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GEO-BASED SYSTEMS IN AUGMENTED REALITY

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A b s t r a c t: Today's life is different to the one that existed not so many years ago. Our everyday life is constantly changing. The use of new technologies play major role in this change. Augmented Reality (AR) is looking to be the 8th mass market to evolve, following print, recordings, cinema, radio, TV, the Internet and mobile. In combination with geo-based technologies, augmented reality provides a completely new way of execution of the everyday activities. This paper presents the basic concepts and key characteristics of these two technologies. Also, the paper presents an example of a use of the technologies in an application meant for students for navigation through the campus of the Faculty.

Key words: augmented reality; 3D objects; geo positioning; visualization

СИСТЕМИ БАЗИРАНИ НА ГЕОГРАФСКО ПОЗИЦИОНИРАЊЕ ВО АУГМЕНТНАТА РЕАЛНОСТ

А п с т р а к т: Животот денес драстично се разликува од она што постоеше пред не толку многу години. Нашиот секојдневен живот постојано се менува. Употребата на нови технологии има клучна улога во оваа промена. Аугментната реалност (АР) има изгледи да биде 8-миот масовен пазар кој се развива, по печатењето, аудио продукцијата, киното, радиото, телевизијата, интернетот и мобилната телефонија. Во комбинација со технологиите за географско позиционирање, аугментната реалност обезбедува комплетно нов начин на извршување на секојдневните активности. Овој труд ги претставува основните концепти и клучните карактеристики на овие две технологии. Исто така, трудот претставува и еден пример за употреба на овие технологии во апликација наменета за студентите за навигација низ кампусот на Факултетот.

Клучни зборови: аугментна реалност: 3Д објекти: географско позиционирање: визуелизација

1. INTRODUCTION

Today's life is different to the one that existed not so many years ago. Our everyday life is constantly changing. The most important characteristics of our era may be the transformation, transmission and dominion of information. We live in an information society where the leading role has been given to new technologies. Our society could not be imagined without new technologies and their role both in this society and in human life in general.

With a growing amount of applications relying on spatial information systems, there is a corresponding increase in the number of naïve users of such systems. Recognized for handling complex decision-making processes, spatial information systems need to be enhanced with real-world views in order to present the information in an understandable, user-friendly way [1]. Hence, the combination of the two emerging technologies of geo based spatial information systems and augmented reality.

Augmented reality (AR) is a technology that enables digitally stored spatial information to be overlaid graphically on views of the real world [2]. AR holds enormous promise to enhance human management of complex systems, such as power plant maintenance procedures, cardiac surgery but also navigation through complex environments.

AR can be used as an enhancement in decision-making and operational efficiency in dealing with the intricacies of both natural and build environments. Considerable work is in progress around the world on hardware and software to develop AR systems.

2. AUGMENTED REALITY

Augmented Reality (AR) is a variation of Virtual Environments (VE), or Virtual Reality as it is more commonly called. VE technologies completely immerse a user inside a synthetic environment. While immersed, the user cannot see the real world around him. In contrast, AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it. Ideally, it would appear to the user that the virtual and real objects coexisted in the same space. Azuma [3] gives a more comprehensive definition of AR as a system that has the following characteristics: (1) combines real and virtual world, (2) interactive in real time and (3) registered in 3D. Augmented Reality enhances a user's perception of and interaction with the real world. The virtual objects display information that the users cannot directly detect with their own senses. The information conveyed by the virtual objects helps a user perform real-world tasks.

Augmented Reality might apply to all senses, not just sight. So far, researchers have focused on blending real and virtual images and graphics. However, AR could be extended to include sound, smell or tactile.

A basic design decision in building an AR system is how to accomplish the combining of real and virtual. Two basic choices are available: optical and video technologies. Each has particular advantages and disadvantages.

Focus can be a problem for both optical and video approaches. Ideally, the virtual should match the real. In a video-based system, the combined virtual and real image will be projected at the same distance by the monitor. However, depending on the video camera's depth-of-field and focus settings, parts of the real world may not be in focus. In typical graphics software, everything is rendered with a pinhole model, so all the graphic objects, regardless of distance, are in focus. To overcome this, the graphics could be rendered to simulate a limited depth-of-field, and the video camera might have an autofocus lens.

In the optical case, the virtual image is projected at some distance away from the user. This distance may be adjustable, although it can be fixed if the display is mounted to the user. Therefore, while the real objects are at varying distances from the user, the virtual objects are all projected to the same distance. If the virtual and real distances are not matched for the particular objects that the user is looking at, it may not be possible to clearly view both simultaneously.

Contrast is another issue because of the large dynamic range in real environments and in what the human eye can detect. Ideally, the brightness of the real and virtual objects should be appropriately matched. Unfortunately, in the worst case scenario, this means the system must match a very large range of brightness levels. The eye is a logarithmic detector, where the brightest light that it can handle is about eleven orders of magnitude greater than the smallest, including both dark-adapted and light-adapted eyes. In any one adaptation state, the eye can cover about six orders of magnitude. Most display devices cannot come close to this level of contrast. This is a particular problem with optical technologies, because the user has a direct view of the real world. If the real environment is too bright, it will wash out the virtual image. If the real environment is too dark, the virtual image will wash out the real world.

A key measure of AR systems is how realistically they integrate augmentations with the real world. The software must derive real world coordinates, independent from the camera, from camera images. That process is called image registration. Image registration is one of the most basic problems currently limiting Augmented Reality applications. The objects in the real and virtual worlds must be properly aligned with respect to each other, or the illusion that the two worlds coexist will be compromised. More seriously, many applications demand accurate registration. Without accurate registration, Augmented Reality will not be accepted in many applications. Registration errors are difficult to adequately control because of the high accuracy requirements and the numerous sources of error. These sources of error can be divided into two types: static and dynamic. Static errors are the ones that cause registration errors even when the user's viewpoint and the objects in the environment remain completely still. Dynamic errors are the ones that have no effect until either the viewpoint or the objects begin moving.

Image registration uses different methods of computer vision, mostly related to video-tracking.

Many computer vision methods of augmented reality are inherited from visual odometry. Usually those methods consist of two parts. First detect interest points, or fiduciary markers, or optical flow in the camera images. First stage can use feature detection methods like corner detection, blob detection, edge detection or thresholding and/or other image processing methods.

The second stage restores a real world coordinate system from the data obtained in the first stage. Some methods assume objects with known geometry (or fiduciary markers) present in the scene. In some of those cases the scene 3D structure should be pre-calculated beforehand. If part of the scene is unknown simultaneous localization and mapping (SLAM) can map relative positions. If no information about scene geometry is available, structure from motion methods like bundle adjustment are used. Mathematical methods used in the second stage include projective (epipolar) geometry, geometric algebra, and rotation representation with exponential map, Kalman and particle filters, nonlinear optimization, and robust statistics.

However, video-based approaches can use image processing or computer vision techniques to aid registration. Since video-based AR systems have a digitized image of the real environment, it may be possible to detect features in the environment and use those to enforce registration. They call this a "closed-loop" approach, since the digitized image provides a mechanism for bringing feedback into the system. For example, in some AR applications it is acceptable to place stationeries in the environment. These stationeries may be LEDs or special markers. The locations or patterns of the stationeries are assumed to be known. Image processing detects the locations of the stationeries, and then those are used to make corrections that enforce proper registration.

According to Young [1] there are three broad components of AR systems: track, retrieve and inform. AR systems operate by tracking events and than providing users with information about those events. For visual AR systems, event monitoring is primarily based on user pose (position and attitude of the user). This information is required to enable the registration of augmented information to the user's view. Registration refers to the process of combining the user's view of the physical environment with additional information provided by the AR system. There are several types of sensors used for tracking, and often a hybrid approach is implemented to enable the AR system to operate in different environments and to provide not only user position, but also attitude. In the retrieve component, event information is used to query the AR system's database. Information can be chosen and sorted according to the restrictions and requirements generated from the event data. The inform component presents the retrieved data in a manner useful to the user. The format of this presentation may vary, and could be visual, audible, haptic or combination of all [1].

3. GEO BASED SYSTEMS

The growing amount of applications relying on spatial information systems is mainly due to the availability of these systems to a wider range of users. This was primarily evoked by the decision of the U.S. Department of Defense and U.S. Department of Transportation in 1997 that civil users will have uninterrupted access to the carrier phase portion of the L2 signal which was only for military use prior to that [4]. In addition, the huge popularity and constantly growing number of users of smart phones and similar hand-held devices enabled to use different geo based systems resulted in high acceptance of this technology at every day user level.

The development of the geo based systems started with the military technologies developed in 1972 when the USAF conducted developmental flight tests of two prototype GPS receivers using ground-based pseudo-satellites and continues with today's development of Satellite-based Augmentation Systems (SBAS) all around the world.

The Global Positioning System (GPS) is consisted of 24 satellites orbiting in 6 orbits around the Earth providing high accuracy and global coverage, with a position fix generally available within 60 seconds of turning the receiver on [1]. GPS receivers for position determination are common additions to AR systems that are used in outdoor environments. There are two improvements to a standalone GPS receiver that have made GPS technology suitable for AR applications. They are Differential GPS (DGPS) and RTK GPS.

DGPS relies on the establishment of a GPS base station, which transmits C/A-code pseudo range corrections to the rover receiver, or the user. Accuracies of up to 0.3 meters are possible. For RTK GPS, the carrier phase is used for range measurement, providing a much more accurate satellite range. Using this technique, real-time positioning at 10 Hertz with an accuracy of up to 0.005 meter is achievable [5].

One more enabler in the development of the geo based systems is the advances in sensor technologies. The abilities of the sensors have changed dramatically in the past 15 years, from use of inertial sensors, accelerometers, gyroscopes and compass to the use of Fiber Optic Gyroscopes (FOG) and Micro Electo-Mechanical Systems (MEMS). The advances in production processes of these sensors have provided the ability of having accurate, small, low consuming and low cost devices. Still, there is no single sensor available that will provide all the necessary data for geo based systems. This is the expected direction of further research and development in this technology.

With geo based augmented reality systems the most important element is to determine user's position and attitude (heading, pitch and roll). The input from the geo based systems is crucial in the tracking component in the AR systems. Its sole purpose is to provide information about the user's environment. Using GPS technology, it is possible to determine the position of user's device with an accuracy of around 1 centimeter [1]. This surely depends on the mode and type of GPS equipment that one will use. Still, by using GPS technology we can only determine the longitude and latitude of the user's device, but we cannot determine his attitude. Meaning, the user can be near the historical monument, and this can trigger to retrieve and present information about the monument in vicinity, while the user is oriented towards the other side turning his back to the point of interest. That is why, in geo based systems for augmented reality, systems for determining the heading, pitch and roll of the user's device is of same importance as the systems for determining the position. Using inertial sensors and dear reckoning tracking systems the relative position and orientation of the user's device can be determined.

4. GEO BASED SYSTEMS IN AUGMENTED REALITY

By combining these two technologies users are provided with a solution that solves number of issues that neither geo based systems nor augmented reality can solve as single technologies. This combination provides users with ability to visually navigate through urban environments, to visually get information on touristic monuments or similar points-of-interest, to visually get information from various GIS systems and databases etc.

In this paper the system for visual navigation through the campus of the Faculty of Mechanical Engineering – Skopje is described. Existing students, but more often the new students have difficulties in finding the classrooms, laboratories or other point of interest along the campus. Since the campus is consisted of 7 different buildings spread on an area of approximately 45000 m^2 often finding the right location of a classroom is difficult if you do not know which classrooms are in which building. Also, students often have to find their way to a classroom fast in order to get to a lecture on time.

In order to solve the above described problem a comprehensive solution had to be created. The solution is consisted of hardware and software with specifically designed architecture. The system is designed primarily to assist students to easily find their way through the campus to various classrooms, laboratories, student's organizations etc. The systems was developed using only of-the-shelf software and usual hardware that is used by this target group.

On the market today a variety of software packages exist for augmented reality. They are developed with a main goal to help the users to easily create an augmented reality scene. Depending on the level of computer literacy, especially on the level of knowledge of computer programming, different software is available.

Basically, no matter which of the existing software for creation of AR scenes is going to be used the procedure for its use and the design of the complete system is pretty much the same. One always needs a personal computer, regardless of its physical shape (desktop, laptop, tablet or smart phone). Depending on the AR software used different operating systems are compatible. The majority of the available software is compatible with Windows, Android and iOS. The final required element to create the AR scene is the 3D virtual object. This can also be video or even a picture. In order to make the system faster and to lower the data traffic over the internet, the solution described in this paper uses pictures with accompanying text as elements for augmenting the reality (Fig. 1).

The first step, in creating the geo based augmented reality is to define the type of virtual objects that are going to be used as augmentation of the user's reality. As mentioned previously, the augmentation can be done using 3D model, a video, a picture or text, or as in this case, it can be done using a combination of the above mentioned. In this case a combination of picture and accompanying text is used. The pictures represent the building of the campus of the Faculty of Mechanical Engineering – Skopje and the accompanying text describes which classrooms or laboratories are inside that building.

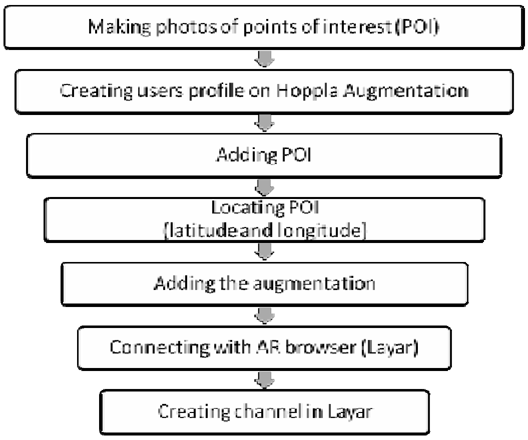

Fig. 1. Flow diagram of creating geo-based application

There are various ways how to combine a geo based system with augmented reality. In any case, one has to map data from a GIS system to data from the augmented reality application (Fig. 2). This is to execute the first component of augmented reality and that is tracking. Since this type of AR applications are marker-less and used in unprepared outdoor environment, the tracking component is done by data from the user's sensors determining the position and attitude.

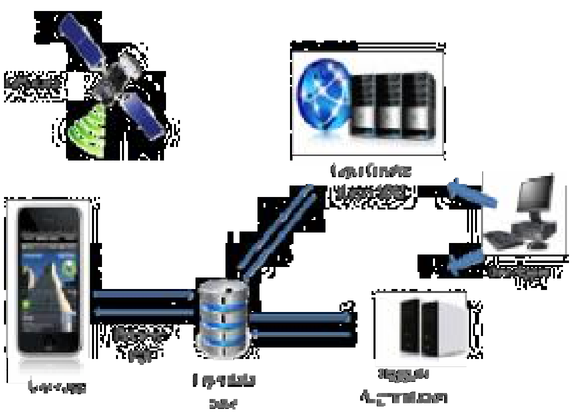

Fig. 2. Design and operating diagram of the application

The system described in this paper is meant for hand held devices that are equipped with devices for position and attitude determination. In order to identify the position of the point of interest, in this case the system of *Hoppala Augmentation* is used (Fig. 3). *Hoppala* is a web based entry point content platform for mobile augmented reality applications. The platform offers seamless support for the three biggest mobile AR browsers: Layar, Junaio and Wikitude. Hoppala provides easy-to-use graphical web interface to create augmented reality contents. It provides a full screen map interface with ability to add images and 3D models as augmentations by uploading them to a personalized inventory.

After creating the content, again using Hoppala users can publish their geo based augmented reality application to all major mobile augmented reality browsers (Fig. 4). Publishing content on mobile AR browser today still requires creating program code, and without any established standards, content creation not only becomes a technology decision, but even a platform decision as well [6].

Next step is to create the application that will be displayed and operated by user on user's device. In this case the application was created using the system of Layar. Using the web based application Layar Creator any registered user can create a layer or a channel that is going to be used by users to display the augmentations. The Layar Creator offers ability to customize the channel by adding picture, logo, short and long text description etc. In addition, it uses metrics for the creators of channels to monitor the use of the created channel.

After that, the Layar Creator is checking and verifying the API Url provided by the Hoppala Augmentaion platform. If the checks are verified, than the layer can be published. With that, end-users are able to open the layer on their handheld device using the Layar app (Fig. 5).

When the described layer is searched using the Layar app, the layer basic description is displayed on the user's handheld device. After starting the layer the handheld device displays the video from the camera showing what is in line of sight of the user. The app sends spatial data collected by the sensors to the server and queries any point of interest in vicinity relative to the user's position and attitude. After retrieving the data, information is registered on user's display augmenting the video of the real world displayed on the hand held device

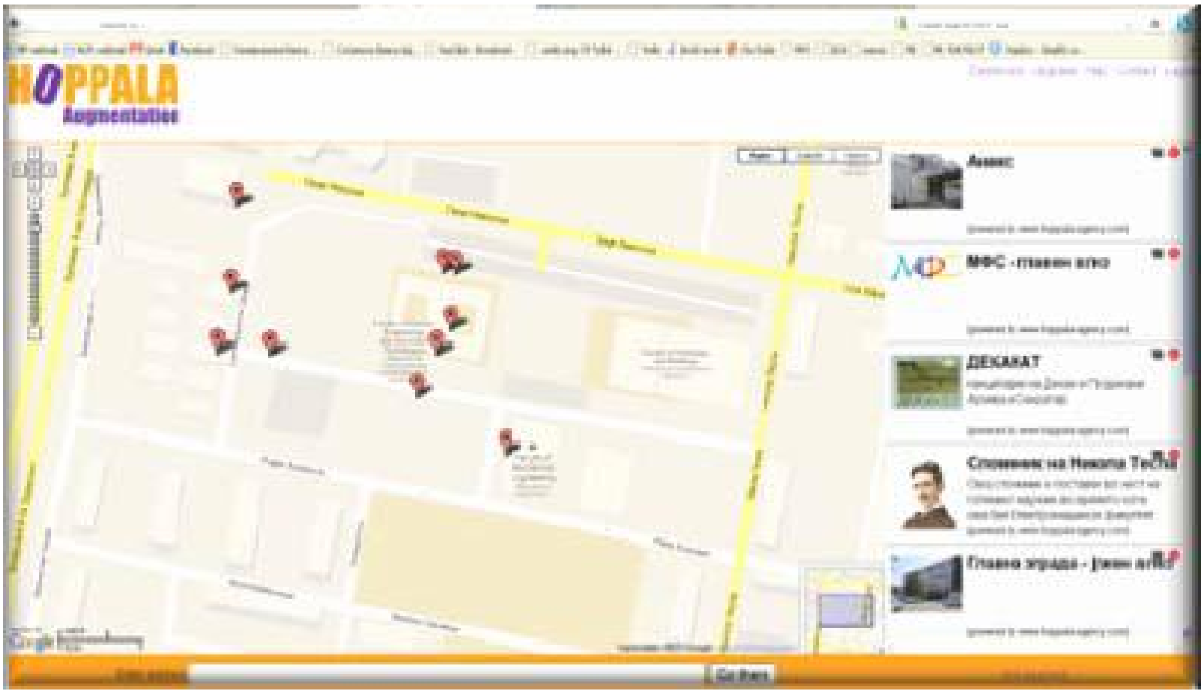

Fig. 3. Interface of Hoppala Augmentation content platform

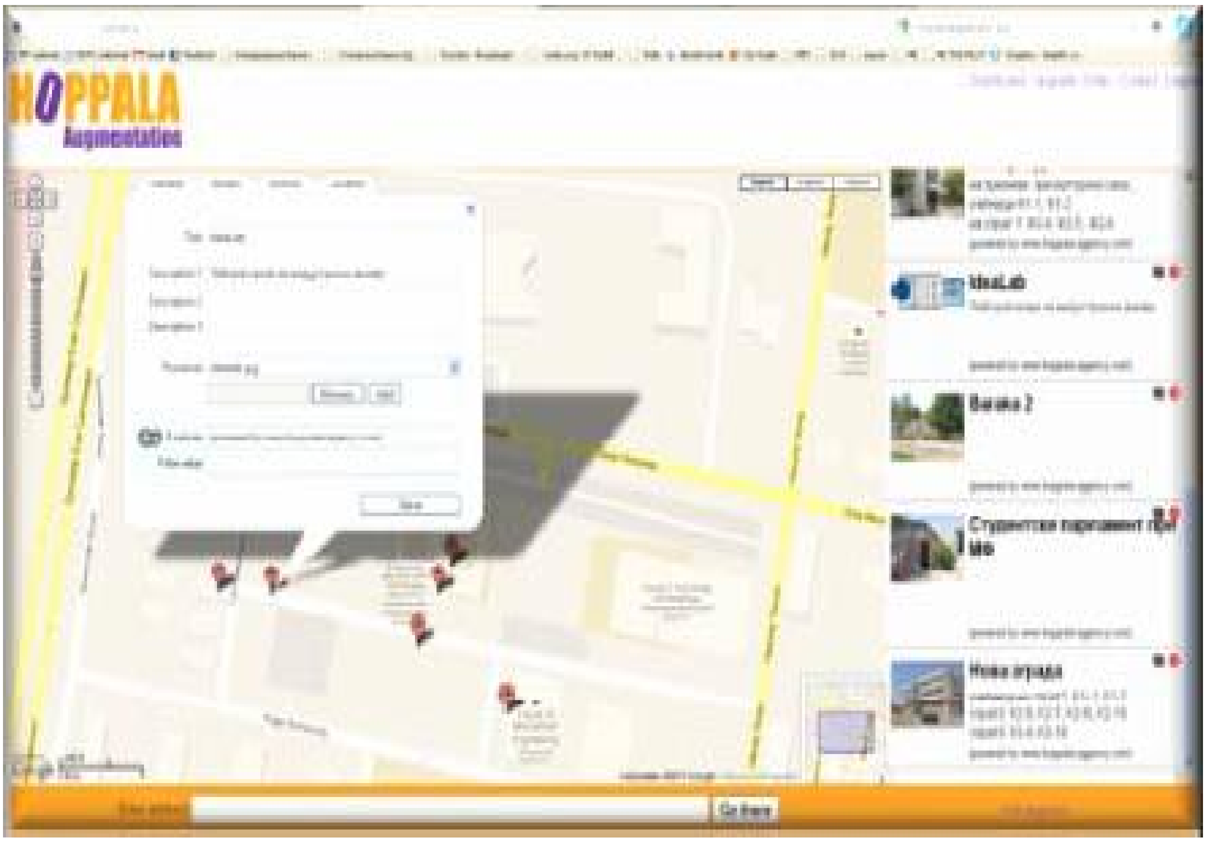

Fig. 4. Adding augmentations using Hoppala Augmentation content platform

Fig. 5. Creating channel using Layar Creator

The layer augments the user's reality by displaying the pictures of the points of interest along with text explaining which classrooms or laboratories are located at that building (Fig. 6). At the same time, the app provides the ability to navigate the user from the current position to the desired point of interest either by foot or by car displaying the distance, needed time to reach the destination.

Fig. 6. Screen shots from application MFS map

In that way, students can find their way through the campus in easy manner and fast. With this tool they can reach their destination on time, hence they can be in the classroom before the class starts (Fig. 7).

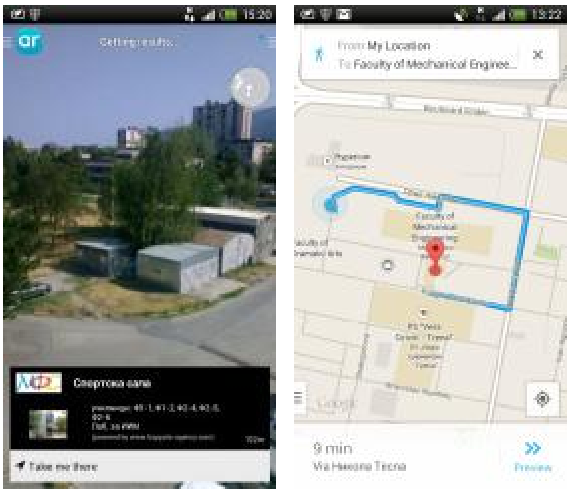

Fig. 7. Navigation using application MFS map

So far, the experience of the students is very positive. Primarily, they see it as challenge because majority of them are using their smart-phone in this manner for the first time. Also, they like using new technologies and things that make them look more technology aware. Last but not least, the majority of students like the design and user friendliness of the application. It is simple and it does exactly what is says it does. The negative aspects of the application are that users will use it only limited number of times. Meaning, students need to find their way around the campus only during their first two weeks of their first semester. After that, they pretty much have been in all classrooms and know their location on the campus. Using the application afterwards, when they are acquainted with the campus is only in rare occasions. The second negative aspect is the internet connection. The use of the application is fully dependable on access to internet. The campus has wireless signal, but sometimes it is weak and users are not able to connect to it. Although, internet is available through the mobile networks its speed is still very low and the prices by the mobile providers are still not competitive for a target group as students.

5. CONCLUSION

This paper presents the basics of geo-based systems in augmented reality and the ability to use this technology as an everyday tool. According to Dan Farber from CBSNews and CNET News "The next big thing in technology: Augmented reality". This statement is getting its verification by every passing day. The "big thing" is getting even bigger mostly due to the enormous spread of use of smartphones and other smart hand-held devices. Augmented Reality (AR) is looking to be the 8th mass market to evolve, following print, recordings, cinema, radio, TV, the Internet and mobile, according mobile industry analyst Tomi Ahonen. The ability this technology is providing to users is unimaginable. Its applications spread each day as more people are becoming aware of it and as they start understand how it can augment their lives.

But still, all this is mainly limited by the key characteristic of the augmented reality – and that is how real the virtual objects are presented. In order for the AR to work, it has to persuade its user that the virtual and real objects coexist in the environment. Here is where geometry has to complete its role. By using various geometric projections a various level of reality is achieved. It is clear that best results would be provided by stereo-metric perspective, but than one should consider the complexity, price and time consumed to produce the virtual objects for AR. Since this technology is mostly used by wearable computers and hand-held devices with limited power of graphical processors the focus is put on lean methods for providing geometrical projections that result with virtual objects that are at the same time real enough and simple enough.

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