Serious Games for e-Health Care

Voravika Wattanasoontorn, Rubén Jesús García Hernández and Mateu Sbert

Abstract In this chapter, we present a state-of-the-art report on serious games dealing with e-health in a broad sense, including medicine, nursing, health care, and physical exercise. The games have been classified according to their main purpose (entertainment, teaching, or health), stages of the disease being treated and the type of users of the system (general population, patients, and health professionals). Additionally, 12 criteria dealing with the game technology have been selected for a fine-grain classification. Forty-one games from academic and commercial environments (including a variety of online games) have been described, analyzed, and classified.

Keywords Serious games · Healthcare

1 Introduction

In this chapter, we survey the serious games that are related to health and classify them with respect to different aspects. Not only games that have been described and evaluated in peer-reviewed publications are presented in this article but the scope of the survey also includes: (1) the commercial games (consoles and PCs),

V. Wattanasoontorn (✉) · R. J. G. Hernández · M. Sbert
Institute of Informatics and Applications, University of Girona, Girona, Spain
e-mail: voravika.wattanasoontorn@ima.udg.edu

R. J. G. Hernández
e-mail: rgarcia@ima.udg.edu

M. Sbert
e-mail: mateu@ima.udg.edu

V. Wattanasoontorn
Prince of Songkla University, Phuket, Thailand

Y. Cai and S. L. Goei (eds.), *Simulations, Serious Games and Their Applications*, Gaming Media and Social Effects, DOI: 10.1007/978-981-4560-32-0_9,

(2) online games, (3) games and application on mobile platforms, (4) games running on specialized platforms in clinics, hospitals, and patients homes.

We begin with reviews of important concepts. First, we provide an introduction of serious games, and then describe health. Next, the intersection of the two fields is described and provides a review on previous surveys. The details of the different ways in serious games in health will be classified. The next section contains a comprehensive list of serious games. A summary of their main characteristics, a comparison table, graphs are presented. Finally, discussion of the results and conclusion of the chapter are presented.

1.1 Serious Games

Today, the term serious game is becoming more and more popular even though there is currently no single definition of the concept. Serious games are defined in contraposition to entertainment games. They inherit gameplay characteristics from entertainment games, but the main focus may be learning or training and the lessons learnt are expected to be used in real-life work environments. Serious games are present in many areas of knowledge, including defense, manufacturing, education, and medicine, among others.

According to (Navarro et al. 2010), serious games are an emerging technology growing in importance for specialized training, taking advantage of 3D games and game engines in order to improve the realistic experience of users. We propose the characterization of serious games by using the following main components: rules and gameplay, challenges, interaction modes, and goals. The gameplay is the pattern defined through the game rules, which connects the player and the game. The goals may be explicit (stated as game objectives) or implicit. Implicit goals may include increasing skills and abilities, gaining knowledge, or acquiring experience (Fig. 1).

1.2 Importance of Health

The World Health Organization (WHO 2006) defined health in its broader sense as a "state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Other definitions simply require being free from illness or injury (Waite and Hawker 2009).

If we use the stricter definition, we may only consider games dealing with the different phases of illness development, both doctor training and patient familiarization with his illness. However, the use of the WHO definition allows us to consider a third variety of games, which has had a big success recently; games dealing with healthy habits such as exercise (including dancing and fitness games), so we shall use this broader definition in this chapter.

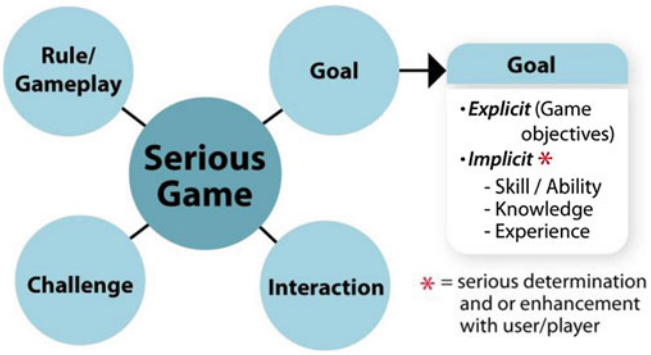

Fig. 1 The components of serious games

In Maslow's hierarchy of needs (Maslow and Frager 1987), health is represented in the second lowest level, after basic needs required for life are fulfilled. Health is then a very basic need, and maintaining health should therefore be a priority. Additionally, the desirable human characteristics located in higher levels of Maslow's pyramid, which are needed for a functioning, peaceful societies are negatively impacted by lack of health in the population. From the reasons stated above, Healthcare is one of the main issues that affects people the most in every stage of life (from infancy to old age). Many researches, such as (Kost 2001) and (Gostin 2000), have shown the need of highly trained and educated health care professionals to avoid medical errors, and the use of serious games in health can provide an additional mean to increase interest in training, education, and evaluation of their performance, as we will see in the next section.

1.3 The Use of Serious Games to Promote Health

Repetitive tasks are needed in many cases to treat patients, but patient boredom has a negative impact on the patient's willingness to continue the treatment. The use of tailored games to replace these tasks therefore has good results.

Additionally, since the recent explosion of videogames, which now are used in two-thirds of households by people of all ages (Online ED 2012), patients can feel more at ease and enjoy their treatment performing an activity they like.

Since 2002 (Roubidoux 2009), many serious games in the field of e-health have been developed, dealing with a wide variety of aspects of surgeon training, radiology operation, Cardiopulmonary Resuscitation (CPR), and patient care, among others. Games aimed at patients have also been developed.

The previous surveys of serious games are described next; (Lopes and Bidarra 2011) present the state of adaptivity in general games and simulations focusing on the purposes, targets, and methods from both academia and industry. Bartolome

et al. (2011) present a systematic review of 21 serious games for health and education described at scientific papers written in English from 2003 to 2011 and projects from the 7th Framework Program. Kato (2010) summarizes the scientific literature of commercially available and tailor-made games used for education and training with patients and medical students and doctors. The classification is based on diseases. Rego et al. (2010) propose a classification designed to properly distinguish and compare eight serious games for rehabilitation systems with respect to their fundamental characteristics. They also describe a particular serious game for rehabilitation, RehaCom, as a case study. Watters et al. (2006) explore the use of games for children with long-term treatment regimes, where motivation for compliance is a key factor in the success of the treatment.

2 Classification of Surveyed Serious Games for Health

There are many interesting criteria to classify serious games in health. In this section, we describe these criteria in detail (Fig. 2).

2.1 Classification by Main Purpose

There are three main purposes in serious games for health:

- The main purpose is entertainment but there is a need to move some parts of the body so the wellness is gotten as a bonus, such as dance–dance revolution (DDRGame 2012), which is the pioneering series of the rhythm and dance genre in video games. The exercise (commercial) games became famous, since Wii was released by Nintendo on November 19, 2012. The motion controlled over the avatar by various accessories inspired people to exercise with the video games.
- The main goal is health but the game is used as a tool to pass on knowledge and/or skills. To use the capability of the game engine, various serious health contents are conveyed to players; for example, Fatworld (ITVS's Electric Shadows 2007), Re-Mission (Tate et al. 2009), Air Medic Sky 1 (University

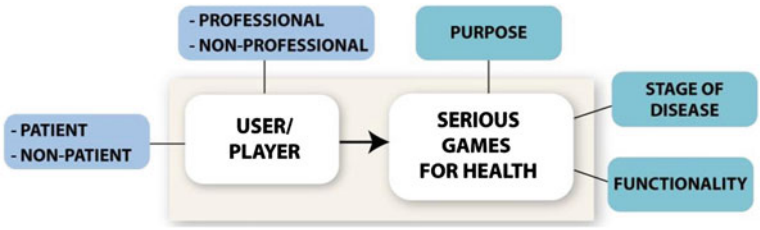

Fig. 2 Classification of serious games for health

Medical Center Utrecht 2012), and many other games shown in Sect. 3 (Review Studies).
- Serious use in health and medical purpose but with a need to simulate the situation to avoid/concern risk, safety, budget, etc. Most of the games in this category are simulation games with use in health and medical field such as Virtual Dental Implant Training Simulation Program (BreakAway, Ltd. 2010), EMSAVE (Emergency Medical Services for the disAbled Virtual Environment) (Vidani et al. 2010), Olive: 3D Hospital Training (ScienceApplications 2010), etc.

2.2 Classification by Player (Patient/Non-Patient)

2.2.1 Patient

To classify the health objectives related to stage of disease (Table 1)

- Health monitoring
- Detection
- Treatment
- Rehabilitation
- Education for self/directed care

2.2.2 Non-Patient

- Health and wellness: Focuses more on lifestyle issues and their relationships with functional health; data from the Alameda County Study (Table 2) (Housman and Dorman 2005) suggested that people can improve their health via (1) exercise, (2) enough sleep, (3) maintaining a healthy body weight, (4) limiting alcohol use, and (5) avoiding smoking.
- Training and Simulation: For both professional and non-professional.

Table 1 Classification of serious games for health (for patient)

Game purpose	Serious games
Monitoring	CHF telemanagement systems (Finkelstein et al. 2010), Healthcare monitoring (Fergus et al. 2009) and The U-health monitoring system (Lee et al. 2009)
Detection	Unobtrusive health (Mckanna et al. 2009) and EEG-based serious games (Wang et al. 2010)
Treatment	Match-3 (Scarle et al. 2011), diagnosis and management of parkinson (Atkinson and Narasimhan 2010), and social skills (Bartolome et al. 2010)
Rehabilitation	Neuropsychological rehabilitation (Grau et al. 2010), chronic pain rehabilitation (Schnauer 2011), upper limb rehabilitation following stroke (Burke 2009), and after parkinson's disease (Red Hill Studios, Inc. 2011)
Education	Re-Mission (Tate et al. 2009)

Table 2 Classification of serious games for health (for non-patient)

Game purpose	Serious games
Health and wellness	A sensory gate-ball game (Kim et al. 2009), dancing in the streets (DITS) (Clawson et al. 2010), fitness adventure (Laikari 2009), Virku (Vtnen and Leikas 2009), and MoFun circus (Nordic Innovation Center 2007c)
Training: professional	HumanSim (Preview) (Applied Research Associates, Inc. 2012), virtual dental implant training Simulation Program (BreakAway, Ltd. 2010), nursing and midwifery (Skills2Learn, Ltd. 2010), pulse (Eliane 2007), EMSAVE (Emergency Medical Services for the disabled) (Vidani et al. 2010), MUVE market virtual patient CareSimulation Lab (John 2010), Olive: 3D hospital training (Science Applications 2010), game-based learning for virtual patients (SAIC, Inc. and The Faculty of Medicine at Imperial College London 2008), Nurse education (AndyWBlackburn 2008), Virtual patient (ScienceDaily 2009), medical simulation training program (JDoc) (Sliney and Murphy 2008), VI-MED (Mili et al. 2008), (Sabri et al. 2010), and Air Medic Sky 1 (University Medical Center Utrecht 2012)
Training: non-professional	Terveellinen Ateria (Janomedia 2006), MC Urho (Nordic Innovation Center 2007b), Valion Energiasummaaja (Nordic Innovation Center 2007a), Fatworld (ITVS's Electric Shadows 2007), and the food detectives fight BAC! game (The Partnership for Food Safety Education 2008)

2.3 Classification by Stage of Disease

Following Merrill (2010), we can classify the progression of an illness in the following stages (Table 3):

2.3.1 Stage of Susceptibility

This is the first stage, in which the person is still healthy. Nevertheless, some people have a genetic predisposition to develop certain illnesses later in life, so even in this healthy stage it is advisable to perform periodic checkups. A serious game in this stage helps the user to familiarize with monitoring procedures, and with illnesses that he or she will possibly develop later in life. Environmental risks or unhealthy surroundings can also affect the probability of developing illnesses, so this should also be taken into account.

Table 3 The objective of the serious games according to stage of disease

Stage of disease	Serious game purpose
Stage of susceptibility	Monitor
Pre-symtomatic stage	Detect
Stage of clinical disease	Treatment and therapy
Stage of disability rehabilitation	Track and trace

2.3.2 Pre-Symptomatic Stage

In this stage, people still feel healthy although the illness is already present. For example, the number of viric particles may still be too small to produce a response in the body, or a failing organ may still be able to cope with the added pressure of the illness with no external indications. The beginning of this stage may be discovered by the periodic checkups mentioned above. In this stage, the specific illness is now known, and the chances of developing it are very high, so more focused serious games can be used to show the patient, the relevant aspects of his illness and his treatment.

2.3.3 Stage of Clinical Disease

In this third stage, the symptoms of the illness are already manifest in the patient. If the illness was not detected in the previous stages, serious games can be used to familiarize the patients with the expected progression of their illness, and the treatment procedures. Alternative treatments can also be shown using games. Games intended to be played by doctors or other medical staff, usually focus on this stage as well.

2.3.4 Stage of Recovery, Disability, or Death

In this last stage of the illness, three different outcomes are possible: the illness may be cured, returning the patient to health or to another stage of susceptibility, or it may have serious effects on the patient's health, making them unable to function at previous levels (disability). The worst outcome of an illness, of course, is the death of the patient. Serious games in this stage normally deal with the rehabilitation procedure, or help the patient cope with their disabilities.

2.4 Classification by Functionality

Rego et al. (2010) identify some criteria for the classification of serious games for health (Fig. 3). We build upon their criteria and add some more interesting characteristics. The description of our classification system follows:

- Application area: The application area or domain describes the part of the real world being modeled by the software. In serious games for health, we will distinguish two main aspects: cognitive skills such as memory, attention span, concentration and reasoning (Cog), and motor skills such as general coordination or re-learning to walk after injuries (Mot).

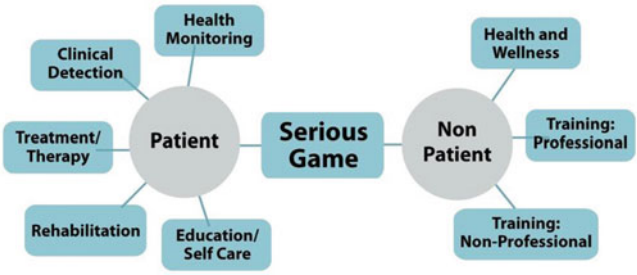

Fig. 3 Classification of serious games for health by player

- Interaction Technology: Interaction technologies are the different paradigms for establishing communication between humans and computers. Both hardware and software interfaces are included. Traditionally, mouse and keyboards have been used; newer means of interaction include Virtual Reality (using head-mounted displays (HMDs), computer monitors, haptic or pseudo-haptic devices such as gloves or pens, or tracking devices. Webcams and web applications are also common. Patients can affect virtual objects in real-time using a variety of senses (vision, hearing, and touching).
- Game Interface: The virtual world inside the game can simulate the real world (three dimensional games, 3D) or provide a top–bottom or sideways perspective of a simpler world (two dimensional games, 2D).
- Number of Players: The number of users concurrently using the world of the game. In general, we distinguish single player games (for one person) and multiplayer games (for two or more people).
- Game Genre: Games can be categorized according to their gameplay; we can distinguish adventure, strategy, simulation, sports and puzzles, among others. In games for health, the games, which evaluate coordination and the movement, are common in rehabilitation; other genres are also used for different tasks.
- Adaptability (Yes/No): Old games used to have a fixed level of difficulty, which could either be programmed or chosen before the game started. Nowadays, many games try to adapt their difficulty to the skill of the player, in order to increase playability and enjoyment by the user. In e-health, adaptability is an excellent trait because it allows the patient to test his limits in a controlled manner.
- Performance Feedback (Yes/No): Performance feedbacks are the indications of the game dealing with showing the users their status and abilities. They allow patients to feel confident that they are progressing and to detect and fix their failures. The feedback can be audition, visual, or haptic.
- Progress monitoring: For patient evaluation, having logs of the patient actions inside the game can be an invaluable asset. We call this feature progress monitoring, since it allows the doctors to monitor the progress of the patients as a function of time.

- Game portability: Portability refers to being able to physically move the game hardware. In particular, we distinguish games located at a hospital or clinic, and games which can be used at home or which can be held portably by the user.
- Game Engine: A game engine is a platform, which provides commonly used functionality in games, so that the game developers can focus on higher level of game design and functionality. The engine provides an API to access lower level functionality and a set of predefined models and materials and scenes (Cheng-yong and Wei-ming 2010).
- Platform: The hardware the game is run on. This may include personal computers (PCs), commercial game consoles (Nintendo Wii, Microsoft Xbox), portable consoles, or custom hardware.
- Health Objective: Objectives related to health include monitoring, detection and treatment of illnesses, rehabilitation, education, health, and wellness, training for patient, and training for non-patient so that they can take care of themselves, or at least know and understand the caring procedures carried upon them. Other general objectives include healthy habits such as exercise, sleeping patterns, and making patients avoid excessive alcohol intake and smoking.
- Connectivity: Games might require an internet or network connection (online) or they may be played in standalone computers (offline).

3 Review Studies

Several serious games and applications for health have been reported in literature. In this section, we review the work developed in this area, including additional games from commercial or online sources. We provide a short summary of each game, indicating their most relevant characteristic, and finish the section with a table overviewing the characteristics of all the games according to the different aspects detailed in the previous section. The games studied are:

- Game1—CHF telemanagement systems (Finkelstein et al. 2010): Home Automated Tele-management (HAT) system for chronic disease management in the patient home. The system helps patients with congestive heart failure (CHF) monitor their symptoms, weight changes, and quality of life while teaching the patient, the characteristics of their disease. The system runs on the Nintendo Wii console. An internet connection is required.
- Game2—Healthcare monitoring in the home (Fergus et al. 2009): A medical diagnostic gaming environment that is used to gather patient information in a casual, non-obtrusive manner that is relaxing for the patient.
- Game3—The u-health monitoring system, with a Nintendo DS (Lee et al. 2009): This application displays the bio-signals of patient onto a monitor of personal computer and LCD of a Nintendo DS using a bio-signal measurement device connected via wireless protocol.

- Game4—Unobtrusive Health (Mckanna et al. 2009): 21 Tally is a collection of 2D games used to detect divided attention unobtrusively, by using performance on a computer game designed to force players to attend to different dimensions simultaneously in order to succeed.
- Game5—EEG-Based Serious Games (Wang et al. 2010): The EEG-based concentration games named Brain Chi (2D) and Dancing Robot (3D) were developed for concentration level control.
- Game6—Match-3 (Scarle et al. 2011): A serious game designed to combat childhood obesity. The Wii-mote is being used for a rowing action which propelled the coracle forward, while direction is altered by leaning left and right on the Wii-fit.
- Game7—Medical Gaming Environment for Diagnosis and Management of Parkinson's Disease (Atkinson and Narasimhan 2010): A medical diagnostic gaming environment that is used to gather patient information in a casual, non-obtrusive manner that is relaxing for the patient. The system employs the Novint Falcon human interface device (Novint Technology, Inc. 2011) to guide a patient who may have problems reaching a specified goal within the game.
- Game8—Neurological development (Bartolome et al. 2010) present a 3D game that can analyze the behavior and promote certain social skills (conversation, negotiation, etc.) of people with neurological development disabilities. The treatment has been planned at three levels. Each level treats a characteristic related to socialization, integration, and the expression of feelings.
- Game9—Neuropsychological Rehabilitation (Grau et al. 2010): single-user and first-person-shooter tasks. Patients navigate through the virtual environment and perform cognitive tasks.
- Game10—Chronic Pain Rehabilitation (Schnauer 2011): This system provides multimodal interaction including full body motion capture by the use of Microsoft Kinect, and other bio-signal capture devices. The patients can manage their state and train physically on their own.
- Game11—Serious Games for Upper Limb Rehabilitation Following Stroke (Burke 2009): Several systems are developed by research group at the University of Ulster, for upper limb stroke rehabilitation through the integration of 3D virtual environments and sensor and camera technology. There are five games including:
  - Game11a: Catch task for bilateral rehabilitation.
  - Game11b: Adaptive whack a mouse game, which designed to encourage movement and to improve the accuracy and speed of the users upper limb movement.
  - Game11c: Rabbit Chase developed for single arm rehabilitation (either right or left arm).
  - Game11d: Arrow Attack for bimanual rehabilitation (both arms) and
  - Game11e: Virtual vibraphone, the use of Nintendo Wii remote controllers for wrist and arm rehabilitation.

- Game12—Games for people with Parkinson's Disease (Atkinson 2010, Red Hill Studios 2011): These nine therapeutic games by Red Hill Studios and the School of Nursing at the University of California San Francisco can help Parkinson's disease patients increase their balance. The games are played by performing movements, which are known to be beneficial for balance control and the movements, then are captured and processed by the system. Patients can use this immersive and engaging virtual world to practice gait and balance in a more interesting setting.
- Game13—Re-Mission (Tate et al. 2009): A video game with 20 levels that takes the player on a journey through the body of young patients with different kinds of cancer, released by the non-profit HopeLab. The main aim is to engage young cancer patients through entertaining game play while impacting specific psychological and behavioral outcomes associated with successful cancer treatment.
- Game14—A Sensory Gate-Ball Game (Kim et al. 2009): PC-based 3D graphics game design for aged people, uses a realistic gate-ball stick and balls as interfaces. In the game, players use the same stick and ball as the real gate-ball.
- Game15—Dancing in the Streets (DITS) (Clawson et al. 2010): DITS is a mobile phone version of the popular arcade game Dance, Dance, Revolution-TM(DDR). Instead of using a dance pad, DITS uses wireless 3-axis accelerometers that are worn around the player ankles and uses a mobile phone to control the game and to display graphics.
- Game16—Fitness Adventure (Laikari 2009): This application platform, which is able to take advantage of a variety of mobile phones, location information and bluetooth GPS receivers, combines mobile games with exercising outdoors. The end result is a location-aware fitness game.
- Game17—Virku-Virtual Fitness Center (Vtnen and Leikas 2009): This system allows users to exercise in a virtual environment. The game is controlled by a user interface based on an exercise cycle, and users may practice individually or in a group. The virtual world affects the difficulty of the exercises in a coherent manner, for example, changing the resistance of bicycles pedals during virtual hill climbing.
- Game18—MoFun Circus (Nordic Innovation Center 2007c): This installation, located at Heureka (Vantaa, Finland) is a cooperative multiplayer action game. After users meet in a circle, a trampoline is created, and users move and capture falling objects. A camera is used to follow the users and display the activity on-screen.
- Game19—HumanSim (Preview) (Applied Research Associates, Inc. 2012): This preview shows the appearance of the HumanSim immersive world. In this world, doctors and nurses train to learn the nuances of complex, unusual, or other error-prone tasks until they become experts. A high-quality virtual hospital is modeled, including operating rooms and other important spaces, and populated with doctors and nurses. It runs on an Apple iPad.
- Game20—Virtual Dental Implant Training Simulation Program (BreakAway, Ltd. 2010) (Medical College of Georgia School of Dentistry faculty 2009): This software provides a 3D virtual environment for students to train in the correct

decision-making protocol to determine patient preparation (both physical and mental) for dental implant surgery. After ensuring that surgery is needed, the student can practice the procedure in a safe and realistic environment.

- Game21—Nursing and Midwifery (Skills2Learn, Ltd. 2010): This program helps nurses and midwives increase their ability to assess patients. The interactive scenario is based on the simulation of the 36 weeks of pregnancy realistically. Multimedia and virtual reality are combined, so that the user can move inside the hospital, interact with patients, and perform the needed tests with the correct instruments.
- Game22—Pulse!! The Virtual Clinical Learning Lab (Eliane 2007): This is the first immersive virtual learning space where health care professionals can train their clinical skills. State-of-the-art graphics create a virtual world in which both civilians and military professionals in the field of health care can practice clinical skills in an interactive and believable universe. This allows them to respond better to patients with injuries due to combat, bioterrorism, or other catastrophes.
- Game23—EMSAVE (Vidani 2010): is a system for training in emergency medical procedures concerning disabled patients. It allows users to experience emergency situations involving disabled persons.
- Game24—MUVE/Market Virtual Patient Care Simulation Lab (John 2010): This software can be used to create simulations of patents useful in training students and professionals (nurses, pharmacists, paramedics, emergency medical technicians, social workers, etc.). The environment is part of Second Life: a massive multiplayer online role-play game (MMORPG) that allows users to choose a different lifestyle.
- Game25—Olive: 3D Hospital Training (ScienceApplications 2010): The On-Line Interactive Virtual Environment (OLIVE) is a dynamic software platform which eases the development and deployment of collaborative virtual worlds. The worlds can be customized and privacy and security are taken into account in the platform. In the virtual world, users can perform planning, training, rehearsing, and operating over long distances using computer networks. The technology has been used to train different scenarios in a hospital operating theater. Real nurses, doctors, and patients appear in the game using their avatars, and remote users can receive standardized Sharable Content Object Reference Model (SCORM) training data and participate in the virtual world.
- Game26—Game-based learning for Virtual Patients–Multi patients (SAIC Inc and The Faculty of Medicine at Imperial College London 2008). A region in Second Life created by the Faculty of Medicine at Imperial College London provides a learning space where virtual patients suffering five different respiratory illnesses (such as lung cancer or pneumonia) can be diagnosed, investigated, and treated by players wanting to perform role-playing learning activities under the feedback and guidance of medical staff.
- Game27—Nurse education (AndyWBlackburn 2008): A virtual learning environment (Second Life), for use in nurse education. Developed at Glasgow Caledonian University.

- Game28—Virtual Patient (ScienceDaily 2009) [Game28]: This system, developed by Keele University, trains pharmacists by using a virtual patient. Traits such as race, age, and gender (which sometimes affect responses to procedures and medications) are taken into account in the treatment of patients, so that learners can understand their clinical significance. Dyspepsia and hypertension are examples of the possible illnesses included in the system.
- Game29—Medical Simulation Training Program (JDoc) (Sliney and Murphy 2008): This system provides a computer-aided junior doctor simulator, using both 1st and 3rd person perspectives to produce immersion. It can be used for training and teaching junior doctors their interpersonal, communication and decision-making skills, and to ease the transference of the medical information available to them.
- Game30—VI-MED (Mili et al. 2008): A virtual training to be used as a precursor and as a supplement to real practical training.
- Game31—(Sabri et al. 2010): Presented an interactive, multiplayer serious game for the purpose of training cardiac surgeons/residents the series of steps comprising the Off-Pump Coronary Artery Bypass (OPCAB) surgical procedure.
- Game32—Air Medic Sky 1 (University Medical Center Utrecht 2012): This interactive biofeedback game consists of mini-games and lectures to describe the basic concepts required for efficient communication and teamwork resulting in patient safety. Complex situations are presented which mirror common occurrences in the work of junior doctors. The solving of these solutions allows doctors to gain insights in how physiological functions affect performance.
- Game33—Terveellinen Ateria (Janomedia 2006): This interactive program aids practical nurses and comprehensive school staff train in the practical aspects of preparing meals for people with different nutritional requirements. The Finnish plate model is used as a basis, and it can be applied to solve the dietary needs of people. The energy content of meals is calculated according to the foods included and their size. Teaching healthy nutrition and weight management habits to the general population is one objective of the program.
- Game34—MC Urho (Nordic Innovation Center 2007b): This system contains a plethora of information regarding lifestyle effects on health. The game can be used in biology and health education classes to teach young people about the effects of smoking, high blood pressure and cholesterol.
- Game35—Valion Energiasummaaja (Nordic Innovation Center 2007a): This online game, aimed at both children and adults, helps build a healthy and balanced breakfast (or general snacks). Food is chosen from a variety of options in a virtual refrigerator, and dragged into a plate. The effects of the meal on blood sugar are shown, and possible improvements in the meal are suggested.
- Game36—Fatworld (ITVS's Electric Shadows 2007): This videogame explores the relationships between nutrition, obesity and socioeconomic factors in the contemporary U.S. Budgets, subsidies, regulations, and physical world characteristics are taken into account.

Table 4 Classification and comparison of health games (1)

	Application area	Interactive technology	Interface	Players	Genre	Adaptability	Progress Monitoring	Performance. Feedback	Portability	Engine	Platform	Objective	Connectivity
[Game1]	Mot	Wiimote	2D	Single	App	x	•	•	•	Flash	Wii	MON	On
[Game2]	Mot	WSN	2D	Single	App	x	•	•	x	–	PC	MON	On
[Game3]	Mot	Electrode	2D	Single	App	x	•	•	•	PALIB	DS	MON	On
[Game4]	Cog	Mouse	2D	Single	Puzzle	•	•	x	•	–	PC	DET	Off
[Game5]	Cog	EEG	2D	Single	Action	–	–	–	x	–	PC	DET	Off
[Game6]	Mot	Wii Fit	3D	Single	Adventure	•	–	•	•	–	Wii	TRT	Off
[Game7]	Cog	Novint	2D	Single	Action	•	–	–	•	SDK	PC	TRT	Off
[Game8]	Cog	Wiimote	3D	Single	Role play	•	•	•	•	Director	PC	TRT	Off
[Game9]	Cog	Mouse	3D	Single	Role play	•	–	•	•	–	PC	REH	Off
[Game10]	Mot	Kinect	3D	Single	Adventure	•	•	•	x	Unity3D	PC	REH	Off
[Game11a]	Mot	VR	3D	Single	Action	•	•	•	•	OGRE	PC	REH	Off
[Game11b]	Mot	HMD	3D	Single	Action	•	•	•	•	–	PC	REH	Off
[Game11c]	Mot	Webcam	2D	Single	Action	•	•	•	•	XNA	PC	REH	Off
[Game11d]	Mot	Webcam	2D	Single	Action	•	•	•	•	XNA	PC	REH	Off
[Game11e]	Mot	Wiimote	2D	Multi	Action	•	•	•	•	–	PC	REH	Off
[Game12]	Mot	–	2D/3D	–	Mix	–	–	–	–	–	PC	REH	–
[Game13]	Cog	Mouse	3D	Single	Adventure	•	•	•	•	–	PC	EDU	Off
[Game14]	Mot	Sensor	3D	Single	Sport	•	•	•	x	–	PC	H&W	Off
[Game15]	Mot	Sensor	2D	Single	Exergame	x	•	x	•	–	Mobile	H&W	Off
[Game16]	Mot	RFID	2D	Single	Exergame	•	•	•	•	SMAC	Mobile	H&W	On
[Game17]	Mot	Cycle	3D	Single	Exergame	•	•	–	x	–	PC	H&W	Off
[Game18]	Mot	Camera	2D	Multi	Action	–	•	–	x	–	PC	H&W	Off
[Game19]	Cog	Touch	3D	Single	Simulation	•	•	•	•	Unreal	iPad	P	Off
[Game20]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	BreakAway	PC	P	Off
[Game21]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	–	PC	P	Off
[Game22]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	BreakAway	PC	P	Off
[Game23]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	NeoAxis	PC	P	Off
[Game24]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	–	PC	P	On
[Game25]	Cog	Mouse	3D	Multi	Simulation	•	•	•	•	–	PC	P	On

Table 9.5 Classification and Comparison of Health Games (2)

	Application area	Interactive technology	Interface	Players	Genre	Adaptability	Progress Monitoring	Performance. Feedback	Portability	Engine	Platform	Objective	Connectivity
[Game26]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	SecondLife	PC	P	On
[Game27]	Cog	Mouse	3D	Single	Simulation	–	–	–	•	SecondLife	PC	P	On
[Game28]	Cog	VoicRe	3D	Single	Simulation	•	•	•	•	–	PC	P	On
[Game29]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	Torque	PC	P	On
[Game30]	Cog	Mouse	3D	Single	Simulation	•	•	•	•	–	PC	P	On
[Game31]	Cog	Mouse	3D	Multi	Simulation	•	•	•	•	In House	PC	P	On
[Game32]	Cog	Biof B.	3D	Multi	Simulation	•	•	•	•	–	PC	P	On
[Game33]	Cog	Mouse	2D	Single	Puzzle	•	•	–	•	Flash	PC	NP	On
[Game34]	Cog	Mouse	2D	Single	Quiz	•	x	–	•	Flash	PC	NP	On
[Game35]	Cog	Mouse	2D	Single	Puzzle	•	•	–	•	Flash	PC	NP	On
[Game36]	Cog	Mouse	2D	Single	Role play	•	•	•	•	Flash	PC	NP	Off
[Game37]	Cog	Mouse	2D	Single	Puzzle	•	•	x	•	Flash	PC	NP	On

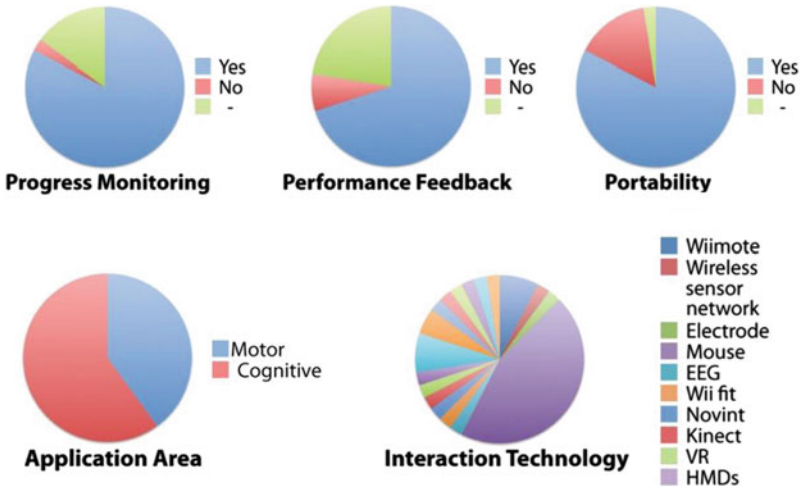

Fig. 4 Breakdown of the values of each characteristic of serious games for health present in our survey (1)

- Game37—The Food Detectives Fight BAC! (The Partnership for Food Safety Education 2008): A 2D web base game for 8–12 year old children to learn about foodborne illness. Created by The Partnership for Food Safety Education.

4 Discussion

Tables 4 and 5 display the classification and comparison of health games. The dash means that this feature is not mentioned in the bibliographic reference, which described the game. Figures 4 and 5 provide a graphical summary of the data.

The objectives are quite varied, but an emphasis can be seen on professional users and rehabilitation. We can see that both motor and cognitive abilities are well-represented application areas. Progress monitoring, performance feed and portability are important features, present in the majority of the games. We can see that adaptability is a useful characteristic, present in about 3/4 of the games.

There are a few used platforms, but most of the games have been designed to run on PCs, and internet connection is used in almost half of the games surveyed. Interaction technologies are quite varied, although the standard mouse interface is used in almost half of the games. There are a wide variety of engines used, although this is not a reported characteristic. Flash is the engine used most often, by a wide margin, and most of the games are currently single player. The simulation and action genres dominate, although there are large varieties of other genres, and 2D and 3D interfaces are both well represented in the sampled games.

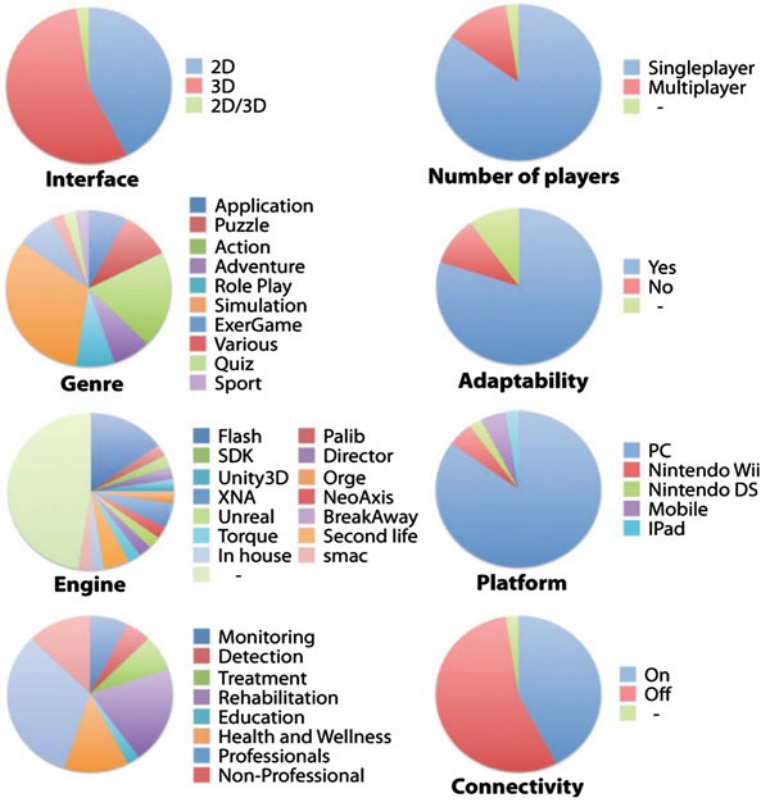

Fig. 5 Breakdown of the values of each characteristic of serious games for health present in our survey (2)

5 Conclusion

We have studied 40 serious games from different areas of health and well being, classifying them according to their characteristics, and described the most commonly present ones. The typical game can be summarized as a portable PC game programmed in Flash, using mouse interaction and including progress monitoring, performance feed and adaptability, although the variability of games is quite large in many aspects. For the future improvement, authors plan to explore more serious games and applications for mobile devices such as iPhone, iPad, etc.

Acknowledgments This work has been supported by the research project coded TIN2010-21089-C03-01 (Spanish Commission for Science and Technology), by grant 2009SGR643 (Catalan Government) and by a mobility grant from the Prince of Songkla University, Thailand.

References

Alhadeff E (2007) Pulse!! news: serious games field testing begins. http://futuremakingseriousgames.blogspot.com/2007/02/pulse-news-serious-games-field-testing.html Accessed 7 March 2012

AndyWBlackburn (2008) Nurse education in second life. Glasgow Caledonian University. http://www.youtube.com/watch?v=xidko60S2Uk&feature=related Accessed 7 March 2012

Applied Research Associates, Inc (2012) HumanSim: a high-fidelity virtual hospital. http://www.humansim.com Accessed 6 March 2012

Atkinson SD, Narasimhan VL (2010) Design of an introductory medical gaming environment for diagnosis and management of Parkinson's disease. Trendz in Information Sciences & Computing (TISC), pp 94–102, 17–19 Dec. 2010

Bartolome NA, Zorrilla AM, Zapirain BG (2011) Can game-based therapies be trusted? Is game-based education effective? A systematic review of the serious games for health and education. 16th international conference on Computer Games (CGAMES), pp 275–282, 27–30 July 2011

Bartolome NA, Zorrilla AM, Zapirain BG (2010) A serious game to improve human relationships in patients with neuro-psychological disorders. International IEEE consumer electronics society's games innovations conference (ICE-GIC), pp 1–5, 21–23 Dec. 2010

BreakAway, Ltd (2010) Serious games for healthcare markets. http://www.breakawaygames.com/serious-games/solutions/healthcare/ Accessed 6 March 2012

Burke JW, McNeill MDJ, Charles DK, Morrow PJ, Crosbie JH, McDonough SM (2009) Serious games for upper limb rehabilitation following stroke, VS-GAMES '09. Conference in games and virtual worlds for serious applications, pp 103–110, 23–24 March 2009

Cheng-yong X, Wei-ming X (2010) Constructing 3d game engine based on XNA. Comput Knowl Technol 6:3401–3402

Clawson J, Patel N, Starner T (2010) Dancing in the streets: the design and evaluation of a wearable health game. International symposium on wearable computers (ISWC), pp 1–4, 10–13 Oct. 2010

Education Database Online (2012) Videogame statistics. http://www.onlineeducation.net/ Accessed 30 March 2012

Fergus P, Kifayat K, Cooper S, Merabti M, El Rhalibi A (2009) A framework for physical health improvement using wireless sensor networks and gaming, Pervasive Health 2009. 3rd international conference on pervasive computing technologies for healthcare, pp 1–4, 1–3 April 2009

Finkelstein J, Wood J, Cha E, Orlov A, Dennison C (2010) Feasibility of congestive heart failure telemanagement using a wii-based telecare platform. Annual international conference of the IEEE engineering in medicine and biology society (EMBC), pp 2211–2214, 31 Aug.–4 Sept. 2010

Gostin L (2000) A public health approach to reducing error: medical malpractice as a barrier. JAMA 283(13):1742–3, url http://www.biomedsearch.com/nih/public-health-approach-to-reducing/10755503.html

Grau S, Tost D, Campeny R, Moya S, Ruiz M (2010) Design of 3d virtual neuropsychological rehabilitation activities. 2nd international conference on games and virtual worlds for serious applications pp 109–116

HCI Lab, University of Udine (2011) The EMSAVE System. http://hcilab.uniud.it/soccorsodisabili/results.html Accessed 7 March 2012

Housman J, Dorman S (2005) The alameda county study: a systematic, chronological review. American J Health Edu 36:302–308

ITVS's Electric Shadows (2007) Fatworld. http://fatworld.org/ Accessed 26 March 2012

Janomedia (2006) Terveellinen Ateria. http://www03.edu.fi/oppimateriaalit/healthy_meal/ Accessed 26 March 2012

Kato PM (2010) Video games in health care: closing the gap. Rev Gen Psychol 14:113–121

Kim J-A, Kang K-K, Yang H-R, Kim D (2009) A sensory gate-ball game for the aged people and its user interface design. Conference in games and virtual worlds for serious applications, pp 111–116
Kost G (2001) Preventing medical errors in point-of-care testing: security, validation, safeguards, and connectivity. Arch Pathol Lab Med 125(10):1307–1315
Laikari A (2009) Exergaming-gaming for health: a bridge between real world and virtual communities. IEEE 13th international symposium on consumer electronics (ISCE), pp 665–668
Lee S, Kim J, Kim J, Lee M (2009) A design of the u-health monitoring system using a nintendo ds game machine. IEEE Eng Med Biol Soc pp 1695–1698
Lopes R, Bidarra R (2011) Adaptivity challenges in games and simulations: survey. IEEE Trans Comput Intell AI Games 3:85–99
Maslow A, Frager R (1987) Motivation and personality. Harper and Row, New York http://books.google.es/books?id=L7_uAAAAMAAJ
Mckanna JA, Jimison H, Pavel M (2009) Divided attention in computer game play: analysis utilizing unobtrusive health monitoring. 31st annual international conference of the IEEE EMBS, pp 6247–6250, Sept. 2009
Medical College of Georgia School of Dentistry faculty (2009) Simulation helps students learn dental implant procedures. http://news.georgiahealth.edu/archives/1921. Accessed 6 March 2012
Merrill R (2010) Introduction to epidemiology. Jones and Bartlett Publishers, London http://books.google.es/books?id=RMDBh6gw1_UC
Mili F, Barr J, Harris M, Pittiglio L (2008) Nursing training: 3d game with learning objectives. 1st international conference on advances in computer-human interaction, pp 236–242
Miller J (2010) MUVE market virtual patient care simulation Lab. http://www.youtube.com/watch?v=FWUpXar6sh8. Accessed 7 March 2012
Navarro A, Pradilla JV, Madrinan P, (2010) Work in progress serious 3d game for mobile networks planning. Frontiers in education conference (FIE), 2010 IEEE, pp T1F-1,T1F-2, 27–30 Oct. 2010
Nintendo, Inc (2012) Wii. http://www.nintendo.com/wii/. Accessed 29 March 2012
Nordic Innovation Centre (2007a) Energiasummaaja. http://nsg.jyu.fi/index.php/Energiasummaaja. Accessed 26 March 2012
Nordic Innovation Centre (2007b) MC Urho. http://nsg.jyu.fi/index.php/MC_Urho/. Accessed 26 March 2012
Nordic Innovation Centre (2007c) MoFun Circus. http://nsg.jyu.fi/index.php/MoFun_Circus. Accessed 26 March 2012
Novint Technologies, Inc (2011) The most immersive way to play video games. http://www.novint.com/index.php/novintfalcon. Accessed 29 March 2012
Red Hill Studios (2011) Games for people with Parkinson's Disease. http://www.redhillstudios.com/#/projects/games/pdwii/. Accessed 26 March 2012
Rego P, Moreira P, Reis L (2010) Serious games for rehabilitation: a survey and a classification towards a taxonomy. 5th iberian conference on information systems and technologies (CISTI), pp 1–6, June 2010
Ma Roubidoux, Chapman CM, Piontek ME (2009) Development and evaluation of an interactive web-based breast imaging game for medical students. Acad Radiol 9:1169–1178
Sabri H, Cowan B, Kapralos B, Moussa F, Cristanchoi S, Dubrowski A (2010) Off-pump coronary artery bypass surgery procedure training meets serious games, IEEE international symposium on haptic audio-visual environments and games (HAVE), pp 1–5, 16,17 Oct. 2010
SAIC Inc (2012) OLIVE–On-Line Interactive Virtual Environment. http://www.saic.com/products/simulation/olive/. Accessed 7 March 2012
SAIC Inc, The Faculty of Medicine at Imperial College London (2008) Game-based learning for virtual patients–multi patients. http://www.youtube.com/watch?v=VhQ8MjdRq_4&feature=related. Accessed 7 March 2012

Scarle S, Dunwell I, Bashford -RT, Selmanovic E, Debattista K, Chalmers A, Powell J, Robertson W (2011) Complete motion control of a serious game against obesity in children. 3rd international conference on games and virtual worlds for serious applications (VS-GAMES2011), pp 178–179, 4–6 May 2011

Schonauer C, Pintaric T, Kaufmann H, Jansen -KS, Vollenbroek -HM (2011) Chronic pain rehabilitation with a serious game using multimodal input, International conference on virtual rehabilitation (ICVR2011), pp 1–8, 27–29 June 2011

ScienceApplications (2010) Olive: 3D hospital training. http://www.youtube.com/watch?v=MhzD0UO_nUY&feature=related. Accessed 7 March 2012

ScienceDaily 2009 (2009) Virtual patient helps train pharmacists of the future. http://www.danshope.com/news/showarticle.php?articleid=83. Accessed 7 March 2012

Skills2Learn, Ltd (2010) Skills2Learn virtual reality and 3D simulation examples. http://www.skills2learn.com/virtual-reality-case-studies.html. Accessed 6 March 2012

Sliney A, Murphy D (2008) Jdoc: a serious game for medical learning, 1st international conference on advances in computer-human interaction, pp 131–136, 10–15 Feb. 2008

Tate R, Haritatos J, Cole S (2009) Hopelab approach to re-mission. Int J Learn Media 1:29–35

The Partnership for Food Safety Education (2008) The food detectives fight BAC! game. http://www.fooddetectives.com/. Accessed 26 March 2012

University Medical Center Utrecht (2012) Air medic sky 1. http://www.airmedicsky1.org/. Accessed 26 March 2012

Vidani AC, Chittaro L, Carchietti E (2010) Assessing nurses' acceptance of a serious game for emergency medical services. 2nd international conference on games and virtual worlds for serious applications (VS-GAMES), pp 101–108, 25,26 March 2010

Vtnen A, Leikas J (2009) Human-centered design and exercise games. In: Kankaanranta M, Neittaanmki P (eds) Design and use of serious games, Springer Science + Business Media, pp 33–47

Waite M, Hawker S (2009) Oxford paperback dictionary and thesaurus. Oxford Paperbacks, Oxford University Press. http://books.google.es/books?id=8H5_od8I6pMC

Wang Q, Sourina O, Nguyen MK (2010) EEG-based serious games design for medical applications. International conference on cyberworlds (CW), pp 270–276, 20–22 Oct. 2010

Watters C, Oore S, Shepherd M, Abouzied A, Cox A, Kellar M, Kharrazi H, Liu F, Otley A (2006) Extending the use of games in health care. Proceedings of the 39th annual hawaii international conference on system sciences, HICSS '06. vol 5. pp 88b, 4–7 Jan. 2006

World Health Organization (2006) Constitution of the world health organization–basic documents (45th edn Suppl)

DDRGame (2012) Dance Dance Revolution for Wii, PS2, PS3, Xbox 360 and PC. http://www.ddrgame.com/. Accessed 29 March 2012