

Virtual reality training system for patients with dementia

Master Thesis

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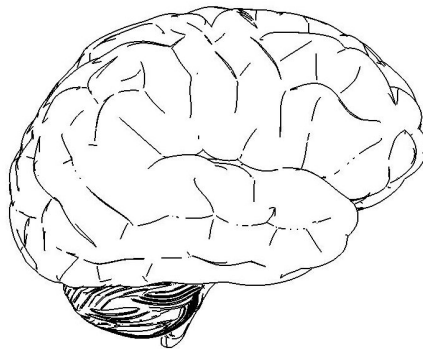
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Virtual Reality Training System for Patients with Dementia



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Master Thesis
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Abstract

Alzheimer patients suffer from cognitive deficits even after successful pharmacological removal of the amyloid plaques. To help these patients regain their lost functions, we developed a Virtual Reality (VR) system they can use both in the clinic and at home. The VR environment consists in a 3D maze containing departments of a virtual supermarket: the SuperMazeMarket (SMM). Patients can move within the SMM and grab items on the SMM shelves using conventional input devices such as a game pad and a dance pad. The patients are instructed to perform several tasks, specifically designed to train spatial orientation and working memory. The system and tasks are designed to be low cost, entertaining, motivating and easy to use. The SMM can be created anew for each session or patient and task nature and difficulty can be individualized using the MissionEditor. Navigation within the SMM trains spatial orientation, while the tasks' nature and demands train working memory. For example, one of the implemented tasks gives a patient a list of items to remember (working memory) and to find and purchase in the SMM (spatial orientation).

The target audience are patients that have been diagnosed with the Alzheimer's disease in an early stage. However, the therapy program can also be used by other dementia patients and patients with cognitive impairment or by healthy subjects for prevention of cognitive degradation.

First tests with young healthy subjects were conducted, who reported the system to be easy to use, while still providing challenging tasks. A second pilot test was then conducted with older dementia patients, who had problems controlling the input devices but still managed to solve the tasks on an easy difficulty setting. Conclusively, the system proved to have challenging tasks for dementia patients, but would benefit from additional research in human machine interaction for elderly people, as well as in determining the fun factors for an audience that normally does not play computer games.

The work of this project showed to be a valuable first step in creating a therapy program for

dementia patients, unveiling important challenges in dealing with the nature of the problem and providing concrete directions for successive research and development.

Cognimat Computer supported neurocognitive rehabilitation

Type Master thesis

Description

New treatments of Alzheimer's disease are capable of removing toxic agents from the patients' brains. However, their lost cognitive abilities are not restored by the treatment. The Institute of Robotics and Intelligent Systems (D-MAVT) and the Institute of Neuroinformatics (D-PHYS) of the ETH Zurich are collaborating with clinicians of the University Hospital of Zurich to develop a system allowing early dementia patients to train and recover their lost cognitive abilities. This so-called Cognimat is a Virtual Reality based system, in which patients can train and restore their cognitive functions in a virtual environment performing functional tasks of activities of daily living. We offer a Master level project in the new, exciting, and fast developing field of Virtual Reality Rehabilitation. The candidate's task will be to develop a virtual reality environment called *SuperMazeMarket* which is able to train lost abilities in patients:

- spatial orientation and spatial memory
- working memory
- language problems

Additional requirements for the Cognimat:

- Should not feel like yet another neuropsychological test, it should be fun to use.
- Providing social interactions (e.g. as an online community or directly to speak with the clinicians)

Requirements

- Good programming skills
- Experience with 3D game programming (not mandatory)
- Motivation to work in a highly interdisciplinary field

Goals

- Development of the virtual reality with the Torque Engine
- Providing interactions (avatars), tasks and performance measure
- Feedback from clinicians, prototype testing with patients
- Final report and outlook for project continuation

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1

Introduction

Humans live to live, and they want to live as long as possible, as healthy as possible, and of course as happy as possible. One could argue that the most valuable advancements in human history have been taking place in the medicine sector. Medicine has found cures for many diseases, made life altogether healthier and as a result even managed to prolong human life span. Few other research sectors have had such a deep impact on the happiness of the people as medicine, because it reduces the suffering and allows to see a healthy future. People tend to forget their own mortality, since most injuries can be healed, many diseases treated, and sometimes even failing organs can be replaced. Except for one; the brain.

By today's understanding it is the brain that defines a human being in his personality. When a human being is cured, it is not just the goal to heal its body, but also to preserve its mental sanity and its personality. Therefore it is not an alternative to simply replace a failing brain. The brain needs to be cured. But the most important organ of our body is so complex that it is extremely difficult to analyze its diseases and to even devise a cure.

The brain can suffer from diseases, that lead to cognitive disorders having severe effects on our lives. Often these brain diseases develop slowly over time and are thus showing their symptoms mainly in the elderly population. Such symptoms include amongst many others the loss of the ability to remember things, the loss of spatial orientation, forgetting the current date and time, and they can be even so severe as to forgetting one's own personality. Symptoms like these are nowadays used as a basis for the diagnosis of dementia, of which the most common form is called Alzheimer's disease.

Most western societies experience increasing life expectations, lower birthrates, and subsequently a population with an increasing average age. This leads -under many pension system employed in western welfare systems- to a smaller workforce which has to support an increasing number of pensioner. The additional financial burden that this causes has to be carried by

1. Introduction

the ever shrinking younger working population. It seems like parts of the western world has to pass through harsh times while this unbalanced situation holds, until the elderly population has thinned out and young and old have regained a sustainable balance.

Combine the knowledge that societies are getting older, that brain diseases mainly affect elderly and that the brain is a complex organ to cure, then you can imagine that the wish of the people to be healthy and sane while getting very old will cost society a lot.

The goal for medicine must therefore not only be to find cures and treatments for the elderly and age related diseases such as dementia, but also to make them so affordable, that everyone can take profit from them, and not just the wealthy population. The goal must be to make people healthy and happy.

Current research of Alzheimer's disease has found amyloid plaques that accumulate in the brain to be responsible for the decline in cognitive functions, because they inhibit neuronal regeneration and growth. Researchers are developing antibodies to remove these deposits and to allow the brain to regenerate normally again. However, the damage of the brain remains, and the cognitive functions are not automatically restored. Extensive training is required to slowly restore the patient's cognitive abilities.

This project's goal is to provide a cheap but effective therapy to people who lost their cognitive functions due to Alzheimer's disease. The aforementioned requirements promote the idea to create a software system, because it allows the patient to train alone at home without the constant supervision of a clinician, thus reducing costs, while also providing concentrated and customized training, that if generating enough fun, can be so motivating that it further stimulates the brain to learn. Since one of the most affected cognitive functions by Alzheimer's disease is spatial orientation, we are taking a novel approach to use virtual reality as a basis for the training scenarios.

The rest of this thesis is as follows: In the remainder of the introduction, some background information is given in order to better understand the used terms. Further, we explain the motivation, the research contribution of the thesis, and the general goal. In the second chapter we review the state of the art of similar projects by providing an analysis of available products. We discuss their shortcomings in order to address the related problems in our project. The third chapter explains the methods used, the goals and requirements of the project are stated, and the design of an implementation is defined. In the fourth chapter, the results of our project are presented. We present the technical results -i.e. the implemented software system called Cognimat-, its documentation, and the experimental observations which were done by conducting two pilot tests. A quality assessment of the implemented solution is also provided in that section. In chapter 5 we discuss the achievements and compare these with the original goals and requirements. In addition, a discussion of the experimental observations providing advice on how to improve some deficits is given. Further, suggestions are provided on different aspects which could be valuable for future work on the technical implementation. Finally, we draw conclusions and provide an outlook on future research.

1.1. Background Information

This section provides a set of background information to the reader in order to understand the following motivation for this thesis and to learn about the research done prior to this work. It also helps to better frame this project into the overall picture of the problem.

Dementia

A cognitive disorder which results in a decline of cognitive function that goes beyond the expected impairment of normal aging is called dementia [12]. Causes of dementia can be a unique brain injury or a long-term disease affecting the brain, destroying neurons or preventing them from being generated. Early stage symptoms are a decline of higher mental functions such as memory, attention, language and problem solving. Later stage symptoms may include disorientation in time, in place and in person. Diagnosis of dementia is done by detecting the symptoms using standardized tests such as the mini mental state examination (MMSE).

Alzheimer's Disease

One of the most common form of dementia is called Alzheimer's disease, named after the German psychiatrist and neuropathologist Alois Alzheimer [10]. To date there exists no treatment for this degenerative and terminal disease, as it is yet unclear what the exact cause is. But research in this area progresses as there were more than 500 clinical trials as of 2008 according to the US National Institutes of Health. It is hypothesised that the aggregation of wrongly folded proteins such as beta amyloids and tau proteins play a central role in the development of Alzheimer's disease [2, 3]. The most affected cognitive functions by this disease include spatial orientation, spatial memory, working memory and also social interaction.

Beta Amyloid

Beta amyloids are depositions of proteinaceous masses that can be found in human and animal brains [11]. The abnormal accumulation of this amyloid plaque are hypothesized to be a major cause for the Alzheimer's disease [2]. Research is looking for ways to decompose these deposits, and has invented and developed antibodies that fight the plaques [5, 4].

Beta Amyloid Antibodies

Antibodies are used to dismantle the amyloid plaques and reduce their depositions within the brain [5, 4]. As a result neuron generation is less inhibited, and it is shown that neurons grow faster and with stronger arborization in certain parts of the brain with the antibody treatment than without. However, simply removing the amyloid plaques does not restore the cognitive functions of a patient. For that, extensive training is required so that the neurons are reconnected and learn to take over the once lost functions.

Virtual Reality

Computer simulations that create perceivable information for human senses, such as visual and audio stimuli, and that maintain known aspects of the real world, such as space and time, are called virtual reality (VR). Most of these simulations are meant to be interactive, providing means for movement and change of view to the user [14]. Many modern games are actually simulating virtual realities, where a player can move within a three dimensional environment with which he can interact and perform tasks. In medicine, virtual realities are used for various therapies, including physical and mental, e.g. for sports training, regaining control of body parts after a stroke, or to treat phobias of spiders, or even the fear of flight [9].

1.2. Motivation

In the introduction we have discussed the fact that society is getting older and that age-related brain diseases leading to cognitive disorders called dementia are a consequence, most common form of which is called the Alzheimer's disease [10]. We also learned in the background information chapter that research has identified beta amyloid plaques as a likely cause of the disease [3, 2]. We further mentioned that scientists have come up with the idea to use antibodies against the amyloid plaques to reduce their deposits in the brain [5, 4]. To date there has not yet been any medication approved for public use, that is proven to increase cognitive functions of a dementia patient having Alzheimer's disease [10]. But there are numerous clinical trials that investigate a large set of developed medications such as these antibodies still in progress, and the hopes are high that reducing the amyloid plaques is a possible cure for the Alzheimer's disease.

However, even if the amyloid plaques are removed, the brain itself is not yet cured, any damage remains. Medication is unable to restore lost neurons, yet neural connections, or alone cognitive functions. The cognitive functions once learned are lost. But they can be learned again. Some stem cells within the brain continuously generate new neurons, and now with less amyloids around even more [8]. These regenerated neuron cells need to be trained, only then it is possible to regain once lost cognitive abilities. Medication to treat Alzheimer's disease is one part, but the training of cognitive functions another important part as well.

This motivates to create a therapy program designed to train newly generated neurons and this is where this project comes into play. The goal of this thesis is to examine possible solutions to a therapy and implement a software system called Cognimat, which allows dementia patients to regain their lost cognitive abilities, with special focus on spatial orientation, spatial memory, working memory and social interactions. The advantage of such a software system is that it can be used at home by the patient alone, thus saves expenses for therapists, and that it feels more like a game that actually is fun to use and thus motivates the patient to train and its brain to learn faster.

There shall also be a clinical setup, that allows the patient to be directly supervised by a clinician who monitors the patient's performance and is able to provide support and feedback. The technical setup presented in the schematics below also allows to train the patient's mobility using a dance pad on the floor, a special input device that detects pressure and thus the movement

intention of the patient. See figure 1.1 for a schematic of the clinical setup.

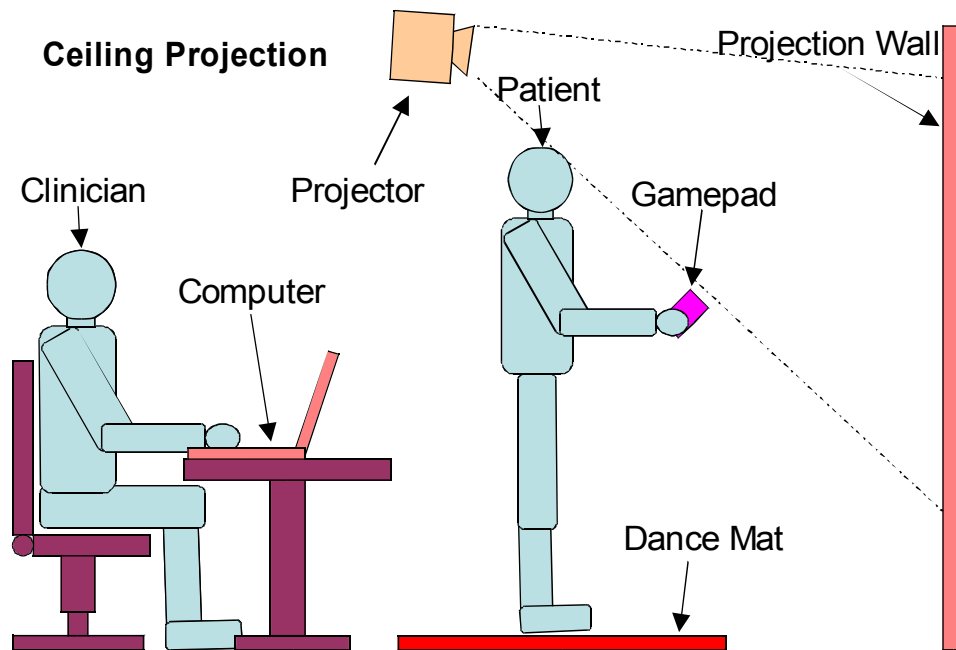


Figure 1.1.: This schematic shows the clinical setup with a dance mat, gamepad and a projector mounted on the ceiling that projects the image on a projection wall.

But before we start with outlining our software system, we first examine in the next chapter what solutions are already around, and find out why they are not sufficient for our needs.

2

State of the Art

This section gives an overview of related software projects that are current state of the art and used either as cognitive therapies or just funny games and brain exercises that can be used as cognitive training. The last section analyzes the presented products and discusses what can be improved or what is missing in the current available solutions.

2.1. Related Products and Projects

It follows a list of products actually used and promoted for the therapy of elderly with dementia or simply to keep the brain fit.

The Brain Fitness Gym

A commercial application containing a set of brain exercises to address age-related cognitive decline (see <http://www.thebrainfitnessgym.com/>).

Smartbrain

Another commercial application that features thousands of mini games and brain exercises designed to stimulate cognitive skills of the elderly people (see <http://www.smartbrain.net>).

2. State of the Art

Dr. Ryuta Kawashima's "Brain Age"

Brain Age is a training program developed for the Nintendo DS console (see <http://www.nintendo.com/ds>) based on research done by Dr. Ryuta Kawashima (see <http://www.brainage.com>). The program contains a set of games that include tasks for reading aloud and arithmetic calculations, since it was shown that they increase the blood flow to the prefrontal cortex of the brain. He claims that his games train cognitive functions that make usage of the prefrontal cortex, and can thus be used for cognitive rehabilitation of dementia patients [7].

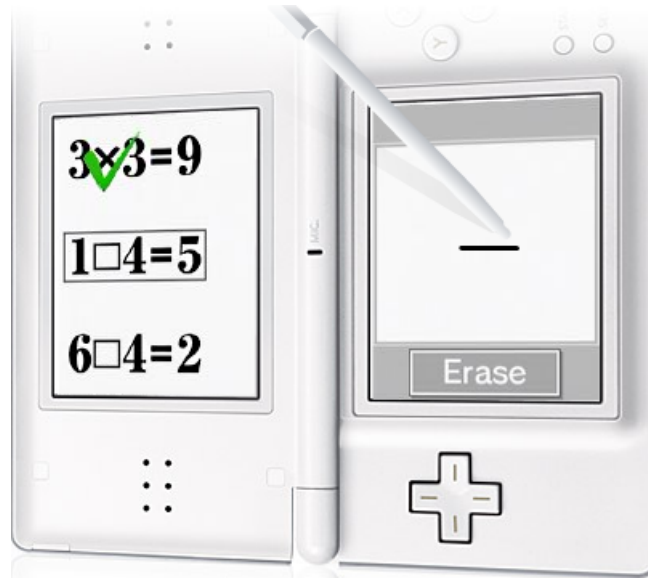


Figure 2.1.: This figure shows an image of the Nintendo DS console running Dr. Ryuta Kawashima's Brain Age game. The displayed arithmetic calculus task is just one of many training task.

CogniFit

CogniFit is a company that provides a bundle of games that is supposed to train various cognitive abilities (see <http://www.cognifit.com>).

PositScience

PositScience develops programs that train the brain's auditory and visual system (see www.positscience.com). Interesting for elderly people who want to keep their mind young, and who want to train cognitive skills used for driving a car.

BrainTwister

BrainTwister is an application developed at the University of Bern (see <http://www.apn.psy.unibe.ch/content/application/braintwister>), based on the research work

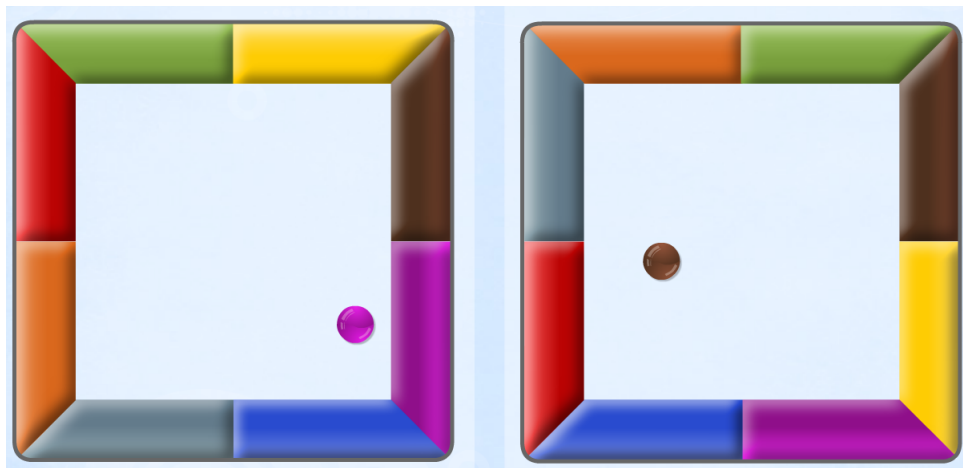


Figure 2.2.: This is a screenshot of one of the training games available online from CogniFit. This task trains the ability to deal with two things at the same time (divided attention) with a conditional implication (shifting). Both balls are moving and the player has to anticipate where on the wall the balls are going to hit. If the wall has a different color at that position than the ball, then the player has to click on the wall.

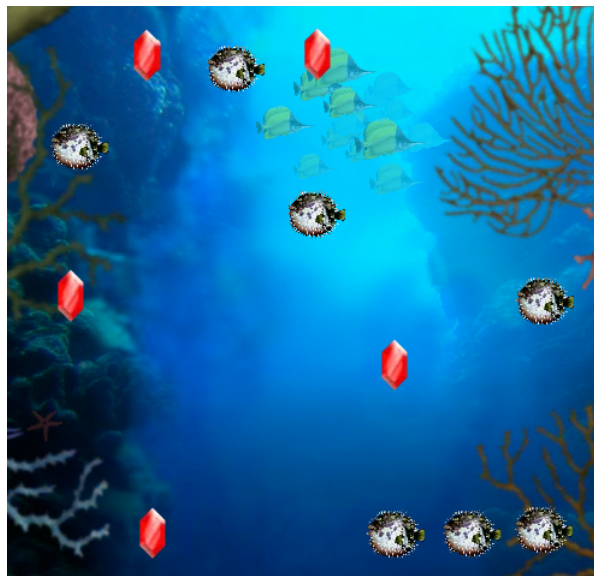


Figure 2.3.: This screenshot shows a puzzle game of InSight, the program from PositScience to train the brain's auditory system. The crystals are shown for a few seconds and then covered by fishes. Then all fishes begin to move and the player has to keep track which fish covers a crystal. After a few seconds the fishes stop and the player has to click on all the fishes that he thinks are hiding a crystal. This task trains the ability to keep track of multiple things at the same time, a skill also required for car driving.

2. State of the Art

of Jaeggi, S.M. and Buschkuhl, M. [6]. It features a dual n-back test that trains working memory and improves the so called fluid intelligence, a general problem solving ability [13].

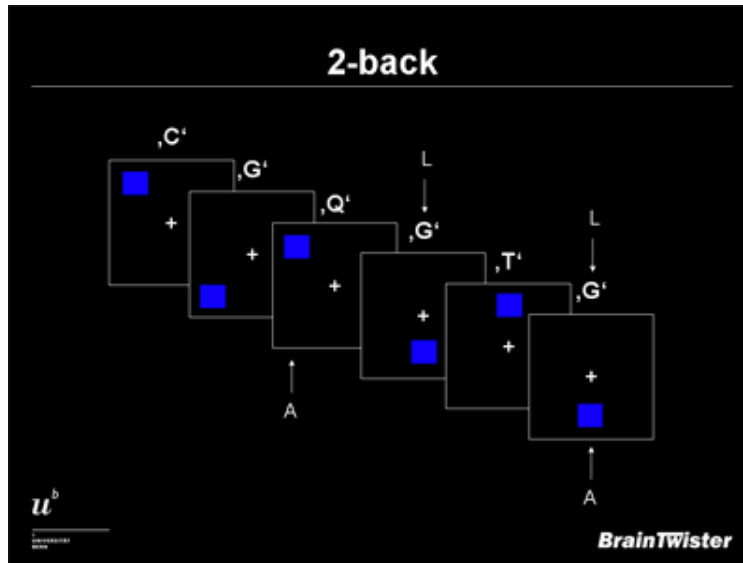


Figure 2.4.: This is a screenshot of the dual n-back test available in the BrainTwister software, explaining the test with a 2-back example. This showed to improve the so called fluid intelligence by training the working memory. The player is presented with a series of sample, showing each sample at a time. Each sample consists of a blue square positioned on one of eight possible locations and a voice spelling a character. The player has to remember these two stimuli and when one or both stimuli are the same in the current sample as they were n samples before, then he has to press a key on the keyboard - A for the visual stimulus and L for the auditory stimulus.

Cogpack

Markersoftware developed this bundle of training tests called Cogpack used for testing and training of visomotor, comprehension, reaction, vigilance, memory, language, intellectual and professional skills (see <http://www.markersoftware.com>).

NeuroActive

Another commercial program for brain fitness with various cognitive ability trainings (see <http://www.neuroactiveprogram.com>).

NeuroSynergy (IQ-EQ Trainer)

An undisclosed project under development that received the Innovation Accelerator Training award at Microsofts Imagine Cup 2009 (see <http://www.microsoft.com/ireland/imaginecup/final09.msp>). It is a project of a team of the Institute of Technology

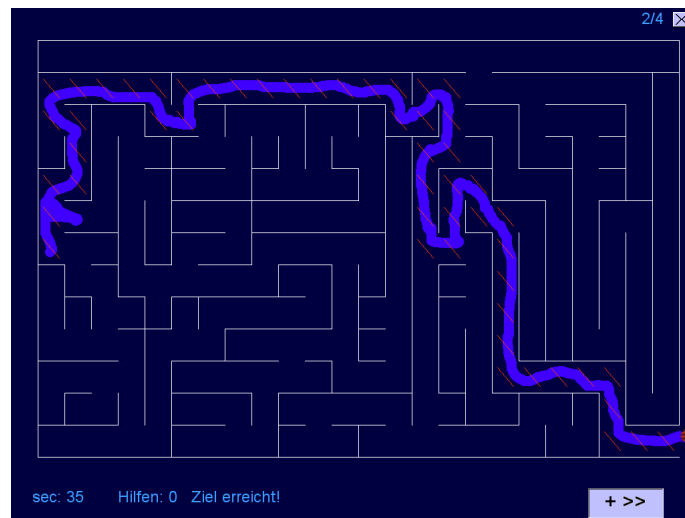


Figure 2.5.: One of the tasks of the copack software is shown in this figure. In a 2D labyrinth the user has to find the path from a start to a goal position using the mouse input device.



Figure 2.6.: This figure shows a training task of the NeuroActive demo program available on-line. It trains the working memory because the user has to remember the attributes and later associate them with the right face.

2. State of the Art

Carlow (see <http://www.itcarlow.ie/>) with the goal to create a (possibly 3d virtual reality based) software to improve the users intelligence quotient (IQ) and emotional quotient (EQ).

NeuroVR

NeuroVR is a virtual reality system developed to allow multiple virtual reality therapy scenarios, including the treatment of anxiety and eating disorders (see <http://www.neurovr.org>).



Figure 2.7.: This screenshot shows a virtual supermarket loaded using the NeuroVR engine. It can be used to treat eating disorders.

Testosterone and Spatial Memory

A project at the Institute of Gerontology of the Wayne State University wants to measure the effect of testosterone on the spatial orientation capabilities of study participants (see http://www.iog.wayne.edu/cognitive_neuroscience.php). They want to use a virtual reality environment to measure the participants performance in spatial orientation tasks. An excerpt of the abstract reads as follows:

Well-designed placebo controlled studies have demonstrated that testosterone may enhance spatial cognition, spatial memory, working memory, and possibly verbal memory. However, a complete review of the extant literature leads to the conclusion that this is an active area of inquiry and a subject of ongoing debate.

2.2. Patent Research

A patent research was conducted to learn about patented software systems focusing on providing a virtual reality therapy solution for dementia patients. A compiled list of related patents found during the research is appended to this document, together with each patent's abstract for the readers convenience.

2.3. Analysis

We can observe that the majority of these products have only two dimensional games and do not provide a virtual reality simulation, therefore they are unable to train spatial orientation, spatial memory and probably also social interactions. Projects aiming at training these skills are either difficult to find or only patented and/or yet under development. We can observe a real need for a virtual reality software training system on the market, a need this project aims to satisfy.

3

Methods

This section defines how the therapy of patients with Alzheimer's disease should look like. First, the goal of the therapy is outlined, then the actual problems analyzed and finally a therapy program defined which meets the goals and solves the mentioned problems.

3.1. Goal

The goal is to heal patients with Alzheimer's disease, such that their cognitive abilities approach the level of performance of healthy persons. The cognitive abilities to train are: spatial orientation, working memory and social interaction, key cognitive functions that suffer from Alzheimer's disease.

The target audience are patients that have been diagnosed with the Alzheimer's disease in an early stage. However, the therapy program should also be usable by other dementia patients and patients with cognitive impairment or by healthy subjects for prevention of cognitive degradation.

3.2. Problem

Connections between nerve cells within the brain, that have been created throughout the lifetime of the patient, especially during his childhood, but that are now lost due to Alzheimer's disease, have to be recreated in order to restore cognitive abilities. The natural way of doing that is by repeating the process that took place during childhood, that is to use one's own body and interact with the environment, such that the brain naturally trains cognitive abilities that are

3. *Methods*

often required. The problem herein lies in the amount of time this process normally requires: an entire childhood. The elderly patients though would like their brain to regain lost cognitive abilities as fast as possible.

Another side of the problem is the costs for the patient's care, which, with a rapidly growing elderly population, will be too high of a burden for the future society to carry. The treatment and therapy of Alzheimer's disease patients should not cost more than the normally required care would. Otherwise such a solution would only be a solution for the wealthy population.

Furthermore, since the therapy requires the patient's own engagement in order to work, the solution should contain motivating aspects that make its appliance interesting and attractive for the patients.

3.3. Solution

The only possible low-cost and yet clinically controllable solution is a software and hardware system. This enables the patient to use the system on its own at home and he can do his training everyday whenever he prefers. This reduces the required time and care of a clinician to a minimum while allowing the patient to train himself as much as he wants. It still allows to have a clinical version, where the patient is supervised by a clinician. In such a clinical setup a group training session could be arranged, that further increases social interaction and communication.

In such a solution, the patient is to be integrated into a customized system employing interface devices capable of stimulating human senses and capturing ones intentions. This setup enables to challenge the patient's brain with a high number of tasks in a relatively short time, effectively training desired cognitive abilities. The patient finds himself in a virtual reality customized and personalized specifically for him with which he can interact, and which appears as real as possible. The hypothesis is that the more this virtual reality appears to be real, the better will the patient's brain be able to learn. Repetitive executions of similar tasks that require the utilization of the aforementioned cognitive abilities encourage the brain to reorganize itself in order to improve the performance of these abilities: the brain learns.

The virtual reality makes it possible to train spatial orientation while walking through virtual labyrinths, which otherwise would require the patient having to walk in a real environment. Walking through a real world labyrinth might be a better stimulation for the patient's cognitive functions, but the effort for creating real mazes and the accompanied necessary care would cost much more and is thus less attractive. In having the possibility to rapidly create and walk through virtual mazes allows for a much more focused training effect. The yet to shown hypothesis is that the virtual reality will activate and stimulate the brain's natural learning process nearly as strong as the real world would, or if not then at least that the diminished learning effect is justifiable by the highly reduced therapy costs.

Since the solution should also train working memory, a list of memorizable items is to be used in various tasks. To improve the social interaction capabilities of the patient, the virtual reality should contain some virtual characters that can be interacted with and that give additional subtasks.

3.4. Implementation

The technical implementation consists of the creation of the virtual reality, the declaration of the interface devices, and the definition of the tasks. See the next chapter for an implementation of these requirements called Cognimat.

Virtual Reality

The motivation to use a virtual reality resides in the assumption that it is the only possible way to train spatial orientation and spatial memory using a software system. It already was experimentally experienced that spatial orientation cannot be trained using a sequence of photo images; the patient merely remembers the images but it has no transferable effect to other spatial orientation tasks [8].

The virtual reality consists in a so called SuperMazeMarket, which architecture is based on a labyrinth, in which some parts represent departments of a supermarket. The walls in these parts have shelves filled with items specific to that department. The user can walk through the corridors and pick up items off the shelves. The SuperMazeMarket has an entrance and a checkout area, where the user has to pay for the items he collected. There is no roof over the labyrinth, instead the sky and a nice landscape can be seen in the distance, which helps the orientation. Virtual avatars can be found throughout the SuperMazeMarket in the corridors, with which the user can interact and who may give tasks to the user. The virtual reality is created and customized using the MissionEditor. The possible objects within the SuperMazeMarket are further specified in the tasks section.

Interface Devices

A thorough discussion of possible interface devices has been conducted and an overview table can be found in the appendix. There were two differing argumentations for the selection of the appropriate input devices. While an immersive virtual reality with intuitive input controls might create a training environment closer to reality and thus with good performance, the target audience does not want to use fancy technical devices that they do not know and with which they lose control of the real world. Instead, a certain maintainable distance to the virtual reality is preferred by the older generation, which did not grow up with computers and video games. The additional requirement that needed consideration was that the patient should be able to use the system at home, and thus be handy and inexpensive. Therefore, more conventional interface devices that were easily affordable and available have been selected.

The output of the system is presented on a large screen or using a projector (see figures 1.1, 3.1), accompanied by loudspeakers. For the input there are several possibilities available, of which the user can choose freely.

Option 1: A dance mat on which the user stands is used to move through the labyrinth. A grasping device which is held in the hands is used to look around and pick up items and perform other interactions with the virtual avatars. The device used for grasping can be a simple game

3. Methods

Back Projection

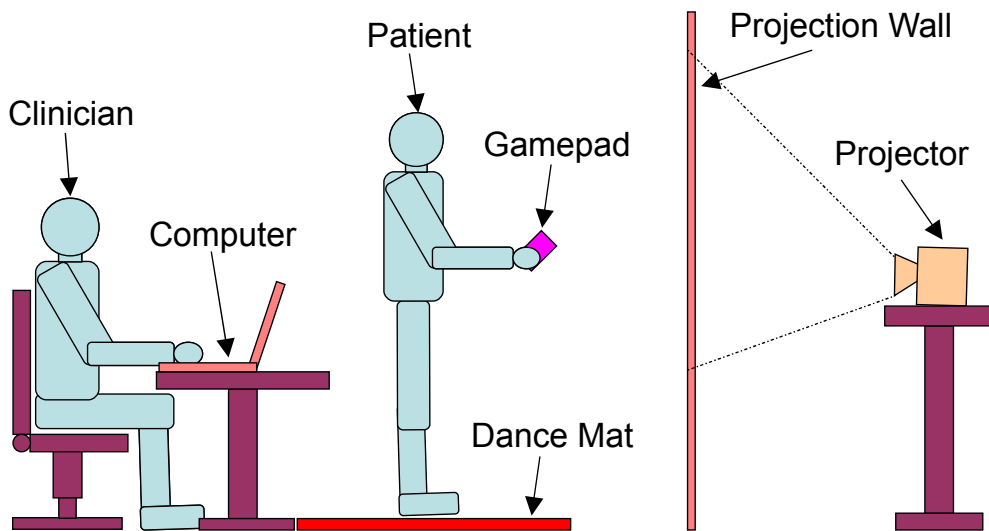


Figure 3.1.: This schematic shows the clinical setup using a dance mat, a gamepad and a projector projecting the image of the virtual reality on a back-projectable wall.

pad, gyro mouse or a complex glove that detects hand movement and finger grasping. The graphical user interface is also interacted with that device.

Option 2: A game pad with two analog sticks used for movement through the labyrinth and looking around. Buttons on the game pad are used to pick up items that are centered on the screen and to interact with virtual avatars. The graphical user interface is also interacted with that device.

In addition to one of these options, a biofeedback close control loop system can be employed, which gathers information about the mood of the patient. This interpreted mood is reflected within the virtual reality on various locations using a “mood mirror”, showing a virtual face with a certain mood. This enables the patient to monitor his own feelings and allows him to better control his mood. A tutor avatar can calm down a user who is emitting stress signals, avoiding diminishment of the training effect. The effect of music can be optimized thanks to the biofeedback to create a pleasant stimulus to the user which should enhance the training effect.

Tasks

The tasks are tailored to train one or more of the aforementioned cognitive abilities. The main cognitive ability, spatial orientation, is trained whenever the user has to find its way through the labyrinth. Working memory is trained when the user has to memorize and remember a list of items, deal with surprising events and calculate sums. Social interaction is trained when dealing with virtual avatars that represent other shoppers, children, supermarket staff, or pets.

The main task of the user is to memorize a list of items that is presented on the screen at the beginning of a mission, and to collect these items in the specified order by searching them in the SuperMazeMarket. In the end he has to find the checkout and pay the collected items. Other subtasks can stimulate further training of the cognitive abilities, and are presented to the user in various ways during the mission.

Option 1: A dialog window pops up on the screen, informing the user of a new task.

Option 2: An audio announcement instructs the user to do an additional task.

Option 3: Interaction with a virtual avatar leads to a new task, this can be presented as a text, audio or video message.

Option 4: No explicit information is given, the user has to figure out himself that there might be something to do.

In the following, some of the tasks are listed (see subtasks in the appendix for an extensive list).

- The original order of the shopping list is changed.
- Some items of the original shopping list are replaced with others.
- The total costs of the products has to be calculated and payed using virtual money.
- A child has to be found and accompanied to its parent.
- A collectible treasure map hints the location of a special item.
- A collectible riddle hints to an item to be found.
- Transparent bubbles floating around the supermarket, each containing a word that together form a sentence, have to be collected in the correct order.

4

Results

In this chapter the results of the project are presented. First the implementation called Cognimat and afterwards experimental observations are described.

4.1. Technical Results

This chapter describes the implementation of the technical solution and requirements derived in the previous chapter. It firstly presents the developed software system called Cognimat and secondly its software documentation.

Cognimat

This section describes what Cognimat is, how it works and how it is used, while the last subsection explains some design decisions. But first an abstract of the system is provided.

Abstract

A therapy program for patients with Alzheimer's disease using cognitive training methods performed on a computer system that handles a 3D virtual reality that represents a maze-like environment, in which spatial orientation, spatial memory, working memory and mobility can be trained. The user interacts with the system using various input devices that allow proper handling of movement and looking around in the 3d environment. The output is provided visually using a TV screen, a PC monitor or a projector.

4. Results

The target audience are patients that have been diagnosed with Alzheimer's disease in an early stage. However, the therapy program can also be used by other dementia patients or other elderly people that suffer from some cognitive impairment.

What is Cognimat

Cognimat was designed as an example of a virtual reality software used to accompany therapy of dementia patients with Alzheimer's disease by training cognitive abilities such as spatial orientation, working memory and social interactions. The virtual reality consists of a maze-like supermarket. This so called SuperMazeMarket is made up of walls and shelves, on which collectible items are stored. See figure 4.1 for a top down view on a simple SuperMazeMarket and figure 4.2 for a view from within a labyrinth.

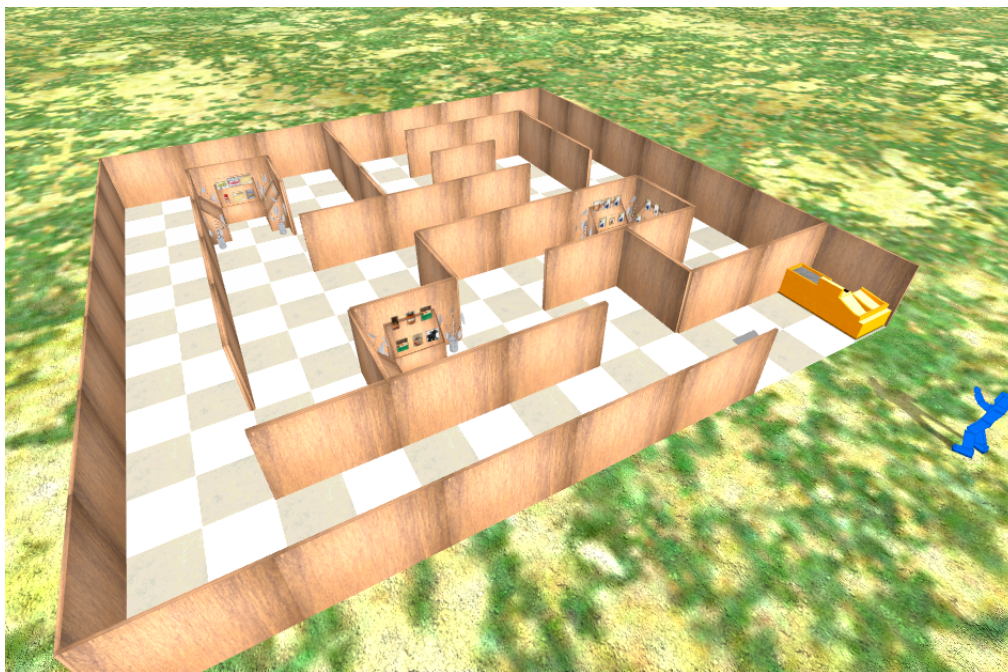


Figure 4.1.: This is a screenshot of the virtual reality of Cognimat. The SuperMazeMarket is visible from a top view, showing its labyrinth structure, departments with shelves and items, an entrance and a checkout area. The blue object on the right represents the player object, which is not visible in first person view.

How it Works

The maze architecture requires the patient to use its spatial orientation abilities in order to move around in the SuperMazeMarket. The training effect results from the continuous usage of that ability. In addition, the patient has to memorize a list of items that are to be found and collected in the given order within the SuperMazeMarket. This exercises the working memory of the patient. Difficulty levels allow to adapt the systems tasks to the capabilities and progress of the user.



Figure 4.2.: This screenshot shows the view the patient has while walking through the labyrinth of the SuperMazeMarket.

How it is Used

The psychotherapist first conducts a neuropsychological assessment of the dementia patient. If the patient is to be found in an early stage of the disease such that he is able to interact with a virtual reality system using any of the provided input & output devices, such as a game pad, and a dance mat, and a large TV screen or projector. Then the therapist gathers personal data of the patient in order to customize the virtual reality experience. That is, he creates a personalized version of a SuperMazeMarket using the MissionEditor. Appropriate input devices for the patient are defined and then the usage of Cognimat is explained to him. A first session is held at the clinic, supervised by the clinician (see figures 4.3 and 4.4). The patient uses the Cognimat system and is expected to perform the tasks the system is giving him. The clinician provides assistance and help where needed, such that the patient learns how to use Cognimat. The system is designed so that the clinician does not have to manually interfere with the progress of the training, which could lead to unnecessary errors of the clinician and unwanted side effects [1]. Once the mission, the difficulty and some parameters are set, the system runs a script of automated training tasks for the patient to perform. This allows the clinician to focus on the patient and making notes about his performance. After this first session, performance results are measured and registered on the patient's file. From now on the patient will use the system at home for his own training. Regular visits to the clinic for testing will provide the therapist with information about the training progress of the patient.

4. Results

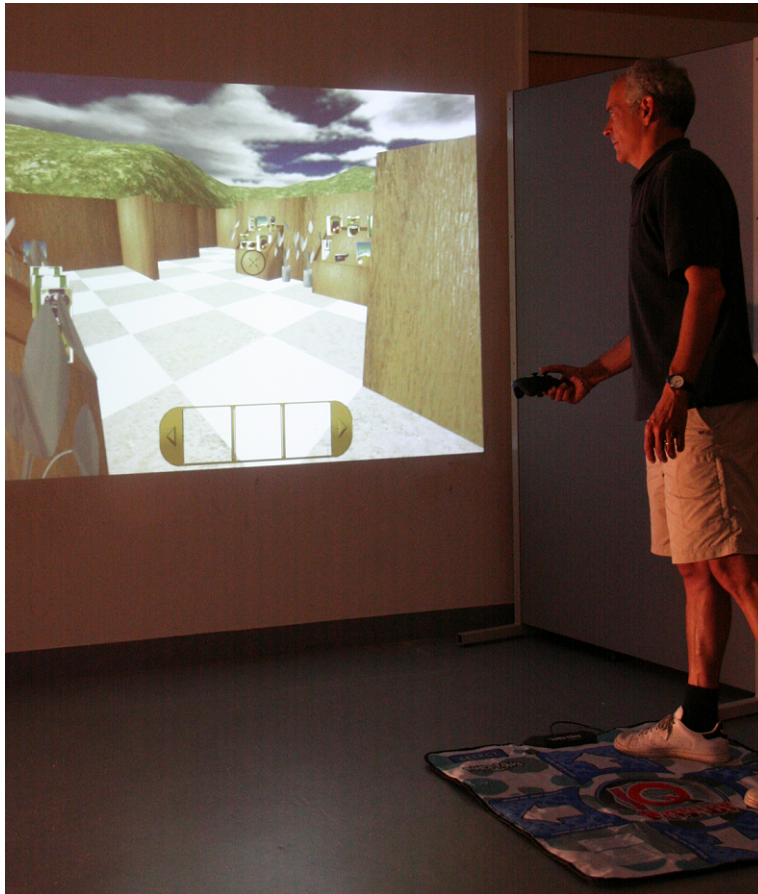


Figure 4.3.: This is a photo showing the usage of Cognimat. The user is standing on the dance mat and holding the gamepad while viewing the virtual reality on the projection wall. A projector is used to project the image from the front.

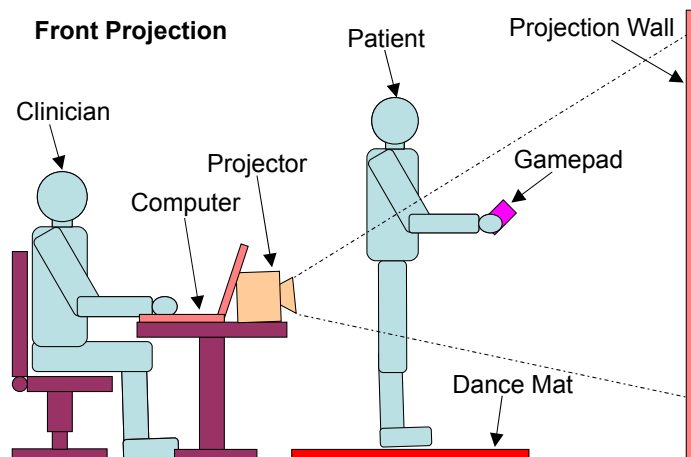


Figure 4.4.: This schematic shows the clinical setup using a front projection. The patient uses a dance mat and a gamepad to interact with the virtual reality and is supervised by a clinician.

Use Case

The patient creates his own profile. He starts a new SuperMazeMarket mission. A list of items is presented to him with the task to memorize the items and to collect them in the given order (see figure 4.5). The test starts when the patient is ready and he can move freely through the SuperMazeMarket and look for the items. When he finds the next item on the list he picks it up. When his inventory is full with all the items he needs to collect, he tries to find the checkout area. When he reaches the checkout area, he has to pay for the products using virtual money. If successful, the system presents his performance results.

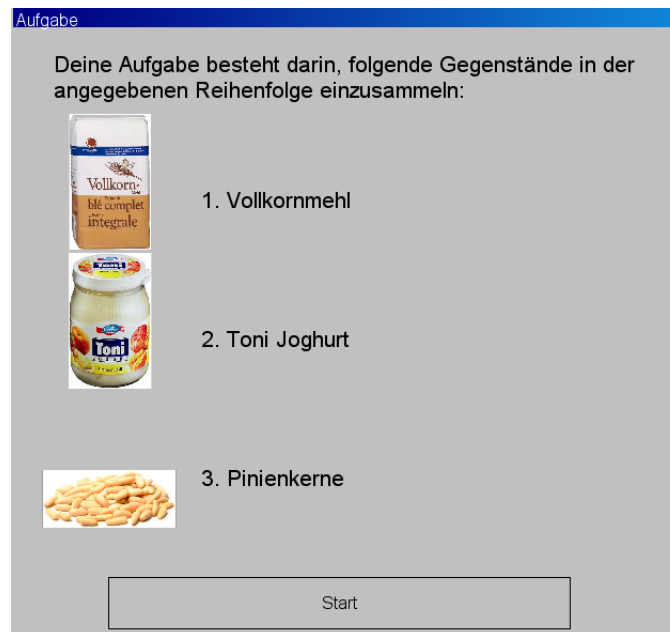


Figure 4.5.: This screenshot shows the initial task description that tells the user to collect a list of items in the specified order.

What is the MissionEditor

This tool is used to generate SuperMazeMarkets, virtual supermarkets with the architecture of a maze, and to specify which tasks can be performed within these scenario missions. It allows to quickly and easily create random 2D labyrinths and to then customize their architecture by hand. Thanks to the reduction to two dimensions the process of creating a maze becomes much easier. Several aspects of the SuperMazeMarket can be further customized, such as to which items can be found where in the supermarket. Again, in order to minimize the time required, the user only indicates which squares of the maze hold which supermarket department. This allows to customize a Cognimat mission according to the personal profile of a patient. The finished mission can be exported as a 3D environment to be used within the Cognimat engine.

There is also an ItemEditor to maintain the list of items and to import new items from a localized online shop, which allows to create localized products (see figure 4.6). These lists can be exported to the MissionEditor and then selected for each mission independently. See the following software documentation chapter for more usage information on these programs.

4. Results

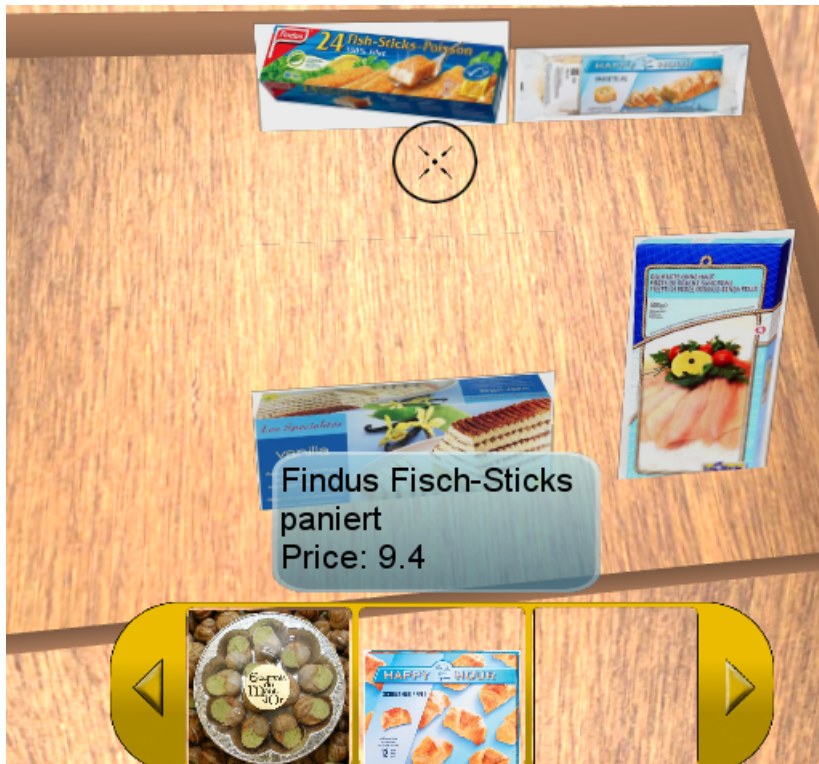


Figure 4.6.: This figure shows a part of a screenshot, showing a shelf with items of a specific department. The user can pick the items up by centering them on the screen and pressing a button on the game pad. Further information about the item below the cursor such as its name and price can be seen in a text bubble in the lower part of the screen. On the bottom the inventory of the player is shown, listing the items already collected.

Design Decisions

The Cognimat system is designed to be platform independent, that means it can run on PCs with different operating systems but also on game consoles. For the Cognimat component the Torque engine was used (see <http://www.garagegames.com>), which is written in C++ and thanks to the support of OpenGL (see <http://www.opengl.org>) is able to run on many different platforms. The Torque engine provides visual rendering capabilities for the 3D virtual reality and additional support for input devices such as game pads and output such as music and sound. The other components, MissionEditor and ItemEditor, have been developed using Java, which also allows for platform independency, and the NetBeans IDE, which makes the GUI creation process fast and simple.

The input devices were chosen to be conventional, available cheap and usable at home. A dance mat was selected to control movement within the virtual reality, and a cordless game pad for looking around and picking up objects. The output is done on a large TV screen, or, if available, with a projector.

Technical Details

It follows a list detailing technical information about the products that were used in the Cognimat system.

Software

- Torque engine version 1.5.2 (see <http://www.garagegames.com>)
- Java Development Kit 1.6 (see <http://www.java.com>)
- NetBeans IDE 6.5.1 (see <http://www.netbeans.org>)
- Microsoft Visual Studio 2008 Professional Edition (see <http://www.microsoft.com/visualstudio/>)
- Microsoft Windows Vista Business SP2 32bit (see <http://www.microsoft.com>)

Hardware

- IQ Publishing Dance Mat Edition V.3 (see <http://www.iqpublishing.eu>)
- Logitech Cordless RumblePad 2 (see <http://www.logitech.com>)
- Lenovo ThinkPad W500, Core 2 Duo 2.66Ghz, 4GB RAM (see <http://www.lenovo.com>)

Software Documentation

This chapter documents the software system Cognimat and explains its components and their usage to end users, such as patients and clinicians.

The system consists of three software components (see figure 4.7) and multiple hardware devices. Cognimat can be used in two setups, a clinical and an easier one for home usage. The clinical setup allows a clinician to supervise the performance of the patient. It requires a desktop PC for the clinician, a projector or a large TV screen to display the virtual reality, a dance mat on the floor to get movement input and a wireless game pad for the patient to look around, pick up items and further interact with the system.

The home version is meant to be used by the patient alone. The patient can comfortably sit in his couch in front of his TV, attach his portable computer (or a game console), and then use a game pad controller device to interact with the Cognimat system, or alternatively he can be standing and use the dance mat in addition to the game pad.

4. Results

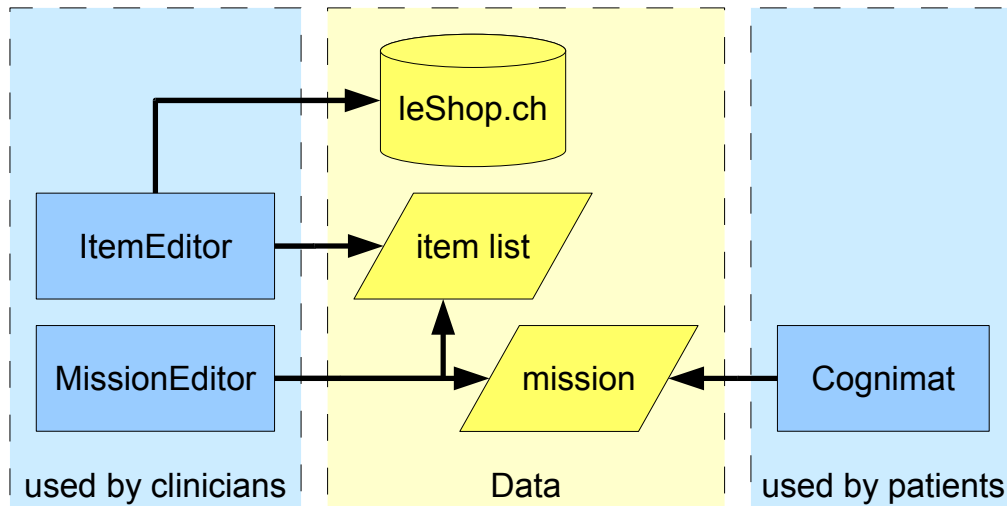


Figure 4.7.: This schematic gives an overview of the software components used. On the left side are the components used by the clinician, such as the ItemEditor and MissionEditor. On the right side is the end user component, the Cognimat engine. In the center are the resources, the data that Cognimat requires, located. The arrows indicate which program generates or uses which data. The ItemEditor can download the items from the online database LeShop.

Cognimat

The Cognimat program is the main component of the software system. When executed, it presents to the user the welcome screen and the main menu. The menu provides buttons to start the training, customize the user profile, change the program options and one to ultimately exit the program.

First, the user can create a new profile using the profile dialog. The profile dialog allows to enter a new profile name and then to create it using the appropriate button. Before closing the dialog the user can select a difficulty for this new profile and then confirm the profile selection.

The user can modify some program options using the options dialog, as for example the display resolution and enable full-screen mode.

When clicking on the training button, a dialog appears in which the user can select a mission scenario and a mission objective. For some objectives a slider allows to parameterize the difficulty. Clicking on the start button loads the selected mission.

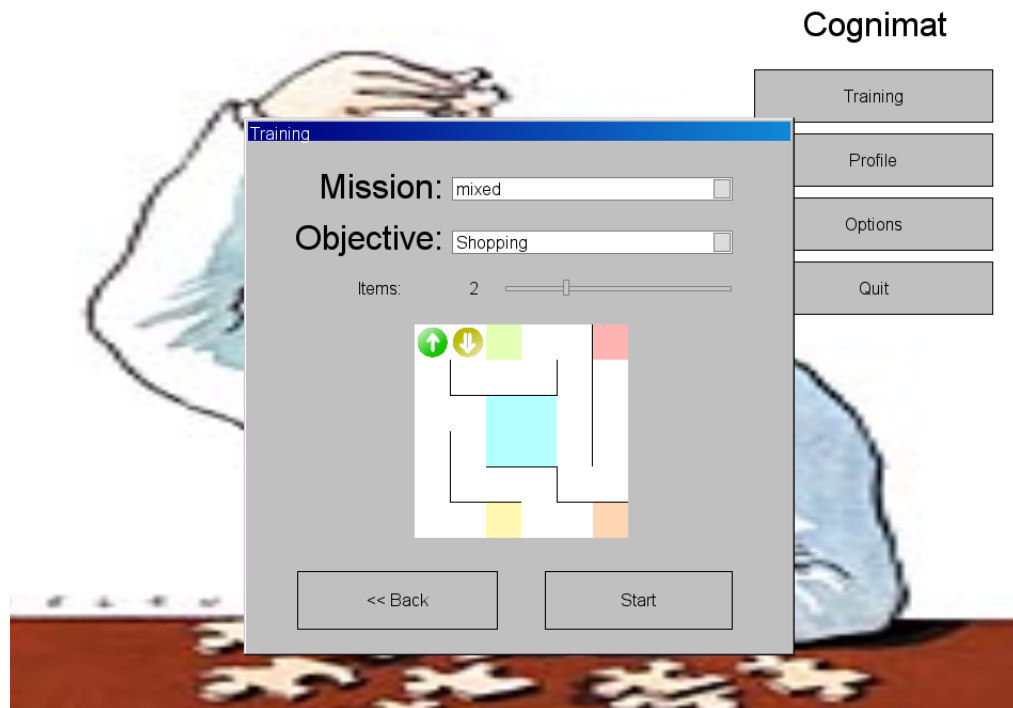


Figure 4.8.: This is a screenshot of the Cognimat menu, showing in front the dialog to start a new mission.

After the mission has been loaded, a first dialog appears describing the mission objective the user has selected earlier. The user has to read the instructions and when ready, click on the start button to begin the training mission. He now finds himself in a 3d virtual reality of the mission he selected, and has to try to complete his tasks.

It follows a description of the main objectives that can be selected. Each main objective has dynamic subtasks that are influenced by the difficulty setting. The user has to complete the main objective as well as any subtasks to complete his training.

Shopping In this mission objective the user is required to do some shopping within the SuperMazeMarket. At the beginning of the mission, a shopping list of items is presented, displaying for each item a small picture and its name (see figure 4.5). The user has to memorize the items in the order they are listed. Depending on the difficulty, additional tasks will change the initial list. One subtask changes the order of two items on the list, another replaces one item with a new one. When the patient has found and picked up the items in the correct order, he has to find out to the checkout and pay for the collected items. At the checkout, a list of the collected products and their prices is presented. The user has to calculate the sum and pay the required amount using the displayed money (see figure 4.9). This task also varies depending on the difficulty setting; on easy setting the user sees the total and also what he already payed, on medium difficulty he has to calculate the sum himself and remember it, and on the hard setting he additionally needs to remember how much he already payed.

4. Results



Figure 4.9.: This screenshot of Cognimat shows the payment process. On the left the list of collected items is presented and their price. A total is calculated and the already paid amount displayed. On the right the user can use the virtual money to pay the bill.

Treasure Hunt This objective requires the user to find the treasure that is located somewhere in the labyrinth. At beginning of the mission, a treasure map is presented, with an X that marks the spot of the treasure in the labyrinth (see figure 4.10). The user has to figure out a path to get from his starting position to the marked position, and then remember its solution. When he reaches the spot indicated, depending on the difficulty, he will receive another treasure map, until he finds the treasure. When he has found the hidden treasure he has to find the way out of the labyrinth.

Training This objective setting allows the user to move freely within a scenario mission without having to solve any tasks. This objective setting can be used to make the user familiar with the input devices and with the virtual reality.

MissionEditor

The MissionEditor is used to create and customize missions used in the Cognimat system. When executed, the user can choose from the File menu to either create a new mission or load an existing one.

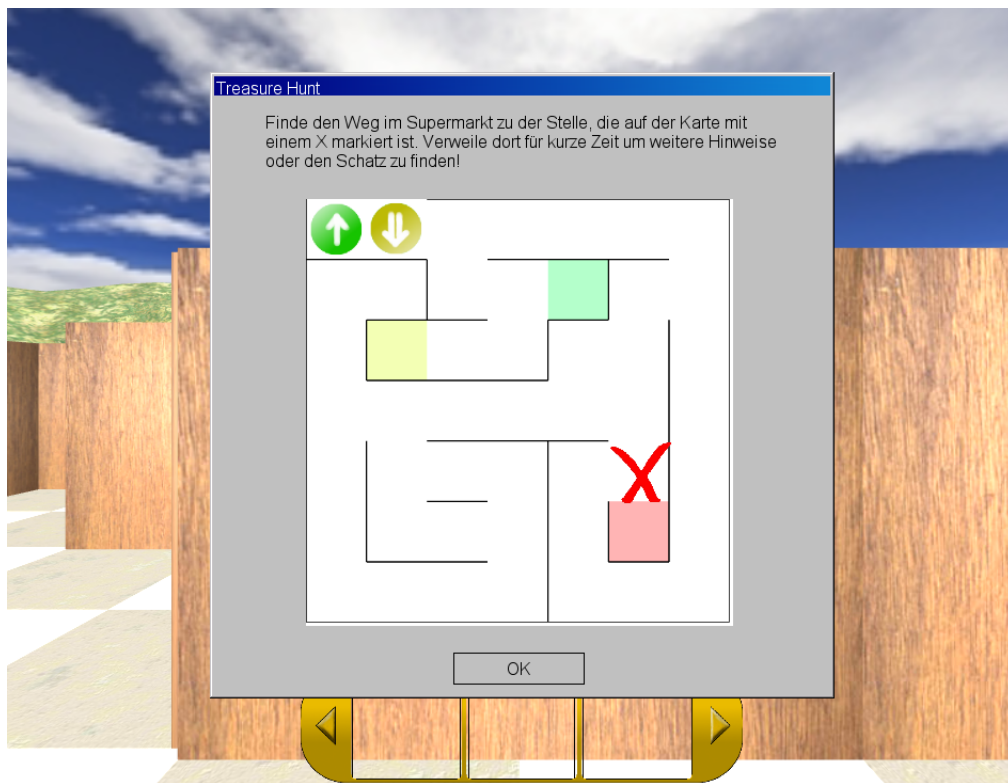


Figure 4.10.: This screenshot shows the task description of the 'Treasure Hunt' objective. The yellow arrow indicates the player's start position and orientation. The red X marks the spot he has to find.

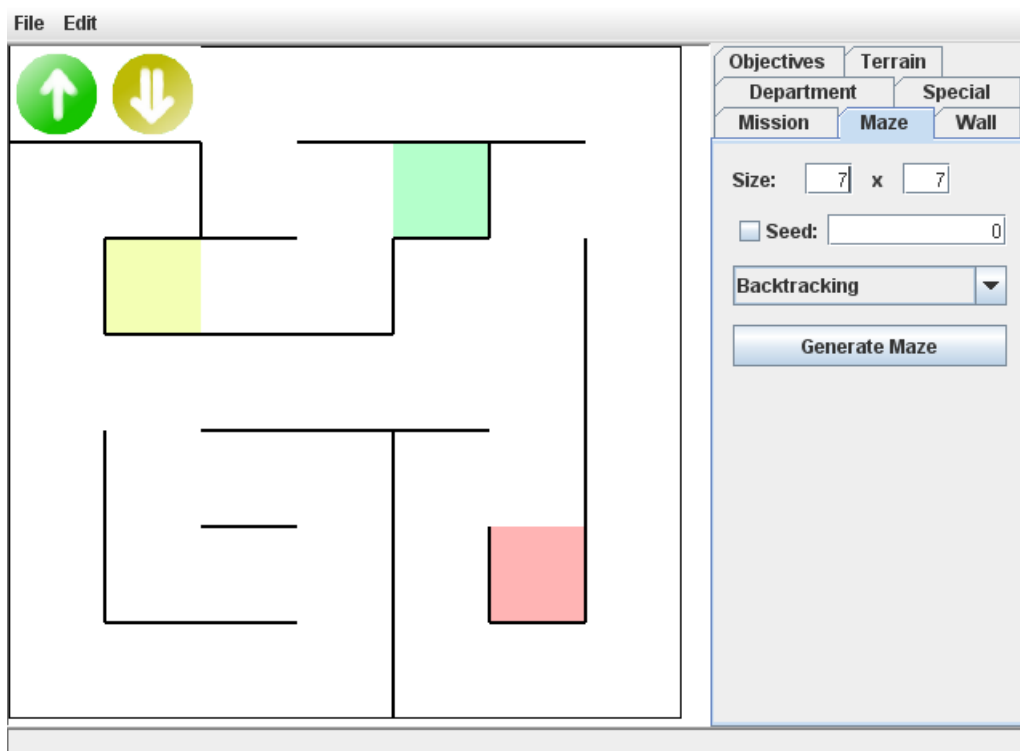


Figure 4.11.: This figure shows a screenshot of the MissionEditor. The main area displays the 2D labyrinth. The panel on the right side is used to specify the work tool. On the top there is a menu to save, load and export missions.

4. Results

The first step when creating a new mission is to generate a random maze architecture. This is done on the maze tab. The user can specify the dimensions of the maze (width and height), and the algorithm to be used to generate the maze. The random algorithm simply randomly generates walls and may create unreachable parts. The divide algorithm recursively divides the space and creates a corridor-like maze, similar to the architecture of an organized supermarket. The backtracking algorithm recursively tries to continue to build angled paths within the maze which results in a rambling architecture.

The randomly created maze can be manually edited when enabling the walls tab. Now the user can place walls directly on the 2D representation by clicking with the left mouse button, and remove existing ones using the right mouse button.

On the mission tab the user can specify an item list file that defines the available items and departments available in the mission. This is usually set to 'cognimat/data/missions/items.lst'. The item list file is exported from the ItemEditor explained in the next section. The reload item list file button needs to be clicked in order to make the new list available in the editor.

Using the department tab the user can select a department to draw onto the maze. Departments are drawn on a square of the maze by clicking with the left mouse button, and can be removed using the right mouse button. When a square has a certain department assigned, then all walls adjacent to that square will be equipped with shelves that contain random items of that department. It is not required to manually select which item is to be placed on the shelves.

The terrain tab allows to specify a terrain to be used for this mission. Terrains can be made by the user using the Torque Engine and the Terrain Editor. The button reload terrains checks for new terrains by looking inside the folder 'cognimat/data/missions/' for files with the extension '.ter'.

On the special tab the user can find special tools to work with, such as a start point and checkout painter. The orientation allows to specify the direction to which the object shall be facing when loaded in the 3d environment. A left click places the special object, and a right click removes it from a square within the maze.

To save the mission use the menu entry in the file menu. This saved mission file can later be loaded and modified. To make the mission available to Cognimat use the export menu entry in the file menu.

ItemEditor

The ItemEditor is used to define the items available in a Cognimat mission. It allows to create and manage item lists that can then be used within the MissionEditor to place departments in the mission.

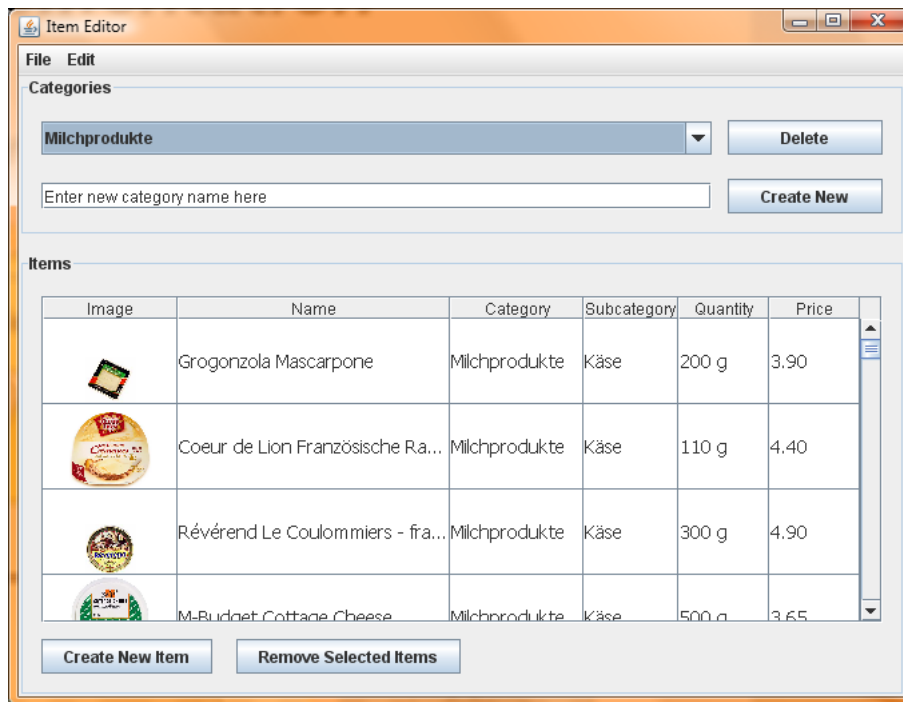


Figure 4.12.: This is a screenshot of the ItemEditor. The lower part consists of a table showing all defined items and their attributes. Above that is a panel to manage the categories. In the menu bar on top it is possible to save and load item lists, as well as to import items from the online shop LeShop.

An item has a set of attributes that can be defined, and a department to which it can be assigned. The attributes consist of the item image, the item name, its category (in the MissionEditor referred to as department), its subcategory (not used by the MissionEditor), the item quantity (not used by the MissionEditor) and the item price.

The main window of the program consists of two parts; a table to list and edit the items, and a section on top of that to manage the categories.

To create a new category, enter its name into the text field and click on the 'Create New' button. To delete an existing category, select it from the dropdown box and then click on the 'Delete' button. All items that were part of that category will remain without a category assigned, and cannot be used until they are assigned to a new category.

To create a new item, click on the 'Create New Item' button below the item table. The new item appears on the end of the list with the name 'New Item' and a default image, located at 'cognimat/data/shapes/items/' with the name 'base.item.jpg'. To delete items, select them in the list and then click on the 'Remove Selected Items' button. To change the item's image, double-click on the image and enter a name of an image. The image names must obey the rule that their suffix is '.item.png'. In front of that the image name or any alphanumeric and special characters can be placed except for other dots. To change the other attributes of an item simply click on their respective text box.

Once your item list is complete, you can export it using the 'File' menu entry 'Export Item List...'. Store the list in the folder 'cognimat/data/missions/' and use the '.lst' extension. You

4. Results

can later import it using the 'File' menu entry 'Import Item List...' and continue to add new items.

There is also the powerful feature to import items from the online shop LeShop (see <http://www.leshop.ch>). This is an online shop that belongs to Migros, the biggest Swiss retailer (see <http://www.migros.ch>), and features only products that are commonly available in Swiss supermarkets and stores. This was chosen to customize the SuperMazeMarkets to the Swiss target audience so that the patients recognize the products and thus feel familiar with the types of products they need to shop. To activate the import select the entry in the 'File' menu called 'Import From LeShop.ch...'. A new dialog opens, in which you can select the preferred language for the items and categories (de - german, fr - french, uk - english). To start downloading, click on the 'Start' button. An internet connection is required for the import to work. Output information about the download progress is listed in the output field below the buttons. To stop the download progress click on the 'Stop' button. To close the download dialog, click on the 'Close' button. The downloaded items should now be listed in the item table along with their images and categories, and all other attributes.

4.2. Experimental Observations

The Cognimat prototype has been tested by various users in order to learn about the impression the software makes and if the difficulty of the tasks or of handling the input devices is adequate. A pilot test has been conducted first with healthy subjects, and afterwards with a small group of dementia patients. Further observations done during development of the project are detailed in the quality assessment section.

Pilot Test #1

The first testing session was conducted with four young and healthy subjects. It served as a preliminary testing for the second pilot test with dementia patients.

Test Setting

The test setting consisted in a dance mat, a game pad, a portable computer, an external mouse and a large PC monitor (similar to the TV screen setup seen on figure 4.13). Each participant was performing the test with supervision. The general idea of Cognimat was explained, and the setting of the training outlined. The input devices were described and then Cognimat was started. The test consisted of three training runs, the first used the objective 'Treasure Hunt', which allowed the users to learn the input controls and to navigate within the mission scenario. Afterwards, the 'Shopping' objective was trained first with the easy difficulty setting and then with difficulty set on hard. All in all, testing took about 15 minutes per participant. After the testing, a questionnaire (see appendix) was given to the participant to fill in feedback of his experience.

Hardware

- IQ Publishing Dance Mat Edition V.3 (see <http://www.iqpublishing.eu>)
- Logitech Cordless RumblePad 2 (see <http://www.logitech.com>)
- Logitech G5 Laser Mouse (see <http://www.logitech.com>)
- Lenovo ThinkPad W500, Core 2 Duo 2.66Ghz, 4GB RAM (see <http://www.lenovo.com>)
- Samsung SyncMaster 204B (see <http://www.samsung.com>)

User Profiles

- 26 years, male, Specialist in Business IT, extensive experience with computer games and game pads used before.
- 27 years, male, Doctoral student in Economy, experience with computer games and dislikes game pads.
- 26 years, female, Master student in Computer Science, some experience with computer games and game pads used before.
- 30 years, female, Doctor in Geology, only little experience with computer games and game pads.

Questionnaire Feedback

The questionnaire (see appendix) features several questions that allow answering with a score from 1 to 5, where 5 is the most affirmative answer to the question.

The male test participants indicated a low fun score (1 and 2), while the female participants enjoyed the testing more (4 both). The training was generally not considered to be difficult or just adequate (1 to 3). They were all able to learn the controls fairly quickly, given the time of only 15 minutes in total, which is represented in the scores (1 to 3). It was only difficult for one male participant to control the movement and looking around, even after learning the controls (highest score 4). Picking up items posed no problems at all (1 for all). The training was perceived to be only mildly exhausting (1 to 3). Some were pleased with their performance and others not at all (scores vary from 1 to 5). The participants think they can improve their performance (4 and 5), except for one (1) who indeed already showed a blistering performance. The participants did not feel really tired afterwards (1 to 3).

4. Results

	male_26	male_27	female_26	female_30
enjoyable	2	1	4	4
training difficulty	2	3	1	2
learning controls difficulty	1	2	3	3
movement difficulty	1	4	2	3
free looking difficulty	1	4	2	3
picking up difficulty	1	1	1	1
exhaustive training	2	3	2	3
pleased with performance	3	1	5	3
improvement possible	5	5	1	4
tired afterwards	1	1	3	2

Table 4.2.: This table shows the feedback results of the questionnaires returned by the young healthy test participants. The scores range from 1 to 5, where 5 is most affirmative with regard to the topic question defined in the first column.

The male participant who was not pleased with his performance and who did not like the test very much explained that he generally gets a slight nausea when playing 3D games, because he lacks the orientational skills he said.

The female participant who enjoyed the testing was also very pleased with her performance. In fact she managed to learn the controls quickly, had no problems moving and looking around and was exceptionally good in solving the presented tasks even with the toughest difficulty setting. She liked the dance mat very much and enjoyed using it.

It was requested that the SuperMazeMarkets contains more variety and distinguishable features to enhance orientation. Also the surrounding terrain and sky could be more versatile to facilitate the orientation task. They missed the sound and music, and would like to see qualitatively better graphics. Those who enjoyed the training would have liked more tasks to continue playing.

Test Impressions

The participants understood the tasks explained to them easily, and managed to learn the control devices quickly and well enough. They were mostly able to solve all the tasks presented to them, only the hard difficulty with three items to collect was not correctly solved by everyone.

Pilot Test #2

The second pilot test consists of two separate sessions conducted with the same group of six to eight dementia patients on two different days, one week apart.

Test Setting

The test setting was mainly the same as with the first pilot test, except for a larger display that was used, a TV screen (see figure 4.13). Also different was that it was not possible to test each participant individually, instead the whole group had to be taken care of simultaneously.

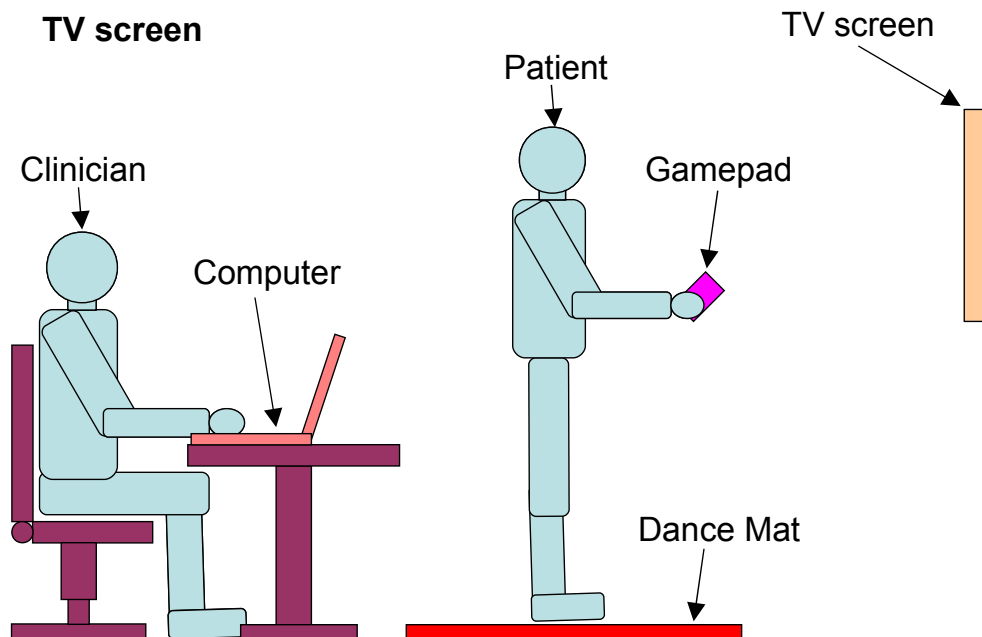


Figure 4.13.: This schematic shows the clinical setup with a large TV screen as output device. The dance mat on the floor and the gamepad in the hand of the patient are used as input devices.

During the first test session the Cognimat system and the idea behind the project were explained and the input devices presented. After that there were two participants who had the courage to try it out, but as the session was going to end, others wanted to try it out as well. So a second testing session was scheduled one week later. The questionnaires were given to those who had tried the system, but they did not want to fill them out straight away but promised to return them the next time. However unfortunately only one questionnaire was returned.

During the second test session a brief repetition of the introduction was given because there were some new patients, and then the system was tested by nearly all patients. However each patient only tried one training mission because of the limited time available. In the end, the patients were asked some of the questionnaire questions and they gave direct feedback instead of filling out the questionnaires.

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Hardware

- IQ Publishing Dance Mat Edition V.3 (see <http://www.iqpublishing.eu>)
- Logitech Cordless RumblePad 2 (see <http://www.logitech.com>)
- Logitech G5 Laser Mouse (see <http://www.logitech.com>)
- Lenovo ThinkPad W500, Core 2 Duo 2.66Ghz, 4GB RAM (see <http://www.lenovo.com>)
- LG LCD-TV 32LG6000 1366x768 (see <http://www.lg.com>)

User Profiles

The user data is subject to patient-doctor confidentiality and can only be specified in ranges. The age of the patients ranged from 60 to 87 years. It was an equally mixed group of males and females, and their scores on the MMSE were mainly in the upper third (22-27), except for one female patient who had a significantly lower score but who also refused to actively participate in the testing.

Questionnaire Feedback

As there was only one questionnaire returned, this section contains its data and also an estimation for other participants using verbal feedback of the participants during and after the testing. See the appendix for the questions of the questionnaire.

Some of the test participants had no problems reading text on the screen and understand the tasks, while others required assistance. Some liked the dance pad better than the game pad while others could not use the dance mat at all and preferred the game pad.

The male participant who returned the questionnaire reported that he enjoyed the stress less nature of the tasks and that he would have liked to spend more time on testing. However, the scores he indicated in the questionnaire are different compared to the performance he achieved during training. This data has to be regarded skeptically. He could have forgotten his performance when filling out the questionnaire at home, or it could also be the case that he perceived to perform very well while in reality it was not at all the case. It is difficult to interpret and shows that additional tests and feedback is required in order to understand the results better.

	male_70	estimation
enjoyable	3	3
training difficulty	3	4
learning controls difficulty	3	5
movement difficulty	2	4
free looking difficulty	3	4
picking up difficulty	2	2
exhaustive training	3	4
pleased with performance	2	3
improvement possible	4	5
tired afterwards	4	4

Table 4.4.: This table shows the feedback results of the questionnaire returned by the male patient aged 70 with a mild cognitive impairment. The third column represents an estimation for the rest of the group based on observation and oral feedback. The scores range from 1 to 5, where 5 is most affirmative with regard to the topic question defined in the first column.

Test Impressions

Compared to the first pilot test the patients had significantly more problems learning the control devices and handling the movement and looking around. Some older patients could not handle the perspectiveness of the virtual reality and had difficulties imagining what controller actions will lead to what reaction of the system. Some had problems seeing the items and text on the screen. One older female patient reported dizziness while watching others do the training. Most had problems using the dance mat either because they did not stand on the correct spot or they were so afraid of the quick response of the system that they tapped the spots too quickly. One of those was planning so long where he wants to go, rotating the view to the left and right, that in the end he never went there. They were initially also afraid of bumping into objects and walls.

However there were two male patients aged 65 to 70 who were significantly better in learning the controls and handling them. They had reportedly only a very mild cognitive impairment. They managed to perform the tasks satisfactorily and were pleased by their performance. They learned how to do the training quickly and it is likely that they will benefit from additional training and improve their performance.

All in all it was a very heterogeneous group with different opinions. Only the two mentioned younger male patients actually fit into the definition of the target audience.

Quality Assessment

This sections provides a quality assessment for the therapy software system and for each of the software components, by summarizing feedback from users and observations made throughout the development of the project and during the pilot tests. However, this section does not assess the training effect on cognitive abilities, merely the quality of its usage.

The overall software system manages to successfully provide a therapy solution for dementia patients. The system is complete in itself, meaning all components are fully functional and work together well. The components are stable and behave as expected. The tools used by the clinicians allow for a simple management of the system data, such as items, missions, profiles and tasks, while the Cognimat engine itself is able to properly benefit from the created data and to provide an appealing and easy to use solution for patients. It seems that the handling of the input devices is easier for younger than for elderly users. This point requires further research.

ItemEditor

The ItemEditor allows to create item lists with all the attributes required by Cognimat. It even allows to import items, images and attributes from a localized online shop, providing high quality images and a familiar localized product collection to the end user, with minimal efforts for the user of the ItemEditor. The program itself is self-explanatory and allows all editing to be done with ease. The import tool is autonomous and stable enough for its purpose, given the nature of method used to retrieve the data. However, the import algorithm may fail if the online shop is down or if it undergoes a significant change of its HTML design. Given the fact that it is not meant for end users it has a nice, appealing and easy to use graphical user interface. The stand-alone tool creates item lists that are used by the MissionEditor, but is not dependent of Cognimat. The tool can be reused for other purposes or for future versions of Cognimat.

There are no known bugs or stability issues.

All in all a valuable and necessary tool for the qualitative performance of the Cognimat system.

MissionEditor

The MissionEditor is a stand-alone tool that creates 2D labyrinths and SuperMazeMarkets. It has a very nice and appealing graphical user interface and allows to create Cognimat missions with a few simple mouse clicks within seconds. The missions can be saved in a format independent from Cognimat and can be reloaded to be manipulated later. This makes the MissionEditor independent from the Cognimat system and can thus be reused for other purposes or future versions of Cognimat with other underlying engines. The current MissionEditor provides an exporter for Torque, which is the engine used by Cognimat (see <http://www.garagegames.com>). One can simply add another exporter for other engines later and completely reuse the MissionEditor.

There are no known bugs or stability issues, there is just a lack of implemented features. The MissionEditor should be extended, as currently it does not provide support to create enough variety within the mission, by for example adding furniture objects.

The MissionEditor turned out to be an indubitably necessary tool for the ease of use and the qualitative performance of the Cognimat system.

Cognimat

The Cognimat program is designed to be simple to use, without unnecessary distractions. Its slim design clearly provides the essential information to the end user. It is able to load missions as they were created with the MissionEditor. Some bugs and stability issues that arose during the preliminary testing have been resolved. Some issues related to the Torque engine remain unresolved, but should not appear during normal usage, only with improper installation of device drivers for the input devices or the graphics device.

The visual appearance is simple and tidy, but could feature more variety. The program would further benefit from audio such as music and sound effects. Additional work by an artist to improve visual quality by adding more resources such as 3D models and 2D images is required.

5

Discussion

This chapter discusses the results achieved in this project and compares it with the defined technical solution to solve the underlying problem, which was defined in chapter 3. It also proposes better solutions to some smaller identified problems and proposes various topics for future work on the project.

The goals that were set in chapter 3 are to create a training system for patients with Alzheimer's disease that improves their cognitive abilities, namely spatial orientation, working memory and social interaction. Cognimat, the resulting work of this project, that was documented in chapter 4 consists of a virtual reality therapy software system that provides training for spatial orientation and working memory, but fails to provide social interactions, because the planned virtual characters were not implemented due to time constraints of this project. Nevertheless Cognimat has shown in the pilot test that was conducted with dementia patients that it is a fully functional software that can be used to train the target audience. Now whether the training actually proves to have a positive effect on aforementioned cognitive abilities of dementia patients remains to be seen in future clinical studies.

5.1. Discussion of Experimental Observations

This section draws conclusions about everything that was learned thanks to the user and patient testing, but also due to self-testing.

The first pilot test with young and healthy subjects showed some weaknesses of the system, such as too fast and strong responses to the users input on the control devices. Some tasks were not explained properly by the system and required additional explanation by the supervisor. The male participants reported little fun, the assumption is that they are used to commercial video

5. Discussion

games with much more action. The female participants liked the dance mat a lot, it seems like they enjoyed the idea to move their body. They criticized the low quality of the graphics and the lack of music and sound effects, something which probably requires engaging a professional artist.

As a result of the first pilot test, the controller sensitivity was reduced, the tasks were better explained and some minor glitches and stability issues resolved prior to conduct the second pilot test with dementia patients.

Main issue during testing of dementia patients turned out to be the input devices. Suggestions to improve and facilitate interaction include either using different input devices, such as other game pads, joysticks, a glove that detects hand movement and grasping, a dog leash (see future work) or else simplify the movement within the supermarket so to only be able to do square-wise movement instead of free movement. One proposal would be to combine the square-wise movement with the dance mat, and to look around and pick up products with a pointing device, such as the Nintendo Wiimote infrared tracking device (see future work).

Whatever decision is taken, it was surprising how the elderly differ in opinion, so it is absolutely necessary to involve dementia patients in early acceptance testing of the input devices.

Another question is how much the elderly patients enjoyed the training. The impression was that they found it interesting, but the feedback on that topic was too moderate to determine how enjoyable it really was. As the motivational aspect is very important for the training therapy, this is certainly a topic for further research. The elderly patients need to be asked more specific questions about how much fun they had during different parts of the training in order to understand better what pleases the target audience. Whatever will be revealed, test feedback so far suggests that the responses will probably be very heterogeneous. Therefore the possibility for the patient to customize the training to its own liking by e.g. providing continuous feedback to the system is an important optimization that Cognimat could benefit from.

5.2. Future Work

This chapter provides a set of ideas that could prove beneficial to implement. Also listed are goals that were not reached during the time frame of this project.

Nintendo Wiimote

The game pad for the Nintendo Wii console (see <http://www.nintendo.com/wii>), called Wiimote, is equipped with an infrared camera that allows detection of the pointing direction of the device. It can thus be used to point on a location on the screen. In Cognimat it could be used to interact with the graphical user interface and to pick up items. The movement and looking around could be simplified so that it is not necessary anymore to look around to pick up the items. Instead, the complete shelf is visible on screen and with the pointing device the user can point to the product he wishes to pick up. The Wiimote also contains four arrow keys that could be used for movement instead of the dance mat. The usage of the Wiimote would

allow the user to comfortably sit in his couch at home in front of his TV and do his training with Cognimat only with the Wiimote in the hand, or alternatively, if he feels fit enough, standing on the dance mat. The Wiimote can be extended with the Nunchuk, which basically provides an analog stick for the other hand, which could again allow the user to look around freely.

Acceptance testing with dementia patients is strongly recommended.

Dog Leash

Another idea for an input device is to use a long joystick that is used like a dog leash. The user can move the leash into the direction he wants to walk. The system can also give force feedback blocking the movement of the leash in some directions, indicating an obstacle for example. Again, early acceptance testing with dementia patients is strongly advised.

Mood Monitoring

As suggested in chapter 3, biofeedback could be used to detect the mood of the patient and to react accordingly within the virtual reality. For example one could analyze the effect of music, and then optimize the selection of music to improve the mood of the patient. It was not done in this project because it was not an essential feature, but it might still be interesting to research the possibilities to include biofeedback into the training simulation.

Profile Performance and Statistics

The current implementation of Cognimat gathers performance statistics of the user for each completed mission such as if the mission was completed successfully or else how many errors were done, how much time was required to solve the tasks and the exact path that was taken when moving through the SuperMazeMarket. The only performance statistics that are currently shown is the success of the mission and the time required. Additional work is required to save the performance scores with the profile, so that the user can monitor its progress, and for its display and analysis a nice graphical user interface with graphs over time for each score is to be designed.

Remote Supervision

One original idea was to be able to let a clinician remotely supervise the patients performance at home. This is not possible with the current implementation, but might turn out as a valuable addition. It could not only allow the clinician to monitor the patient's progress, but also to provide live assistance if the patient is stuck or needs help that the system itself cannot provide.

Implement more Subtasks

Many subtasks were defined during the definition progress of this work, but in the end only a few found its way into Cognimat due to time constraints of this project. See the attached list of proposed subtasks and their description in the appendix for the complete list of ideas for subtasks. Many subtasks require virtual characters to be supported by the system, and many do require additional work by an artist to create additional resources such as 3D models and 2D images, as well as music and sounds.

Virtual Characters

Social interactions is a major aspect that the therapy software system should train. The system was defined to have virtual characters scattered throughout the SuperMazeMarket who can be interacted with and who give subtasks to perform. These virtual characters should train the social abilities of the patient. However, due to time constraints of this project, virtual characters were not included in the Cognimat engine. Adding virtual characters and avatars would be the most important next step to improve Cognimat, and to completely reach its laid-out goals.

Sound and Music

Accompanying the main and most important visual output, music and sound effects can play a crucial role in providing an immersive experience to the patient, and allowing feedback that is not possible with video only. The definition of the system included auditory feedback, but due to the lack of resources and time constraints of this project, sound and music were not implemented. Music can be used to change the mood of the patient, and maybe together with the performance results analyze the music with which the patient performs best. The system could then increase the occurrence of that music to improve the overall training performance of the patient. Sound effects could be used to further mark areas within the SuperMazeMarket, such as departments, or other areas of interest. Voices of people add to the impression of being in a supermarket. Some subtasks may require the patient to actually find some virtual characters like a child or a dog, and then it might be easier when hearing the 3D positioned sound effects of that character, e.g. singing, playing, or barking.

Tutorial Missions

During the pilot test it became clear that the patients require an initial learning phase to get familiar with the program, its tasks and its input devices. Therefore it seems beneficial to create some tutorial missions that are able to introduce the patient to Cognimat without the need of a supervisor such as a clinician. These tutorial missions can explain the purpose of the training with Cognimat, its goals, its virtual reality environment and the nature of the tasks. These explanations can be done using a virtual avatar to appear more appealing to the patient. The missions then further provide small training tasks to learn control the input devices. Small repetitive tasks that the patient needs to do accompanied with direct performance feedback from

the virtual avatar might alleviate the initial hurdle of learning the input devices. This tutorial avatar could also be extended to be available in normal training sessions and activatable by the patient whenever he is in need of help or advice.

Extensive User Testing on Target Audience

The pilot tests were only preliminary testings, and even the dementia patients were not primarily of the target audience. Extensive testing with patients in a very early stage of dementia or Alzheimer's disease is required to determine the quality of the therapy program with regard to motivational and fun aspects, but also with difficulty of handling input devices, and last but not least to determine the adequacy of the training tasks.

Clinical Study with Dementia Patients

Once the quality of the Cognimat therapy system has been proven by involvement of the target audience in extensive user testing, serious clinical studies need to be organized in order to research the training effect of Cognimat in the cognitive areas of spatial orientation, working memory and social interactions. Studies could include research into whether the virtual reality is good enough to train spatial orientation compared to training in a real environment, whether virtual avatars that accompany the training enhance the patient's learning ability, and if the virtual characters and their interaction improve the patient's social abilities with real people.

5.3. Conclusions

This project showed that a virtual reality therapy software is feasible. Cognimat, the resulting work of this project, is a functional therapy software system that was developed in allegiance with the goals and requirements defined in this project. Even though its implementation has not reached all of its goals and not fulfilled all of its requirements, the performed preliminary testing with dementia patients showed Cognimat's basic usability as a therapy software for the target audience. To confirm the success of this project, the next step would be to continue development on Cognimat using the propositions in the previous section, and to bring it from its prototype state to an actual end user product. The imagined final solution will allow elderly dementia patients to seriously train their cognitive functions while at the same time having a lot of fun.

Conclusively, the system proved to have challenging tasks for dementia patients, but would benefit from additional research in human machine interaction for elderly people, as well as in determining the fun factors for an audience that normally does not play computer games.

The work of this project showed to be a valuable first step in creating a therapy program for dementia patients, unveiling important challenges in dealing with the nature of the problem and providing concrete directions for successive research and development.

Acknowledgments

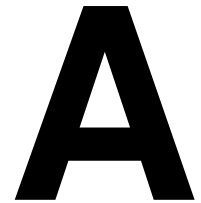
I would like to sincerely thank my supervisors *Robert Riener*, *Daniel Kiper* and *Pawel Pyk*. They introduced me to this highly interdisciplinary research field and supported and encouraged me throughout my master thesis.

My further thanks go out to *Prof. Christoph Hock* and *Prof. Roger Nitsch* for their valuable input and insight into their research work.

I am also very grateful to *Dr. Olga Ballach* for providing feedback and help to organize a pilot test with dementia patients.

And of course I would like to thank again all those who participated in the testing of Cognimat.

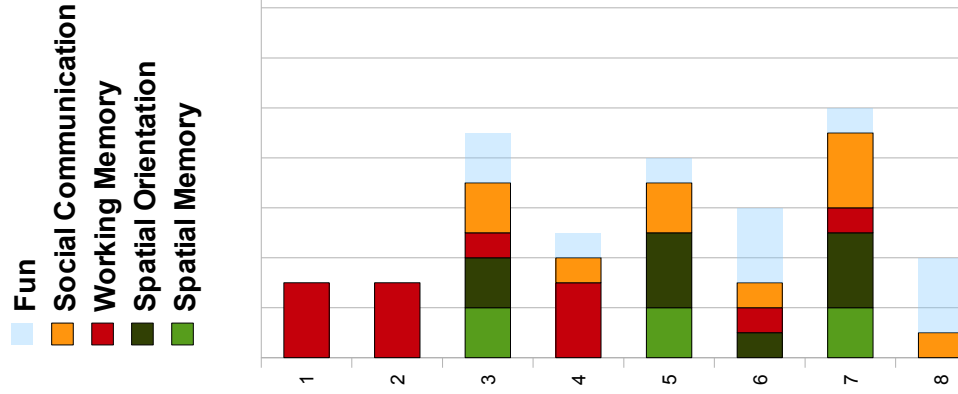
Last but not least I heartily thank my beloved *Chiara Odette* for her compassionate encouragements, without which I hardly could have finished this thesis in time.



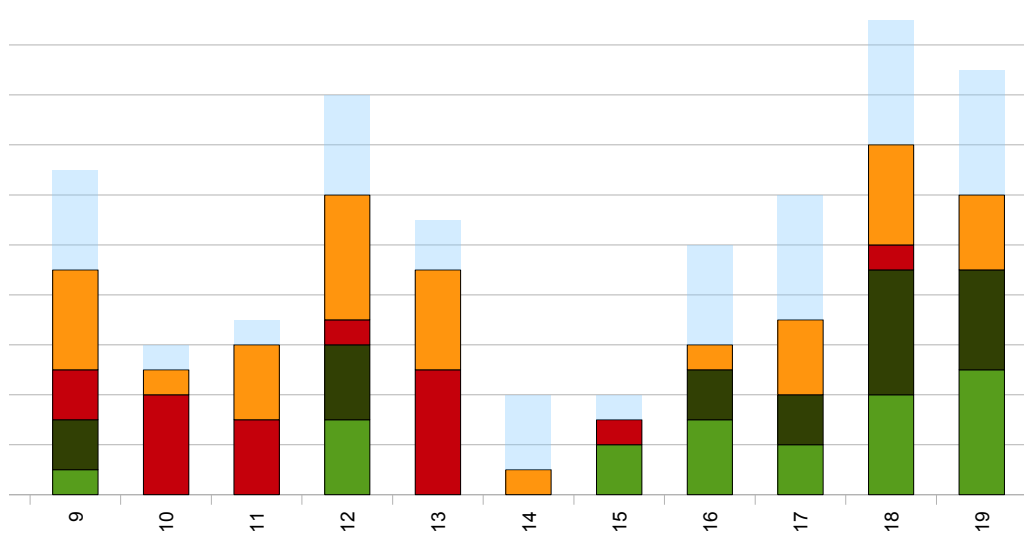
Subtasks

It follows an extensive list of subtasks that are proposed to be implemented for Cognimat. Each subtask is described and has an indication of what cognitive ability is trained how much. There is also a fun indicator, and whether the subtask is intended for a group session (only at the clinic), or just for one user.

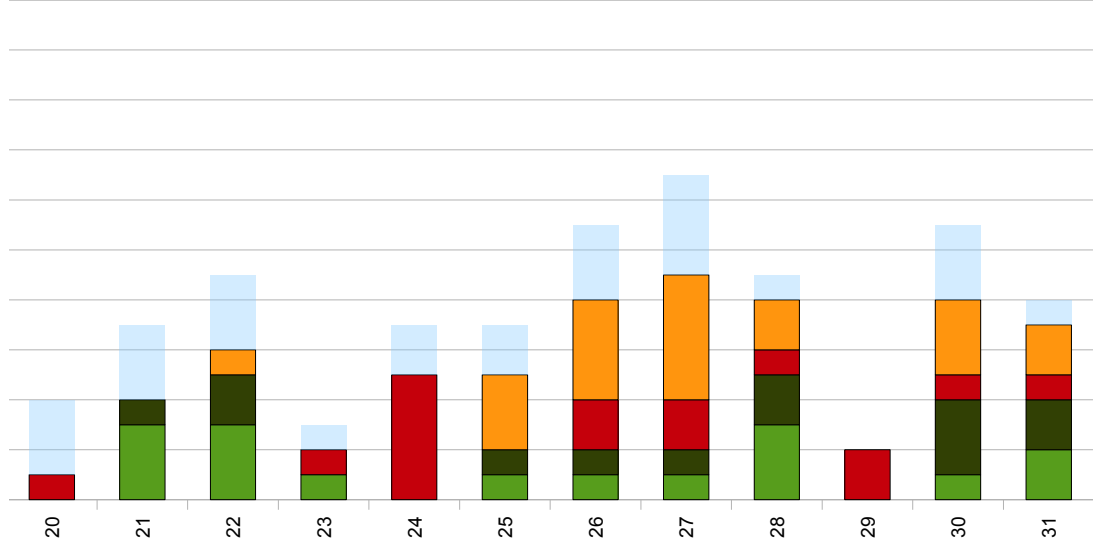
#	Subtask description	Group					Fun
		Spatial Memory	Spatial Orientation	Working Memory	Social Communication	Fun	
1	Collect an item of the shopping list as first item.	No	0	0	3	0	0
2	Exchange an item of the shopping list with another item.	No	0	0	3	0	0
3	Find an item requested by a character and bring it to him.	No	2	2	1	2	2
4	Pay at the checkout the demanded amount by selecting the money off your purse.	No	0	0	3	1	1
5	Help a character who is lost by telling him the direction of the exit.	No	2	3	0	2	1
6	Be the first to find and collect an item of a certain type.	Yes	0	1	1	1	3
7	Help a child find his parent by guiding it to him. Keep the straying child focused.	No	2	3	1	3	1
8	Be the first to complete your task of gathering the items on the shopping list.	Yes	0	0	0	1	3
9	Team up with someone else and divide the items on the common list to collect them faster.	Yes	1	2	2	4	4



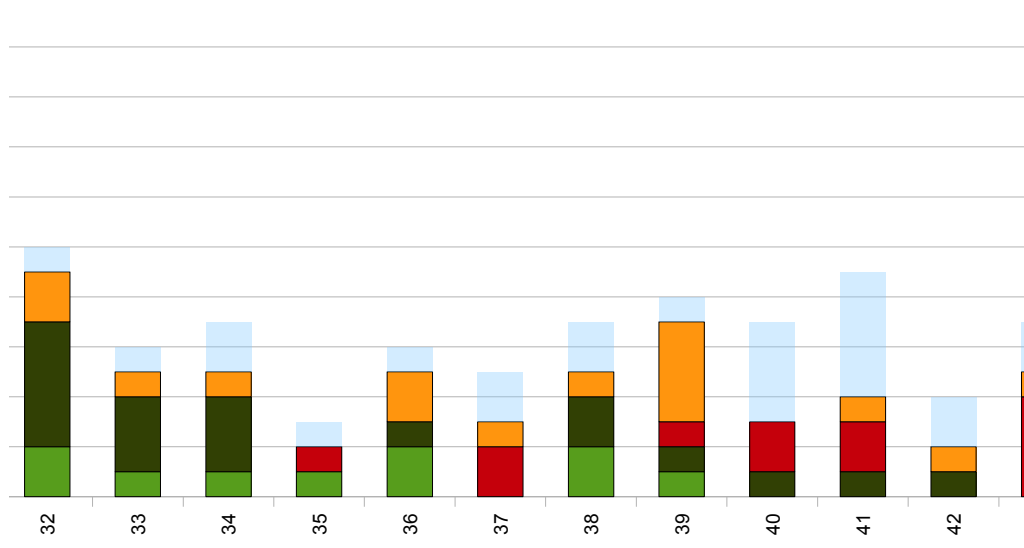
10	Sum up the displayed costs of the collected items and pay at the checkout.	No	0	0	4	1	1
11	Buy an item for a character who gives you money and give him back the change.	No	0	0	3	3	1
12	Team up with someone else to find and bring as many lost children to their parents as possible.	Yes	3	3	1	5	4
13	Team up with someone else and divide the collected items to pay them with your limited money.	Yes	0	0	5	4	2
14	Gather as many special hidden items as you can.	Yes	0	0	0	1	3
15	Put items found on the floor on their correct spot on the shelves.	No	2	0	1	0	1
16	Steal an item and hide from the guards.	No	3	2	0	1	4
17	Play 'hide and seek'.	Yes	2	2	0	3	5
18	Play 'thieves and guards'. Thieves have to steal certain items without being caught by the guards.	Yes	4	5	1	4	5
19	Play 'last one loses' and quickly collect the item that is announced when the music stops.	Yes	5	4	0	3	5
20	Solve the riddle and find the item in question.	No	0	0	1	0	3
21	Find a treasure map and follow the hints to find the treasure.	No	3	1	0	0	3
22	Play 'treasure hunt'. React to audio announcements of lost items and find them.	Yes	3	2	0	1	3



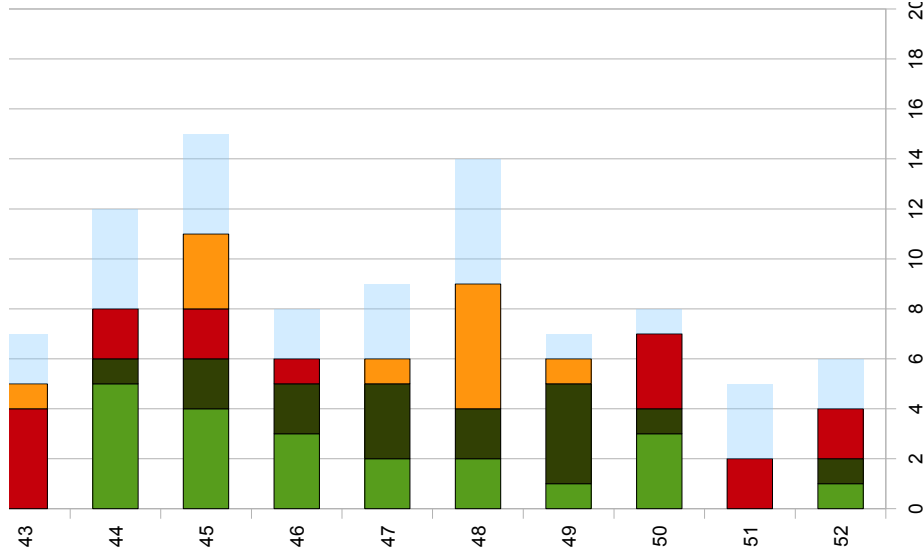
23	Find for each item on the shopping list the cheapest product.	No	1	0	1	0	1
24	With a cooking recipe for x persons, find the necessary items and calculate the required quantities for y persons.	No	0	0	5	0	2
25	Help a character who has lost an item by asking other characters if they have seen or found it.	No	1	1	0	3	2
26	Play 'detective'. There is a thief in the supermarket and you have to find out who it is by engaging all characters in conversations and make the thief contradict himself.	No	1	1	2	4	3
27	Play 'detective' in a team and be the first to find the thief.	Yes	1	1	2	5	4
28	Report sold out items to the staff.	No	3	2	1	2	1
29	Gather for each item on the shopping list a certain quantity.	No	0	0	2	0	0
30	There is a birthday party being held somewhere in the supermarket. Find it using the music as an orientation and bring the right present along.	No	1	3	1	3	3
31	Guide a group of children to a certain item type (ice creams, toys, drinks, etc.)	No	2	2	1	2	1
32	The supermarket is being reorganized. Some shelves change their position while you walk around, closing old passages and creating new ones. You can ask the staff for directions.	No	2	5	0	2	1
33	Help the staff by bringing empty carts to their resting place.	No	1	3	0	1	1
34	Bring as many carts to their resting place as you can.	Yes	1	3	0	1	2



35	You can only hold a limited number of items in your hands. Take a basket or a cart along depending on how many items you have to carry around.	No	1	0	1	0	1
36	Help a character to find the bathroom.	No	2	1	0	2	1
37	Local artists are displaying their paintings throughout the supermarket. Some lights for the paintings have gone out. Remember which ones and at the checkout tell the staff about them.	No	0	0	2	1	2
38	Local artists want to display their paintings throughout the supermarket. Help the staff to hang them up at the right places.	No	2	2	0	1	2
39	Help a character in a wheelchair to do his shopping.	No	1	1	1	4	1
40	The supermarket is hosting a race event. Sit in a shopping cart and race through the corridors. Pick up items on the track.	No	0	1	2	0	4
41	The supermarket is hosting a race event. Sit in a shopping cart and race through the corridors. Pick up items on the track and be faster than your opponents!	Yes	0	1	2	1	5
42	A rock concert is going to be held within the supermarket, but the rock band has lost their instruments. Find and bring them to the right performer.	No	0	1	0	1	2
43	To acquire a ticket for the concert from the staff you have to answer a multiple choice quiz about music. The answers can be found around the supermarket when buying special items.	No	0	0	4	1	2



44	A roman history museum has organised an advertisement campaign within the supermarket. The marmor statues are labelled incorrectly and you have to correct this by exchanging them to win an entry ticket.	No	5	1	2	0	4
45	Some characters have lost their pets. Find and lure them back to their right owners using the correct food.	No	4	2	2	3	4
46	The local zoo has put cages with wild animals throughout the supermarket. You need to feed them the correct food.	No	3	2	1	0	2
47	The zoo animals have escaped from their cages! Lure them back using the appropriate food.	No	2	3	0	1	3
48	The zoo animals have escaped from their cages! As a group drive them back into their cages.	Yes	2	2	0	5	5
49	There is a power outage and the lights in the supermarket are off. You have to use a flashlight to find your way out.	No	1	4	0	1	1
50	In an effort to make people read more, the local library has joined with the supermarket and put up some shelves with books. Unfortunately, they are in total disorder. Help bring order into the chaos.	No	3	1	3	0	1
51	Find a cooking book on the library shelves, choose a recipe and buy the required ingredients.	No	0	0	2	0	3
52	To solve some difficult riddles and puzzles, you need to find and read the right books.	No	1	1	2	0	2



B

Input and Output Devices

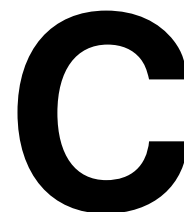
In order to find suitable input and output devices for the system, a preliminary search for such devices and a discussion about their usefulness and adequacy for elderly people was performed. It follows a table listing various devices with a pro/contra discussion and a usefulness rating for the purpose of this project.

#	Device description	I/O	Pro	Contra	Rating
1	Mouse & keyboard	I	commonly used, many input possibilities, great flexibility, good for point and click interfaces	requires to sit in front of a desk, keyboard rather clumsy, unintuitive, too many buttons	***
2	Gyromouse	I	Can stand up and use device free in air, does not require a desk.	requires a steady hand, requires additional device for other hand to perform special actions, difficult to learn and to handle precisely	*
3	Joystick	I	nice to hold, enough buttons for special actions, intuitive to move around, cheap	cannot stand up freely, unintuitive for looking around	**
4	Gamepad	I	nice to hold, enough buttons for special actions, intuitive to move around, intuitive to look around, can stand freely or sit anywhere, cheap	requires initial learning phase, not suited for point and click interfaces	****
5	Body movement sensors	I	intuitive, can stand up freely, does not require a desk	must stand up, needs a moving floor pad such that person is not really moving while walking, body movement directly coupled with virtual world (might be undesired), needs to put on sensors and calibrate them, requires additional devices in the hands with buttons for special actions, expensive	*

6	Brainwave sensors	I	fun to see remote effects caused by the mind (telekinese), urges the usage of the mind	not precise enough to allow multiple functionalities, must be coupled with other device, requires individual calibration, very expensive	*
7	Thought sensors	I	fast intuitive input	not possible yet, would probably require lots of individual calibration	
8	Sport equipment (bicycle)	I	combines fun with sportive exercises	suited only for special tasks, requires additional devices to allow special actions, requires space, expensive	**
9	Touchpad	I	flexible usage for many different tasks	not suited for movement in a virtual reality	*
10	Touchscreen	I/O	suited for point and click interfaces, flexible and intuitive usage for many different tasks	not suited for movement in a virtual reality, requires additional device	***
11	Microphone & speech recognition	I	great for social communication, actions through voice commands	faulty, slow, commands are confusing for first person perspective	****
12	Biofeedback	I	gathers user information (relaxation, cognitive performance), allows dynamic adaptation to the user, good for clinical usage	requires bio-sensors, expensive, tedious for home usage	***

13	Video camera & movement recognition	I	intuitive, can stand up freely, does not require a desk	must stand up, needs a moving floor pad such that person is not really moving while walking, body movement directly coupled with virtual world (might be undesired), requires additional devices in the hands with buttons for special actions, difficult to install	*
14	Monitor	O	commonly used with a computer, cheap	requires to sit in front of a desk, usually not very large	***
15	Beamer	O	creates a large view, good for standing freely or sitting comfortably on a couch	requires a projection wall, dark room, expensive	**
16	TV screen	O	commonly available, large screen, good for sitting comfortably on a couch or standing freely	low resolution or expensive, requires mostly a portable computer to be attached (desktop too far away)	****
17	Loudspeakers	O	create sound and music, important for virtual ambience	could annoy user	****
18	jDome (beamer projection on a semi-sphere)	O	conveys a better immersive virtual experience, user stands freely, good for clinical version	must stand up, requires high resolution beamer, expensive, requires space, difficult to install	***
19	Headmounted display	O	conveys a true immersive virtual experience	must put on equipment, user could feel trapped inside virtual world, very expensive	**

20	Force feedback	O	convey touch and hit sensations for obstacles, found in input devices (joystick, gamepad)	could annoy user, not precise information feedback	***
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Pilot Test Questionnaire

The following questionnaire was used to retrieve the user feedback for the pilot tests.

Cognimat Questionnaire

Juli 2009

Für die Antwort die entsprechende Zahl auf der Skala von 1 bis 5 umkreisen und optional einen kurzen Kommentar verfassen.
Vielen Dank!

Ihr Name (freiwillig):
Ihr Geschlecht:
Ihr Alter:

Hat die Benutzung von Cognimat Spass gemacht?

Langweilig	1	2	3	4	5	Spassig
------------	---	---	---	---	---	---------

Empfanden Sie das Training als schwierig?

Einfach	1	2	3	4	5	Schwierig
---------	---	---	---	---	---	-----------

War das Erlernen der Steuerungsgeräte schwierig?

Einfach	1	2	3	4	5	Schwierig
---------	---	---	---	---	---	-----------

War es schwierig, die Fortbewegung zu kontrollieren?

Einfach	1	2	3	4	5	Schwierig
---------	---	---	---	---	---	-----------

War es schwierig, das Umherschauen zu kontrollieren?

Einfach	1	2	3	4	5	Schwierig
---------	---	---	---	---	---	-----------

War es schwierig, Produkte vom Regal aufzunehmen?

Einfach	1	2	3	4	5	Schwierig
---------	---	---	---	---	---	-----------

War das Training anstrengend?

Entspannend 1 2 3 4 5 Anstrengend

Wie zufrieden sind Sie mit Ihrer Leistung?

Enttäuscht 1 2 3 4 5 Zufrieden

Denken Sie, dass Sie Ihre Leistung mit mehr Training noch steigern können?

Kaum steigern 1 2 3 4 5 Stark steigern

Fühlen Sie sich jetzt nach der momentanen Sitzung müde?

Fit 1 2 3 4 5 Müde

Was hat Ihnen besonders gut gefallen?

Was hat Ihnen nicht so gut gefallen?

Was würden Sie wie verbessern wollen?

Was ist Ihnen beim Training schwer gefallen?

Würden Sie Cognimat als kognitives Training verwenden und weshalb?

Weitere Kommentare:

Vielen Dank für die Teilnahme am Cognimat Test und für das Ausfüllen des Fragebogens!



Patent Research

SYSTEM FOR PREVENTING/REMEDYING DEMENTIA BASED ON VIRTUAL REALITY USING INTERNET

PUB: 11.10.2002

DOC: KR102002076829AA

PURPOSE: A system for preventing/remedying a dementia based on a virtual reality using the Internet is provided to enable a dementia patient to receive a medical treatment by making the dementia patient receive a medical examination in a remote place and perform a dementia treating scenario on a virtual reality on the Internet. **CONSTITUTION:** If a patient connects to a web server, a dementia web page is supplied on a web browser of the patient(S211). Personal information of the patient written in a member joining process(S213), a patient detailed questions table, and a reserved time for a medical examination are stored in a member information DB(S214). Thus, an environment for a remote medical examination between a doctor and the patient and a prescription is supplied(S215). An environment capable of treating the patient is supplied in accordance with a scenario in a virtual reality prescribed by the doctor(S216). The result is stored in the member information DB, and the result is supplied to the doctor(S217). If a medical examination is received from the doctor again(S218), the above stages are repeated.

Virtual reality tools and techniques for measuring cognitive ability and cognitive impairment

PUB: 13.11.2008

DOC: US020080280276A1

D. Patent Research

Techniques and tools for measuring cognitive ability and/or detecting cognitive impairment or decline. For example, techniques and tools are described that can be used to diagnose or test susceptibility to cognitive impairments in children or in elderly people (such as cognitive impairments associated with Alzheimer's Disease). Techniques and tools are described that can be used to evaluate treatment effects and/or measure cognitive decline over time.

Virtual reality immersion therapy for treating psychological, psychiatric, medical, educational and self-help problems

PUB: 30.07.2002

DOC: US000006425764B1

A method of treating a psychological, psychiatric, or medical condition by choosing a psychological strategy for treating the condition, encoding electronic instructions for a virtual reality environment in such a way that the interactive virtual reality environment implements the psychological strategy, loading electronic instructions into a virtual reality technology unit (10, 22) equipped with a display (14, 40) for displaying the virtual reality environment and with a patient input device (14, 22, 32) for receiving responses to the environment from the patient, and instructing the human patient how and when to use the virtual reality technology unit to interact with the environment. The interactive environment contains instructions for a scoring procedure for quantitatively analyzing the medical condition of the patient, and/or counseling instructions or self-help instructions. The environment can be used in conjunction with a physical parameter measuring device (36) connected to the virtual reality technology unit (10). The process is comprehensive and takes place during immersion in fully interactive three-dimensional virtual reality environments utilizing computer generated graphics, images imported from photographs, and video for sensory stimulation. Immersion is achieved with goggles, a head-mounted-display, or other form of visual stimulation, such as surround projection screens or monitors or devices that permit the user to have a virtual experience. It includes the use of voice, music, and sound and other forms of physiological stimulation and feedback. Body sensors and devices such as a hand-held grip permit the user to interact with objects and navigate within the virtual environment.

VIRTUAL REALITY THERAPY SYSTEM AND METHOD OF USE

PUB: 26.10.2000

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A virtual reality system which includes a stimuli system which delivers at least form of stimuli to an individual and a support structure connected to the stimuli system which positions the system adjacent to but spaced from a stimuli receptor of the individual corresponding to the form of the stimuli.

METHOD FOR WORKING OUT THE BEHAVIOURAL STRATEGY OF A PLAYER USING A COGNITIVE VIRTUAL REALITY, DEVICE FOR CARRYING OUT SAID METHOD AND AN INFORMATION-CARRYING MEDIUM FOR SAID DEVICE

PUB: 03.04.2003

DOC: CA000002456265A1

The invention relates to means for working out the behavioural strategy in different life situations, learning, psychological training, for professional selection and defining a professional aptitude in various activities. The aim of the invention is to improve the flexibility of a system for working out the behavioural personal strategy which can be integrated into existing systems without the radical modification thereof. The psychophysical profile of a player's personality and the matrix of the event reaction thereof are defined by testing. Said testing can be carried out openly for the player before the game and secretly for said player during the game, the tests being a game component. The game instruction is formulated taking into consideration information thus obtained, thereby comparing the game process with the concrete characteristics of the player, practically from the very beginning of the game. Program items characterising persons, objects and certain game processes are compared with data obtainable as test results of the persons and objects of the game, thereby investing the persons with the characteristics of the player. The actions of the player are traced and compared during the game with various aspects of the individual psychophysical profile of the player's personality and the matrix of the event reaction thereof. The games of said type can be carried out on individual personal computers and using local or global telecommunication and computer networks of any type.

E

Abbreviations

MMSE	mini mental state examination
VR	virtual reality
IQ	intelligence quotient
EQ	emotional quotient
2D	two dimensional
3D	three dimensional
HTML	hypertext markup language
PC	personal computer

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