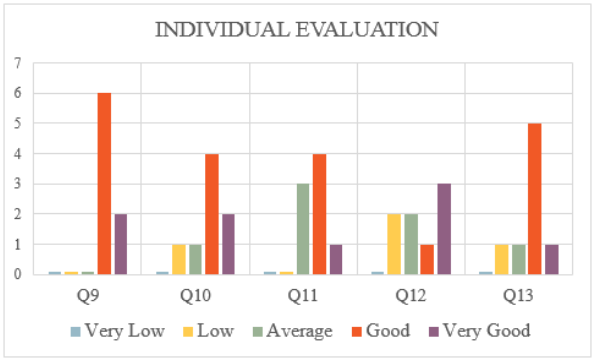

Figure 9: Individual evaluation

Finally, descriptive question was presented:

Q14: Have you any suggestions on some kind of game or something that could help balance using Kinect/Natural Interface?

Six of eight participants suggested changes and/or reported problems in the game. The most recurrent problem was the difficulty in understanding the distances between the avatar towards the objects, the sense of depth and the environment itself. After this assessment, a lightning effect on the objects as they come closer to the player was included and the camera parameters were changed to exaggerate a bit the perspective effect. These changes were thought of in order to help improve the sense of depth.

4. Discussion

It can be seen from the Tests of Potential data in Figure 8 that professionals well acquainted with games had some knowledge regarding Serious Games and Game Design assessed SIRTET-K3D. They presented though not so much knowledge on Serious Game designing. From what they have witnessed from a demo session, these participants reckoned that the game would not be

difficult thanks to the Kinect with an average difficulty on understanding the game mechanics of SIRTET-K3D. The difficulty of the whole sequence of challenges posed by the game to the elderly were assessed as difficult – although the elderlies are not required to fulfill all challenges to benefit from the game.

The game design students/professional that assessed SIRTET-K3D also found that elderly people would have a good amount of fun playing the game and would feel good about the game as a whole as well as the graphics of the game and the visual feedback. The sound feedback was not so well evaluated which suggests that some improvement is needed.

The answers of the Test of Potential suggested that SIRTET-K3D seemed to be on the right track but improvements on the interface, lettering and sense of depth were required by the answers given to the last discursive question.

The biggest challenge of designing SIRTET-K3D was on guaranteeing the sense of depth for the players. Lightning effects, sizes and shapes for the tunnel were alternatives experimented but did not add too much for this end. One aspect that seemed that diminished the cognitive overload as well as the interface was guaranteeing that the game would issue one "challenge" at a time in order to avoid multiple challenges crowding the interface. Therefore, it could be said that IBC – Interval Between Challenges variable has a minimum value which accounts for the travel time for a challenge to run all the way of the tunnel.

Colors were also a tricky part because elderly people have impairment on eye sight as the age progresses so the interface should not too colorful but not too dull at the same time.

Physiotherapists can prepare challenges according to the target population. SIRTET-K3D is ready to accommodate children to adolescents by simply selecting and adjusting specific values for FAST, SLOW, LONG and SHORT on a set of XML files.

5. Conclusion

The activity of care and assistance for the elderly, as well as the area of geriatric physiotherapy are the areas where the SIRTET-K3D can be applied presenting its greatest benefit. These areas have been growing significantly in recent years by their own market demand driven by the proportional growth of the elderly population in the demographic pyramid (a phenomenon that is ongoing and promises to extend for a long period ahead). In addition, although the game has focused on reducing the risk of falls in the elderly, it serves, in addition to entertainment, as a motivating factor and stimulating the appropriate physical activity for this population, resulting in an improved quality of life. Thus, whereas a conventional computer game using the Kinect camera is a low investment and can meet various people, we conclude that this feature can be applied both in clinics, nursing homes and even in the homes of older people themselves.

SIRTET-K3D brings a different approach to improving the quality of life of elderly people, whether caregivers in their homes, in clinics or nursing homes, assist them. With SIRTET-K3D, these locations can take advantage of the following benefits arising directly from the use of a Serious Game with Natural Interface developed with specific focus on the balance of frail elderly:

- Reducing the cost of hospitalizations - with improved cardiorespiratory, muscular and vestibular condition of the elderly , its events of clinics and drug interventions tends to decrease;
- Likewise, the risk of complications inherent in medical admissions decreased proportionally thereby lowering the cost of these two aspects besides the risk of death (since the elderly have less resilience to diseases acquired in such circumstances);

The improvement in the general condition of the elderly contributes to improve your self-esteem and autonomy in daily living tasks, events decreasing depression and associated complications. This latter aspect affects the quality of life of the elderly as well as all her/his family.

It is worth mentioning that SIRTET-K3D was developed with a technology that will allow it to be applied not only to the elderly but also adults and even children with difficulties in motor coordination, whether in walking or balance itself, since it can have its parameters fully tailored for other target population taking advantage of the same gameplay. Remembering that a game is a tool that can bring fun while instructs and/or trains.

Acknowledgements

To Bethesda Hospital, UDESC and, FUMDES - Secretaria de Educação do Estado de Santa Catarina

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