

THE USE OF VIRTUAL REALITY RESOURCES TO INCREASE SAFETY IN THE TRAINING OF FIRE AND RESCUE CORPS UNITS

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ABSTRACT

The work of fire departments is influenced by various factors that bring risks. The security of fire fighters is the most important thing when performing their job. Therefore, it is necessary to ensure their security by identifying risks and eliminating them in advance. Virtual reality resources help to increase the safety of firefighters during professional training activities. These activities are conducted with the usage of simulators, practical exercises and simulations; however, these exercises can only partly get them closer to reality. We claim that virtual reality is a huge aid for firefighters, and that by using this tool, efficient protection of life and health as well as property can be provided. The submitted article discusses the current state of virtual reality resources and their use

in the professional training of fire brigades and rescue units. It also discusses the benefits of virtual reality use.

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INTRODUCTION

Rescue units are organized into Integrated Rescue System (IRS) services in Slovakia. The basic units of this system are the following: Fire and Rescue Corps, Emergency Medical Service, chemical laboratories for civil protection, Mountain Rescue Service, and Mining Rescue Service.¹

The following article focuses on one of the basic units of IRS, namely the Fire and Rescue Corps. The article describes the issue of virtual reality and its use for fire brigades. It discusses the virtual reality resources currently available on the market, that can contribute to the improvement of the work of fire brigades and to their safety.

The issue of virtual reality use in IRS has been discussed by many scholarly works worldwide. The authors focus on the issue of virtual reality use in the simulation of the tactical exercises of IRS members.² They also focus on virtual reality use in the training of rescue workers related to extreme incidents, e.g. mass casualty incidents.³ Specific systems for virtual reality use have been proposed by many authors, for example simulation systems are mainly focused on coping with extreme incidents, while simulated fires are possible teaching aids for petrochemical industry. These systems display realistic simulations of fires, allowing the firefighters to carry out drills and thus prepare themselves

¹ D. Boguská, A. Majlingová, M. Monoši, *Kritické miesta v súčinnosti záchranných zložiek integrovaného záchranného systému Slovenskej republiky*, 1st edition, Prešov 2016, p. 188.

² E. Prasolova-Forland et al., *Active Learning Modules for Multi-Professional Emergency Management Training in Virtual Reality*. [in:] *6th IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, 2017, p. 461-468.

³ P.H. Pucher et al., *Virtual-world hospital simulation for real-world disaster response: Design and validation of a virtual reality simulator for mass casualty incident management*, "Journal of trauma and acute care surgery", 2014, vol. 77, issue 2, p. 315-321.

for real-life firefighting.⁴ Another proposal made by the authors are virtual reality simulators of fire drills that could be used at training so as to boost faster decision-making as well as safe and well-organized reactions during real fires.⁵

Virtual reality as a new and developing technology becomes a part of our everyday life. This new phenomenon, which only used to be discussed as some sort of sci-fi scenario in the past, now becomes reality.⁶ Watching films, playing video or console games, participation in special simulation drills, or preparing designs via virtual technology is now possible.⁷ Therefore, it may be predicted that virtual reality may also find its use at work and training of security and rescue units of IRS.

1. THE PROFESSIONAL TRAINING OF FIRE AND RESCUE CORPS MEMBERS

Fire and Rescue Corps belongs to the basic units of the IRS of the Slovak Republic. It consists of the presidium, eight regional headquarters, 49 district headquarters, other workplaces, as well as the Fire and Rescue unit of the capital of the Slovak Republic, Bratislava.⁸

Fire and Rescue Corps is a professional firefighting and rescuing unit belonging to Ministry of Interior of the Slovak Republic. Their basic duties are protection against fires, the provision of state fire inspection, rescuing people at crashes, natural disasters and other events, as well as the protection of human health, property and environment. They also work in the area of prevention, education and the restocking of technical hardware.⁹

The continuous vocational education of Fire and Rescue Corps is conducted by means of the professional training of all fire and rescue unit members. An employee is obliged to participate in professional training and the testing of professional knowledge. Professional training of the personnel focuses on achieving the knowledge, skills, physical abilities and habits needed to act while firefighting and performing rescue activities during natural disasters and other

⁴ F.J. Yu et. al., *MDIS Cloth System: Virtual Reality Technology for Firefighter Training*, [in:] *15th ACM SIGGRAPH International Conference on Virtual Reality Continuum and Its Applications in Industry (VRCAl)*, Zhuhai 2016, p. 219-225.

⁵ M. Cha et. al., *A virtual reality based fire training simulator integrated with fire dynamics data*, "Fire safety journal", 2012, vol. 50, p. 12-24.

⁶ S. Aukstakalnis, D. Blatner, S.F. Roth, *Silicon mirage: the art and science of virtual reality*, Berkeley, CA 1992.

⁷ Zákon č. 315/2001 Z. z. o Hasičskom a záchrannom zbore v znení neskorších predpisov, [in:] Zbierka zákonov Slovenskej republiky.

⁸ *Hasičský a záchranný zbor*, [in:] *Ministerstvo vnútra Slovenskej republiky*, 2018, <http://www.minv.sk/?hasicky-a-zachranny-zbor> (accessed 02.07.2018).

⁹ *Ibidem*.

extreme events.¹⁰ Professional training can be divided as follows, according to the edict no. 611/2006 of the collection of laws issued by the Ministry of Interior:

- **Basic training**, whose contents are: the legal regulations on fire prevention, the organization of fire unit service, technical drill, basic fire processes, fire extinguishing substances and rules of the use thereof, methodology of fire-fighting and rescuing, basics of first aid, health and safety principles, physical drill.¹¹
- **Improvement training**: it is performed in firefighting units and all employees take part. It is performed by commanders of all levels and by dedicated employees according to the yearly plans of improvement training. At the end of the year, the employees take part in the testing of theoretical and practical abilities in front of the testing committee. Tactical exercises are also part of this training.¹²
- **Specialized training** is intended to improve the qualifications of the employees and the members of the units; it consists of professional training and the confirmation of the participants' abilities in the areas of firefighting, rescue work, and the operation of firefighting equipment.¹³
- **Cyclical training** is intended to deepen the knowledge and further develop the skills, physical abilities and habits needed to perform firefighting and rescuing work. It confirms the professional competences of rescue workers.¹⁴
- **Physical training** is performed throughout the whole year, with the aim of strengthening and increasing the rescuers' physical abilities, developing their physical skills, and helping them acquire habits needed for firefighting and rescuing work. Physical training consists of general physical training and special physical training. Every employee, without age restriction, participates in the general part. It focuses on the general strengthening and improving power, speed, endurance and mobility, which are the bases of the physical fitness of the employees. Special training is a part of the preparation of the employees to service; it focuses on strengthening as well as on developing special physical, strength-related and endurance-related abilities and attributes that correspond to the character of work in firefighting units. This training includes

¹⁰ Vyhláška č. 611/2006 Z. z. Vyhláška Ministerstva vnútra Slovenskej republiky o hasičských jednotkách, [in:] Zbierka zákonov Slovenskej republiky.

¹¹ *Ibidem*.

¹² Vyhláška č. 611/2006, *op.cit.*

¹³ *Ibidem*.

¹⁴ *Ibidem*.

the so called firefighting sport. Competitions are being organized in this sport, according to the uniform rules issued by the Ministry.¹⁵

The role of abovementioned trainings is to provide theoretical as well as practical knowledge and skills for the members of fire and rescue units, which are necessary for firefighting and rescuing work during natural disasters and other extreme events.

All types of training include simulators, practical exercises, and the simulations of real interventions. However, such exercises can only partly imitate reality. This is why virtual reality can play an important role here, as it has a huge potential to be used in the future for the training of fire and rescue unit members and other members of IRS to increase security and to provide a better basis for the accurate identification and elimination of risks.

2 . THE CURRENT STATE THE USE OF VIRTUAL REALITY RESOURCES FOR FIREMEN

At the beginning, let us discuss virtual reality. Virtual reality can be also called 'near-reality', which can be understood as getting reality closer via computer simulation. Virtual reality is a tri-dimensional, computer generated environment, which is experienced by a human being.¹⁶

Virtual reality devices work on the basis on input information from the user as well as from a program or application that controls the virtual system – from the stage of rendering (i.e. the creation of 3D picture) and from the output information headed to the user.¹⁷ Virtual reality devices are equipped with special tracking systems which make it possible to capture and evaluate in a detailed way every movement of the user, at the same time providing them the experience that is very close to reality. The most commonly used tracking systems are: optical tracking system, magnetic tracking system, acoustic tracking system, inertial tracking system, and mechanical tracking system.¹⁸ It is necessary to take a closer look to the concept of so called cyberspace. We can define it as a synonym of the term 'virtual reality'. Cyberspace is often called virtual reality and vice versa.

The basic feature of virtual reality is the ability to picture the spatial models and scenes as accurately as possible so that they could be manipulated, to 'create'

¹⁵ *Ibidem*.

¹⁶ *Virtual Reality Society. What is Virtual Reality?*, 2018, <http://www.vrs.org.uk/virtual-reality/what-is-virtual-reality.html> (accessed 20.07.2018).

¹⁷ Jerald J., *The VR Book: Human-Centered Design for Virtual Reality*. San Rafael, CA 2015.

¹⁸ *Ibidem*.

the real world or its part with all its laws and rules, and to depict movement in 3D space in real time. To achieve that, processes from the realm of computer graphics are used. These methods are strengthened by the use of special peripheral devices, which allow for pictorial, tactile, audial and position interaction. Those are e.g. special glasses, helmets with built-in displays and headphones, position sensors, data gloves and data suits, touch devices, simulation cabins, movement devices etc. By means of these devices, the perception comparable to that of the real world is created.¹⁹

Virtual reality and haptic systems aimed as helps in training firemen already exist on the world market. Virtual reality devices that are mostly used in foreign Fire and Rescue units are simulators to perform firefighting training.²⁰ The work of fire brigades is very dangerous; therefore, it is necessary to perform regular trainings and exercises. Such trainings can be very dangerous; moreover, they can also be expensive and time-consuming. This could be changed by a newly built virtual digital simulator called FLAIM Trainer, which consists of the device for picturing virtual reality, the haptic system and a special suit which monitors the vital functions of trained firemen.

Unfortunately, firemen trainings are not always enough practical; nor are they always safe. Sending an underqualified team to fight fire (even if it is just a training spot) may not end up well. For these reasons, digital simulations started to be used, even though they are not fully realistic. FLAIM Trainer is an attempt to fill up this white space in the market. It has been first introduced on CES 2017 exhibition as one of the possible examples of Vive Tracker extensions to be used with a virtual reality head set HTC Vive.²¹

Vive Tracker add-on can track the movements of any object to which it is connected, and replicates the object's movements into virtual reality environment. FLAIM device has Vive Tracker mounted to the end of the fire extinguisher; therefore trained firemen can extinguish virtual fires with the equipment used in the real world.²²

¹⁹ Mihalíková J., Líška O., *Využitie virtuálnej reality vo vzdelávacom procese*, "Transfer inovácií", 2006, no. 9.

²⁰ Jerald J., *The VR Book...*, *op.cit.*

²¹ *FLAIM Trainer. Immersive VR combined with a patented haptics feedback system and real equipment provides a unique emergency services training experience*, 2018, <http://flaimtrainer.com/#-FLAIM%20Trainer> (accessed 25.07.2018).

²² *Ibidem.*

FIG. 1. FLAIM TRAINER™ PLACES FIREFIGHTERS IN THE REALISTIC TRAINING SCENARIO AVAILABLE BY UTILISING SEVERAL CUSTOMISED ELEMENTS.



(source: FLAIM Trainer)²³

The fireman dives into the virtual world by means of the HTC Vive headset, which comes with its own set of breathing mask that adds to the authenticity of the situation. There is also a haptic system present, which provides tactile feedback and simulates the pressure of water on the hose. The protective clothing

²³ *FLAIM Trainer, op.cit.*

is equipped with the heating system. It can heat the suit into such extent that the fireman feels as if standing next to a real fire.

The suit is the newest addition issued by Dimension Data Company, a new partner in the FLAIM programme. It is equipped with an electrocardiograph (EKG) and it monitors the general condition, the physiological reactions, and the performance of the user. Obtained data can be saved locally or remotely in the cloud. They serve as an aid for instructors, who can compare the results among a given group of trainees.²⁴

Another company that deals with virtual reality systems dedicated to fire and rescue units is a Swedish company Qwake. Their project connects expanded reality and not just training, but true lifesaving. The company is developing a helmet for firemen that can be used for faster and better orientation in smoke-filled area.

Thermal cameras have been used in this sector for many years. However, this technology cannot evaluate the state of the environment in real time and is, therefore, slower. Firemen have to stop, take a picture with the camera and the situation shows up on the display. It is definitely a useful function; however, sometimes it cannot be used effectively (e.g. in the case of a falling building, where every second counts).

FIG. 2. C-THRU SMOKE DIVING HELMET



(source: Industrial Designers Society of America)²⁵

²⁴ *Ibidem.*

²⁵ *Industrial Designers Society of America. IDSA, 2018, <http://www.idsa.org/awards/idea/graduate-student-designs/c-thru-smoke-diving-helmet> (accessed 08.08.2018).*

The abovementioned helmet evaluates the events in zero visibility, real time. This system is based on a thermal camera combined with biometric sensors, edge detection and environment toxicity sensors. All data are processed by the device itself. The device is of the size of a pack of cards, and is powered by nVidia Tegra mobile processor. The image is transferred wirelessly to the AR glasses placed in the glass shield of the helmet.²⁶ Even in a smoke-filled room, the fireman gets the exact picture of the surroundings. They are able to determine where the wall or the door is, and whether the temperature is too high or too low. Three modes are available: edge display, temperature map, or the combination of both. Helmet also includes the sound system which improves the audibility of the sounds from the environment as well as structural sounds such as the cracking of the floor.²⁷ The system device is small and suitable for use accompanied with rescue technologies such as robots, drones or cameras. Currently, the system is still under development and engineers plan to add the function of route tracking to track the route of the rescue worker for better orientation. Another function that is considered is the function of recognizing people.

3. THE BENEFITS OF VIRTUAL REALITY USE IN THE PROFESSIONAL TRAINING OF FIRE AND RESCUE UNITS

Virtual reality has not yet been used for trainings in Slovakia, which is a pity, as there are various devices on the market that could be a considerable help at professional trainings.

Simulation technologies can be used in various types of training, continuous education, as well as periodic tactical exercises. The possible areas of use are the following:²⁸

- firefighting – extensive forest fires, fires in buildings, fires in the exterior, the training of firefighting activities, evacuation, firefighting strategies, focal point of fire and its extinguishing;
- rescue work – rescuing people from crashes, natural disasters (floods, landslide etc.), environmental protection;
- the management of fire brigade and training in mutual cooperation – among the members of the same unit and various units of IRS;

²⁶ *Qwake Technologies*, 2018, <https://www.qwake.tech/> (accessed 11.08.2018).

²⁷ *Ibidem*.

²⁸ Petz I., Nečas P., *Simulation techniques and modelling in training*. [in:] *ICMT '09: International conference on Military Technologies 2009*, Brno 2009, p. 482-485; A. Fanfarová, L. Mariš, *Simulačné technológie – prostriedok pre zvýšenie bezpečnosti hasičov*, "Journal of Safety Research and Applications" (JOSRA), 2016, vol. 1-2.

- the coordination of rescue work and activities – mass casualty incidents, first aid, transportation of the wounded, the behaviour of the crowd;
- activities accompanying rescue work – evacuation control, removal of barriers and roadblocks, rescuing people, extinguishing focal points of fire, the monitoring of interventions;
- dangerous substance leak, detection of chemical substances, contamination and decontamination;
- others – e.g. explosions, searching for focal points of fire with thermal camera, detection of dangerous substances, trapping systems, terrorist attacks.

The advantages of virtual reality usage are:

- the opportunity for drilling situations and scenarios that are difficult to reproduce in the form of real-life tactical exercise due to environmental, legal or community-related restrictions;
- taking into account the fact that the use of live tests as training modules for extreme event modelling can be expensive, risky, and inflexible., and that it is difficult to adjust to alternative scenarios or replicate such scenarios – virtual reality simulations provide new opportunities, they are less expensive and, accordingly, they are used for such purposes more often than before;
- simulation technologies and virtual reality can get close to reality and contribute to the quality of training and to an increase in the safety of firemen;
- the use of virtual reality in firemen training is less time-consuming than traditional drills: virtually simulated training can be easily paused, repeated, or used in different variants to verify various methods in a row and choose the most effective one;
- the use of virtual reality in training provides a higher level of security and better protection of health at work than real-life training;
- virtual reality can simulate and generate various options of emergency events as well as various conditions, circumstances or environments thereof directly on the spot.

After an interview with a professional fireman from Fire Department in Kosice, we can claim that virtual reality resources could be very helpful at professional trainings of firemen. According to his words, such resources would also help to train the members of the volunteer fire unit in the city. The reason for this claim is that a professional fireman is obliged by law to participate in a whole set of training schemes: basic training, professional training, improvement training, specialized training, cyclical training, and physical training. Vocational exercises for professional firemen include simulators, practical exercises and simulation of real interventions, as well as tactical exercises, cooperation training with other units of IRS, etc. In contrast, the members of volunteer fire brigades, that operate

on the level of city districts, do not have as many possibilities as professionals. They have to take part in the basic training, but it is not sufficient. Therefore, as the professional fireman of Kosice fire brigade believes, virtual reality devices for the professional training of firemen can be particularly beneficial for the members of city volunteer fire brigades.

4. CONCLUSION

The safety of fire brigade members must come first and can by no means be underestimated. On the other hand, the process of the improvement of fire protection efficiency is conditioned by various factors. One of them is the professional readiness of fire brigade members working in the division of fire protection. Therefore, it is necessary to create suitable conditions for the improvement of the quality of further education and professional trainings for firemen.

Even a professional fireman can fail if an unexpected situation occurs. Quality training for extreme events can decrease the risk of failure. The introduction of virtual reality into the process of professional training and education of fireman can lead to an increase of firemen's security. Firemen trainings are, unfortunately, not always enough practical and enough safe, and to send an unqualified team to fight fire, even if it is just a training site, can be dangerous. Firemen can practice various cases; however, rescuing lives in real-life situations cannot be trained in full scope in simulated conditions: people must 'live it', and this can be provided by virtual reality. Therefore, we recommend introducing virtual reality as an aid in the professional training of firemen.

Systematic professional education and training, aimed at sustaining, improving and completing knowledge, skills, abilities and habits needed to perform state service in the fire brigade, are an effective means of expanding fire unit members' qualifications. The forms of these educatory actions are determined by the respective Slovak Ministry.²⁹

This article discussed the advantages of the usage of virtual reality devices in the professional training of fire and rescue unit members. Having considered the advantages that have been enumerated, we can conclude that the gradual introduction of virtual reality resources into the training process of fire brigade members can be very effective both from the educatory and security-related point of view.

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