АНАЛИЗА НА МОЖНИ ТЕХНИЧКИ РЕШЕНИЈА ЗА ВИЗУЕЛИЗАЦИЈА НА ВОЗИЛА ВО ПРОЦЕСОТ НА ВЕШТАЧЕЊЕ НА СООБРАЌАЈНИ НЕЗГОДИ БАЗИРАНИ НА АУГМЕНТНА И ВИРТУЕЛНА РЕАЛНОСТ

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АБСТРАКТ

Современите технологии на визуелизација наоѓаат своја примена во многу области од човековото живеење. Аугментната и виртуелната реалност претставуваат технологии на визуелизација во кои виртуелните објекти се комбинираат со реалните и тие коегзистираат во просторот, односно се прави целосно заменување на реалноста со компјутерски моделирано окружување. По својата природа, овие технологии отвораат можности за нивна примена и во процесите на вештачење сообраќајни незгоди. Во овој момент на развој на техниките потребно е да се направат почетни обиди за нивно користење во споменатата област. Постојат реални очекувања дека таквите техники можат да служат како дополнителни алатки во процесот на вештачење сообраќајни незгоди, односно дополнителна алатка во рацете на вештите лица кои се бават со вештачење сообраќајни незгоди. Во трудот се дадени резултати од истражување кое се одвива во насока на користење на технички решенија за визуелизација на возила во процесот на вештачење на сообраќајните незгоди, прикажувајќи ги нивните позитивни карактеристики како и ограничувачките фактори.

Клучни зборови: аугментна реалност, виртуелна реалност, 3Д визуелизација, вештачење на сообраќајни незгоди и техничка визуелизација.

ANALYSIS OF THE POSSIBLE TECHNICAL SOLUTIONS FOR VISUALISATION OF VEHICLES IN THE PROCESS OF CRASH FORENSICS BASED ON AUGMENTED AND VIRTUAL REALITY

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ABSTRACT

The advanced technologies find their application in many areas of todays’ human life. Augmented and virtual reality are visualization technologies in which the virtual objects are combined with the real ones and coexist in the same space, or completely substitute the reality with computer modelled environment. In their nature, these technologies open up opportunities for their application in the processes of crash forensics. In this stage of development of these visualization technologies, initial steps have to be made for their use in the area of crash forensics. Real expectations exist that these technologies can serve as additional tools in the process of crash forensics, or as an additional tool in the hands of the experts that make the crash forensics. This paper presents the results of conducted research in the direction of use of technical solutions for visualization of vehicles in the process of crash forensics, presenting their positive characteristics along with their limitations.

Key words: augmented reality, virtual reality, 3D visualization, crash forensics and technical visualization.

1. Introduction

The advanced technologies find their application in many areas of todays' human life. Augmented and virtual reality are visualization technologies in which the virtual objects are combined with the real ones and coexist in the same space, or completely substitute the reality with computer modelled environment. In their nature, these technologies open up opportunities for their application in the processes of crash forensics.

The advanced visualization technologies became part of the forensics process very soon after their deployment. Their use in the forensics process has been well accepted and appreciated. Based upon factual data, forensic animations can reproduce the scene and demonstrate the activity and location of vehicles, objects, and involved persons at various points in time using 3D modeled scenes and objects, 3D animations and recently augmented and virtual reality. This ability to model and visualize in 3D, has enabled the users to observe the scene from various viewpoints such as the driver's view, the victim's view or the witness' view. The advanced visualization techniques for reconstruction of crime scenes are replacing the traditional illustrations, photographs, and verbal descriptions, and they are becoming popular in today's forensics (M. Ma, et al. 2010).

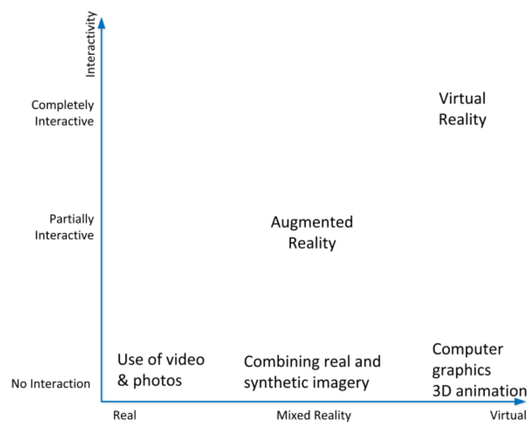


Figure 1 – Visualization techniques and their level of interactivity (Source: M. Ma, et al. 2010).

The diagram in Fig.1 presents the key difference between AR/VR and other visualization techniques and that is the level of interactivity. The use of visualization techniques like videos and photos use only real object while computer graphics and 3D animation use only virtual object. By combining the real and synthetic imagery a mixed reality is created. In all these three cases there is no user interactivity. VR and AR provide an interactive real-time 3D graphical environment that responds to user actions such as moving around the virtual world or maneuvering virtual objects. VR⁄AR can put the user in the driver's seat for accident reconstructions and allow the user to observe a scene from a desired point of view, which is impossible in film or photos. A VR⁄AR user can also, for example, play the various roles in an accident like perpetrator or witness to experience the reconstruction of the incident.

2. Augmented Vs. Virtual Reality

According to Azuma (1997), Augmented Reality (AR) is a variation of Virtual Environments (VE), or Virtual Reality as it is more commonly called. In these so called Virtual Environments the user is completely surrounded by a synthetic environment. In that state, the user can not perceive the real world and the real environment that surrounds him/her. On the contrary, the Augmented Reality (AR) allows the user to perceive the real world while the virtual elements are superimposed upon or composited with the real world (Sutherland; 1968). In this manner, the augmented reality is enriching user's perception of the reality rather than totally replacing it like in the case of the virtual environments. The ultimate goal of the AR is to convince the user that the two environments, real and virtual, coexist (Rizov; 2015).

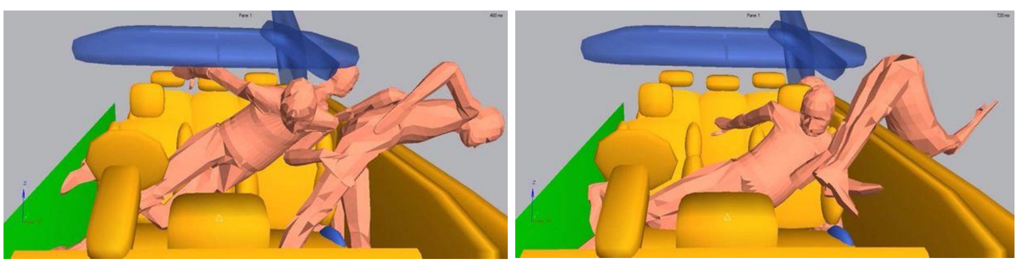
Experts also differentiate between Augmented Reality and Virtual Reality (VR). VR is a completely computer generated, immersive and three-dimensional environment that is displayed either on a computer screen or through special stereoscopic displays. In the VR all objects are synthetic so their coexistence in the space is easily organized since occlusion and registration are solved easier. The main down side of the VR is the cost for creation. In contrast, AR combines both the virtual and the real. Users of AR are still able to sense the real world around them; this is not possible when people are immersed in VR. Besides the need to model all the objects in the environment, the laws of physics also have to be simulated (Pejic; 2016).

AR is made possible by performing four basic and distinct tasks, and combining the output in a useful way. **(1) Scene capture:** First, the reality that should be augmented is captured using either a video-capture device such as a camera, or a see-through device such as a head-mounted display. (**2) Scene identification:** Secondly, the captured reality must be scanned to define the exact position where the virtual content should be embedded. This position could be identified either by markers (visual tags) or by tracking technologies such as GPS, sensors, infrared, or laser. **(3) Scene processing:** As the scene becomes clearly recognized and identified, the corresponding virtual content is requested, typically from the Internet or from any kind of database. (**4) Scene visualization:** Finally, the AR system produces a mixed image of the real space as well as the virtual content (DHL; 2014).

3. Analysis of existing technical solutions for visualization of vehicles in the process of crash forensics

The technical solutions for visualization of vehicles in the process of crash forensics have not been fully adopted according the development of the software and hardware used in these visualization solutions. In the beginning, the use of technical solutions for visualization in the process of crash forensics was in line with the development of visualization solutions based on computer graphics and animation. The use of technical solutions based on 3D modelling and Virtual Reality in the process of crash forensics was lacking behind of the development of these technical solutions. This was mainly due to the fact that the learning curve required to master the technology was too long. The development of Augmented Reality as a visualization technology has progressed rapidly in the last 10 years. However, its use in the process of crash forensics is still very limited.

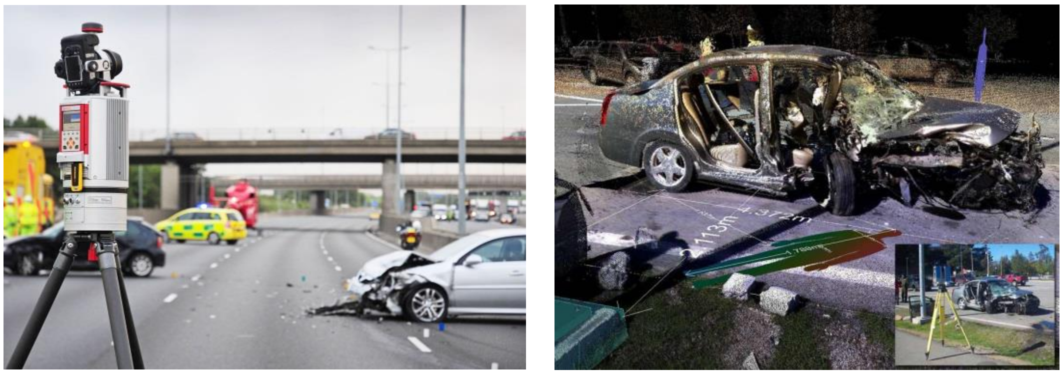
Other various technologies have supported the adoption progress of the visualization technologies in the forensics process. The use of CAD software that use dynamics simulation are one of these technologies. In the United Kingdom, computer records are acceptable as evidence if they can be proved to be correct and accurate (Burton et al.; 2005). This leads to the significance of introducing dynamic simulation (a.k.a. physically based simulation) to forensic animation, because dynamic simulation is capable of accurate modeling of objects and human motions based on Newton's laws of motion (M. Ma et al.; 2010).



a) b)

Figure 2 – Copmuter Grafics Animation results from a CAD software using dynamics simulation to determine the motion of objects in an accident; a) what the perpetrator described, b) what the software simulate based on evidence and marks on the vehicle. (Source: Advanced Symtech; 2015).

One more very important technology that supported the adoption progress of the visualization technologies in the forensics process is the use of laser scanning. The laser scanning devices offer the possibility to acquire a huge number of accurate measures from an accident scene providing the technicians with the ability to acquire the measures and leave the incident site very fast. After scanning the site, the acquired data are introduced to a CAD software in order to create a 3D model of the accident and complete the crash forensics process. The main barriers of this technology are the very high price of the laser scanning equipment, the accuracy and portability of the equipment and again the learning curve of the technicians for mastering this technique.



a) b)

Figure 2 – Laser Scanning of a crash site. a) Scanning an accident site, b) Measuring important distances using CAD software based on the data aquired by laser scanning. (Source: MAPTEK; 2016).

Vehicular accident reconstruction work often focuses on estimating the speeds of crashed vehicles. Vehicle velocities are often estimated by correlating the crush deformation of a crashed vehicle with vehicle speeds using stiffness coefficients determined from crash tests. Vehicle crush is determined by measuring the crashed vehicle and comparing these dimensions with a reference vehicle, the exemplar. Other methods include measuring the length of skid marks, vehicle displacement and other accident geometry (Higgins; 2004).

Standard practice in most police departments today is to measure accident scenes and vehicle crush manually using calipers and tape measures. This is time-consuming, slow, sometimes dangerous and often limited to a few tens of measurements. Slow is a big problem in areas of congested traffic. Closing a lane to measure accident sites often leaves the driving public stuck in traffic, which can lead to collateral incidents. The police officer in charge at the scene sometimes has to make a tough call to balance the requirement to take sufficient measurements for evidence against minimizing disruption to the driving public (Higgins; 2004).

4. Analysis of possible technical solutions for visualization of vehicles in the process of crash forensics based on Augmented Reality

This paper presents the results of conducted research in the direction of use of technical solutions for visualization of vehicles in the process of crash forensics, presenting their positive characteristics along with their limitations. The focus of the research was to determine if the technical solutions for visualization based on AR and VR can help collecting the necessary data on faster, more precise and reliable way, and provide additional information valuable in the process of forensics.

The concept idea for use of AR based solution is to eliminate the use of expensive equipment and to foster the rising performances of the all present hand-held devices (smart phones and tablets). The mid and high-end range hand held devices are equipped with sufficient processing power along with sensors with satisfactory accuracy (GPS sensor, infrared, gyroscope etc.). This provides an opportunity to move the technical solutions for visualization of vehicles from laboratories to the actual incident scene and from the expensive equipment to the hand-held devices.

Using the software application for mobile devices Augment, the crash site reality can be augmented by adding a 3D CAD model of the same vehicle overlaying the crashed one as presented in Fig.3. This results in enriching the sight of an expert assisting him/her in visualization of the level of deformation on the crashed vehicle by comparing it to the original shape and dimensions of the same type of vehicle.

The application was tested using a real crashed vehicle and a CAD model of the same type acquired through the Google Warehouse database of 3D models. The next step was to adjust the CAD model by setting the correct scale of the model and the appropriate coordinate system. Next, the CAD model of the vehicle was uploaded to the servers of Augment in order to later use it in their application for hand-held devices. For the purpose of this research, as a test specimen a crashed vehicle available at a local dealership was selected. The specimen vehicle is moved from the original crash site and the front bumper is removed, but these parameters are considered to be not important for the goal of the test and that is to analyze the applicability of the solution. On a regular iPad tablet the Augment app was installed and logged in to the previously made account where the CAD model was uploaded. At the location of the crashed vehicle, the CAD model was loaded to the iPad. The back faced camera of the iPad displays the video feed of the crashed vehicle and its surrounding to the screen of the tablet. The previously loaded CAD model is overlaid on the real view of the crashed car resulting in an Augmented Reality as shown on Fig.3.

This tool should assist the expert in completing the crash forensics process easier and in higher accuracy right at the accident scene. By using the real crashed car and the real environment of the accident site this visualization technology results in lower costs. That is because these elements do not have to be modeled in CAD. In addition, this lowers the time needed to master the use of the technique. The downside on the software side of this solution is the need of a comprehensive data base of 3D models of different types of vehicles in order to use them as reference in the comparison. This can be solved in different ways, for instance by including the vehicles manufacturers by providing the 3D CAD models of their vehicles since they are already part of their production management processes. The downside on the hardware side is the lack of ability to make measures using the software application, measuring for instance distances or angles between the real objects and the CAD model. The current generation of hand-held devices is not equipped with such sensors to measure depth. Nevertheless, this is the case of the devices used by general population. Already today on the market devices that have this technology incorporated exist, like Google's Project Tango, Structure's Sensor for iPad or Microsoft's Kinect.

Figure 3 – Visual presentation of vehicles in the process of crash forensics using Augmented Reality.

5. Analysis of possible technical solutions for visualization of vehicles in the process of crash forensics based on Virtual Reality

The concept idea for use of VR based solution is to overcome the downside of the AR based solution for making measures in the process of crash forensics. Instead of using a high-end laser scanning equipment, this research investigates the possibilities of using a hand held scanning device – Google's Project Tango. This device, similar to its rivals, is equipped with a stereo camera (4 MP 2mm RGB-IR pixel sensor and 1 MP front facing with fixed focus), motion tracking camera with 3D depth sensing ability. This device incorporates all necessary sensors and processing capabilities under one chassis making it ideal for this application.

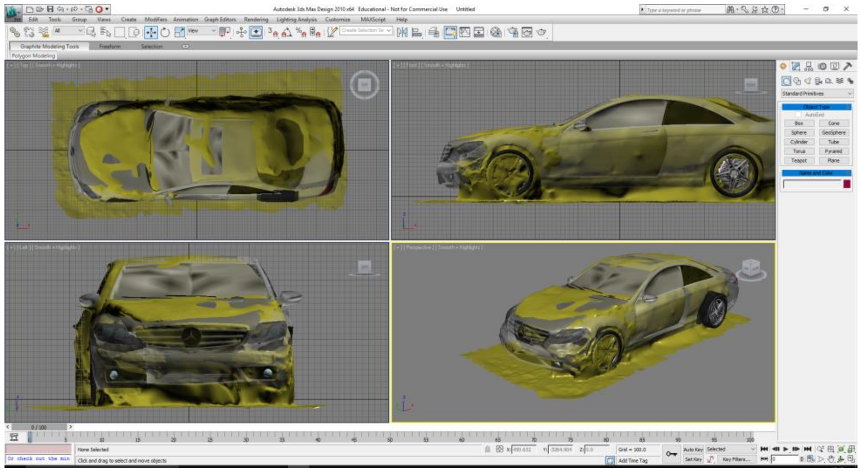
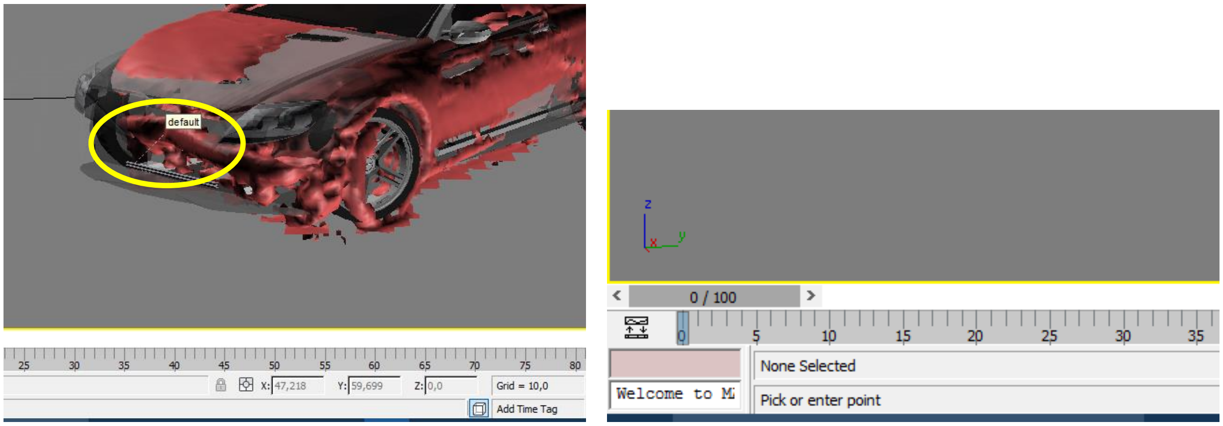


Figure 4 – Visual presentation of vehicles in the process of crash forensics using Virtual Reality.

Using the Tango tablet the crashed vehicle is being scanned and a 3D CAD model is exported. The scan was done on the same specimen vehicle at a local dealership. The ability to export .OBJ file types provides the opportunity to use different types of software applications. For the purpose of this research the Autodesk's software 3ds Max was used. The .obj file from the scanned crashed vehicle is imported in 3ds Max and overlaid on the CAD model of the vehicle as presented in Fig. 4.

This provides the same visualization and comparing capabilities like the AR solution. In addition, this solution provides the ability to make accurate measures between the elements in the scene (distances and angles). Like presented in Fig. 5a, the displacement between two points can be easily and accurately measured. The displacement of a point from the CAD model of the vehicle and the same point selected from the crashed vehicle is presented by all three axes relative to a same Cartesian coordinate system. For the purpose of this research, related to the characteristics of the crash, as point of interest the front lateral beam of the chassis understructure was selected. The tested VR solution provides the ability to measure the displacement according the *x*, *y* and *z* axes of all points of this element from its original position to its deformed position after the crash. This task is conducted in a form of a dialogue where after starting the command of the “Measure” tool, the software asks the user to select the first point by clicking on one of the models, than selecting the second point while presenting a dashed line between the two selections illustrating the measured distance. The result is presented on the command line (Fig.5 b.).



a) b)

Figure 5 – Virtual Reality based solution's ability to make measures of distance between objects. a) Selecting points to measure distance; b) Displacement of the selected point by all three axes.

The main downside of such solution is the accuracy of the scanned crashed vehicle. The selected vehicle did not have significant damage, so the faces of its shape acquired with the Tango tablet were accurate enough and easy to recognize. But if the crashed vehicle has significant damage than the level of accuracy provided with this hardware is not going to be sufficient. Additional techniques can be introduced for improving the scan quality like use of markers, limiting the reflection of the surfaces and securing the adequate level of light.

6. Conclusions and recommendations for further research

The presented technical solutions for visualization of vehicles in the process of crash forensics based on Augmented Reality and Virtual Reality impose as possible additional tool for the experts. They are reliable and easy accessible, with short learning curve. At this point, they can be perceived as assistance to the process only if they are used by experienced forensics experts with broad understanding of vehicle dynamics and mechanics.

Further research and development in this field should move towards closing the loop – that is by using the data (measures) acquired through this solution to result in the end with assistance in calculating accurate information like speed and direction of moving of the vehicles, components of the acceleration, intensity and angle of the forces applied to an object, etc. This would make the presented solution much more usable and productive in the crash forensics process.

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