The Influence of Augmented Reality in Construction and Integration into Smart City

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This paper presents the current state of AR technology applications in the field of construction through some examples already applied in simulation of the organization of utilities networks, simulation of site organization in various stages, simulation of the new urban plan, modeling of building details, interior organization and navigation site and proposes to design of an IT application that integrates these benefits into a unitary application, easy to use by all parties involved in project: project owner, architects, builders, local community and public authorities. The application will be specific to the Android platform and will provide a virtual view of the stages in the construction. It will also run on mobile devices such as smartphones, tablets, or other devices that have a camera, internet connection, and location sensors.
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1 Introduction

We live in an era where technology evolves very fast, an era in which technology can change the world and the way people interact with the environment. It evolved so much that now we use everyday smartphones and gadgets which ten years ago we could only dream of, we use applications which helps us and ease the daily activities, the technology became a part of our life. One of the benefits of this evolution is represented by the fact that you could use your personal smartphone to do almost everything. It's used for its real purpose to make phone calls and communicate with others, for the complex apps (like ones for personal time management, desk apps, GPS apps, informational apps and so on), or it's used for recreation (games, workout monitoring, augmented reality apps). One of the most interesting directions followed when virtual technology started to be used on smartphones was augmented reality.

In our days, augmented reality represents a promising application development. Augmented Reality (AR) is a physical live view, direct or indirect, in the real environment, in which elements are completed by computer with an artificial world, through sensorial inputs, sounds, graphics, virtual persons and GPS data. It is important to make the difference between augmented reality and virtual reality (VR) [1]. AR is supposed to display pictures over a transparent screen, so the addition of new virtual elements is made by overlapping and integrating them in the environment. VR is defined as "use of the technology to create a simulated environment" [1].

AR applications use the phone camera to reveal an image of the real world, then a layer of information, text and/or images, is overlapped on the superior part of that view. The applications can use AR for fun, like Pokemon Go game or for informing users, like Layar application (this application can show information about places which someone visits; those information appears on the superior part of the scanned objectives). VR produces a total different reality according to the environment in which the user is. VR can be artificial, like an animated scene or a real place which was photographed and added into a VR app. Google Earth is an example of an application which uses VR; with its help we can explore extreme locations like peak of the Everest mountains or the bottom of the oceans or locations outside the earth like other planets or satellites (Mars, the Moon and so on).

The "Smart City" is that city which highly uses the new "Smart" technologies for the improvement of public services, the rise of

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comfort level of citizens from rural and urban areas, streamlining resource consumption and reducing spending on medium and long term. The Smart Cities evolution brings the necessity of collaboration between specialists from different domains, such as: urbanists, architects, engineers, service suppliers, responsible for making public politics, businessmen and entrepreneurs, civil society, academic environment and citizens. So, a Smart City can be defined by the following characteristics: intelligent buildings, intelligent infrastructure, intelligent technology, intelligent energy, intelligent citizens, intelligent leaders and intelligent education [2].

In the context of Smart Cities, AR can be used in development of applications which improve the use of public resources and the relation with the citizens and also can be used by private companies which resides in that area. So, the AR can be used in domains like commerce and marketing (placement and promotion of products through interactive applications, simulation of how to organize space by adding products, help in choosing the right clothing), medicine (images with internal organs, which cannot be observed through different medical methods, which can be very efficient for the final diagnosis or in chirurgical practices), education (creation of virtual objects in museums and expositions, attractions in thematic parks, rebuilding battles using current landscapes, leisure activities), tourism (rebuilding of runes and historical buildings which are in high stages of degradation, planning of guided tours), industry (projection of industrial installations and the integration in fabrics, advanced systems for auto industry), emergency services or military plans (creation of evacuation plans, simulation of disaster management).

The purpose of this article is to analyze how augmented reality can be used in building stages and how technology supports simulation processes for space organization, building preview and spatial orientation and, based on case studies in different contexts that will be presented below, we are planning to design an Android mobile application that uses augmented reality to facilitate the transition from classical methods used in the present to modern technologies based on technology, smart cities.

Section 1 presents a general description of how augmented achievement evolved over time and the stage it has reached today. The concept of Smart City is also presented; one of the points on which it is based is the augmented achievement. Section 2 shows the areas where augmented reality can be used, among which we can list e-government, public health, public transport, culture promotion, heritage and tourism. Also, there are a series of papers and views on how augmented achievement can help traditional cities become Smart. Sections 3 and 4 present a mobile application architecture model that will lead the design of building plans to buildings on another level.

The novelty of an article is the design of a modularized application based on the Android platform and uses augmented reality for visual presentation; so virtual images are superimposed on the real image captured by the mobile device in order to present the user various simulations.

2 Literature review - Application areas of AR

Augmented reality is valuable in public environment when reflects real data, regardless of whether this data is accessible through public initiative and are generated by networks based on sensors and by the smart infrastructure around us or they are captured as unstructured data from mobile users, from formal or informal networks which have a high potential which comes from shared economy and another sources of structured or unstructured data. For a good management of the data which can be processed and presented through AR, once with the technology evolution, started to be used devices like mobile devices(smartphones and tablets), head-up displays (HUDs) for screens and windscreens(for cars), eyeglasses, headphones, contact lenses, space displays [3].

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Nowadays, there are more and more uses of augmented reality and the potential of this is limited only by the creativity and inventiveness of users. Applications which have AR technology incorporated are used in cities like Copenhagen, Amsterdam, Wien, Barcelona, Paris, etc.[4]. There are developed applications for e-government, public resources management, public safety and emergencies services, public health, public transport, culture promoting, heritage and tourism.

In e-government there are developed applications which can be seen on a large amount of devices (smartphones, intelligent lenses, screens and so on), with a full range of aid (sound, graphic instructions). For example, the citizens can visualize through the AR technology the plans of planned public works, how will look the new highways, or water and energy installations, public parks and so many others [5].

In order to improve public safety and emergency services, firemen can use emergency vehicles equipped with devices which offer route guidance, real time data about the disaster, dangerous condition, and environment. With the AR devices and cameras attached to the helmet they can see and hear through fire, smoke, bad weather and many others [6]. Also, the AR applications and devices can offer information for citizens who are looking for a safe place, can be used to guide them on safe routes and can offer assistance in case of emergency.

The citizens and companies can access geographical data and statistics about crimes and others environmental factors only by pointing a building or a street or the community for which the data is wanted. For improving the public health services through AR technology communities interested in encouraging a healthy and sustainable life for their citizens can correlate various areas like parks, recreations facilities, farmer market and urban farms, festivals with healthy activities like walking or cycling. Also, different sensors for environment quality (air, water, soil etc.) can be connected with AR devices and applications which can offer real time decision support for citizens [7].

Regarding the urban transportation and mobility, the means of transport may have AR displays that provide real-time information such as traffic incidents, route changes, passenger needs, vehicle maintenance data, and users can access visual or auditory information about the route it uses.

In developed countries, protecting heritage and culture is a priority, and one of the most important ways of using it is to promote objects such as historic buildings, castles, heritage monuments. Also, museums and buildings that are important from a cultural point of view can be promoted through the interior of applications that use augmented reality [6]. Natural resources, including national parks, rivers, forests and unique areas combined with ARs can provide a strong educational experience, adequate use and conservation of natural resources. Previous examples of using augmented reality in the public sector are just a few of the possible real use cases that are becoming known to the general public. The augmented reality is emblematic in the fourth industrial revolution, a blur of lines between the physical world and the digital world [1].

Increasing availability of the Internet along with technological developments has accelerated the development of intelligent and interconnected infrastructure between cities, regions and countries. Roads, utility networks, public buildings and facilities, communications networks, cars and homes, etc. become "smarter" every day. This intelligent infrastructure and the massive amount of data it generates can provide very good support for AR use in the public sector and cities around the world are starting to move to Smart City. Nowadays, augmented reality and technologies specific to intelligent cities can open new opportunities in citizens' lives and solve some of the problems caused by urbanization, agglomeration, space organization, etc. Thus, it can be said that the augmented reality has a positive impact on the tourism industry and increases the satisfaction of the visitors [8] it may involve many actors

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in making the most appropriate decisions for the development and way of organizing the cities and supports the design of the buildings [9].

Mobile Augmented Reality for City Planning

Building solutions (Architecture, Engineering and Construction) using augmented reality have been created to help people and city officials understand and to comment on organizational and architectural plans from the very beginning of the building design phases. Studies indicate the high acceptance of these IT solutions and the added value that they bring to the decision-making process [10]. In [11], the authors analyzed the way of organizing the constructions both in physical format and with the augmented reality and evaluated the usefulness and strengths, respectively the AR weaknesses. Their conclusion was that augmented reality applications are an extremely useful tool for viewing plans in an intuitive way, facilitating the presentation of information, understanding plans, providing additional value to traditional viewing, and helping to make the most appropriate decisions.

The authors of the previous cited articles expect augmented reality to become a standard tool used in building design and to be used by public authorities and residents and other parties involved, how data presentation is more intuitive, the buildings can be viewed in 3D from any point, and the decision-making process is assisted by applications using AR.

Visual and participative urban planning services

Urban planning is perceived as a complex, time-consuming process that can bring unclear plans, misunderstandings about the most appropriate election, and decision-making without the involvement of all stakeholders. Participating in the organization of the city and advanced visualization using innovative tools involving augmented reality facilitates the debate of ideas and finding solutions that improve the lives of inhabitants [12].

From a technical point of view, most of the AR applications use panoramic imaging and 3D architecture and run on devices such as tablets, smartphones or PCs. Advanced approaches to visualizing land-based spatial planning and urban planning solutions can present improved solutions in real-time on the spot by overlaying the current image with the elements to be achieved [13].

New applications using augmented reality can present new buildings, their size and scale, their impact on the site and the environment, as well as other information that is difficult to see at the time of design. Thus, the new visual tools involve the entire community in choosing the best solution and have the opportunity to enhance the quality of future urbanism projects, directly influencing the quality of people's lives [14].

Mobile city guide

The purpose of city guide applications is to create and test new ways of presenting news and information about events, places and people. Prototypes of augmented reality applications offer real-world vision with the camera over which virtual information is superimposed. Applications can be used to provide digital content to nearby users, and can be viewed through both the camera and on the maps [15],[16].

While using City Guide applications, experiences may vary, new opportunities appear, positive experiences are anticipated, interest is growing to meet new goals, but frustration can also arise over some unfulfilled challenges. For projects in the development phase of the concept, the results were very promising, especially to the young audience. A concrete example of a city guide that uses the augmented reality is the applications dedicated to tourists, applications that include content related to the tourist attractions (past or present images), public transport, art galleries and museums, city information, projects and construction works, challenges and objectives to be achieved so that the experience is unforgettable [17].

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AR in architecture

This section outlines the opportunities of augmented reality in the field of construction and architecture. All of the research presented below is of a qualitative nature, and the research methodology follows a series of key steps that outline the categories of interest and how it has been applied in practice.

The case studies to be presented have been selected according to the lifting phases of the constructions to which they contribute (stages in which each basic functionality of an application corresponds to a specific stage in the construction). Thus, the functionalities are based on full scale design visualization, location of utility networks, orientation inside large buildings, construction site organization, simulation of interior design, virtual reconstructions.

Mobile Augmented Reality (MAR) is increasingly used to visualize design and support the design process. The combination of real and virtual elements provides an ideal context for a design team to analyze all space issues in a collaborative context. Through AR, multiple users can share the same physical space and view in the same way the "spatial presence" of a digital object.

Full Scale Design Visualization

The most common use of AR is in overlapping a real place with virtual objects. A growing number of AR applications allow you to visualize the building's building steps, from early design to construction. The visual exposure of the model through the MAR transmits in an intuitive way the appearance, scale and intentional design features proposed by team members. It is ideal for urban proposals, where a project is communicated to a large number of people, and MAR applications avoid traditional patterns of technical presentation of construction plans, reducing communication errors between design professionals and those affected by the planning process [18].

Fig. 1 Raseborg & Jätkäsaari[19]

AR was used in 2011 in Finland to design a hotel complex (Fig. 1), the project being addressed to local authorities for approval. Within the project, a virtual tour of the complex was available using mobile devices. The audience noted that using AR helped to estimate the volume of the building better than other methods and helped them understand the construction plans.

Fig. 2 - Kämp Tower Tours [19]

A year later, an important building in Helsinki, the Kamp Tower (Fig. 2), was presented to city officials using MAR. These cases of use have shown that AR technology can be used in large-scale design and can be a precedent for approval of construction plans.

Component Scaling & Clash Detection

MAR applications can deliver the real scale of the object to the desired location and distinguish individual elements from a spatial layout for a full scale presentation. Overlaying a virtual object on a one-to-one scale can avoid making a mistake in estimating space. By using virtual elements, AR eliminates manufacturing costs and materials for making prototypes in the real world. MAR applications are useful in detecting conflicts

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and detecting overlaps between the proposed virtual content and the actual elements [20].

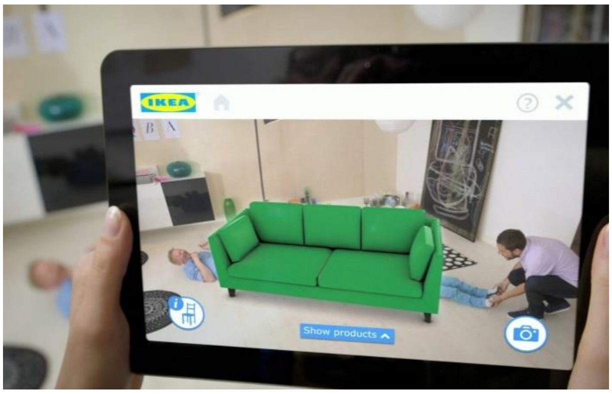

Fig. 3 IKEA [21]

IKEA has launched an augmented reality application (Fig. 3) through which users can visualize how items are marketed in the space available to consumers. By using the camera and scanning a product-specific QR code, the application shows the real frame on which changes are made by overlapping the desired object.

Virtual Reconstructions

MAR applications can transmit architectural details by overlapping information inaccessible to the viewer over a building or architectural details. In applications for cultural heritage, MAR applications show virtual reconstructions of historical sites that have degraded over time. AR allows users to view historical artifacts without touching or degrading them.

Fig. 4. The Visible City [22]

In "AR-sight-seeing," virtual overlays provide hidden space glimpses, giving the user 'X-ray vision'. Use of AR can bring immediate interactivity by attracting users into direct contact with a real site or artifact. There is a limited sphere of communication of the architectural narrative in today's professional practice, but opportunities abound through educational uses and cultural events. Visible City's Vancouver Museum (2013) (Fig. 4) presented users with a virtual exhibition of city history, aiming at the growth, decay and revival of the neon in Vancouver. Application users may stay at hotspots set up in the city and see historical images appropriate to their locations.

Fig.5. Street museum Apps[23]

A precedent in 2010 - The London Museum's "Street-museum" (Fig. 5) has similarly covered historical photo content on real-world sites using the AR. In both cases, MAR offered accessibility and interactivity to historical content and significantly increased the number of visitors to exhibits.

Geo-Locating Data on the Construction Site

In the construction works, the data used in the AR applications have three main uses: to view what is not yet built (the future); to see what is hidden (buried elements or obstructed objects in sight); and to see what cannot be seen (alignment and organizational information, site boundaries, or environmental events - such as a flood level rarely encountered) [24]. Overlaying data on real items can benefit professionals performing on-the-spot inspections and contractors check the progress of the construction. The AR can confirm the exact installation locations for the building components; location of materials and equipment, safety areas for site location; location of construction details and component. Also, visualization of hazardous work areas, emergency situations, or

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information required by ARs can improve on-site safety.

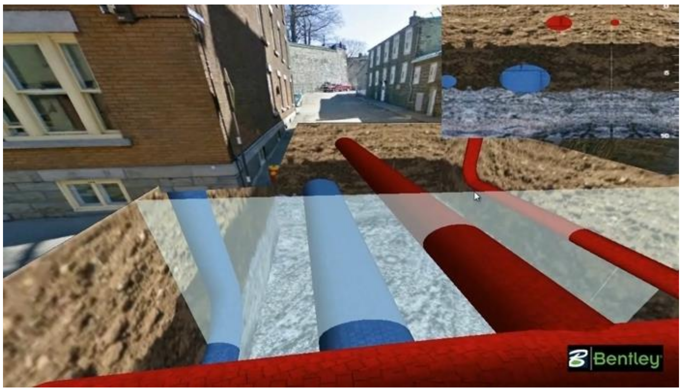

Fig. 6. Revealing Hidden Data - Visualizing Subsurface Utilities [25]

An Augmented Panorama by Bentley (Fig. 6) supports design and construction by viewing data about utility networks (electrical systems, sewerage, water, etc.) directly on real images. The application also allows users to add their own geo-tag directly to the site and manage this information that is accessible to remote team members

4D Phasing of Construction Work Sites
AR can extend the 4D planning of design and logistics planning to the construction site. MAR applications can overlay virtual objects on physical planes to communicate dynamic component behavior or to overlay virtual objects directly to detect potential factions of real-world equipment. Industrial manufacturers operating in closed environments are pioneering the use of AR to better understand their factory processes and maximize the use of production space.

Fig. 7. MAR to plan Virtual Construction Work Sites [26]

An AR system that overlaps 3D animated paper objects allows entrepreneurs, consultants, and planners to quickly evaluate the movement of equipment or machines on the spot, detect potential conflicts, and evaluate the construction phase over time.

Site navigation
Today's navigation applications combine AR with Geographic Information System (GIS) data, overlapping visual landmarks on real scenes to direct users to a particular direction or places. MAR applications can help users navigate real-world buildings, navigate inside a city, or within a specific facility. In some situations, users can easily evaluate their position on the map or within the building, and in this sense key elements that the user can provide to the application can determine their position on the map. Thus, MAR platforms can also be helpful in guiding tourists within cities or buildings, as well as workers inside a building under construction, workers inside a factory, etc.

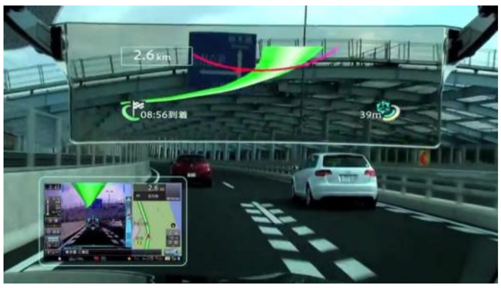

Fig. 8. Cyber navi [27]

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The Cyber navi application (Fig. 8) shows the route to be followed by a live video that makes it possible to understand the intersection and the surroundings, measure the distance between vehicles, detect signal modification, etc. by real-time video analysis. Also, there is a "road creator" function that generates real-time road data and can use it to make routes that are not currently recorded in the application [28].

Fig. 9. Copenhagen Airport [29]

Fig. 10. Copenhagen Airport [29]

The interior of Copenhagen Airport (CPH) (Fig. 9) and (Fig. 10) has since 2011 been the first airport in the world to use MAR to help passengers navigate inside it (because GPS positioning is commonly used for geo-based external applications -location, and the GPS cannot be reliably used inside). The CPH application uses the airport's Wi-Fi infrastructure for tracking.

3 Methods for designing and implementing an AR mobile application

During the design phase of the mobile application we will use a qualitative methodology, taking into account the case studies previously presented and the functionalities of each of the 6 applications: full scale design visualization, simulation of interior design and collision detection, virtual reconstructions of old buildings, location of networks utilities, construction site organization or closed-end orientation. Thus, we will design a modularized application that contains a module for each functionality, the printer the advantages of this modularized application can be said to add new functionalities according to needs at any time, and the maintenance process is streamlined.

The functionalities of the application and how they integrate as a single application, as well as the interaction with users, will be presented through UML diagrams, more precisely through the use case diagrams for the general case of use, but also for a particular case. The charts will be built using the Visual Paradigm environment. Mobile application developers have begun to use augmented reality techniques by taking camera information and overlaying real-time images, usually using meshed up to highlight where real-world image or virtual object is. The most appropriate way to begin developing an application that uses augmented reality is to use an existing AR service, such as Layar. It offers features for Android and iPhone platforms [1]. The Layar service allows anyone to add data that can be displayed to users and manage AR details [1].

Implementation of the AR contains two main parts: the "live" data on which the work is done and the metadata used for augmentation. For an overlay example in the real world, the live data we process will usually be a combination of information taken from the device's camera, the current location, and the device's direction of movement. This information is then merged with a metadata list [1]. For example, in the case of building organization use in an area, the AR service must have augmentation data for each building, including latitude and longitude. Using this information and the direction that indicates the device / camera, we can approximate the location of each building as an overlap in the search window and display an icon over its position [1].

The augmentation data source (for example, the list of buildings) can often be a preloaded

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database or a web service that can be filtered to nearby points of interest. The rest of the AR implementation is using camera APIs, graphical APIs, and sensor APIs to overwrite augmentation data on live data and to create a user-friendly experience.

a. *Camera data*. It is used to display the live stream of your Android device's camera. Camera data is available using the APIs available in the android.hardwareCamera package. If the application does not need to analyze the frame data, then it is sufficient to start a preview normally by using a SurfaceHolder object with the setPreviewDisplay () method. With this method, you can show what the camera records on the screen for use. If the application needs frame data, then call the setPreviewCallback () method with a valid Camera.PreviewCallback object [1].

b. *Location data*. It is required to determine the location of the device (and therefore its user). To do this, location information typically accessed through the APIs available in the android.location package, the LocationManager class, must be accessed. In this way, the app can handle location-related events and use them to determine the places where items of interest are located in relation to the device. When localization data is not used, a "marker" or "tag" is often used. This is an easily recognizable object where the orientation and scale of an object can be determined quickly [1].

c. *Sensor data*. It is important for AR implementations, for example, to know the orientation of the phone or when trying to keep the data synchronized with data provided by the camera. To determine the orientation of an Android device, you'll need to use the API available in the android.hardware.SensorManager package. Among the most used sensors are:

- Sensor.TYPE_MAGNETIC_FIELD
- Sensor.TYPE_ACCELEROMETER
- Sensor.TYPE_ROTATION_VECTOR [1]

An important point of the augmented reality is to overlay something over the camera's feed, which helps to get the imager that the user sees it, and for that can be added an overlay of a frame on the screen (it can be a Bitmap or a Bitmap texture on a 3D surface). For example, you can use the android.hardware.Camera.PreviewCallback class, which allows the application to obtain frame images with a frame. Alternatively, you can use SurfaceHolder with the android.hardwareCamera object [1].

Finally, the way the objects are drawn depends on the individual case of the module - there are both 2D or 3D graphical APIs available on Android, especially the APIs in the android.graphics and android.opengl packages. For example, you can use 2D graphics APIs to view building detail or site navigation, while 3D graphics deployments are required to simulate interior design or fit the building into the existing organization of the area.

Often, the data that helps with this process can be stored locally or in an online or cloud database accessed through a service. If augmented data was preloaded on the device by using a SQLite database for quick and easy searches; you can find the SQLite APIs in the android.database.sqlite package. For data stored online, it is necessary to connect to a web service using the normal methods: HTTP protocol and XML parsing. To do this, use the java.net.URL class with one of the XML parsing classes, such as the XmlPullParser class, to analyze the results [1].

4. The Application Design Results

Previous case studies show various ways in which augmented reality has been integrated into mobile applications to date, and how it manages to help users through virtual imagery to perform various simulations or to enter into closed spaces. It helps when you try to buy some new furniture in house, comes in handy for companies, especially companies in construction area, with 3D plans and schemes, and so on. The utility of AR is limited only by people's imagination. Thus, in order to increase efficiency in the field of construction, to understand as accurately as construction plans and the involvement of all factors

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(builders, architects, public authorities, community, owner project, etc.), we propose the design of a mobile application running on the capable Android platform to provide another way of every step of building constructions, from the initial state to the final one when the building enter in use. The application will support the understanding of the building project before the construction works are launched and will be useful for construction professionals as well as for those who are not specialized in this field.

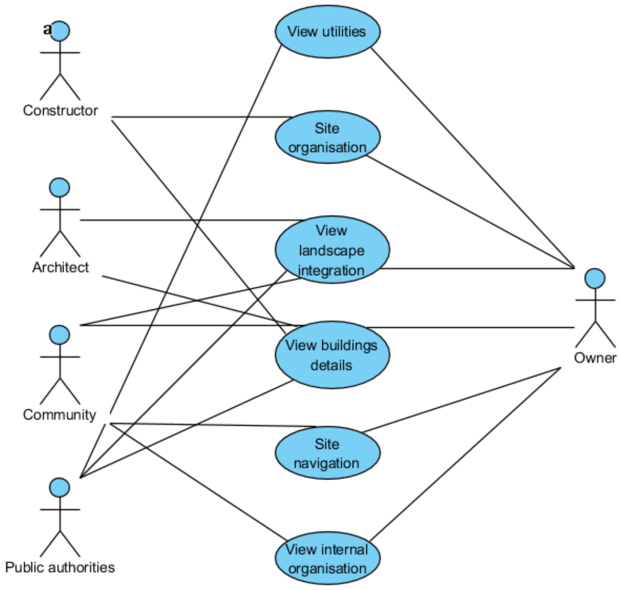

Fig. 11. General Use Case

The application includes a number of 6 modules, each module having a precise task and it can be used by any of the categories of people involved. It should also be remembered that the viewing mode will be based either on a real image, over which changes will be made by overlapping virtual objects, or a virtual image will be used over which virtual objects will be overlapped. Thus, the 6 modules can be used in various stages of building construction, having a role in:

- Visualization of user networks in the area and their planning
- View the stages of site organization
- Viewing the new urban plan
- View building details
- View the interior of the building
- Site navigation inside the building (valid for a large building).

Figure 10 shows the diagram of all cases of using the application, in short. Thus, we can see that each of the actors involved (public authorities, designers, architects, community, owner project) will interact with the application in a different way, each using those modules that can influence it in the sense of a good understanding of the construction and how it will integrate into the already existing organization. The activities they perform in the application are similar to the naming of the previously mentioned modules.

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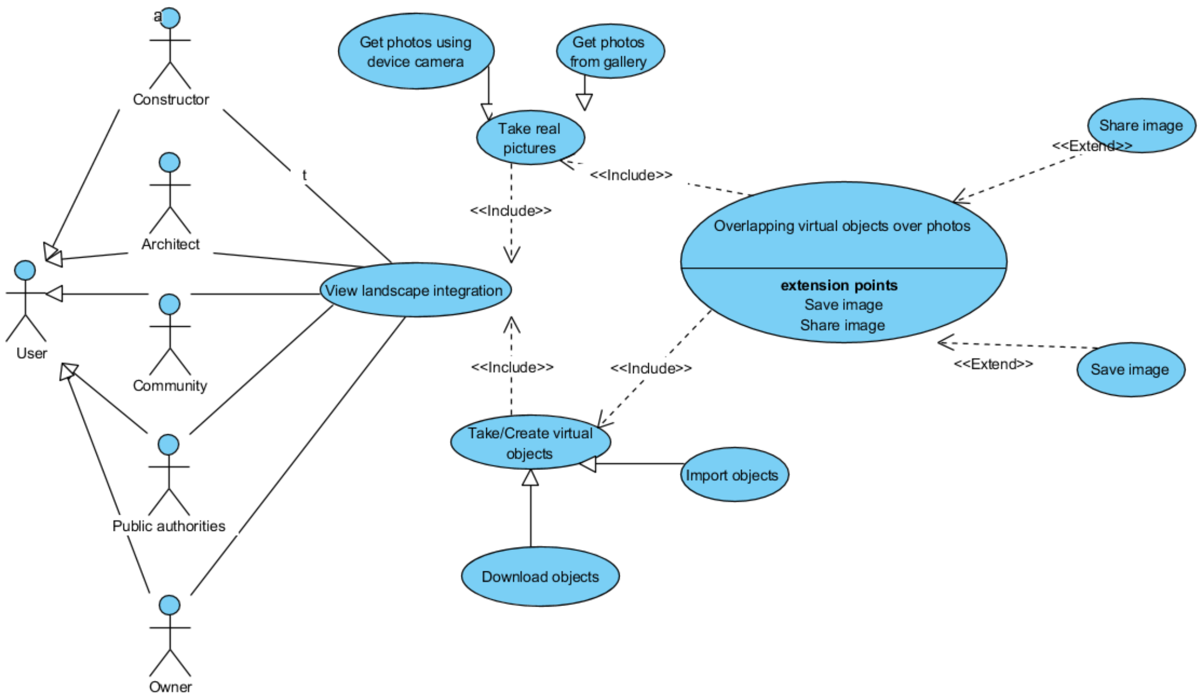

Fig. 12. Landscape Integration Use Case

The particular case proposed for the analysis is represented by the visualization of how the building to be built will fit the already existing urban organization. Thus, through the Fig. 11 are presented the actors who will use the module themselves, actors that inherit a common behavior of the base user. In order to perform the required view, it is imperative that the application executes a real image acquisition (the existing urban design at the time of the construction design) and a takeover of the object (s) (building or assembly of buildings) to be overlapped. Loading of actual image can be done by capturing the photo at the place of construction or by downloading a previously performed image from Gallery, while downloading virtual objects can either be done by drawing them on the device or by importing objects already drawn on another dedicated device construction design. The final stage is the visualization of the image representing the simulation, which can be saved on the device or distributed to other actors involved.

In conclusion, augmented reality is a broad topic that touches many aspects of Android development and many APIs. Implementation methods can be used for each particular case presented earlier, using the necessary Android components and the Android SDK [1].

5 Conclusions

The main conclusion of this article is that the augmented reality is a technology with potential in the field of construction and must be exploited by developing applications that revolutionize the design of buildings in the current period. Augmented reality can provide much more information to application users than the classic presentation of past work plans. Thus, the previously designed application combines a number of useful modules that can be previously simulated through various images, using the mobile device and augmented reality.

The secondary conclusions that we can draw from all the presented analyzes refer to the fact that the potential that augmented reality and technology offer to this field is unlimited. Thus, all stakeholders involved in building projects can develop applications that ease their work and allow them to perform various simulations without time and resources. Also, the integration of the augmented reality by

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these factors facilitates the transition of classic cities to Smart City.

References

[1] L. D. Shane Conder, "https://code.tutsplus.com/," 18 January 2011. [Online]. Available: https://code.tutsplus.com/tutorials/augmented-reality-getting-started-on-android--mobile-4457. [Accessed 21 April 2018].

[2] Wikipedia, „https://en.wikipedia.org/wiki," 18 January 2018. [Interactive]. Available: https://en.wikipedia.org/wiki/Smart_city . [Accessed 18 March 2018].

[3] A. Barbu, „http://www.adibarbu.ro," 17 June 2016. [Interactive]. Available: http://www.adibarbu.ro/2016/06/ce-este-realitatea-augmentata-cum-este-folosita.html. [Accessed 18 March 2018].

[4] B. Cohen, „https://www.fastcompany.com," 13 January 2014. [Interactive]. Available: https://www.fastcompany.com/3024721/the-10-smartest-cities-in-europe. [Accessed 18 March 2018].

[5] J. A. G. L. S. L. M. J. M. H.-M. J. F. M. P. Verónica Gutiérrez, „https://link.springer.com/content," [Interactive]. Available: https://link.springer.com/content/pdf/10.1007%2F978-3-642-38082-2_15.pdf. [Accessed 18 March 2018].

[6] S. Partner, „https://smartcitiescouncil.com/article," 3 September 2017. [Interactive]. Available: https://smartcitiescouncil.com/article/six-ways-augmented-reality-can-help-you-see-more-clearly. [Accessed 15 March 2018].

[7] K. Hoshang , K. Saleh, M. Ramin , S. Majid and S. Mino, „Augmented reality in smart cities: applications and limitations," Journal of Engineering Technology, pp. 28-45, 2018.

[8] Tom Dieck, M.C. and T. Jung, „A theoretical model of mobile augmented reality acceptance in urban heritage tourism," Current Issues in Tourism, pp. 1-21, 2015.

[9] P. Salvini, Urban robotics: Towards responsible innovations for our cities. Robotics and Autonomous Systems, 2017.

[10] W. C. and H. M., „Mobile mixed reality system for architectural and construction site visualization. In Augmented Reality - Some Emerging Application Areas," InTech, pp. 115-130, 2011.

[11] T. Olsson, A. Savisalo, M. Hakkarainen and C. Woodward, „User evaluation of mobile augmented reality in architectural planning," in Proc. ECPPM 2012, Reykjavik, Island, 25-27 July, Reykjavik, 2012.

[12] V. Oksman, A. Väätänen and M. Ylikauppila, „Future Illustrative and Participative Urban Planning.," in In CONTENT 2014, The Sixth International Conference on Creative Content Technologies, 2014.

[13] V. Oksman, A. Väätänen and M. Ylikauppila, „Co-creation of Sustainable Smart Cities.," in In UBICOMM 2014, The Eighth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, 2014.

[14] P. Välkkynen, S. Siltanen, A. Väätänen, P. Honkamaa și M. Ylikauppila , „Developing Mixed Reality Tools to Support Citizen Participation in Urban Planning," in EXS 2.0 Exploring Urban Space in the Web 2.0 Era, Munchen, 2013.

[15] D. Wagner and D. Schmalstieg, „First Steps towards Handheld Augmented Reality," in Proc. of the 7th International Conference on Wearable Computer, 2003.

[16] T. Höllerer and S. Feiner, Mobile Augmented Reality. In: Telegeoinformatics: Location-Based Computing and Services, H. Karimi & A. Hammad, Eds. Taylor & Francis Books Ltd, 2004.

[17] E. Karapanos, J. Zimmerman, J. Forlizzi and B.-J. Martens, „User Experience over Time: An Initial Framework," ACM Press, pp. 731-738, 2009.

[18] B. Daniel, Z. Peter and S. Bernd, „http://programm.corp.at/cdrom2013/papers2013/CORP2013_29.pdf," 2013. [Interactiv]. Available:

http://programm.corp.at/cdrom2013/papers2013/CORP2013_29.pdf. [Accessed 15 April 2018].
[19] "http://virtual.vtt.fi," 6 March 2012. [Interactive]. Available: http://virtual.vtt.fi/virtual/proj2/multimedia_old/index_dm.html. [Accessed 20 April 2018].
[20] D. Lee, „https://www.theverge.com/," 20 September 2017. [Interactive]. Available: https://www.theverge.com/2017/9/20/16339006/apple-ios-11-arkit-ikea-place-ar-app. [Accessed 15 April 2018].
[21] L. Bastien, „https://www.realite-virtuelle.com," 28 September 2017. [Interactive]. Available: https://www.realite-virtuelle.com/apple-arkit-marques. [Accessed 20 April 2018].
[22] R. Abboud, „http://architecturenow.co.nz/," 23 April 2014. [Interactive]. Available: http://architecturenow.co.nz/articles/architecture-in-an-age-of-augmented-reality/. [Accessed 20 April 2018].
[23] http://www.dailymail.co.uk, „http://www.dailymail.co.uk," 26 February 2014. [Interactive]. Available: http://www.dailymail.co.uk/sciencetech/article-2567739/Streetmuseum-app-creates-hybrid-images-London.html. [Accessed 20 April 2018].
[24] D. Wilcox, J. Marvin and C. Peter, „Augmented Reality: Bringing BIM to Life.," Journal of Building Information Modeling, pp. 18-19, 2012.
[25] G. Masoud, F. Mohsen, C. Pojui and I. Javier, „https://www.researchgate.net," October 2016. [Interactive]. Available: https://www.researchgate.net/figure/Virtual-excavation-for-subsurface-utilities-as-shown-in-Cote-2011b_fig2_258243663. [Accessed 20 April 2018].
[26] https://www.trvc.net, „https://www.trvc.net," [Interactive]. Available: https://www.trvc.net/services-4d-phasing-3d-construction-sequencing. [Accessed 20 April 2018].
[27] https://wordlesstech.com, „https://wordlesstech.com," May 2012. [Interactive]. Available: https://wordlesstech.com/cyber-navi-augmented-reality-hud-video/. [Accessed 20 April 2018].
[28]„https://gigazine.net/gsc_news/en/20110509_carrozzeria," 9 May 2011. [Interactive]. Available: https://gigazine.net/gsc_news/en/20110509_carrozzeria. [Accessed 15 April 2018].
[29] https://park-it-solutions.com, „https://park-it-solutions.com," March 2018. [Interactive]. Available: https://park-it-solutions.com/augmented-reality-airports/. [Accessed 20 April 2018].

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