# Thirteen ways of looking

*Representation as an act of design.*


## 1.0 Abstract

It is considered common knowledge that architects communicate information at different scales, such as 1:5, 1:50, 1:200 or 1:500, and that each scale has an associated level of detail, making the notion of representation and abstraction important aspects of architectural practice. This have been necessary since these have classically been communicated through drawings [1] or models, but today it is possible to have a high level of detail across scales with complex 3D models, 3D prints or photorealistic renderings. However, is this increased precision and detail necessary? And what are these technological advancements besides mere computerization of an already existing processes? Therefore, this early stage research wishes to ask the open question: "*can technology be pushed past representational use? Or will it remain a tool to augment the status quo?*". This idea is explored a sculptural series that have been developed based on theories found in cognitive and computer science.



**Keywords:** *Discrete geometry, digitally implicit, representation, data modeling*

## 2.0 Context

The project situates itself in the practice of architectural discretization, while acting as a comment to current practice of discretisation. Generally discretisation in architecture refers to the act of decomposing form into series of parts or components, making it possible to assemble complex form, where the resemblance depends on the number of pieces. This practice has therefore often been used by Zaha Hadid, due to the high formal complexity of their projects, where facades often are composed of several individual panels as seen in the Heydar Aliyev Centre, Baku or the DDP project in Seoul (fig 1). Any technical literate architect is able to read the modelling technique(fig 2) in the paneling of the DDP Seoul project. The great reveal is the valence 5 vertex as highlighted by a white dot in fig 1b, making it appear as if they have transposed the digital geometry into the physical.

This project aims to avoid this transposition of the digital by utilizing discretization techniques as a design approach, whereby the digital geometry becomes a scaffold from which design is derived. This will be achieved by implementing techniques found in cognitive and computer science as a way to study alternative discretization strategies than those found in architectural geometry.

## 3.0 Theory

In cognitive science we find various techniques to identify objects in images or break objects into parts [2], and in computer science we find a similar techniques, where objects are clustered into parts as a means to identify center lines of point clouds [3] or meshes [4]. Common in both cases is the use of implicit information from geometry, which is possible to access through computational processes in computer aided design (CAD) software. Implicit information is the composite of digital objects that makes it possible for the computer to show them on our screens. In architectural research we find examples of this being used in design experiments such as the *neo-baroque columns* of Hansmeyer [5], or by CITA's *Inflated Restraint* project [6] (f ig 3).

Both projects aimed to make a material manifestation matching that of their high resolution digital model, which in the Inflated Restraint project lead to studies into how one can compare the physical to the digital. Ultimately realising it had not been possible to replicate the digital itself, but they were within a tolerable margin and could identify why it had not been possible to replicate the digital [6]. The columns of Hansmeyer ran into a similar problem of scale and resolution, since they had to rely on 3d printing technology or stacking of thin laser cut cardboard. Making the experiments look well from a far, but it was possible to read the resolution up close, something that is believed will be resolved in the future with technological advancements.

However, in the examples of cognitive and computer science the goal was inverse, it was one of simplification, which would make certain tasks simpler such as animation [4]. Therefore, it is the ambition of this research to explore this notion of simplification as a mode of design and method to build complex geometry. In cognitive science the curvature of objects are used to group objects into sub-parts [2]. however, digital geometry have more information ready available such as surface


**Figure 1:** Image a) shows an aerial view of the DDP, Seul project. Image b is a zoomed in image near a pathway going under the building, the white dot hightlights a valence 5 vertex, meaning 5 edges meeting in a point, which is a sign of mesh modeling.

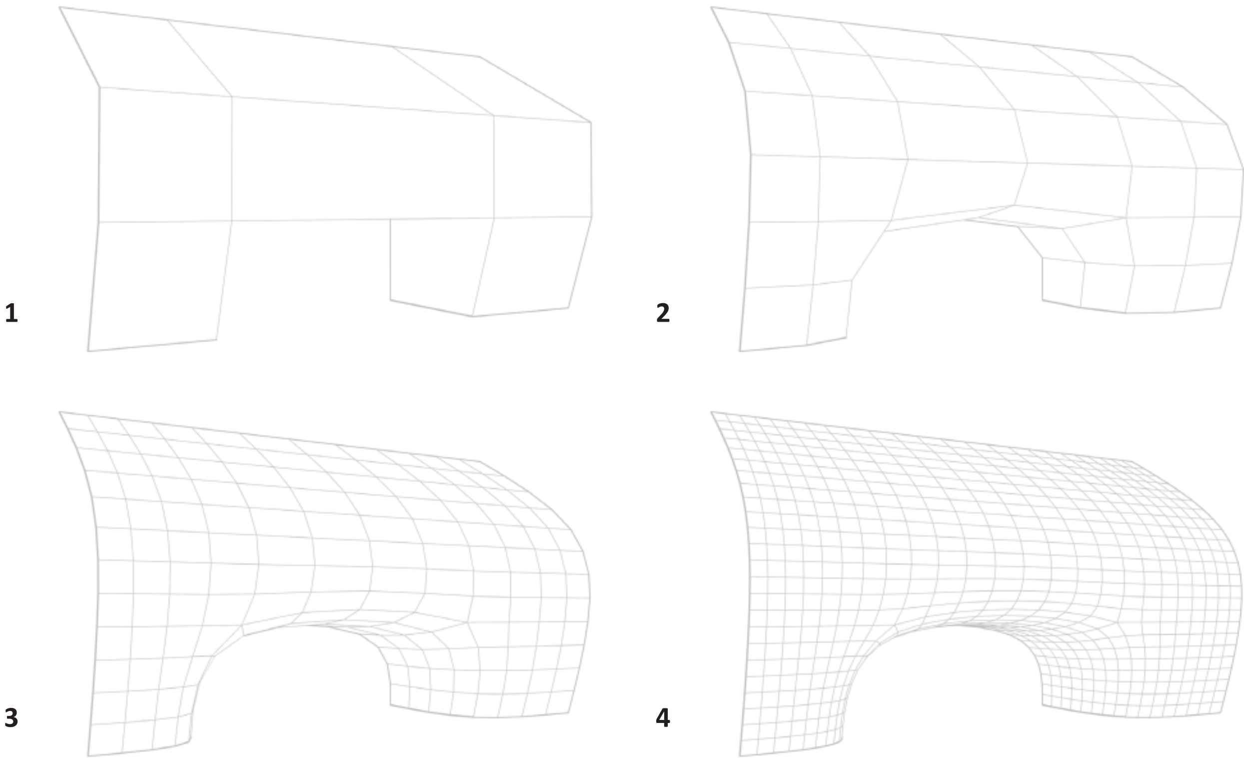
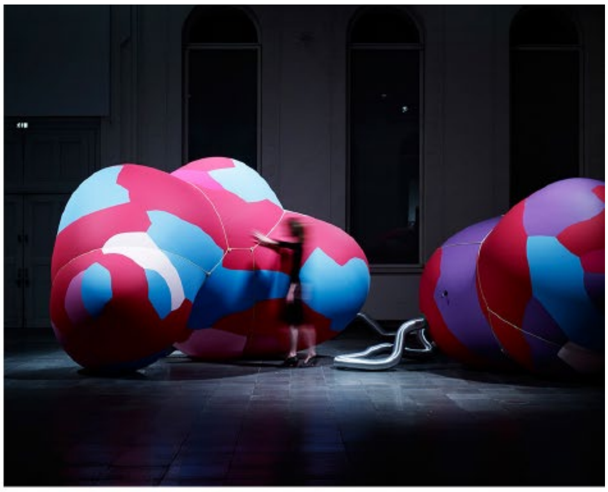



**Figure 2:** Images 1 through 4 shows the process of modeling the DDP, Seoul project, where the starting condition is 1) that is then smoothed to meet 4), the criticism is placed on the direct translation of 4) into physical space.

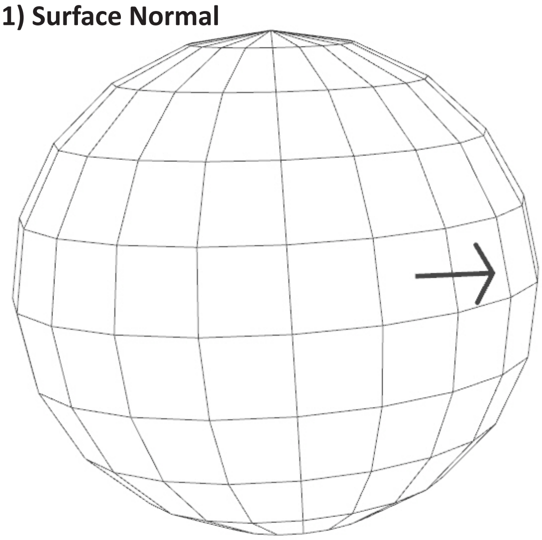
a



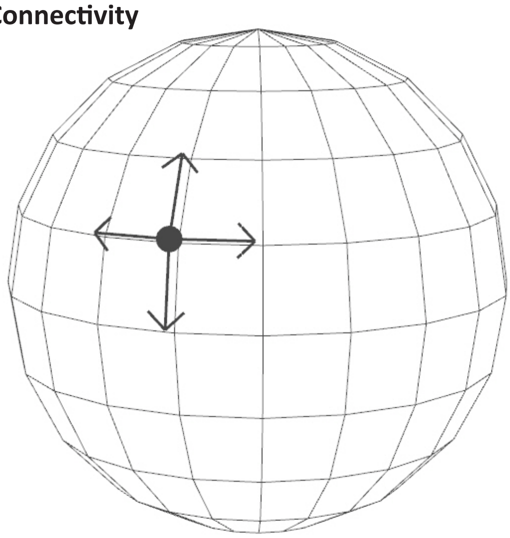
b

**Figure 3:** image a shows the neo baroque columns by Michael Hansmeyer, where he used geometrical information to drive recursive subdivision of a set of base columns. Image b, is of the inflated restraint project from CITA, where implicit information was used to derive construction information. After construction it was evaluated through 3d scans to see how close it matched the digital.

**1) Surface Normal**



**2) Connectivity**



**3) Topology**

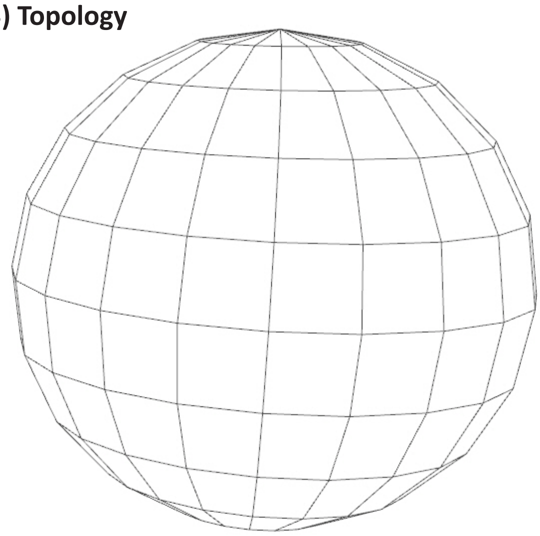


**Figure 4:** *1) normals,* a vector perpendicular to a surface, mesh face or vertex. *2) connectivity,* it is possible to access neighbouring information such as vertices or faces. *3) topology*, an object can change shape and still be topologically identical, but if number of faces or vertices change it will result in topologically different objects.

normals, connectivity or topology (fig 4), all of which can be accessed through computational processes. The aim therefore becomes to rethink the use of this information by making it a driver for design, pushing the process of discretisation past that of replicating the digitally made objects. This will lead to a process of form finding, not based on physical constraints but one of the possibilities latently hidden in the geometry, this approach has provisionally been labelled as object oriented design (OOD), and section 4 will describe more about the process.e process.

## 4.0 Experiments

This research was carried out using Rhinoceros and Grasshopper3d as its modeling environment, where Grasshopper3d is a parametric modeling software, that functions as an open environment that can be tailored to ones need, wherein it is possible to unfold the theory into two projects. Both projects were inspired by the poem “thirteen ways of looking at a blackbird” by Wallace Stevens [7], which, as it implies, describes different ways of looking at a blackbird through a series of composites. The notion of looking therefore plays an important role in the projects, begging the question: when breaking a complex object into smaller parts, when do we recognize the initial object? The starting point for this investigation is the same digital geometry as in the described Zaha Hadid project - meshes. One project acts as a calibration method, identifying potentials for the other project, additionally using the same geometry type, will make the projects linked and comparable.

### *4.1 Thirteen ways of looking at a sphere*

The calibration project, *thirteen ways of looking at a sphere*, makes use of a sphere, as its basis of design. The sphere is grouped into parts based on mesh normals, connectivity and topology, it was chosen to not use surface curvature as a parameter, in spite of it being used a lot in cognitive science. The reason for leaving out that parameter is that spheres have constant both Gaussian and mean curvature throughout its surface [8]. As the name implies the experiment was structured around making 13 different spheres using the 3 different discretization parameters, where each parameter was used to 4 individual spheres, lastly one was made as a product of the 3 other spheres. The parameters were used to break the spheres into smaller pieces or groups by a generalized clustering method, named kMeans [9], making it possible to use data derived from a given shape to find alternative versions of it, which can still be considered to be the same as the original. Fig. 5 describes the process

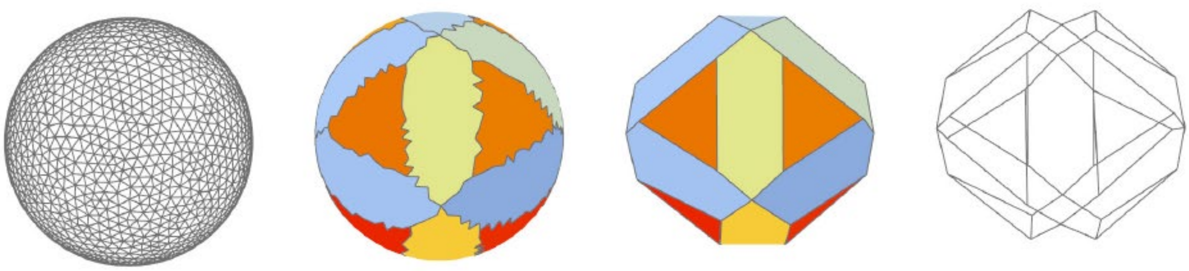


**Figure 5:** shows the process of going from complex geometry, to clustering and finally to a simple line network ready for fabrication as a result of discretization based on normals.

of grouping a sphere into parts based on mesh normals, which was clustered based on an initial seed of normals (fig 6). It was subjectively decided that using mesh normals as the clustering strategy presented the highest design potential since it blurred the reading of the digital modeling technique in the final geometry, see Fig 7 for a full range of designed spheres.

### *4.1 Three ways of looking at a sphere*

The calibration project lead to the development of another project, three ways of looking at a man, which focused on discretization based on mesh normals as per the conclusions drawn by the calibration project. An interesting aspect that revealed itself from this method is that it allows emulate how an object would look from different angles and form a composite from it, resulting in a line or patch network (fig 5). This has the potential to instigate a conversation about from which sides is an object most recognisable and from how many side do one need to look at an object to recognize it as a whole, but more importantly it opens up new design avenues. This new layer, is also why the starting condition was shifted from a simple platonic solid to one of a higher formal complexity - a man (fig 8), but it maintained the same geometrical type. The project therefore serves as an exploration into the notion of OOD simplification through discretisation as a design idea.

As the name implies, this project consists of three different sculptures, where two are different and the third is the composite of the two (fig. 9). As mentioned these composites resembles different ways of viewing an object, which has to do with the nature of normal's of a surface, which are vectors and therefore indicate directions in space, when these are grouped into sub patches (fig 5), they start to resembled parts directly visible from a certain angle or view. Therefore the series becomes a composite image of a man that is build up through three sculptures, something our eyes and brain does so effortlessly on a daily basis.

### *4.2 Assembly logic*

As part of the discretization process, was an element of rationalization was needed of the edges of the sub-groups (fig 4), since they were all different. This lead to a simpler fabrication and assembly process. Each group was reduced to a line network consisting of rod elements (pine sticks or copper coated welding rods), which were assembled by 3d printed nodes. All nodes had assembly information

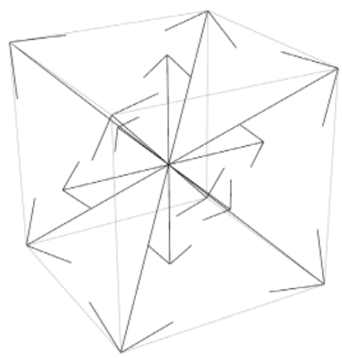


**Figure 6:** shows the normal directions used in Fig 4.

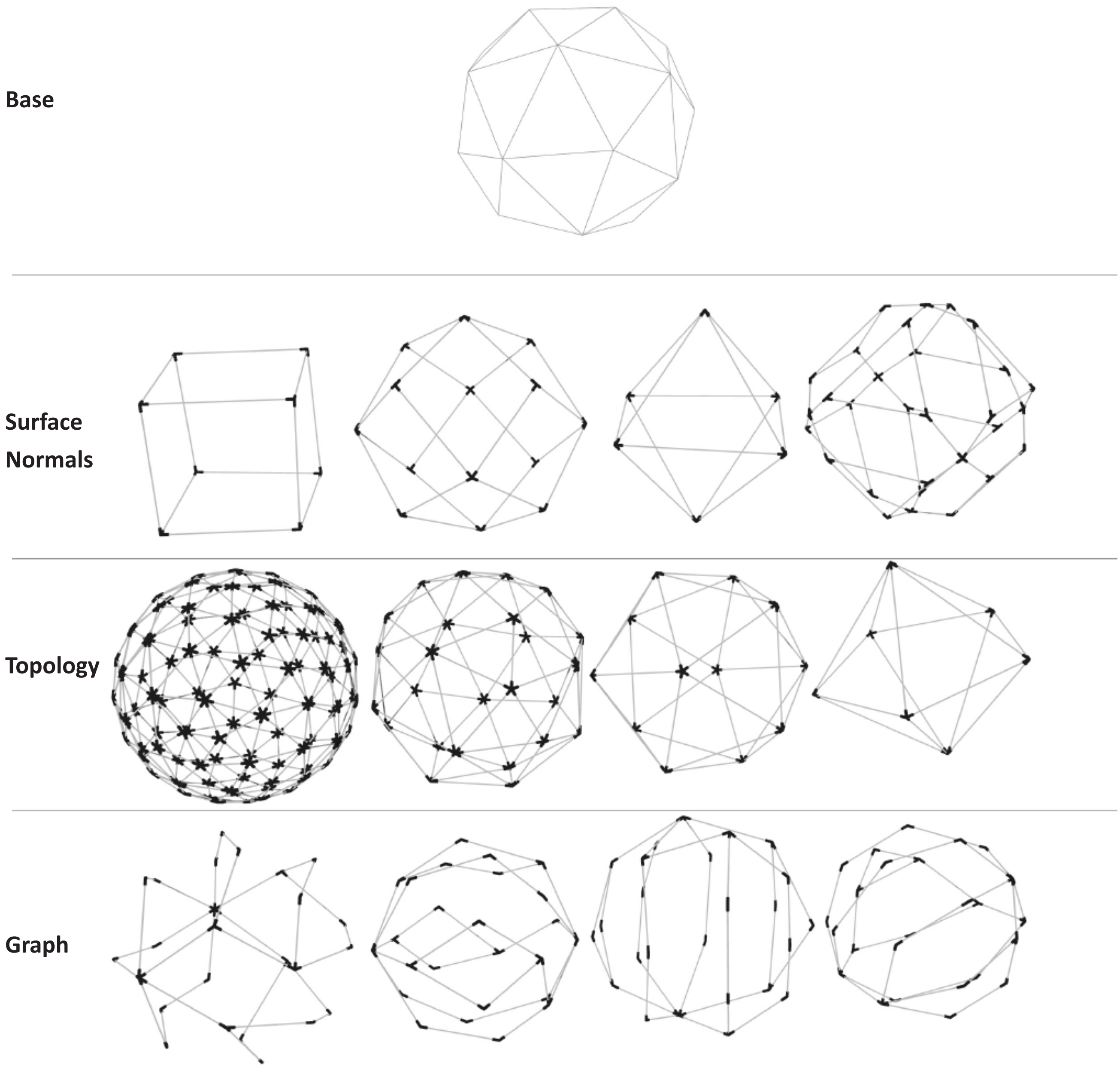



**Figure 7:** shows the 13 different spheres that were designed as part of the calibration experiment, the top row presented the highest design potential.

**Figure 8:** The base mesh and the process of grouping it into parts for further simplification.

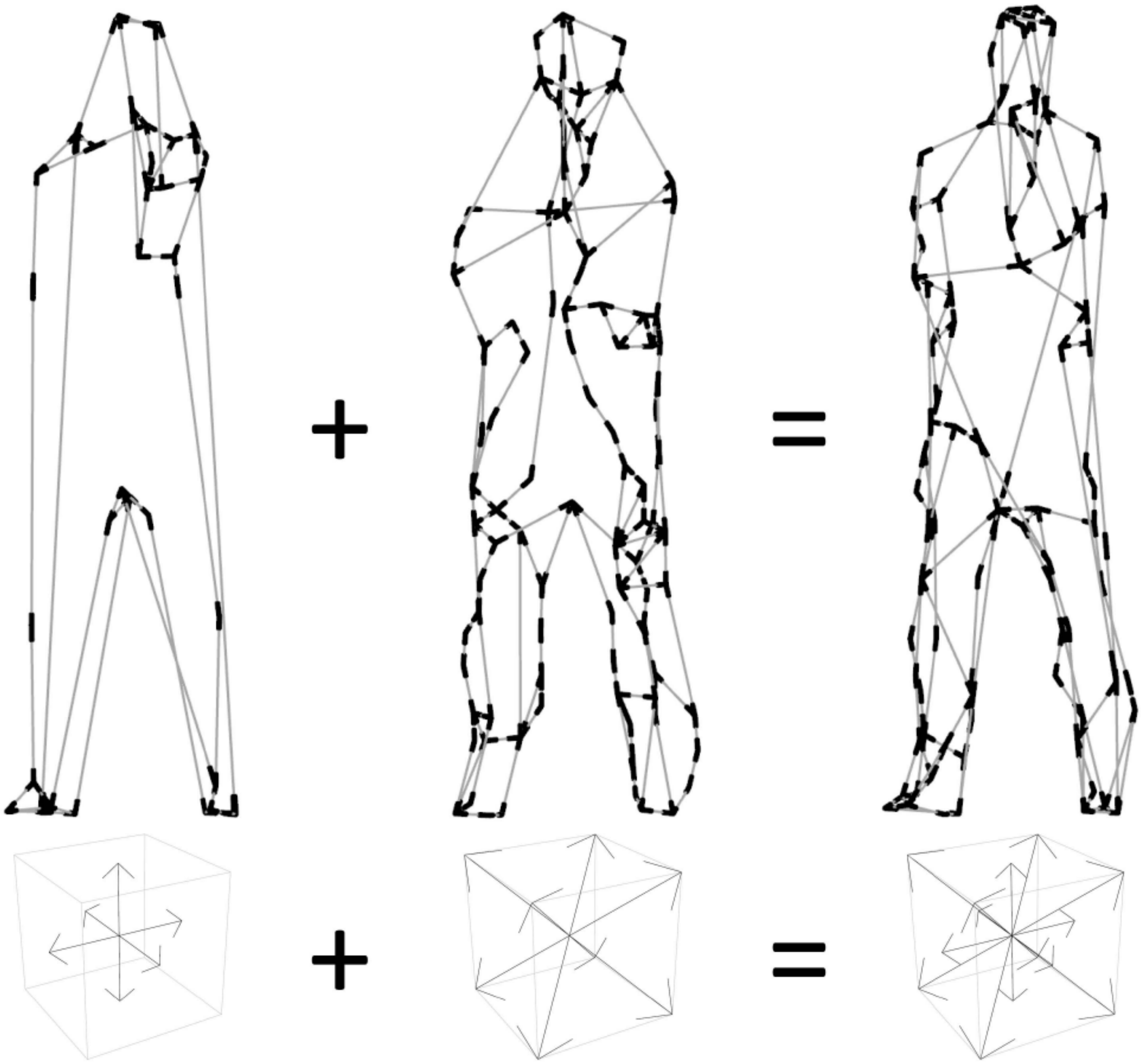


**Figure 9:** The three sculptures, where when the first two are merged they form a more holistic image of the digital base mesh.

printed on them (fig 10), meaning that they can only be assembled in one way, effectively making the structures into a big 3d puzzles or construction drawings.

### *4.3 Results*

This subsection of the section 4 contains images of build pieces through fig 11 – 13, which are on the following pages.

## 5.0 Conclusion & Future work

The project presents a novel approach to design by utilizing computational techniques as a way to rethink the notion of digital representation, by making use of representational information as a design method. Through the projects series it was shown that this technique can uncover new space for design. Although the research is still within its infancy it presents new avenues of exploration within the field of computation in architecture and arts, where techniques such as 3D scanning and its high-res point clouds could be new subject matter to explore. This leap from using meshes to point clouds is possible since the method is flexible in nature, because it occupies itself with the grouping of data, making it useful in relation to any geometry from which data can be derived. There exist other examples of data related research within architecture, where the build experiments outlined

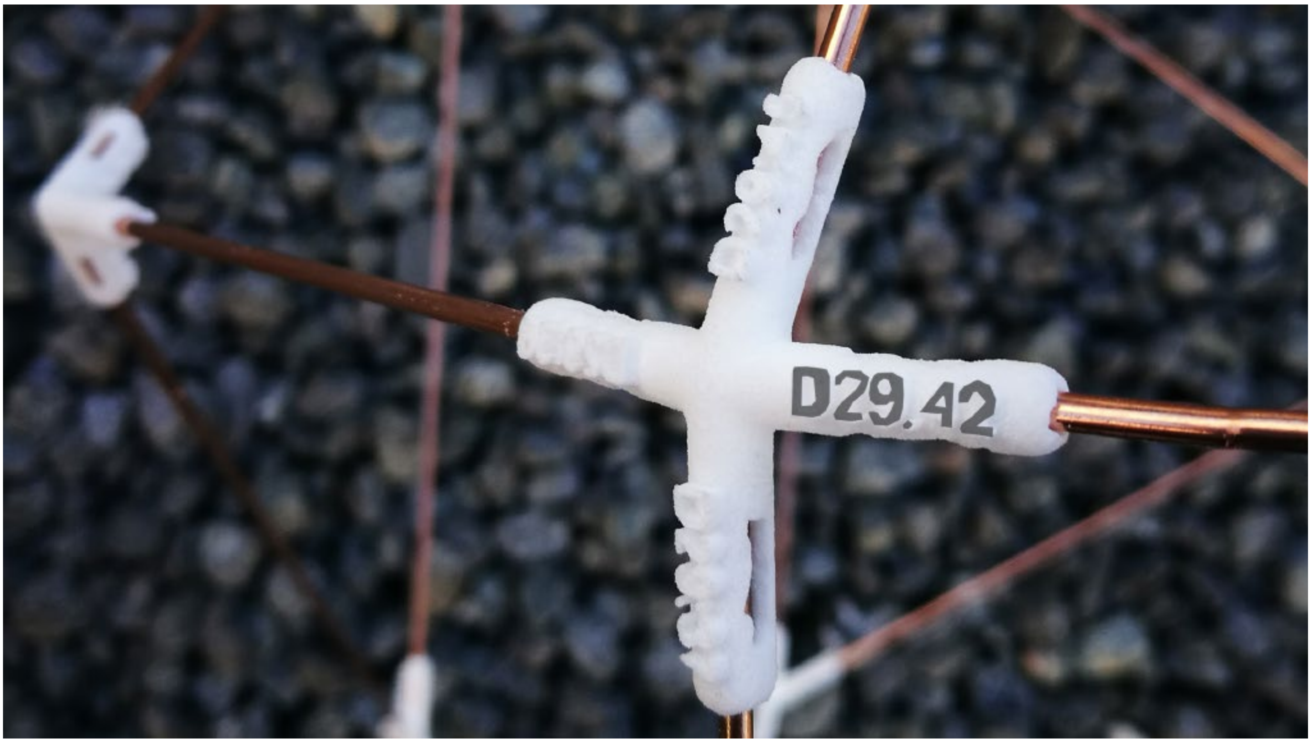



**Figure 10:** The numbering on the node reads out “D29:42”, where D denotes what sculpture it is part of, 29 the number of the leg and is printed on each leg of the node, and 42 speaks to which rod goes into the specific leg.

**Figure 11:** spheres build from the normal discretization method.

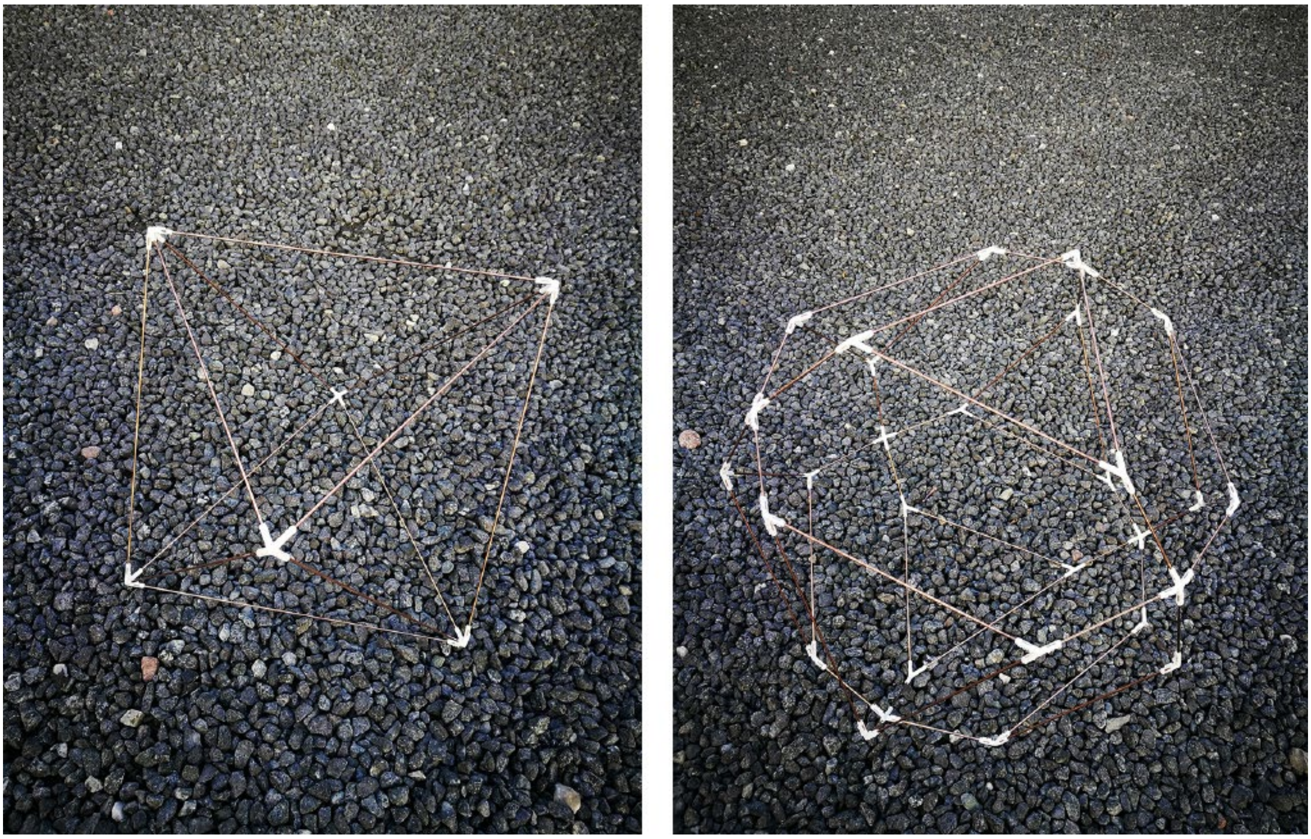


**Figure 12:** spheres build from the normal discretization method.

**Figure 13:** One of the ways of viewing a man based on the normal discretization method.

by Santiago R. Perez in his article titled Loss of Control [10] is of significance. He describes design experiments dealing with data shuffling that lead to unforeseen results in some design build projects. Another similar approach is the data bending described in the article Postdigital Materiality [11], where the simple 3d scanning technique – photogrammetry, is explored and manipulated, uncovering new ways of making form. Their use of manipulating data hints that the presented technique could be introduced into an already existing wider field of the post digital in architecture. Lastly the project proposes a future exploration of the technique relating it back to architectural practice, by applying the technique onto a complex surface geometry found in a build project. This future project will also contain the panels that would go in between the lines of the rod network, making the project add to the wider conversation of architectural components, and exploring the OOD paradigm as described earlier.

## 6 References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## 7 Figures

Fig 1 : Author’s illustration, with images from the following websites:

- http://www.thegofever.com/architect-zaha-hadid/
- http://archiquality.blogspot.dk/2016/12/seul-corea-del-sud-open-dongdaemun.html

Fig 2 : Author’s illustration

Fig 3 : Author’s illustration, with images from the following websites:

- Neo – Baroque project: https://www.archdaily.com/138323/subdivision-michael-hansmeyer
- Inflated restraint project: http://www.complexmodelling.dk/?p=1379

Fig 4 : Author’s illustration

Fig 5 : Author’s illustration

Fig 6 : Author’s illustration

Fig 7 : Author’s illustration

Fig 8 : Author’s illustration

Fig 9 : Author’s illustration

Fig 10 : Author’s illustration

Fig 11 : Author’s illustration

Fig 12 : Author’s illustration

Fig 13 : Author’s illustration