AUGMENTED REALITY – NEXT DIGITAL STEP FOR THE EUROPEAN INTEGRATED EMERGENCY SYSTEM

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ABSTRACT:
THE PRESENT PAPER AIMS TO BRING INTO THE SPOTLIGHT ONE OF THE NEWEST SOLUTIONS FOR IMPROVING THE EMERGENCY SYSTEMS DYNAMICS, A SOLUTION AROUSED FROM THE DIGITAL ENVIRONMENT WE FACE TODAY: AUGMENTED REALITY. THE POSSIBILITY TO REPLACE COSTLY AND HEAVY MAINTENANCE REQUIRING MACHINES WITH AUGMENTED REALITY COUNTERPARTS, THE POSSIBILITY TO BRING INTO FOCUS ENTIRE SETS OF DATA AT THE EXACT TIME AND PLACE AS TO ENSURE THE BEST MOMENTUM FOR STRENGTHENING THE EMERGENCY RESPONSE AS WELL AS THE POSSIBILITY TO PROVIDE REAL-TIME DATA OVER ELECTRONIC NETWORKS IS A MANDATORY NEXT STEP FOR THE EMERGENCY SYSTEMS. THE PAPER PRESENTS AND COMPARES DIFFERENT WORLDWIDE USED APPROACHES FOR INTRODUCTION OF AUGMENTED REALITY INTO THE DIGITAL ENVIRONMENT WE USE TODAY. THE PAPER ALSO PRESENTS A SET OF CASE SCENARIOS FOR POSSIBLE INTRODUCTION OF AR SUPPORTED ACTIONS WITHIN THE EMERGENCY RESPONSE SYSTEMS. TECHNICALLY SPEAKING, THE SMART USE OF DIFFERENT VIRTUAL REALITY APPLICATIONS, SUCH AS AUGMENTED REALITY, CAN BE THE BEST SOLUTION, ON SHORT TERM AT LEAST, FOR THE ROMANIAN AND EU EMERGENCY SYSTEMS TO IMPROVE QUALITY WHILE KEEPING THE COSTS DOWN.

KEY WORDS: AUGMENTED REALITY, DIGITAL HIGHER EDUCATION, VIRTUAL REALITY TRENDS, DRONES

INTRODUCTION

Augmented Reality (AR) is a reality that catches up to us at a very fast pace. During the last couple of year, the Augmented Reality applications invaded all types of electronic human-machine environment, from personal computers to movies, from mobile phone to video gaming consoles. Nevertheless, we have to remind that this type of applications is, by no means, something unique and new to these last several years. The Augmented Reality applications started more than 50 years ago – closer to the times of world war two than today. The first AR application is now generally considered to be the machine known as "Sword of Damocles". The name came from the famous ancient Greek story of Damocles, because the machine was in fact suspended on top of the user's head (see figure 1), hanging from the ceiling. Professor Ivan Sutherland, from USA, working together with his student Bob Sproull, are the pioneers that managed to design, develop and build that unique machine.

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Figure 1. The first AR device developed in 1967 – “Sword of Damocles”[3]

As in case of a lot of modern era developments, the first section of the society that tested and later adopted the new concept was the military. In fact, today, AR is almost standard equipment on most of the latest, state-of-the-art military machines. The largest, and first chronologically speaking, large user base for AR was the air force. The pilot helmets, the equipment that seemed to come from the ages, became an active player in the air force, now actively helping the pilot to control the plane, acquire targets and even direct fire. The concept became known as HUD (head up display) and, even though, basically, is a direct development of Sutherland’s machine, it is light years away from it, in both size and capabilities. Besides the air forces, now virtually all branches of the advanced countries military employ AR in most of their deadly arsenals: tanks, ships, guns and rockets all use different AR applications to enhance their capabilities.

We will introduce in this article several ideas and concepts that support the use of AR not only for military, but for public emergency systems.

MAIN PUBLIC WIDE-SCALE USE OF AUGMENTED REALITY

Despite the aura of high tech devices, nowadays in fact everyone can get in touch with the Augmented Reality! All mobile phones categorized as smart phones are in fact able to connect to the AR field, through software applications that take advantage of the different sensors already placed inside these devices.

We have today the ability to put AR applications to good use in very different civilian-life fields, such as education, tourism, support, medicine or scientific research. Besides these approaches, a huge impact on both present but mostly future use of AR is done by the gaming industry. In 2003, an American company launched a new type of video game – a “virtual reality” game that became iconic for the first decade of this millennium, Second Life. Even

[3] Image available from: http://etsanggarp.blogspot.ro/2016_03_01_archive.html

though Second Life was more of a simulation game and did not involve actual Augmented Reality features, the players that formed the huge ecosystem of the game (started 14 years ago, and still existing!) are, of course, more prone to make the next step and bring reality into their online environment, embracing without reserves the new mixture of real and virtual that form the Augmented Reality of today.

Many specialists today consider that we are today at the beginning of fourth stage, from the point of view of computing power. This integrated approach defines the new computing power as an integrated continuum of numerous sensors, online cloud platforms, big data analysis, artificial intelligence algorithms and electronic wearables. This 4^{th} stage is bases on technology directions such as AR (augmented reality), VR (virtual reality) and MR (mixed reality). Per a public report of the Bank of America “It [AR/VR/MR] has the potential to become the ‘form factor’ for nextgen computing as a universal, smart, and intuitive interface for the internet of things (IoT) ecosystem. It could be the technology that disrupts the rules – bridging the digital and physical worlds”[4].

There are two different approaches to public AR use, that we can discern very easy: dedicated devices and software applications on convergent devices.

SOFTWARE APPLICATIONS FOR AUGMENTED REALITY

The software approach of implementing AR has a huge advantage from the start – the pricing. If one already has a smartphone and considering that the internet access (still a mandatory requirement for most AR applications) is today something as trivial as water access, electricity or public transportation – going even further, in several countries internet access is already a right in itself, stipulated within the legislation in the case of Finland for example[5] – of course that the next logical step is to allow this person to enjoy AR without having to buy another hardware device. All one should do is use the GPS inside the phone – for location triggered AR – or point the camera to a certain type of AR marker.

Software applications for AR are most widely used for tourism, education, support services and gaming but, lately, they started to appear in retail sales too. We should also note that, in clear majority, these applications are focused on mobile devices such as smartphones and on the traditional vehicles for new technologies in the IT field, the personal computers – in either desktop or laptop flavors.

There are several interesting facts that we can comment on, regarding this mobile/smartphone orientation of the AR software applications. As in all life aspects usually, there are pros and cons to this situation. The applications being target to smartphone mostly means that we are always ready to use them, so AR becomes more and more something that is right at hand and will, at some point, become as normal as internet browsing today. For example, based on an AR application that you can use for free an any smartphone, one can see how the ancient Colosseum looked like almost 2000 years ago, (see figure 2), how will the new couch will fit inside the living room (see figure 3) or shoot some hoops over a virtual arena (see figure 4).

[4] https://www.bofaml.com/content/dam/boamlimages/documents/articles/ID16_1099/virtual_reality_primer_short.pdf - Public Report of Bank of America – Merrill Lynch, published: September 22, 2016; last access: July 29, 2017

[5] TĂBUȘCĂ, Silvia-Maria; *The Internet Access as a Fundamental Right*, Journal of Information Systems and Operations Management – vol.4 no.2 pp.206-212, 2010

Figure 2. Colosseum through an AR application that can reconstruct different sections[6]

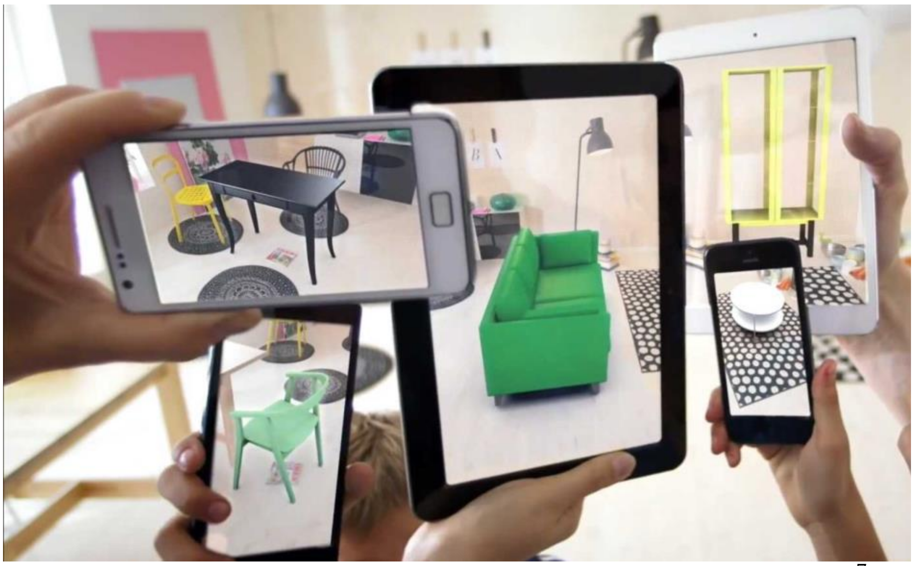

Figure 3. Augmented Reality application from IKEA catalogue[7]

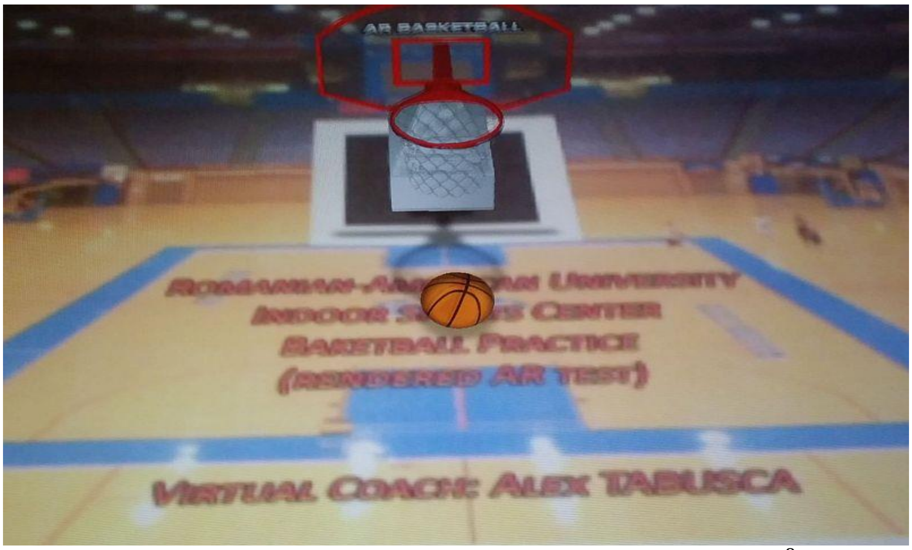

Figure 4. Capture screen from AR demo application[8]

[6] Image available from: https://www.youtube.com/watch?v=WOVjISxlhpU
[7] Image available from: http://www.businessinsider.com/ikeas-2014-augmented-reality-catalog-2013-8
[8] Image from AR demo application presented by the author, Alexandru TĂBUȘCĂ, at MLIBCW-2016 international conference (http://mlibcw.rau.ro)

HARDWARE BASED AR APPLICATIONS

Besides relying on "your" software, AR applications can also require specialized, dedicated hardware in order to provide different services. One field that can greatly improve AR quality experience is computing power. The CPUs of today are still the brains of a computer but, strictly number wise, they are sometimes put to disadvantage by the sheer computing power provided by the dedicated graphic cards/CPUs of today. The two main vendors of graphic solutions for computers today, NVidia and ATI, have both integrated different enhancements into their architectures, so as different applications, including AR ones, could take advantage of the huge capabilities of number crunching and memory size that a modern GPU can add to the total computing power of a device[9]. Together with other cases, such as very difficult mathematical calculations or weather predictions, AR greatly benefited from both GPU usage and modular software architectures[10].

The best-known AR hardware dedicated device is the (now defunct) Google Glass. Even though the idea and even the implementation were very good, the device did not manage to get itself on the market, mainly based on potential privacy issues and not because of any hardware/software problems. We are quite convinced that this device was a little bit ahead of its time and, in the next decade, something very similar if not a direct offspring will emerge and become a game-changer product, much like iPhone or iPad on the smartphone and tablets markets.

Think for a moment, of a Google Glass implementation for emergency services. Let alone different privacy issues – real and important, of course – the possibility of the medical personnel to wear and make use of such devices would be of an invaluable help. If the emergency team that arrive to a certain accident site has no surgeon included, and the closest one is 500 km away – the possibility to live-stream, directly from the Google (or whatever the name) smart glasses, the situation seen through the onsite doctor's eyes to the specialist at 500 km afar in invaluable. The smart glasses, together with different AR applications, can even propose a certain diagnostic to the onsite physician or help with different proposals and data gathered automatically through its own or connected sensors.

One hardware device that managed to clearly impose itself as a real contender to classical solutions - based on price, ease of use and comfortability – is the drone. Yet again, we have to mark that first wide-scale usage was again for military purposes. But the military drones, even though much cheaper than the previously classical solution for throwing bombs, spying or recon, are very expensive and require specialized maintenance. On the other hand, the public-use drones have become event cheaper than some high-priced toys! Almost all drones today have versions that can carry, or come equipped with, a digital camera that can take pictures or shoot movies. Almost all drones today have an attached application to control it through one's smartphone, tablet or personal computer.

One of the latest and state of the art implemented technologies on civil drones make use of AR for an optimized way of flying. The implementation of AR for drones is used at software level, by automatically recognizing objects such as vehicles and humans. Using algorithms for recognizing humans is a leap forward in the use of small sized civil drones. The algorithms recognize humans not to suppress them, as their military cousins do, but to try to avoid or help them. A further usage of AR drone technology means not only to recognize things but also to track them through a real, urban-like environment. This approach is at a

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[9] PÎRJAN, Alexandru; *Managing graphics processing units' memory and its associated transfers in order to increase the software performance*, Journal of Information Systems and Operations Management – vol.11.no.1 pp.106-117, 2017

[10] STĂNICĂ, Lavinia; *Modular Software Architecture for Authoring Mathematical Content*, Journal of Information Systems and Operations Management – vol.9 no2 pp.493-504, 2015

different level of complexity and usually requires a hardware supplement on the tracked item, in order to ensure an optimum tracking capability for the drones[11].

The usage of AR can be further enhanced by employing drones with implemented AR technology for recognizing humans at accident sites, a solution than can be integrated into the European Integrated Emergency System. The AR implementation can have many uses, depending on what purpose has to be achieved. Basically, the main construction of algorithm classes of recognizing humans could be enlarged with child classes for different features. In figure 5 we have an example of a civil use of active tracking for humans, using AR technology implemented on civil drones. Together with the real landscape and the different persons engulfed in a sport activity, we can observe different indicators such as speed and position. From this forward, we can think on other implementation such as identifying persons on accident sites and even assessing their state.

Figure 5. Demo image for DJI Phantom 4 Pro Quadcopter[12]

Accurate classification of the subjects is very important, so that different types of actions can be initiated. Initially, all subjects are identified based on main characteristics - such as form. Advanced algorithms of visual recognition will be carried out automatically, so that subjects are clearly identified by classification and thus reducing the risk of software confusion to a minimum. For example, in case of the AR integration to an emergency system, main types of subjects that need to be recognized as vehicles would be: civilian, emergency, police, special transportation. Going further to a set of sub-types for vehicles, we should have something in the lines of: two wheels, four wheels, goods transportation, people transportation etc.

To help with the easily distinguish between the civil vehicles and the emergency/police ones, specific visual printed elements can be physically added on the latter. In this way, the software algorithm will have a certified element to check/rely on, and subsequently, will be able to categorize and act much faster while minimizing the risk of confusion between vehicle types.

It is important to specify that visual elements are not something of a mandatory requirement, because the main construct of the identification classes has enough elements of

[11] CALLOWAY Thomas, MEGHERBI Dalila, ZHANG Hongsheng; *Global localization and tracking for wearable augmented reality in urban environments*, Computational Intelligence and Virtual Environments for Measurement Systems and Applications (CIVEMSA), 2017

[12] Image available from: https://www.amazon.com/DJI-Phantom-Professional-Quadcopter-CP-PT-000549/dp/B01N639RIJ

classification. Nevertheless, because of the importance of using this technology in rescue missions any means of minimizing the risk of confusion must be used.

Other characteristics that can be determined using the AR technology are quality elements such as color, temperature, altitude, moisture, etc. These are characteristics that are already widely and easily used in today's smartphones, based on different type of sensors. Having already behind the experience of the smartphone, implementation of all these sensors into other devices, such as drones, is quite an easy feat.

Quantity of identified information, gathered from the AR enhanced drones, is important in the process of estimating the dimension and size of an accident site. Quantitative elements include the dispersion of identified elements and the number of involved elements. Example of quantitative elements could be: how many vehicles are detected, how many persons are detected, the dispersion of the accident site fragments (for and size of a space designated as accident site), altitude, temperature, wind speed etc.

At least at this time, based on using of-the-shelf equipment, an example of using drones for emergency situations is not exactly straight forward. Sending remote drones to the site from a faraway rescue center is not doable, because of signal range problems and battery range issues. More likely, the usage scenario involves send a drone after the moment a real rescue vehicle arrives to the accident site – thus, flying the drone locally. One can say that there should be a specialized person that can fly the drone on site. But as drones come today equipped with many sensors that can put it in autopilot mode, the presence of specialized personnel is not a very relevant requirement – a short several-hours training can render anybody into a drone-user.

A real-case example can be as follows:

- the rescue team arrives at the accident site
- anyone of the rescue-team members takes the drone out of its casing and positions it as close to the accident site as possible, then pushes a single button
- the drone initiates a set of standard actions predefined for such rescue missions
- the drone elevates to a certain altitude and gathers as much information as possible
- the drone sends the information to a predefined smart device such as tablet or smart phone, to the on-ground personnel
- the drone can also be turned to manual mode, if a human controller needs a customized information gathering service

Going even further, the AR software on the drone can be configured to act based on recognition of different gestures, form different actors involved. In figure 6 we can see an example of AR acting on gestures in order to recognize a human. This recognition can trigger an action of flying directly above the human and transmitting its exact coordinates to the rescue team. The gesture triggers can be made available only for rescued/in need of rescue subjects, so as to limit the confusion of getting false triggers from other unauthorized onsite persons.

Figure 6. AR identified human gestures[13]

Of course, all identified characteristics send by an AR application would be used to categorize the subject but also to transform the raw data into human-like messages, based on a database of corroborated values and artificial intelligence. After receiving the set of data from the drone sensors, the AR should be able to interpret it and provide something more complex, like for example: "*The values of color, temperature and moisture indicate a certain inflammable or explosive material is identified on site*".

Gathering all the information from the devices used on or off accident site are crucial in acting based on highly rapid and documented decisions. The information must be gathered and stored on onsite servers as well as on centralized servers (based on a cloud solution). In this way, if there is a signal error contacting main servers, the onsite emergency delegated officials can take immediate and more documented actions even without having to wait for the repair of the communication breach between the respective location and the central site.

Of course, the introduction of AR drones will not only bring benefits, it will also bring about the issue of the devices maintenance and own emergency situations. Fortunately, the issue of the drones' emergency in-flight situations has already been studied and solutions have been found in order to keep it controllable and able to return to the human controller even in case of rotor malfunctions[14].

CONCLUSION

Smart devices, equipped with state of the art hardware and software technologies such as augmented reality, can offer – even NOW, not somewhere in a more or less distant future - a more reliable and faster decision based action in crucial moments such as rescuing lives from accident sites.

The only visible and important drawback of the equipment that we can use today is the lifespan of the energy source. Unfortunately, the best of-the-shelf drone today have batteries that can help them fly, in best conditions, around 30 minutes on average. As with all other smart devices today (laptops, tablets but more important smartphones) this issue of energy recharge requirement is critical and it becomes more and more so. As time passes, more and more intelligent algorithms are developed, more and more miniaturized components and

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[13] Image available from: https://www.newegg.com/Product/Product.aspx?Item=9SIAAWD5325941

[14] MERHEB Abdel-Razzak, BATEMAN Francois; *Emergency Control of AR Drone Quadrotor UAV Suffering a Total Loss of One Rotor*, IEEE/ASME Transactions on Mechatronics – vol.22 issue 2 pp.961-971, 2017

sensors are available – but all of them need power to operate. We consider that the next brake through that smart device really need is not something related to computing power, is not a new type of sensor or a better camera, is a new type of battery that would last a lot longer and charge a lot faster.

While many herald the economic downsize in costs, related to AR devices being implemented on large scale, there is no definite answer at this time. The technology is in fact quite at the beginning, and even though it has a huge potential there will probably not be a world-wide scale replacement of personnel only activities with AR counterparts. Others consider that the best approach would be a safe one, as to first go through a MR (mixed reality) solution before relying solely on VR (virtual reality).

As a further direction of this study, we aim to finish a hands-on research that will provide hard data on economic costs related to implementing a complete AR supplement component (hardware, software, controller training, personnel) to an emergency system response team such a Romanian SMURD team.

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