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Architectural Draughtsmanship

From Analog to Digital Narratives

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Graphical Reconstruction of the Historical Buildings from the San Francisco de Borja Fontilles Sanatorium

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Abstract This paper explains part of the work being carried out as part of *the San Francisco de Borja Fontilles Sanatorium. Analysis model for the comprehensive recovery of sanitary complexes with heritage value, research project*, funded through the *National research, development and innovation programme geared towards the challenges faced by society*. This paper aims to show the graphic documentation obtained, using the very latest photogrammetric technology that not only allows technicians to reconstruct the image, but to use augmented reality technology, which enables active immersion through the use of modern virtual reality technology.

Keywords Graphic modelization · Heritage · Fontilles · Virtual reality

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1 Leper Colonies. Sites with Both Tangible and Intangible Heritage

Facilities used to isolate and treat patients suffering from leprosy and other infectious diseases, *lazarettes,* possess a singular reminder of an entire period of European history, a period marked by the efforts of scientists to fight against diseases associated with poverty, and the social and cultural exclusion of sufferers of these types of diseases. Facilities where the ill were "isolated" from society, immersed in self-sustaining facilities which, over the course of time, developed into micro societies scattered across the whole of Europe and which rebuilt the same social structures and social habits as those on the outside.

Although there are historically documented cases of leprosy dating back to ancient times, it was not until 600 AD that the first lazarettes first began to appear in Europe. The first known leprosarium in England was the *Blyth Leper Hospital* in Nottingham, and these were so numerous that by about 1300, it is estimated that there were a total of 19,000 establishments across the whole of Europe. The first leper colony in Spain dates back to 1067 in Palencia, founded by Rodrigo Diaz de Vivar, El Cid, while the *Hospital de San Lázaro* in Seville was founded in 1248 and remained operational all the way through to the 1930s. It was also the template used for hospitals that were later founded by Spain in its colonies in the Americas (Fig. 1).

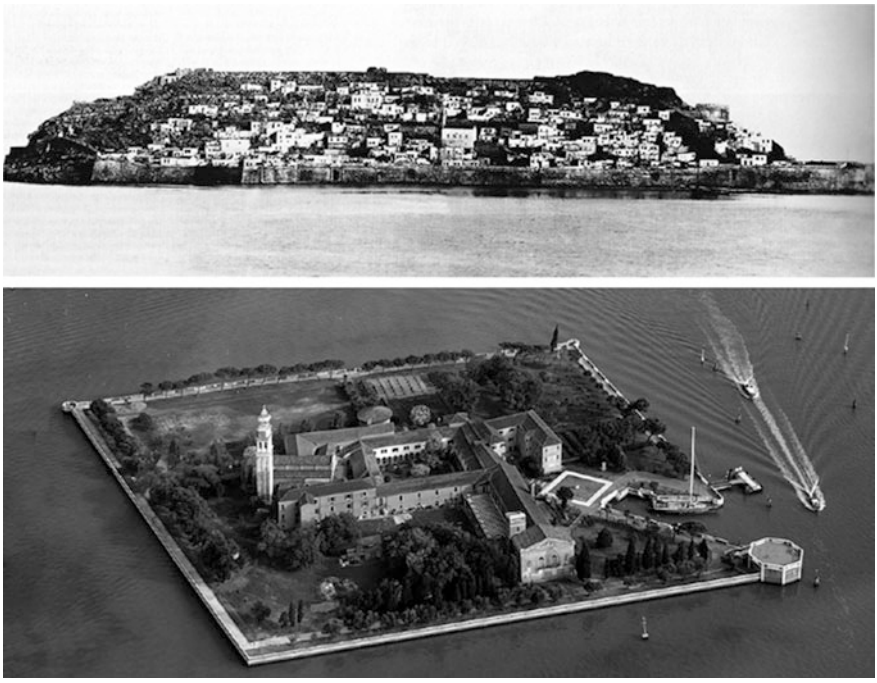

Fig. 1 The isolation of the disease: Spinalonga Island (Crete) and San Lazzaro degli Armeni (Venice)

The facilities began to evolve at the start of the 20th century, becoming colonies that aimed at mitigating the forced isolation of the sick, by creating medical compounds that were designed to be tiny, enclosed, self-sufficient cities. This was the case for the *San Francisco de Borja Fontilles Sanatorium* in Alicante (Spain), the San Martino Leprosy Hospital in Genoa (Italy), the St. Jørgen Hospital in Bergen (Norway), la Leprosaria Nacional Rovisco Pais (Portugal), the Tichilesti Leper Hospital (Rumania), and the Spinalonga Island in Crete (Greece), which in 2012 went on to form part of the *International Coalition of Historic Sites of Exclusion and Resistance*, with the medium-term aim of being added to the list of UNESCO designated World Heritage Sites.

This paper presents some of the work carried out as part of the *San Francisco de Borja Fontilles Sanatorium. Analysis model for the comprehensive recovery of sanitary complexes with heritage value, research project*, funded through the *National research, development and innovation programme geared towards the challenges faced by society* (HAR2013-42060-R), which in collaboration with the *International Coalition of Historic Sites of Exclusion and Resistance*, aims, using the Fontilles Sanatorium as a model, to develop new graphical interpretation methodologies to value the cultural heritage assets, both tangible and intangible, of these historic sites.

2 The San Francisco de Borja Fontilles Sanatorium

The Fontilles Sanatorium was founded in 1905. It has an extensive history of construction work, having undergone a number of changes and adaptations over the years, so that currently it comprises a group of buildings from different periods and with distinct architectural styles, which includes, in addition to the clinics, pharmacies, laboratories and other buildings used specifically for medical purposes, separate medical and residential buildings for men and women, buildings specifically for sick families, a theatre, a chapel, washhouses, refectories and even its own cemetery, spread out over a valley that occupies some 73 ha of low brush. The colony was completely surrounded by a 4-km-long and 3-m-high wall, used to isolate the colony due to the terror that the mere mention of leprosy might cause to the outside world at that time.

As with the rest of the colonies, life was structured around the medical treatments, but in an attempt to make the day to day lives of the sick as normal as possible, a whole series of activities were devised to "replicate" wherever possible life on the outside (Comes Iglesia 2009). Carpentry workshops, maintenance tasks for the upkeep of the facilities in addition to farming in the vegetable gardens within the enclosure, provided some degree of normality and led to a slow but relentless transformation of the landscape that gives us the image and structure of compound that is seen nowadays as a reflection of how life went on within its walls (Fig. 2).

As a whole, the architectures found at the Fontilles Sanatorium are modest, unassuming structures, built using limited material means, in keeping with the

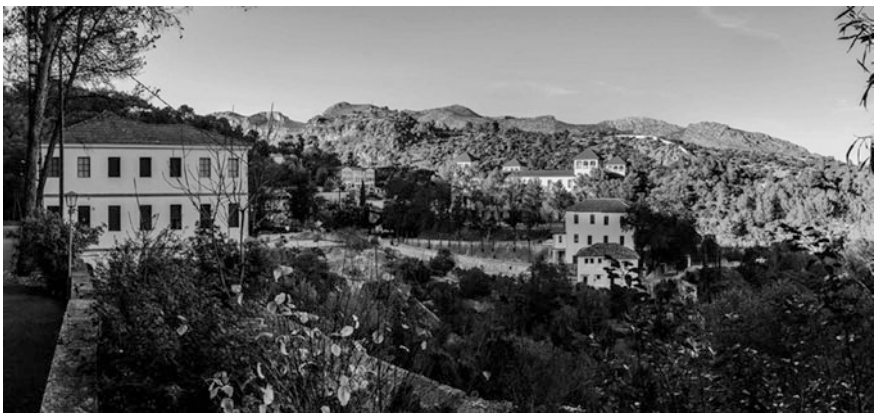

Fig. 2 General overview of the San Francisco de Borja Fontilles Sanatorium with the perimeter wall in the background

aesthetics of medical facilities built at the start of the 19th century using local building techniques. Over the long period that the Sanatorium has existed, a number of different architectural changes have been implemented. On the one hand, it did not comprise a single event but is rather the result of a series of successive events, which led to the gradual occupation of the valley, originating from a nucleus of very simple buildings. Furthermore, with the changes in the medical needs and the constant growth, the complex set the standard for the country, causing a number of physical transformations of the building to make them more suitable for their new functional requirements. Demolition work, rebuilding, extensions and additions, new uses for buildings that were different from their original purpose, led to the fact that there is no single Fontilles Sanatorium, but rather a series of successive sanatoriums whose history is part of a bigger whole.

One particular aspect, which allows us to highlight the aim of the project, is the theatre. As seen today, the building is the result of three successive periods of construction work. The first theatre, designed by Enrique Llopis Soriano was opened in 1915. In the January 1913 edition of Revista Fontilles, there is a reference to a *magnificent chalet with bathrooms, recreation room, operating theatre, doctors' staff room, and other amenities in keeping with the purpose for which it was built* (Bonilla and Bertolín 2010). Later on, in 1922, we see the extension to the Baths, with the addition of a new floor that was to be used as an assembly hall for the Colony. The same style and construction techniques as the original building were used, adding six additional oculi and therefore adding to its length, *with enough room for 18 porcelain baths on the ground floor, recreation and dining room on the main floor and a room for drying the clothes on the upper floor*.

Years later, the purpose of the Baths evolved, due to breakthroughs in healthcare treatment of the disease, so the building underwent a new transformation, with the building of a theatre and cinema to play host to the social and cultural activities that went on at the Medical Colony. This latest addition was opened in 1958, designed

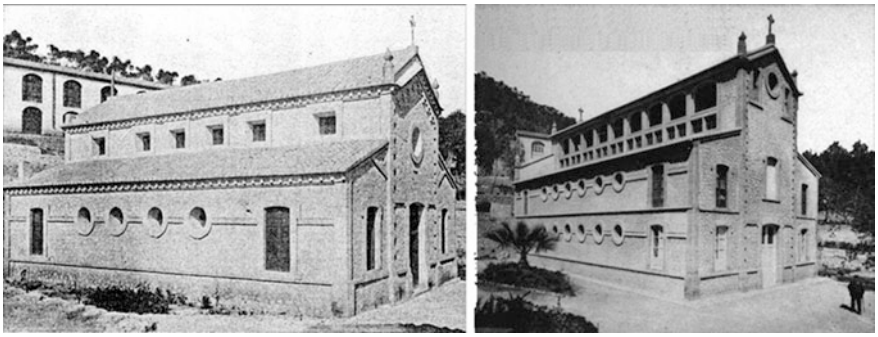

Fig. 3 First and second phases of the theatre: The bath Pavilion (1913) and the extension for its dual purpose of bath house and assembly hall (1922)

by Manuel Peris Vallbona (Bonilla and Bertolín 2010). Currently the building still retains its theatre although admittedly it is used for other purposes, as a mortuary with an autopsy room on the ground floor (Fig. 3).

This chronological sequence, which is shared by many of the other buildings in the complex, is attested to by an abundant supply of documents, both architectural and socio-cultural in nature, which enable us to test the viability of the proposed methodology in order to visually transmit the architectural transformation, by linking the archival documents that refer to the role of the building in the daily lives of the patients during each period of its history, to the photographs of the architecture. In fact, the project is based on a broader concept of the heritage assets of the colony. It might be said that it is impossible to *come to grips* with the complex without knowing the characteristics of the way of life of the patients and the way in which their daily activities shaped both the complex and the immediate environment. Fontilles boasts a vast movable heritage, both from the original residential quarters and from the medical and healthcare materials, which give us a better understanding and allows us to interpret the history of the fight against this disease throughout the 20th century. And lastly, the immense socio-cultural heritage, preserved in the form of photographs, letters, biographies and stories, both written and oral, which give a sense of meaning and enable us to understand the history and the evolution of this architectural enclave. We need to conserve and disseminate all the information as a whole in order to preserve the memory of architectural spaces that are part of one of the most overlooked human dramas of our society, social exclusion due to a disease and the uprooting and ostracism of those afflicted by it (Fig. 4).

This particular heritage, prevalent across the whole of Europe, covers a wide range of disciplines such as Architecture, Medicine, Sociology, History, Psychology, Town Planning, Landscaping, etc., and given its intangible nature, modern Information and Communication Technologies (ICTs) are an essential tool when it comes to the conservation and dissemination thereof. There is great value to the documentary

Fig. 4 Life in Fontilles. Historical photographs

collections and archival materials from these colonies, attested to by the fact that the documentary archive collection of the *St. George's Hospital* in Bergen have been referenced in the *UNESCO's Memory of the World Programme* since 2000.

3 Aims

The project proposes carrying out a global analysis of the heritage site, as well as a general overview of its uses and functions, making it possible to maintain and disseminate the site's rich heritage, as described earlier. An essential aspect of this

series of activities is the use of advanced graphical display to enable us to get a comprehensive understanding of the complex by cross-referencing its current condition with the documentary information we have available, In such a way, it is possible to understand not only the form and space that the current sanatorium occupies, but also to display how it has evolved over the decades, as have the lives of the people living there.

The work has been divided into two phases. The first, which is currently underway, sets out to carry out a comprehensive graphic reconstruction of the complex, both in its current state and during its most significant earlier stages, as well as the media available such as photographs, plans and documents that are part of the historical archives of the Sanatorium. In this way, we can display each architectural object, both inside and outside, allowing us to travel from one period to the next from a single perspective, allowing for the active movement through space using game engines such as Unreal Engine 4 (UE4). It would be a question of providing graphic documentation, which, based on digital display techniques, would allow us not only to reconstruct the image, but also to move around the complex, viewing each of the historic stages of this monumental site.

The aim of the second stage is to build a set of fully integrated digital applications with which to recreate a part of European heritage through "immersive experience". To do this, technically advanced interfaces would be required, such as augmented reality and virtual reality, which would allow us to explore the different panoramas through the distinct historical periods, together with gesture recognition techniques to facilitate browsing and navigation through the information. The aim of this project is to explore different cultural contents through interactive experiences in order to achieve a better understanding of the implicit socio-cultural implications of these heritage sites.

4 Proposed Methodology for the Graphic Modelling of the Building

The first phase of the survey consists of state modelling. For the digital reconstruction of the different architectural stages of the colony, three levels of graphical analysis, with complementary methodologies, have been developed: data collection from photogrammetric flights, restitution using a 3D scanner, photogrammetric restitution using Structure From Motion (SFM) procedures and the three-dimensional modelling of the buildings through Reverse Engineering.

To geo-reference the buildings, two aerial fl at different altitudes were taken: firstly a digital photogrammetric fl covering an area of 400 ha, collecting data for the complex in Fontilles, carried out using a light aircraft at an altitude of 698 m, comprised of 76 images with a resolution of 9420 × 14,430 pixels and a focal distance of 100.5 mm using a UltraCam X, S/N UCX-SX-1-50013345 camera with a GSD (Ground Side Distance) resolution of 5 cm (Fig. 5).

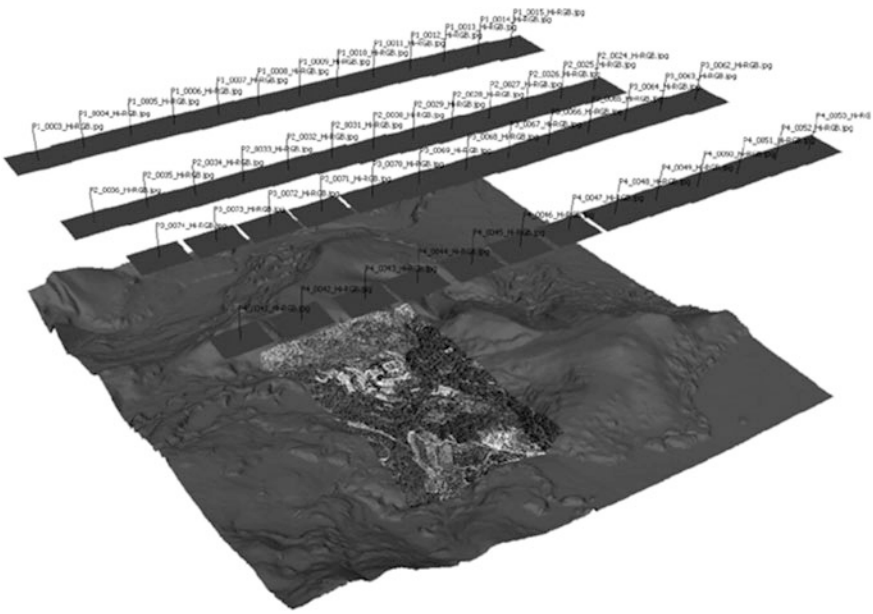

Fig. 5 Result of the photogrammetric flight using a light aircraft

Secondly, and with the participation of the LFA-DAVAP Group from the University of Valladolid, a low-altitude flight using a remote-control drone was carried out, providing escalation data for the complex in Fontilles. Some 460 photographs were taken using an Olympus E-Pm2 camera with a focal length of 24 mm at an altitude 50 m (taken from the highest point), and a GSD (Ground Side Distance) resolution of 1 cm (Fig. 6).

The flights were aligned using 30 coordinates that were recovered from the first flight thanks to the Photomod application and looking for the respective points from the images taken from both flights. The result was a comprehensive definition of the relief lines for the complex as well as the exact positions of the buildings.

For the modelling of the buildings, both the cloud point taken with the laser scanner and the modelling using the mass aerial photography were used.

For the topographic survey, the Leica HDS6100 scanner, manufactured by Leica Geosystems, was used. The point clouds for each measuring station were registered using Cyclone software, designed by the same company. For the scanning of the laboratory pavilion in Fontilles, 86 measuring stations were used to carry out a comprehensive survey of the building over the course of an 8-h day. The density of the scan was "high", which means that at 10 m from the scanner, we get a point density of 6.3 mm $\times$ 6.3 mm. In order to speed up the field work, markers were not used in situ. This meant that back at the laboratory, the registration would be carried out manually using the Leica Cyclone Register programme using the "cloud to cloud" method, in other words, identifying the shared points between pairs of point

Fig. 6 Result of the escalation flight using a remote-control drone

clouds to carry out registration. Sure enough, the complete point model is obtained by pairing up the clouds obtained from two consecutive measuring stations. Cyclone auto-adds cloud constraints between non-consecutive measuring stations to optimize the aligning of the clouds and reduce general error. As with the photo-based modelling, the information obtained in this way was supplemented by the one carried out using the two flights described earlier.

For the volumetric modelling based on the taking of photographs, an example of the methodology used is the three-dimensional modelling of the different construction phases of the theatre. For the definition of the current volumetrics, a vast series of photographs (2247) were taken and then calculated as a single group, using a variety of different focal distances, relative to the element and the position from which it was taken. Once all the photographs were aligned, we proceeded to

calculate the dense point cloud, resulting in a point cloud with a density of 144,591,713 points. The following phase comprised of cleaning up and converting the point cloud into a mesh. The final model had a weight of 288 million polygons, making it unfeasible for later processing, so to facilitate the work, these were divided into 15 parts, decimating it as such to 10 million polygons to be able to comfortably work with the software applications used. The next step was to extract the geometry of the mesh; to do this, reverse engineering was used. Using the "Rapidform XOR3" application, a series of sections were taken from each of the elevations which allowed us to transpose directly onto the mesh, enabling a greater control of the elements contained therein. Lastly, the sections and elevations taken from the mesh were imported into the "Rhinoceros" modelling application used to build 3D models, allowing us to carry out a thorough analysis of the building. Finally, the model was textured, and the orthophotos were extracted for a clearer focus in the CAD application environment. At this point, an analysis was carried out of the *scars* resulting from the numerous interventions carried out on the building, returning the buildings back to their original state (Figs. 7 and 8).

This three-dimensional graphical reconstruction is the basis on which we regress back to the very first Fontilles colony established at the start of the 20th century,

Fig. 7 The laboratory. Original photograph and topographic survey using a laser scanner

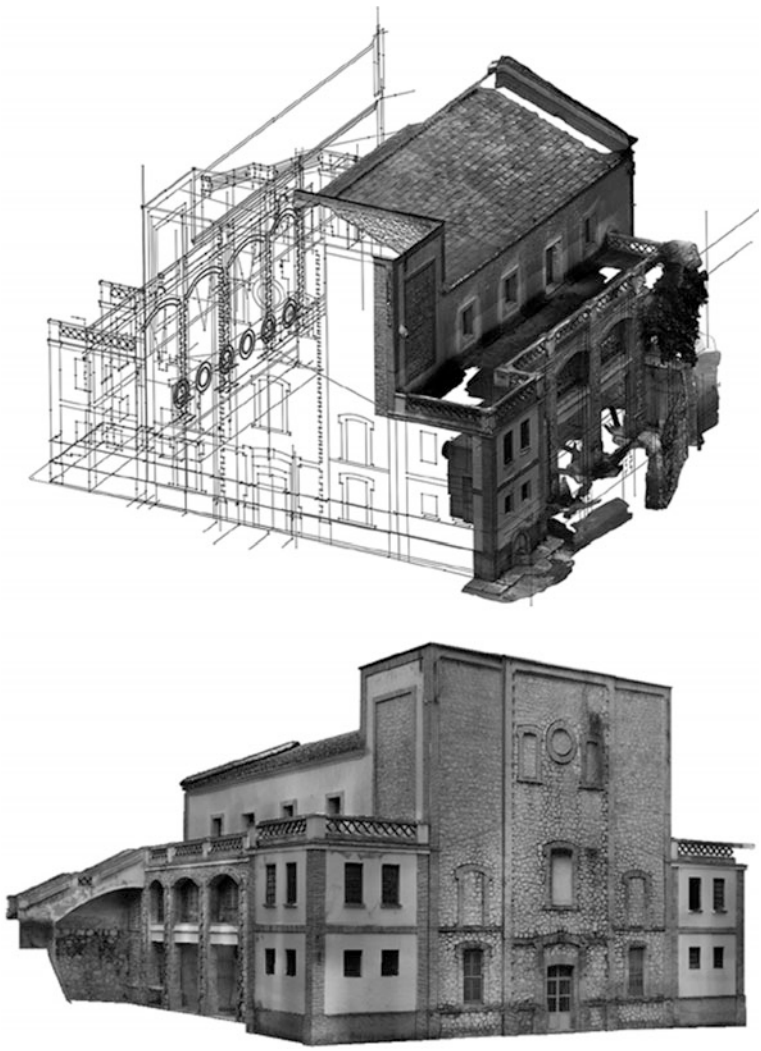

Fig. 8 Three-dimensional modelling of the theatre

passing through all the important stages in the medical colony's history. To do this, one uses the graphic material from the historic archives of Fontilles, using the restitution of the conical perspective of the images and the present buildings as a reference.

5 Methodological Approach to Visualise the Model

The aim of this second phase of the work is to propose an interactive methodology that allows the user to discover and deal with the current state of the historic images, both exterior and interior, making it possible to have interactive tours based on the graphical reconstruction of the original spaces.

The display method is a multi-step process that requires the use of more than one software package, in addition to the exporting and importing of a variety of different data elements. The game engine is compatible with the main 3D applications such as 3ds Max, Maya, Softimage, Cinema 4D and Blender, which means that there are no real limitations as to the file formats that it supports.

With regard to the vegetation, the effective creation of very detailed and natural environments will be carried out using two different vegetation processing technologies, SolidGrowth and PlantFactory. SolidGrowth is based on random growth technologies that ensure that there are never two plants of the same species and simulate the different colour tones in nature for even greater variety and realism. PlantFactory boasts multiple mesh algorithms, with a system that is able to reproduce very high quality trees, as well as distant vegetation using triangles or *quads.* The plants are generated at the optimum level of details, based on render resolution and viewing distance. This ensures the best quality results with the minimum use of resources.

Illumination is carried out using a photometric sunlight model that employs real-world data, generating the physical simulation of the sun. Atmospheric lighting intensity is carried out using image based lighting (IBL), and High Dynamic Range (HDR) images taken at the Fontilles Sanatorium itself, facilitating photorealistic rendering.

The final aim of the project focuses on the development of multiplatform tools to promote heritage, based on the interaction of the subject with information to achieve a greater understanding of the heritage asset and, consequently, a great implication of the general public in the preservation of architectural heritage. For that reason, the project aims to integrate different types of information sourced from a series of computer applications providing a comprehensive approximation of the architecture and its history: 3D information, such as virtual buildings, models of non-existent buildings and other objects; multimedia information such as photographs, digitized documents and videos; as well as textual information such as letters, medical records, administrative documents, etc. (Fig. 9).

Lastly, the collaboration established with other research groups to put forward a European proposal presented within the framework of the Horizon2020 programme, have opened the possibility of exporting the model to a variety of different interactive tools for mobile platforms, such as smart phones and tablets. The experience of the *Institute of Automation and Industrial Computer Science* (AI2) at the Polytechnic University of Valencia and *The Expertise Centre for Digital Media* (EDM) at Hasselt University, both of which are project partners in the *Digital Model for Disseminating and Highlighting European Heritage: The Leprosy*

Fig. 9 Leap motion + Oculus rift

Heritage Sites, has led to the possibility of implementing augmented virtual reality solutions, as well as creating interactive interfaces, such as *Leap Motion*, geared towards the dissemination to the public at large of the characteristics of the heritage that these sites provide.

6 Conclusions

The recently approved Horizon2020 European programme at last includes heritage research as one of its strategic European aims for the coming years. And it has done so by focusing its attention on the use of digital tools to draw attention to and disseminate and protect the rich cultural heritage legacy of our continent. The scarce implementation of digital strategies to promote a better understanding of the architectural heritage amongst the general public is one of the tasks that are still to be undertaken by organizations and institutions that work to study, assess and disseminate architectural heritage. To achieve this goal, new digital tools have the potential to do much more than be used as the mere graphical reconstruction of architecture. Modern tools allow us to actively interact with heritage information, pushing the envelope of graphics and giving a boost to representation as a method of comprehensive comprehension, making it possible to have immersive virtual tours through tools that are commonly used in videogames and animated film, but also making it possible to fully integrate the documentary information that enables us to better understand architectural assets in greater detail than just the mere spatial representation, transmitting as such the image of what it once was and the ways of life associated with them. It is essential that these types of activities use an inter-disciplinary approach, and it is worth noting that this particular project is being carried out by a team comprising architects, historians, doctors and IT specialists whose ultimate aim is to develop a dissemination strategy that can be applied to other places in Europe that are part of the *International Coalition of Historic Sites of Exclusion and Resistance.*

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Eduardo Baviera Llópez Degree in Architecture from the Polytechnic University of Valencia (2012). His preferred field of research is digitized architectural surveying and augmented reality applied to heritage. He is currently working on his Final Project of his Master's on the application of laser scanner and photogrammetry in topographical survey of the laboratory building at the Fontilles Sanatorium.