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EMERGENCY RESPONSE TEAMS TRAINING IN PUBLIC HEALTH CRISIS – THE SERIOUSNESS OF SERIOUS GAMES

OBUKA TIMOVA ZA REAGOVANJE U JAVNOZDRAVSTVENIM KRIZAMA − OZBILJNOST OZBILJNIH IGARA

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Summary

Introduction. The rapid development of multimedia technologies in the last twenty years has lead to the emergence of new ways of learning academic and professional skills, which implies the application of multimedia technology in the form of a software –"serious computer games". **Three-Dimensional Virtual Worlds.** The basis of this game-platform is made of the platform of three-dimensional virtual worlds that can be described as communication systems in which participants share the same three-dimensional virtual space within which they can move, manipulate objects and communicate through their graphical representatives- avatars. **Medical Education and Training.** Arguments in favor of these computer tools in the learning process are accessibility, repeatability, low cost, the use of attractive graphics and a high degree of adaptation to the user. Specifically designed avatars allow students to get adapted to their roles in certain situations, especially to those which are considered rare, dangerous or unethical in real life. **Discussion**. Drilling of major incidents, which includes the need to create environments for training, cannot be done in the real world due to high costs and necessity to utilize the extensive resources. In addition, it is impossible to engage all the necessary health personnel at the same time. New technologies intended for conducting training, which are also called "virtual worlds", make the following possible: training at all times depending on user's commitments; simultaneous simulations on multiple levels, in several areas, in different circumstances, including dozens of unique victims; repeated scenarios and learning from mistakes; rapid feedback and the development of non-technical skills which are critical for reducing errors in dynamic, high-risk environments. **Conclusion**. Virtual worlds, which should be the subject of further research and improvements, in the field of hospital emergency response training for mass casualty incidents, certainly have a promising future.

Key words: Mass Casualty Incidents; Emergency Responders; Inservice Training; Disaster Planning; Video Games; Computer Simulation; Ethics; Cost-Benefit Analysis; Quality Improvement; Risk Management; Medical Errors; Learning

Sažetak

Uvod. Brzi razvoj multimedijalnih tehnologija u poslednjih 20 godina doveo je do nastanka novih načina učenja akademskih i profesionalnih veština primenom multimedijalnih tehnologija u formi softverskih proizvoda − *ozbiljnih kompjuterskih igara*. **Trodimenzionalni virtuelni svet**. Osnovu platforme ovih igara čine trodimenzionalni virtuelni svetovi koji se mogu opisati kao komunikacioni sistemi u kojima učesnici dele isti trodimenzionalni virtuelni prostor i mogu da se kreću, manipulišu predmetima i komuniciraju preko svojih grafičkih autoprezentacija − avatara. **Obuka u virtuelnim svetovima.** Argumenti za korišćenje kompjuterskih alata u procesu učenja su: laka pristupačnost, ponovljivost, niska cena, mogućnost korišćenja atraktivnih grafika i visok stepen prilagođavanja korisniku. Specifično dizajnirani avatari omogućavaju učenicima da se adaptiraju na svoje uloge u određenim situacijama, pogotovu onim koje su u realnom životu smatraju retkim, opasnim ili neetičnim. Treniranje velikih incidenata, koje uključuje i potrebu kreiranja okruženja za obuku, ne može se sprovesti u realnom svetu zbog visoke cene, neophodnosti angažovanja obimnih resursa i nemogućnosti istovremenog angažovanja potrebnog zdravstvenog osoblja. **Diskusija**. Nove tehnologije za sprovođenje treninga, virtuelni svetovi, omogućavaju: trening u bilo koje vreme kada to druge obaveze dozvoljavaju; istovremene simulacije na više nivoa, u više oblasti, u različitim okolnostima i sa desetinama jedinstvenih žrtava; ponavljanje scenarija i učenje na greškama; brze povratne informacije i razvoj netehničkih veština (efektivna komunikacija, liderstvo, upravljanje stresom, svest o situaciji) koje su kritične za redukciju grešaka u dinamičnim, visokorizičnim okruženjima. **Zaključak**. Virtuelni svetovi, uz potrebu za daljim istraživanjima i poboljšanjima, svakako predstavljaju, u domenu obuke zdravstvenih timova u reagovanju na javnozdravstvene krize, budućnost koja obećava.

Ključne reči: masovne katastrofe; zdravstveno osoblje; stručna obuka; rešavanje problema u katastrofama; video igre; kompjuterska simulacija; etičnost; isplativost; unapređenje kvaliteta; upravljanje rizikom; medicinske greške; učenje

Introduction

New ways of mastering academic and professional skills using multimedia technology in the form of software products and educational computer games have been developed in the last few years [1]. Although the idea of video games as an effective learning instrument is not a new one, modernization and financial

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Abbreviations
3-D – three-dimensional
VED – virtual emergency department

pressure imposed on contemporary health systems urged the development of new methods of training, which are both time and cost-effective [2].

The rapid development of multimedia technology during the last twenty years has led to an increased worldwide use of computer games [1, 2]. Gaming consoles, computers, and mobile phones allow online advanced-technology gaming with people all over the world in the very comfort of your own home. Many of these games have been developed for educational purposes and are described as games with a useful purpose, which are not created for pleasure or serious games [2].

Three-dimensional virtual worlds

Along with the growing interest for serious games, the number of three-dimensional virtual worlds (3-D virtual worlds) has grown simultaneously; 3-D virtual worlds being the very basis of the gaming platform [3]. Based on the development of the internet, multimedia technologies and high power graphic cards which offer the possibility of creating a three-dimensional representation and realistic interactive environments [4, 5], virtual worlds can be described as communication systems in which participants share the same three-dimensional virtual space and can move freely, manipulate objects and communicate *via* their graphics representations, *avatars* [6, 7].

Through sensory information, three-dimensional virtual worlds offer the users a sense of real-time experience known as presence - presence in the virtual world, while actually sitting at their desk at home. This presence is experienced through *merging* while becoming aware of the environmental senses through a continuous stream of experience and stimuli, through co-presence (people see other avatars as representatives of real people), and real-time situations (the extent to which other objects, including avatars imitate reality) [8]. The expression avatar originates from Sanskrit and denotes a deity taking a human form [3]. These animated figures, avatars, are managed in such a manner so that they can run, walk, swim, go through closed doors, open drawers, etc. [3, 8]. Avatars interact with other avatars and communicate via text or voice messages using a headset and a microphone [8]. Thus, instead of being a passive observer of the image on the screen, the user becomes an active participant in a computer-created virtual world which enables him to learn, socialize and behave in a way similar to the behaviour in real-time and to practice new behaviours in realistic scenarios without the risk of making mistakes as in the real world [8].

Three-Dimensional Virtual Worlds in Medical Education and Training – Pro et Contra

One of the objectives of education and training of health professionals implies the creation of teams of practitioners with the knowledge and skills enabling them to work competently and in a safe environment [9]. Although the health care system emphasizes the team activity, given that team training is the most effective way of improving team performance, the efforts are generally focused more on individual training, probably because training sessions need to be coordinated with the individuals' commitments and with team members joining the team from different locations [10]. This supports the tradition of individual training in medicine, while patients remain the primary medium. However, all of the procedures to be performed on the patient are designed from the aspect of patient's care, and not from the educational one. The increased risk of complications, inability to repeat procedures and learning from mistakes, and the fact that the procedures can be learned only on an adequate patient, make the *living patients* poor instrument of training, requiring from medical personnel to learn their skills and exercise away from the patient's bed [2]. Arguments in favour of the use of computer tools in the learning process are: ease of accessibility, repeatability, low cost, possibility to use attractive graphics, a high level of adjustment to the user who accepts games as interesting and useful activities [1]. Compared to conventional teaching instruments (books, lectures, mentor's instructions), virtual worlds include more instruments which imply critical thinking, collaboration, and teamwork [2] as well as components of social learning (conversations and interactions) that represent the attributes of effective teaching [8]. Specifically designed avatars allow students to adapt to their roles in given situations, especially those considered to be rare, dangerous or unethical in real life [7]. The acquired understanding of clinical situations is applied in real-time and is more effective than simply memorized facts [2]. Gaming anonymity allows better progress, even for people with higher levels of inhibition (63% of participants are much more relaxed, and 56% more active than during traditional classroom teaching) [2, 7].

One of the concerns is the fact that people who have never played computer games may lack computer skills, which can create difficulties in learning and training processes, affecting the users' abilities to focus on the training objectives, because they are busy using computer tools, managing the screen and understanding the game [2, 7]. The increasing use of computers in everyday life makes this issue seem rather insignificant [2]. The objective problem for clients unaccustomed to install software components into their computer systems can be found in rapid technological changes of platforms that require frequent software updates. The solution to this problem lies in the fact that virtual environments should become part of standardized interface of web browsers, which would reduce the need for software updates [7].

Healthcare Team Emergency Response Training for Mass Casualty Incidents

After September 11th 2001, the expression *medical disaster emerged* and events including a large number of victims were placed highly on the list of public

health priorities. Even though these events are still considered as *the events of low probability* [11], disasters whether caused by natural events, infectious diseases, terrorism or technology [12] occur at a rate of one disaster a day [4]. During 2011, the world suffered 325 catastrophic events (175 natural and 150 caused by men) which forced nearly 15 million people to leave their homes [4]. Large-scale events have shown that disasters are almost inevitable and that health-care professionals must be ready to respond promptly and on time [13]. Some most disastrous events are the collapse of the World Trade Centre in 2001, Hurricane Katrina in 2005 - destroying 90 000 square miles of State Mississippi and flooding New Orleans thus causing 1,500 victims [14]; a fire in "Kiss" nightclub in Santa Maria, Brazil in 2013 with 234 victims, while almost 800 people requested medical assistance [15], and the terrorist attacks in Paris in 2015 with 150 victims. During the past decade, governments, public health organizations and hospitals were asked to develop action plans so as to react to disaster resulting in a large number of victims caused by different agents, wherein the component of training in all plans was inevitable. The Joint Commission on Accreditation of Healthcare Organization (JACH) included the United States Hospital Emergency Preparedness Program in the accreditation standards and demanded training implementation twice a year [16].

Although training of health personnel represents a critical component within the program for disaster preparedness, gaps in education and training [4] show that the existence of *the book knowledge* does not necessarily result in the transfer of this knowledge into practice [17]. There is no such training which can absolutely prepare clinicians to react in real incidents involving a large number of victims [13]; the current standard of training is limited by several factors, primarily by credible real-time situations which are very difficult to achieve [17]. Types of disasters and their locations can be very different and cannot be completely replicated. In real-time situations, the personnel must work in conditions of physical and emotional stress, in a potentially unstable and dangerous environment with many injured, disoriented and panicked people. Real-time environment and the scale of trauma are usually completely different from anything that the medical personnel experienced or practiced through training. This discrepancy between their knowledge and beliefs and the reality exposes practitioners to unstable conditions that can induce negative emotions (anxiety, anger, guilt) which have adverse effects on their performance, jeopardize the decision-making process and lead to degradation even of those skills that were routinely practiced [13, 18]. Mastering the knowledge and skills of affective control resulting in less vulnerability to external stressors cannot be a part of the given training [13]. This type of training is very expensive (USD 35,000-1,000,000), engaging various types of human resources (volunteers, moulage teams, security), materials, equipment and environment (e.g. closing an entire block to simulate a terrorist incident) [13, 18]. It is very difficult, almost impossible, to engage a large group of healthcare personnel, take them away from their daily duties [11, 17]. Due to high costs and other constraints, these exercises do not provide much opportunity for multiple test skills, and the preparation of post-action reports can take months, therefore participants usually receive only minimal feedback on the evaluation of exercises [17].

It has become clear that training to handle major accidents, including the need to create a learning environment, cannot be implemented in the real world [19]. This introduced the application of new technologies for training implementation, such as virtual worlds, which would enable the simulation of assessment and management of large numbers of victims of probable disasters on different levels and locations [20]. The efficient and practical model of gaming techniques of serious games, such as avatar model, provides a number of advantages within training in virtual worlds [11]: 1) training can be done at any time of day or night when the participants do not have to look after their patients; 2) participants do not have to be at the same location to manage avatars; 3) modifications can be made in different environments and conditions in order to simulate the complexity of real life situations; 4) scenarios can be reloaded (learning from mistakes); 5) the virtual environment allows simultaneous simulations on multiple locations or in multiple facilities and the presence of tens of unique victims in different conditions (crowd, dark, smoke, noise, damage to infrastructure, contamination, infection) which enable the participants to practice their individual and team skills under conditions highly similar to real-time ones; 6) all activities during training are automatically recorded and can be reviewed during the post-action period. Training in virtual worlds also enables the development of non-technical skills (effective communication, leadership, stress management, awareness of the situation) that are critical for reducing errors in dynamic high-risk environments [18]. Despite initial expenses put in to create and develop virtual environments (USD 20,000 to 100,000), virtual training is a financially more acceptable solution than *live* disaster exercises because these expenses are compensated for by a large number of users, applications and scenario reloading [13]. Virtual environment platforms include different components of persuasion, integrative information technologies designed to change users' attitudes and patterns of behaviour [10].

Virtual Worlds for Healthcare Teams Training

Systems for emergency response training for mass casualty incidents have a wide range of technical options, from personal computer software to fully immersive platforms of high credibility where students work with the help of three-dimensional googles or head-mounted displays [18]. For the purposes of this study, we will present some of the most common applications that apply to personal computers and software with broadband internet connection.

System for Triage Training and Incident Management

This computer-based system for disaster simulation in virtual reality, developed by E-Semble BV (Delft, Netherlands) and the Centre for Teaching and Research *Trauma*, Acute Care, and *Disaster Medicine* of the University of Linköping, Sweden, is used for training in fourteen European countries. The system introduces realistic scenes, with minimal programming effort, including any number of motor vehicles (buses, trains, planes, vehicles for emergency response), people (observers, victims, police officers, firefighters, and medical personnel), different sceneries, and disaster situations (fires, explosions, gas leaks, etc.). Using a control pad, the users move through the sceneries, examining each victim. By clicking on the victim, a descriptive palette in Excel appears on the screen with all information about the victim and their physiological status. Clinical information necessary for triage is obtained by clicking on the appropriate part of the body of the victim. Assessment of the victim's palpable pulse, for example, is done by clicking on the wrist victim; a "yes/no" answer is obtained from the victim's database. When the user has sufficient information to determine the triage category, he uses the control pad to select the red, yellow, or green category to mark the victim. All activities of the participants are automatically entered in the Excel table, which allows post-action analysis of the length of each step in the selection process and the sequence of the examination of clinical parameters [4].

Triage Trainer

The scenario predicts a bomb blast in a crowded city street, the scenery is showing the destruction of infrastructure with numerous victims around (3-10 victims). The user applies the cursor to reach the victim, and checks on the medical status by clicking on the victim. After checking the victim, using the priority icon, the user determines the victim's priority for the triage process. After completing triage in post-action phase, the user checks the precision within the triaging process, where he points to the correct steps in the assessment of each victim but also points to any mistakes made during the process [19].

Virtual Emergency Department I

Based on the Atmosphere platform, beta version of the software by Adobe Systems Inc, Virtual Emergency Department I (VED I) represents a virtual emergency department including six injured patients [11]. Ten clinical scenarios introduce the patients with injuries such as rupture of the spleen, thoracic injuries, fractures of extremities, etc. The trauma team must evaluate the status of each patient and begin appropriate treatment. The vital signs of patients (heart rate, blood pressure, respiratory rate, and oxygen saturation) are designed to demonstrate a favourable response if the appropriate clinical activities are selected. If the clinical priorities are incorrect, vital signs will worsen in ten minutes, causing *death* of the virtual patient. In order to get an improved sense of engagement inside the trauma team, the virtual patients' conditions are changed 50% faster than in real-time. Members of the trauma team enter the VED by clicking on a hyperlink on a standard HTML web page. Using the mouse or the direction keys on the keyboard, they move their avatars to perform various diagnostic and therapeutic activities (over 30 of these activities are programmed) by choosing an option from the Control menu. In order to complete certain diagnostic activities, the participants must position their avatars minding the patients correctly. Each participant communicates with the patients and other team members by using a headset. Avatar's activities are visible to other team members, but the results of the activities are shown only to the team member who had performed those activities. Thus, the team members must share information about their activities verbally in order to be a functional team because effective communication among team members is of critical importance in real life [21].

Virtual Emergency Department II

Virtual Emergency Department II (VED II) was developed using the Olive platform by gaming experts of Forterra Systems Inc. and represents a replica of the emergency room (ER) department at the Stanford University Medical Centre. The platform includes twenty different scenarios in which the patients' avatars are presenting with signs and symptoms of poisoning due to exposure to nerve gas (sarin) in a train and to trauma caused by the explosion of a *dirty bomb* in a local bank [11]. The Olive platform enables participants to conduct triage outside the hospital, while the other team simultaneously conducts triage inside the hospital. The patients are represented with ten avatars of different ages and sexes with different comorbidities and injuries. The vital parameters of patients are programmed to deteriorate at various speeds, depending on the severity of injuries. Without proper treatment, most patients subject to injury thirty minutes after arriving at the hospital [20].

Discussion

Virtual worlds have become a part of everyday life of a great number of people who actually rely on them in different segments, so that virtual and real-time activities progressively intertwine. Virtual worlds are not only 3-D multiplayer games. The seriousness of these *serious games* provide a true experience of real presence in virtual environments, social networking in real-time and a unique form of social network interaction, including creative collaboration.

The emergence of platform technology for virtual reality applied in response training for mass casualty incidents including a large number of victims offers significant advantages over other traditional training standards. The immersive and participatory nature of training in virtual worlds gives a unique realistic quality of training, which is generally not present in other modalities of teaching and retains a large cost advantage over different forms of training in real life [18].

The educational usefulness of serious games within response training for mass casualty incidents can certainly be and should be discussed. Further research is necessary for their validation in relation to already existing methods of training in this field [2]. Therefore, it is necessary to determine whether there is an improvement in triage, intervention and efficiency scores by using serious games and how these scores correlate with the scores achieved by traditional models of training [2, 17]. The triage training for major incidents, where teamwork is most important, showed a great performance improvement introducing a combined system of conventional methods of training and serious games [2].

Conclusion

Managing mass casualty incidents which include a large number of victims is only possible with adequate training, difficult to implement in real-time. Virtual worlds, which should be the subject of further research and improvements, in the field of hospital emergency response training for mass casualty incidents, certainly have a promising future.

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