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Digital craftsmanship: from the arts and crafts to digital fabrication

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Abstract

Alberti's writings introduced a new conception of the architect that started with the Renaissance and continues to dominate until today. During modernity however there have been movements that challenged that idea, like the arts and crafts, by placing importance on concepts like craftsmanship; concepts that had their roots in pre-modern practices. Digital fabrication protocols are offering a possibility to reconnect to some of those properties, albeit in a new, protocol-mediated fashion.

Keywords

Digital Fabrication; Protocols; Arts and Crafts; Modernity; Antimodernity; Altermodernity; Cratsmaship

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1. Authorship in Modernity

When, in the middle of the 15th century, Leon Batista Alberti was writing his ten books on architecture under the title De Re Aedificatoria, he was forming a new concept of the architect. Alberti, following the values that humanism was dictating, established in this publication, among other things, the idea of authorship in relation to the profession of the architect. As Mario Carpo points out (2011, p. 138), when Alberti was writing his books the term '*author*' (auctor) had two different meanings: when used in relation to written works it referred occasionally to the writer once she or he defined a new literary tradition, but it primarily referred to the patrons who supported or commissioned the work, that is the agents who 'authorized' the work. However, it was also used, in a broader context to signify the originator, the inventor, the creator or the maker. Alberti in De Re Aedificatoria "*conflates the two meanings of the term: the architect is the originator, inventor, and creator of the building, but at the same time, the architect's design becomes as authoritative as any 'authorized' literary text*" (Carpo 2011, p. 138). That new, double meaning of the author becomes fundamental in modernity. The 'auteur', the author in modernity, is someone who generates a concept, a vision or an idea while the act of creation is the process of materializing that concept. Everything else comes after that first concept and has to submit to it. The process is the means that will make the initial idea work. There is, therefore, a clearly defined temporal relation in place: The concept comes first and its materialization follows and has to remain as faithful to the initial idea as possible.

The way that modernity appreciates the concept of the architect is a variation on the way it understands the concept of the author at large. An architect too, in the context of modernity, is after all an author, a creator. Therefore in architecture too, if we try to idealize the design process, we will find that it is the concept, the idea, which comes first. The architect is the 'mastermind' that conceives that idea and has to pursue it to the end. Alberti makes clear that this temporal relation is very important in architecture: The architect has to generate his design, make as many revisions as required, but after it is finalized nothing should change; "'*the author's original intentions' should always be upheld*" (9.11.5 Alberti 1997, p. 319/ Carpo 2011, p. 22). This conception of the author during modernity, in architecture finds its highpoint in what we usually describe as modern architecture. For example, Le Corbusier's Plan Voisin is very characteristic of this notion: His idea of the orthogonal street grid and the sixty-story cruciform towers was the focal point of the project; everything that followed was serving that idea. Even if that meant that the whole center of Paris had to be razed to the ground in order to generate the clean, empty space required. So the architect in modernity, in her or his most successful and ideal version, is exactly this: a generator of concepts that can follow them all the way until they get realized. Alberti's ideas survive – largely intact – to the present day.

2. Architect and master builder / craftsmanship

Of course, that was not always the case. Before the Renaissance, in the place of the architect was the Master Builder. The master builders were artisans, like stone masons and carpenters, that were eventually rising to the status of the master builder; that is acquiring more responsibility or a leading role in the building process, usually because of their proficiency in their art (Murray 1969). Therefore the proficiency or virtuosity of the master builder in relation to the actual process of 'building' was of great importance.

ber of technological innovations of that period: Around 1400 for example, paper starts to get used for drawings and until the 1500 its use is generalized. Until the 1600 the use of pencil for drawing is also generalized. At the same time, from the 14th to the 16th century we have the invention of linear perspective and geometric projections. It is those technological innovations that allow Alberti to formulate his new conception of the architect. All of them make possible the generation of drawings that can accurately describe the three-dimensional form of a building. Therefore they accommodate the possibility for someone to design a future building represented on paper accurately enough to direct the builders to realize it. Whereas before, the designer had to be, not only constantly present during the construction, but more importantly a skilled builder as well. In those situations the design was emerging out of the building process and it did not precede it. Manuel de Landa in a similar observation notes: "*Craftsmen did not impose a shape but rather teased out a form from the material, acting more as triggers for spontaneous behavior and as facilitators of spontaneous processes than as commanders imposing their desires from above*" (DeLanda 2002, p. 135). Of course the change from the master builder to the architect was a gradual one. Up to the 1700 the master builder was still the dominant model except for special cases, such as big public projects. But with the advent of the industrial revolution and the introduction of mechanized mass-produced objects, and therefore building parts, the transition is largely intensified until the master builder becomes a model of the past and the architect arises as the main figure of the design process. The domination and idealization of the role of the architect as the creator is further intensified and reaches its high point, as mentioned before, in the 20th century.

In that process of transformation some of the main characteristics of the master builder lost their importance or became irrelevant to the profession of the architect. Craftsmanship was one of them: The individual skills necessary for the production of the elements of a building that before modernity were an integral part of the design process. With the advent of modernity the architect started to distance himself from the art of crafting and with the industrial revolution this transition was fully realized: mass production left little space for the unpredictability and intense individual labor that craftsmanship required. But not without some notable exceptions.

3. Arts and crafts

In 1849 John Ruskin publishes his book "The seven Lamps of Architecture". The book marks a significant moment in the history of architecture during modernity as it puts forth a polemically critical stance towards the architectural principles that defined the era that started with the renaissance. Ruskin in his book calls for a more spiritual, even mystical, version of architecture, largely in contrast with the changes that the industrial revolution was bringing to architectural production. While his book served as a 'summary' of the principles behind the 'gothic revival' of that period, it also formed the theoretical basis – or better: starting point - for the arts and crafts movement and the theories developed by William Morris.

The arts and crafts movement therefore, had at its basis a fundamentally 'anti-modern' approach. William Morris' theory was initially based on the observation that art since the renaissance was becoming increasingly disassociated from its social surroundings. He explicitly notes that "*it is not possible to dissociate art from morality, politics and religion*"(Morris 1911). In his quest to reconnect art and architecture with its social surroundings he

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emphasizes the importance of craftsmanship and makes the use of machinery in archi-
tectural production - especially as taken to an extreme by the industrial revolution - his
main opponent. He unambiguously states: "*As a condition of life, production by machinery is
altogether an evil*" (Morris 1911, p. 335). This radically critical stance towards mechanized
production however took later on in the development of the movement a less polemical
approach and the form of more 'refined' expressions. Morris himself was eventually led to
finally admit that machines can be used "*as an instrument for forcing on us better conditions of
life*"(Morris 1911, p. 352). Along the same line of thinking, Charles Robert Ashbee, a central
figure in the later part of the development of the movement, writes characteristically: "*We
do not reject the machine, we welcome it. But we would desire to see it mastered*" (Ashbee 1894).
Besides Morris' stance towards the machine however, the central point of the arts and
crafts movement was exactly the concept of craftsmanship. The direct relation with the
material and the virtuosity needed in order to manipulate it and form it. In other words
an approach that shares many things in common with pre-modern practices that go all the
way back to the medieval times. And it is exactly this relation to craftsmanship that places
the arts and crafts movement at odds with the principles of modernity; and consequently
brings the concept of the author under question. Morris is again very explicit: "*That talk of
inspiration is sheer nonsense, […] there is no such thing: it is a mere matter of craftsmanship*"(Pe-
vsner 1975, p. 23). For Morris and the arts and crafts movement therefore, the result of the
design process (or any artistic process for that matter) comes out of the direct harnessing
of material through craft; it is not a 'grant' idea that is first conceived and subsequently
materialized but rather what emerges from manual, material labor.

4. A different reading

Following our line of thought up to that point, it becomes clear that the arts and crafts
movement was based on principles in direct opposition with those of modernity; in es-
sence the arts and crafts can been seen as an anti-modern condition that was soon to be
left behind as architecture moved into the 20th century and modernity found its 'ideal'
architectural expression in modern architecture. It might come as a surprise then that for
the literature of modern architecture, and especially for the mainstream approach to the
history of the modern movement, the arts and crafts movement is considered as one of
its main precursors.
In fact this approach, that the arts and crafts contained the seeds for modern architecture,
was not widely accepted until 1936 when Nikolaus Pevsner publishes his book 'Pioneers
of Modern Design". In that book Pevsner argues that the seeds for modern architecture
can be found in three previous approaches: The Art Nouveau, the work of 19th century
engineers and the arts and crafts movement and especially the work of William Morris. The
first chapter of the book is dedicated to the arts and crafts and traces a line from William
Morris to Walter Gropius: "*The history of artistic theory between 1890 and the First World War
proves the assertion on which the present work is based, namely, that the phase between Morris
and Gropius is an historical unit. Morris laid the foundation of the modern style; with Gropius its
character was ultimately determined*" (Pevsner 1975, p. 39). After Pevsner, the arts and crafts
movement continued to be considered as one of the predecessors of modern architec-
ture, even for much more recent historians. In Kenneth Frampton's History of Modern
Architecture for example, the arts and crafts hold again the place of the first chapter
(Frampton 2007). The paradox that emerges - the arts and crafts movement as both an
anti-modern condition and as a precursor to modern architecture, the ultimate expression

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of modernity in the field of architecture - might be difficult to decipher if we consider modernity and forces that are opposed to its principles as elements that exist independently. We can follow however a different approach: Antonio Negri and Michael Hardt in their book Commonwealth place specific importance into those moments of antimodernity exactly in that sense. They talk about modernity as a dual condition where modernity and antimodernity, the mainstream and the opposition, coexist in a purely dialectical relationship where one is necessary for the existence of the other: "*Modernity is always two. […] a power relationship: domination and resistance, sovereignty and struggles for liberation […] forces of antimodernity […] are not outside modernity but rather entirely internal to it.*" (Hardt & Negri 2011, p. 67) For Negri and Hardt modernity and antimodernity are always operating together. If we follow that line of thought it might become easier to understand how a clearly anti-modern condition as the arts and crafts movement can be seen under a specific point of view as something that led to a condition that can be identified as modern; like the modern architecture movement.

It is important however to identify those moments of antimodernity as such, since they can contain the beginnings for alternative ways to think about our current condition where modernity seems to become more and more a thing of the past. Negri and Hardt in their work move on from the dialectical relation of modernity to anti-modernity and go on to define our current condition as what they call altermodernity. Altermodernity according to them has its roots in antimodernity but is free of dialectics. It is not based on an opposition to something else. It is a positive state, based on affirmation. It carries within it however the traces of antimodernity or those moments of resistance or opposition to the mainstream: "*We intend for the term 'altermodernity' […] to indicate a decisive break with modernity and the power relation that defines it since altermodernity in our conception emerges from the traditions of antimodernity – but it also departs from antimodernity since it extends beyond opposition and resistance*" (Hardt & Negri 2011, p. 103). It is in that sense that examples as the arts and crafts movement might become useful to us today.

5. Arts and crafts revisited

It would be reasonable to argue that today we can trace elements of change that are transforming the way we design and understand architecture in a way similarly fundamental with the transformations that happened during the transition from the 'pre-modern' tradition to what we can today identify as modern. Or, at least, we have in place a new technology whose consequences are as profound as those of the generalization of the use of paper and pencils or the invention of projective geometry: *the digital computer,* or more precisely digital media in general.

And through the computer, maybe surprisingly, architecture and design gets reconnected to the idea of craftsmanship or, in other words, to a direct relationship with the manipulation of matter. Firstly, that happens at the level of digital craftsmanship or in relation to the manipulation of "digital matter". Working in the computer with three-dimensional design software brings the designer in a direct relationship with the different kinds of geometrical representation that they employ. Diverse representations like nurbs, polygons, subdivision surfaces or splines, in effect 'virtual materials' (DeLanda 2002), require different ways of working, and most importantly thinking, while at the same time they yield very different results. Consequently, and maybe surprisingly enough again, virtuosity in the manipulation of matter, albeit digital in this case, becomes again relevant. The ability of the designer to
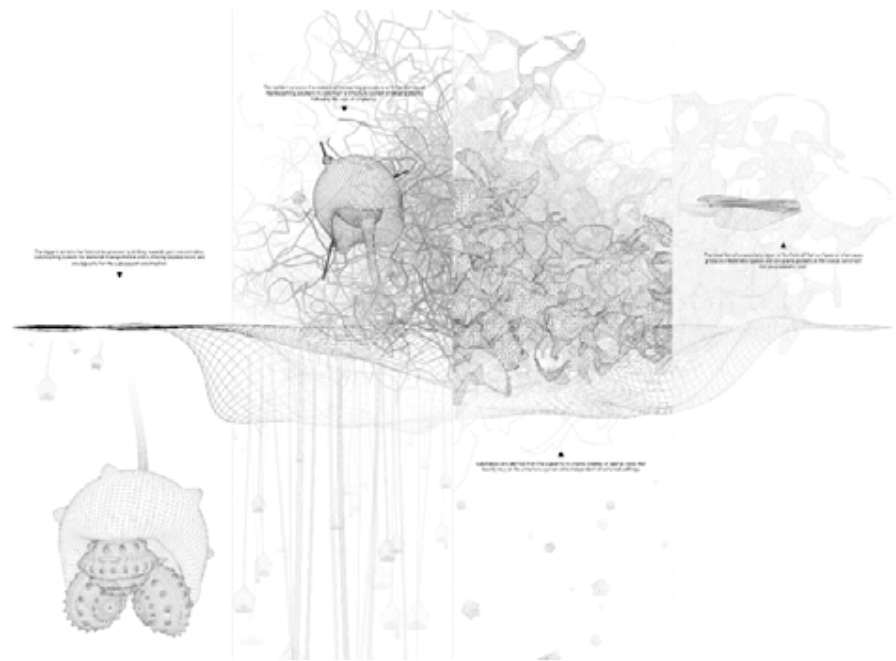
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Figure 1.

Involuntarily Real. Corrupt Gold graduate studio, Spring 2014, School of Architecture, Washington University in St Louis. Student: Zhiyang Wang Instructor: Dimitris Gourdoukis.

use her or his tools along with her or his specific choices of those tools defines in a very direct manner the final outcome and therefore becomes increasingly important. In that sense, some of the main characteristics of the arts and crafts movement reappear in architectural production, initially – and ironically since they are now totally based on a machine – in a purely digital form.

And yet, that is obviously not enough. In order to be able to talk again about craftsmanship in relation to materiality in architecture a connection needs to be established between the digital world and the actual material world. This is happening - or can happen - through digital fabrication. Architects today have direct access to the machines that are able to translate a digital model into an actual object. They have access to the machines and the software that control them. Learning how to use them is part of their academic education. Therefore they reconnect themselves with the material aspect in a direct way. Only that now this connection is mediated through *protocols*. That is, through the framework that allows the computer to communicate with the machine and therefore the framework that allows the translation from a digital, virtual object to a physical one. More specifically a protocol "*refers to the standards governing the implementation of specific technologies*" (Galloway 2004). Anywhere that there is any type of communication between two or more different devices, a protocol is always in place to facilitate this communication, with the TCP Internet Protocol that is responsible for the functioning of the Internet being a prominent example. In our everyday life there are hundreds of protocols constantly at work. The current state of our society would be impossible to function properly without them. Therefore in contemporary societies protocols are the means to control

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Figure 2.
Conveyor. Corrupt Gold graduate studio, Spring 2014, School of Architecture, Washington University in St Louis. Student: Youngjae Lee Instructor: Dimitris Gourdoukis.

Figure 3.
3d milled model. Fabrication Protocols / Digital Crafting seminar, Spring 2014, School of Architecture, Washington University in St Louis. Student: Jeffrey Glad Instructor: Dimitris Gourdoukis

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6. Fabrication protocols

In the case of digital fabrication, protocols come in the form of specialized software that reads a digital model and translate it into machine code so that the machine can fabricate it; software that is of course designed and implemented by specific companies. In order for those software packages to be general enough to accommodate the many different – and often unpredictable – cases that the different users will inevitably have to handle, they have to rely on *standardization*. In other words they have to define standards as to the ways that the different processes will happen and therefore be implemented. For example software that prepares models for three-dimensional CNC milling offers a limited number of predefined ways to generate the tool paths, based in most of the cases on a concept of efficiency in relation to the movement of the machine. Accordingly, software that enables digital models to be 3D printed performs the translation from 3d model to machine code based on standards that are largely defined according to optimization principles in relation to the time required fir the 3d print or to the efficiency of the material used.
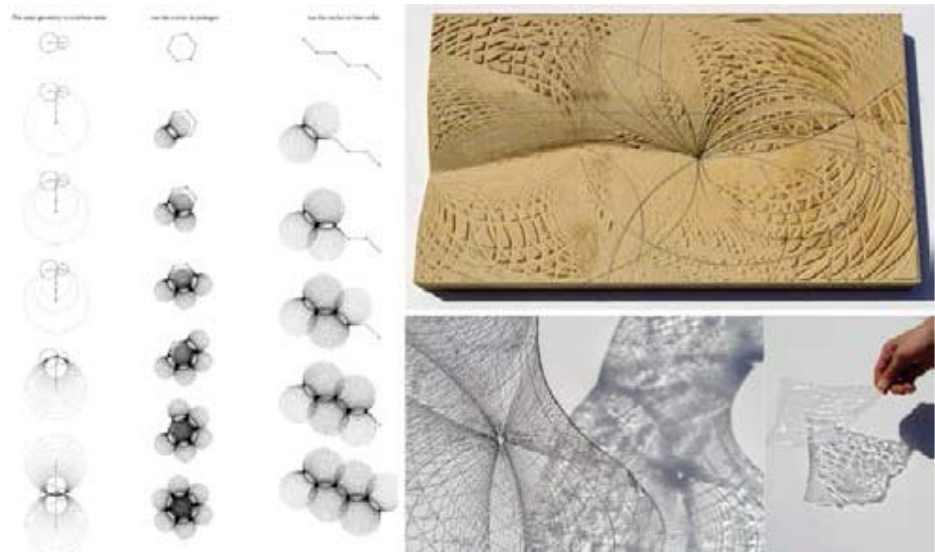

Figure 4.
3d milled model and Vacuum formed surface. Fabrication Protocols / Digital Crafting seminar, Spring 2014, School of Architecture, Washington University in St Louis. Student: Nasim Daryaee Instructor: Dimitris Gourdoukis.

At this point however another paradox is emerging: It is those fabrication protocols, the means to control, that are offering to the architects the chance to reconnect with materiality and craftsmanship while at the same time, through standardization and simulation, are taking away the properties of unpredictability and emergence that are inherent in processes that are harnessing materiality. In other words, the designer might be able again to work directly with materiality and use it as a means to design, but at the same time the tools that offer this possibility are taking out individuality by favoring standardization over individual experimentation. A paradox that is inherent in protocols at large: While they tend to be

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While they tend to be democratic in the sense that they try to include everyone and everything (a protocol does not care about what kind of data is communicated, it just makes sure that the communication happens and hence does not discriminate content) in order to achieve this they have to rely on standardization, and therefore become almost fascistic in that sense: "*The contradiction at the heart of the protocol is that it has to standardize in order to liberate. It has to be fascistic and unilateral in order to be utopian*" (Galloway 2004, p.95).
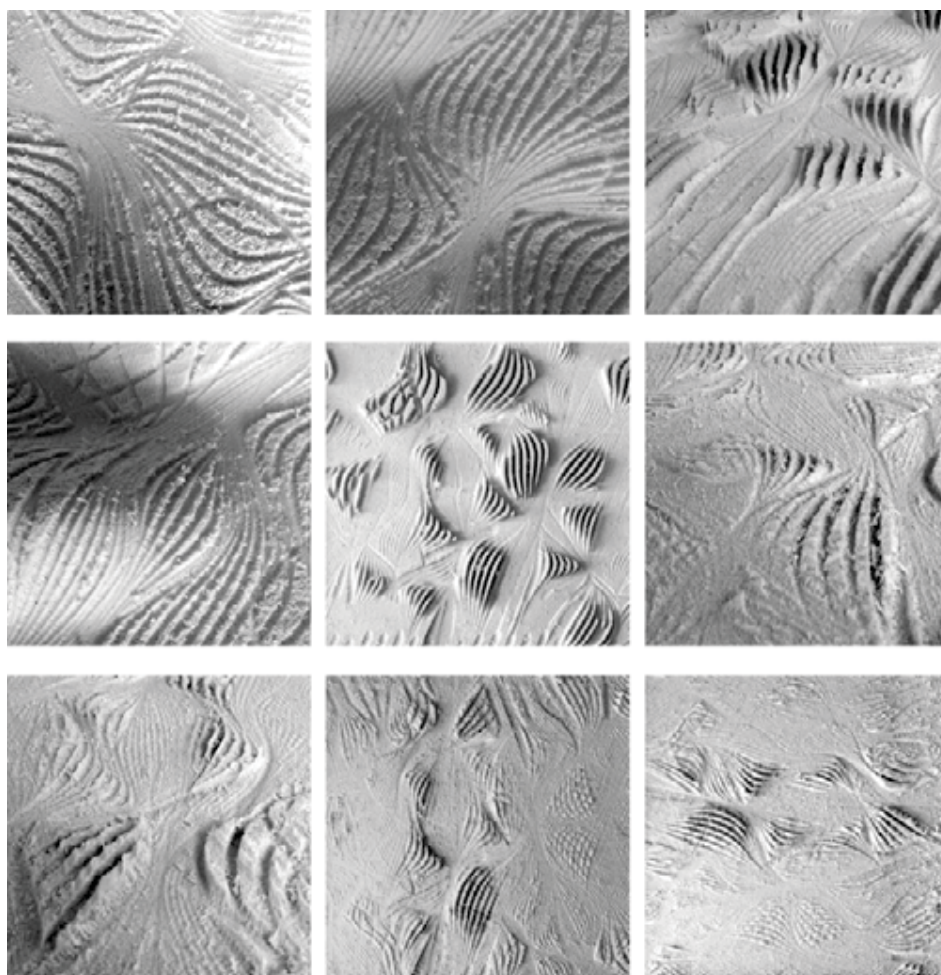

Figure 5.

3d milled models. Fabrication Protocols / Digital Crafting seminar, Spring 2014, School of Architecture, Washington University in St Louis. Student: John Patangan Instructor: Dimitris Gourdoukis

The common working 'pipeline' consequently when working with digital fabrication methods is that an architect or a designer submits a digital model and the protocol / software does the translation according to the preset standards, most often by following some idea of an optimal solution. Of course there is always a process of trial and error taking place, albeit one that is in most cases carried out through that standard, present option provided by the software. It is at this point that the opportunity for a meaningful reconnection of

design to craftsmanship can actually be realized in a fundamental way. The real challenge for architecture in this case is to try to harness those protocols and instead of following the preset standards to try and invent new ways of operating the machines. Otherwise the machines remain out of the control of the architect and they become just tools that functions in a manner that in most cases the designer does not understand and, most importantly, does not control. In essence the process of following the standardized way with digital fabrication serves the designer to the extent that it helps her or him to realize a preconceived architectural idea.
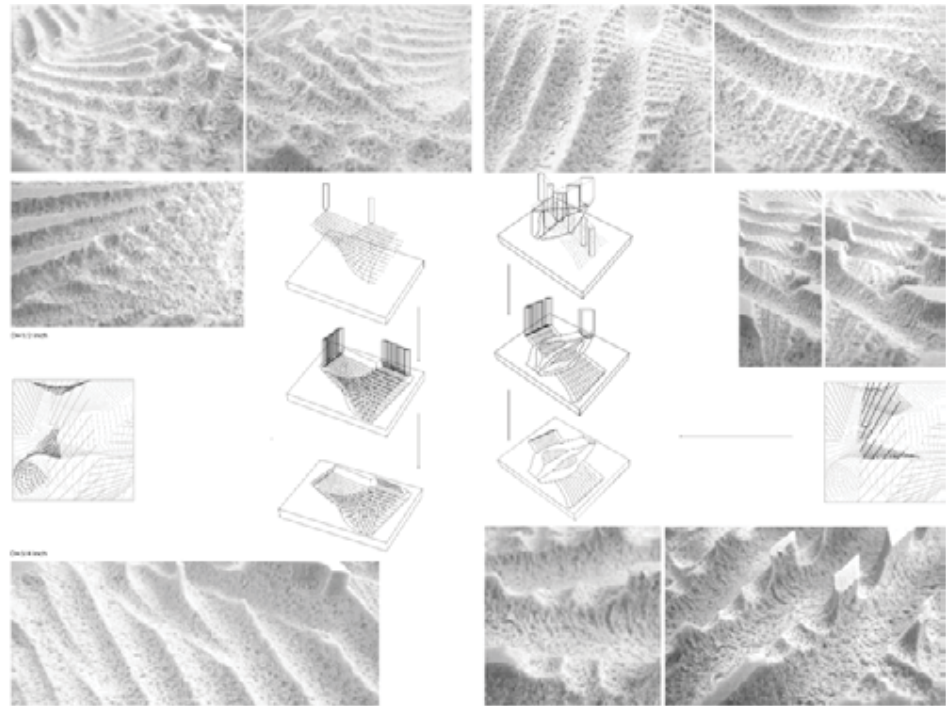

Figure 6.

Toolpaths and 3d milled model. Fabrication Protocols / Digital Crafting seminar, Spring 2014, School of Architecture, Washington University in St Louis. Student: Fan Wu Instructor: Dimitris Gourdoukis

Figures 3-9 illustrate a simple example of the above-described method, through student work from a seminar class taught in spring 2014 at the School of Architecture at Washington University in St Louis. Aim of the seminar was to explore the concept of digital craftsmanship and how fabrication protocols can be harnessed by the designer in a very simple case: that of a 3-axis CNC milling machine. The students were asked, instead of modeling something in the computer and trying to fabricate it, to directly design the machine's tool-paths and in that way to create a design process through the experiments they were conducting with the machine. Following that line of working no preconceived idea for the final outcome existed at the beginning of the process. Instead, the produced result emerged out of the direct interaction with the machine. Design intent, limitations posed by the machine and possibilities arising out of its use, and the properties of the material were operating in parallel and at the same level resulting in a bottom-up production of the final

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outcome. The process for all the projects was characterized in most cases by similar steps: The first attempts led to fabricated outcomes that looked like failures. But through several iterations, that led to an understanding of how the machine operates and how it can be directly controlled through line drawings, the outcome was characterized by increasingly refined results. During the refinement of the technique, properties of the produced models were observed and they subsequently became the driving force of the process. Design intent was not imposed on the process and on the material but was rather continuously formed through the interaction with them.
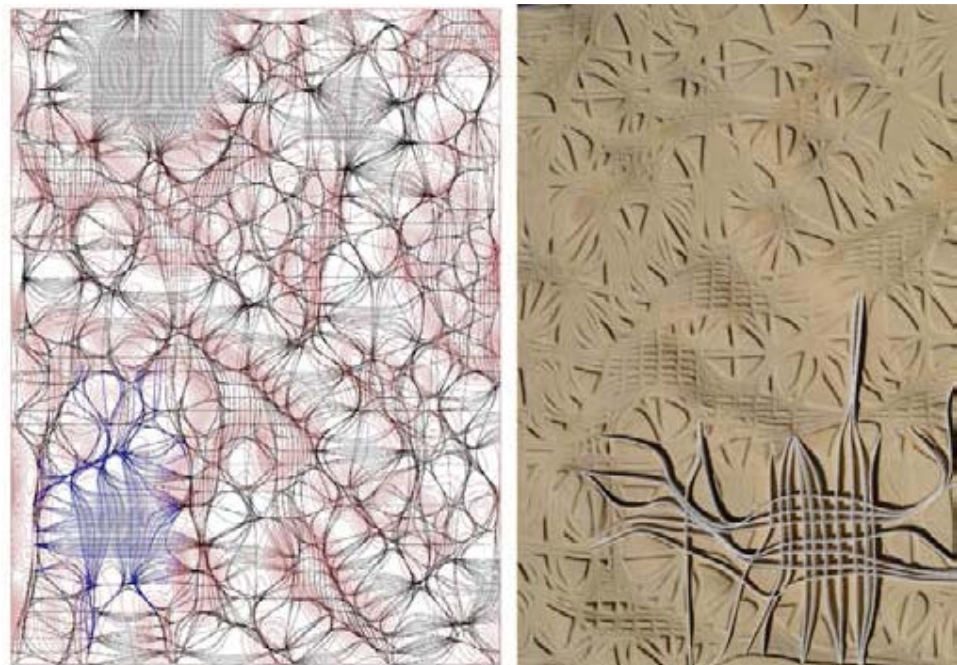

Figure 7.

Toolpaths and 3d milled model. Fabrication Protocols / Digital Crafting seminar, Spring 2014, School of Architecture, Washington University in St Louis. Student: Jeffrey Glad Instructor: Dimitris Gourdoukis.

At this point Ashbee's quote mentioned above about the machines and their use gains a new, updated for the 21st century, meaning. In order to avoid the standardization and the homogeneity produced at large by the new technologies, their rejection would hardly be a solution. Instead through the affirmation of their properties and characteristics, control over them can be achieved and subsequently mastering them and transforming then into design tools becomes possible.

8. Conclusion

As computation gets more and more connected with the construction and inevitably gets related to materiality, it becomes apparent that it is essential to consider how this connection is happening. There is an approach that follows the example of modernity: One that is driven by the principle that new technologies can be used to serve the initial intention of the architect / designer. Therefore they come after the definition of the design
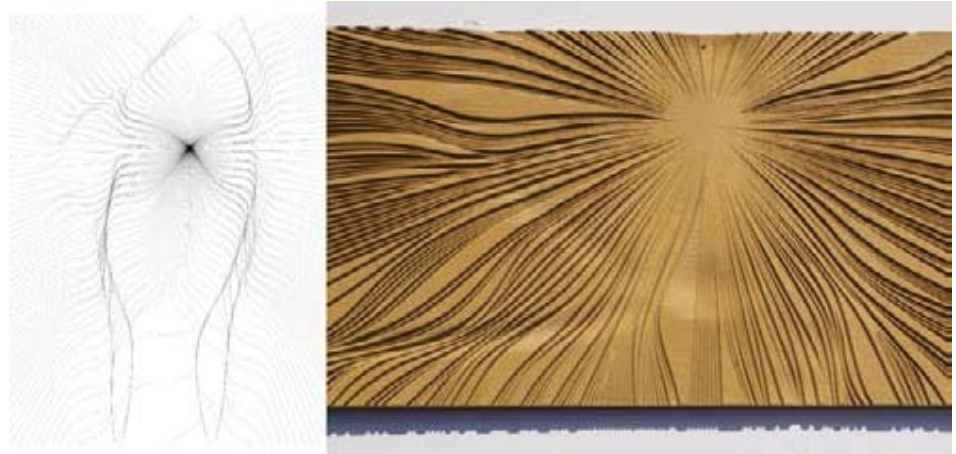
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Figure 8.

Toolpaths and 3d milled model. Fabrication Protocols / Digital Crafting seminar, Spring 2014, School of Architecture, Washington University in St Louis. Student: Leslie Wheeler Instructor: Dimitris Gourdoukis.

intend and they operate on a different, second level that is hierarchically depended on the first; that of the design concept. In that context it is understandable that material science becomes important. Materials can be designed in order to fit and serve the needs that arise from a design proposal. New materials can be created and can be programmed to perform in a way that will answer in a very specific design problem that is predefined by the designer. Alberti would have been pleased.

But there is also another possible way: One that works from the bottom up and where the scope does not preexist but rather emerges as a result of the things discovered and, especially, invented in the way. Such an approach has a direct relation to some of the ideas that were prominent in the arts and crafts movement: the result of the design process, and maybe more importantly the meaning that it conveys, is not the outcome of an initial, preconceived idea; it is not based in what Morris rejects as inspiration (and can take many names like idea, concept etc.), but it is rather a result of craftsmanship, both digital and analog. Only when mediated by protocols, and when the designer is the one in control of those protocols, that approach can achieve an altogether new meaning where it is no longer defined as an opposition to something else. It is no longer an anti-modern condition operating always in a dialectical relation with modernity in Negri and Hardt's terms; instead it becomes a positive approach that can operate on its own, forming a new proposition for the alter-modern condition.

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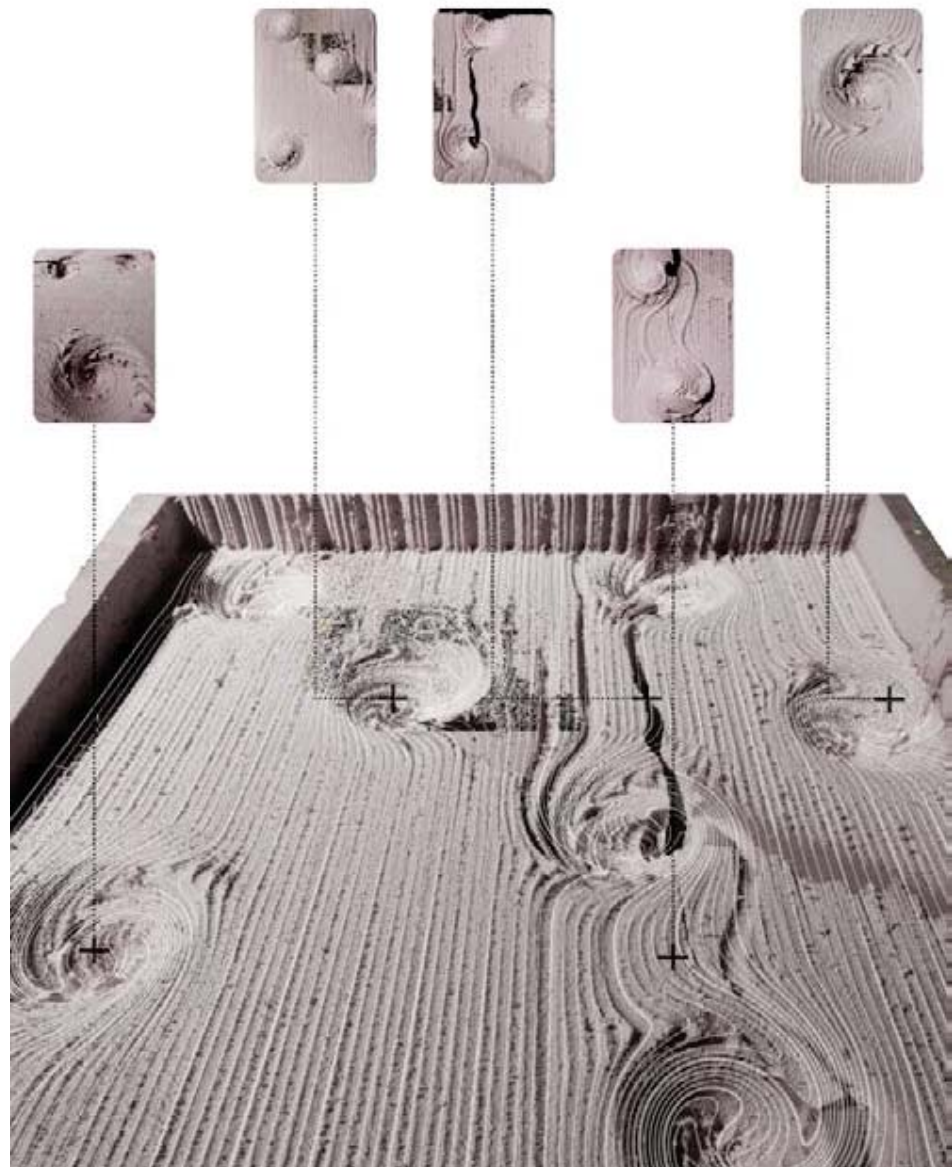www.enhsa.net/archidoct
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Figure 9.

Toolpaths and 3d milled model. Fabrication Protocols / Digital Crafting seminar, Spring 2014, School of Architecture, Washington University in St Louis. Student: Leslie Wheeler Instructor: Dimitris Gourdoukis.

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