A conceptual model of agumented virtual and reality in cadet training

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***Abstract*—Through digital communication in the educational process, its stakeholders, professors and students, become creators of new information practices, which in involve modern technologies augmented reality (AR) virtual reality (VR). The research objective was aimed at detecting AR and VR information concepts important for determining students' digital intelligence in the digital creativity domain. In the education of the cadets, some issues have been observed acknowledged, particularly the issues of defining the set of information which is necessary to be transferred to the cadets by AR and VR and the issue of detecting feedback expressed through the learning outcomes previously acquired. The main research challenge is correlation of information sets and how to structure them into a standard cadet training information model. The research was conducted by using the method of content analysis of software solutions and the questionnaire method. The cadets and expert at military academy have been selected as the research sample as they undergo through both the process of acquiring theoretical knowledge as well as practical training. The paper presents the research aimed at VR prototype development and its evaluation with two cadets generations and military professionals, who were introduced to VR technology in different ways. The obtained research results present basis for an AR / VR conceptual model to be further defined, that will contain set of abstract elements, relationships, and information that depict a complex real cadet training system. In this sense, this paper represents an initial step in defining the framework of a standard AR / VR information model in the military training that can be further developed by creating additional categories of data that do not appear in any of the existing information models.**

Keywords—communication, conceptual model, virtual reality, augmented reality, cadet training, military

I. INTRODUCTION

By Virtual reality (VR) we mean computer simulations that should create a sense of being present in a virtual environment [1]. These include simulation and real-time interactions across multiple sensory channels [2]. Sensory modalities can be visual, auditory, haptic, smell (odor) and taste [1]. The concept of virtual reality has existed for a long time. For a clearer picture of virtual reality, it is crucial to cite the division that has been defined in the research and resolution of the reality question. There are three major types of virtual reality divisions for which some of the main characteristics are listed:

- Virtual Reality, VR;
- Augmented Reality, AR;
- Mixed Reality, MR.

If we look at virtual reality, we can find in it a new, virtual world that we see with the help of specific head mounted devices (like Oculus Rift HTC Vive, OSVR, and others) and, if necessary, use accessories to operate the game console. Furthermore, augmented reality is at any place with the user staying in the real world which is added with digital content. On the one hand augmented reality exposes digital image in the real world and on the other hand, mixed reality shows digital objects housed in the real world. It also allows to tour objects in real space and view objects from all angles [3]. Today VR has numerous applications in real life in the following domains: healthcare, military technologies, education, virtual heritage, design and architecture, entertainment and marketing [1]. Military organizations have been investing in VR technology since its inception, as it has been used as simulation training to acquire various military skills [1]. These types of simulations are useful because they reduce exposure in an unsafe environment and can increase concealment [4]. However, training is just one of the many areas where VR technologies are applied. Another example of very useful utilization of VR in a therapy of military personnel diagnosed with post-traumatic stress disorder (PTSD) and other cognitive disorders [5].

In this regard, this paper seeks to explore new technologies that will enhance military education which is highly complex and demanding, and each part of education seeks to approach a specific realistic task. The idea of military education is in fact to bring all its requirements as close as possible to actual tactical situations within the combat area. Often, such ventures often involve an enormous amount of expense, and are sometimes a great danger to the trainers themselves and the trainees. This paper discusses the application of augmented and virtual reality within the military domain. As such, it enables tactical situations to be created in a very simple way, thereby raising the level of security to the highest level.

The paper is structured as follows. First, the theory of augmented and virtual reality is elaborated, technology advantages and disadvantages will be presented, and its general utilization within military domain is described. After that, the idea of AR and VR prototypes developed specifically for the purpose of the research performed within Croatian Military

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Academy (CMA) "Dr. Franjo Tuđman" is presented with obtained prototype evaluation results. Paper discusses potential of AR and VR prototype as a reference for creating virtual simulations and future solutions in AR technology that could be implemented within cadet education and then within the armed forces trainings.

II. RELATED WORK

A. The application of Virtual Reality in military domain

The Army is an institution that seeks to maintain preparedness and ability to act through the implementation of training, i.e. field training within all military branches. For the purpose of carrying out the training as successfully as possible, it is necessary to prepare and plan it in the best possible way in order to achieve expected training outcome. Through the preparation phase, virtual simulations emerge, as well as other software systems that could be beneficial for a trainee to practice a certain activity. Within aviation, there are available simulators for military airplanes and helicopters, within the navy there are ships and submarines simulators, while within the ground forces there are simulators for anti-armor systems, tanks, combat and non-combat vehicles, and even simulators for various types of rifle and self-shotgun shooting [6]. Military simulators are very useful in training but also very expansive and with limited availability for trainees - they can be used within carefully planned and sufficiently frequent time slots.

Virtual reality is taking up more and more space for military training and military exercises, which is being developed to better condition tactical military units. One example is the VirTra system [7], for developing tactical skills within the military and police. The simulator seeks to provide soldiers with the latest tactical operations that require rapid responses under high levels of stress. VirTra uses multiple platforms with different views that surround users and display specific tactical situations. It also provides more users. Depending on the complexity of the platform, the following version is available [7]:

- Virtra V-100 - shown in Figure 1, a single-screen simulator that allows multiple soldiers training at the same time;
- VirTra V-180 - shown in Figure 2, the primary difference from the above mentioned version is a 180-degree viewing angle that high-level sense of reality;

Virtual Reality Exposure Therapy (VRET) [8] is a virtual system in which users are put into a 3D environment staged as a real tactical situation. VRET was tested with Vietnam War veterans who were placed in a jungle area accompanied by helicopters and thus managed to reduce PTSD symptoms. The University of Southern California Institute for Creative Technology has developed Bravemind [9] as the type of VRET that really aims in suppressing PTSD. Their researchers concluded that younger soldiers are easier to accept this form of therapy, given that they went through 3D interfaces through video games. Virtual reality applications can be found within the Navy and Air Force branches. The Oculus Rift was used in the BlueShark project [10], which, with the help of VR glasses, provides a 3D view of the vehicle's environment, in this case the space around the ship, giving in this way a clear picture of enemy aircraft position, submarines, rockets, ships or torpedoes. US Navy's Office of Institute Creative Technology (ICT)at the University of Southern California (USC) participated on this project. VR is combined with the touch screen to simulate all the controls that the operator works with.

Fig. 1. VirTra V-100 (upper scene) and VirTra V-180 (lower scene), Source: https://www.virtra.com/overview-mil/

B. Application of Augmented Reality in military domain

With the development of technology, augmented reality has found its place in the military domain as well. There are numerous military training solutions currently in use in this area, but as far no specific niche for this technology is defined. The following examples show the existing AR solutions for conducting military training. The first of these is the STE - Synthetic Training Environment or a synthetic training environment which seeks to improve the readiness and ability of soldiers in various tactical environments. It is possible to perform various tactical tasks, that is, to create scenarios with the help of One World Terrain (OWT) [11] where 3D rendering imitates different entities that are placed in the real space.

C. Simulators in the Croatian Armed Forces (CAF)

The Croatian Armed Forces use both ground and air force simulators, while naval simulators do not have any pronounced application within the CAF. The simulations seek to rehearse the unit before performing the exercise. In this way, they increase unit effectiveness and accomplishing the ultimate task. Inside the Air Force there is a Full Mission Trainer cockpit installation Simulator A-10, which provides a 3D view of flight and aircraft operations in various situations. In this way, the crew gets a realistic picture of the flight and thus rehearses their actions. The following simulators are used [6]:

- Simulator VS II - a simulator for training ground forces of the Czech army through the operation, operation and maintenance of combat vehicles such as the T-72 tank and the BVP combat vehicle;

Identify applicable funding agency here. If none, delete this text box.

- MUSE GCS UAV - simulator for simulation of work of front observers:
- CROTREND M1.1C and CROTREND M2.2C (FAUST) - trainers for the Malyutka anti-armor missile system (NATO name: AT-3 Sagger), Fagot (NATO name AT-4 Spigot) and Metis (NATO name AT-7 Saxhorn).

Moreover, there are so called actual simulations which emphasizing by the MILES 2000 system that came to life within the CAF. The system enables "simulation of a two-sided exercise by collecting data on the effects of direct firing on an individual, independent targets, weapons crews (combatants) and combat vehicles." Therefore, each pedestrian and combat vehicle is assigned a control unit and laser transmitter that are connected to the central unit. In this way the real circumstances of using real-time weapons are simulated, taking into account the rate of fire of the weapon, the time intervals between shots, the time required to change tanks, etc. The MILES 2000 system consists of [6]:

- Combat vehicle systems;
- A system of independent goals;
- Crew Weapons System;
- Personal weapon systems;
- Dedicated weapons system;
- AAR system - post-action breakdown system;
- Surveillance devices and auxiliaries.

III. PROTOTYPING AND EVALUATION OF VIRTUAL APPLICATION FOR MILITARY ACADEMY USE

A 2-year research was undertaken in which participated scientists and students from technical and computer field, and professionals and cadets from the military academy.

The main objective of the research was to investigate potential of utilization of VR and AR technology as well as the conceptual schemes serious games in the education of cadets. In order to perform the research, AR and VR prototype applications were developed [12]. VR prototype scenes are shown in the Figure 2.

Fig. 2. Scenes from the application for military unit presentation

The aim of the prototype application is to introduce available military units to cadets in the form of the serious game based on VR. Military units are presented by using specific unit objects selected based upon the information provided by cadets from these units [13]. By interacting with these objects, users are introduced to the specifics of each military unity.

The VR prototype development process was as follows: Initial idea was proposed by two cadets during their undergraduate final work [14][15]. The idea was described and presented as a low-fidelity prototype. Then student project was initiated containing the team of 4 students and 2 teachers from the field of engineering and computing, with the duration of 15 weeks, which resulted in application prototype based on VR and developed in technological platform Unity. Key input information for the prototype were provided by undergraduate cadets at the 4th year of military academy who were not specifically trained to VR environments and most of them had not any experience in using it. Cadets participate in the design of the application scenes by providing list of objects to be displayed. They provided information about prototype based on their own experience related to the military unit they belong. After the prototype was finished and functionally tested, an evaluation in research year 1 was organized at military academy.

A user survey was conducted with cadets who participated in the development process and actually performed user testing of developed prototype, and with military professionals who took the role of evaluation experts. The objective was to evaluate:

- the overall user's level of satisfaction with the developed VR prototype application, with focus on designed scenes and used interaction techniques in the virtual environment.
- prototype usefulness in terms of its future use in cadet education, focusing on technical improvements and general concept of VR serious game applications.

In the evaluation process total of 40 participants were involved, from which 87% were cadets. Each participant individually used the application with the following evaluation scenario:

- group presentation of application functionalities
- individual free use of application (in order to get feeling of interactions and virtual environment since the most participants used VR for the first time)

- completing given task - with the support of evaluation moderator (person who monitors evaluation and provides key inputs to users) participants should have visited two selected military units, interacted with specific objects and used two different motion in virtual environment (*tunneling* and *teleportation*).

In order to measure user satisfaction with VR education prototype, the Likert scale questionnaire was used. Every statement was rated with a grade from 1 to 5, where 1 denoted strong disagreement, and 5 strong agreement with the statement.

Evaluation question were about the following prototype features:

- usability
- attractivity
- usefulness
- user comfort during interactions
- general user experience with emerging into virtual environment

Evaluation survey results for the generation 2018 are presented in [16]. Based on this result the application was slightly improved, mostly in the part with user interactions with the objects.

In research year 2 new cadet generation was introduced to VR applications potential usage in military domain, but they were introduced within the lectures. Also this generation had to complete several research tasks to get more knowledge about the VR application in military domain. Only after they participated in the evaluation of the VR prototype, the evaluation results are shown in the Figure 3.

As the Chart 6a shows, participants consider VR prototype easy to use with the average grade 3.86 - possible argumentation for this could be that most of the participants were exposed to VR for the first time. Comparison of results for two generations: Average grade 2019, n = 46 / 3,86; Average grade 2018, n = 29 / 3,91.

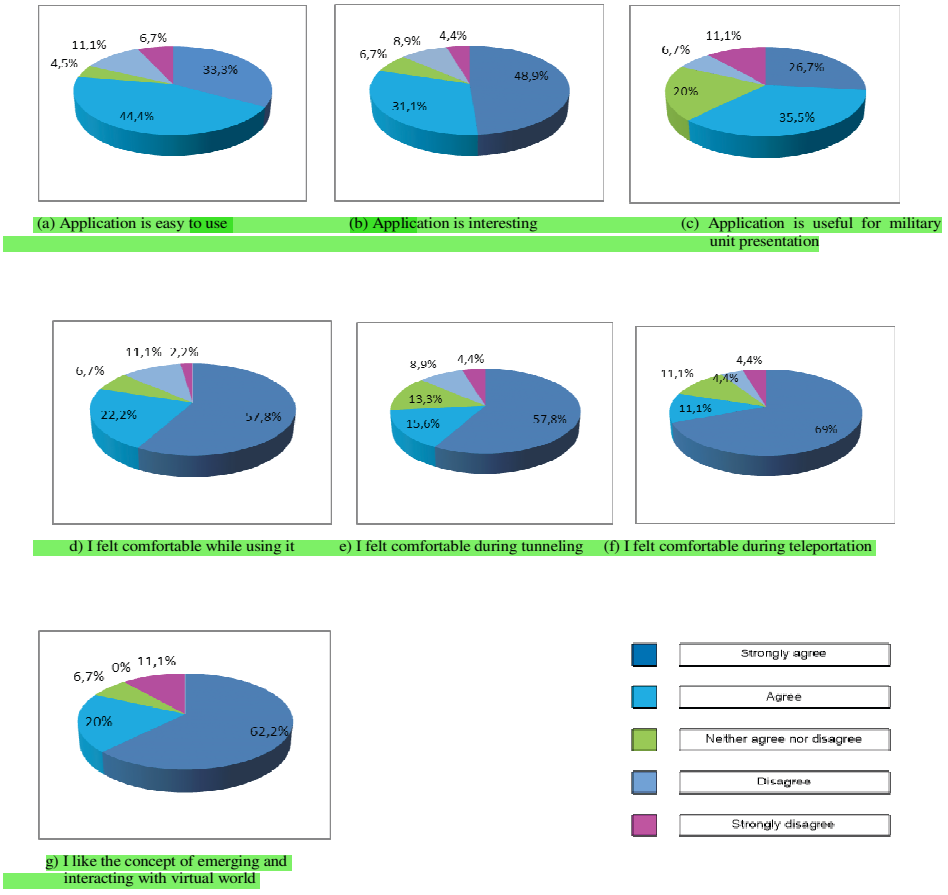


Fig. 3. Evaluation survey results for VR prototype and cadet generation 2019

It can be seen in Figure 6b that 48.9% of participants consider application interesting. The average grade is 4.11 (in previous evaluation: 4.25). A slight decrease of this grade is present. Suitability of the application for presenting military units is rated with an average grade of 3.6 (Figure 6c). Although 11.1% of the cadets strongly disagree with usefulness of application, one third of them strongly agrees that the application presents military units well. Comparison of results for two generations: Average grade 2019, n = 46 / 3,6; Average grade 2018, n = 29 / 3,78.

Statements about movement in the virtual reality showed no difference between level of comfort while using tunneling and teleportation. The overall comfort of using the application is rated with an average grade of 4,22 (Chart 6d) Comparison of results for two generations: Average grade 2019, n = 46 / 4,22; Average grade 2018, n = 29 / 3,94. Tunneling motion is rated with an average grade of 4.13, while the teleportation is rated with an average grade of 4.33. Both generation of cadets did not find tunneling more nauseous than teleportation.

The concept of emerging and interacting with virtual world is rated with an average grade of 4.22. (Figure 6g). Comparison of results for two generations: Average grade 2019, n = 46 / 4,22; Average grade 2018, n = 29 / 4,22. According to the results of the prototype user evaluation, cadets showed overall satisfaction with the application, usable and comfort.

A. Researching potential of AR technology in improving key cadets skills

After presenting VR prototype, AR technology was introduced to cadets as well as AR application functional prototype for presenting possible functionalities of AR interactions for the example of tank, military vehicle and weapon (Figure 4).

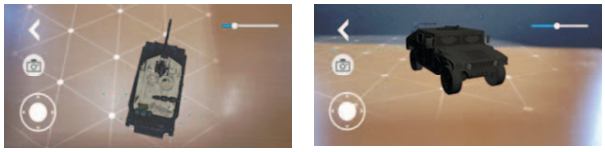


Fig. 4. AR prototype application scenes (tank and vehicle)

After presenting the prototype and individual use of it, cadets were given a task to reflect on capacity of AR technology for improving interpersonal, technical and conceptual skills. The obtained results were as follows:

B. Improving interpersonal skills by utilization of AR

In armor and logistics domain - user could have to complete specific tasks on a tank model, vehicle and a specific type of weapon (familiarizing in this way with the tank structure, vehicles and weapons) or issue an operating order to start the action in front of the audience. In addition, VR gloves would be used for operating on the sandbox (model technical means). In this way instructor and other cadets can give quality feedback to the user.

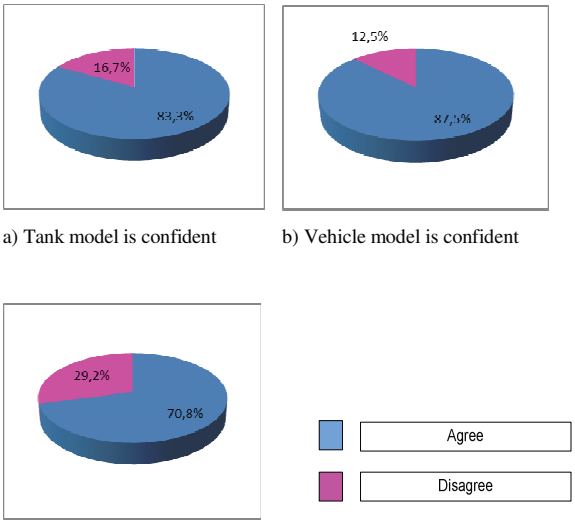
C. Improving technical skills by utilization of AR

In military engineering - by using AR glasses and data gloves user works to operate tanks, vehicles and weapon. Namely, VR glasses can give cadets virtual augmented reality where the tank, vehicle, and armaments all have real parts and are no different in physical appearance from real ones. Also, in virtual reality, it is crucial that cadets perceive that they have the necessary protective clothing intended for this work (helmet, protective suit and gloves). Furthermore, using gloves, cadets could disassemble parts to the smallest detail, just as they would in reality. Doing that way, it is important that the tank, vehicle, and armaments in the virtual reality are identical to the ones in the real world, including dimensions, the relationship of dimensions and positions of separate parts, the force required to disassemble or assemble separate parts, and the similarity. Also, this is a much cheaper way of training and the immeasurable advantage of this type of training is safety and the absence of risk, since once a system is developed it only requires maintenance and upgrades when the need arises, as opposed to acquiring a sufficient amount of real assets.

D. Improving conceptual skills by utilization of AR

In view of the contemporary threats that are taking place in the urban environment, AR could be used to train a faster process in eliminating the technical malfunctioning of a tank, vehicle and weapon. In doing so, the cadets would perceive which parts or elements of the system were defective to be replaced using AR glasses. Also, VR gloves would be used to rehearse the procedures when changing parts (tank, vehicle, weapon). More situations would come up where, at an initial stage, it would be easy to figure out problem. After applying this method of training, it would start over and each of the above situations would reappear, given a different space and other problems to solve.

Figures 5a, 5b and 5c showing cadets' satisfaction with using a tank, vehicle, and weapon assets within AR prototype.



a) Tank model is confident

b) Vehicle model is confident

c) Weapon model is confident

Fig. 5. Evaluation survey results for AR

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IV. CONCLUSION

Emerging technology, such as AR and VR has a great potential of utilization in military education. Although there are numerous solutions in this field, they are under-researched. During the research described in the paper, AR and VR prototypes were developed, with several purposes: to introduce cadets to these technologies, to add value to education given the content of the prototypes, and to motivate in a structure way both cadets and military professionals to reflect about future potential beneficiaries of solutions. Their active involvement in the process of developing any future education solutions based on emerging technology is prerequisite since they can provide valuable software requirements and ideas how the direct solution design and content to be useful and increase military capacity in terms of improvement of education, interpersonal, technical and conceptual skills. As with any new technology, it is hard for user to reflect on something that has not been in use, so the prototyping and evaluation methodology applied in this research provided structured way of fast-tracking introduction of user to the emerging technology features.

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