Vr-GIS and Ar-GIS In Education: A Case Study

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Abstract—ICT tools and platforms endorse more and more educational process. Many models and techniques for people to be educated and trained about specific topics and skills do exist, as classroom lectures with textbooks, computers, handheld devices and others. The choice to what extent ICT is applied within learning contexts is related to personal access to technologies as well as to the infrastructure surrounding environment. Among recent techniques, the adoption of Virtual Reality (VR) and Augmented Reality (AR) provides significant impulse in fully engaging users senses. In this paper, an application of AR/VR within Geographic Information Systems (GIS) context is presented. It aims to provide immersive environment experiences for educational and training purposes (e.g. for civil protection personnel), useful especially for situations where real scenarios are not easily accessible by humans. First acknowledgments are promising for building an effective tool that helps civil protection personnel training with risk reduction.

Keywords—Education, virtual reality, augmented reality, civil protection.

I. INTRODUCTION

THE role of ICT within education and training almost spans everyday's activity, both in educational institutions as well as in working contexts. ICT not only include a set of tools and good practices to improve learning environments, but they also endorse educational institutions in keeping their syllabuses up to date with advances and changes in on-the-edge topics; this includes elective courses [1] as well as the so-called MOOC [2].

There is a lot of models and techniques for people to be educated and trained about specific topics and skills [3]- [5]. These include classroom lectures with textbooks, computers, handheld devices and others. The choice to what extent ICT is applied within learning contexts is related to personal access to technologies as well as to the infrastructure surrounding environment; moreover, educational contents can be accessed via a variety of media, ranging from non-interactive books to highly interactive digital experiences that fully engage the users senses.

In this sense, the mantra for bringing intelligent devices into learning scenarios has changed over the years from "a computer on every desktop" to a "computer/tablet on every lap" and finally to a "device in every hand" [6], a.k.a. "Bring your own device" or BYOD [7].

Personal devices have indeed several unique features [8] as portability, social interactivity, context sensitivity, connectivity

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and individuality that endorse a plethora1 of unique modes of interacting, such as distributed, collaborative investigations, peer-to-peer networking or joining physical and virtual space in instruction. The last frontier though is going to be crossed: virtual reality (VR) and augmented reality (AR) devices, platforms and applications [9].

Apart gaming and simulations context, the role of AR/VR is becoming more and more central, indeed an international survey of practices improvements in teaching shown that it comes from intensive use of videos in teacher education [10]; moving from simple to immersive video experiences via AR/VR is one step away.

AR/VR are educational mediums increasingly accessible to young users. The use of these technologies looks very promising in many fields of education, particularly in those areas where field experimentation is very important but at the same time difficult to implement. These technologies are generally mixed with other emerging concepts as social networks (i.e., Twitter, Instagram, Facebook), the Internet of Things (IoT) and wireless sensor networks (WSN) or Geographic Information Systems (GIS). Our attention concerns the use of GIS combined with Virtual and Augmented Reality (in the following we name this combination AR-GIS and VR-GIS). Due to their novelty, not much consideration has been given to the performance enhancement that would result through their use in education. These work aims for the benefit of these tecniques.

In this work we introduce a case study where AR/VR is exploited for GIS scenarios in an educational context (e.g. personnel training). In particular, in Section II a brief related work about the use of VR-GIS and AR-GIS in Education is introduced. Sections III and IV illustrate the case study and some implementation issues. Finally concluding remarks are pointed out in Section V.

II. VR-GIS AND AR-GIS IN EDUCATION

Virtual Reality is the name for a set of experiences that share the simulation of visual sensation thanks to the use of computer generated images, which make the user feel as he is in a real world built of computer graphic objects - in this case the environment will be called 'immersive' - or in an environment not similar to a corresponding one in phisical reality. VR-GIS technology is a combination of virtual reality (VR) and GIS technologies. The major manufacturers [11] of hardware providing VR experiences are Google (Daydream View VR, Cardboard), Valve and HTC (Vive), Samsung (Oculus Rift) and Sony (PS VR). These consist, with minor design variations, in a occluding headset visor that leads the user to an immersive experience and in two wireless console controller.

Augmented Reality is a form of Virtual Reality, because it shares with VR the modality of experience and simulation, but it's possible to experience a set of 3D CGI objects overlapped to a real environment. This is made by adding a spatial mapping unit to compute the 3D space of a real environment and then overlapping the computer generated space to the view of the real environment.

As shown in [12], GIS is used for spatial analysis, cartography and visualization. In this case GIS maps the exact locations of the set of points in the space.

VR-GIS and AR-GIS have a great potential for being used for research purposes in social, behavioural, economic and human centered computer sciences, with many applications in the public and environmental health arenas. VR-GIS (and so AR-GIS) have the same visualization problems: VR must be as fast and interactive to satisfy users frame rate need, in order to prevent 'motion sickness', namely the sensation of having headache obtained by the frame rate inferior to the maximum one perceptible to human. Also VR must create huge amount of geometric data that must also be continuously updated.

VR/AR exploitation in educational context is considerable, thanks to the improvement and potential they confer to each application. Assorted examples are available, e.g. earthquake experiences [13], Tsunami evacuation [14], smart cities [15] and many others. For earthquake education, several proposal exist, though most of them rely on textbook, videos or web based training system (WBT), whereas real cope with serious earthquake can be a crushing experience, that's why an immersive simulation is really useful to increase people awareness and their ability to face with panic scenarios in everyday life; [13] exploits Android terminals and AR markers to this purpose by simulating furniture falling.

A similar enhancement is described in [14], since evacuation drills, though worldwide adopted to train personnel, do not involve persons as AR/VR so. Therefore authors introduced a Real-World Edutainment (RWE) program with marker-based AR and binocular opaque head-mounted display (HMD), then shifting to smart glasses (a lightweight optical see-through HMD) which allows participants to view digital materials while moving quickly to provide immersive experience.

In [15], the power of VR-GIS lead to simulation/visualisation opportunities that can be adopted in environmental planning, impact assessment, as well as neighbourhood walkability, street noise level assessment and so on. These tools allow to engage stakeholders and communities in city plans proposals, affecting the places they live and work in.

III. The Case Study

In our initial project, focused on Virtual Reality, the user was allowed to walk or navigate in various way on a terrain that was generated as a 3D model starting from photos and heightmap that was previously captured by a photographer drone which flew over the captured area and took multiple pictures. On this application various tool were designed. Most of these were not directly suitable for the aim of Augmented Reality, so it's been decided to design an application that would keep the original mechanics of localization and of using tools but that would also adapt to new environment constraints of Augmented Reality, like spatial mapping, optimization of memory and aim of education.

The application is designed to be deployed on mobile devices provided with embedded frontal camera and monitor, such as smartphones, in order to be free to move around the chosen area experiencing the application capabilities. However, it is possible to deploy them on augmented reality smartglasses Microsoft HoloLens linked to a computer. In this case, designed functionalities may vary due the different nature of these technologies, so when not specified the case study is described as set up on mobile devices.

As the application starts, the user can see what's around him on the screen of the mobile, thanks to the frontal camera; in the HoloLens variant no frontal camera is needed for this purpose. Some points are located in the augmented reality space with comic's bubble on them, which can show information about the place, or give some tips, or play videos and show images inherent to the situation. This information points are hooked to certain part of the terrain, and it is possible to see their content or activate their handler event by walking to the point. The user can add some own contents hooked to where he is located, as will be said in the paragraph below, to save and later recall or analyze his own clipboards.

A graphical user interface (GUI) is then shown, with a set of distinct components on the corner of the screen. When using HoloLens, it would have been uncomfortable for user experience to place GUI in the corner of the glasses view, so it is possible to show a menu with these GUI by using hand gestures. Here it's located a dynamic map of the place, which is hooked to the user as he's seen from the top at a certain ground clearance; the map shows the 3D reconstruction of the environment in which the user is walking, the user symbol and the information points located in the area. As the user moves, the map updates. The user is always located at the center of the map, so the top visible area slides under the user symbol. However the 3D model of the terrain can be seen in full by typing on the map, and there it is possible to see the position of the user in the entire area, and set destination to a specified information point; thus the distance in meters between him and the destination will be continuously calculated. In another corner of the application is located a GUI (graphic user interface) with continuously updated information about Northing, Easting and Altitude. Also a compass is present, able to rotate according to Orientation of the user, and when a destination is set in the map, a part of the compass is highlighted, according to the direction of the destination from the user.

An important GUI component (see Fig. 1) is a "Menu Button" that, if activated, shows some useful tools, like "Add Info" or "Virtual Meter". With "Add Info" the user is able to add his own information point in the current position, and add to this information points some text, images and videos. With "Virtual Meter" is possible to set two position on the ground and calculate both the minimum distance between this to points and the 'distance on the surface', namely the distance between the points but considering the irregularities of the

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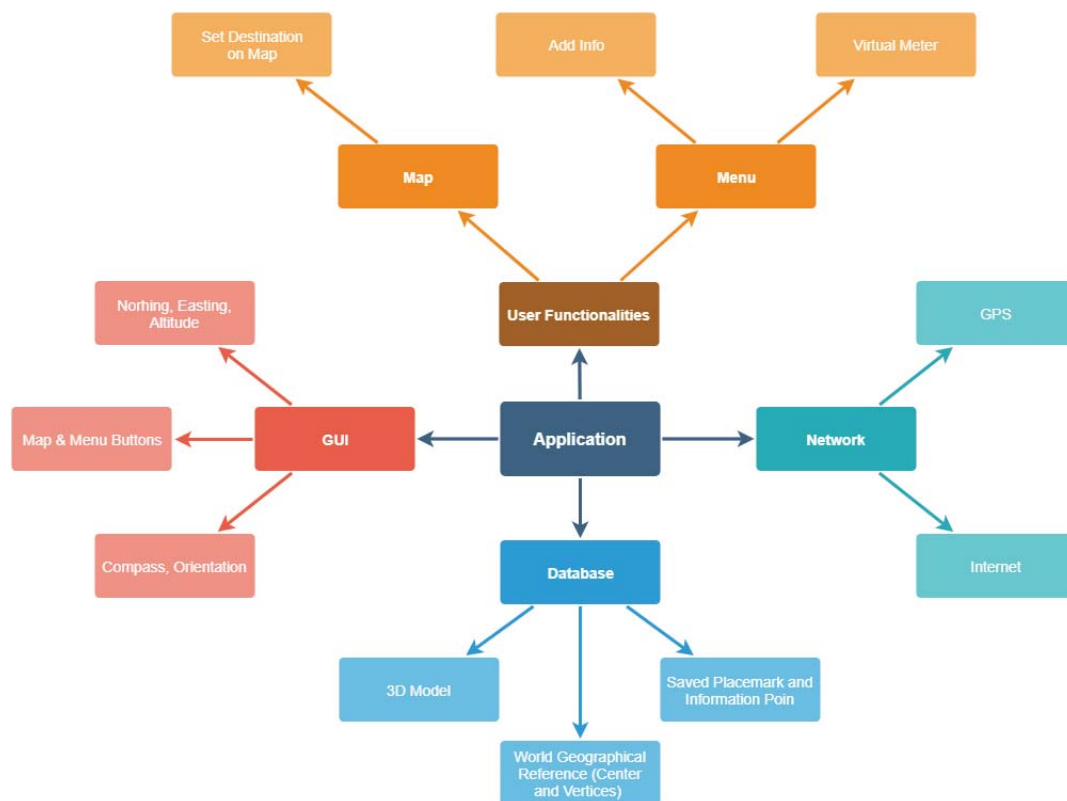International Journal of Educational and Pedagogical Sciences
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Fig. 1 Architectural Diagram

ground and moving close to it, which can be useful to estimate wideness or height of both a crack on the surface or a walkable area. To close the menu it is possible to tip again on the menu button, which hides the tools' GUI. The way all component of the application are related each other and to the application itself has been reported in the figure below.

IV. IMPLEMENTATION

A. Use Cases

The space in which the user can walk has already been mapped by flying drones, so all information about heights has been, previously, used to create a 3D model of the area using 'heightmaps', namely data which associate each point in area to a certain height. The model also is chained to a file that contains information about coordinates of the center of the terrain and the lowest and highest values of Northing, Easting and Altitude in the specific area. The application consider the model and additional information to calculate distances and to convert points in world space.

All data such as Northing, Easting, Altitude and Orientation is taken from GPS localization and used both to give accurate coordinates and, at the same time, to locate the user in the 3D model. In these cases, the application receives the GPS position data, and convert this position to a position relatively to the 3D model described above.

When tools like "Add Info" or "Virtual Meter" are used, the information about points and surface are caught from the 3D model. In this way there's a more realistic measure of distances and a better handling of terrain irregularities.

B. Technologies

1) Hardware Technology: As described above, the application is thought to be developed both on mobile systems and on Microsoft HoloLens. We discuss of the second choice, as Unity (see below) is able to build portable software between most of the mobile operative systems.

HoloLens glasses are a head-mounted display unit, when someone wears them, HoloLens render on their transparent lens 3D images. A set of sensors is placed on the front of them, directed orthogonally out of the wearer, so they are able to provide spatial mapping of the area the user is in and, with this information, locate the 3D assets in a 3D space build at runtime. Thus when the user is moving he has the sensation of being surrounded by both real and computer generated images.

HoloLens also have speakers but not as immersive as most virtual reality tools, because of the fact that the user must move and interact with virtual objects but in a non-virtual environment. HoloLens implements events activated by hand gestures: if a user tap with his hand on a CGI object, a gesture handler will perform an action, for example trailing the object along the hand motion, or showing a menu.

HoloLens are essentially wireless, but to test, deploy and reload batteries the hardware can be connected via USB to a computer. During testing is also possible render on a computer what the user is seeing, thanks to the frontal camera. Frame rate must be very high to prevent motion sickness, but also to guarantee a realistic experience.

2) Software Technology: To develop all the scenes and to test the experience it's been chosen Unity3D v. 2017, which

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provide portability of the application both on Android and Microsoft HoloLens. Unity is composed of a set of windows to control various parts of the scene and development, such as the Scene Window, where it's possible to locate the assets as they'll be seen in the final version of the software, the Game Window, where it's possible to test the runtime behavior of the software while editing it, and the Hierarchy, where the developer is able to keep track of all the active asset in the scene.

Every asset has a component that describes it. The essential one is the "Transform" component, which describes position, rotation and scale of the object in the scene. If an object is visible he must have a "Renderer" component, which can be a 2D or 3D Renderer, depending on purpose and design. Other important components are "Collider", which calculates where there's been a collision between objects and collects information about it, "Rigidbody", which simulates the behavior of an object subject to kinematic and dynamic laws.

Unity also helps to set position of 2D objects in 3D space by using the Canvas object, which is a table placed in front of the camera at every frame, and where it's possible to add GUI components and hook to certain position of the square region.

When a script, which implements an object-oriented paradigm, is created, it is attached to the object as a component. It's responsible of computation of data, but also of controlling and coordinating components, in order to obtain aimed behavior in the scene.

V. CONCLUSIONS AND FUTURE WORK

The rapid developments in computer technology are opening up new application frontiers for VRGIS and ARGIS in the domains of education. The presented case study shows how these emerging thecnologies can be used in massive education. Looking at the future, there are virtually no limits to the possibilities of VRGIS and ARGIS in civil protecion. The ARGIS capability on mobile device allows users to confidently localize content and produce georeferenced information. Furthermore, a 3D viewer plug-in permits the advanced visualization of special assets useful for civil protection scenarios.

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