



Training the Mind: The GARDINER Platform

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Abstract. Recent research has shown that the systematic involvement of a person with games, which are designated to exercise memory and concentration, contributes to the long-term preservation of the human memory and therefore leads to the prevention of dementia. Our work seeks to capitalize on the positive effects of serious games' use in a variety of ways. In particular, we provide insights into the design and development process of two serious games dedicated to being used by elderly people with dementia. In their context, we also elaborate on the basic elements of a novel web-oriented platform, namely GARDINER (Games pLatform foR minD traNing aNd mEmory peRk), aimed at making available various memory games which may have been crafted by various sources. Finally, some empirical data derived from the use of our platform and games in practice is provided.

Keywords: Serious games · Games for elderly · Game-based training
Memory training · Game data · Dementia · Dementia-related games
Serious games hub

1 Introduction

Today, a large proportion of people worldwide, approximately forty-eight million, live with dementia, a serious, progressive and fatal disease causing the gradual attenuation of elderly people's mental processes [1]. This figure is expected to get dramatically increased in the near future as the global population ages [2]. Dementia comprises several stages which are characterized by common symptoms. The more advanced the stage is, the more the patient loses his initial abilities including, among others, concentration, problem solving skills and memory. At the final stage, critical body functions are dramatically deteriorated resulting to patients' death. Despite the ever-increasing need for efficient and effective means for dementia's prevention and treatment, no traditional medications still exist [3]. However, some very encouraging and promising results have been achieved during the last few years by the serious game research community [4]. In particular, some researchers turned themselves towards serious games, in order to measure their potential in cognitive training of aged gamers and affected by dementia users. More precisely, experimental results have shown

significant improvement in players' performance after the systematic play of dementia-oriented games. The type of these games is varied depending on their orientation, which may be diagnostic assessment or rehabilitative care [5]. The former is primarily concerned with the early detection of the disease and focuses on the delay of cognitive decline while the latter on restoring cognitive functions. Serious games used for dementia also vary significantly with respect to the type of impairment at which they are aimed (i.e. physical [6], cognitive [7] and emotional [8]). Different types of impairment may necessitate the use of radically different game-design elements (e.g. avatars, 3d worlds or 2D boards) and raise a number of implementation-specific requirements (e.g. multi-modal interaction) which, in every case, seriously affects the game design and its computational implementation processes.

Generally, the field of serious games for dementia remains highly unexplored. It is indicative that most of the published works make use of conventional games, in the context of mostly commercial platforms like Wii or Nintendo DS, which have been properly adapted for the needs of this purpose. Our work seeks to contribute to the state of the art in many folds. Firstly, we propose a generic web-based architecture capable of hosting and unifying serious games for dementia which might have been crafted by various sources yet being made accessible via a unified interface. As a result, properties and qualities supported by our platform (i.e. monitoring API) will also become properties of the hosted applications. Secondly, we provide insights on the design details of two games which we have specifically developed to help users with dementia. Finally, we provide practical evidence on an experiment we have carried out and we elaborate on the results which have been properly traced and which persisted in their context. The role of the data which is collected is critical since it is given to professional experts of the domain for further analysis, comments and/or suggestions.

2 Related Work

During the last years, the serious games industry appears to have made some very early but significant efforts in the domain of dementia-related games whose aim is to facilitate the prevention, rehabilitation and deceleration of the development of cognitive impairment in elderly people via cognitive training methods. As a result, a wide range of games has been made available with great impact on the consumer audience. Even though dementia related-games have been proved to work in practice, there is only a limited number of works available. One of the few taxonomies which have been proposed for their classification is presented in [5]. Classification schemes are crucial for the success of the serious games for dementia (SG4D) since they establish the grounds for researchers to reason about, compare and evaluate different works yet with compatible characteristics and similar objectives. According to [9] SG4D can be classified with regards to their type, as preventative, rehabilitative, educative and/or assessing and regarding their category as cognitive, physical and social emotional.

Other more technologically driven criteria also exist which mainly concern platform availability, including PCs, smartphones, the Nintendo Wii or even the MS Kinect and the I/O capabilities and instruments supported on top of the hosting environments [4]. Depending on the axes upon which a SG4D falls, the mechanics underpinning the

game design, the metrics which need to be measured and the type of experiment that should be carried out, are significantly affected [18]. Therefore, the focus of the application and its objectives must be known before its execution and they need to be seriously considered throughout the design phase. Nonetheless, so far, no design principles have been proposed for SG4D game development. Therefore, their development is grounded merely on designers' personal experience, if any, and ad-hoc or random design choices whose success can be accessed only at runtime by "trial and error" efforts in the context of experiments explicitly set out for this purpose. The state of the art seems to have been focusing on determining whether and to what extent serious games can play a role in preventing or ameliorating the effects of dementia.

An indicative work in the context of SG4D is Lumosity [10], a popular online suite comprising more than fifty brain training games whose aim is to strengthen cognitive abilities of users in a way tailored to the individual needs of each one. In particular, each user can interactively define their personal training schedule and goals via their profile, choosing from selected categories the exact games to be played and their sequence of being played. At all times, a user-specific dashboard is sustained which provides detailed insights on a user's performance, in terms of certain metrics depicted through dedicated visual means, in accordance with the goals set by this user. These metrics include speed, memory, attention, flexibility and problem solving rate. Social and emotional engagement is supported via the ability to contradict personal performance with that of specific community users or with the community's average. Based on the experiment undertaken in 2006 [11] with twenty-three participants of an average age of fifty-four, the group which received Lumosity training for twenty minutes per day for five weeks, displayed improvement in their working memory and in their visual attention performance.

Brain Age [12] has been developed to stimulate users' brain, being available for the Nintendo DS platform. There is a diversity of games provided which includes simple math problems, a variety of puzzles, sudoku puzzles, reading classic literature out loud and so on with the users being able to interact either via the touch screen or the integrated microphone. Despite the fact that the game is not targeted to people with dementia, lots of neurologists suggest its use due to its positive impact on users' cognitive activities [13]. In fact, the outcome of some experiments which have been carried out in the context of the 'Brain Age' game, with the aim of measuring its effects on the elderly and non-gamer users, has shown improvement in users' executive functions and processing speed [14].

Wii Sports, developed by Nintendo, comprises a simulator of group-games including tennis, baseball, bowling, golf and boxing. In the context of a series of experiments, in which patients diagnosed with dementia took part, Wii Sports have shown that within a timespan of nine weeks, participants improved their score and managed to memorize the game rules with great success [15]. According to another research in which two elderly females with mild cognitive impairment were engaged in Wii playing for a narrow period, results have shown an increase in the attention of both participants while they have also indicated that the participants found the game entertaining and fun [16].

MasterQuiz [19] is a reminiscence game which is specially designated for patients suffering from mild dementia. The game has been compiled against the Android API

instead of that of the Web since it is specifically targeted on patients who live in Norway where the Wi-Fi coverage is quite limited. The core of the game is a quiz with an image displayed on the left-hand side and a set of alternative text-based answers displayed on the right-hand side. In case of a correct answer users are congratulated, while on the contrary, they are asked to try again, for as many times it is necessary until they find the correct one. As the game progresses, it monitors and updates the number of failed attempts required to the correct answer. Users are allowed to show their preference either for generic or personalized questions via the game settings menu. The personalized questions must have been previously uploaded to a custom web database. The generic questions can be filtered by decade or customizable tags for each of the images such as sports, home, science, arts, just to name a few.

3 The GARDINER Platform

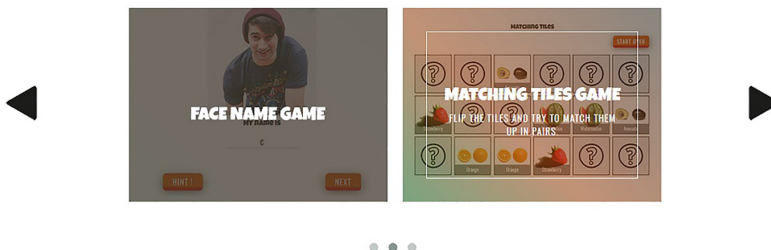
The aim of this study is to provide a valid and novel way to assist clinicians in assessing a person's cognitive status by means of analysis of data collected throughout the gameplay of two well-known serious game prototypes, the 'Face Name' game and the 'Matching Tiles' game (see Fig. 1). Both games focus on two cognitive functions, which severely decline as dementia progresses, the short-term memory and word and object recognition. Regarding the first game, the focus is on assessing the capacity for retrieving information from the short memory, while on the second game the goal is to match card pairs by means of object recognition. Their implementation addresses requirements which have been derived from various existing serious games dedicated for elderly people [20]. The game environment is straightforward and with clear challenges while being primarily designed for elderly players strives to minimize possible negative feelings of tension and confusion. The games present an adapted difficulty, providing a unique experience for each user based on their individual abilities, thereby encouraging them to play the games frequently. It is also important to note that various data are collected throughout the gameplay which are stored under each user's personal profile for further analysis and assessment.

GARDINER




 kostas

SELECT GAME TO START



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Fig. 1. Game selection

Our platform, the GARDINER (Games plAtform foR mind traIning aNd mEmory peRk) is designed and implemented in such a way and with the use of the proper interactions artifacts that support the existence of more serious games for training the mind. When a new game is ready to be uploaded to GARDINER, a shortcut icon for the game is placed at the carousel type game menu (see Fig. 1). The positioning of the game in the carousel menu interaction artifact depends on the placement criteria set up by the platform administrator, these criteria can be one or more of the following: chronological (i.e. creation date), difficulty level, random order etc.

The main idea behind the development of these serious game prototypes is to map challenges in the design of serious games applied to assessment and cognitive stimulation with people suffering from Alzheimer or elderly people. The collection of in-game data and player performance can be used as part of a diagnostic test for cognitive decline. This recorded information can be very useful for health professionals in the diagnosis of any suspected cognitive problems, while it could also help in monitoring the progression of these conditions and provide a potential alert for signs of cognitive deterioration. The great expectation of this study, is to help users train and evaluate their four cognitive spheres which are memory, planning skills, initiative and perseverance [17] while being entertaining, interactive and easy to use in the same time.

The general architecture of GARDINER (see Fig. 2) includes tools and services for (a) enabling players to have authorized access to the platform and the games,

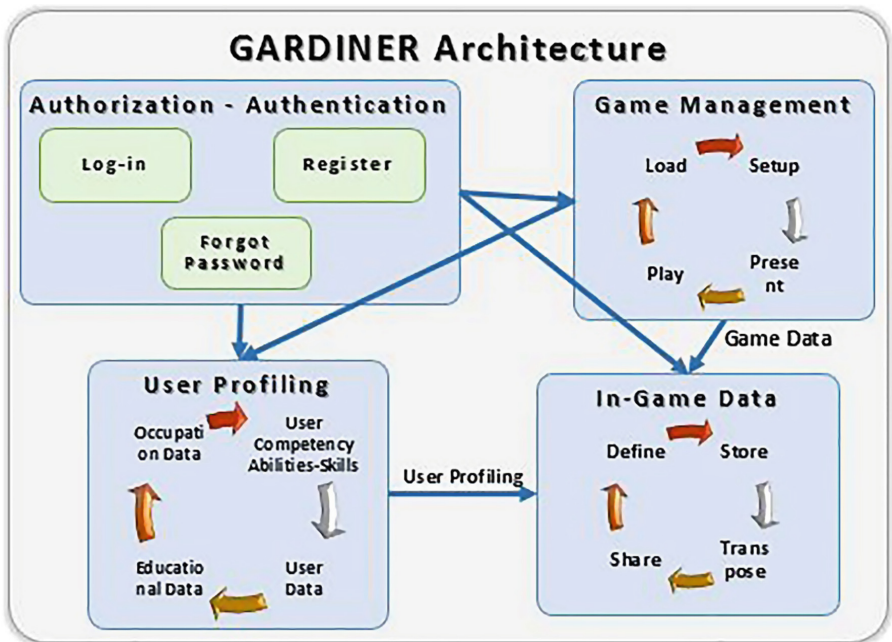


Fig. 2. GARDINER’s architecture

(b) allowing trainers and platform administrators to upload, setup, present within the platform and initiate serious games, (c) permit trainers and trainees to define use centered data related to occupation, education, competences and abilities and hence define the user profile which can be used to customize games according to user preferences, abilities and desires and (d) enable the platform to define, store, transpose and share in-game data and therefore provide information to trainers or carers to evaluate training sessions and achieve mind training and recovery conclusions as well as allow game guidelines to be updated from in-game metrics and trainee choices while playing.

The GARDINER platform and the games are implemented with Php, Mysql, JavaScript and HTML. The combination of these technologies was selected for the ease of the development and the flexibility in the access as it is working in a browser without demanding any further installation. The design of GARDINER includes not only textual instructions output modality yet visual and audio modalities as well. Multi-modality output is used to make our serious game prototypes, accessible to people with hearing or vision issues. Audio technology can help elderly people interact with technology in general and with the games of the GARDINER platform in specific.

The figure displays three overlapping screenshots of the GARDINER 'PLEASE SIGN UP' form. The top-left screenshot shows the 'Personal Information' section with fields for First Name, Middle Name, Last Name, Username, Password, Confirm Password, Email, Gender (Male/Female), Date of Birth, and Place of Birth. The top-right screenshot shows the 'Residence and Web Appearance' section with fields for Phone Number, Profile URL, Website URL, Residence Address Street, Residence Zip Code, Residence Address State, Residence Address City, and Residence Address Country. The bottom screenshot shows the 'Work and Education' section with fields for Current Occupation, Interests, and Add Education Level, along with 'Previous' and 'Register' buttons. Each section is highlighted with an orange box and a numbered circle (1, 2, 3) indicating the order of completion.

Fig. 3. User profiling

User profiling is an important module of the platform as it enables game customization according to user details and provides necessary insights for collecting sound and useful in-game data for further training analysis. The unique user-player profile is created by the user and apart from some few data that are mandatory such as username and password for accessing the platform all other user information are

optional. The registration i.e. user profiling processes, services and interaction screens (see Fig. 3) are designed and implemented in such a way that protect user rights and preserve user anonymity. In more detail GARNIDER's user profiling module includes three data tabs namely the "Personal Information" tab, the "Residence and web Appearance" tab and the "Work and Education" tab. At the "Personal Information", the user is asked to enter the username and password as minimum mandatory data and other personal data such as name surname gender etc. optionally. The "Residence and web Appearance" tab urge user to submit residence address, telephone number(s), web URL, profile URL etc. and therefore enhance its user information. As a last step at the user profiling module the user is asked to provide information such as current occupation, education, preferences, abilities and interests. All data collected is anonymous and assigned a unique user-id at GARDINER's Data Base (RDB).

The user profile contains relevant demographic data about the trainees which will be used to enrich the analysis of user's progress over the game training sessions (Fig. 3). Furthermore, the user profile contains relevant data about the user's performance for a set of game activities, such as completion time for each individual game and final score of the completed activity, number of hints that the player used and the overall errors that the user committed during the game training session.

Authorization and authentication are facilitated via the Login process and are realized as illustrated in the upper left module of Fig. 2.

The Game Management module allows trainees, trainers and platform administrators to upload, setup, present and play the serious games supported by GARDINER according their role permissions. The trainee, in our pilot implementation, can choose between the two memory training games namely the "Face Name Game" and the "Matching Tiles".

In the "Face Name game", the player is invited to remember and write down the name of the people depicted in the section. The game starts with the presentation of the faces with their names respectively. The user can control the game pagination, so she/he can take her/his time to observe each face with its name and she/he could have the opportunity to remember the matches while playing the level (Fig. 4).

When the presentation of all face pictures of the specific game level is finished, a "start the game" button is shown up. When the user enters the play mode (see Fig. 5), the faces are shown as before but instead of the name label, now a blank text field takes place where the user fills with his answer. The main difference at this stage of the game is that the navigation button "Previous" is replaced with the operation button "Hint", as shown in Figs. 4 and 5, which helps the user to complete the level and go on. Thus, the user can only navigate forward which means that she/he cannot go back and correct or complete a previously given answer and she/he can ask the system for help, with a point penalty, by pressing the "Hint" button. Each time the user presses the "Hint" button one more letter of the name is given by the system. When each level finishes the "next level" button shows up to take the user to the next level.

The "Matching Tiles" game aims to reveal every tile by matching pairs of identical tiles. The user can continue to guess until matching right each tile. The game promotes point-and-click interactions. When the user turns over a tile there is an audio and visual feedback regarding the attached tile (Fig. 7). All these simple mechanisms have been designed in order to make the game easy to learn and play. The game completes when the user has matched every tile on the board. The game settings allow the user to select



Fig. 4. Memorizing names & faces, training the mind

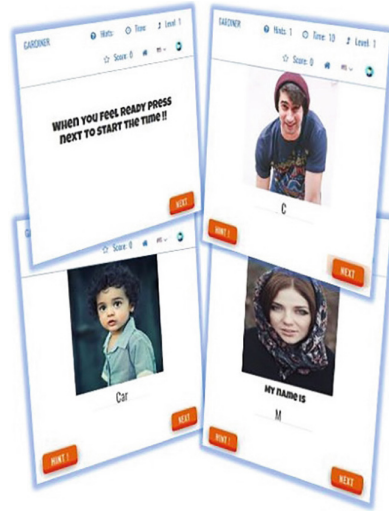


Fig. 5. Remembering names & faces, testing the mind status

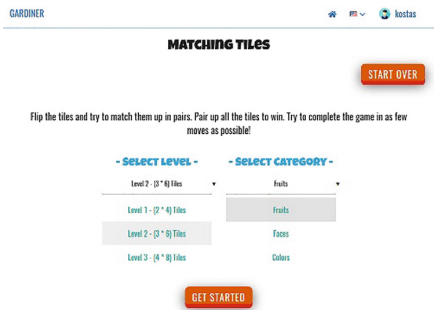


Fig. 6. Matching tiles settings

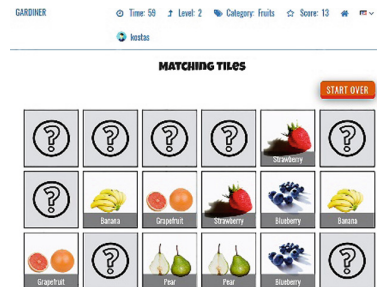


Fig. 7. Matching tiles

the level and the category of the game she/he is going to play as shown in Fig. 6. He can choose between different categories such as fruits, faces or color and between three levels of difficulty.

When the user completes either of the two games in our pilot implementation or any other game, when more games will be added to the GARDINER platform, all in-game data is recorded into log files for further processing.

4 Conclusions and Future Work

Our work proposes a generic web-based platform capable of hosting and unifying serious games for dementia which might have been crafted by various sources yet being made accessible via a unified interface. We provide insights on the design details

of two classical games which we have specifically developed to help users with dementia. Furthermore, we have carried out a preliminary experiment on a small number of volunteers (approximately 15). The volunteers have tested the web-based architecture as well as the two memory games by playing them twice in a time interval of 20 days. Initial results showed a general overall enhancement on numbers which force us to carry out more extensive and elaborate experiments with more users and from a more dispersed age, occupational and educational user group. The role of the collected data is critical since it can be made available to professional experts of the domain of memory training i.e. neurologists for further analysis, comments and/or suggestions. Further research on the field of multimodal input/output has to be carried out in order to provide support to non-visual and gesture-based interaction schemes. Additionally, more serious games need to be crafted and be introduced to the GARDINER platform so as to address even more cognitive abilities.

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