Abstract – Serious games are computer games used as educational technology or as a vehicle for presenting or promoting a point of view. They can be similar to educational games, but are often intended for an audience outside of primary or secondary education. Serious games can be of any genre and many of them can be considered a kind of edutainment. Serious games are intended to provide an engaging, self-reinforcing context in which to motivate and educate the players towards non-game events or processes, including business operations, training, marketing and advertisement. Serious games can be compelling, educative, provocative, disruptive and inspirational. The potential of games for entertainment and learning has been demonstrated thoroughly from research and clearly in the market place. Unfortunately, the investments committed to entertainment dwarfs that which is committed for more serious purposes. Furthermore, game development has become more complex, expensive, and burdened with a long development cycle. This creates barriers to independent game developers, and inhibits the introduction of innovative games, or new game genres, i.e. serious games, or games accessible to communities with special needs. In this paper we introduce PlayMancer, a work in progress that aims to overcome such barriers by augmenting existing 3D gaming engines with new possibilities and thusly creating a novel development framework. In section I of this paper we briefly survey the serious games market. In section II we introduce the PlayMancer project and its objectives, whereas in section III we present the platform architecture and modules. Section VI describes an application scenario where a PlayMancer-based game is being used as additional therapeutic tool (combination of standard psychological individual approach plus use of videogame) to treat chronic mental disorders, such as eating disorders and behavioral addiction.

I. SERIOUS GAMES: AN EMERGING MARKET

In its annual report “Global Entertainment and Media Outlook: 2007-2011”, the financial firm Pricewaterhouse-Coopers predicts that the video games market will continue to expand at a compound annual rate of 9.1% over the next five years [6]. Video gaming is one of the fastest-driving segments of the digital media market, no matter what region of the world is considered. According to PricewaterhouseCoopers by 2011 the worldwide gaming market will be worth $48.9 billion, and its 9.1% expected growth rate exceeds the 6.4% advance that the financial analyst estimates for the overall entertainment economy during the same period. According to digital media analysts such as Pacific Crest Securities, the real growth in video games will come from the casual and nontraditional game market. The growth of the video games market is expected to be supported by the attraction of new audience categories, such as casual players. At the same time traditional games are becoming too complex for all but the most hard-core players in the industry. An outstanding example of this audience shift is Nintendo’s revolutionary Wii system, which has forged a new audience for gaming among families, women and older people, who had been turned off by the complex, violent and solitary adventures that once dominated the market.

A clear sign of video games increasing maturity is in fact the popularization of games, whilst hard-core players and critics are becoming a smaller part of the audience.

In light of these trends a new niche of games is emerging: serious games. A serious game is a piece of software that draws from game technology and design principles whilst aiming at a primary purpose other than pure entertainment. Serious games can be used as educational technology or as a vehicle for presenting or promoting a point of view. They can be similar to educational games, but are often intended for an audience outside of primary or secondary education. Serious games can be of any genre and many of them can be considered a kind of edutainment. Serious games are intended to provide an engaging, self-reinforcing context in which to motivate and educate the players towards non-game events or processes, including business operations, training, marketing and advertisement. Serious games are used for non entertainment purposes including education, corporate and military training, and health care. The category includes games developed for professional use as well as recreational games adapted for serious purposes.

The serious games sector, while still at an early stage of development, is rapidly growing and is being adopted by many organisations of different types and sizes. As predicted by several analysts [24,25,26] corporate learning and development has proven to be one of the fastest-growing sectors of the overall market. Demand for Corporate serious games is increasing, with several companies commissioning serious games development. A sector with a growing demand for serious games is that of Healthcare providers (e.g., training for surgery, for emergency medical response, and for managing surgical teams). The overall figure for the serious games market is expected to be around $1.5 billion in 2008 in the U.S. As serious games are gaining momentum in Europe and the video game industry is finding more and more business outside the entertainment sector, this figure is expected to rise to $2 billion shortly.

For instance, the size of the U.S. market for brain stimulation products has more than doubled between 2005 and 2007 to $225 million, according to a new report by the consulting
II. INTRODUCING PLAYMANCER

While 2008 has seen acceleration in adoption of serious games, the market is still in its early life and far from being mature. Analysts agree that a fundamental steps to be taken towards maturity is the a transition of many serious games vendors from being perceived as “games” companies to being recognized as “solutions” companies. In other words, the market shall overcome the common wisdom that games are inherently not serious. The serious games market will require game developers to shift from the traditional business-to-consumer model to a business-to-business one. In order to attract investments that will turn serious games from a promising trend into an established market it is important to provide easier means for customers to find producers and to lower the costs which are still very high for such projects.

PlayMancer aims to reduce production and distribution cost and increases competitiveness and productivity. The goal is to implement a framework and a platform for serious games by augmenting existing 3D gaming engines. More specifically, the objectives of our project are:

- to construct a next generation networked gaming environment, mainly augmenting the gaming experience with innovative ICT modes of interaction between the player and the game world;
- to allow for a shorter and most cost-effective game production chain, by enabling techniques for procedural content creation based on generative modelling, and thus reduce the cost of offering a full-fledged pre-designed gaming world;
- to evolve the principles of Universally Accessible Games for application into 3D-based games, following a design for all philosophy, with the ultimate goal of designing games to be equally challenging to players of different abilities;
- to evaluate the proposed framework and gaming infrastructure by developing and testing a series of serious games modules as applied to two application domains: physical rehabilitation, and therapeutic support and lifestyle management programs for behavioral and addictive disorders.

The PlayMancer project (www.playmancer.eu) leverages on the current market momentum towards next generation gaming platforms. After the mass-market adoption of 3D graphics acceleration cards recent game technology advancements are introducing new interaction modalities. The gaming platform will be built by encompassing an Augmented Reality (AR) 3D game-like world. AR has been used so far for scientific applications with success, but due to the fact that these applications are very specialized, AR constitutes a very limited market and as a consequence the average cost of AR products are exaggeratedly high for an average game user. However, we believe that reducing the games production cycle will accelerate create an economy of scale that will drive down the cost and increase the availability of games, games components and technology. Thus it is expected that the cost of AR technology will be considerably dropped, if future game platforms massively exploit them, the same way that 3D games did for 3D acceleration card costs.

III. THE PLAYMANCER PLATFORM

The general architecture of the PlayMancer platform, presented in Figure 1, has been designed taking into account: (i) functional and technical specifications derived from generic and specific domain user requirements, and (ii) the main technological challenge of the project – the rendering of an open source game engine multi-modal. In particular, the multi-modality is achieved by developing an enhanced multimodal dialogue interaction platform, based on the RavenClaw/ Olympus architecture [1], which is further extended to render other modalities than speech. The platform relies on a modular architecture, where components processing the data streams from the individual modalities and input sources interact through the central hub of Olympus, which allows synchronous or alternative use of input/output modalities. In this way, in addition to traditional inputs/outputs used in games (joystick, keyboard, mouse, display), the PlayMancer architecture integrates also speech, touch, biosensors, and motion-tracking. These additional modalities allow the introduction of new game paradigms that offer enhanced game experience for the average game player. More importantly, however, they provide the means for development of a new range of serious games for fighting various eating and addiction disorders, or for physical rehabilitation purposes, which is an essential goal in the PlayMancer project.
As shown in Figure 1, the PlayMancer platform is composed of three major parts: (i) Game Engine, (ii) Game/Application Manager, and (iii) Multimodal Dialogue Manager, as well as the Hardware Abstraction Layer, providing the interface to the input/output devices, and some auxiliary components. Of the auxiliary components, the Configuration Manager provides the means for configuration setup of the interaction modes, game resources, user specific game settings, etc. The Logging Component handles the long-term logging of data, which are processed statistically, and stored in a format convenient for interpretation by the healthcare supervisors (i.e. medical doctors, psychologists, rehabilitation experts, etc). The networking and Quality of Service (QoS) monitoring component, which is distributed over the server and client(s) sides for effective game state update, provides the means for multiplayer experience over existing global or local area networks. The User Modeling and Profiling component is responsible for personalization and adaptation of interaction (input/output modalities, dialogue flow, etc.) to user preferences. User profile is initially generated by static modeling of directly acquired user data and preexisting system knowledge about the user’s group (stereotype) [2]. At runtime, this profile is updated and models are generated by dynamic modeling of context-dependent user preferences, both for individual and multi-user environment.

**Game Engine.** The Game Engine provides the necessary components to display the game's graphics, play the sound and music, and manage the game state. The graphics component is a fully featured 3D graphics rendering engine. Evaluation of various open source game engines, with respect to the PlayMancer requirements, led to the selection of the Object-Oriented Graphics Rendering Engine (OGRE) [3] as the most suitable for integration in PlayMancer environment. The sound component is capable of playing prerecorded sounds and music, and provides facilities for real-time procedural creation of sounds. The game state component manages the runtime state of all game entities, ensuring correlation between state changes and game logic. In addition, it gives access to the game state for other components of the architecture, mainly the Game/Application Manager.

**Game/Application Manager.** The Game/Application Manager (GAM) hosts the brain of the system. It is responsible for the smooth interaction among the system components and the overall operation of the PlayMancer-derived games. Through the Context Awareness and Interpretation component, the GAM manages the smooth interaction between the physical world and the synthetic world of the game, offering a high-level supervision of the user interaction, experiences and reactions (i.e. increased hearth rate due to time restrictions in the game). In addition, GAM hosts the Emergency and Crisis Handling component, which enables alteration of the interaction style and the game flow, to prevent danger and...
harm to the gamer in case of atypical behaviors or of emergency situation. Monitoring of context parameters and detection of atypical behaviors is supported by personalized game-specific user profile data, set-up by the supervisor for each player. Finally the Argumentation-Based Reasoning and Decision Making component implements the top-level decision making logic of the system that is responsible for achieving the goals of the application.

**Multimodal Dialogue Manager.** As Figure 1 presents, the Multimodal Dialogue Manager has a composite structure, which involves the processing and interpreting components for the different input data-streams, the synchronization and disambiguation components and the dialogue flow manager. The major task of the Multimodal Dialogue Manager is to handle user-machine interaction: handle events from different input modalities, interpret inputs, fuse and disambiguate these inputs when necessary, personalize and adapt interaction, etc.

Interactions which were previously handled directly by the game engine are now handled by the Multimodal Dialogue Manager, and even an ordinary mouse click in the game world is analyzed as part of a complex task completion when the game task requires so. Thus, different types of game data, although shown as separated in the architecture block diagram are related to each other. Dialogue Data are related to the interactive 3D Graphics Data. To give a very simple example, let’s consider the player as standing in front of a locked door in the game world, and intending to open it. Using the stand-alone game engine the player is only offered to click with the mouse on the door to try to open it. If the player holds a key the door will open with the first click. The currently presented approach has the following features:

(i) The description of the 3D object “door” has been enhanced with information regarding interaction modalities allowed and dialogue data (interaction resources, such as understanding grammars for speech interface) to be used for each modality. This data will be used by the Multimodal Dialogue Manager to select the most suitable modality for interaction and the resources to be used by each input/output modality when interaction is requested.

(ii) Use of interaction task description data, which will be used by the Dialogue Flow Management to decide if the input received from the player is enough, or multimodal input is needed, thus synchronization and data fusion should be employed. In our door example, if the user will first click the door, this action will be interpreted simply as identification of the interaction object, but the Dialogue Flow Management will wait for a command (either by voice or other input) to be applied (i.e., OPEN or UNLOCK) to the object (i.e. “Open *this* door”, where the “*this*” object has been indicated by the previous mouse click).

(iii) Interaction ambiguities solving is employed by the Multimodal Dialogue Manager when commands, which apply to more than one interactive object, are issued by the player. For example, the player only speaks “Open”, but near him there is also a box which can be opened.

To this end, spoken dialogue interfaces are used in various domains (information services, phone-banking, etc), but are still the most difficult to integrate in the game domain. This is true especially when it comes to the multi-modal gaming environment, where the domain boundary is not always clear. Specifically, the components of the speech interface are the Voice Activity Detection (VAD), Speech Recognition, Speech Understanding, Text-to-Speech Synthesis (TTS) and Natural Language Generation (NLG). The VAD component serves as a gate to the Speech Recognizer, by detecting and feeding the Speech Recognizer with speech utterances, and discarding any non-speech audio or segments with environmental noise. The Speech Recognition component transforms the incoming speech input into transcribed utterances. Subsequently, in the Speech Understanding component, these transcriptions are mapped into high-level concepts, meaningful for the dialogue flow. The Dialogue Flow Manager, which operates on the level of concepts, processes the inputs of the various modalities and generates the feedback to the user in terms of concepts. In the NLG component this feedback is transformed into semantically correct messages (sentences), which are further transformed into audio output by the TTS.

The inputs and outputs for the other modalities are processed in a similar manner. Specifically, the data stream of the infrared Motion Tracking Sensor array is processed by the OpenTracker framework [4,5], which in Figure 1 is designated as Motion Tracking and Interpretation component.

The biosensor input is used to monitor various bio-indicators of the player. The biomedical data are recorded for diagnostic purposes. In addition, the speech and biosensor data streams are fed to the Emotion Recognition component, which is trained to detect a specific set of basic emotion categories. The emotional state of the player is taken into consideration by the Game Engine and the GAM components. Furthermore it is used as an additional indicator for estimating the cognitive load of the player. Depending on the purpose of the game and accounting for the emotional state and the cognitive load of the player, the GAM and Game Engine can implement different strategies; change the interaction style; or the level of difficulty in the present scenario. The last is intact with the desire of PlayMancer project to promote games that are equally accessible to players in different physical and psychological conditions.

The inputs from the mouse, keyboard, joystick, and touchscreen are processed by the Gesture Recognition component. The data streams from all modalities are time-aligned in the Modality Synchronization component, and then disambiguated and fused in the Heterogeneous Data Fusion component. This synchronization and disambiguation facilitates the operation of the Dialogue Flow Manager, which receives a harmonized flow of concepts, corresponding to the player’s input and/or physiological conditions.
Given the increasing interest of many national health care systems in extending the accessibility of services and treatment programs, telemedicine has started to be applied in many illnesses [8, 9]. To date, the use of new technologies has been applied for a range of mental illnesses, including obsessive-compulsive disorders [10], schizophrenia [11], eating disorders (EDs) [12] and anxiety disorders [13]. Furthermore, additional virtual reality, approaches have already successfully been applied by minor mental disorders, such as: posttraumatic stress disorders [14, 15], anxiety disorders [13] and addictive behaviors [16].

Previous literature review studies suggest that computer games in general can serve as an alternative form of treatment or as additional intervention in areas such as schizophrenia [17], asthma [18] and motor rehabilitation [19]. Although, several naturalistic studies have been conducted, showing the usefulness of serious videogames for enhancing some positive attitudes [20, 21], increasing problem solving strategies [22] and modifying some abnormal behaviors [17] and phobias [23], there is a lack of controlled studies in the literature dealing with video-games as additional therapeutic tool for mental disorders.

By chronic mental disorders, such as eating disorders and behavioral addictions, some specific traits are difficult to be modified and resistant to be changed (e.g. specific personality traits, attitudinal and emotional aspects, and uncontrolled behaviors), even after using standard and well established evidence based psychological therapies. Hence, as shown in some preliminary studies, the potential capacity of videogames to change underlying cognitive processes is going to be tested within this project.

The PlayMancer video-game prototype to be adopted for chronic mental disorders (mainly eating disorders and behavioral addictions) treatment, introduces the player to an interactive scenario where the final goal is to increase his general problem solving strategies, self-control skills and control over general impulsive behaviors. After using the game, specific targeted attitudinal, emotional and behavioral changes are expected by the subject. An interactive 3D environment made up of different islands will be used as scenario. Each island will permit access to one or several types of resources which will facilitate and improve the game character’s, and hence the player’s, relaxation techniques and planning skills. The game encourages the player to learn and develop new confrontation strategies. A multidisciplinary team of clinicians, designers and engineers is developing this videogame, by taking into account user requirements and specific profile of the target patients, but also emotional reactions and personality profile of the potential users.

A controlled study is going to be conducted, where the PlayMancer videogame will be use as additional therapeutic tool (combination of standard psychological individual approach plus use of video-game), following a prospective longitudinal cohort study (patients and controls). Setting of the study is going to be consecutively patients who will attend to a specialized outpatient Clinic. All cases will be assigned consecutively to two conditions: Condition 1: individual psychological therapy + weekly video-game; condition 2: individual psychological therapy). The individual therapy program will be composed of 17 individual outpatient weekly sessions. The procedure is psychological evaluation through semi-structured face to face interviews and psychometric scales administered previous to treatment, at the end of treatment and at 3 and 6 follow-up. Additional physiological testing will be also conducted to analyze the subject’s performance.

In this paper we introduced PlayMancer, a platform for rapid development of serious games. The potential of serious games has been demonstrated thoroughly from both a research and a business standpoint. However the investments committed to entertainment dwarfs that which is committed for more serious purposes. Furthermore, game development has become more complex, expensive, and burdened with a long development cycle. This creates barriers to independent game developers, and inhibits the introduction of innovative games, or new game genres such as serious games, or games accessible to communities with special needs. Our answer to this scenario is PlayMancer, a work in progress that aims to overcome such barriers by augmenting existing 3D gaming engines with new possibilities and thusly creating a novel development framework for serious games. The PlayMancer platform relies on a modular architecture and brings together state of the art techniques from multimodal interaction, 3D engines, virtual and augmented reality, speech recognition and natural language processing. A multidisciplinary team of clinicians, designers and engineers is developing a serious game with PlayMancer that will be adopted as an additional therapeutic tool to complement an individual psychological therapy. A controlled study is going to be conducted to assess the benefits of this solution.

Due to the modular nature of the envisioned PlayMancer gaming platform architecture and the commitment to Design-for-All philosophy, the project results could be generalized to other serious games applications and user communities. Ultimately, PlayMancer aims to support the right of all people for equal opportunities in social interaction motivated by playing, putting forward inclusive entertainment as a key quality of an inclusive Information Society.

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