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Symbiosis between panoramic photography, CGI and freehand drawing in landscape representation

This article aims to highlight the value of immersive panoramic photography, computerized drawing and traditional freehand drawing when representing the landscape, not only analyzing the particular interest inherent to each one of these techniques, but also underlining the added value that involves the integration of these three techniques when representing a landscape project.
Architects learn to use most of the above mentioned representation methods, but photography seems to be the great absent in many of the curricula of the Spanish architecture schools. Therefore, in our lectures at Master's degree in Landscape, we emphasize the importance of photography as a representation technique and we show several panoramic photography techniques that are really useful in landscape representation. Panoramic landscape photography will help us to represent the landscape environment, since these panoramic images compose a starting canvas on which we can already work from an early phase of the project superimposing the elements that will conform the project, with the freshness spontaneity and dynamism that characterizes the freehand drawing. Later, when the project is mature, we can also superimpose more elaborate elements that can be carried out with the help of software tools that allow us a very detailed and precise definition. This methodology has an additional advantage, so the representations can complementarily be viewed interactively from a computer or mobile device or they can even be visualized immersively using a personal viewer such as the affordable Google Cardboard, which uses a Smartphone as a display.
In order to illustrate the advantages and the interest of this integrative representation methodology, we will describe bellow the used techniques and tools, together with some results and application examples.

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PANORAMIC PHOTOGRAPHY AND LANDSCAPE REPRESENTATION

Panoramic photography is understood as the one who covers a large field of view of the scene. Traditionally, the photographers used this kind of photography to transmit to the viewer the beauty of landscape scenes and evoke the feeling of immersion, thus creating a discipline with its own character that requires a high degree of specialization and technical control [1].
The practice of landscape photography was complicated when the Daguerreotype was invented by Louis Daguerre, based on the previous advances of Nicéphore Niépce, and its presentation by the French Government in 1839. The photographic equipment was very limited and the lenses did not allow to cover a wide field of view. This problem was lessened thanks to the resourcefulness of some pioneering photographers, such as Girault de Prangey, who prepared his special daguerreotype plates by giving them a panoramic format, in order to evoke a great visual field in the viewer. To achieve this effect, he moved away of the scene as much as possible, in order to frame a big amount of landscape elements (Fig.1). This limitation was later overcome with the appearance of wide-angle lenses.
Another way to expand the field of view, consisted in putting together two or more photographs, taken from the same point of view, but pointing at the proper direction to allow their overlapping and union. This type of composition, technically called panography, was very complicated in the case of using daguerreotypes, so they were a unique piece that had to be protected with a chassis closed by a glass, since the image would be damaged if touched, like the wing of a butterfly. However, the photographic method on paper, called Calotype or Talbotype, developed by Henry Fox Talbot practically at the same time as the Daguerreotype, was very suitable for achieving these kinds of compositions (Fig.2). The methods evolved over the time and photography on paper ended up being imposed. Therefore, the panography is a very expressive technique that has lasted to date.

The photographs composing a panography cannot be perfectly joined to conform an image without visible seams, since, when the images are arranged on the same plane, the continuity of the perspective is lost. However, in this imperfection lies one of its greatest virtues, because this discontinuity produces a very attractive collage character. Probably, many readers will recall the fantastic panographies by the architect Enric Miralles [2] or also those by David Hockney, who deliberately changes the viewpoint between photographs to increase the rupture and provide the work with a certain cubist character. Currently, these compositions can be easily carried out by means of any photo editing program (Fig.3).
The horizon of panoramic photography has expanded in recent years with the introduction of digital photography, multimedia devices and virtual reality, which have led to a new model of panoramic photography that allows us to view the entire scene interactively, using a computer or any mobile device, or even immersively, when a virtual reality viewer is used.
This new paradigm is called immersive panoramic photography which consist in taking a set of photographs, from the same viewpoint, and joining them without visible seams using a specific stitching software. These kinds of programs are

Fig. 1 - Girault de Prangey, 1842. Panorama of Rome. Daguerreotype 24 x 9.5 cm.

Fig. 2 - Henry Fox Talbot,1844, Panography composed of two photographs. Calotype

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Fig. 3 - Panography of Calella de Palafrugell (Gerona). Hans Brinker

Fig. 4 - Pictures projected onto a plane to obtain a partial panorama.

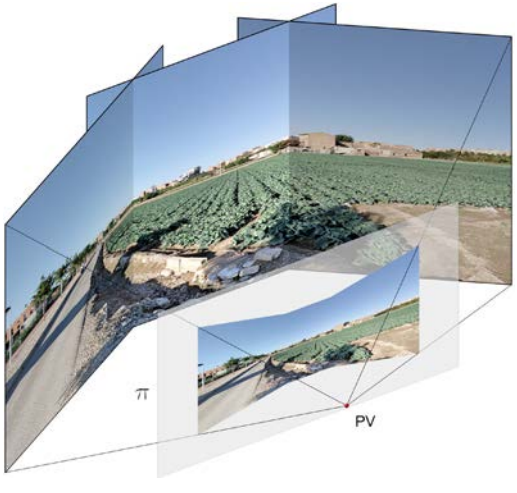

Fig. 5 - Pictures projected onto a cylindrical surface.

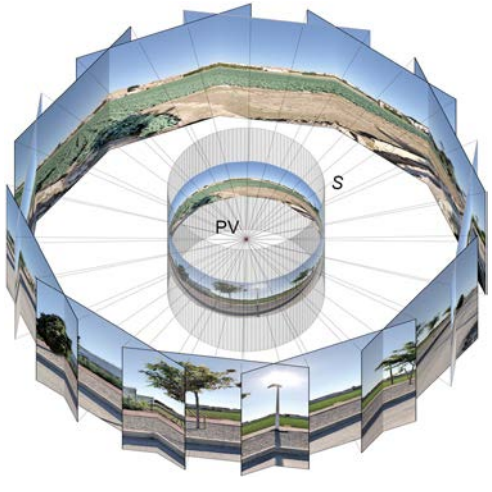

Fig. 6 - Pictures projected onto a spherical surface.

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Fig. 7 - Equirrectangular projection of a spherical panorama.

Fig. 8 - Manual and automatized Panoramic Heads.

designed to align properly each one of the photographs in the space, and project them onto a surface, thus providing a panorama that can cover the whole scene.

The technique of stitching images allows us to create several types of panoramas, such as partial, cylindrical and spherical panoramas. A partial panorama is usually generated from a limited set of images, which are oriented in space and projected onto a plane (Fig. 4). The result would be equivalent to a conventional photograph taken with a wide angle lens. Nonetheless, the resulting panorama would have much more resolution than the picture taken in a row using a wide angle objective.

In order to display the panoramic image immersively, a larger number of photographs must be taken. The simplest option is generating a cylindrical panorama, which is composed of a set of pictures configuring a closed ring. During the assembly, the photographs are spatially oriented and projected onto a cylindrical surface. The panorama is obtained by unfolding this surface (Fig.5), and can be seen immersively using a computer or a mobile device.

The maximum expression of an immersive panoramic photography is achieved through a spherical panorama, which needs a much greater number of photographs to cover the entire scene. In this case, the images are spatially oriented and projected onto a spherical surface (Fig.6). Since the sphere is not a developable surface, the equidistant cylindrical projection, better known as equirectangular projection, is used. This projection of the sphere results in a flat image that can be remapped again onto a sphere for subsequent immersive visualization (Fig.7).

Using spherical panoramas is very suitable for representing a landscape project, as they are not only an excellent way to visualize and document the scene completely, but also a way of obtaining multitude of derivative graphics, such as partial panoramas, cylindrical or even panographies, in case of preferring a collage look.

To create a spherical panorama, in a precise way, a conventional digital camera mounted on a tripod

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Fig. 9 - Cubic format Panorama.

and a panoramic head should be used. A panoramic head is an accessory that consists of an articulated arm and regulations for the camera to pivot around a fixed point. There are many panoramic heads on the market, some of them are manually operated while others are motorized (Fig.8). To guarantee a perfect union between photographs it is necessary to avoid parallax errors during the shooting. For that reason, it is very important to calibrate the position of the camera on the panoramic head, so that the center of perspective of the lens, or no parallax point, is located on the center of rotation of the head. The number of photographs needed to capture a spherical panorama will depend on the field of view of the lens, so it is convenient to use a wide-angle lens to capture the scene with fewer photographs. For a correct assembly of the panorama, it is crucial to overlap the contiguous pictures at least 1/3 of its surface.
During the capture process, it is advisable to block the exposure of the camera, so that there are no light differences between shots. Nevertheless, this can be problematic when photographing a scene in broad daylight, due to the high contrast between lights and shadows. In this case, it is advisable to use the high dynamic range (HDR) capture technique, which consist in setting a bracketing of, at least, 5 shots, for each position of the camera, varying the shutter speed 3 EV between shots. These shots are combined later in a high dynamic range panorama, which contains all the light spectrum of the scene. HDR capture method has the additional advantage that the resulting panorama can be used as a source of illumination in virtual simulations of the landscape project.
It is also very recommendable to use RAW capture format, which is available in almost all the cameras, since this format will allow adjusting the white balance afterwards, during the RAW development process, and obtaining a higher overall image quality.
Another very important factor to consider is the depth of field of the scene, that is, the sharpness with which the areas that are ahead and behind the focused motive are perceived. Depth of field depends on several factors, being the camera

ISSN 1828-5961

diaphragm aperture the most decisive. So that, closed apertures produce greater depth of field, which is desirable in landscape photography. This does not mean that we should always close the diaphragm to the maximum to achieve a greater depth of field, since selecting a very closed diaphragm has, on the contrary, a negative effect on the overall quality of the image, due to the physical phenomenon of diffraction of the light, which produces an alteration of the light beam that crosses the diaphragm when hitting its edges.
Therefore, a balanced solution must be found to achieve a good depth of field while avoiding diffraction. The thumb rule is to use an intermediate diaphragm, between f8 and f11, in order to optimize the image quality.
Finally, it is convenient to block the focus during the capture, being advisable to focus manually at the hyperfocal distance [3], before starting the capture, to maximize the depth of field.
There are many stitching programs on the market, such as AutoPano Giga, PtGui or Hugin [4] , being the latter distributed under general public license. All of them work in a very similar way and the stitching process consists of three essential steps: the detection of homologous points between images, the orientation of the photographs in space and the reprojection of images onto a surface to obtain the final panorama.
Spherical panoramas provide us with an excellent background on which to represent the landscape project, combining other techniques such as freehand drawing and CGI. However, equirrectangular projection shows some distortions when displayed as a flat image.
This makes it difficult to work and draw on them, since the image is not a perspective projection.To solve this problem, the equirrectangular images can be transformed into a cubic format, which consists of projecting the panorama onto the faces of a cube that, once developed, provides an image containing 6 perspectives, one for each face of the cube (Fig.9).
It is more convenient to work on this type of images with the rest of the graphic techniques that will be seen next.

PERSONALITY AND ANALYTICAL CHARACTER OF FREEHAND DRAWING

Freehand drawing provides a particular character that reflects the personality of the person who draws. The act of drawing is a process that involves an analysis that forces us to a deep knowledge of what is drawn.
As Professor Leopoldo Uría Iglesias said, when speaking about Mariano Olcese's travel sketches: *"If the phototurist 'shoots' his camera (...) the traveling sketcher does not freeze time with the speed of the shutter, but deploys it by opening the eye-diaphragm until the subject is exhausted; The rich mechanism of the brain does not work in fractions of a second. Faced with the increasing automatism, which enhances the 'passive' register, the drawing is (and Olcese's drawing is especially so) 'active' and 'analytical' "* (Translated fragment) (Jesús, Alonso, & Blanco, 2011).
The sketcher develops, in a natural way, an active response between what he sees, what he transmits to the brain and what he communicates to the hand.
For this reason, drawing is the result of an incessant struggle between the hand as a tool, with its limitations that vary from one artist to another, the personal consciousness that inherits from observation and all the memories that we store in the course of our life. In addition, the more we look at the objects we represent (sketchers are forced to do it constantly), the more our knowledge about them is unconsciously expanded.
Walter Benjamin highlighted the power of observation when he said that, what is seen, awakens sensitivity.
This philosopher considered that drawing notebook was a fundamental element to register and then remember our environment.
Moreover, as Professor Francis Ching said, *"Regular and continued practice is necessary to learn how to draw, which is really about learning how to see (...) Drawing encourages us to take the time to pay attention to things and relationships that might normally pass unnoticed"* (Barros & Hidalgo, 2015).
Leonardo, in his treatise on painting, also recommended observing the places and acts of men and take record of them in a notebook that one should carry. *"... you should go wandering frequently and, on your walks, observe and consider the places and acts of men. Draw them with brief strokes ... "*
It seems undeniable that drawing is about looking and learning to see, but we must not limit the dialectical capacity of drawing: its ability to communicate and represent.
Drawing allows to analyze, express and transmit shapes, spaces, textures, but also depth, movements, smells, atmospheres. In this way, drawing becomes a link that goes from the imitation of reality (the places) to the suggestion of other less measurable and personal values that result from the acts and the concrete characteristics of the physical and temporal space.
Drawing offers the possibility of possessing time, lives, dreams and illusions that were present for a moment (Solaguren, 2002). For this reason, when several sketchers represent the same subject, the results tend to be quite diverse.
According to Frank Ching, trends and processes of design thinking occur in cycles. Now that technology and photography have matured and become more accessible, it seems that the pendulum is returning to the valorization of freehand drawing, especially of the one taken in situ.
An example of this is the growth of the Urban Sketchers movement, which uses drawing as a means of connection between the eye, mind, hand and the surrounding environment. For them, drawing in situ is, at the same time, contemplative, enveloping and authentic. (Barros & Hidalgo, 2015)
The expressiveness and personality of freehand drawing provides landscape representations with a distinctive element that makes the difference with other types of more conventional and standardized representations.
Now that practically everything is done by computer, including elements drawn by free hand gives a personal touch that can attract the viewer's gaze and help to transmit particular sensations.

ISSN 1828-5961

Fig. 10 - Freehand drawing of an orchard landscape.

EXPERIENCING SPACE WITH COMPUTER-GENERATED IMAGERY

Within the set of graphic documentation that accompanies the landscape project, ortographic projection views are those who require a higher level of interpretation skills to understand and imagine the projected landscape. However, photographic images and perspective representations will allow us to easily perceive the projected place, since they provide the observer with information related to the experience lived in that environment. If plans and sections offer us quantifiable data about the proposal, perspective images are capable of transmitting sensory aspects (the warmth of the light, the gentle breeze, the smell of the grass ...) that will influence the observer during the complex process of perception of the environment.

In the field of virtual reality applied to leisure or psychology, the term sense of presence is used to define the ability of the observer to feel at the represented place (Heeter, 1992). Although the total comprehension of a space is only possible through its physical experience, the images allow us to partially experience what we would feel in the represented space. Being the main aim of three-dimensional representations to allow the observer to evaluate the proposal of the landscape project, we can consider that the goal is achieved when the viewer feels quite immersed in that space, that is, when his sense of presence is greater.

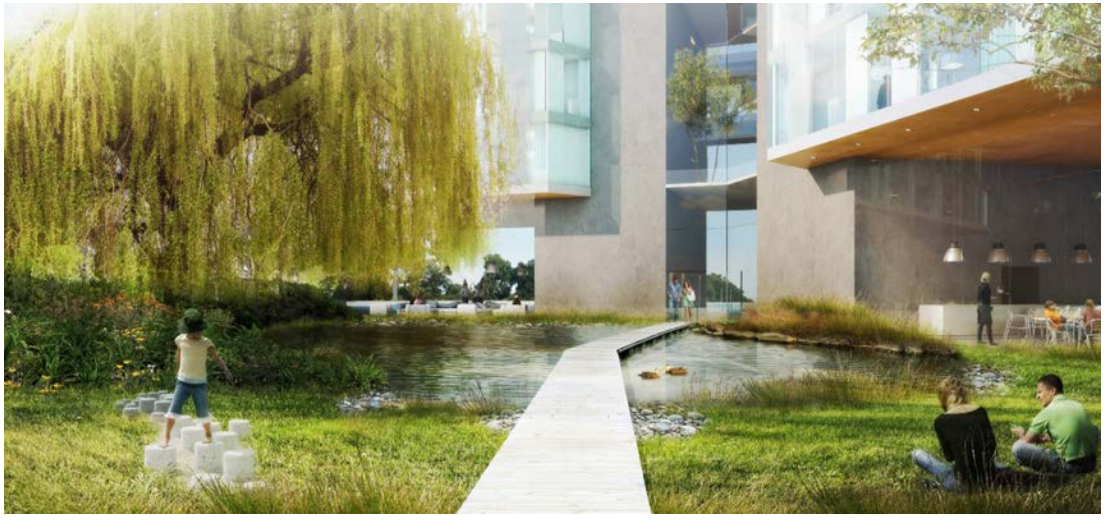
As mentioned above, one of the difficulties of achieving realism in the representations of a landscape project lies in the complexity of modeling the natural environment faithfully. The textures and forms of nature require multiple technological resources to achieve a minimum degree of realism. For this reason, the images made only by computer, with the means of which a landscape architect usually has, tend to be artificial and little credible, where it would be difficult to transmit all the sensitive qualities of space.

However, when using panoramic photography as an environment in which a three-dimensional model is inserted, it would be much easier to

ISSN 1828-5961

Fig.11 - West End Lane London. Project. CGL architects. Picture: BGSvisual.

Fig.12 - Vertical village towers Manchester. CGL architects. Picture: BGSvisual.



achieve a representation that allows the observer to experience the sensations that the designer wants to transmit.

When teaching the subject Landscape Representation, we focus on, not only the technical and methodological aspects that allow achieving these kind of images, but on the sensory dimension of these representations. Based on extensive research, carried out in our Department in this area, we have been able to obtain some conclusions about visual strategies that improve the sensory quality of the image (Llinares et al., 2018).

This research has studied the emotional response of the observer to a wide range of images, representing landscape interventions of quite different styles, relating the perceived emotions to the different attributes of the images. In this way, we have been able to determine that the greater or lesser presence of natural elements affects the feeling of well-being, warmth and nostalgia. Also, the presence of built elements influences the sensation of innovation, while the presence of people does not have much influence over the evaluation of space.

Although these conclusions are hardly translatable to different social contexts, it can be assured that the combination of different image attributes can modify the emotional response of the observer, which has a direct impact on the evaluation of space.

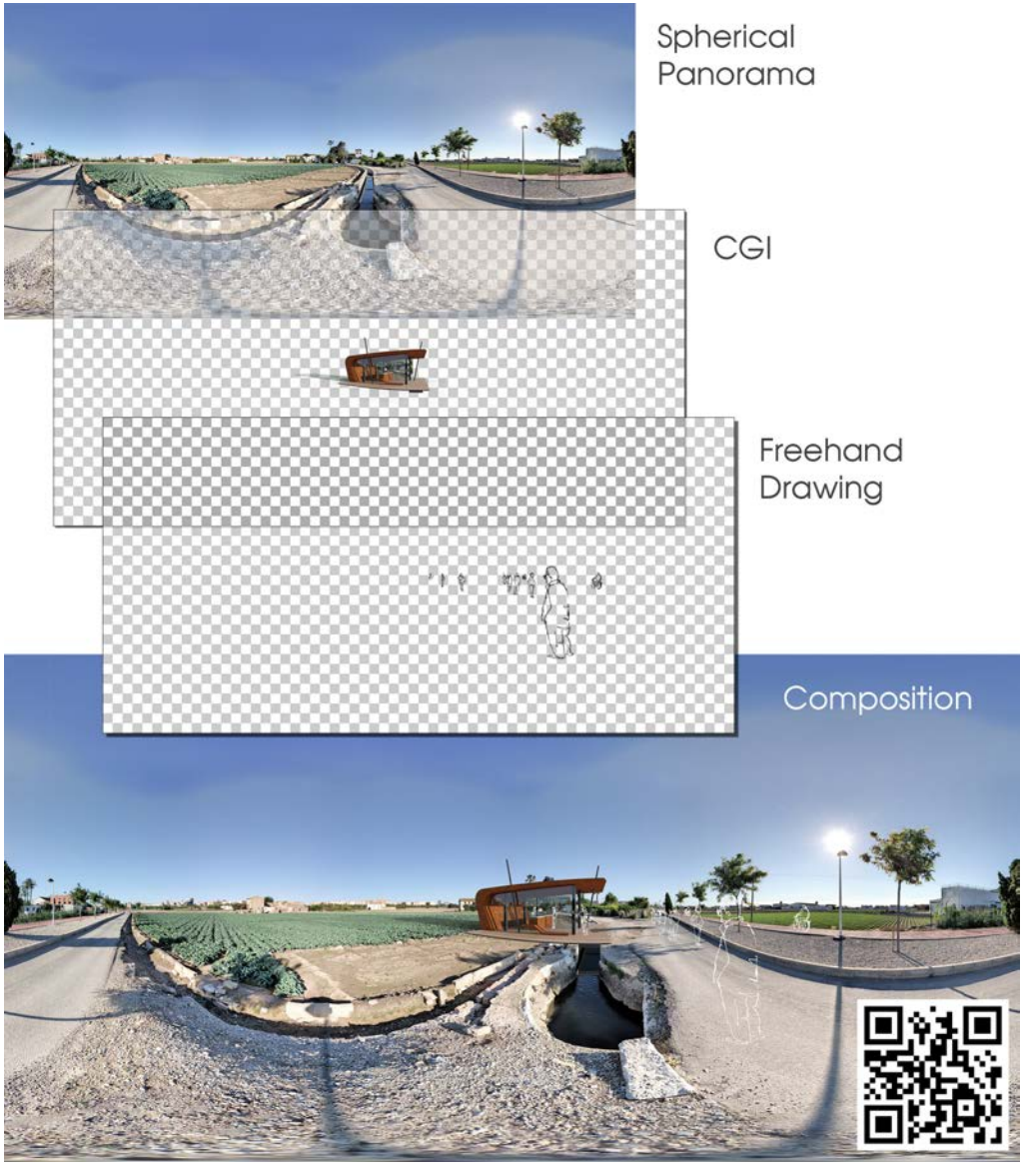
In this sense, it seems essential to incorporate the emotional dimension in the learning process of the graphic strategies. Thus, in the development of our teaching subject we work around the sensations-emotions that the place should awaken in the viewer and the student must work on his graphic speech to ensure that the presentation of the project is capable of transmitting that feelings to the observer.

ISSN 1828-5961

RESULTS AND CONCLUSIONS

The methodology that we promote in our Master's degree in landscape is the integration of all the exposed techniques, since this symbiosis allows us to enrich the representations, making them more personal and impressive. The process begins with the acquisition of a spherical panorama, being the viewpoint selection of the utmost importance, since, although the panorama will encompass the whole scene, it must have a very clear intention. In this case, it is a question of proximity and scale, because those elements closer to the camera acquire a greater importance.
After capturing the panorama, the main elements of the landscape project will be designed and fusioned with the photographed scene using CAD programs. The majority of rendering software allow using a spherical panorama as a background, which facilitates the positioning and adjustment of the virtual model over the environment. In case of having an HDR panorama, is possible to illuminate the model with the real lighting conditions of the photographed scene.
The addition of some freehand drawn elements reinforces the personality and the expressiveness of the representations, for that reason the panorama can be used in cubic format to draw on it some motives such as people, trees or any other elements of the project. Once the drawing is finished, it is easy to create an equirrectangular projection of the hand-drawn elements to superimpose them on the final panorama.
Figure 13 shows, as an example, a synthesis of the composition process. It is a project of a small stand on a vegetable garden, which serves as an information point and to supply walkers and cyclists who travel through the cycling line that runs along the orchard.
We can see the three layers that configure the final composition. The first layer is formed by the spherical panorama of the landscape, which was obtained using the high dynamic range photographic technique. The second layer is constituted by the digital model of the stand, which has been rendered using the spherical environment

Fig.13 - Combination of techniques for obtaining the final interactive composition.



ISSN 1828-5961

Fig.14 - Panography obtained from the previous composition.

provided by the panorama as the source of illumination. Finally, the third layer is composed of the freehand drawn elements that represent people who walk and bike on the road, which also serves to provide a scale reference, dynamism an depth.
The final composition can be viewed interactively, using a mobile device following the QR code shown in the figure.
It is a 360º video, which has been hosted on the YouTube platform, as it is one of the few repositories that allows visualizing this kind of interactive content. By viewing this video, the viewer can look in any direction while listening to the real sounds that occur in the place. This experience can be much more immersive, when using a personal virtual reality viewer, such as the cheap Google Cardboard.
This 360º representation can also be viewed through any computer by following this link:
https://youtu.be/RourB-vxtnI
As we have stated previously, this methodology provides us with a very important range of derived outcomes. Figure 14 shows a panography which was obtained from the previous composition.

We believe that this symbiosis between the different graphic techniques produces personal representations that can make the difference when comparing with the majority of the proposals that we can find today in the architectural competitions that seem to follow exactly the same pattern.
Therefore, we are convinced that having an adequate training in each of these techniques is very advisable for students, since this interdisciplinary will help them to express their ideas and to reinforce their graphic representations skills.

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NOTE

[1] To get more information about landscape photography techniques see, for example, Fray (2010), Hammond & Adams (2002) or Mellado (2014).

[2] Some panographies of Enric Miralles and David Hockney can be seen in Lopes (2013).

[3] Hyperfocal distance depends on the focal length, on the diaphragm aperture and on the minimum acceptable circle of confusion, it can be calculated through tables, or through on-line applications that can be found by following this link: https://www.dofmaster.com

[4] This software can be downloaded from: http://hugin.sourceforge.net/

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