For a Digital Archive of Interactive Models by Marcello D'Olivo

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Abstract

For the centenary of the birth of Marcello D'Olivo (1921-1991) we started an activity of geometric analysis and reconstruction of some of his important works with the aim of establishing a digital archive –interactively explorable both in presence and at a distance– to tell the multifaceted production of the Friulian professional in the national and international architectural panorama. A first result was presented at the exhibition Homage to Marcello D'Olivo. Geometries, tactile models, virtual reality *organized at the Polo Scientifico Tecnologico of the University of Udine in December 2021. Based on drawings kept at the Gallerie del Progetto of Palazzo Valvason Morpurgo in Udine, which houses most of the architect's drawings, and belonging to private collections, the research has been oriented to the digitization and three-dimensional modelling of realized and unfinished architectural complexes, with a triple purpose: on the one hand to reveal and document the intimate geometric system of volumes as a fundamental teaching tool; on the other hand, to use these models to experiment with new technologies of interactive navigation and dynamic exploration through virtual reality interfaces; a third aim is dissemination on the territory, creating physical models in rapid prototyping, to allow the user a haptic perception according to the directives of the "Design for all" that provide to replace the imperative prohibition to tactically use the models in museums the most inclusive 'forbidden not to touch'.*

Keywords: Marcello D'Olivo, digital documentation, geometric analysis, rapid prototyping, interactive models.

Introduction

The work of Marcello D'Olivo –a significant architect working in the second half of the 20th century– is now widely documented, both in monographs by the author and in a series of analyses of his figure. Prolific figure both in the conception of architectures –author of about 400 design proposals– and for the material production of sketches and graphic elaboration s, however he occupies a unique position among the authors of the second half of the twentieth century. Only a few critics mention him as a significant designer when he was alive, including Bruno Zevi [Zevi 1957, 1965] and Francesco Tentori [Tentori 1957, 1992]. Despite his work on a national and international scale, his works reported in the publications are few and repeated: in reality, most of his drawings are in various archives and, in many cases, without cataloguing and therefore difficult to consult. The aim of this research, therefore, is twofold. On the one hand, we want to expand knowledge about this author by analyzing the autograph design heritage to try to provide new tools of investigation to those involved in drawing, history of architecture and architectural and urban design. On the other hand, using specific representation tools, we intend to present the works studied –both in the scientific and popular field– using advanced tools of digital modeling and virtual simulation. The intent is to transform the documentary heritage into content with a strong dynamic impact on the user, in the now widespread 'digital twin', or the digital reproduction of analog artifacts, with high informative value.

Marcello D'Olivo architect

The figure of Marcello D'Olivo (1921-1991) is very complex: architect, urban planner, artist, but also a professional mindful to the structural problems that in forty-five years of career created many projects for worldwide public and private works.
Leonardo Sinisgalli defines his work as the "Architecture of the future" [Sinisgalli 1954, p. 38]; today we can identify D'Olivo as a forerunner and exponent of organic architecture in Italy. Author of numerous writings and architectures of great importance, in both size and quality, his elaborations pose us with great questions about the diachronic relationship between anthropic and natural, as well as the possibility of creating innovative projects in pre-existing and stratified urban contexts.
The Udinese architect applied his multiple interests – always aimed at the sciences as well as mathematics, physics, chemistry, but also at the natural sciences and cybernetics– to find his poetic identity and motivate the forms he experimented: spirals and mathematical figures, vegetal, and animal morphologies, which constitute the archetypes of his compositional language [Ferrieri 2008, pp. 144-145]. In fact, he argued that: "Nature is dominated by curves. I am a pencil worker, and my trace must be an architecture of curves. To respect nature and architecture". Indeed: "Each curve" –he said– "gathers within itself a powerful mathematical formula dictated by nature" [D'Olivo 1972, p. 57], preferring in this way more complex geometric shapes to replace pure ones, now insufficient.
For D'Olivo the architectural project is an opportunity to restore the now lost balance between man and nature. However, to achieve this purpose, it is necessary that the project act emulates the geometries holding harmonic rules that can be inferred from the natural context.
The constant interest in experimentation is evident in his many drawings, but also in theorizing and disseminating his own thought, which deviates from the Italian cultural panorama of the time. To promote his thinking, in 1972 he published in three volumes *Discorso sopra un'altra Architettura* [D'Olivo 1972] [1]. The monograph is a collection of drawings of great evocative ability and projects drawn up from 1948 to 1971, which narrate and investigate the question of the relationship between architecture and the physical-natural world. For D'Olivo "Every construction, once completed (and deliberately here neglecting to frame it in its aesthetic canon) is first of all an artificial element destined to fit, with greater or lesser resistance, in the whole of a natural framework" [D'Olivo 1972, p. 18].
However, only the integration between natural presence and technological aid can lead to an architectural structure with the same harmony as a "Tree of a primary forest" [D'Olivo 1972, p. 19].
Specifically, the organic form allows the designer to derive interesting considerations, deductions, and analogies: like nature, even architecture must find the most suitable solution to fit into an environment. Moreover, it must be considered as a single organism that can be conditioned also by the presence and density of the other entities of the whole, such as ecosystems.
D'Olivo also clarifies his project idea for the home and living of contemporary man by identifying a double analogy between the tree and the city (fig. 1), and between the leaf and the house, in an ideal world in which artificial reality can finally be assimilated to nature because it is regulated by the same laws [D'Olivo 1972, pp. 55-56].
In his poetics, the architecture must observe nature and from it understand its functioning, the static principles, the ability to modify and the balanced environmental control.

Graphic elaboration s by Marcello D'Olivo

Drawings, paintings, models, geometries, calculations and notes of incredible charm and interest, document a 360° design approach of a professional who draws to build, however, remaining at the same time elaborations sometimes difficult to understand. In fact, his drawings show the close relationship between design and construction practice, as well as the research for a dialogue between the center and the periphery in Italian architectural culture.
An all-round demiurge architect, able to conceive for each project its own feasibility from the territorial scale to the constructive detail, applying to architecture and urbanism the same organic and mutable laws of nature, according to an intense generative force of geometric matrix. D'Olivo's ideas are independent of schools and

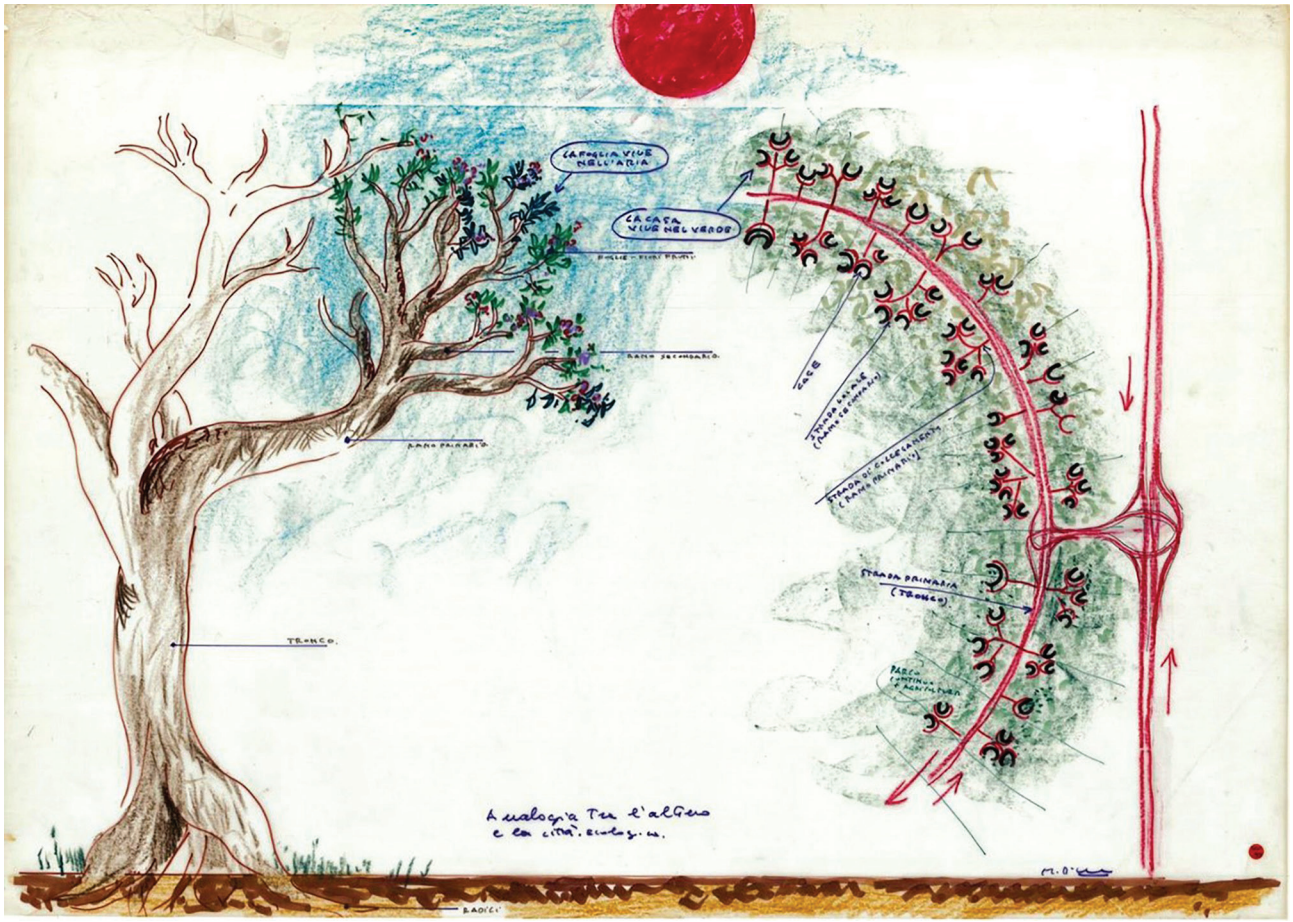

Fig. 1. Marcello D'Olivo, "Analogy between the tree and the ecological city" (Archivio D'Olivo).

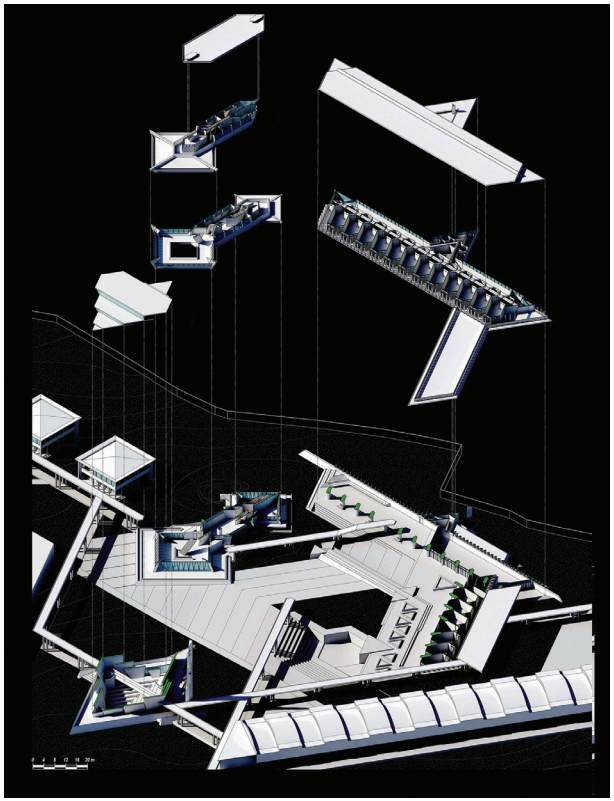

Fig. 2. Exploded axonometric reconstruction of the Villaggio del Fanciullo in Opicina (graphic elaboration Elda Amatruda).

predetermined categories, and experiment declinations of the Usonian and structuralist language in realizations oriented to the territorial scale and characterized by an absolute constructive originality.
Works not easy to interpret built transversely throughout the Friuli Venezia Giulia region overcoming the parochialism, show determination and diplomacy that allow him to build also in Africa and the Middle East. In fact, the architectural and urban ideational dimension frequently finds its concrete and effective realization abroad –especially in Gabon– in contexts in which the pre-existing and stratified human structure is almost absent.
We also add that, from the analysis of the archival iconographic documentation, emerges a professional figure willing to combine alternately geometries from the very rigorous rectilinear plant to incursions in figurations of curvilinear type, depending on the context in which he works.
A careful investigation conducted with the disciplinary tools of drawing on a plurality of complex forms reveals interesting interpretative novelties on this important personality in the field of architecture.
We cannot overlook his own words about some singular figures mentioned in a critical essay: "The triangle is the most solid figure known […] the most bound, three knots only. The circle is the fullest, a single center and infinite radiii" [Lacorazza 1952, p. 38]. These words highlight his predilection for the two geometric figures that, in alternating phases, he proposes as design matrices both for architecture and for urban structures and plans.
In fact, we find that at the basis of every project, the architect makes an almost obsessive recourse to geometry. This aspect is very evident in the planimetric drawings, but also in the profiles of elevations and sections: circles, equilateral triangles, and through the application of more complex graphic-mathematical expressions such as spiral, parabola and hyperbole.
Some of his works, realized and unfinished, have been investigated with the aim of obtaining informative models useful for physical and virtual translations. In this way, the digitalization –as acquisition of analog material from archive sources– becomes the main tool to initiate analytical operations and create 2D-3D reconstructions oriented to the documentation and dissemination of cultural heritage.

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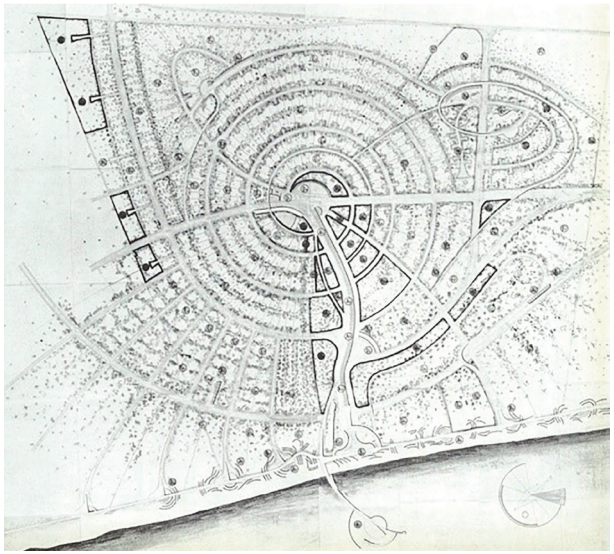

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Fig. 3. Aerial photo of Lignano Pineta with the definition of the traffic spiral (a); Marcello D'Olivo, Plan of the project for Lignano Pineta (Archivio D'Olivo) (b).

Analysis of some case studies

We chose the case studies for the D'Olivo's digital archive evaluating the different intended use and scale, as well as for the generative matrix of the geometric plan. Among them, we examined the Villaggio del Fanciullo in Opicina (1950-1957); the two versions of the Mobilificio Tolazzi in Tricesimo (1954-1955) and the two solutions of the coeval villa Mainardis attached to the urban spiral of Lignano Pineta (UD) planned by himself and where he designed several variants for the square on the sea (1985-1986); the residential proposal for villa Morandotti in Meduno (PN) never realized (1962-1963); the project for the headquarters of TV Libya in El Beida, Benghazi and Tripoli (1966-1967); finally his last build work, the multi-purpose school in Gorizia (1987-1991).

We acquired and digitalized the iconography preserved in large part at the Archivio D'Olivo, sometimes resorting to photographic straightening procedures, while we extracted other documentation from textual repertories of D'Olivo and from photos taken on the site for his realized buildings.

Starting from the original drawings, we transferred the geometric outlines from the analog to the digital extension –first two-dimensional and then three-dimensional– also exploiting the dimensional and angular specifications noted by the architect in his drawings. The digital extension has also allowed us to better understand and quantify the compositional genesis of the projects, which confirms a specific morphological structure in triangular, circular or sometimes spiraliform definition.

The first project analyzed concerns the Villaggio del Fanciullo in Opicina (TS), a work that will make D'Olivo well-known in Italy and abroad [Luppi 1998; Luppi, Nicoloso 2002, pp. 102-104; Reale 2005]. Built between 1950 and 1957, the center was built to give support and a future to children orphans of the Second World War. The intention of the complex was therefore to provide food and accommodation to young people, but also a professional education that would guarantee them a job. The structure includes a multitude of buildings used as dwellings and spaces for community, education and leisure. In fact, in addition to the residences, D'Olivo designs a restaurant, a church, pavilions for general services, workshops and printers, also providing an outdoor theater, a farm, sports fields and a gym (fig. 2).

Thanks to this experience on the karst plateau, D'Olivo measured not only with the theme and the architectural dimension, but also with the structural intention and the specificity of urban planning. The analysis carried out on the definition of the buildings revealed the use of overlapping grids and the use of the equilateral triangle of side 1.5 m, which defines a variety of environments at different altitudes [Prandi 2008, p. 222]. The various traces compose hexagonal, square and triangular basic architectures according to different combinations, whose inclined walls and long ribbon windows define elevations. The complexity and the articulation of the neighborhood clearly draws inspiration from Frank Lloyd Wright's Taliesin West, albeit preferring reinforced concrete as a construction material instead of local one. Buildings and open spaces gathered within the grid make up a neighborhood of jagged polygonal layout, completely devoid of sinuous lines and curvilinear paths. Having defined the basic module and its size, in detail the three-dimensional reconstruction involved the buildings used as restaurant and general services, the general pavilion, the housing module and the church not realized.
During the construction of the complex on the Trieste plateau, D'Olivo was commissioned to design the seaside town of Lignano Pineta (1952-1963): for its spiral configuration, it is certainly one of the most important contemporary urban planning experiences in Friuli and an undoubtedly unique example in Italy (Fig. 3). The intent of the Udinese architect was to integrate the infrastructure and architectures defined by pure geometric shapes through the urban layout into the lagoon and maritime environmental context. In this context, the choice fell on the tracing of a very large arithmetic spiral, whose lines of the plan merge with the landscape as huge territorial excavations in which it becomes explicit the analogy between tree and city. A principle that has always distinguished and guided D'Olivo to geometric-figurative results of great interest for the emulation of the functioning mechanisms of nature [Di Biagi 2002, p. 13]. The Archimedes spiral is that curve described by a point whose distance from the center (pole) remains proportional to the amplitude of the angle covered during the displacement. The whole city is based on this involute construction type. The distance between the loops is constant, with a progression of 3 meters every 10° of displacement, while the band between the loops extends for a width of 100 meters to connect

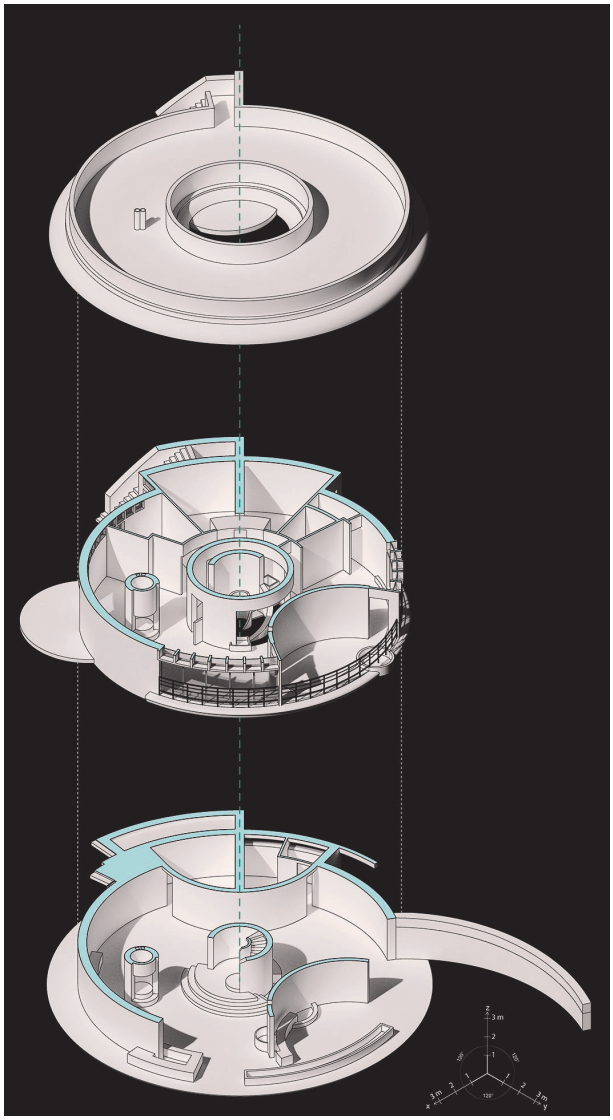
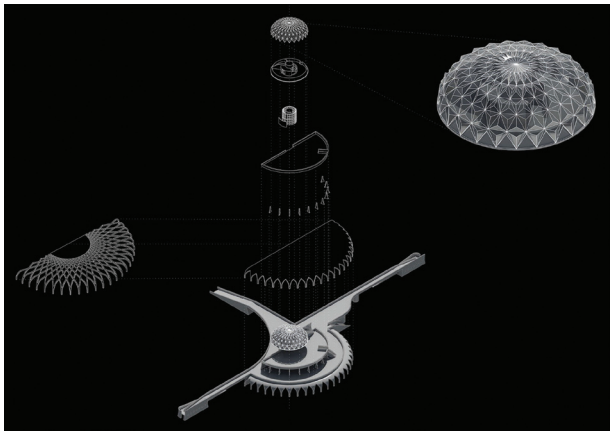


Fig. 4. Exploded axonometric reconstruction of villa Mainardis (graphic elaboration Veronica Riavis).

the 50-meter-deep lots, and to respect the natural landscape and harmonize the architecture to the environment [Barillari 2014].
Another significant example investigated is Villa Mainardis in Lignano Pineta [Nicoloso 1998, p. 41; Luppi, Nicoloso 2002, p. 118], where curved geometry is once again the dominant element. Like the urban plan of Lignano, villa Mainardis (fig. 4), adopts a similar criterion of insertion in the existing landscape. In fact, the holiday homes in Lignano Pineta had to be set back 20 meters from the road to be confused with the ground, vegetation, must not exceed two floors, and their covered area must not exceed 20% of the lot [D'Olivo 1972; Nicoloso 1998, p. 36; Luppi, Nicoloso 2002, pp. 107-109, 112].
The spaces of the building are defined according to the boolean principles of intersection, union, and completion of the circular elements. The architecture has a largely centripetal geometry: starting from the central spiral staircase, it spreads throughout the rest of the plan. In particular, the perimeter walls are all curvilinear –like arcs of circumference having the same center– while the radius elements always start from the same point and head outwards, to create connections between arcs and segments of a straight line. It is no coincidence that even the road system of the entire small town, replaces the classic 'streets' with the name of 'arches' and 'rays' as systems of classification of urban routes. 'We identified this villa, due to its peculiar morphology, as an architecture particularly suited for analysis with new technologies. In fact, as we will better discuss later, we reproduced the stereometric geometry both with a rapid prototyping system and with 3D viewers of interactive virtual reality, for a highly informative use of this architecture. The data derived from traditional archives, therefore, have been implemented for the digital determination of the new archiving system.
In addition to the analysis of the main shape of Lignano, as mentioned above, we studied the architect's design hypotheses of completion towards the sea (fig. 5). Inside the large urban spiral, in fact, there is a sinusoidal backbone. Inside the large urban spiral, in fact, there is a sinusoidal backbone, which houses commercial activities and houses. It extends for about 600 meters, starts from the geometric center of the involute and heads towards the sea. Called the "train" because of its connected wagon shape interspersed with short pedestrian crossings, the building was to conclude with a large marine round-



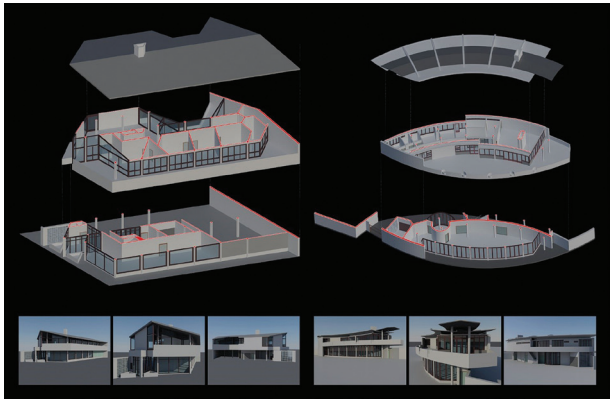


Fig. 5. Exploded axonometric reconstruction of the sea square project in Lignano Pineta (graphic elaboration Andrea De Lorenzo).

Fig. 6. Mobilificio Tolazzi, Digital reconstruction and comparison of the two projects versions (graphic elaboration Roberta Callegari).

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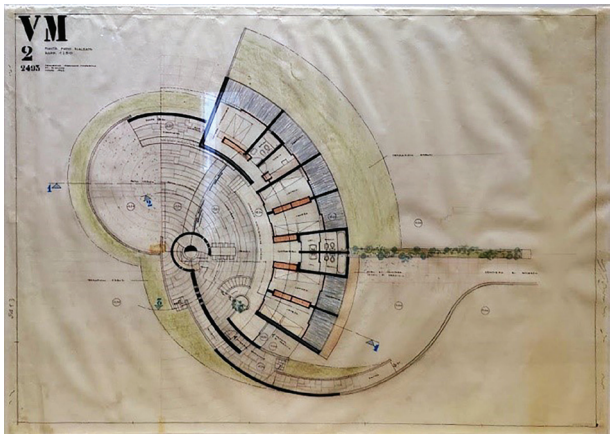

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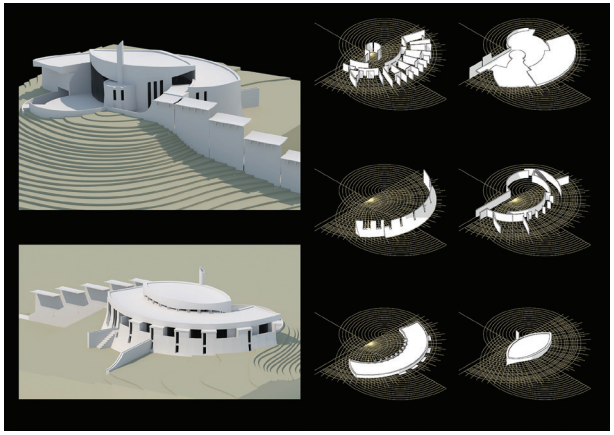

Fig. 7. Marcello D'Olivo, Plan of first floor of villa Morandotti (Archivio D'Olivo) (a); Digital reconstruction and geometric genesis of villa Morandotti (b) (graphic elaboration Giovanni Toninelli).

about, containing services for bathers [Borella, Luppi 1998, p. 112; Luppi, Nicoloso 2002, pp. 110-112].
For this project proposal there are various planimetric and altimetric drawings, which offer graphic representations of great communicative effectiveness, reinforced by significant chromatics in the elaboration of the tables. We carefully analyzed and compared the five solutions conceived by the architect. The study carried out reveals a clear interest of the designer in spiral matrix geometry. This almost seems to seal the compositional process of the entire urban system with this last solution –also in temporal terms, since he proposed it more than thirty years after the preliminary project of Lignano Pineta– which once again testifies to the great processing capacity of the architect in the use of unusual forms. We point out that the spirals of the all five projects of the square at the sea are Archimedean, which are generated by reconstructing matrices of concentric circles, to which are associated control points that allow to identify the spiral-shaped genesis. The planned functions essentially concern pedestrian paths, alternating with terraces, and ancillary rooms for the restaurant and parking, all modeled on the logic of curvilinear spaces.
However, these solutions are clearly different from the tectonic structure of the "train", which had a much-defined articulation and a pagoda roof quite characterized on the expressive plane. He also proposes this solution for other architectures built in the same period, including the villa designed for Leonardo Sinisgalli (1954-1955) and especially the second version of the Magazzini Tolazzi in Tricesimo (1954-1955) [Borella, Luppi 1998, p. 114; Luppi, Nicoloso 2002, pp. 123-125]. In fact, in these buildings we find the same upper articulation, in an "almond" space that from a geometric point of view, like the juxtaposition of two opposing circumference arches. The last work just mentioned is particularly significant because it expresses the double interest on the part of the designer for the use of geometries composed of straight-line segments and curved matrix figures, the latter identified by the architect as optimal design solutions. In fact, the first solution dated 1954 recalls the triangular geometric setting that can also be seen from the Trieste experience, as well as from the Wall House designed by Wright in 1941. Otherwise, the 1955 version seems to recall the architectures of the hemicycle houses, always designed by the American architect, such as the Jacob House (1944), the David Wright House

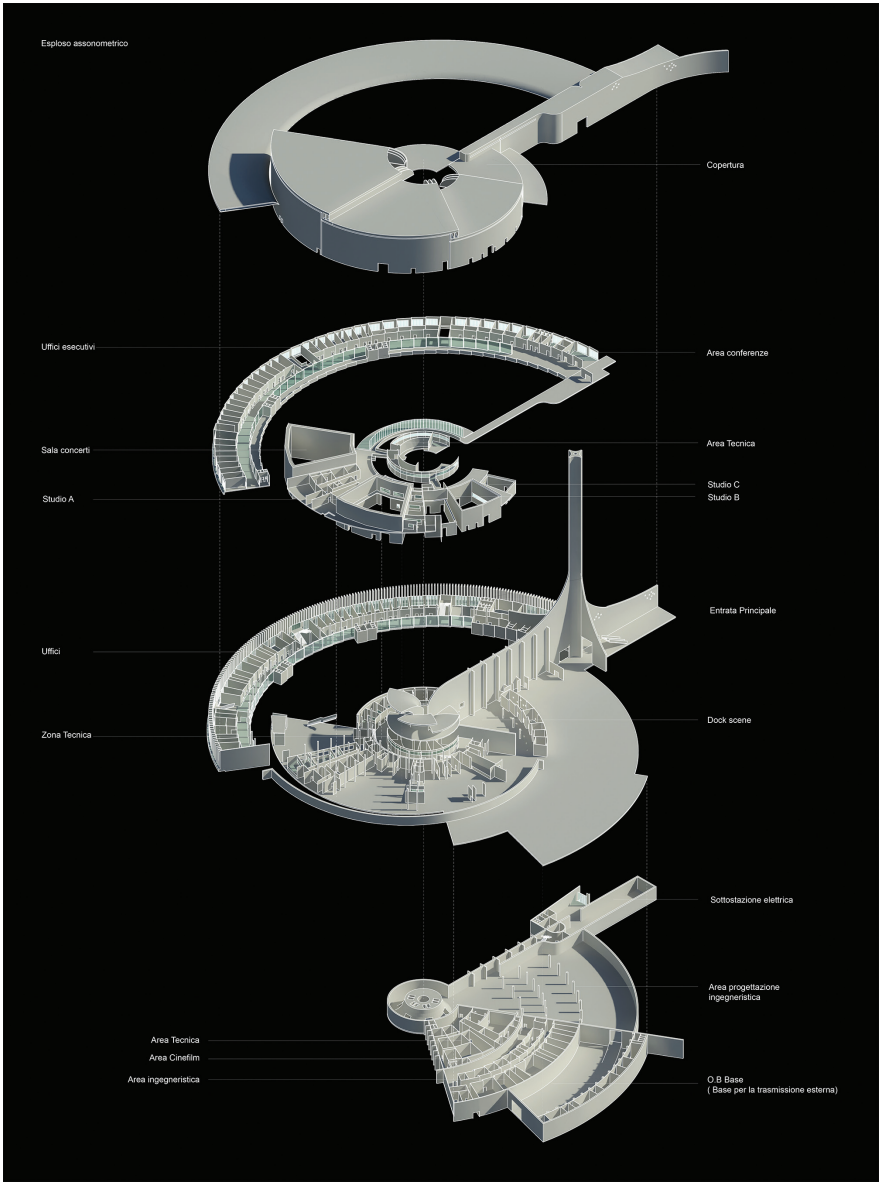

Fig. 8. Exploded axonometric reconstruction of the project for TV Libya (graphic elaboration Houssam Jaber).

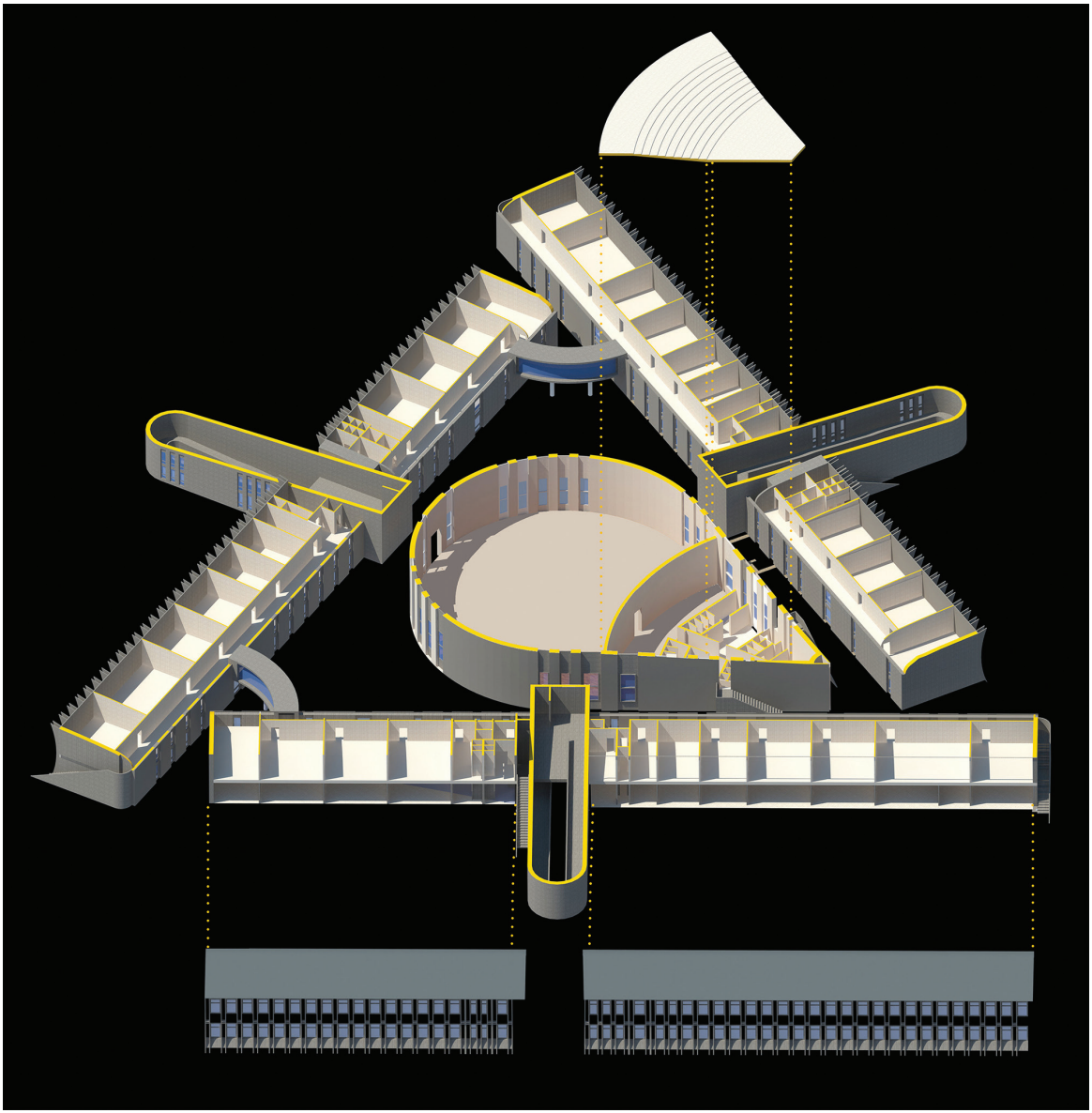

Fig. 9. Exploded axonometric reconstruction of the Slovenian School Center in Gorizia (graphic elaboration Giovanni Lutman).

(1950), but especially the Robert Llewellyn Wright House (1953) of which the architecture is contained in the intersection of two different circumferences, just like the dolivian solution. The distribution of the spaces of the Mobilificio takes place on two floors, the rooms are obtained from the radial subdivision of walls, pilasters, and circular elements, and as we mentioned above, the roof is of the 'pagoda' type.
The spiral geometry is still recurring in other projects: on the one hand to the small residential architecture –as in the case of the villa Morandotti in Meduno (PN)– on the other to the much larger building, suitable for hosting a service center such as TV Libya.
In particular, Villa Morandotti (fig. 7) [Borella, Luppi 1998, p. 131] integrates the spiral-shaped construction to the principle of intersection of two circumferences, like what developed in 1955 at the Mobilificio Tolazzi, with a clearer distribution of the radial interior spaces. For this building, D'Olivo also designed the systems of walls and slabs, similarly exploiting the intersection of circles. The geometrical setting recalls, even with further developments, the first version conceived by the architect for Villa Mainardis. The construction of the 3D model, and its arrangement in the hilly context, made it possible to understand more explicitly, the complex configuration system proposed by the architect. In fact, the spiral of Morandotti differs from the one proposed for Lignano in that its genesis is logarithmic. As the carapace of the nautilus, often figuratively described by Le Corbusier, it has a curvilinear dynamism on an exponential basis, so it also happens in the planimetric geometry of Morandotti, which has in common with TV Libya a similar syntactic articulation (fig. 8).
In fact, the headquarters of TV Libya was to be built in three important cities in the Middle East: Tripoli, El Beida and Benghazi. D'Olivo presents several project tables and related models, to better understand the composition of the large telecommunications headquarters [Zucconi 1998, p. 16; Borella, Luppi 1998, p. 137; Luppi, Nicoloso 2002, p. 163]. He prefers the use of the logarithmic spiral, whose matrix is evident above all at the planimetric level. Thanks to it, we find full and empty spaces defined by volumetric subtractions, and the introduction of a vertical element that from the central core of the shell roof grows plastically in height. We must remember that the spatial articulation of this kind of spiral is particularly complex to manage architecturally, compared to an Archimedean one (not present in nature). For example, in the second case from the structural point of view, a supporting system with pillars or partitions can be sufficiently regular, unlike a geometry that changes with each turn. It is no coincidence that Le Corbusier also prefers the Archimedean one –as in the 'square spiral' solution of the unrealized project of the Museum with unlimited growth of 1931– while evoking the shell of the aforementioned mollusk.
Finally, we delved into the last work created by the Udine architect, namely the multipurpose school complex in Gorizia (fig. 9), now Slovenian institute IIS "Simon Gregorčič, Primož Trubar" [Borella 1998, pp. 79-85; Borella, Luppi 1998, p. 169; Luppi, Nicoloso 2002, p. 187]. For this architectural complex, D'Olivo created innovative geometric solutions, among which some never experimented before. In a similar way to what previously realized, the plan is clearly perceptible only from above. Three long distinct volumes, intended for educational classrooms, compose a triangular geometric envelope. These elements are connected to each other at two points by a circumferential arched aerial bridge, while a teardrop-shaped building containing auditorium and gymnasium is created in the inner courtyard. D'Olivo inserted a system of covered inclined ramps to go up to the first floor of the buildings. Particularly interesting is the design of the double reinforced concrete walls that mark the elevations of the classrooms volumes and recalls the similar solution adopted many years before for the residential and hotel complex Zipser of Grado (1960-64).

For a digital archive of D'Olivo

The results of this advanced digitization were compared and presented within the exhibition *Homage to Marcello D'Olivo. Geometries, Tactile Models, Virtual Reality*, (December 21, 2021-March 22, 2022) held at the University of Udine (fig. 10). On this occasion, we proposed a selection of historical photographs and reproductions of the architect's drawings, and we wanted to narrate the projects described above in the form of a multiplicity of processing tools. In fact, we exhibited wireframe drawings, geometric analysis and three-dimensional restitutions, haptic perception tactile models, and finally visitable models thanks to a 3D consultation system that uses virtual reality (VR).

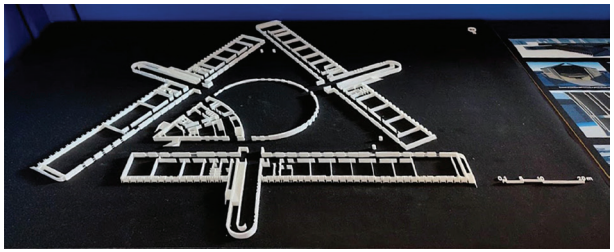

Fig. 10. Inside the exhibition "Homage to Marcello D'Olivo" at the Polo Scientifico Tecnologico, University of Udine.

Fig. 11. Tactile model of the Slovenian School Center in Gorizia.

Fig. 12. Immersive experience with the VR headset by a visitor in the exhibition.

In this way, we can experience the potential of the technological tool that allowed a first phase of the preparation of the advanced digital archive on the works by Marcello D'Olivo.
For the plastic modeling part, we obtained the physical translation of the shape by choosing different scales of reduction or sectioning by Fused Deposition Modeling (FDM) rapid prototyping. We produced scale models of the headquarters of TV Libya and the third variant of the Piazza sul Mare in Lignano Pineta, whose volumetric articulation –understood together in its planimetric and altimetric extension– is better understandable. Otherwise, we defined in a reduced scale the volumetric section of the restaurant building of the Villaggio del Fanciullo, to make understand at the same time the plan and the interior of the architecture, associating it with a module of a living volume.
The tactile model of Villa Mainardis is reproduced in scale 1:100 and it can be explored by levels. Through the manual intervention, the visitor can discover the architectonic structure and its interiors, including the central spiral staircase, and the way the house fits into the natural dune.
Instead, for the perception of the Slovenian school in Gorizia we chose the solution of the tactile map of place in scale 1:150, sectioning the building at the height of 1 m from the ground. The installation has the maximum extension of about 120 cm. Standing in the extension of the arms –as required by the regulations for museum accessibility–, the model allows the user to understand the geometries of the structure, but also it shows him how to orient himself inside and identify the openings. We integrated the tactile plan by also inserting the graphic scale expressed in meters and the symbol of geographic north (fig. 11).
We created these models with a functional reproduction scale to the perception of the shape and the tactile threshold of the details. We hived off the models intended for 3D printing into solid elements, and we adjusted them according to the machines and the prototyping process. We removed seams and staircase effect of the assembled parts to eliminate sharp elements and uniform surfaces to ensure a better perception to the sense of touch.
We have also prepared some virtual models for immersive exploration, to highlight even the unrealized variants as well as the most symbolic architectures. The

visit allows the visitor to appreciate the exterior of the buildings but also to walk them inside them thanks to a headset and manual controllers available to the system. Specifically, are accessible in virtual reality (VR) the two variants of the Mobilificio Tolazzi in Tricesimo –to compare the first version from the second one then built–, the never built complex and extensive headquarters of TV Libya, and the two different solutions for the centripetal villa Mainardis in Lignano Pineta (fig. 12).
Finally, in the case of the not built Villa Morandotti, based on the documentary material provided by the Archivio D'Olivo, we experimented the spiraliform growth of the building through parametric and computerized modelling software applying to the complex geometries the material stratigraphy of reinforced concrete, which the architect often employed to give shape to his architectures.

Conclusions

The study aimed at collaborating with the Archivio D'Olivo, aims at digitizing and understanding the architecture of the prolific Friulian architect. The will is to continue in the future with the study and advanced acquisition of his projects so as to support public bodies to the dissemination of his thought and his applications in architecture, also thanks to advanced forms of representation with high information content. The traditional archive of drawings and documents of the singular architect from Udine, therefore, is amplified by a digital reinterpretation of his work, such as to constitute –in the logic of the 'digital twin'– the numerical interpretation of its multiple compositional plurality, such as to constitute a further deepening for all the scholars of his work.

Note

[1] The second monograph dates back to 1986 [D'Olivo, Mainardis de Campo 1986].

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