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Awareness on Seismic Risk: How can Augmented Reality help?

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ABSTRACT:

To communicate the importance of knowing the risk of non-structural damage caused by earthquakes, we developed applications based on Augmented Reality (AR) features. These applications run on mobile devices, such as tablets and smartphones, by using their video camera and other on-board sensors, such as GPS, accelerometer, and gyrocompass, from which AR users do take advantage. Combined with a specifically designed exhibit, our AR applications can contribute to increase the common awareness on seismic risk, providing useful information on how to have safer homes in case of an earthquake. Building codes do not take into account non-structural elements, leaving communities at risk of injuries, blocking escapes and even causing deaths. In this framework, the personal preparedness is of paramount importance. The development of our AR applications is supported by the European project KnowRISK (Know your city, Reduce seISmic risK through non-structural elements).

Keywords: Non-structural damage, Earthquake hazard, Augmented reality, Risk reduction, Dissemination

1. INTRODUCTION

The collapse of buildings is the major reason of victims from earthquakes. The societal impacts of earthquakes, however, is not limited to the collapse. Injury, loss of property and of functionality from earthquakes can also occur in resilient buildings in form of non-structural damage. Furniture, partitions, balconies, hydraulic system are only a few examples of non-structural elements of buildings the damage of which is still grossly underestimated. Indeed, even the effects of a small (low-magnitude), superficial earthquake can lead to high costs for the lack of simple (and low-cost) solutions that can prevent non-structural damage. Moreover, in medium-to-high magnitude earthquakes moderate-heavy damage (D2-D3), when non-structural elements start to play a major role, usually occurs over a wide area. Communities are scarcely aware of the relevance of this kind of damage and, therefore, they are not prepared (Crescimbene et al, this volume). Often there is a lack of effective communication tools specifically tailored for the public engagement in its own safety.
The European project KnowRISK (Know your city, Reduce seISmic risK through non-structural elements; Grant agreement ECHO/SUB/2015/718655/PREV28) brings together engineers, seismologists, architects and sociologists. Focusing on non-structural damage, the goal of the project is twofold. First, it explores solutions to reduce non-structural damage from earthquakes in pilot areas of Portugal, Iceland, and Italy. The second goal is the promotion of preventive action, with a public engagement approach (Musacchio et al., this volume). Indeed, seismic risk reduction calls for preparedness not only in terms of countermeasures for building construction and reinforcement. It also requires effective scientific outreach activity to convey useful information to people living in regions prone to earthquakes, increasing their personal capability to cope with hazard and being prepared.
A key issue for a successful outreach activity is the choice of tools that can prove to be simple and effective. We propose Augmented Reality applications as they fulfil both requirements. In the following, we describe the prototype of the KnowRISK exhibit, an interactive poster that was specifically designed for our scientific dissemination purposes.

2. AUGMENTED REALITY

Unlike reality, which is the state of things as they actually exist (Oxford University Press, 2017), Augmented Reality (AR) enriches the real world with digital information by using a cutting-edge technology. It operates overlaying real-time images (coming from a video camera) with virtual elements, such as 3D models, pictures, and videos. Virtual and multimedia elements are superimposed using different information layers in order to obtain a unique view for users' eyes. Elements that can "increase" reality can be viewed through a mobile device, such as a smartphone or through a tablet with a video camera. Point Of Interest (POI) can also be added to the real world using other on-board sensors, such as the internal GPS device, nowadays present in every new-generation mobile phone. The process to create AR is based on the real-time capture of images from any device (typically on-board cameras) and GPS location; software generates layers full of virtual items, such as image contents, queries to a web page or to a database, etc. AR also gathers a wide variety of user's experiences. It is possible to distinguish three main categories of AR tools (Augment Web Site, 2016):

"Augmented Reality 3D viewers, like Augment, allow to place life-size 3D models in your environment with or without the use of trackers. Augmented Reality browsers enrich your camera feed with contextual information. For example, you can point your smartphone at a building to display its history or estimated value. Augmented Reality games create immersive gaming experiences, like shooting games with zombies walking in your own bedroom!"

The best results of AR require the development of a complex software (generally one or more APPs – an APP is typically a small, specialized program downloaded onto mobile devices), working with image processing and computer graphics. Most of the useful data can be directly derived from real-time and/or offline images. For example, imagine a user who needs to know how many restaurants are located around his/her own actual position. In this example, the results of the search with AR mark the GPS coordinates of restaurants extracted from internal data to the user's device (Fig.1).

Figure 1. A typical example of AR from Nokia-Microsoft APP (HERE City Lens) using internal GPS and compass.

Throughout the process of graphics overlay, images can be added to or can even remove/hide parts of the real environment. Optical and video AR technologies are both under development (a tablet screen vs optical glasses) to better increase user's perception of reality.

3. SOFTWARE: THE WIKITUDE EXPERIENCE

Developed by an Austrian company (Wikitude GmbH), Wikitude was the first AR APP distributed worldwide. Wikitude (2016; http://www.wikitude.com/products/studio/) is an impressive tool to create AR software. It can visualize data of the real environment through a camera and includes an Image Recognition Tool and a 3D model. Furthermore, Wikitude distributes a social framework called

Wikitude Studio, with which developers have the opportunity to make exciting AR experiences.

3.1. KnowRISK APP

Our KnowRISK APP was built using the Wikitude Software Development Kit (SDK) for Android. This exploits web technology (i.e., HTML, JavaScript, CSS) and allows the developer to write software within a multi-platform system. Architect elements are the basic building blocks; an Application Programming Interface (API) is also available to connect the APP to the most used operating systems (e.g., Windows, Linux, Android). The interaction between the Wikitude SDK and the KnowRISK APP was obtained by adding a special "view" called ARchitectView user interface to our platform.

Three main different modules were implemented in order to obtain the results described in section 4: Image recognition, Video Overlay, and Location Based Service.

3.1.1 Image recognition

Based on the Computer Vision concept, the Image recognition is one of the most powerful tools available inside the Wikitude framework. When the Image recognition tool is active, the AR APP is ready to display new contents on layers that overlay to the real world. In addition, the user can navigate and interact with local or remote data provided by the application. This interactivity is based on three main methods to acquire data:

- Target image: If a target image (or multiple different images) is recognized by the viewfinder, then an animation runs (for example, a new layer with images, videos or HTML content will appear);
- Target collection: The user will access an archive containing all the images the tracker can recognize;
- Client tracker: By using the live camera image of the smartphone, it detects the targets stored in the related target collection.

3.1.2 Video Overlay

In addition to images, text, and HTML content, it is possible to add videos with the help of Wikitude libraries. The Video Overlay module can display a video on any image recognition target as well as at any geolocation. We use this tool to "activate" the exhibit described in the following showcase. Like any other drawable element, it is possible to position, scale, rotate and change the opacity of the video. As with all other resources, the video can be loaded both locally, from the application bundle, and remotely, from any server.

3.1.3 Location Based Service

The Location-Based Service (LBS) is a software-level service that uses location data to control features inside Wikitude APPs. Enabling the geolocation permission, the APP is able to run an animation or anything the developer chooses, depending on his/her real position. In this way, images produced by the live camera will be "augmented" with new elements introduced during the development of the APP. The user will also be able to access multiple contents depending only by his/her own actual position.

4. THE SHOWCASE OF SCIENZAPERTA

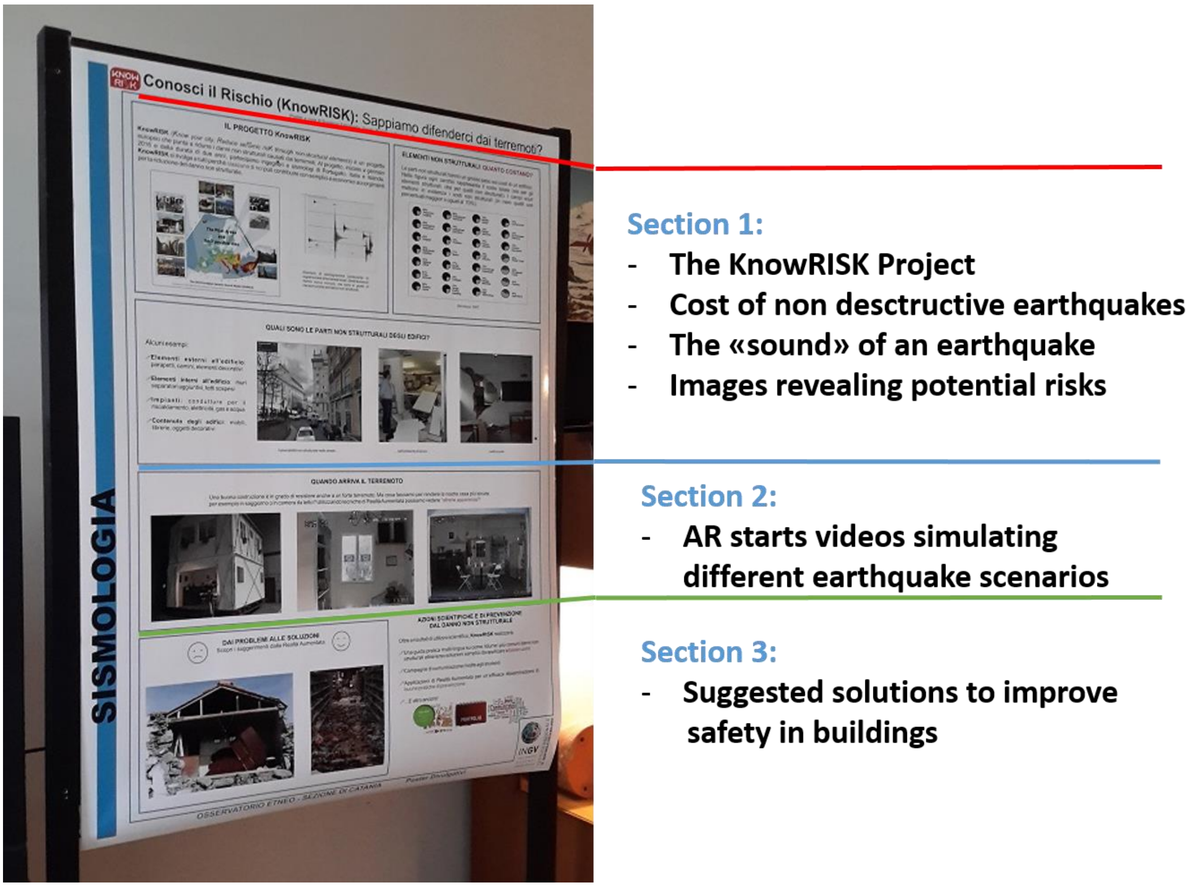

Figure 2. Scientific content and layout of the poster.

We tested in 2016 our KnowRISK APP along with a prototype of interactive poster during “ScienzAperta”, an open-door scientific, outreach event that INGV yearly organizes in Italy for schools and the public (Falsaperla et al., 2016). We designed an “animated” exhibit according to the working scheme of Fig.3. We divided our poster into three different sections, containing target (static) images (Fig.2). These target images were the “virtual button” to activate our AR application. It is worth noting that AR might apply to all senses, not just sight. For example, our APP included sounds: a target image associated with a seismogram (at the top of our poster, in Section 1, see Fig.2) allowed visitors to experience the “sound” of an earthquake by using a proper frequency shift.

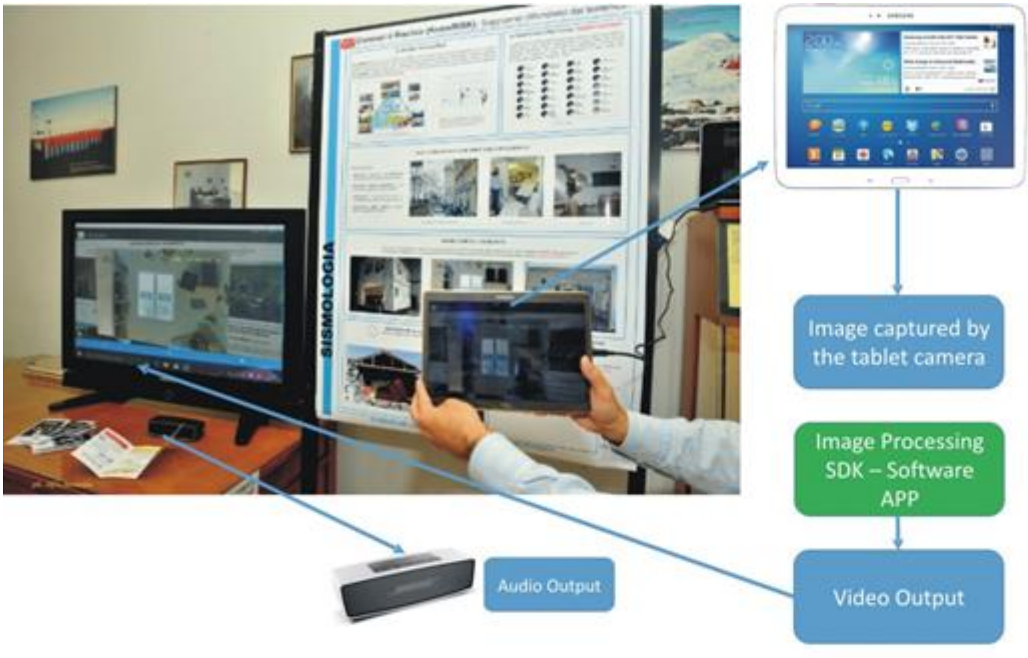

Figure 3. The interactive poster of the KnowRISK exhibit based on our working scheme of Augmented Reality.

The exhibit was open to the visitors at INGV Catania, Italy, during the 5-day-long event, from 16 to 20 May 2016. Part of the images of the poster in Fig.2 were frames of videos depicting visible effects inside and outside a building anchored to a shaking table. Our APP allowed visitors to see what happens during a shaking-table test, which simulates different scenarios based on non-destructive earthquakes. When a target image came into focus, the software recognized it and played the video on a tablet (Fig. 3).
The total number of persons who visited the exhibit was ~600. As each group of visitors was large (between 12 and 18 people – Fig.4), we decided to transfer the data from the tablet to a bigger monitor to improve the vision (Figs.3-4). An audio-surround device was also associated with the videos to make effects more impressive (Fig.3). Eventually, the poster itself "suggested" solutions to improve safety in buildings, by switching various images on the screen; for example, before and after the application of simple solutions to fix a problem (e.g., fall of objects, heavy furniture).

Figure 4. Presentation of the KnowRISK exhibit at Catania during "ScienzAperta" 2016.

5. DISCUSSION AND CONCLUSIONS

In case of high-magnitude earthquakes, the non-structural damage can potentially strike a region of vast extension in addition to the collapse of buildings in the mesoseismal area. This can heavily affect the return time to normal life, also with repercussions on the resumption of economic activity. Yet, even low-magnitude earthquakes with shallow foci can yield high costs due to non-structural damage (Azzaro et al., this volume). In this case, the mesoseismal region will be smaller, but effects may be comparatively costly.

There are many solutions to prevent the possible tumbling and falling of objects and furniture. Some of them have low costs (a few Euros only), and their application does not require technical skills. Simple examples are steel brackets to fasten tall furniture to the wall, latches on cupboard doors and drawers, etc. The adoption of these solutions along with others that require specialized staff - for example, the anchorage of chimneys or utility systems, such as gas, water, and power– is of paramount importance in regions potentially prone to damaging earthquakes (e.g., EQC Earthquake Commission, 2016).

We propose an interactive exhibit combined with AR software (KnowRISK APP), which allow the user to focus on non-structural elements inside and outside buildings. The KnowRISK APP provides information in form of sounds, video clips, and animated snapshots. The interactivity offers an easy engagement of the user.

Italian pupils and students tested the first prototype of the KnowRISK exhibit at INGV Catania in May 2016. A heartening measure of the success of the exhibit was the wide participation of children, who were also asked to discuss the safety of their home and, in particular, of their bedroom. The exhibit made them aware of the potential danger of heavy furnishings (e.g., sport cups) above their bed or close to doors, causing injury or hindering escape in case of fall.

The majority of visitors was aware of the concept of Virtual Reality while they were not familiar with AR. The launching of the game "Pokémon go" in summer 2016 gave to AR worldwide visibility and resonance. Hardware and software have evolved fast ever since. This also fosters our efforts towards new developments of AR APPs, which can contribute to seismic risk reduction.

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