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THE ROLE OF AUGMENTED REALITY IN DEFENSIVE ACTIVITIES

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Abstract: Achievement of strategy objectives of defensive organizations is in close connection with the use of an adequate technology. This paper explains why augmented reality, technology that superimposes digital information over real world information, requires special attention in defense industry. The authors identified and described several key roles of AR in defensive activities: real situations with special focus on critical situations, trainings, real-time remote collaboration, maintenance, repair, and overhaul, as well as security system checks. Some challenges of using AR in defensive activities are outlined, and hints for future researches of this increasingly important technology are given.

Keywords: augmented reality, defensive activities, defense industry, role of augmented reality, technology.

1. INTRODUCTION

Defensive organizations, as important security bases of every national infrastructure, require developed strategy regarding using technology in their work, since technology has important function in defensive activities.

As it shown in Figure 1, augmented reality (AR) represents a new step in development of technology. Since 2015, AR has become significant widespread technology [1]. Except the fact that AR is successfully moving "from cool to meaningful" technology [2] and it is justified in terms of return on investment in business, its potential has been already recognized by governments that invest large resources for civil security and military activities in this innovative field.

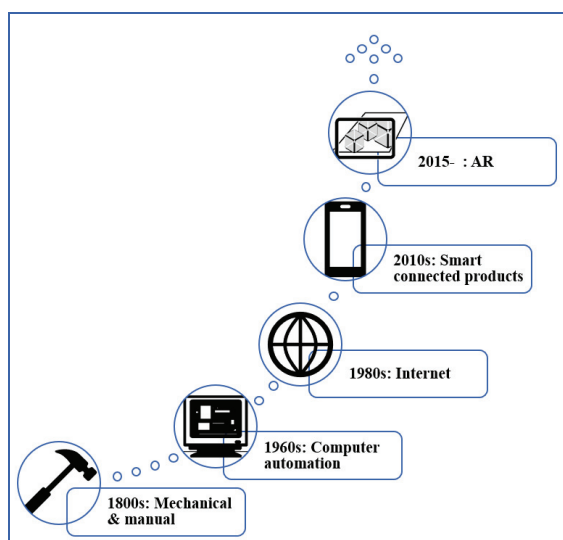


Figure 1. Technology timeline [1]

Future trends show that the military AR market is estimated to reach US\$ 1,797.5 Mn by the end of 2025 [3]. Development of products and systems that use AR technology consequently increases use of AR in defensive activities.

The aim of this paper is to consider the key roles of AR in defensive activities. Defensive technologies, as significant advantages for realization of defensive activities, are becoming increasingly important because of recent fast-paced technology changes and necessity to adapt and improve defensive activities to follow the increasingly demanding needs for taking security measures.

2. AUGMENTED REALITY IN DEFENSE INDUSTRY

Augmented reality is raising technology in all industry fields in the last 30 years [4]. It is based on the principle of overlaying or superimposing of digital information (computer-generated enhancements) over real world information (from real-time environment) [5,6], with the purpose of better understanding of simplifying existing reality. Therefore, AR augments the sense of reality in real time [6]. AR technology is usually visual, but often includes audio and tactile elements.

Three most important elements of AR system are [7]: *sensor(s)* for getting sensations from physical environment, *a processor* for evaluation of the sensor data, *a display* (as a part of smartphone, tablet, smart glasses, etc) for showing integrated picture of the real and digital world.

Example of device which improves user experience with using AR, often cited in the literature, is head-mounted display (HMD). HMD can be used in military, for example,

in aviation sector, for displaying superposition of runway and projected landing route, for showing maps with filtered data on the route, for most safely pre-flight checking using digital instructions, etc. AR technology demands camera-enabled devices, and mobile phones and tablets are the most suitable for commercial needs.

The number of articles dealing with AR in defense industry at Google Scholar in the last 30 years is shown in Figure 2 – the following searching phrase is used: "augmented reality" AND "defense" OR "defence" OR "security" OR "military", while patents and citations are excluded. It is obvious that the number of articles is increasing in the last decades, and it is reasonable to expect that the growing trend will be continued. This suggests that future researches, as well as applications in practice, are welcomed in this field.

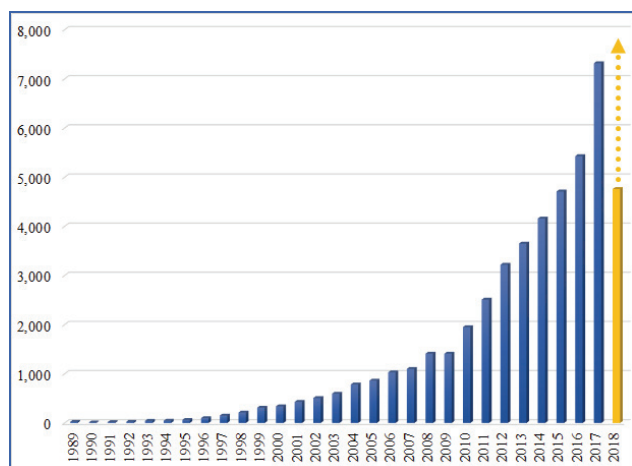


Figure 2. Number of articles dealing with AR in defense industry

It is clear that AR finds its place in defense industry and related projects. Some examples of AR projects in defense industry are given in Table 1.

Table 1. Examples of AR projects in defense industry

Project	Short description
X38	X-38 is a research project of NASA designed to develop technology for Crew Return Vehicle for the International Space Station, where AR is used for enhancing navigation of the NASA X-38 spacecraft.
JFX3	Joint Focus Experimentation 3 (JFX3) is a project of The UK Ministry of Defence (MoD) realized with the aim to conduct evaluation of opportunities and barriers of AR solutions for defense purposes.
ULTRA-Vis	Urban Leader Tactical Response, Awareness & Visualization (ULTRA-Vis) is research project founded by The Defense Advanced Research Projects Agency (DARPA) with the purpose of improvement of real-time insight into real environment in urban warfare [8].
TARGET	TARGET (Training Augmented Reality Generalised Environment Toolkit) is European project funded by European Union's Horizon 2020. The project uses AR technology and focuses on developing training for Security Critical Agents in extreme stress situations, and with low cost [9].

3. BENEFITS AND THE KEY ROLES OF AR IN DEFENSIVE ACTIVITIES

Defense industry is one of the most important drivers for development of technologies, including AR. On the other hand, defense industry has benefits from the commercial development of AR technology for wide use. In the case of AR, one of important benefit is increasing accessibility (hardware and software are becoming cheaper). Its commercial development leads to the fact that AR solutions are becoming more user-friendly: more suitable for use, more precise, user customizable, and can be used with less specific training. This further means cheapening of its use in all areas where training is needed, which scientifically affects the total cost of its use in military.

Despite the fact that application of AR technology in defense industry is still in early stages, some of the key roles are already recognized, and will be described in the following lines.

3.1. Real situations

AR provides information in real environment. It is one of the most important advantages of AR technology in real situations, compared to related technologies (for example, virtual reality). Namely, realization of security and military operations in real situation demands contact and interaction with physical environment, and the level of immersion in virtual world must be limited. Otherwise, the operation may be compromised.

Additionally, with AR, information about the real world are improved with computer information, which also represents important advantage in real situations. Human ability of soldiers or security personnel (detectives, policemen, firemen, etc.) can be significantly improved in different ways, for example:

- Perception – 360° view camera, danger warnings, marking the enemy or points of interest on the battlefield can reduce errors and the time needed for detection and identification of possible dangers.
- Orientation – precise navigation can be provided on terrain by using instructions (for example, visual instructions – navigation lines, arrows, compass, distances, etc), because AR software uses GPS data.
- Keeping focus – in difficult and complex situations on the ground, crucial importance is showing only relevant information.
- Specific knowledge – thanks to AR, personnel can get specific information needed at the exact moment, and in accordance of the user's mission profile [10], whether they are embedded in the AR application itself (for example, 3D model of demolished building that is shown at its original location [11]) or obtained from remote experts.

All above mention ability can be available hands-free (for example, by controlling the display with voice or facial recognition [12]) and at the eyes level. By receiving all necessary data via screen on this way, there is no need to take eyes off the environment [12]. Some examples of such devices are: HMD, head-up display (HUD), eyeglasses, etc. The devices can be used in many different types of

situations/operations – in the case of flying, driving, running, sailing, etc.

3.1.1. Critical situations

It can say that critical situations are real situations and that every real situation in this field is in some way critical. However, since critical situations have a special significance, the authors highlight them as a subgroup, having in mind situations when human lives are directly endangered or when vital material damages are possible. In such situations AR can be particularly useful in combination with previously existing data – for example, architectural and construction 3D drawings of objects can be used in actions of releasing hostages in a building facility in an urban environment. Further, knowledge transfer in real time from remote locations is of particular importance – for example in the case of dismantling bomb.

Rapid development of urban zones has moved critical situations from the battlefield to urban areas. Cities are frequent targets of terrorist attacks. For the purpose of defense in urban areas, AR solutions are being developed and showed as useful, especially for situation awareness on terrain in critical situations. For example, Urban Warfare Augmented Reality (UWAR) represents concept and system that is based on AR and specially designed to enhance combat capability in urban warfare environment of today's [8]. Another example is Battlefield Augmented Reality System (BARS) which uses AR technology for complex, 3D environment of military operations in urban terrain [10, 13].

3.2. Trainings

Training of special units can be long-lasting, costly, and simulation of emergency situations insufficiently well executed. All this adversely affects the level of training and readiness for defense. The use of AR technology concerning training and military exercises significantly improves their efficiency and quality at the same time.

Facilitated acquisition of challenging skills (for example, pilot training) significantly reduces the number of hours and costs, having in mind that instructions are available in front of the pilot's eyes, superimposed on real environment, and the flights are much more reliable. AR technology improves practical lessons and possibilities for learning in rescue action trainings, which has paramount importance in the case of real situations.

3.3. Real-time remote collaboration

Real-time remote collaboration represents one of the key advantages of using AR technology. This characteristic improves cooperation in:

- Emergent situations: it accelerates decision making process, enhances situation awareness, reduces time-to-repair.
- Regular activities: it reduces travel costs, allows remote cooperation in projects, facilitates logistics.

3.4. Maintenance, repair, and overhaul (MRO)

AR technology is shown to be useful for helping

maintenance of equipment without need to study two-dimensional printed manuals, because instructions show as layers over real 3D object. This also reduces errors and the usual time needed for regular maintenance.

AR is especially efficient for emergency repairing of equipment at remote locations. Thanks to AR solutions, the remote experts can see in real-time the same as persons on the terrain, so they can guide them through repairing process safely. This is particularly useful in emergent, dangerous, and complex procedures, and it is especially important in operations when time for repairing is very limited.

One example of technology developed for this purpose is Adroit AR. This technology is suitable for real-time use in extreme situations. It can be used for emergency repair battle tanks in real combat situation. It can detect, scan and recognize objects, communicate with remote data center to receive necessary data and instructions for successful repair under the extreme stressed combat circumstances. This technology can also be used for MRO of vital industrial equipment.

3.5. Security system checks

AR solutions reduce errors and efforts when performing security system checks by:

- Visualization of information – information presented in a visual way, and in three-dimensional space, facilitates understanding, mutual comparison, and extrication of the most important data.
- Step-by-step instructions – complex actions require simplification of procedures.
- Digital security check-list – their use prevents skipping of steps.
- Real-time security monitoring – it is used for direct danger detection in radar systems, monitoring of security systems of objects, etc.

4. CHALLENGES OF USING AR IN DEFENSIVE ACTIVITIES

4.1. Information related challenges

Information overload is one of the main threats in critical defensive activities, particularly because of increasing ability to collect and present data to warfighters in real time [14]. This potential problem can appear in two ways threat:

- for information systems failure, and
- for human capability to process information.

Adding relevant information represents intrinsic characteristic of AR technology. This distinctive feature enables AR solutions to filter data, to use the extensive libraries, and to reduce information overload by providing suitable information according to given situation. By reducing data load, AR helps to overcome the information overload challenge, both for information systems and humans.

4.2. Technical related challenges

This group of challenges includes finding technical and

technological solutions that need to solve a series of practical problems and requirements in real situations on the battlefield (for example, power supply, mobility requirements, proper measurement and data collection, the way the data are displayed to humans, etc).

4.3. Human related challenges

In addition to general user related specifics, AR usage in defensive activities involves some organizational roles of individuals. For example, requirements of AR solution for a military commander are not same as for a pilot or a tank driver. Design of AR solutions have to provide an adequate set of devices and apps suitable for each role that human can take in defense.

5. CONCLUSION

Augmented reality represents growing technology in defense industry. It is increasingly present in defensive activities. Some of key roles and benefits of its application are presented in this paper. The key roles are interweaved, mutually complementary, and leads to creating a new value in the dual (real and digital) world of data [12]. The challenges that humans face with in defensive activities can be successfully resolved thanks to AR solutions.

AR has a distinctive feature to change the way in which information can be delivered [10]. It helps to save lives of civilians, fighters, and members of special units. This points to necessity of future researches in order to improve technology design and find specific solutions that impose defensive activities.

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