

Reflection on the theory and technology behind “The City as Canvas, Architecture as painting; an intuitive approach to 3D printing”

Tiwánee van der Horst

4024079

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Architecture as painting

Architecture as painting is a new method imagining an architecture in which a materialized atmosphere does not need to be subdued to constraints in production. The method is an interpretation of the existing 3D printing techniques and robotic manufacturing. Through intuitive experiments inspired by painting techniques I seek to accelerate and improve 3D printing methods for architecture and elicit a reaction in the field of material science, programming and mechanical engineering.

This research analyzed different painting techniques such as pointillist, impressionist, expressionist and action painting and put them in relation to bodily movements of the painter. When comparing 3D printing methods with painting, resemblance can be found on the level of mixing and blending techniques, stroke and brush types, layering technique and arm and hand movement.

The architectural potential

Before coming to this area of focus I performed an extensive exploration on the architectural potential of 3D printing. Firstly, I questioned how using 3D printing for building construction can lead to a transformation of the parties involved during the process and their position. To answer this question observations were made during the biannual event InDeSem '15 with this year's theme re.Craft. The International Design Seminar revolved around the possible impact of emerging fabrication technologies in the architectural practice. Personal interviews with participating students, lecturers and tutors revealed current trends in thought on how these new digital fabrication methods will influence the architectural practice. I interviewed 63 Students; 43 international and 20 Dutch students. All students were able to use analog crafting methods such as clay and sewing machines and digital methods such as 3D printers and a laser-cutting machine. During the week observations were made by comparing comments at the beginning and end of the week and the physical design results.

A result was that it cannot be said that the digital fabrication methods will revolutionize the architectural practice in that sense that it will become the best method to work with. For each case, all available tools will need to be evaluated according to its architectural potential. In that sense it would be valuable for further research to map out current developments of new technologies and break down the advantages, disadvantages and challenges in applying these technologies in architecture. Areas of developments, which need to be taken into account during the design process primarily lay in the field of programming the movements of the machine and in material science where improvements need to be made in strength, mechanical properties, fire resistance and solidification process of the fluid material. The architect in turn requires having knowledge of these fields, he needs to be able to imagine the possibilities and at the same time provide accurate drawings to inform the programmer and material scientist with the needed information. The traditional way of drawing would not suffice therefore the final drawing and file of this project inherits information directing both the programmer and the material scientist.

Materiality of plastic

Secondly I studied the materiality of plastic through 3D printing. In this research the material properties have to be considered during the application of the computer when

it is converting the digital file into a three dimensional format in order to direct the 3D printer with more precision. The research therefore searches for the language of an integration of a three-dimensional digital file into a programmed aesthetics. The novelty of this material application calls for continuous exploration on the aesthetic language in architectural design. With the emergence of digital fabrication, complexity is no longer intrinsically valuable. Therefore it is important to know what gives form its meaning when employing these new tools. Through an empirical research by continuous exploration of form its architectural quality could be determined. I decided it was necessary to free ourselves of existing architectural typologies to explore the essence the material behavior with the assumption that all manufacturable objects can be reduced to basic geometries. Consequently I chose to perform the form studies starting from these simple geometries. The geometries need to relate to an architectural motive to be able to put them in relation to the subject. In this case the form studies started from the conception of the enclosure.

Results on material behavior were largely inherent in the used PLA's rheological properties defining the needed extrusion temperature, the temperature of the printable surface and the hardening time. All studies were performed with white or gray PLA using one extruder. Dual or multiple extrusion could accelerate the printing process. Gravitational forces cause 3D printed PLA to sag when it is not supported. When letting the printer go its course the printer starts dripping. The rheology of the material could in that sense be compared to paint and the printing technique to painting techniques. The layering technique could be compared to brick laying.

Between liquid and solid

The first comparison resulted in this one specific area of research, painting, which I was personally most fascinated by. Long before this project I always had an interest in painting but I have also been fascinated by movements of a material in liquid state and how they can be so unpredictable. The art of painting in a way captures this in its solidification. To me, exactly because of this it was interesting to deepen out this concept of building with materials in between the liquid and solid state. Subsequently I decided to dive into this analogy, which still provided a wide range of possibilities. I experimented with many materials, which were in my reach to play with this phase transition in form making. Glue, epoxy resin, acrylic paint, ink, aquarel, oil paint, gel paste, clay, acrylic seal, silicone seal and PLA plastic. It showed that when we learn to let go of control we can come to unusual designs not thought of but led by the intrinsic properties of the liquid material under influence of natural laws. The material experiments provided information on the play area of the in-between state. In the design one can play with the amount of control one has over the material but also the degree of liquidity and the speed of solidification.

A hypothetical material

I started specifically from the material PLA, a reusable bio plastic, which can be compostable. Generally the material that is used for the additive fabrication method is liquid during extrusion and solidifies over time, a property inherent to both plastic and paint. Although the starting point of the research was PLA, I decided to start from on a hypothetical material, with resemblance to plastic and paint, of which the needed material properties have become clear through the research and design.

Plastic might have negative connotations regarding environmental issues and does not seem like a comfortable building material to live in. Plastic however, provides an endless possibility for transformation. In the arts plastic has been extensively applied. The art of

painting teaches us how we can apply it in architecture and might release the material from its negative connotations. When it becomes possible and accepted to use this material as a building material not only for small appliances, connections and floorings but also as entire structures and enclosure, it becomes possible to build in leftover space in between the existing urban fabric. Addressing the housing problem caused by the large increase in population of dense urban settlements.

Transformation does not only occur in form but also in terms of material properties. Through additives it becomes possible to change, fire resistance, transparency and mechanical properties. Thus making the material ready for building construction. Therefore it is necessary to know what this new kind of architecture might look like and how it adds value to the architectural practice. The essence is that the design exists of painting strokes and a paint-like material. You will see the entrance and the enclosure but you will also see that the brushstrokes are the subject of this architecture. A side-aspect that I find interesting in this project is the difference between capturing paint and image into eternity and the temporality of the reusable plastic which was the starting point of this project, as being able to 'melt' the house pointing temporal use of the home and the nomadic lifestyle.

Precision and coincidentalality

The design aims to showcase how the use of 3D printing in building construction can be improved to accelerate the building process by accurately determining when to keep in control or lose control over the material. The paradox of losing control of the material outcome with 3D printing lies in the fact that, this fabrication technology works with a digital file, in which the computer can accurately determine the outcome. The design therefore is a combination of ratio and intuition, of precision and coincidentalality. Again this notion of coincidentalality and unpredictability is what interests me. Precision flows over into vagueness creating a certain atmosphere in which the duality becomes visible. In the future this area can be deepened out when researching quantum physics on both a technological as well as philosophical level.

Laws of nature

As mentioned the architect needs to master knowledge on material science, programming as an extension of its own expertise of building science regarding structural principles and hierarchical order in detailing. It masters the laws of nature such as gravity and centrifugal forces and is able to use this rational information for an intuitive design process. During the design process I intuitively experimented with the materials mentioned earlier. This resulted in a design in which I focused on the laws of gravity and centrifugal forces that come into play, how hierarchy of structural principles naturally flow from it. These steps become clear in the building process, which shows how and when material is applied with control or without. In the arts this opposition between control and freedom can be roughly found in realism and abstraction. In architecture there is a tendency to go against gravity, to go upwards into verticality, to take control over the natural laws. The context in which we find ourselves as architects today is a time in which mechanization leads the way for production and design. Where the machine is taken into consideration when designing. Mechanization of production shifted preference to the orthogonal. In the arts we have seen shifts in painting styles, from figurative, to realist to surrealist, impressionist, pointillist and action painting to name a few. The painting styles I focused on in this research were those, which imply and show movement, literally the movements of the painter; the impressionist, expressionist, pointillist and action painting. The machine remains to work through mechanization but it is a mechanization of movement. By studying the movements of the

paint one comes to an understanding of the mechanization needed for the machine. Consequently, I take into account two temporal components; movement in a direction from A to B but also movement through physical states.

The architect: an artist and an engineer

The new building process requires a shift in thinking in three dimensions. It repositions the architect in relation to the painter and the sculptor. By delineating the notions that define each artistic discipline and their interrelations on both an artistic and scientific level it becomes clear how painting, sculpture and architecture come together through this new building method.

A painting is paint on canvas and an imaginary picture of the world. A sculpture is a three-dimensional mass and an image, and a building both an object of utility, matter and structure, as well as an evocative spatio-temporal existential metaphor. The artistic work manifests itself in both the physical reality of its materialization, and in the reality of the artistic image and expression. If a painting can become sculptural by painting into three-dimensional space, a painting can in theory become architecture. But when putting this idea into practice this remains only true as a metaphor. In the same way it would be ironic to make architecture look like Van Gogh's *Starry Night* as architecture is not an imaginary picture of the world. And the *Starry Night* is not an object of utility, matter and structure. This being said, the hypothesis of the research, which states that the painting can become the design as well as the building and the city becomes the canvas, is refuted. The metaphor remains a source of inspiration and positions the project in relation to artistic works and the technological developments they are subjected to. After all Walter Gropius appointed the goal of all artistic labor as construction, where everything becomes a whole.

Finally, I would like to highlight one specific artist, Sigmar Polke, his art was a reaction to the deliberate industrial look of the art of Roy Lichtenstein. It was not precise, not industrial, but messy and smudgy. However, he was a thorough scientist who was able to make paintings, which could change color according to the temperature of the environment. And it is exactly this line of thought which is inspiring to me in terms of what we can learn from the art of painting to denormalize and destabilize the engineer inside the architect and with that bring out the artist.