EXPLORING THE POSSIBILITIES FOR THE APPLICATION OF AUGMENTED REALITY IN THE GIS TEACHING PROCESS AT THE UNIVERSITY OF FORESTRY

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Abstract
The University of Forestry has many years of educational experience in the use and application of GIS technologies for resolving issues in the fields of natural sciences and the different sectors of economy, social and public life. That result stems from the fact that technologies based on the use of georeferenced data have a high level of interdisciplinarity, which makes them suitable for utilization in education in a wide range of specialties at the university, such as forestry, landscape architecture, ecology, business management, alternative tourism and others. Combining GIS with the opportunities provided by augmented reality and virtual reality is a relatively new field for computer technology integration which allows users to benefit from the connection between GIS and the ever-widening market for mobile devices using contemporary GPS technology and at the same time allowing the development of computer applications for a wide range of fields. The present paper analyzes the opportunities for the application of augmented reality in different stages of the educational process, application within disciplines that are directly connected with teaching GIS, such as cartography, creation of databases, the cataloguing of different plant species and tools for their online use, as well as usage in the context of disciplines incorporating different informational technologies or within their corresponding sections. An overview has been made on the use of specialized products for environmental modeling and the implementing of their content in GIS software, and opportunities for the use of digital models from GIS environment in an environment of augmented reality. Results from these studies can be used as a basis for the transitioning towards interactive education based on technologies incorporating virtual reality or for the development of specialized products and mobile applications.

Keywords: GIS, augmented reality, education, mobile technology

INTRODUCTION

The modern world is characterized by turbulent dynamics of the processes of development in all socio-economic spheres. This is observed mainly in the sphere of ICT, which necessitates a big change of the technical-economic paradigm, connected with innovations. The influence and impact of digital technologies on all sectors leads to rethinking of the traditional models and the creation of great numbers of new products and innovations. In order to preserve competitiveness and to cope with the transition to intelligent economy, the digitalisation of all sectors is necessary. These changes involve the educational process as well, where traditional forms of education are being increasingly supplemented and boosted by mobile and other computer based technologies. In recent years the market for mobile devices marks a progressive growth. In the last 10 years the number of sold smartphones to end consumers has increased with more than 1200%1 and this is accompanied by an extensive development in terms of their functionality and effectiveness. This, in combination with the ubiquitous usage of computers leads to the evolution of the teaching environment into an inseparable part of real life, characterised with availability from any point in the world and anytime, and interactiveness in the form of synchronised or asynchronised communication. The acquisition of new skills and knowledge by the students, associated with finding the right information, in the right format and layout

corresponding to contemporary standards, is of crucial importance for the basic aims of the teaching process to be met – the improvement of quality and effectiveness. The usage of innovative technologies like augmented and virtual reality, in addition to currently used methods in teaching, could be employed as an instrument for speeding the access to informational resources. At the same time they would help in expanding the opportunities for the introduced informational channels, including communication-wise, as per the environment capabilities, in which applications for sense improvement work.

The University of Forestry prepares students in the following specialties: “Forestry”, “Ecology”, “Agronomy”, “Landscape architecture”, “Business management” and “Alternative tourism”. At this stage an introduction is intended for all of them with the technologies based on the use of georeferenced data that possesses a high level of interdisciplinarity, which makes them suitable for application in the educational process of a wide range of disciplines at the university. The benefits from the usage of GIS technologies are mainly in two directions: on one hand, with their usage as an effective approach in data collection and execution of different spatial analyses that give an opportunity of the obtaining of more punctual results from different planned activities; on the other hand, with their usage as a tool for the presentation of the results themselves [1]. GIS could find practical application in almost all spheres of human activity, as they serve as an efficient instrument for the solution of both problems with global impact and specific tasks in a specific field such as the deciphering of tree species and age groups by aerial color orthophotoimages [2].

Augmented reality on the other hand, in the terms of being a system, that gives opportunity for the implementation of virtual three-dimensional dynamic or static objects in a real environment, and affiliated digital data, can be used as an addition to GIS-created models of the environment, with which a slow transition from reality to virtuality can be made. The current study aims to aid the educational process through analysis of the opportunities for application of augmented reality to the different stages of training process: in disciplines concerned with the teaching of GIS, connected with cartography, database creation, plant species cataloguing and the development of an instrumentarium for their online use; in the context of other disciplines, connected with different informational technologies or their corresponding sections; for the usage of digital models from a GIS environment to an augmented reality environment. The realised results will be used in the next stage of implementing technologies of virtual reality in the teaching process.

AUGMENTED REALITY AND GIS IN THE EDUCATIONAL PROCESS

1. Augmented reality

The usage of technologies, connected with augmented reality, dates back to the 60’s of the 20th century. But just now, in recent years they gain popularity among society and become increasingly applicable [3]. Augmented reality, in the context of other technologies related to it, is viewed as a mixed reality – the merging of both real and virtual worlds in one and continuum of mixed reality, that serves as a taxonomy of the different ways, through which „virtual“ and „real“ elements could be combined together [4].

A range of different approaches for classification of augmented reality from a more contemporary time define it from a point of the taxonomy of its own environment, based on a specific functional aim [5]; through taxonomy, based on the idea that every AR system can be comprised of six under-systems containing image acquisition, virtual model generator, undersystem for reality mixing, display, real manipulator and a tracking undersystem, all of which can be defined through the help of already existing taxonomies [6]; through taxonomy, based on 4 axes – compulsory tracking, type of enlargement, content, visualised through the AR application, and non-visual ways of presentation [7]. One of the most common definitions for augmented reality describes it as a system, which allows for real and virtual objects to exist within the same space, in which they can interact in real time [8]. Augmented reality, regardless of whether being executed on the basis of location, markers, or images, allows the consumer, with the proper tools, to enhance the current reality through virtual three-dimensional objects with the option for their manipulation or granting of additional information related to them, in digital format. When realized based on location the information is shown on the display through a combination of data based on the physical location, acquired through the device’s GPS and the direction, towards which it is oriented. Markers in the form of asymmetrical graphics, containing a unique geometrical combination are the second way of realizing augmented reality. They are used for software recognition, during which an object is generated in advance with the aid of different products for three-dimensional modelling (Figure 1), while the object corresponds to the marker and is shown on the display. The third approach is based on a georeferenced location of the consumer, with the localisation of which, from a previously generated database with images, related to the object or its surrounding environment, the respective content is submitted. Based on a sensible interface operating with physical objects, the applications using this technology grant an opportunity for the acquisition of interactive experience, through the manipulation of virtual information connected with them.
The dynamic layering of information, the different opportunities for virtual interpretation in a specific context transform AR into a valuable instrument in the field of education, which leads to a great change in the traditionally known learning process. The option for layering a great variety of multi-media information over real world objects and their manipulation, through different mobile devices connected to the Internet, means that this information could be accessed by students in the exact time and place. The variety of available data on the Web gives a chance for not only the physical parameters of objects of the surrounding environment be understood, but also the visual properties, related to them. The functionality and effectiveness in the use of AR are defined by specific geospatial information, connected with the necessity for a combination between data and the specific coordinates and the dimensional connections between the camera and the surrounding environment.

2. Geographic information systems

In recent years the usage of GIS in the learning process far exceeds the scope of specialised education targeted mainly towards the field of geography and it is already a basic part of the general training of specialists in many other science fields. The different geobrowsers bring to the front a different kind of GIS, making the geospatial data in our time accessible for a wider range of people. Their use does not require a high level of spatial literacy because they are based mainly on the technical part of usage, and not so much on the specific needs of society [9]. Regardless, these technologies are still mainly connected with the concept for spatial thinking aimed towards the development of spatial capabilities, through their use as an instrument shaping perception [10]. With the granting of an opportunity for combining databases with spatial information about the objects, GIS platforms are being further established as a basic module, which allows for the development of business instruments and the automatization of different processes. Geospatial data and affiliated analyses become more widely used due to the constant exceeding development of the geographical informational technologies and technologies giving opportunity for science research and for the assistance in decision-making in a variety of fields including engineering and social sciences [11,12]. GIS incorporate highly technological methods with the option for an intuitive interface for communication and are especially suitable for accomplishing the process of merging of both the physical world and the related three-dimensional computer georeferenced information. The presence of GIS applications with the option for operation through mobile devices makes access possible from anywhere and anytime, which in turn makes them a powerful tool that is symbiotically connected with the application of technologies like augmented and virtual reality. On the one hand, that symbiosis leads to an easier understanding of the specific geospatial information, related to the objects, through the granting of an additional multimedia content, and on the other hand, through the opportunities for the export of data in different formats from GIS applications, an accurate geolocalised information for the needs of AR could be acquired.

APPLICATION OF AUGMENTED REALITY IN THE PROCESS OF GIS TRAINING IN THE UNIVERSITY OF FORESTRY

The blending of GIS with the potential of AR and VR is a relatively new field for integrating computer technologies, which allows consumers to take advantage of the connection between GIS and the evermore-expanding mobile devices market, which use contemporary GPS technologies and allow for the development of a vast selection of computer applications that could find use in different areas. This article examines the opportunities for application of augmented reality in the different steps of the teaching process, as in disciplines concerned with the teaching of GIS, connected with cartography, database creation, plant species cataloguing and the development of an instrumentarium for their online use, as well as in other disciplines, connected with different informational technologies or their corresponding sections. Examined is the starting stage of a project targeted towards research of the opportunities for the implementation of the created informational databases in the teaching process of students in different disciplines, in an innovative way of teaching and learning the matter, through the use of technologies for augmented reality.
Subsequently, this will be used as a basis for the transition towards a teaching based on the use of virtual reality. For the aims of the project it is intended for the surrounding park area and the university's dendarium to be used, which serve as an educational environment for all students. The catalogued plant species of that territory include 59 different types, 12 of which are gymnosperms, 24 are angiosperm trees and 23 angiosperm shrubs. Along with that, the zone provides an opportunity for modelling the terrain and different computer simulations, because of that it is included in the teaching process of disciplines, related to the study of GIS and Landscape architecture of an environment. The aim is, through the use of mobile applications with the corresponding functional capabilities, an opportunity be provided for the information gathered so far to be added in the form of integrated multimedia content to a part of specific tree species, which will serve as pilot units in the introduction of the project (Figure 2).

Figure 2. Layering an additional information via mobile devices to specific tree species

1. Selection of GIS software for the aims of the project

The University of Forestry has a long-standing experience in the use and application of universal software platforms for GIS, both as a part of the teaching process for Bachelor's degree and Master's degree for the disciplines „Forestry“, „Landscape architecture“, „Business Administration“, „Alternative tourism“, „Ecology“ and „Agronomy“, and also as a part of wide-ranging research, conducted by representatives of the different faculties. In the period of 2015-2017, the University of Forestry has bought licenses for Pitney bowes – Mapinfo ProTM 15.2 and has updated the versions of the software products of ESRI - ArcGIS™ 10.4, which has dramatically improved the capabilities and scope of teaching in the field of GIS. In previous years the university has used earlier versions of the product AutoCAD®Map 3D as part of the family of products by AutoDesk. In addition, as part of the teaching process and scientific research purposes open-source universal software solutions for GIS have been applied, like GRASS, QGIS, gvSIG and MapWindow GIS. The main characteristic of the researched software platforms are shown in Table 1.

<table>
<thead>
<tr>
<th>Product</th>
<th>Current version</th>
<th>Type of Software</th>
<th>Type of Product</th>
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<tr>
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After conducting the analysis, the most suitable for the aims of the project is determined to be ArcGis 10.4. Apart from the great number of resources, created on an earlier stage, related with the use of the product for the longest time in the university, the choice is also influenced from the opportunities for using its affiliated application with a direction towards augmented reality „AuGeo“2. It is free for ArcGis users, available for download in the iTunes and Google Play stores and allows an easy import of data from already existing point layers of ArcGIS products to a mobile application for AR.

![Figure 3. Example of using AuGeo application](image)

Used primarily as a time-saving tool for people to find what they are looking for, through more intuitive presentation of hidden objects using mobile camera lenses (Figure 3), “AuGeo” can be successfully used for project purposes for which tree species are implemented as a point layer. The pilot study includes four plant species from the park area and the university's dendrarium (Figure 4).

![Figure 4. Territory of park area and dendrarium of the University of Forestry](image)

2. Specialised products for Landscape modelling of the environment

2 https://www.esri.com/arcgis-blog/products/apps/3d-gis/ar-for-your-gis/
From the point of specificity, of all the applied specialised software products in the teaching process with a focus on landscape modeling of the environment, the most suitable for use in the current research are 3D Nature\(^3\) and Vectorworks\(^4\). The first one is focused on the needs of GIS, foresters, agronomers, ecologists, landscape architects and others in the field of Nature resources. It allows the execution of mathematical modelling, computer simulation and animating of nature and man-made phenomena in the environment, regardless of the scope and complexity in full photorealism. It is suitable for use, due to the opportunity it provides for the import of realized approaches through the use of GIS software in the form of „.shp“ files. The other software product in the form of a module provides a platform for the designing of landscape and city areas, offering a rich variety of solutions for the rationalisation of everyday tasks with leading instruments of the industry. The built-in objects, the supported databases and the opportunity for an effective sharing of projects and the flexible functions for documentation allow for the optimisation of the work process and facilitated modelling of the surrounding environment. Their combined use will give rise to the opportunity for the import of already existing overlays, developed with GIS software, in their environments with the aim for better modelling. For research purposes related to the development of 3D models, it is appropriate to use the Unity\(^5\) software product in terms of both the free licenses granted to students as well as the possibility of compatibility and integration of the created three-dimensional objects in virtual reality technologies.


The addition of interactive multimedia content can be realised through every one of the methods described above – based on an image, markers, or location. If an approach for realisation based on an image is accepted then the implementation of additional information can be realised through an instrument allowing an opportunity for a new vision, in which through augmented reality an additional layer to the surrounding environment can be created in the form of an informational landscape, which will be then directly and successively added to the vision in a very accessible way [13]. The realisation through markers can be done through the embedding of QR codes into the information plates of tree species, with the scanning of which, information can be started in the form of augmented reality. For a realisation through location georeferenced data about tree species inputted in advance could be used in an application realised with GIS software, through which the GPS coordinates of tree species and photos of the surrounding environment could start the presentation of the inputted in advance information, related to the specific object.

CONCLUSION

The use of innovative solutions in the field of education is necessary due to the quickly changing requirements of the surrounding environment. The use of the technology of augmented reality as an addition to the teaching process, realised through standard methods and tools could give an opportunity for the transitioning towards a new stage – teaching with the option of realisation outside laboratories and into the real world, which in turn will lead to the better learning of the taught material. The developed models of the surrounding environment, described in this article can later be used as interactive models for teaching through the methods of virtual reality. The future directions for work on the project intend for 360° videos to be made, which are distinguished by a new approach in filming and post-production. The used video technology which constitutes of rigs of different numbers of independent cameras with several sensors. The positioning of the camera and lightning is vastly different from those in the filming process of a standard video, and in addition, for the specific needs of the project, spherical sound, as well as telemetrics for the collection of data, such as distance, speed etc. Such video footage requires recording in high resolution and high frame speed, which may vary depending on whether the video is viewed panoramically (on a monitor or smartphone) or through VR glasses (headset). An additional step in post-production is the so-called „stitching“ of the raw material, which is comprised of connecting all the separate videos into a single 360° picture. The last stages include montage, color corrections and compositing. That, in combination with augmented reality technologies will make possible the realisation of the transition from reality to virtuality in the teaching process.

\(^3\) https://3dnature.com/
\(^4\) http://www.vectorworks.net/
\(^5\) https://unity3d.com/
REFERENCES


7. Normand Jean-Marie, Myriam Servières, Guillaume Moreau, A new typology of augmented reality applications, AH ’12 Proceedings of the 3rd Augmented Human International Conference Article No. 18


BIOGRAPHY

Associate Professor, Galin Milchev, PhD is a lecturer at the Department of Computer Systems and Informatics at the Faculty of Business Management at the University of Forestry in Sofia where he conducts research related to the application of information and communication technologies in the economy. He has worked in a team on projects, including "Analysis and Evaluation of Systems, Methods and Mechanisms for Corporate and In-house Company Management", "Exploring the possibilities of applying methods of modeling and virtual reality in priority research areas", "Development of a Center for Electronic Forms of Distance Learning at the University of Forestry". The main areas of scientific interest are related to the areas of Information Economics, CAD/CAM/CAE systems, GIS and Databases.

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