Educating Architects towards Innovative Architecture

Editors: Constantin Spiridonidis and Maria Voyatzaki

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Contents

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Didactic Experiences of Digital Representation of Architecture From 3D Survey to 3D Simulation

New technologies could be an interesting opportunity of education for a student in the academic curriculum of the Faculties of Architecture. Not only because they help him to understand better the architecture itself, thanks to the new more direct approach to knowledge – especially referred to internet archives, or to numerical databases of information – but also for the possibility to analyze and draw architecture in a different way from the past. The introduction of 3D modelling and advanced visualization was, in fact, the real revolution started from the first Sixties of XX Century.

The didactic experiences presented here were developed at IUAV University of Venice and at University of Trieste, in Italy, were I teached, in some specific fields such as: the application of 3D laser scanning, for example on some Venetian ancient buildings, the Rapid Prototyping reconstructions of some architectural details, and digital 3D modelling and animation of some unbuilt or destroyed architectures, such as one of the most important work by Le Corbusier, that is the Philips Pavilion in Bruxelles, for 1958 Expo event.

All the activities were done to give students the possibilities to experience the last innovations in the field of representation of architecture, in order to amplify their knowledge on general and specific subjects, and apply technologies to their future works.

The consideration we did during this experience was that it is very important for the teacher to transmit to students the necessity of the experimental approach to research themes in order to try to pick up all the challenges that new technologies could offer to architects. The difficulties in thinking, elaborating, producing, developing, using Computer Aided Design and their similar systems of visualization, could be passed if the University offers software and hardware instruments, but also if exact procedures of using were given to realize a specific project. The video animations realized are, in fact, all digital products realized by students, although under the direction of an academic teacher. In some cases specific seminars on the matter were organized, and students operated with expensive technologies, such as 3D Laser Scanners.

But the knowledge of new technologies is not the only way to develop advanced researches in architectural representation. It is really relevant that all the past information about traditional means and ancient methodology were studied by students such as the innovative ones. The historical values and the preceding efforts to go over some problems are continuously examined to relive the hard works done. A rich series of documents on traditional representation were given to students for comparing with recent studies, to understand the difficulties that the innovation has simplified.

In the case of the Le Corbusier's Pavillon, for example, all the architect's drawings, sketches, texts, letters, notes, publications, physical models, were carefully analyzed; all the archives were consulted, and the student tries to reconstruct the digital *maquette*, as resolving an enigmatic complex question, defining all the aspects that the author has not considered in his solution. This approach helps students to behave as they were in the

Le Corbusier's studio for a stage, under the supervision of the architect that asks them to define details and to consider aspects for the final solution and for building drawings. Definitely starting to do what every young architect does after having finished his studies.

This educating methods allow students growing with the consciousness of their forces, and new technologies could help them in intensifying the comprehension of the rules of architecture, closely connected with the efforts done in the past.

Digital Survey of the Palazzo Fortuny in Venice

The first experience which will be described concerns a didactic activity developed in two forms: the first one is an Advanced Survey Workshop on Palazzo Fortuny in Venice for a limited number of students organized at the Faculty of Architecture of the IUAV University of Venice in collaboration with CNRS Gamsau-Map Research Unit in Marseille (F) and partially sponsored by the European Community. The second one was a more complex analysis of the survey data of the building done by a single student during his graduation thesis, who worked at the CNRS Unit for a stage.

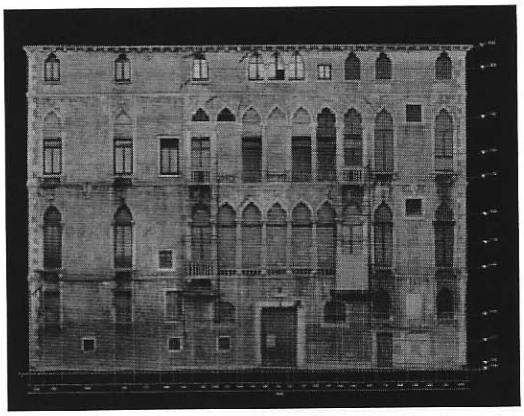

Figure 1. The façade of the Palazzo Fortuny in Venice.

Figure 2. The phase of data acquisition with 3D time-of-flight laser scanner.

In detail, the first step was the digital survey of this interesting Venetian building, using two laser scanners: a time-of-flight one and an optical triangulation one. With the time-of-flight scanner all the data of the façade were stored in some files, in the form of digital points' clouds, ready to be manipulated for obtaining singular sections of the front-side of the object. The second scanner was used to register the detailed data of some elements: an angular column and a lion head on a balcony. The optical triangulation, in fact, allows to have immediately a specific mesh in digital format, that could be easily transformed in a single object. It can be manipulated with rendering and animation softwares, but also post-processed with Rapid Prototyping machines in order to have physical 3D objects, usually solidified with laser radiance.

At the same time we decided to use the photo-modelling technique that utilizes some pictures of the architectural object taken in a particular way, with an application that can calibrate the pictures together and construct – with graphic primitives – the solid digital model of the element. The particular aspect of the procedure is that the realization of the model was done with the original texture taken by the photographs so that the final representation is very similar to the real one, and not only a digital simulation of it.

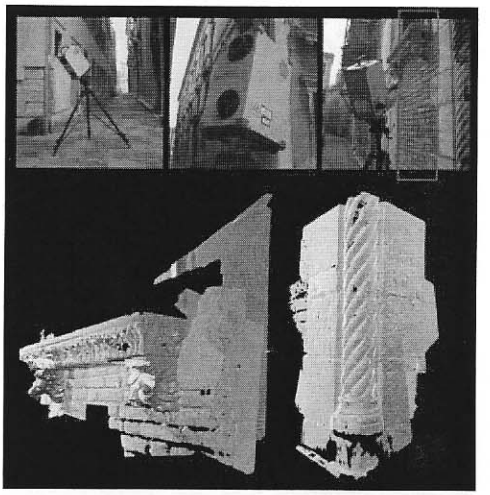

Figure 3. The phase of data acquisition with 3D optical triangulation laser scanner.

The final elaboration of the data was the optimization of the polygonal surfaces of the façade, using a particular algorithm, named *occlusion rays*, in order to close all the shadow zones during the phase of acquisition. The lion head and the column were processed in the same way, and these ones were transformed in STL format, for the realization of the prototype. In this case we worked with two different typologies of solidification: the Selective Laser Sintering (SLS) and the 3D Printer (3DP). In the first case we used the sinterization of nylon powder, obtaining some physical models in real scale and reduced scale, with progressive sections with a quality of 1/10 mm. In the second one the technology utilized plaster powder solidified with a glue chemical procedure. In the end

Figure 4. The procedure of photo-modelling applied to the façade.

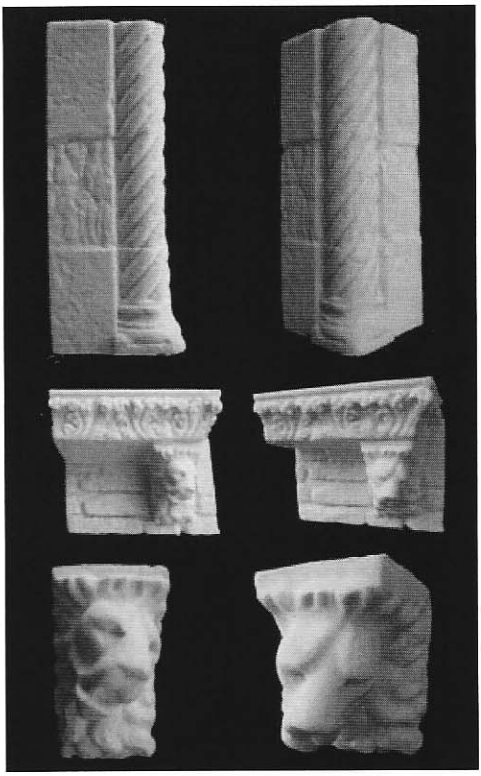

Figure 5. The physical models produced with the Rapid Prototyping techniques.

we obtained some stereometric models, that have the same morphological configuration of the real ones.

The aim of this research was to define all the digital procedures of the survey, from the acquisition of the data, to the reconstruction of the single element, in order to register the form with the damage of the material, to control – thinking to apply the method in a long period of time – the state of the surface, before and after the restoration.

Digital reconstruction of the Philips Pavilion by Le Corbusier

The second research was on the Philips Pavilion by Le Corbusier, and it started at the Faculty of Architecture of the University of Trieste, and then it was developed during a graduation thesis at the IUAV University of Venice.

Without any doubt the most complex geometrical structure constructed by Le Corbusier was the Philips Pavilion, realized in occasion of the International Expo held in Bruxelles in 1958. In this case a lot of hyperbolic paraboloids were composed in order to create a building with a very high level of new technologies inside. In reality, the Philips art director, Louis Kalff, didn't want to show technical products, such as the other exhibitors did, but wanted to create an event that could represent the state of the art in the field of electronics, videoart, music of XX Century. So the Pavilion should have been a work of art itself, showing the new potentiality of the scientific research on this subject. For this reason Le Corbusier decided to call it the *Poème Électronique* to express better the intention of the design. To obtain the best solution he asked two persons to help him for this work: the first one was Edgar Varèse, that was the music composer that have already worked with the architect creating some electronic sounds for the bell-tower of Ronchamp chapel. Although in this case the music wasn't used, Le Corbusier appreciated his work and decided to base the whole musical support of Bruxelles Pavilion on the Varèse's composition. The second collaborator was the Greek engineer Iannis Xenakis who, in that period, worked inside the studio. Not only was Xenakis involved in structural, acoustic and lighting problems but also he was a musical composer as Varèse, so

in this case questions of tectonics were studied better in relation to acoustic behaviour of sounds.

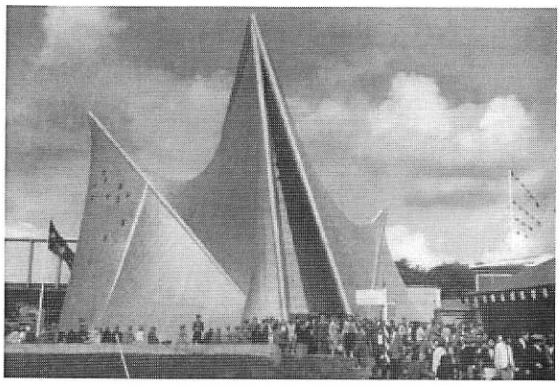

Figure 6. The Philips Pavilion at the 1958 Expo in Bruxelles.

To understand the process of composition it is very useful to read some notes by Xenakis describing the first ideas by Le Corbusier and the way in which they started to develop the complex shape: "In October 1956, Le Corbusier asked me to draw up these ideas and try to 'translate them using mathematics'. He handed me a sketch. Le Corbusier [proposed that] the building would be a 'bottle' containing the 'nectar of the visual presentation and the music' For the film spectacle, he wanted flat vertical surfaces. For the spatial effect, he wanted a tapering 'bottleneck' high up in the ceiling of the pavilion where the projected images would disappear. For the desired luminous colours, he wanted concave and convex surfaces [...] He agreed with the requests of the architects of the adjacent Dutch pavilion: 'We would recommend a simple and convex surface as the back of the Philips pavilion, so that it does not overpower the garden and the greenery which surround the Dutch buildings'. As it is night inside the 'bottle', beauty is not really a concern".

Explaining the work in the book that was published in occasion of the inauguration of the building, Le Corbusier and Xenakis used these words: "They would to transform the conoids in hyperbolic paraboloids for simplifying the calculation and the executive process. The construction couldn't be a self-supporting structure. The logic solution was to use a double curved cables and a double wall, similar, definitively to a tent". The main formal idea was a plan drawing of a section of a stomach. What happens inside it – a great change that conditions the physical human subject and his state of wellness – expresses very well the different condition of perception by the people visiting the Pavilion, from the entrance o the exit. As the curved sketch of the main plan was very simple, the configuration of elevations was more complex. In this case, in fact, a lot of ruled surfaces in space were created, started from the form of hyperbolic paraboloids. But it is very interesting to note that to obtain the result Le Corbusier used a very simple instrument, made by two linear elements connected one to the other with some rubber bands. In this way every single forms was generated by hands, "playing" and having a different position of the two sticks. In order to understand clearly the procedure, a double operation was done: in the beginning the construction of a similar physical instrument, to replicate the movement of Le Corbusier's hands. Then, we decided to redo this one in a digital manner in order to add a new value using a video

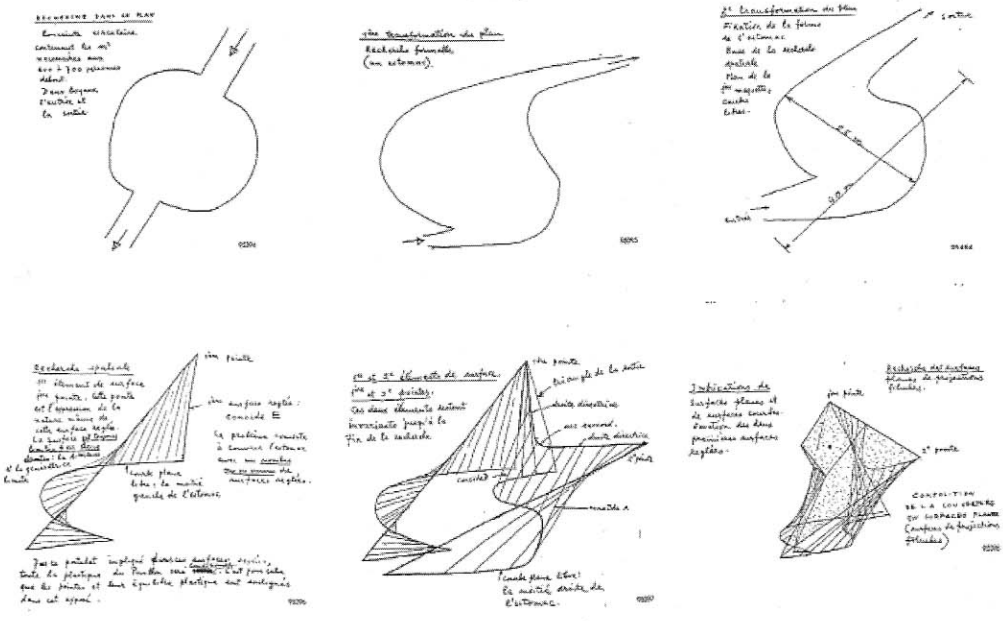

Figure 7. Sketches by Le Corbusier of the first schemes of the pavilion.

animation. So the genesis of every single surface allows to understand the first and final step of generative process, to explain in detail the evolution of the form. We have also to ad some information about the method used by Le Corbusier to verify and physically build the idea. Another important tool for controlling the status of the shape is the *maquette*. A lot of abstract and realistic models were done by Le Corbusier using different materials. In the beginning these were iron-made, to study the structured figure in the real condition of tension. During the phase of construction there were a lot of models in scale to verify the behaviour of concrete, and it was necessary to contact a great French firm in the field of structure that would undertake the calculations and eventually the realization of the pavilion: the Ancient Etablissements Eiffel.

Then, it could be very interesting to listen from the words of these representatives the conclusions after the valuation of the work, showed with drawings and scale models: "We believe that the ideas expressed in your model correspond to the construction rationale upon which we have decided: rigid structural frames of metal upon which are supported flexible surfaces in the form of hyperbolic paraboloids and whose transverse surfaces comprise metallic cables set in opposing curves". The definition of the structure is well described by Marc Treib in his book on the Pavilion, in which he reported

also the discussion during the meeting between Xenakis and Eiffel engineers: "Two networks of cables of opposing curvature would compose each screen wall segment; in turn, these would be sandwiched between two skins of bituminous *ruberoid*. The engineers were confident of their ability to execute the calculations without delay, as they knew that time was a consideration. The use of *gunitage* was dismissed because it was inelastic, and given the flexibility of the frame, the sprayed cement was sure to crack. In spite of their favouring a system of cables suspended from a structural frame, the engineers also allowed that it was possible to realize the walls in reinforced concrete. While it was technically feasible, the inclination of some wall segments was far from vertical, undermining the structural efficacy of the hyperbolic paraboloid as a structural form".

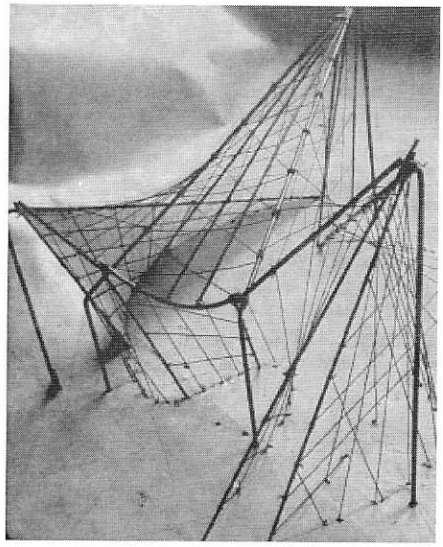

Figure 8. Wire-frame model by Le Corbusier to understand the complex geometry of form.

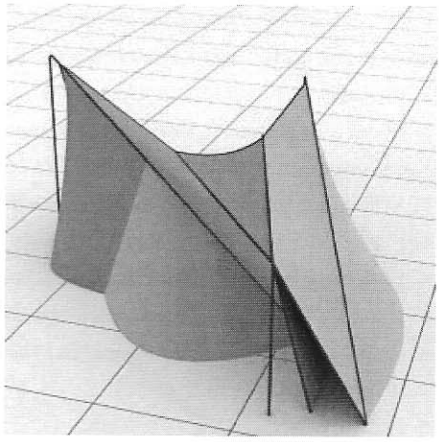

Figure 9. Schematic digital model to understand morphology (elab. M. Soraperra).

So we can consider the final realization – having an area of about 600 m^2 and a maximum elevation of 22,5 m – as the best representation in real scale of the idea. The quantities and qualities of hyperbolic paraboloids allows to confirm this project as one of the best solution of architecture of XX Century, to express the innovation in the field of building construction. The best words to understand the specific aspect of this work are by Marc Trieb, the main researcher on this architecture. He called it an "eccentric building" in which a lot of aspects are put together: "Architecture, colour, voice, sound, and images were superimposed, without any full comprehension in advance of the nature of the resulting work. The completed *Poème électronique* would *emerge* as a conglomerate greater than any of its constituent parts, to some degree planned, to some degree the product of fortuitous accident". A significant way to analyze the generative procedure of a complex shape whose mathematical aspects are strictly determined by the architect that controlled *a priori* a geometry instead using it without consciousness.

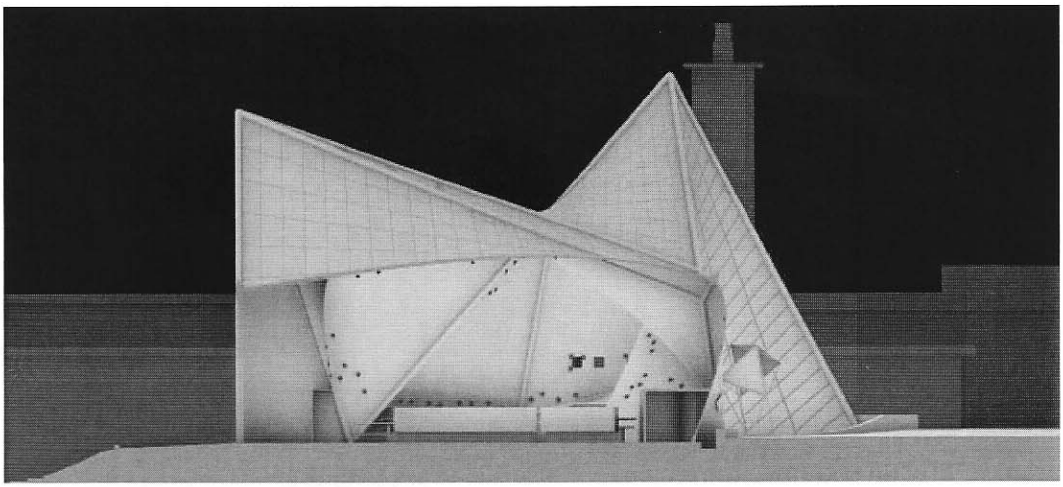

Figure 10. Final digital model of the Philips Pavilion (elab. M. Soraperra).

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