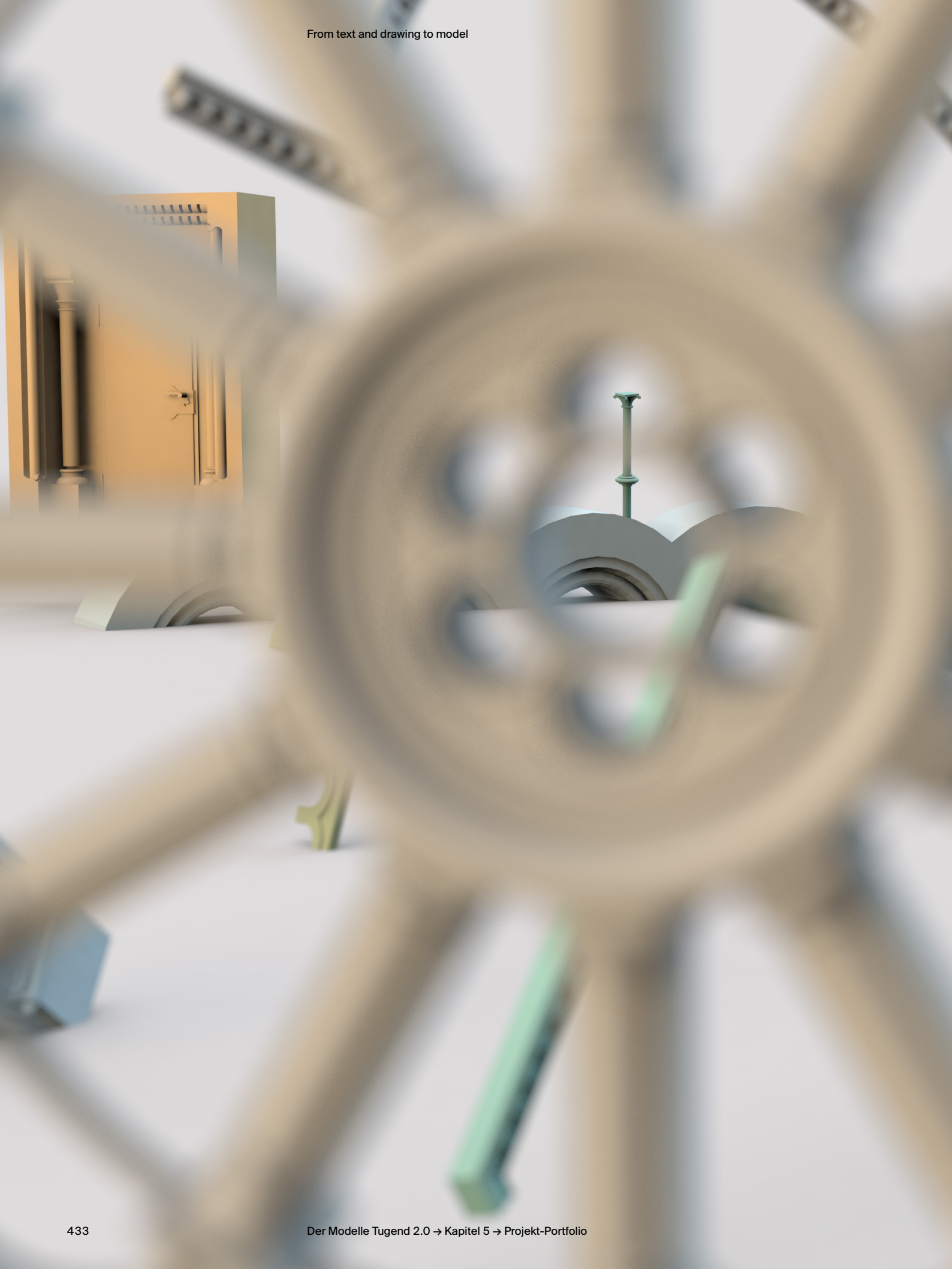


**Fabrizio Apollonio**

# I. From text and drawing to model

## → 3D virtual reconstruction, 3D semantic segmentation, C. N. Ledoux, knowledge representation

This case study, amongst the various cases of virtual reconstruction, exemplifies the application of a methodological approach adopted able to allow many types of analysis and to introduce new and meaningful innovations to the interpretation methods and techniques concerning hypothetical reconstruction of projects designed or never built architectures.

Original old drawings and hermetic texts, implemented by different kind of documentary sources, have been used for the digital reconstruction of a large part of the unbuilt projects by Claude-Nicholas Ledoux for his ideal city of Chaux, addressing the issues of architectural coherence from their constructive hypotheses point of view, as well as the use of representation codes able to **reproduce** the graphic characteristics of the original engravings.

The digital reconstruction based on architectural drawings or sketches and supported by textual descriptions and notes, is meaningful inasmuch as it is an exemplary issue to explain the relationship between the certainty of the data used as a source and the accuracy of granularity of the data itself. Each different type of source is characterized by its own specific grade of information granularity that can be transformed into a hypothetical 3D model with its own level of detail. The geometrical definition of each constitutive elementary unit is, therefore, not dependent on the level of detail of the source data (e. g., scale of representation of 2D drawing) but by the type of information that has to be induced, deduced or interpreted. However, a lot of issues related to the formulation of the hypothetical 3D reconstruction of edifices only designed and never built are still to be explored, so we aspire to reach the purpose of describing and representing the whole process of **reinterpretation** accomplished.

# I.1 Case study: reconstructive process after Drawing

This project deals about the unbuilt projects by Claude-Nicholas Ledoux. He is one of the Emil Kaufmann's three revolutionary architects 01 who conceived at the end of the 18th Century a publishing work in which he collected a theoretical reflection on architecture and society, designing the ideal city of Chaux. 02 It was conceived as a reformed city for which the author explored a large amount of possible architectural programs, from the stock exchange market to the public bath, from the Pacifère to the Temple of memory, from the Playhouse to the Oikèma.

The book collects hundreds of tables documenting some constructed buildings, fully redesigned and often modified and idealized by Ledoux, alongside numerous new projects for the architecture of the new imagined city.

These case studies start from original old drawings which has to be implemented by different kind of documentary sources 01, able to provide — by means evidence, induction, deduction, analogy — information characterized by different level of uncertainty and related to different level of accuracy.

This project produced the digital reconstruction of a large part of those projects, addressing the issues of architectural coherence from their constructive hypotheses point of view, as well as the use of representation codes able to **reproduce** the graphic characteristics of the original engravings.

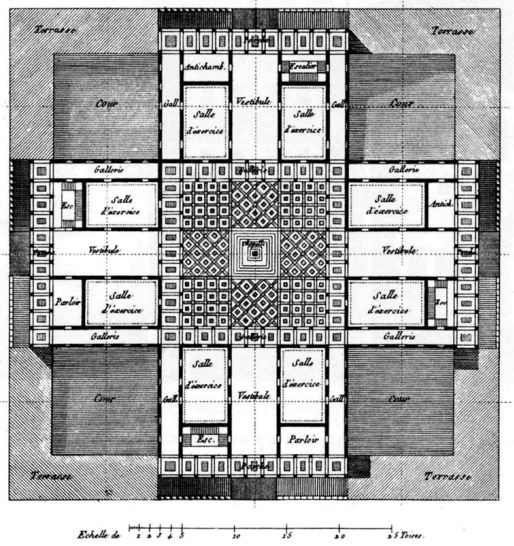
All methods adopted in a digital hypothetical 3D reconstruction process show us that the goal of all researchers is to make explicit, or at least intelligible, through a graphical system a synthetic / communicative level representative or the value of the reconstructive process that is behind a particular result. 03

■ **01**
**Emil Kaufmann, Three Revolutionary Architects, Boullée, Ledoux, and Lequeu, Philadelphia 1952. p. 133.**

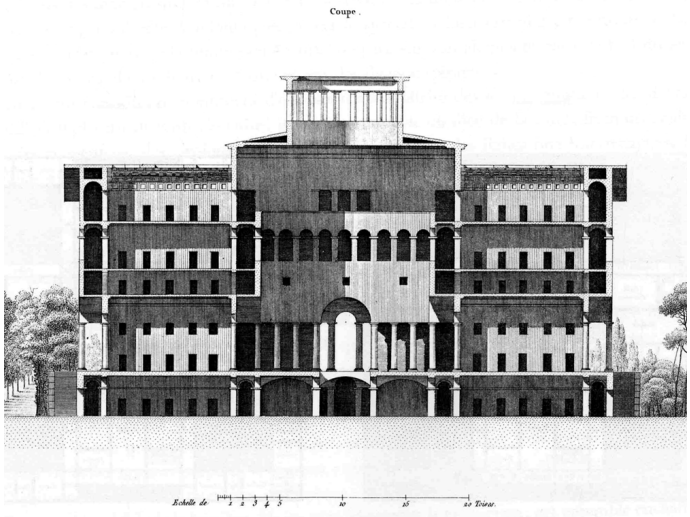
■ **02**
**Claude-Nicholas Ledoux, L'architecture considérée sous le rapport de l'art, des mœurs et de la législation, Paris 1804.**

■ **03**
**Fabrizio I. Apollonio et al., Villa Contarini a Piazzola sul Brenta: studi per un'ipotesi di attribuzione palladiana servendosi di modelli tridimensionali, in: Disegnare idee immagini, 42, 2011, pp. 42–55; Fabrizio I. Apollonio, Federico Fallavollita, Elisabetta C. Giovannini, Riccardo Foschi, Salvatore Corso, The Reconstruction of Drawn Architecture, in: Studies in Digital Heritage, 1 (2), 2017, pp. 1:380–1:395.**

# Maison d'Education




Plan

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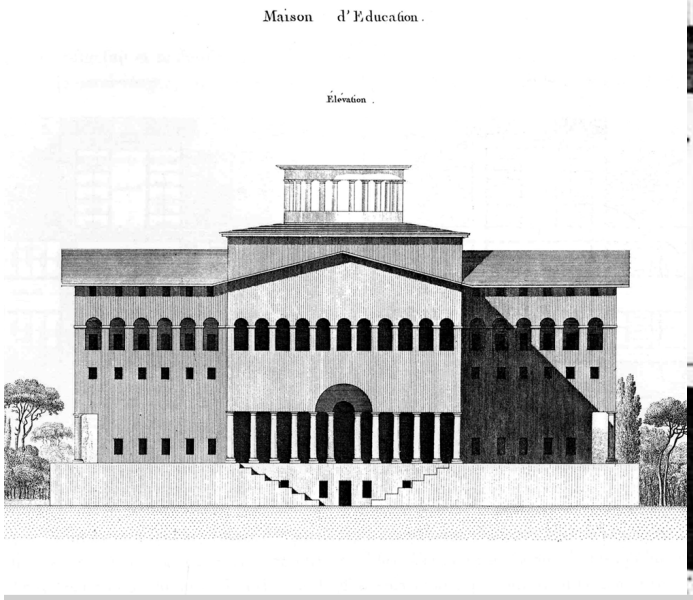
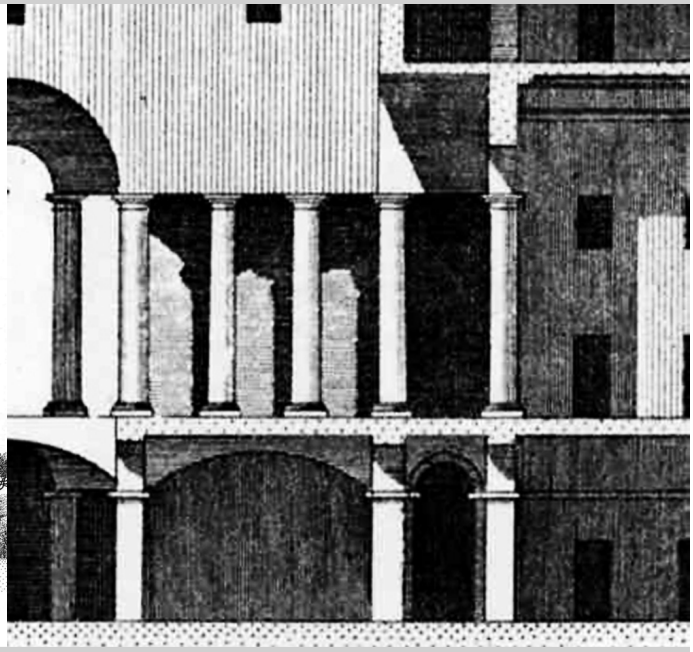



Elevation



Detail

☐ 01
Claude-Nicholas Ledoux: Maison d'Education. Primary sources (Original tableaux Pl. 105, from L'architecture considérée sous le rapport de l'art, des moeurs et de la législation, Paris 1804, reworked by Fabrizio Apollonio).

# I.2 L'Architecture of Ledoux

The large number of studies, projects and works that Claude-Nicolas Ledoux has left us, is an extraordinary heritage still not fully explored and not so well known.

French architect comparable perhaps to Le Corbusier, Claude-Nicolas Ledoux is one of the major figures of the Enlightenment. Hard to keep track of the writings of the 18th Century on the architect and monographs published after the famous text by Emil Kaufmann 04, which inaugurated his rediscovery after a period rather ominous, during which, particularly in the 19th Century, many of his accomplishments have been demolished and its architecture has been violently criticized and described as **bizarre**.

■ **04**
**Emil Kaufmann, Von Ledoux bis Le Corbusier, Ursprung und Entwicklung der Autonomen Architecktur, Vienna 1933.**

The spectacular achievements like the Saline of Arc-et-Senans or octroi barriers of Paris, alongside a theoretical reflection attested by the publication of the visionary book **L'Architecture considérée sous le rapport de l'art, des moeurs et de Legislation** 05, kept Ledoux busy for more than two decades. The first recordings of the book began, in fact, around 1773.

■ **05**
**Ledoux 1804.**

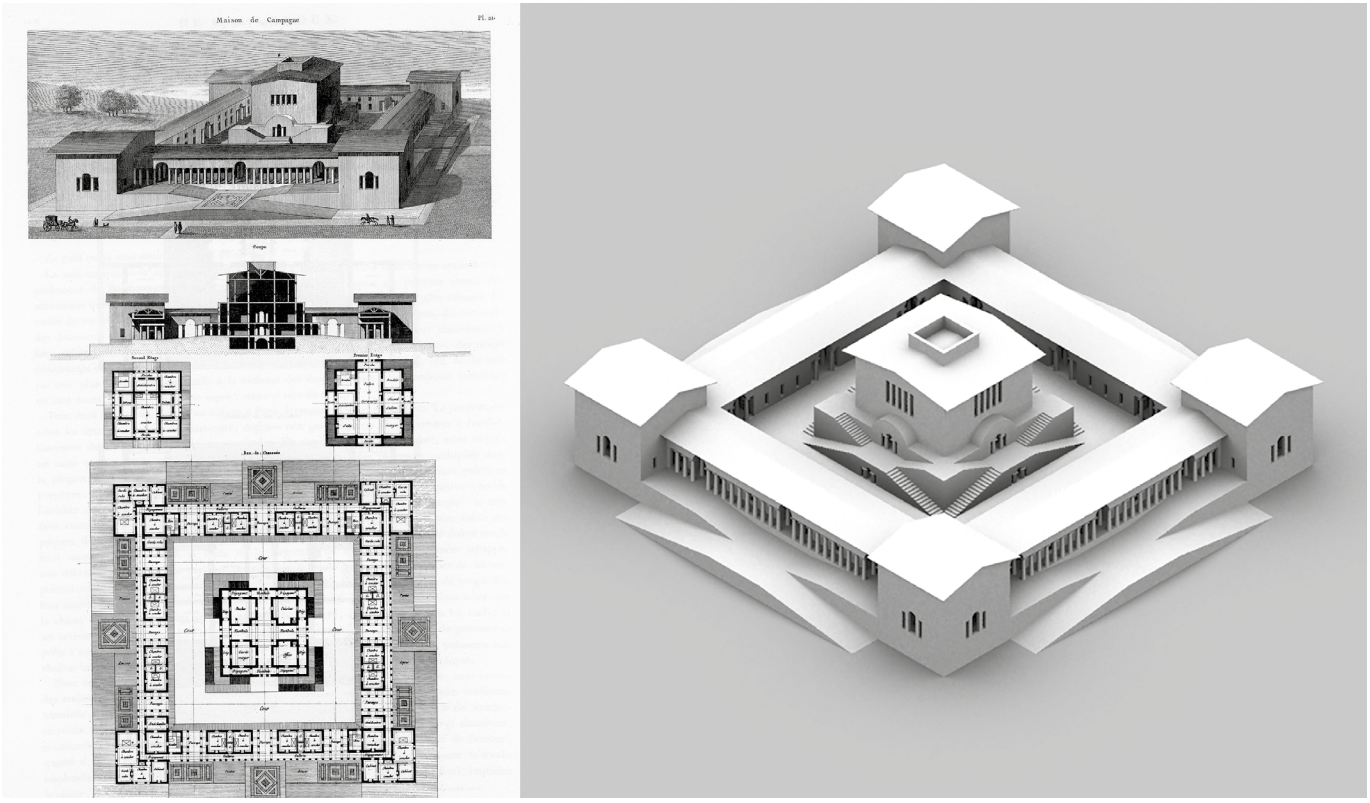
**L'Architecture**, published in 1804, is only the first of the volumes that Ledoux devoted to his built work while its projects remained on paper. A posthumous volume, with other incisions that Ledoux could not print before his death in 1806, was published by Daniel Ramée in 1847 in Paris. 06 This is a volume without accompanying text, essentially focused on the revolutionary architect built architectures. It composed of a long explanatory text and 125 engravings. The first volume is dedicated mainly to the ideal city of Chaux, the buildings that up (only partly realized) and the theater of Besançon, built in 1776–1784. Inside the section reserved to Chaux, it was made a typological grouping of buildings in order to guide the visitor in the exploration of the architectural work.

■ **06**
**Claude-Nicholas Ledoux, Architecture de C. N. Ledoux. Premier volume contenant des plans, élévations, coupes, Paris 1847.**

A further field of investigation, which is particularly challenging, consists of the documents published in the book **Inédits pour un Tome III**. It is a collection of one hundred and thirty unpublished planches dessins exhibiting projects for the country houses or incisions to the Castle of Saint-Vrain, for the branch of Clichy or even for churches and burial chapels. In this collection, especially in the seventies tables devoted to private residences, in a sort of intoxicating variation on the theme of space and virtuosity, Ledoux claims the use of a geometry based on a clear articulation of simple figures, typical of his vocabulary, emphasizing yet more the role that domestic cell plays as generating principle of a new social order.

The 125 tables of engravings collected in **L'Architecture** are introduced, described and accompanied by a text, rich in theoretical content, often emphatic and metaphorical. Text and engravings document the achievements and the architect's projects, according to the self-referential model inaugurated by Andrea Palladio in 1570. 07

■ **07**
**Andrea Palladio, I quattro libri dell'architettura, Venezia 1570.**




☐ 02
Claude-Nicholas Ledoux: Maison de Campagne Pl. 21 (l.) Original tableaux from L'architecture considérée sous le rapport de l'art, des moeurs et de la législation, Paris 1804 — (r.) Reconstructed 3D model by Fabrizio Apollonio.

Deeply influenced by the great reformist thinkers like Jean-Jacques Rousseau, Ledoux processes utopia based on the idea that a completely regenerated architecture could transform society. Starting from the semicircular plant of the Royal Saline of Arc-et-Senans, Ledoux conceived the ideal city of Chaux. A reformed city in which the author explores all possible architectural plans, the stock exchange market, the public toilets, the school, the building to the Community and thet for the satisfaction of pleasure. 02 03

According to Ledoux, architecture should help shape and recognition of different professional spheres. In this way the concept of **architettura parlante** 08 is applied with a primarily educational purpose and not linked to the recognition of the social hierarchy. The Pacifère (common household) as the house of the overseer on the Loue River or the house of the director of Saline, must express the activity that takes place within each building through a monumental language, at the same time extremely light.

■ **08**
**The term architettura parlante was coined by the french architect Léon Vaudoyer (1803–1872) to refer to the expressive architecture of C.-N. Ledoux.**

The house of the overseer of the Loue will follow these principles across the water of the river itself. For the house of the director is proposed a giant order with rusticated quoins interspersed with squares, crowned by pediment close to oculus that symbolizes the eye of the director who controls his workers. Also the house of pleasure in foul form also responds to an educational and moralizing function.

The darkness of the text and the expanded processing time of these projects do not make the forms of this city always clear and understandable.

Especially as many buildings, mainly those conceived in the mid-70s are not only fully redesigned by Ledoux but often modified and idealized. The aim is to give more consistency to his architectural production by adapting to the style of his early works to his full maturity. The author edits mainly the elevation and more rarely plants and sections.

In the Saline, for example, the attics are mostly replaced by domes; more generally, the moldings are simplified, the rusticated well as sculptural elements tend to disappear. The cube, cylinder and sphere become subparagraphs favorite of his architectural language.

Information technologies offer us opportunities hitherto unexplored and unimaginable in order to reconstruct in an integrated and more fully intelligible that extraordinary masterpiece that is **L'Architecture**.

Without having the ambition to replace the enjoyment and knowledge provided by wonderful tables and engraving with the accompanying text, the digital reconstruction of buildings designed and never built aims to provide a Ledoux for his model of an ideal city, which remained only on paper. This way, they can to be offered again and following new perspectives to historians, architects as well as to the public of non-specialists.

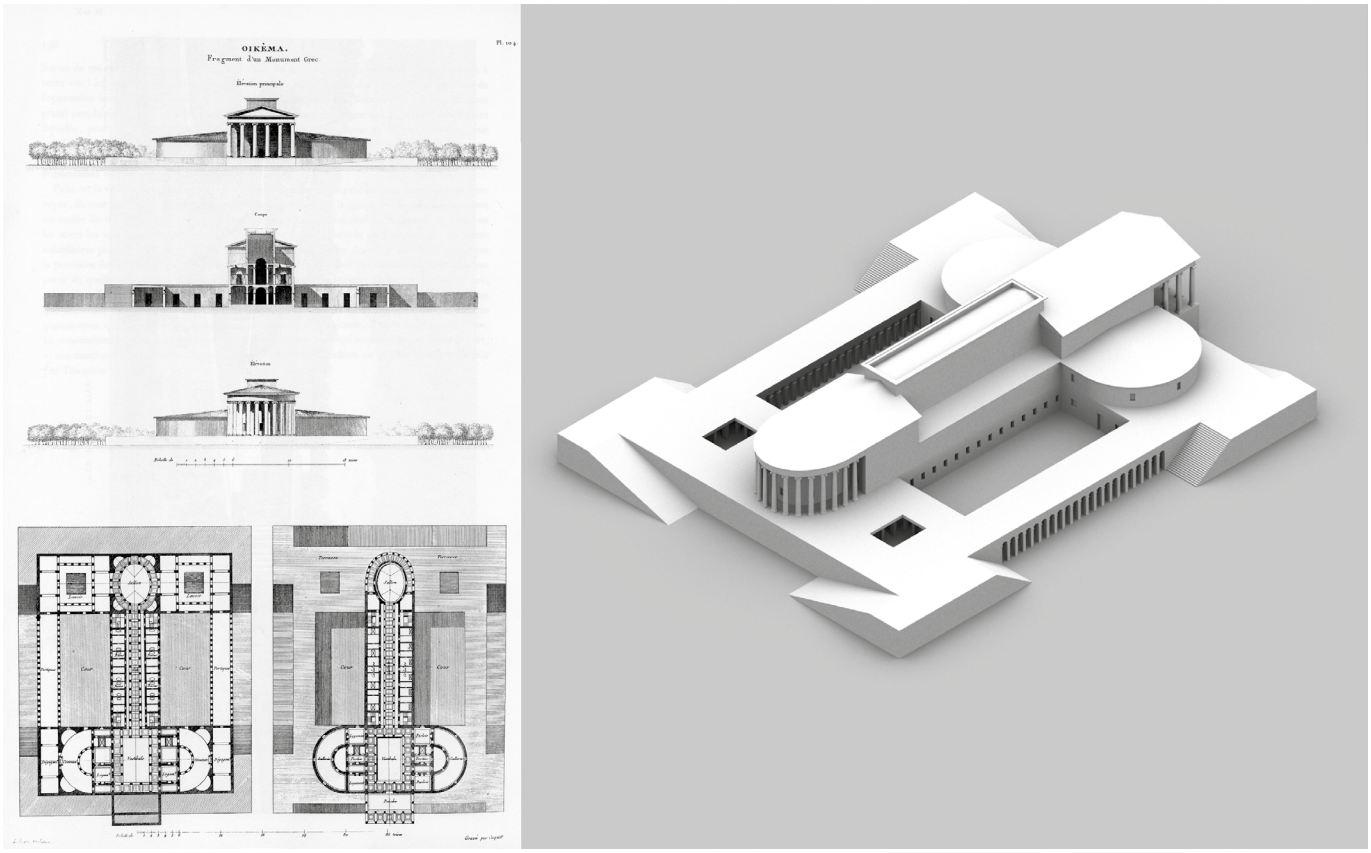
# I.3 From drawings and text to 3D digital model

Within the context of virtual reconstruction a huge amount of studies have been carried out on the multidisciplinary approach for processing spatial data (acquisition, manipulation and management) and on defining new protocols in order to offer new opportunities to the reconstruction regarding no longer extant historic objects. 09

The outcomes of virtual reconstructions, as stated in many authors 10, are based on complex chains of reasoning which gives primary and secondary evidence necessary in the authoring of a historically probable hypothesis due to partial data sources available. In order to complete the reconstructive process we may be aware of the presence/absence, certainty / uncertainty, accuracy/inaccuracy of information.

The result of a reconstructive process acts in the definition of three intimately related areas that concur to define the digital consistency of the artifact object of study: Shape (geometry, size, spatial position); Appearance (surface features); Constitutive elements (physical form, stratification of building / manufacturing systems). 11

■ **09**
**Sander Münster, Workflows and the role of images for virtual 3D reconstruction of no longer extant historic objects, in: ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, ISPRS, II-5/W1, 2013, pp. 197–202.; Marc Grellert, Mieke Pfarr-Harfst, 25 Years of Virtual Reconstructions Project Report of Department Information and Communication Technology in Architecture at Technische Universität Darmstadt, in: Proceedings of the 18th International Conference on Cultural Heritage and New Technologies 2013 – CHNT 18, 2013, Wien 2014, pp. 1–13.**




☐ 03
Claude-Nicholas Ledoux: Oikèma Pl. 104: (l.) Original tableaux from L'architecture considérée sous le rapport de l'art, des moeurs et de la législation, Paris 1804 — (r.) Reconstructed 3D model by Fabrizio Apollonio.

Defining the shape of an artefact (its geometric characteristics, its size, its position in 3D Cartesian space), as well as its constitutive characteristics (building technologies and material) means face to the definition of a given degree of accuracy, connected with the scale to which the process of modeling could be related to.

Such information is derived by sources that we have collected, distinguished by the deficiency of specific references useful to the formulation, more or less reliable, of the hypothetical reconstructions.

Each of these sources or references is characterized, therefore, with reference to information that can be inferred related to the reconstruction process, by a specific degree of uncertainty / reliability and by a degree of accuracy.

Among the different type of sources, in the case of projects of never built architecture, drawings, sketches, images, pictorial representations and textual descriptions are the only available sources to carry out a hypothetical reconstruction.

■ **10**
**George Bruseker et al., Semantically documenting virtual reconstruction: building a path to knowledge provenance, in: 25th International CIPA Symposium 2015, Taipei, ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, ISPRS, II-5/W3, 2015, pp. 33–40; Piotr Kuroczyński et al., 3D models on triple paths, in: Sander Münster et al., 3D Research Challenges in Cultural Heritage II, Springer International Publishing LNCS Series, 2016, pp. 149–172.**

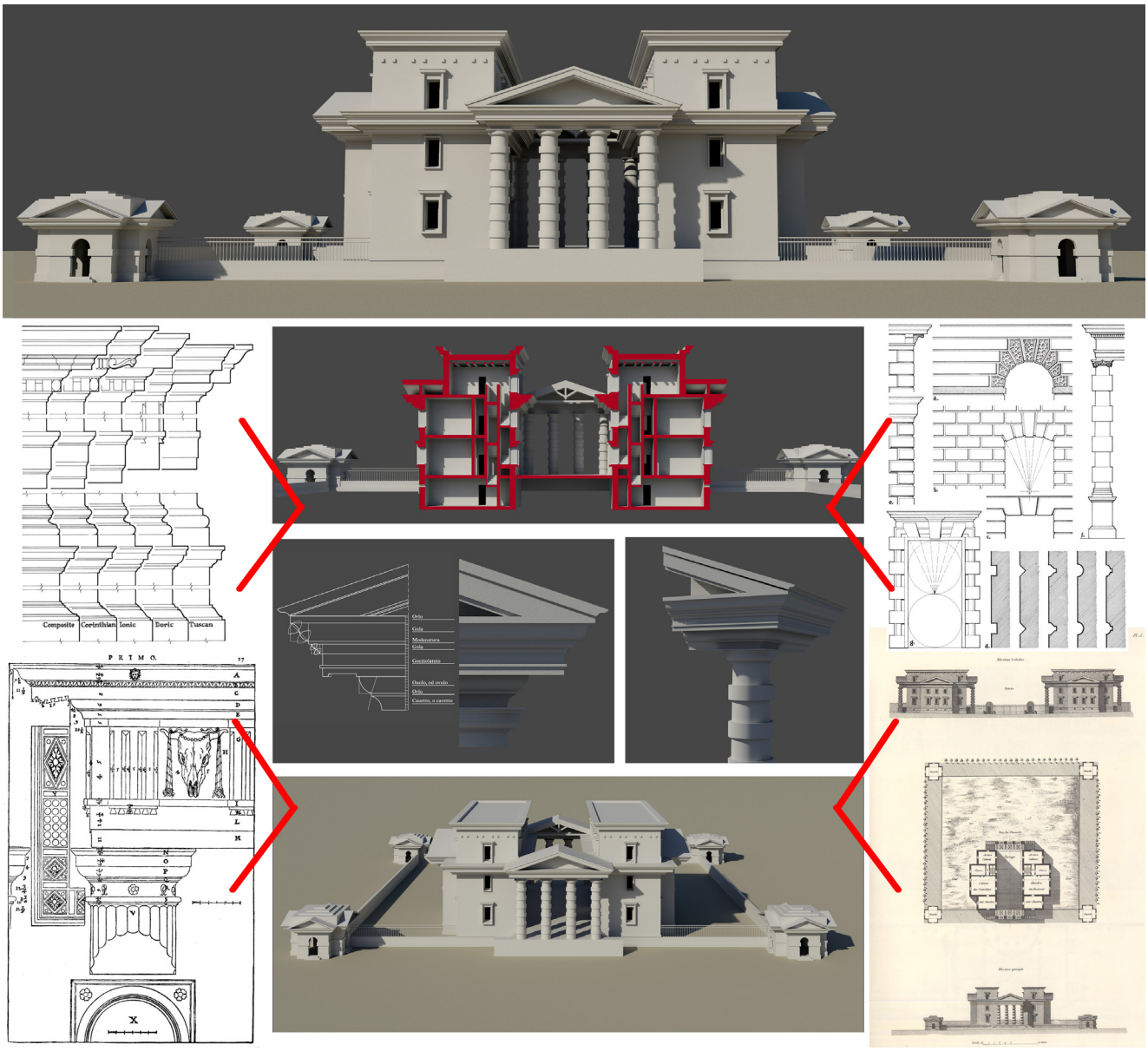
■ **11**
**Fabrizio I. Apollonio, Classification Schemes for Visualization of Uncertainty in Digital Hypothetical Reconstruction, in: Sander Münster et al., 3D Research Challenges in Cultural Heritage II, Springer International Publishing LNCS Series, 2016, pp. 173–197.**

The Digital reconstruction of the collection of projects designed by Ledoux for the ideal city of Chaux is organized following this approach, leading to a result that does not impoverish the original content and provides with new insights the scholars. The reconstruction process can take place according to the following steps: 04

- → analysis and understanding of the text published in **L'Architecture**, a sort of storytelling, in order to let the prose more intelligible, sometimes hermetic and obscure that characterizes the text;.
- → analysis and understanding of the drawings regarding the projects for the edifices designed by Ledoux, and collected in hundreds of engraving plates.
- → definition of a semantic structure.
- → 3D Modeling based on a semantic structure.
- → definition of the rendering techniques of the surface characteristics.
- → the text, in particular in the case of Ledoux, constitutes a matter of extreme importance since it allows to complete, in some cases, the information concerning the projects that can not be inferred directly from the drawings.

These detailed engravings published in **L'Architecture**, in fact, collect refined quality drawings that represent — as in a sort of manual or treatise — plans, sections, elevations whose task is the description and documentation of the formal, the geometric, the functional distribution and the architectural characteristics of different kind of buildings. In some case they are illustrated by perspective views that render project within a typical country-landscape context, characterized by trails, paths, tree lines or masses of trees, mountains, rivers, with some human figures and animals. All the plates reproducing technical drawings are accompanied by a graphic bar scale in Toises du Chatelet. 01

This made it possible to determine the corresponding measure in meters according to the conversion that consider a Toise du Châtelet equal to 1,949 meters. The resolution of 600 dpi (236.22 px/cm) used for digital scanning in TIFF format allows to evaluate the accuracy of the digital model that is drawn on the order of ± 2 cm, also taking into account error inherent in the assessable drawing, on the basis of lesser thickness graphic sign.




☐ 04
Claude-Nicholas Ledoux: Barriere du Chemin de St. Denis: (top) perspective of reconstructed 3D; (bottom) the different parts of the reconstructed 3D model and the relative documentary sources: primary, secondary and tertiary. (Fabrizio Apollonio)

These are not drawings in scale of the detail, but considering the ensemble, through which it is not possible — in general — to deduce information related to architectural details, the graphic signs were interpreted. The Ledoux laminae represent, in fact, the different buildings designed, collecting in each sheet drawings in very different scales of representation. Depending on the size of the building he switches, in fact, from drawings in scale of around 1:150 for the Maison de Commission, of the Saline of Arc-et-Senans, to drawings in scale of around 1:250 for Maison d'Employee, from drawings in scale of around 1: 384 for Bains to drawings in around 1:500 for Panarèthéon.

The details of the architectural apparatus (moldings cornices, architectural orders, balustrades, cornices and lintels of doors and windows, etc.) can be derived, in some cases, by the text written Ledoux, where he describes the ornaments that would characterize an edifice or part of it, or the number of columns and their intercolumns of a colonnade.

As a preliminary step we identified some design references belonging to the author's methodological sphere more or less contemporary to the case study. Those references belongs to the drawing used as a source, in search of stylistic similarities that they can present and therefore they can be used as a means of verification for all formal and architectural features. Vice versa, to solve several basic design issues, we conversely used as reference books or treatises of architecture, in which the architect exposes his formulas for orders, for rooms measurements, for the design of the staircaises, and the architectural details (columns, pilasters, moldings, architraves, sizing of doors and windows, etc.). As a result these can be taken as the reference for the entire design system. Other elements, whose features couldn't have been model on the information in the drawing, required more perceptive interpretations referencing to other treatises, i. e. **I Sette libri dell'architettura** by Serlio. 12 Their primary focus was on the building systems used at that time in order to formulate reconstruction theories that were plausible from a technical, structural and design point of view.

The text is sometimes evocative, allusive, hermetic where in the description of **Vue perspective de la porte d'entrée de la Saline de Chaux. (Planche 35)** 13, he refers to the rules that underpin the harmony of »Those who circumscribe their genius in the pentameter (five measures, the five orders) of the school are abused« 14, in others he is accurate when he suggests as an exemplary case in describing the rules of the columns of the Place of Louis XV, »They have ten diameters, the intercolumning nearly four. The entablature is between the quarter and the fifth. The ones you see have five, the one spread. The cornice is between one-third and one-quarter«, to go back to allude only to the general regulatory principles »the pediments that have abjured their ancient proportion to dominate everything around them«.

■ **12**
**Sebastiano Serlio, Tutte l'opere d'architettura di Sebastiano Serlio Bolognese, Venezia 1584.**

■ **13**
**Ledoux 1804, pp. 107–108.**

■ **14**
**Ledoux 1804, p. 108.**

He is still precise and detailed in the description of the **Coupe de la porte d'entrée de la Saline. Coupe du batiment des ouvriers (Planche 36)**:

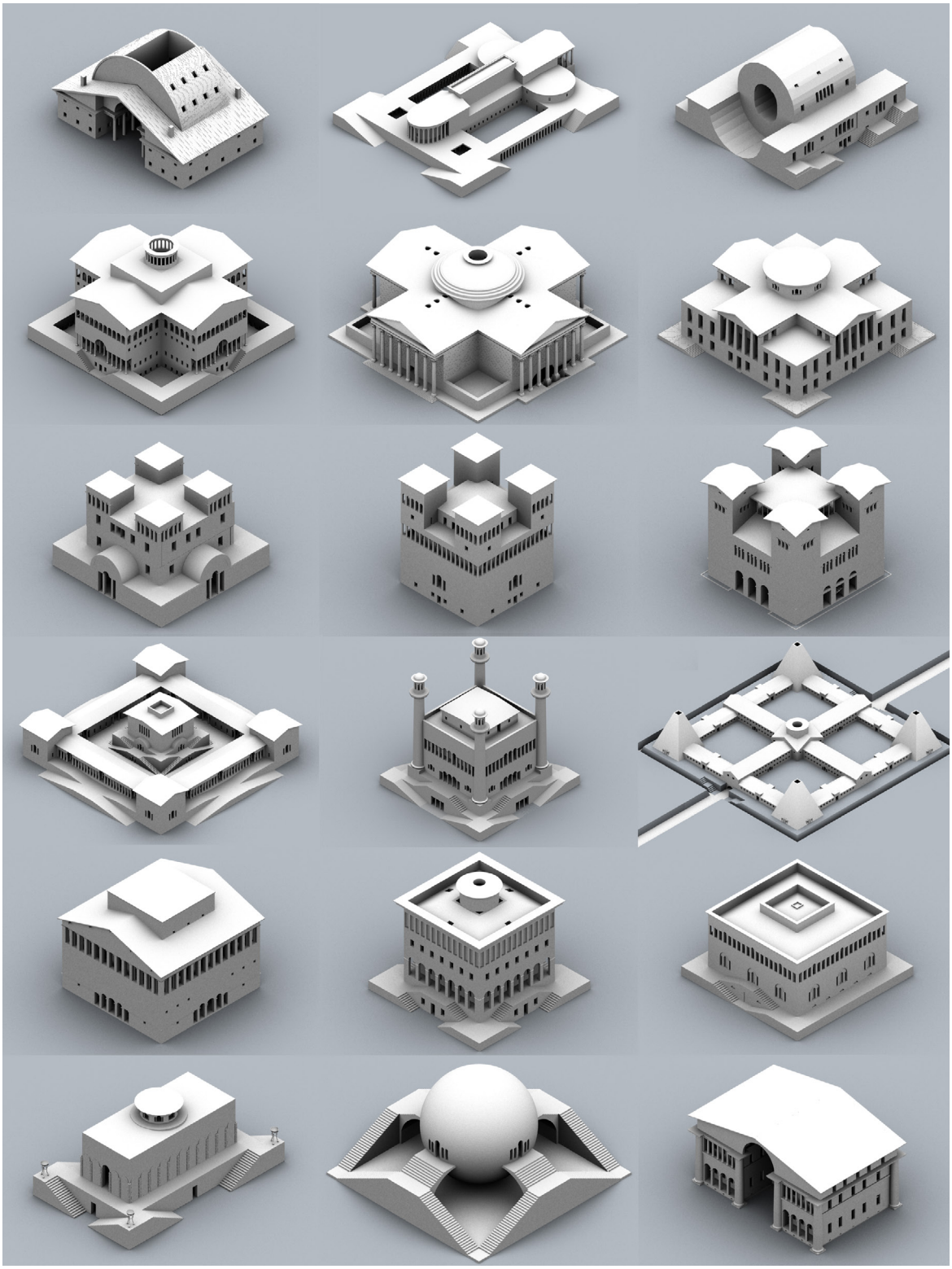
»Look at the first section, it indicates a very strong diameter; the intercolumning tightens to add to its power that the proportion commands. … The profile of the cornice is great because there are few divisions. The rock astonishes the spectator; the divisions of the plates establish the levels; the framework of the roofs even offers resorts to the convenience that does not neglect any, and easy links with the buildings on the side«. 15

■ **15**
**Ledoux 1804, pp. 109–110.**

Where there is no any indication you need to find the references in the works or in the same architects mentioned by Ledoux, the temples of Paestum, the Propylées in Athens, the masterpieces of Mnésiclès or Palladio, or moreover to refer to the numerous works (edifices) that the French architect built throughout his distinguished career, some of which still exist: the Saline of Arc-et-Senans, Théatre de Besancon, Rotonde de la Villette, Hotel d'Hallwyl, Barrière du Throne, to mention a few.

# I.4 Conclusion

The digital reconstruction based on architectural drawings or sketches and supported by textual descriptions and notes, is meaningful inasmuch as it is an exemplary issue to explain the relationship between the certainty of the data used as a source and the accuracy of granularity of the data itself. Each different type of source is characterized by its own specific grade of information granularity that can be transformed into a hypothetical 3D model 05 with its own level of detail. The geometrical definition of each constitutive elementary unit is, therefore, not dependent on the level of detail of the source data (e. g., scale of representation of 2D drawing) but by the type of information that has to be induced, deduced or interpreted. However, a lot of issues related to the formulation of the hypothetical 3D reconstruction of edifices only designed and never built are still to be explored, so we aspire to reach the purpose of describing and representing the whole process of **re-interpretation** accomplished.



☐ 05
Claude-Nicholas Ledoux: Samples of 3D virtual reconstructed models after L'architecture considérée sous le rapport de l'art, des moeurs et de la législation, Paris 1804 (Fabrizio Apollonio).