[BAU Journal - Health and Wellbeing](https://digitalcommons.bau.edu.lb/hwbjournal)

Volume 1 Issue 3
SPECIAL ISSUE
Urban Health & Wellbeing Building Collaborative Intelligence for Better Lives in Cities

Article 30

ISSN: 2789-8288

October 2018

# DIGITAL DESIGN AND FABRICATION TECHNOLOGIES TOPROMOTE VALUES OF HUMAN WELL-BEING

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## Recommended Citation

KHOURY, CHADI Assistant professor, Faculty of Architecture – Design & Built Environment (2018) "DIGITAL DESIGN AND FABRICATION TECHNOLOGIES TOPROMOTE VALUES OF HUMAN WELL-BEING," *BAU Journal - Health and Wellbeing*: Vol. 1: Iss. 3, Article 30.
DOI: https://doi.org/10.54729/2789-8288.1082

# DIGITAL DESIGN AND FABRICATION TECHNOLOGIES TOPROMOTE VALUES OF HUMAN WELL-BEING

## Abstract

Nowadays, thanks to technological development and knowledge, digital design has assumed a fundamental role in building human's well-being. No longer a mere functional element, today it is an interdisciplinary tool par excellence in the construction of new forms of relationship between human and his vital context. The process of design is subject of many studies in the field of psychology or social science or technologies. Its wealth is based on its complexity and the variety of operating conditions that include during its progress. This paper studies how it is possible for digital design and fabrication technologies to promote human well-being with the aim of responding to the needs of every human being, understood first as a person and not as an anonymous user. With the great development of technology, digital design and robotics are gaining potential to be explored in the merging process of digital fabrication. An investigation on computer aided integrated design and production using advanced automated tools aims to provide integral solutions for the design and production of geometrically complex forms merged with machines restrictions that could serve as potential design parameters. Beyond functionality, comfort and technology, the objective is to proposes a conscious and creative dimension of living, offering an anti-stress formula for the design and daily management of the space. The paper will conclude by considering open issues and future work in the development of digital design approaches for human well-being.

## Keywords

Well-being, Digital Design, Information Technology, Integral Manufacturing, Robotic fabricat

# DIGITAL DESIGN AND FABRICATION TECHNOLOGIES TO PROMOTE VALUES OF HUMAN WELL-BEING

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**ABSTRACT:** *Nowadays, thanks to technological development and knowledge, digital design has assumed a fundamental role in building human's well-being. No longer a mere functional element, today it is an interdisciplinary tool par excellence in the construction of new forms of relationship between human and his vital context. The process of design is subject of many studies in the field of psychology or social science or technologies. Its wealth is based on its complexity and the variety of operating conditions that include during its progress. This paper studies how it is possible for digital design and fabrication technologies to promote human well-being with the aim of responding to the needs of every human being, understood first as a person and not as an anonymous user. With the great development of technology, digital design and robotics are gaining potential to be explored in the merging process of digital fabrication. An investigation on computer aided integrated design and production using advanced automated tools aims to provide integral solutions for the design and production of geometrically complex forms merged with machines restrictions that could serve as potential design parameters. Beyond functionality, comfort and technology, the objective is to proposes a conscious and creative dimension of living, offering an anti-stress formula for the design and daily management of the space. The paper will conclude by considering open issues and future work in the development of digital design approaches for human well-being.*

**KEYWORDS:** *Well-being, Digital Design, Information Technology, Integral Manufacturing, Robotic fabrication*

## 1. INTRODUCTION

There is a conviction that has always led the studies of design, interior architecture and furniture with the aim of responding to the needs of every human being, understood first as a person and not as an anonymous user. In other words: human has not only physical health, but also (or above all) a psychic health. It is therefore essential that he is psychologically well because he is able to enjoy his physical health, to appreciate it, to use it and to make the most of it as a means capable of leading him to many joys and satisfactions. We must also keep in mind that the concept of indoor and outdoor spaces and the aspirations associated with them, vary a lot according to the culture of belonging. They also vary according to the periods of life and it is normal to feel the need to change something (or everything) in these spaces, in a synchronous manner with respect to the changes we face. The indoor space is a mirror and at the same time influences us, it is important to choose it, build it and take care of it, as in a love relationship. Listening, awareness and the courage to change, to renew and not to be satisfied with the easy and ready solution, besides the professional help, can really help us to improve the relationship with our spaces, because staying well in our indoor and outdoor spaces it's really one of those things that can improve the quality of life.

According to the reflection of the American sociologist Alvin Toffler (Toffler, 1987) highlights three different waves that have changed the history of architecture and society. The first wave reaches the end of the 18$^{th}$ century and is determined by an agricultural society rigidly divided by a decentralized economy that had the land as a basis of it, life and culture; the second is characterized by the steam engine and the artificial production of energy “the Industrial revolution". The period that changed the way of thinking and operating, led to great social upheaval. The third wave is "the Information revolution", the one we live in, where the information (the basic raw material) and its treatment are the protagonists of research, replacing the one based on the industry. "The third wave", thus defining a historical phase characterized by the importance of the role of the information in economic and social processes. So now, the interest turns to the operation, to the representation of an architecture that is part of contemporary communication.

## 2. DESIGN AND WELL-BEING

Well-being is often considered the highest value to which other values can be subsumed: it is that what makes ones life good, a good life is for many people of the highest value. The most notable approach in ethics of technology that holds this position is the approach of value-sensitive design where well-being is considered as an important value that can be incorporated into designs (Friedman, Kahn, Borning, 2006). Within this approach, to say that an artifact embodies a value such as well-being is not to say that the artifact will deterministically bring about well-being, however and whoever uses it. The use of the artifact will tend to promote for human well-being (Van De Poel, 2012).

According to Philip Brey (Brey, 2015) four different approaches for the design and well-being could be presented: the Emotional Design, the capability approaches to design, the positive psychology approaches and the life-Based Design.

- Donald Norman coins the term “Emotional Design” and it focuses on emotional experiences of users with products and emotional meanings associated with product use. The aim of emotional Design is to provide products with additional utility by designing them to evoke pleasure and other positive emotions in users.
- The capability approaches to design has been developed by Martha Nussbaum , it take a different approach then the Emotional Design, it focuses on the enhancement of human’s basic capabilities for leading a good life rather than focusing on the arousal of positive feelings. This approach for well-being and welfare rests on the assumption that human’s ability to attain well-being is dependent on their development and possession of a number of basic capabilities that allow them to engage in activities that promote their well-being.
- The positive psychology approach focuses on studying and improving human’s positive functioning and well-being, it emerged as the dominant psychological approach to well-being. Its stands apart from many other psychological approaches by focusing on the enhancement of creativity, talent and fulfillment, rather than on treatment of mental illness.
- The life-based design is a design approach that aims to improve well-being by looking at human’s whole lives and the role of technologies in them. Looking at whole lives involves studying human’s forms of life, values, and circumstances, and considering these in design. There are four phases in Life-Based Design the first is the Form of Life Analysis where a particular form of life is described, including the rule-following actions and practices that are typical to it, the values that people share in the form of life, and typical actors, contexts and actions, and explanations of their connectedness. The second is the Concept Design and Design Requirements, a more precise definition of the problem to be solved is developed and it is conceived how this problem may be solved through a technological design. It states how a technology may achieve action goals that are believed to make the user’s life better, and ends up with a technical design and implementation. Then the Fit-For-Life Design, in this phase, it is investigating, in interaction with users, if the proposed design ideas does really their quality of life, and if the technological solution to do so is optimal (Amichai- Hamburger, 2009). This iterative process may lead to repeated improvements in the technology. The Innovation Design, in this final phase, procedures are developed and implemented for incorporating the new technology into real-life settings and making it ready for general use. This includes accounts of the social and technical infrastructure for the technology, development of a marketing plan, and further needed auxiliary activity.

## 3. DESIGN AND TECHNOLOGIES

The practices of digital technology as developed today in the field of architectural design and fabrication have instrumented the idea of an uninterrupted development of the shape. The chronological chain, from design to fabrication, is no longer a linear approach but becomes a series of simultaneous developments and possible variations. The emergence of new materials or new components and their relating technicalities makes possible this continuum of shape (de)formation and virtualization on a basis of potential variations of the production tools (Meyer, Duchanois, Bignon 2015).

### 3.1 Parametric Design process

The transition from the industrial society to the information society has brought profound changes, even for what concerns the design and the way of operating of the architects. The strategy to shape the objects is less used than the strategy of using direct geometry that formalizes an idea. In fact, the morphological research, from the initial idea of the project until its final form requires many adjustments that are incompatible with a linear approach to geometric modeling. It hypothesizes that the genesis of the forms is the result of the further processing of the form, based on the objectives and semantic driven by one or more mental images. The progress of the design consists of tests and redefinitions of the main forms of the objects. These variations can be produced directly from the designer or by generative algorithms, also called parametric design, "the traditional ways of the geometric representation, based on descriptive methods, favoring a formal language of" flat elements "easy to be enrolled in a rectangular coordinate system and built using traditional technology. In generative advanced modeling techniques used in architectural design digital objects are not "designed" but are "calculated", which means that the designer does not directly model the external form, but its generative logic inside” (Helenowska – Peschke 2012). The great challenge of contemporary society is brought about by opening the way for a new design language that is no longer based on repetition.

The parametric design process focuses on defining a set of parameters that influence the shape: the final shape is not in the middle of research, but it is induced. Changing parameter values generates not only an object but also a set of variations: the process is not simply based on metric values, but on the set of relations among the objects that make up the form. A modification of an element causes one transformation of the system in its entirety. The parametric model can automatically update all links and associations, a possibility to enter the geometric model in a series of variations based on the digital concept of associativity. Thus, the design consists of a set of geometric rules and logical relations between the first elements of the model: these initial components, points, lines or surfaces, constitute in their assembly and in their related relationships the hypotheses of the project. Changing one of the parameters will change the whole system, so the parametric design allows the manipulation of the object at all scales.

Michael Hensel and Achim Menges (Hensel and Menges 2006) give an example of parametric component defined by an analog manipulation of a paper tape (Fig. 1). The component integrates the constraints of the material, its opportunities for modeling and deformation and methods of assembly: it is a unitary element that if multiplied includes a larger system. The system is in itself potentially transformable for the differentiation of each parametric component. Here, the multiplication of the components is based on the principle of "proliferation" of a geometric surface.

This distribution of the component in its "proliferation environment" may depend on a set of parametric rules or algorithmic principles to join then the generative methods.

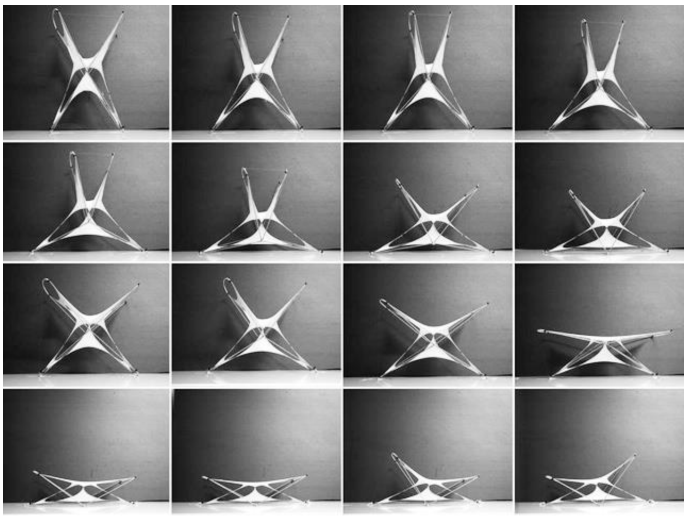

Fig. 1 Example of a parametric component
Hensel and Menges 2006

Here the problem is the geometry of a device in an operational implementation perspective. These are opportunities for the changing values of the parameters that allow the exploration of expanded solutions. The experiments conducted in this direction could be integrated by approaches incorporating dimensions, not just constructive, but also economic and social.

### 3.2 Robotic Fabrication

In the field of architecture, experiments are underway within of the Swiss Federal Institute of Technology (ETH Zurich), through the work of Fabio Gramazio and Matthias Kohler of the department of "Architecture and Digital Fabrication "(Gramazio and Kohler 2008). Their approach is characterized by the use of a robot of the automotive industry, put to the service of the construction of architectural devices. It is equipped with six rotation axes, installed on a track, and can therefore operate in a perimeter of three by three by eight meters (Fig. 2). The main advantage in using this technique it is based on the possibility of constructing, on the one hand, a method for addition and on the other a method for subtraction. The robot is somehow one universal tool, able to perform different types of actions in operation of the equipment at the end of his arm. These tools can be drills and clamps, and act by subtraction of material as well as by addition.

Fig. 2 Gramazio & Kohler (Architecture and Digital Fabrication, ETH Zurich)
Gramazio & Kohler 2008

Lisa Iwamoto (Iwamoto 2009) also provides a classification of the forms to this decomposition of the volume in a series of cuts, called "Sectioning" (Fig. 3). The work does not lead to the realization of drawings in two dimensions, but to the realization of a process of successive parallel cuts at specified intervals of an object in three dimensions. Each section realized defines the following path of the cutting tool. This strategy is very effective at the design stage and allows the achievement of both surfaces and structural elements.

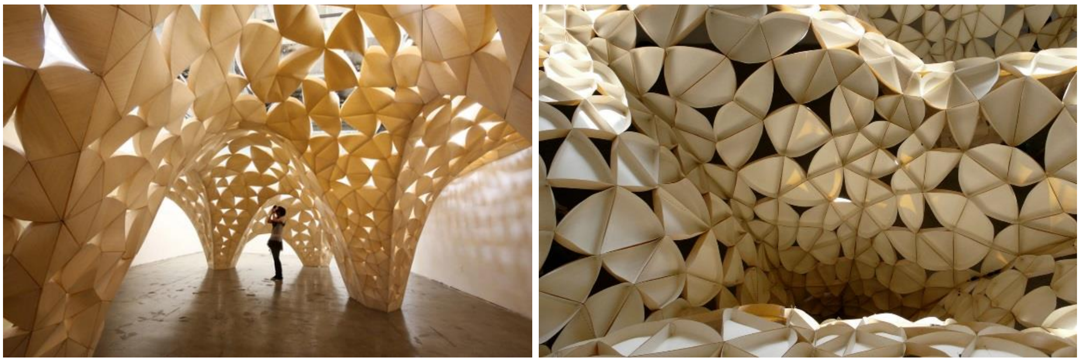

Fig. 3 Lisa Iwamoto, Digital fabrication works
Iwamoto Scott 2009

## 4. OUTDOOR EXPERIENCE DESIGN

To verify the potential use of parametric design modeling we opted for the fabrication of ten benches whose main function was to provide the users at Beirut Arab University main campus with a rest area. That definition was based on the design time (3 months) and on the number of the available students. This research was carried out in the Independent Learning Club (ILC) in the Faculty of Architecture – Design and Built Environment who aim to provoke a collaboration among students to help each other in learning new softwares and tools concerning Parametric Design and Digital Fabrication. With the objective to verify the development process of benches by using parametric digital modeling. The workshop was organized in two phases: exploratory literature review and the physical simulation of the bench prototype. In the exploratory phase, the objective was to verify which design requirements should be considered in developing a bench. These requirements were used as input parameters in the algorithm to be created in the Grasshopper program. In the physical simulation phase, there was a testing for the bench.

The geometry of the bench integrates aesthetic, structural and constructive constraints in a single synthetic form. The followings parameters determined the shape of the bench where the form should express a certain simplicity and self-evidence, be economic and had to be rapidly assembled. The solid and the voids of the sections contributes to the ergonomic performance for a comfortable seat.

The bench was entirely designed in a 3D CAD software Rhinoceros/Grasshopper including the support beams and rods. The geometry was transferred to the robot program Kuka PRC a plug- in in the Grasshopper environment. The simplicity of the detailing, a high degree of prefabrication, the direct data transmission, and the several testing inside the Digital fabrication lab in Beirut Arab University Debbieh campus enabled the benches to be realized in a very short time.

Fig. 4 Proposal for the bench "Harmony"
Design and rendering by the author November 2017

This is the concept we choose for the final object (Fig. 4). The form is simple with slight curvatures, yet engaging as this philosophy repeats throughout the design. The bench "Harmony" is suited in isolation as it fills a space with its visual impact.

Robotic fabrication was used to fulfill our vision, as precision is needed to execute profiles based on mathematic equations, which are beyond human capabilities.

### 4.1 Ideation

The construction strategy was based on defining a standard material to be dealt with and matching the proper aesthetics with the fabrication procedures and the restrictions of the machines to be used. The fabrication of the components would be as simple as positioning the panels on a table, and with a simple definition to be sent for fabrication. However, the relation among the robotic arm constraints, tool capabilities and the raw material characteristics would have to be taken into consideration. Special fixations on the table were in this case set up so that the panels would be properly fixed to the working table.

Therefore, what needed to be dealt with in the design process was the way in which the sections would be connected, taking into consideration that each section would have a different size.

A definition was created in Grasshopper KUKA/PRC in order to the milling on wooden panels that would serve as slots. The procedure consisted in intersecting the wooden panels with the sections, which would result into two straight but inclined lines that would later guide the inclination of the tool tip attached to the robotic arm, its distance, and the depth of cut. In addition, such lines would help in defining the relation between the wooden beam and the tool tip with suitable planes and step-down distances between each cut until reaching the bottom of the intersection, thus allowing multiple passes instead of one single cut. Since the tool used had a 12mm diameter, only the depth equivalent to the diameter would be executed in order to avoid damage of the tool (Fig. 9).

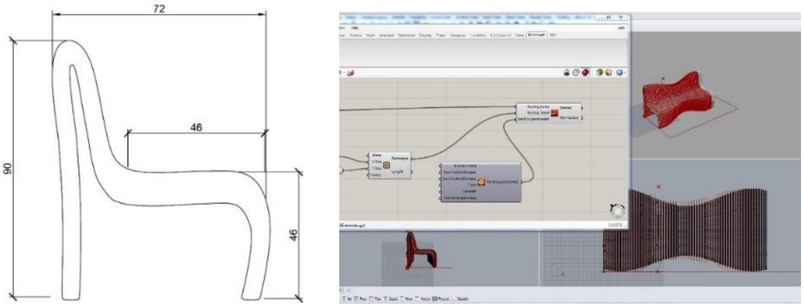


Fig. 5 Profile and nesting for the bench
Designed by the author November 2017

Concerning the panel layout, components were laid out by lines on six standard plywood panels of 1220mm x 2440mm with 16mm plywood thickness. The fact that the basic geometry can be developed as a single, continuous surface helped to organize the faces on the panels with a minimum of waste. This is an important advantage for the economic construction of the optimization of material consumption. In the absence of the dedicated tool, we construct this work manually. The sections that compose the bench were reported to the same plan one by one and were numbered. (Fig. 6).

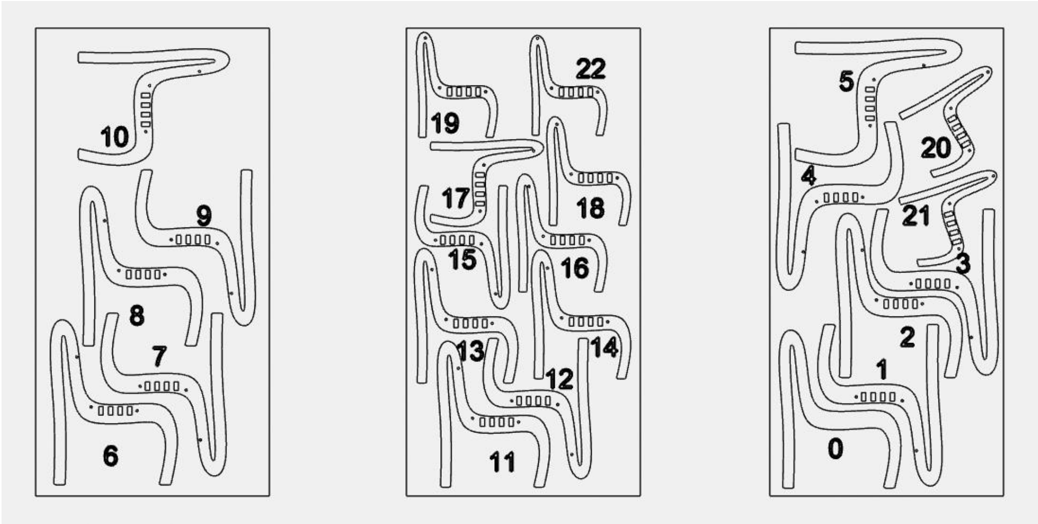


Fig. 6 Panel layout example to be transformed into a G-code
Image from the author November 2017

## 4.2 Robot programming

Nowadays, a large number of computer numerically control machines are available on the market. They can be distinguished according to freedom of movement, cutting tools, machine code, and control software. (Buri, 2013)

The cutting method presented in this paper utilizes the Kuka robotic arm with 6-axis planes (Fig. 7), already used by some woodworking companies. In addition to the usual three X, Y and Z translational axes, 6 axis enabled machines are equipped with additional cardanic rotary axes defined as A4, A5, and A6, which allow the tool to be oriented longitudinally, and which does not need to be perpendicular to the working table (XY plane).

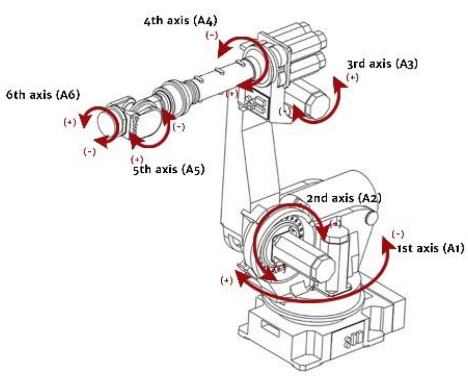


Fig. 7 Basic scheme of movement for the Kuka robotic arm
Image from the author 2017


DOI: 10.54729/2789-8288.1082

The next procedure to set is the tool path. In this case, a second script generated the order of milling operations and the tool path. The sections had to be fixed on the machine base so that they do not move when they were cut out of the plywood panel. Therefore three drilling holes were defined in each section. The position of these holes had to be controlled so that the screws are not in the way of other milling operations. Each side of the section is milled in three runs. The number of runs is linked to the tool size and the milling speed. Three holes for dowel connections are drilled in the vertical side and four rectangles on the horizontal side. Their position are fixed automatically in function of the length of the sides and in order to keep a minimal distance to the edge.

Later, the machine code was generated as a script supposed to translate the tool path into the machine code, which in this case was the g-code (Fig. 8). The machine code then was tested 50cm below the machine table and with low speed to evaluate its correctness. The sections were milled within two days for each bench. Each section is marked by its number.

```
&ACCESS RVP
&REL 1
&PARAM TEMPLATE = C:\KRC\Roboter\Template\vorgabe
&PARAM EDITMASK = *
DEF millinglast ( )

;FOLD STARTPOSITION - BASE IS 0, TOOL IS 10, SPEED IS 45%, POSITION IS A1 -95,A2 -90,A3 100,A4 0,A5 10,A6 0,E1 0,E2 0,E3 0,E4 0
$BWDSTART = FALSE
PDAT_ACT = {VEL 45,ACC 100,APO_DIST 50}
FDAT_ACT = {TOOL_NO 10,BASE_NO 0,IPO_FRAME #BASE}
BAS (#PTP_PARAMS,45)
PTP  {A1 -95,A2 -90,A3 100,A4 0,A5 10,A6 0,E1 0,E2 0,E3 0,E4 0}
;ENDFOLD
PTP {E6POS: X -884, Y 2319, Z 1041.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0, S 'B 110'} C_PTP
LIN {E6POS: X -884, Y 2319, Z 1041.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0}
LIN {E6POS: X -884, Y 2319, Z 941.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0}
LIN {E6POS: X -884, Y 2319, Z 861.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -884, Y 2496, Z 861.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -786.715, Y 2496, Z 861.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -786.715, Y 2469, Z 861.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
.....
.....
.....
LIN {E6POS: X -856, Y 2469, Z 861.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -856, Y 2466, Z 861.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -641.191, Y 2141.191, Z 861.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0} C_DIS
LIN {E6POS: X -641.191, Y 2141.191, Z 941.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0}
LIN {E6POS: X -641.191, Y 2141.191, Z 1041.26, A 0, B 90, C -90, E1 0, E2 0, E3 0, E4 0}
PTP {E6AXIS: A1 -95, A2 -90, A3 100, A4 0, A5 10, A6 0, E1 0, E2 0, E3 0, E4 0} C_PTP

END
```

Fig. 8 G-code generated from the drawing
Image from the author November 2017

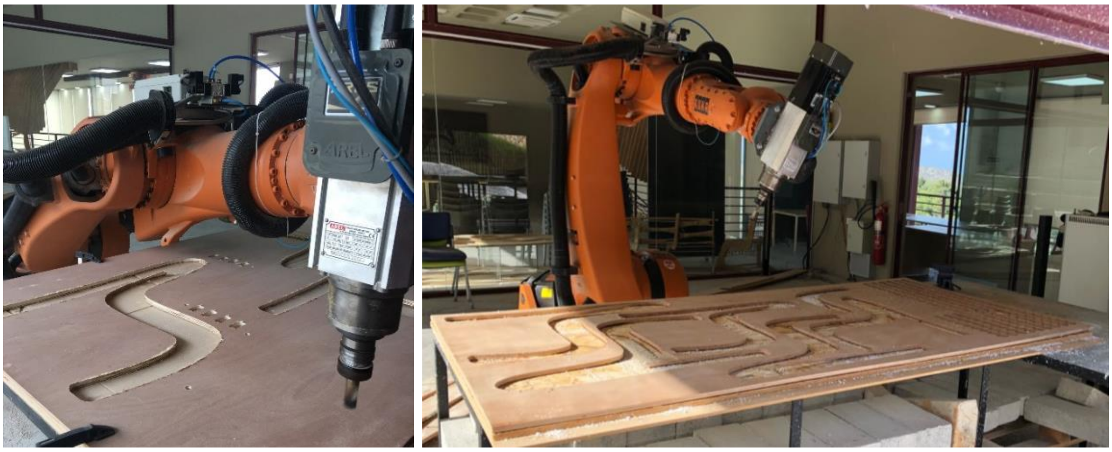

Fig. 9 Profile and nesting for the bench
Photographed by the author December 2017

Despite the digital tools available to us many manual actions have complete the fabrication of the benches. (Figg. 10-11).

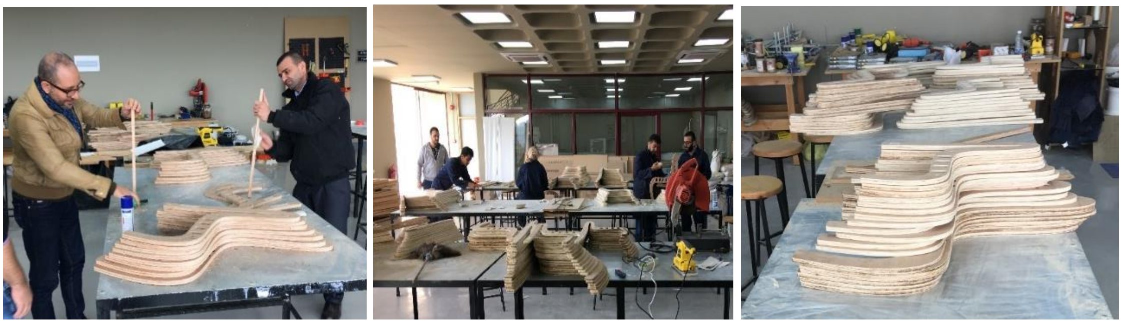

Fig. 10 Profile and nesting for the bench
Photographed by the author January 2018

### 4.3 Fabrication and erection

For the assembling, the sections were assembled horizontally with forty-six pieces (Fig. 7), which together create a kinetic effect. Three all threaded metal bars string profiles and spacers together tightly. In the next step, the sections were assembled lying vertically by their number from zero to forty-five, which make the structure erected and then connected with the first, and the last side. Once assembled the bench is lacquered and varnished in natural color (Fig. 7).

Fig. 11 Profile and nesting for the bench
Photographed by the author February 2018


DOI: 10.54729/2789-8288.1082

Fig. 12 Profile and nesting for the bench
Photographed by the author April 2018

## 5. CONCLUSIONS

Within this paper, an experiment related to digital design and production of urban furniture has been presented. Undertaken investigations range from the research of new geometric design methods to optimizations of integrated manufacturing techniques. The spectrum of the research has been spread in order to provide a global approach to the problem of design and production of architectural free-form objects for the human well-being. It is highly important to situate the links of the digital chain within the global context of the design process engaged.

The applications presented show how beneficial and time-saving the use of a complete design chain can be, allowing to intervene independently at any of the design or production steps and permitting changes within the design process to be integrated smoothly. The initial appraisal, claiming the lack of feasibility of free-form structures shows the importance of the optimization of design and production processes involved within the realization of architectural free-form objects. In addition, the generation of the data describing the constructional components of iterative geometric objects raised methods for data structuring, thus allowing the set of geometric data to be conditioned for processing throughout integrated manufacturing.

Digital design for human well-being is still at its beginnings and for certain aspects one could say that this research is supporting the rediscovery of what is obvious intuitively. However, many aspects of the digital design can be considered antithetical to this knowledge deep. We know that the relationship with nature is important and, when we ask people to think about their comfort; most of them describe an outdoor place. On the other hand, we use the term 'recreation' by forgetting how it contains the idea of recreating that is, restoring oneself. Therefore, while the empirical evidence is accumulating, we should tend more and more towards the restoration of the relationship between design and human well-being in an anthropized environment.

## REFERENCES


- Amichai-Hamburger, Y. (ed.) (2009). *Technology and psychological well-being.* New York: Cambridge University Press.
- Brey, P. (2010). 'Values in Technology and Disclosive Computer Ethics', in: L. Floridi (ed.). *The Cambridge Handbook of Information and Computer Ethics*, Cambridge: Cambridge University Press, 41-58.
- Brey, P. (2015). Design for the value of human well-being in: L. Floridi (ed.). *The Cambridge Handbook of Ethics, Values and Technological Design. Sources, Theory, Values ans Application Domains (pp.365-382). Springer.*
- Buri, H. U. (2010). *Origami-folded plate structures.* PhD Thesis n°4714, Ecole Polytechnique Fédérale de Lausanne.
- Desmet, P. & Pohlmeyer, A. (2013). *Positive design: An introduction to design for subjective well-being.* International Journal of Design, *7*(3), 5-19.
- Friedman, B., Kahn, P. and Borning, A. (2006). 'Value Sensitive Design and Information Systems,' in *Human-Computer Interaction in Management Information Systems: Foundations*, eds. P. Zhang and D. Galletta. Armonk, NY: M.E. Sharpe.
- Gramazio, F. and Kohler, M. (2008). Digital Materiality in Architecture, Lars Müller Publishers, Zürich.
- Helenowska, P. M. (2012). *Applying generative modelling tools to explore architectural forms.* University of Technology, Department of Visual Arts, Poland.
- Hensel, M. and Menges, A. (2006). *Morpho-Ecologies: Towards Heterogeneous Space in Architectural Design. Architectural Association Publications.*
- Iwamoto, L. (2009). *Digital Fabrications. Architectural and material techniques.* Princeton: Princeton Architectural press.
- Meyer, J. Duchanois, G. and Bignon, J-C. (2015). *Computer Design and Digital Manufacturing of folded architectural structures composed of wooden panels. Testing and validation of the proposed digital approach*. Proceedings of the 20th International Conference of the association for Computer-Aided Architectural Design Research in Asia CAADRIA 2015, 641-650.
- Toffler. A. (1987). *The Third Wave.* Morrow, New York (Italian edition. *La terza ondata*, CDE, Milano).
- Van de Poel. I. (2012). *Can we design for well-being? In The Good Life in a Technological Age*, eds. P. Brey, A. Briggle and E. Spence, Routledge, 295-306.



DOI: 10.54729/2789-8288.1082