Visionaria. An Open Design Approach for the Regeneration of Historical Urban Heritage

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Abstract. This paper aims to investigate how the open-design approach can help in the regeneration processes of historical urban heritage through participatory design path. The opportunity to experiment with the methods and techniques of open-design was offered by a research project called Visionaria conducted in the city of Senigallia (Marche, Italy). Visionaria consists of a series of open activities by dedicated young people under 35 years of age, with the aim of regenerating an urban space at an important central location in the city center. The planning of the project was shared and achieved through a digital fabrication workshop based on a mix of parametric modeling and low-cost manufacturing solutions.

Keywords: Customized furniture · Algorithmic design · Parametric modeling · Urban heritage

1 Introduction. Open/Open Design/Open Design Furniture

The open-design approach comes from the open-source and free-software movements. These movements were originally limited to computer science and engineering. However, nowadays, we talk about open-data, open-science, open-governance, open-innovation, and indeed open-design. Open Knowledge Foundation defines the idea of 'open' as: "Open means anyone can freely access, use, modify, and share for any". Open-design come up when the open approach to product design.
Particularly, as in [1] while design concerns the formulation of the idea of a solution to a problem and fills the gap between the felt need for a product and the current reality, manufacturing is concerned with the actual realization of the design in terms of material and construction techniques. Therefore, the product development is divided in two distinct processes. The first being the phase of planning, which results in the design and the second phase is manufacturing, which results in the product.
Open source has a deeper background in software and the open approach is to be found most widely represented in the software sector. The second sector most involved in open design practices is the design, or rather, the re-designing of the objects widely used in everyday life.
Among these, furniture is the most suitable product for hacking and customizing operations. Open design approach seems to democratize and shorten the designing process

of objects of everyday use because they are low-tech and the way to use them is familiar to everyone such as furniture even if they are not involved in design studies.
In this regard, it should be noted that the Internet has become the main carrier of shared information and the place where entire communities share their interests and their experiments.
In fact, among several aspects of open-design, two aspects are fundamental, namely, the digital form of the contents, and peer-to-peer collaboration, because everyone can use and edit the content.
Open Design concepts is spreading thanks to the rise of low-cost digital manufacturing solutions and thanks to the digitization of almost all steps of the design process.
Open design approach applied in the field of product design and furniture design led to different typology of outcomes. One of these is the *construction kit* where all the construction elements of a product with related assembly instructions are provided in as a single package. Another innovative outcome is a new form of design-generating tool that works on the instructions and variables entered by the user [2].
This paper aims to investigate how the open-design approach and innovative outcomes addressed to users who are unfamiliar with design processes can help in the regeneration processes of historical urban heritage through participatory design path.

2 Case study: Visionaria project

The opportunity to experiment with methods and techniques of open-design was offered by a research project called Visionaria, conducted in the city of Senigallia (Marche, Italy), promoted and financed by the National Association of Italian Municipalities (ANCI) as part of a project for the development of creativity among the youth for urban regeneration. Visionaria consists of a series of open activities by dedicated young people under 35 years of age, with the aim of regenerating an urban space that is centrally located in an important place in the city center. The planning of the project was shared and achieved through a digital fabrication workshop based on a mix of parametric modeling and low-cost manufacturing solutions. The Visionaria project was created in response to the specific need of devoting spaces in the Piazza del Duca in Senigallia to photography and visual arts to make the city a cultural center dedicated to those arts (Fig.1).
The city of Senigallia has, in fact, been home to important exponents of photography such as Giacomelli and Ferroni who belonged to the Misa group. However, the city has failed in promoting strategies to fully exploit this resource.
Currently, the Museum of Modern Art, Information and Photography (MUSINF) in the city organizes exhibitions and events on photography.
In this context, Visionaria's aim is to convert the selected spaces into a laboratory for designing, constructing, re-elaborating, involving, and attracting the entire city.
Visionaria has the ambition to be the startup of a larger project as the center of an evolution of photography, on the one hand through experiment with new forms of narration one side and large expositions on the other, and support youth entrepreneurship. Visionaria's activities are, therefore, aim at building a community of young artists who can, in some way, find themselves, confront and make significant contribution to the growth of the whole city.

Fig. 1. Palazzo del Duca in the center of Senigallia (Italy)

The project is located in the spaces that were once the city's hostel, and a portion of the Palazzo del Duca, which is an important building owned by the city where the main exhibitions are held (Fig.2). That space may, in fact, represent one of the poles of a system of places dedicated to photography: a sort of pop section of the MUSINF that would attract not only scholars but diverse audiences and, introducing to them through various activities the world of photography and visual arts. A place that, starting with photography and the visual arts, will establish itself as a center for the expression of creativity by youth, and as a cultural space of Senigallia.

Fig. 2. Pictures of the former hostel in Senigallia

3 Applied methodology. Automated procedures and parameters

The design project, even more than the architectural project, in its evolution from idea to object, requires investigations that make use of the comparison among the suggested models. During the creative process, the designer pursues the multidimensional images

present in his imagination by rapid transcription on a sheet of paper or as a scale model study (fig. 3).
Three-dimensional models facilitate the investigation of form as an expressive and functional entity. The prototype makes it possible to evaluate the proportions, the relationship with man, and the context of the product being conceived. Simultaneously, the prefiguration of the physical model makes it possible to evaluate the different images of a mutant model.

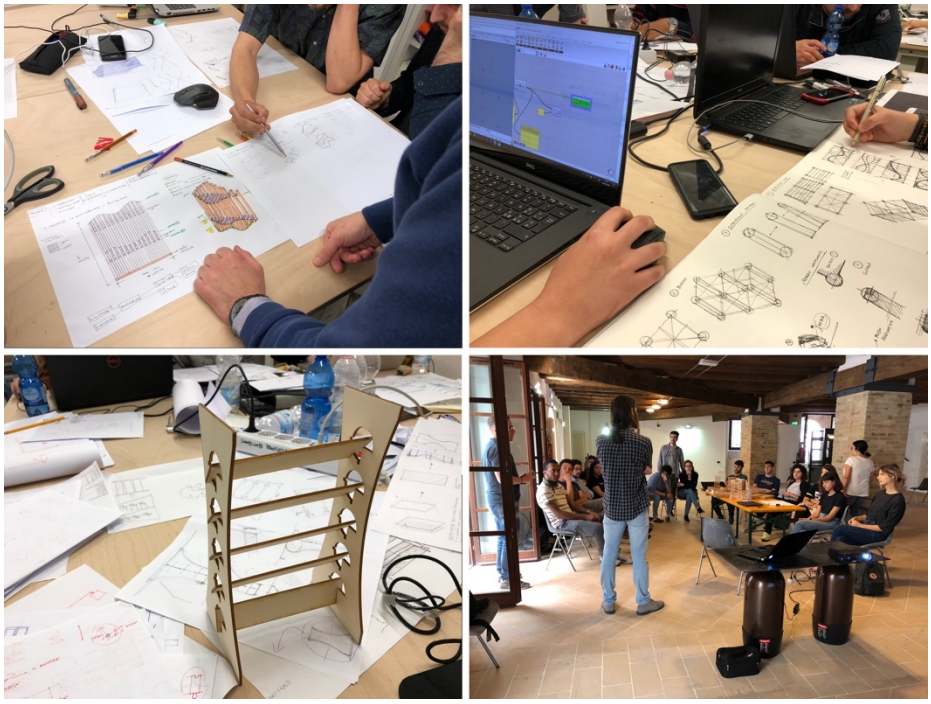

Fig. 3. Analog and digital models to support the design of the parametric product.

In recent years, as a result of the development of low-cost tools for rapid prototyping, the relationship between the digital model and the physical model has become more and more consolidated. Also, thanks to automation by the use of algorithms, a greater diffusion of visual languages has occurred, which makes it necessary to what is an Algorithm?

"An algorithm is a formal procedure that solves a certain problem through a finite number of steps. A problem that can be solved by an algorithm is called computable" (Wikipedia).
This generic definition immediately clarifies the fact that the algorithmic procedure is not related to any specific discipline but can process any sequence of actions aimed at achieving a goal. The procedure is automated using computer, which employs for this purpose common programming language and syntaxes. Designers can manipulate visual arts and techniques, but they are not computer experts. The rapid transition from

alphabetization to digital automation of algorithms, was achieved mainly due to the spread of visual programming with Visual Programming Language (VPL).
The automation of the algorithms facilitates the explicit introduction of parameters in the models, which introduced the concept of responsiveness of the design project, which is expressed in two potentially independent aspects. On the one hand, we have the possibility of enriching the designed product using devices that allow the movement of the product through processes that are linked to external inputs. The inputs are selected for the product according to a programmed behavior that also determines the different reactions. The other concept of responsiveness is intrinsically expressed in the digital model. The model, after the introduction of parameters in the construction of the design, assumes a controlled mutability.
The parameters that change the shape are modifiable values, making the computer-designed model, a kind of digital mockup, with which to experiment with the shapes.
Each value of the input variable corresponds to different outputs; therefore, mutations of the same project are linked together by a common code, which guarantees a relationship among the models that have been generated by flowing through the input data that has been changed by making certain changes in the inputs to obtain different forms of the same project linked to a common definition. The forms that are generated are characterized by a common essence, making them belong to the same "family of models". By family of models we mean the products generated by a common algorithmic structure guaranteeing a kinship among the forms.
Within the system of variable models, it is however possible to find invariant elements visible in the forms but dependent on the common algorithmic definition that generated them. For this reason, we will call the algorithmic definition that generates the models "typological algorithm"[3].

4 The Workshop for learning the method

Displayed The design of the typological algorithm is based on a logical path that leads to subdivision of the parameters into:

- Main parameters;
- Secondary parameters;
- Detail parameters;
- Manufacturing parameters.

In this way, consecutive moments of parameterization are created, triggering relational dependencies for the subsequent parameters with respect to the previous ones.

4.1 Coding and parameterization of the typological model

We now refer to one of the products, a chair, designed in the workshop. We define the main parameters that determine the basic forms of seat (fig. 4). The first part of the definition allows us to work on the simple model where we can decide the height and depth of the seat, **the** inclination and height of the backrest to create a typological 2D model in wireframe.

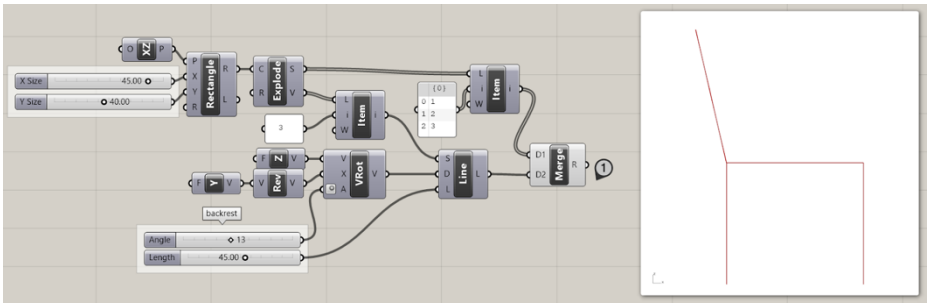

Fig. 4. Definition of the typological algorithm and main parameterization.

The typological algorithm must now be linked to a technological process to satisfy static and productive needs. The Open Design approach provides for the customization of the product designed by the designer and the possibility of building it through Rapid Prototyping processes. The technology chosen for the manufacture of the models was the CNC milling machine that requires the development of digital models in the plane, the extraction of the profiles of the developed elements and the creation of cutting paths. The various built elements are then reassembled in a real environment for the reconstitution of the entire product.
The adopted technology guides the subsequent steps of parameterization that involve the construction of simple lines with which to synthesize the forms that come from the mind of the designer and lead the model towards the process of manufacture. The latter involves the use of flat sections for the generation of repetitive elements. Elements consisting of L-shapes differently oriented to create a minimum module composed of a trio of broken lines where one side will always constitute the seat, the other side will be alternately the front leg or the backrest or the back leg. Depending on the number of repetitions, few of many, the process will produce a chair or, in its elongated form, a bench (fig. 5).

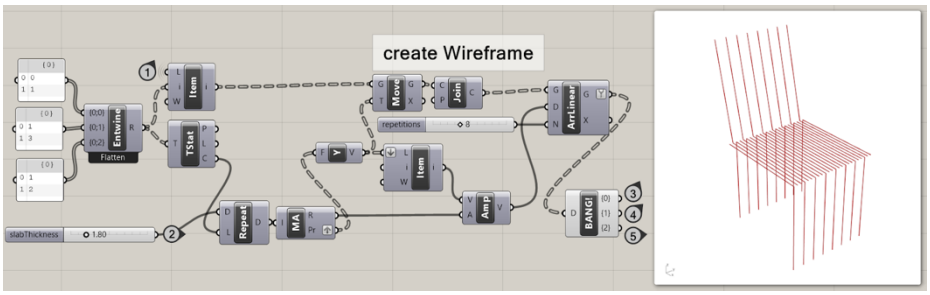

Fig. 5. Secondary parameterization and coding of the definition that combines form with manufacturing processes.

The implementation of the code involves adding details by transforming and modifying the wireframe construction. By means of variable movements along the X-direction of the L-shaped elements, it is possible to bend the elements to enhance the product's

ergonomics. In addition, the lines that represent the front legs are shorter than the back legs to facilitate the seated person to rise from the chair.
The wireframe model, therefore, contains all the formal and functional characteristics of the final model. These geometries become master profiles of the detailed volumetric elements in relation to material and static considerations. The subsequent steps of the VPL definition generate the curvature of the L-shaped sections, and the depth and width of the individual elements (fig. 6).

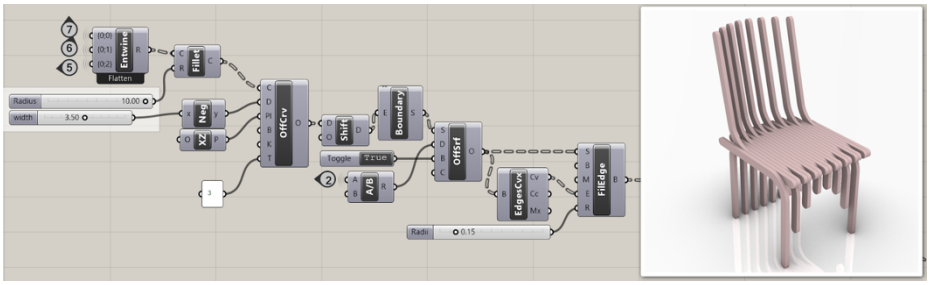

Fig. 6. Coding and parameterization of the details for the material and static yield of the product.

The last part of the code collects the manufacturing parameters and returns the paths that the CNC machine must follow for the construction of the individual wooden ribs. Each operation takes place after determining the center of gravity (CG) of each element. The CG is the origin of each of the vertical planes that divide the ribs symmetrically. The planes section the solids and, together, determine the curves, which, when oriented on the horizontal plane become the paths that the cutter will follow to reduce each panel, section by section, to the desired shape. Once manufactured, the parts will be assembled by the user himself who in this way, besides making a controlled creative contribution upstream of the project also plays an active part in the manufacturing phase of the customized product.

4.2 Configurator tool set-up to designing customized furniture

Program The definition of the model by means of an algorithm to which parameters are provided at successive stages of construction, constitutes the explanation of a logical sequence, which makes the model dynamic. It lends the product the possibility of expressing itself through multiple images, adapting itself to or imposing itself upon the scene into which it is inserted. The logical sequence is an algorithm that organizes iterations marked by a common genesis that retains the type of the conceived product. The designed type includes an infinity of configurable models shaped by n number of variable parameters provided through VPL programming.
The Open Design is characterized by the close relationship that are established between the designer and the end-user because the latter had already assumed an important role at the time of the prefiguration of the product. The user has an active part in the project. The variable parameters of the composed definition are divided into two groups, namely, open and embedded.

The open parameters are those that allow the end-user to make some choices of a formal nature. These are the parameters that change the model, configuring different solutions with the same type of product.

The embedded or the built-in parameters are for the exclusive use of the designer and, together with the VPL encoding, are hidden from the end-user. In this way the topology of the form, the function and the technique of producing the product remain in the hands of the designer who, through the code, holds a sort of direction and validation of the project. The boundary between open parameters and embedded parameters, in the workshop experience, is constituted by the presence of a web configurator that proposes a graphic interface that reveals only the open parameters released for the customization of the product by the end-user. The end-user customizes the product by modifying the open parameters, observes the results of the variations and, thanks to a viewer that, in real time, returns the prefiguration of the product, and decides the desired configuration. Once the shape has been chosen, the configurator allows the downloading of the files that are useful for the manufacture of the product; in this case, the chair. The files are in .dxf format for dialogue with a CNC milling machine.

In the experience of Visionaria, ShapeDiver was used. It is a tool that provides a graphical web interface for sharing, editing, and displaying parametric products modeled with Grasshopper (fig. 7). Also, for a better dialogue between the portal and the code, the plug-in provides additional nodes in VPL. The platform saves the interactive models in a cloud space, and for this reason they are always accessible using a web browser to connect to the portal. The viewer itself is customizable through the graphical choice of windows that contain the sliders for product modification. The interface is embedded in proprietary sites.

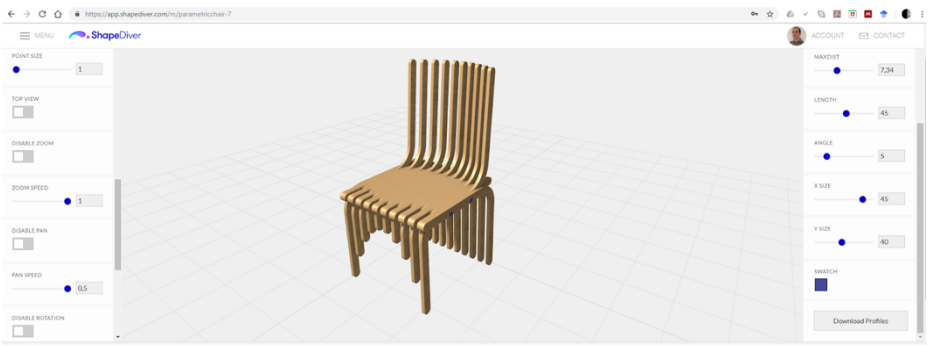

Fig. 7. Standard interface of the configurator accessible via web. Left: parameters for changing the display and navigation of the model. On the right the open parameters for product change.

4.3 From the virtual model to the real model

For Once the various furniture models were obtained using the configurator, the various furniture items were realized through two distinct phases. The first was that of the scale model. Scales appropriate to the size of which the designer had the details, were defined within the Visionary workshop as a verification and control phase. Aesthetic and functional control were useful for verifying the correct composition of the furniture. Once

the digital models in the plan were developed, we proceeded to the extraction of the profiles of the elements that made up the furniture. From here the cutting paths were created that could be used in the laser cutting process. The laser patch was used as the first manufacturing technology for scale verification models, as the technology offered much greater accuracy than the CNC milling machine. The superior precision and the smaller processing area allowed us to realize the model in reduced scale and verify the stability of the multiple connections between the parts of the furniture (fig. 8).

Fig. 8 – Furniture mock-up

After the verification of the scale models and after the necessary corrections were made, the project passed to phase two of the realization process—creating new cutting paths of the model on the real scale. To complete the CNC milling process it is necessary to insert the cutting paths inside the CAM instrument. It is one of the many tools that are used to formulate the tool path that the machine must follow in relation to the vector model of the products. The cutting process that was carried out to produce the furniture accessories was that of flat cutting. In the cutting process, the material to be worked is positioned, which in this case was a marine plywood panel of 20 mm thickness. The same thickness that was used as a binding parameter in the code for generating profiles. After the material was chosen, the element that physically goes to cut the material is, in the technical language, called the cutter. The cutter is the tool which, thanks to the sharp cutting edges, allows the machining of materials for chip removal. The drill was chosen to match the thickness and hardness of the material (the resistance that the material offers relates to the penetration of the cut). Once the parameters were chosen, the machining process was begun, which consisted of all the movements that the tool that were calculated by the CAM instrument (fig.9).

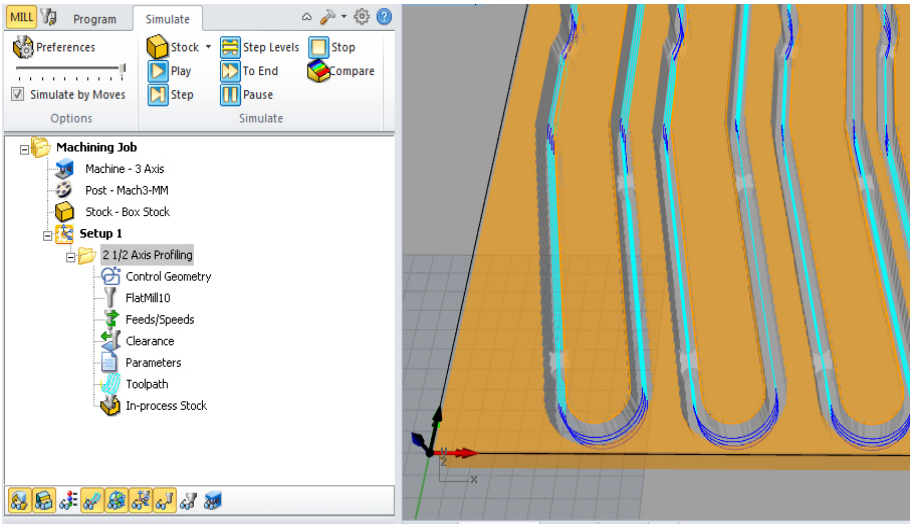

Fig. 9 – CNC milling machine CAM path

This process generates an information code that is inserted into the management software of the CNC milling machine in order to start the process of physical realization of the various elements that make up the product.
Once the manufacturing process is complete, the product, which is in its separate parts, is assembled by the end-user (figg. 10-11). The assembling of the product is facilitated by the perpendicular elements and the ribs of the product. This is achieved by joining the parts with a fastening method called interlocking. The type of the joint, which was chosen during the design phase, was the comb joint.

Conclusions

The The article illustrated how an open design approach can be useful to regenerate a historical part of a city involving citizenship, and, in particular the youth community, in shared design actions for spaces dedicated to creative activities.
This design activity took the form of a workshop based on parametric modeling and digital manufacturing. The objectives achieved by the workshop were multiple. On the one hand, a series of furniture elements were created that would furnish the spaces of the former Senigallia hostel, and, on the other hand, the workshop participants experimented with innovative open morphogenetic systems that can be reconfigured by anyone using a web-based interface.

Figg. 10-11 – Furniture designed by the students of the workshop through the use of shared parametric processes.

The design workshop was structured in four distinct phases: 1) Analysis of the state of the art; 2) Formulation of the concept; 3) Analysis and generative parametric development; 4) Configurator tool set-up to design customized furniture.
The analysis of the state of the art served to outline the typology of the furniture to be considered to furnish Visionaria urban spaces. In the formulation of the abstract idea, distinctive signs were set. These signs came from a critical view of the urban heritage of the city of Senigallia and they were taken into consideration as well as other elements (material, material processing, interlocking joints) for the realization of the open design furniture.
The algorithm of construction of the various elements was defined through the use of the Grasshopper tool, which allowed us the flexibility for formal modification of the object parameterizing the user-defined aspects. As the final result the parametric modeling phase of the furniture objects, an easy to use graphical interface tool was set up, and a simplified interface to allow users to modulate the furniture according to the characteristics of use was provided. Other results of the open design furniture workshop was a design book that described the entire workflow is described, a graphical interface tool, and an instruction sheet for the end-user that outlined the system of assembling customized furniture independently.
Some of the pieces of furniture designed by the workshop participants were designed to be validate the results and verifying the usability and ease of assembly.

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