Serbian Association for Geometry and Graphics

The 7th International Scientific Conference on Geometry and Graphics

moNGeometrija 2020

September 18th - 21st, Belgrade, Serbia

PROCEEDINGS

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TOPIC 2: APPLIED GEOMETRY AND GRAPHICS

CONTENT

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THE CONTEMPORARY VISUALIZATION AND MODELLING TECHNOLOGIES AND TECHNIQUES FOR THE DESIGN OF THE GREEN ROOFS

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ABSTRACT

The contemporary design solutions are merging the boundaries between real and virtual world. The Landscape architecture like the other interdisciplinary field stepped in a contemporary technologies area focused on that, beside the good execution of works, designer solutions has to be more realistic and "touchable". The opportunities provided by Virtual Reality are certainly not negligible, it is common knowledge that the designs in the world are already presented in this way so the Virtual Reality increasingly used.

Following the example of the application of virtual reality in landscape architecture, this paper deals with proposals for the use of virtual reality in landscape architecture so that designers, clients and users would have a virtual sense of scope e.g. rooftop garden, urban areas, parks, roads, etc. It is a programming language that creates a series of images creating a whole, so certain parts can be controlled or even modified in VR. Virtual reality today requires a specific gadget, such as Occulus, HTC Vive, Samsung Gear VR and similar.

The aim of this paper is to acquire new theoretical and practical knowledge in the interdisciplinary field of virtual reality, the ability to display using virtual reality methods, and to present through a brief overview the plant species used in the design and construction of an intensive roof garden in a Mediterranean climate, the basic characteristics of roofing gardens as well as the benefits they carry.

Virtual and augmented reality as technology is a very powerful tool for landscape architects, when modeling roof gardens, parks, and urban areas. One of the most popular technologies used by landscape architects is Google Tilt Brush, which enables fast modeling. The Google Tilt Brush VR

app allows modeling in three-dimensional virtual space using a palette to work with the use of a three-dimensional brush.

The terms of two "programmed" realities - virtual reality and augmented reality - are often confused. One thing they have in common, though, is VRML - Virtual Reality Modeling Language.

In this paper are shown the ways on which this issue can be solved and by the way, get closer the term of Virtual Reality (VR), also all the opportunities which the Virtual reality offered us. As well, in this paper are shown the conditions of Mediterranean climate, the conceptual solution and the plant species which will be used by execution of intensive green roof on the motel "Marković".

Keywords: Visualization, Landscape architecture, Green roof, Virtual Reality

1. INTRODUCTION

Urban environments face many challenges, especially those related to the preservation of the green environment under the influence of infrastructure development and the rapid expansion of infrastructure facilities that have contributed to minimizing green spaces. In the absence of enough space to form new green spaces in the city, a good way to go back and create a better, more comfortable, healthier and more functional space in the city is to build green roofs, which do not take up additional space in urban spaces and have a great function in creating better microclimatic conditions of the city, reducing the reflection of the sun's rays, reducing the reflection of city noise and reducing the accumulation of heat in the summer. Green roofs represent a very profitable investment, because their lifespan is twice as long as the duration of a conventional roof, thus reducing the need to re-cover buildings [1]. The presence of plants has a positive effect on people by reducing stress and mental fatigue, which are the most common causes of the disease [2]. The notions of two "programmed" realities are often confused - virtual reality and augmented reality. One thing they have in common, though, is VRML - Virtual Reality Modeling Language. It is a programming language that is created through images that create a whole, and certain parts can be managed or even changed. Virtual reality in today's form requires a specific add-on (gadget), in the form of Occulus, HTC Vive, Samsung Gear VR and the like. Augmented reality today certainly requires a ubiquitous gadget - a smart phone. An ideal example of a well-known example of augmented reality is the world-famous game Pokemon GO. Global modernization and following trends subtly requires that the design solutions be as realistic as possible and that it represent a project that will be executed as faithfully as possible to the solution presented. For that reason, augmented and virtual reality can provide a lot to various disciplines, especially in Landscape-architectural projects. Augmented reality is a type of virtual reality in which certain information exists, imperceptible to the human senses, and which is observable and registered in an enlarged representation of reality with the physical world. The difference between virtual and augmented reality is that in virtual reality, the real world is completely replaced by the virtual [3]. Augmented reality has largely found application in a related discipline such as architecture. The big

get a sense of how big the room is [4]. Following the example of the application of augmented reality in architecture, this paper deals with proposals for the use of augmented reality in landscape architecture so that clients and users in a similar way, have a virtual sense of scope, e.g. roof garden, city urban areas, parks, roads, etc.

2. MATERIAL AND METHODS

The method of work is based on the study of professional literature and after the research of making a conceptual solution of the roof garden. The presentation of the conceptual solution in this paper is on the example of the motel Marković, which is located in Šušanj (municipality of Bar) Montenegro, on the coast, where it is planned to build an intensive roof garden so that motel users can additionally enjoy their vacation. Domestic as well as foreign literature related to climate, roof gardens, plants, ways of visualization and modeling was used. In addition to the available professional and scientific literature, consultations with experts in the field, internet portals with available information in the field of visualization, modeling and augmented reality were used. The aim of this paper is to acquire new theoretical and practical knowledge in the interdisciplinary field, with 3D model designed with chosen plant species used in construction of intensive roof garden in Mediterranean climate presentation using contemporary technologies, as well as to give a brief overview of rooftop gardens as well as the benefits they bring.

3. AUGMENTED AND VIRTUAL REALITY

The first system for displaying images of augmented and virtual reality with a head-mounted display (HMD) was developed in 1968 by Ivan Sutherland and his student Bob Sproule. The system worked on the basis of CRT technology and was primitive in terms of interface and realistic display, while the graphics showed the contours of a three-dimensional object. The model was named The Sword of Damocles because of its massive construction that descended from the ceiling to the user's head [5].

The term "augmented reality" is mentioned in the early 1990's, by Caudel and Meisel, scientists at the Boeing Corporation, who developed the unique AR a system that allows workers to connect wires more easily [6]. Virtual Reality (VR): providing information that changes in real time with the feeling and experience that the user is somewhere else. Augmented Reality (AR) is a supply of information that changes in real time with undisturbed observation of the real world and participation in it [7].The requirements that need to be met in order for virtual and augmented reality to be exploited are: Interactive action in real time; Combining real and virtual world in a real environment; and Matching real and virtual objects. The ability to implement computer graphics in the real world is collectively called augmented reality (AR). Unlike virtual reality, augmented reality interfaces at the same time allow users to see the real world as well as virtual recording related to real locations and objects. In the augmented reality interface, the world is viewed through a hand-held or head-mounted screen (HMD) through which the graphics can be seen or overlapped in a video of the surrounding environment. AR interfaces enhance the real world experience, unlike other computer interfaces that distract users from the real world into the virtual [8]. 1994 - Paul Milgram and Fumio Kishino define and present the Reality-Virtuality Continuum in their work [9] (Figure 1). Their continuum considers the space between the virtual and the real, within which there is augmented reality. This research of theirs is generally accepted and represents the unavoidable basis of all modern research in the field of augmented reality.

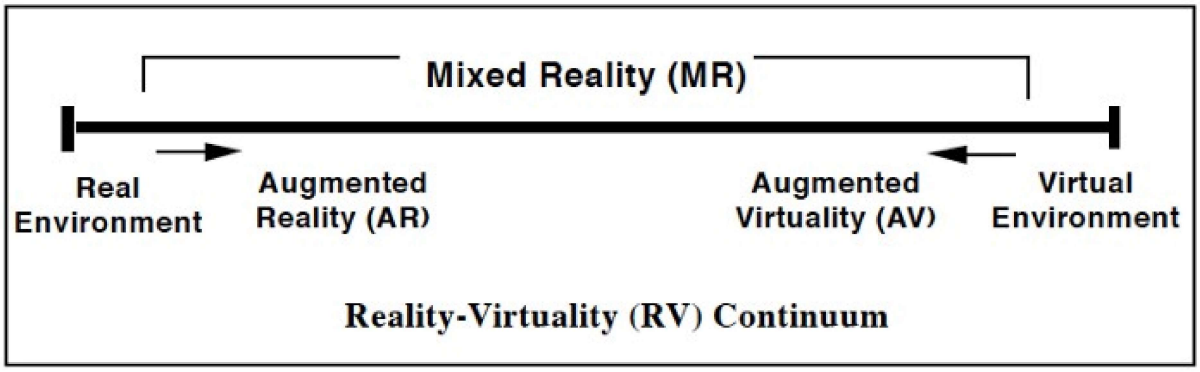

Figure 1: Real-virtual continuum (Milgram et.al. 1994)

The reality-virtuality continuum (Figure 3) ranges from the real, i.e. physical environment, all the way to the virtual environment. Between these extremes there is a mixture of the real and the virtual, the so-called mixed reality [9].

Mixed Reality - (MR Mixed Reality) presents:

-virtual continuum between completely virtual (VE Virtual Environments) and completely real scenes (RE Real Environments),

-inserting virtual elements into the real scene, AR augmented reality

-inserting real elements (images, videos into the virtual scene AV (audio-visual system) supplemented virtual scene (dominated by virtual scene)

-hiding (removing) objects of the actual scene is included (image processing is required) it is necessary to remove shadows of objects (other influences on the scene).

In order to bring the use closer to the users, in a later paper [10] Milgram lists seven types of MR images:

1. Monitor based (non-immersive) video displays. Showing a video about the real world to which digital images are superimposed.

2. The HMD displays the video. Same as type 1 but the content is in HMD.

3. Optical transient HMD. Transparent view that allowing virtual images to be displayed above the real world.

4. Transparent HMD video. It is same as 3, but displaying video from the real world in front of the users by virtual graphics.

5. Monitor-based AV system. Display 3D graphics on a monitor with superimposed video.

6. Full or partial AV that appears in the user environment. This way 3D graphics is shown on a display that turns into an impressive featuring video.

7. Partial AV systems. AV systems allow additional interactions in real objects, such as interaction with one's own real hand.

As the world is three-dimensional and interactive, it requires that the augmented reality system must have the following characteristics [10]:

-combines real and virtual,

-has real-time interaction, and

-functioning is three-dimensional.

The development of modern digital technology has enabled the creation and presentation of three-dimensional virtual models of objects. The basic division of methods for digital representation of objects is:

-Digital images,

-Animation,

-Virtual reality and

-Augmented reality

Virtual and augmented realities as a technology are a very powerful tool for landscape architects, when modeling roof gardens, parks, and urban areas. One of the most popular technologies used by landscape architects is Google Tilt Brush, which enables fast modeling. The Google Tilt Brush VR app allows modeling in three-dimensional virtual space using a work palette using a three-dimensional brush. This equipment was released by Google on April 5, 2016.

Required equipment for Google Tilt Brush VR app is [11]:

-HTC Vive hardware as a head set

-Controllers with motion tracking (brushes)

-Work space

Computer features that could handle these needs are presented on Fig. 2

Component	Recommended system requirements	Minimum system requirements
Processor	Intel Core i5-4590/AMD FX 8350 equivalent or better	Intel Core i5-4590/AMD FX 8350 equivalent or better
GPU	NVIDIA GeForce GTX 1060, AMD Radeon RX 480 equivalent or better	NVIDIA GeForce GTX 970, AMD Radeon R9 290 equivalent or better
Memory	4 GB RAM or more	4 GB RAM or more
Video output	HDMI 1.4, DisplayPort 1.2 or newer	HDMI 1.4, DisplayPort 1.2 or newer
USB port	1x USB 2.0 or newer	1x USB 2.0 or newer
Operating system	Windows 7 SP1, Windows 8.1 or later, Windows 10	Windows 7 SP1, Windows 8.1 or later, Windows 10

Figure 2: Minimum and optimal computer characteristics for using the Google Tilt Brush VR application (https://www.profweb.ca/en/publications/articles/forging-in-3-dimensions-using-vr-and-google-tilt-brush)

3.1. Virtual Reality and Augmented Reality center University of Arts in Belgrade

Within the research work, consultation with colleague from University of Arts in Belgrade was crucial for this paper. The most useful for the preparation of this work is access to the office and laboratory of associate professor Dr. Art Branko Sujić at the Faculty of Dramatic Arts in Belgrade, whose doctoral thesis was done using virtual reality called "Look into the infinity". In the professor's laboratory, there is also equipment that allows entry into the virtual world (Figure 3 and 4). Consultations with the professor were conducted on several occasions, as well as research and training on the use of equipment on the Oculus rift model with three sensors (Figures 5 and 6).

Figure 3: Oculus rift (Photo Isidora Marković)

Figure 4: Holder - *room scale* (Photo by Isidora Marković)

The first experience with virtual reality equipment was made possible by Professor Dr. art Branko Sujić, with a review of films from “Oculus studios”: “Oculus first contact”, “Lost”, “Oculus dream deck” as well as the professor's actual artwork entitled, “Look into the infinity” (Figures 5 and 6).

Figure 5: Testions Oculus rift Equipment in the laboratoire of the Faculty of Dramatic Art of the University of Belgrade (Photo by Branko Sujić)

Figure 6: Test of the Oculus rift Equipment in the laboratoire of the Faculty of Dramatic Art of the University of Belgrade (Photo by Branko Sujić)

3.1.1. TRACKING SENSORS

Monitoring sensors in virtual and augmented reality systems are:

• Camera (computer vision) - used to visually monitor the real world or its individual parts [12].

• Stereoscopic camera - allows visual monitoring of the real world and has the ability to determine the distance of real objects from the cameras [13].

• TOF (Time-of-Flight) camera - a camera that has the ability to detect the spatial distance of each pixel of the image it captures relative to it [14].

• Global Positioning System (GPS) - enables real-world global tracking [15].

• Magnetic compass - measures the magnetic field of the globe. It is used in the navigation process to determine and monitor the change of direction in real time [16].

• Gyroscope - a device for determining the direction of movement or a relative compass (because it only measures the movement of a plane as a result of the influence of force and does not coincide with the direction of the north) [16].

• Accelerometer - a device for measuring the acceleration of a moving body.

• MEMS (Micro-Electro-Mechanical-System) - a microchip for a complete navigation system with compact integration of several sensors simultaneously [16].

4. GREEN ROOF GARDENS

Green roofs date back to ancient times. The first known roof gardens were on the terraces of ziggurats in ancient Mesopotamia, and the ancient Romans planted plants on their flat roofs because they believed that greenery protected them from storms and thunder. Ornamental plants on the roofs were nurtured by the people of northern Europe, in Iceland, and in Scandinavia, within the framework of traditional architecture. The primary reason for this was the level of thermal protection of the roofs, which was so high that the buildings did not require intensive heating even in harsh winters. With the advent of the Renaissance in Italy, King Matthias was the first outside Italy to build hanging gardens at his court in Višegrad [17]. In modern times, the goal of roof gardens and plants on them is to enrich the urban environment as much as possible.

4.1. CLASSIFICATION OF GREEN ROOFS

There are two basic categories of roof green areas: green roofs and roof gardens. Green roofs are called extensive roof greenery, and roof gardens are called intensive roof greenery [18].

The main differences between these two categories of green areas on roofs stem from the type of construction and the category of plants used to raise them.

According to the International Green Roof Association (IGRA), roof gardens are divided into three categories: intensive, extensive and semi-intensive. The criteria for categorizing the types of green roofs according to the GAME are: maintenance intensity, irrigation, plants suitable for planting, depth of substrate, weight of the roof garden, lifting price and benefits of the roof garden.

Intensive roof garden is a garden that includes the use of trees, shrubs, grass areas, water surfaces, as well as the installation of park furniture and paths. This approach requires constant maintenance in terms of irrigation, plant care, maintenance interventions, etc. Maintenance costs are high and are more appropriate for public and commercial facilities [19].

4.1.1. General climatic characteristics of the Mediterranean area

A Mediterranean climate is any climate that resembles the climate of the countries of the Mediterranean basin that makes up half of the surface with this type of climate worldwide. Apart from the area along the Mediterranean Sea, this climate type is prevalent in the western parts of North America, in parts of western and southern Australia, in southwestern South Africa and in the central parts of Chile. The climate is characterized by hot, dry summers and cool, humid winters [20]. Climatic characteristics of Bar in Montenegro: The climate of the Bar area is defined by geographical position, in the zone of temperate climate zone, position right next to the Adriatic Sea and the existence and direction of the mountain range Rumija, which results in openness to maritime influences from the west and continental from east and northeast. The basic features of the Mediterranean climate are mild winters, warm summers, pleasant autumns, long and warmer than spring. For 300 days a year, average monthly temperatures above 10 ° C prevail here, and for 6 months, temperatures are above 15 ° C [21].

Roof gardens are characterized by low tree cultivars that are dwarf, spindle-shaped or mournful. Thin and brittle trees and leaves of light consistency cannot be used. Regardless of the lower height, the trees require additional anchoring (due to higher wind speeds) and increased depth of the substrate (which also increases the load on the roof structure). Therefore, a lighter substrate is used that contains enough nutrients necessary for plant

development. Shrubby plants are widely used in intensive roof gardens, but they must also be of smaller dimensions or dwarf, creeping forms. Creepers are also very often used in intensive roof gardens, but for their use it is necessary to provide adequate conditions, such as a solid and stable base with which to develop. In nature, vines often grow next to a tree; however, the trees used in roof gardens are not a good base. In roof gardens, pergolas or grilles made for this use (upright, in the form of bridges or frames) are a safe base for roofs. In addition to a stable base must also have a strong woody vase that will ensure safe growth. The basic function of woody plants in intensive roof gardens is not shading, but functionality and improvement of the space [22].

Selection of plant material for intensive roof gardens in the Mediterranean climate:

The use of woody plant material in intensive roof gardens depends primarily on the owner of the roof, his needs and desires when arranging. By using various decorative plants, the space on the roof can be enriched and made more pleasant to stay. Due to the specific conditions that prevail on the roof and the height at which the garden itself is located, woody plants of large dimensions are not used, but those of lower growth or different cultivars of dwarf growth. Light plants predominate due to the strong sun exposure of the roofs, but depending on the position of the roof and shading, semi-shade and shade plants can also be used [23].

5. THE CONCEPTUAL MODEL OF THE GREEN ROOF ON THE EXAMPLE OF THE MOTEL "MARKOVIĆ"

3D modeling of the garden (in the software designed for landscape architects) as one of the possible computer-graphic solutions, beside VR/MR/AR is used during design thinking. Main research and the final design solution is an obtained using an available software such as Realtime Landscaping Architect 2016. Realtime Landscaping Architect offers a wide range of plants, garden furniture, type of paving, etc. Photographs used as a background when creating the conceptual solution were made using a drone DJI SPARK Drone Controller Combo. The surface of the building is 950m^2, while the dimensions of the planned roof garden are 7.5m x 10m. The accommodation capacity of the motel is 80 people.

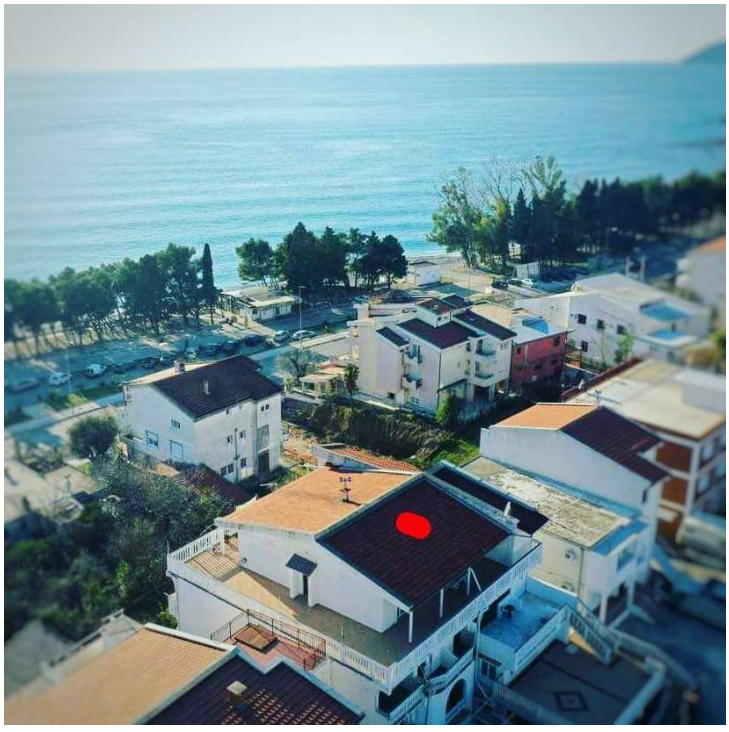

Figure 7: View of the location of the motel in relation to the promenade and the coast (Photo Isidora Marković)

The location of the motel "Markovic" is characterized by close proximity to the coast, promenade and the center of Bar (Figure 7). Due to the large number of visitors to the motel and the interesting location on the Adriatic coast, the following is a presentation of the conceptual solution of the roof garden. The selection of plant species was made on the basis of the climatic characteristics of the Mediterranean area, as well as on the type of roof garden that will be performed - intensive roof garden, which is shown in the legend of plant material (Figure 8).

The Realtime Landscaping Architecture software offers a wide range of plants, divided into groups into: annual plants, cacti, perennials, shrubs, trees, tropical plants, plants used for aquatic habitat, topiary plants and a search of plants by name (Figure 9).

Legend of plant material used in this conceptual design project:

1. *Laurus nobilis*L.

2. *Berberis vulgaris* L.

3. *Acacia decurrensvar.dealbata* (Link) F. Muell

4. *Rhus typhina* L.

5. *Prunus laurocerasus* L.

6. *Hibiscus syriacus* L.

7. *Yucca filamentosa* L.

8. *Clematis x jackmanii* T. Moore

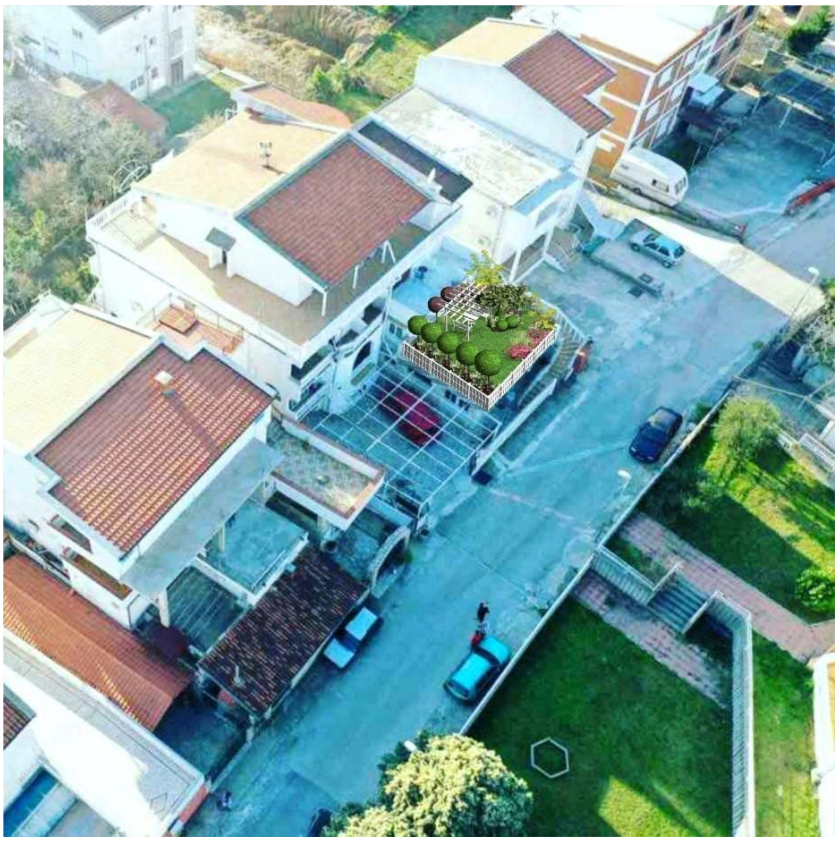

Figure 8: Conceptual design of rooftop garden

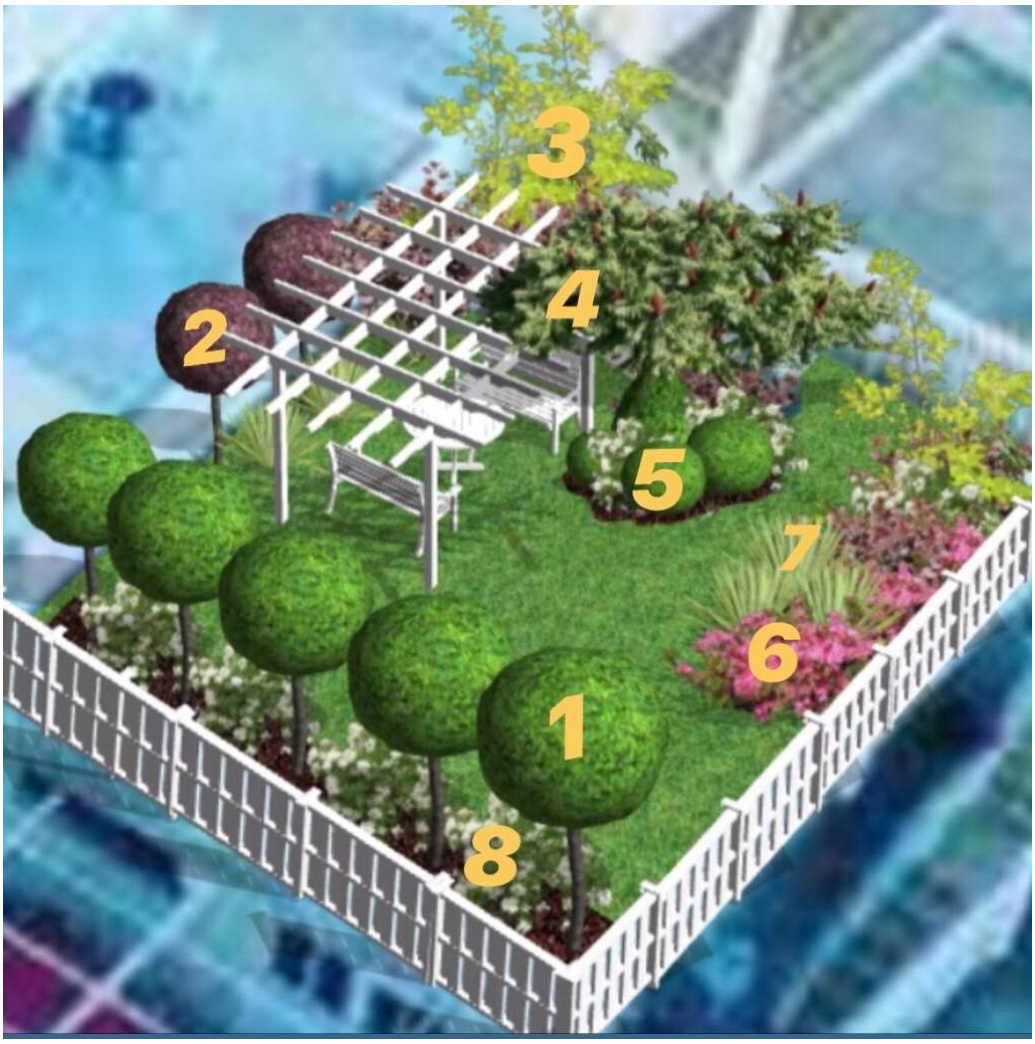

Figure 9: Detail of the conceptual design of rooftop garden with marked plant species 1-8

6. CONCLUSIONS

Virtual reality (VR) and Augmented reality (AR) already exists and will be more and more present, that is, there is a growing use in everyday life of a display system that implies some kind or elements of augmented reality. Therefore, landscape architecture as a modern and interdisciplinary science should follow new trends and be up to date with emerging innovations that are yet to be developed.

Since the Mediterranean is rich in greenery the green roof garden at the motel "Markovic" could give additional value to this specific landscape where there is no so many rooftop gardens in this area. Besides that green roofs also give a special function by providing better connected green system in this part of the city on the coast, following the best practice and actual trending.

Roof gardens are primarily efficient in urban, urban environments, given that roofs make up a large percentage of the city's area. Such roofs have economic (increase of energy efficiency of buildings), ecological (modification of climatic parameters and air composition, reduction of noise and in any form influence on improvement of living conditions in the city) and aesthetic significance, increase of decorative value of flat roof.

In this paper are shown the ways on which this issue can be solved and by the way, get closer the term of Virtual reality (VR) and Augmented Reality (AR), also all the opportunities which the Virtual Reality (VR) and Augmented reality (AR) offered us. As well, in this paper are shown the conditions of mediterran climate, the conceptual 3D design model and the plant species which will be used by execution of intensive green roof on the motel “Marković”.

Specific research questions in this paper are addressed to using contemporary technologies in 3D modeling design process green rooftop gardens. The main scientific contribution of this work is in the field of experimental design.

New knowledge is developed here as a result like experiments done in the VR lab at the University of Arts in Belgrade concerning applications of the various 3D modeling design solutions for rooftop gardens.

This research is first one connected to this inter or transdisciplinary landscape architecture topic done in cooperation between two Universities in Belgrade (University of Belgrade and University of Arts). So, it is just first step in future planned collaboration. Methodology is experimental design approach and evaluation as well as development of visualization techniques will be researched in next phase of common projects where students of landscape architecture and students of University of Arts will work together on new projects that are using VR technologies. Benefits and drawbacks will be investigated using questioners when more research results in the form of 3D models design projects of rooftop gardens will be done.

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