Choreographed Soft Morphologies: Exploring New Ways of Ideating Soft Architecture Through Material Elasticity

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KEYWORDS
Choreography; embodied interaction; choreography; soft interface; elasticity; architecture; motion capture technology; physical-digital.

HOW TO CITE
Castán, Marina and Daniel Suárez. 2018. “Choreographed Soft Morphologies: exploring new ways of ideating soft architecture through material elasticity”.
Temes de disseny 34: 60-73.

This research aims to contribute to the current field of architectural design by offering evidence of how a collaborative and embodied approach to soft architecture can inform a new physical-digital design process. Current design technologies (e.g. sensors, 3D scanners, procedural modelling software), together with the use of the body as a source for designing a space, offer new methods and tools for designing architecture (Hirschberg, Sayegh, Frühwirth and Zedlacher 2006). However, the potential for experiencing and digitally capturing a soft and elastic material interaction through the body as a dynamic system capable of informing soft architectural design has not yet been widely explored. By using the felt experience as a tool for design, we allow the material to express its qualities when activated by the body, revealing its form instead of it being imposed from outside (DeLanda 2015). Taking an embodied approach used in interaction design and fashion design (Loke and Robertson 2011; Wilde, Vallgårda, and Tomico 2017), this research proposes a hybrid method to explore a textile-body ontology as an entity that has the potential to design a space, along with the use of motion capture technology in an effort to re-connect the experiential (the body) with the architecture (the space).

Through a custom-made interface, made of soft and hard materials, we explored the dynamic and spatial qualities of material elasticity through choreographed body movements. The interface acts as a deformable space that can be shaped by the body, producing a collection of form expressions, ranging from subtle surface modifications to more prominent deformations. Such form-giving processes were captured in real time by three Kinect sensors, offering a distinct digital raw material that can be conveniently manipulated and translated into architectural simulations, validating the method as a new way to inform soft architectural design processes.

The findings showed that: 1) the direct experience of collaboratively interacting with a soft and elastic interface allows the identification of the dynamic qualities of the material in relation to oneself and others, facilitating an immediate spatial meaning-making process; 2) exploring the design of a soft and elastic space through choreography and motion capture technology contributes to the creation of augmented relational scales across physical and digital

realms, proposing a new hybrid design method; 3) the soft and elastic interface becomes a new entity when shaped by the body (textile-body ontology) giving the opportunity for a variety of formal expressions and offering a source of digital raw material for architectural design.

1 INTRODUCTION

The use of the body as a choreographic tool to inform the design of space has been widely explored by architects in recent decades. Architects have collaborated with dancers and choreographers to translate movement into notation systems through analogue-digital workflows. In this way, the design of an architectural form or spatial arrangement is often materialised through rigid and static prototypes (Kato and Glynn 2017; Salazar Sutil 2015). Pacher's work takes a performative approach to architecture and proposes working with our sense of movement and its ability to affect how space is perceived and enacted by actions of the body. Using Kinect sensors, Pacher developed a mobile application that allows the user to use his or her actions as inputs to influence the design of space in real time (Pacher 2014). Architect and dancer Chryssa Varna uses dance notations to create a choreography for designing kinetic architecture based on the use of robots and paper fans as responsive devices, offering a new spatial design language (Varna 2013).

Similarly, based on an embodied approach to textile architecture, this research explored a collaborative process of soft architecture that goes beyond the design of an architectural form, aiming to introduce a new method for designing soft architecture through material elasticity at multiple scales (a surface, facade, transitional space or pavilion). The design of a soft space by means of body-material interactions has received little attention within the field of architecture in contrast to other fields such as interaction design or fashion design in which the relationship between the material and the body is often more direct. The most obvious reason that emerges for this is one of scale: architects' direct experience with materials is often relegated to a physical model that does not match the scale of the body. Thus, the hybrid method we are putting forward in this research project would allow architects to improve their interaction with the material in terms of direct experience by bridging the gap between the scale of the model and the scale of the body. As Schillig points out, the interactive, kinetic and performative aspects that come into play when approaching the design of a space mediated by the material and at the scale of the body results in a dynamic and transformative space that "anticipates a precursor of virtual space – a virtual space where the body is not suppressed, but for which it becomes the initiator of space". *Performative Geometries* (A. Agkathidis et al. 2010) documents the way that a collection of soft envelopes challenges the definition of space traditionally understood as something static and rigid, offering instead an organic and emergent space mediated by the materiality of textiles.

In the same spirit, this research aims to engage with architecture in a more experiential way, connecting physical spatial experiences with digital design processes. Our contribution lies in the creation of a hybrid method that simultaneously connects physical actions with their digital counterparts. By doing this, various stakeholders can co-shape the space and, subsequently, the architectural form in both the physical and the digital realm. The event is captured in real time and enables the digital creation of visualisations, offering a new soft form vocabulary, based on the particularities of the temporal transformations of the textile-body ontology. In this way, the direct experience of inhabiting a space that is soft and dynamic would not only inform new spatial logics but would also offer a catalogue of formal expressions that arise as a result of the interaction between the material and the body in movement. The digital captures are first re-constructed as a mesh (to make them stable enough to work with modelling software) and later manipulated to display their potential as architectural design material.

The result of using a combined perspective of embodied design (by means of choreography) and technology (by means of motion capture tools and modelling software) are twofold. Firstly, the experiential quality that this method brings allows the exploration of the qualities of a soft space and the relationship to others in a very immediate manner. Secondly, the digital captures enable working at different scales and the generation of visuals of soft architectural designs, providing a distinct digital material with numerous formal and spatial explorative possibilities. A hybrid method such as this brings together the expertise of architects, textile designers, dancers and choreographers in a collaborative process that enables analysis and reflection on the outcomes from different perspectives, contributing to expanding the understanding of space towards a more personalised concept thereof. We start by providing a brief introduction to the concept of materiality and the relationship between matter and form from a philosophical point of view, continuing by offering a brief overview of embodied interaction design. Finally, we describe our experimental setup and the hybrid method before analysing the value of collaboratively designing soft architecture through choreography and motion capture technology.

2 THE CONCEPT OF MATERIALITY IN THE PHYSICAL AND DIGITAL REALMS

Working within a physical-digital context in design necessarily requires different approaches and methodologies in contrast to other design processes that do not involve digital data. The digital realm introduces computational material which must be addressed. Ahlquist and Menges highlight the importance of distinguishing between computation and computerisation, as they believe that the majority of contemporary architecture is still based on an approach that uses computational design as a way to operate more efficiently or faster within the design process (computerisation) rather than as a new way of thinking that generates more information and brings certain particularities (computation).

The origin of this shift in architecture from a static and linear process to a more complex and dynamic system comes from automated design and cybernetics. Approaches such as this position computers as an extension of human beings, with their proximity to human thinking (Ahlquist and Menges 2011)

This understanding of the physical and the digital world as a system is very much in line with the contemporary approach within Human-Computer Interaction Design, in which the physical and digital are understood as a composition rather than as two separate things (Wiberg and Robles 2010). This implies a shift in the way physical and digital materials are used within the design process. In this sense, our method combines a soft and elastic interface connected to the digital realm through motion capture sensors, operating as an extension of our actions, behaving as an integrated system that unfolds its own materiality, thus allowing for a continuous design flow. Much has been said about the materiality of computational technology and the turn towards an understanding of it as an expressive and graspable material (Brownell 2006; Landin 2005; Löwgren and Stolterman 2004; Vallgårda and Redström 2007; Vallgårda and Sokolar 2010). Vallgårda argues that the computer becomes a material for design, helping designers to achieve their creations through complex form-giving processes that necessarily contain the interaction between the physical material, the computational material and the interactions carried out by the user (Vallgårda 2014). Landin claims that computational technology within the context of interaction design is not just a neutral tool to implement the technical aspects of design, but an 'expressive design material instead' (Landin 2005, 117). Acknowledging the expressive and tangible qualities of the digital material enables a more integrated creative process, in which the physical and the digital are continuously fed into each other, not only co-shaping a particular design process but also resulting in distinct outcomes. How do we design, then, with materials whose qualities are different? Since the publication of the foundational book on interaction design by Dourish (1999) in which he develops an embodied approach to interaction design, new methodologies that use, in different ways, the notion of the *lived body*, have emerged. This notion comes from a break with the mind-body dualism proposed by Heidegger, Merleau-Ponty and other theorists such as Dewey (Pragmatist Aesthetics), Bourriaud (Relational Aesthetics), DeLanda, Braidotti or Barad (New Materialism). In the last decade, a growing interest in these theories have resulted in a variety of methods that offer an alternative to other traditional approaches to design. Loke and Robertson give a comprehensive account of the way that design researchers use the body as a source to inform design and analyse, ideate or test their prototypes (Loke and Robertson 2011). Methods such as these combine philosophical understanding with practice-based design research, using the material, the body and the context as materials for design. Importantly, digital technologies transform our realities into technological mediated environments, enabling the role of the body to become central within the early phases of design (Wilde, Vallgårda, and Tomico 2017).

Drawing on the notions of 'material capacities' (DeLanda 2015), we will demonstrate how a combined approach of embodied design and motion capture technology in relation to soft architecture fosters a new spatial experience and contributes to the creation of a novel form-giving process for architectural design.

3 A CONTEMPORARY PHILOSOPHICAL UNDERSTANDING OF MATTER - FORM IN THE CONTEXT OF ARCHITECTURE

DeLanda states that there is a conceptual shift regarding materials as systems that are defined not only by their properties but also by their capacities. From a philosophical point of view, this means that materials, or 'active materiality' as DeLanda terms it (DeLanda 2015, 85:2), reveal a different

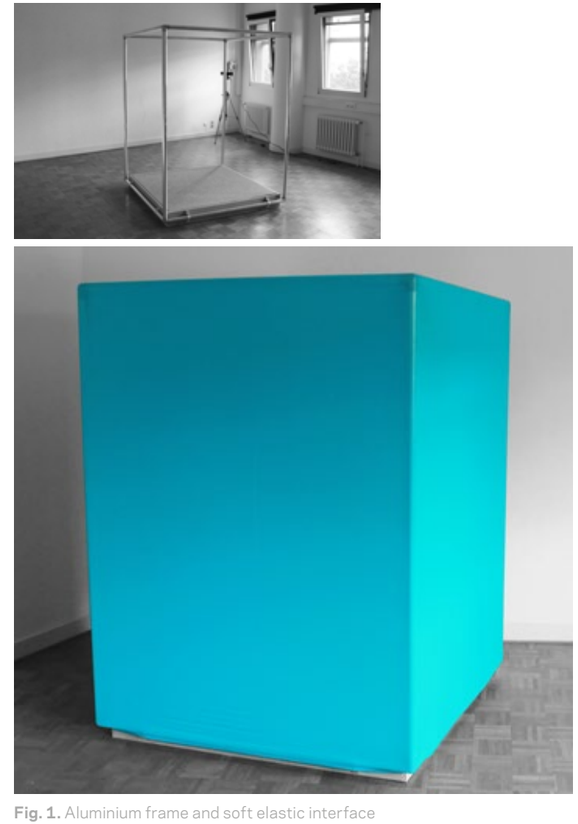


Fig. 1. Aluminium frame and soft elastic interface

Fig. 2. Inside view of the dancer's movements

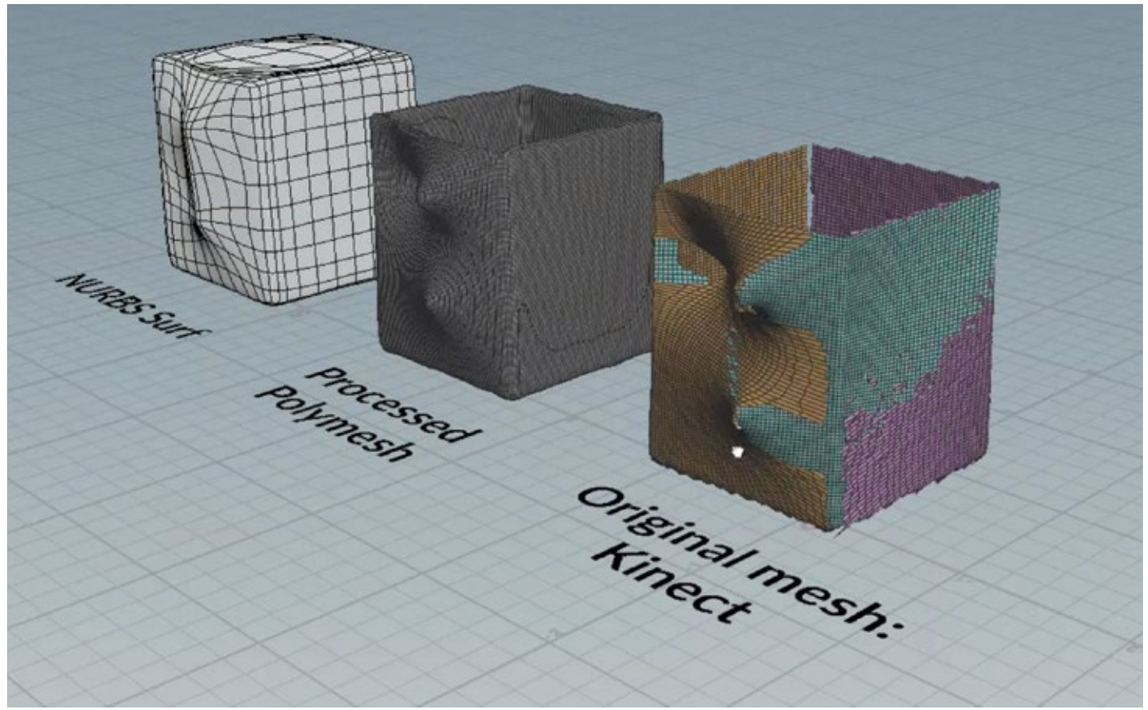
state when in use: that is, its capacities. Whereas material properties always exist, a material's capacities are a temporary quality of that material, meaning that they might emerge but they are not necessarily present in an actual way. DeLanda defines this twofold condition of materials as systems that have a double existence as the 'structure of a possibility space' (DeLanda 2015, 85:3). Thus, understanding matter as an entity of a space of possibility enables thinking about matter in terms of something that has the capacity to generate form by itself. In the same vein, Ingold argues that 'the forms of things are not imposed from without upon an inert substrate of matter, but are continually generated and dissolved within the fluxes of materials across the interface between substances and the medium that surrounds them' (Ingold 2010, 1). Menges (n.d.) points out that the design of a form in architecture has traditionally been understood as a separate process to that of its materialisation, and that, even nowadays in digital architectural practice, form definition and construction processes are approached separately. What Menges' research explores instead is an integral approach to the morphogenetic in which all elements of the design process (form, material, structure and context) are connected in a complex web of relationships that are explored through computational design. According to this way of thinking, materials are not simple substances with certain properties. Rather, they are complex systems that trigger multiple transformations across the design process.

4
EXPLORING THE SPATIALITY OF AN ELASTIC INTERFACE THROUGH CHOREOGRAPHY: SET-UP OF THE EXPERIMENTAL WORK

Inhabiting the soft interface enabled us to rather intuitively explore the spatial relationships and material qualities of a soft space to fully understand its particularities, as well as its formal possibilities, in terms of design expressions. As in the previous iteration (Castán and Suárez 2017), a collaboration with dancers was set up: in this case the Berlin-based Salvatore Siciliano company was contacted to suggest a collaborative project. Our previous work with dancers made us aware of the advantages of collaborating with dancers in terms of body expression and because of their role as possible future users of a soft space. The purpose of the collaboration was to acquire knowledge about which material and spatial qualities could be drawn from the direct experience of collectively interacting with the soft and elastic interface while capturing the resultant form expressions at the same time. The collaboration took place at the University of the Arts, UDK Berlin, where the authors built a bespoke interface consisting of a quasi-cube made out of an aluminium frame (1.50 x 1.50 x 1.80m), that operated as a structural element, and a piece of 5 x 2.20m of elastic fabric (82% polyester, 18% lycra) that was pre-tensed onto the whole structure (Figure 1).

The differences compared to the previous iteration (Castán and Suárez 2017) were as follows: 1) the use of a multi Kinect setup; 2) the focus on a specific material property (elasticity), and 3) the design of a bespoke soft space that operated as an interface between the physical (bodily experience) and the digital realm (visualisations), made out of hard and soft materials, that offered different thresholds of elasticity. A new textile-body ontology is generated when the bodies activate the soft and elastic interface, through a co-shaping process that enacts the structure of a space of possibility, a system that unfolds its material capacities (DeLanda 2015). Such material capacities are what we call dynamic qualities, the temporal qualities that arise when the bodies and the interface interact together. Three dynamic qualities were identified as a result of the interaction between the dancers and the soft and elastic interface:

1) Transparency. The more the dancers pushed the walls of the interface away, the more the outside was revealed to them. Thus, the materiality of the elastic interface reveals a gradient of transparency that mediates the relationship between the inside and



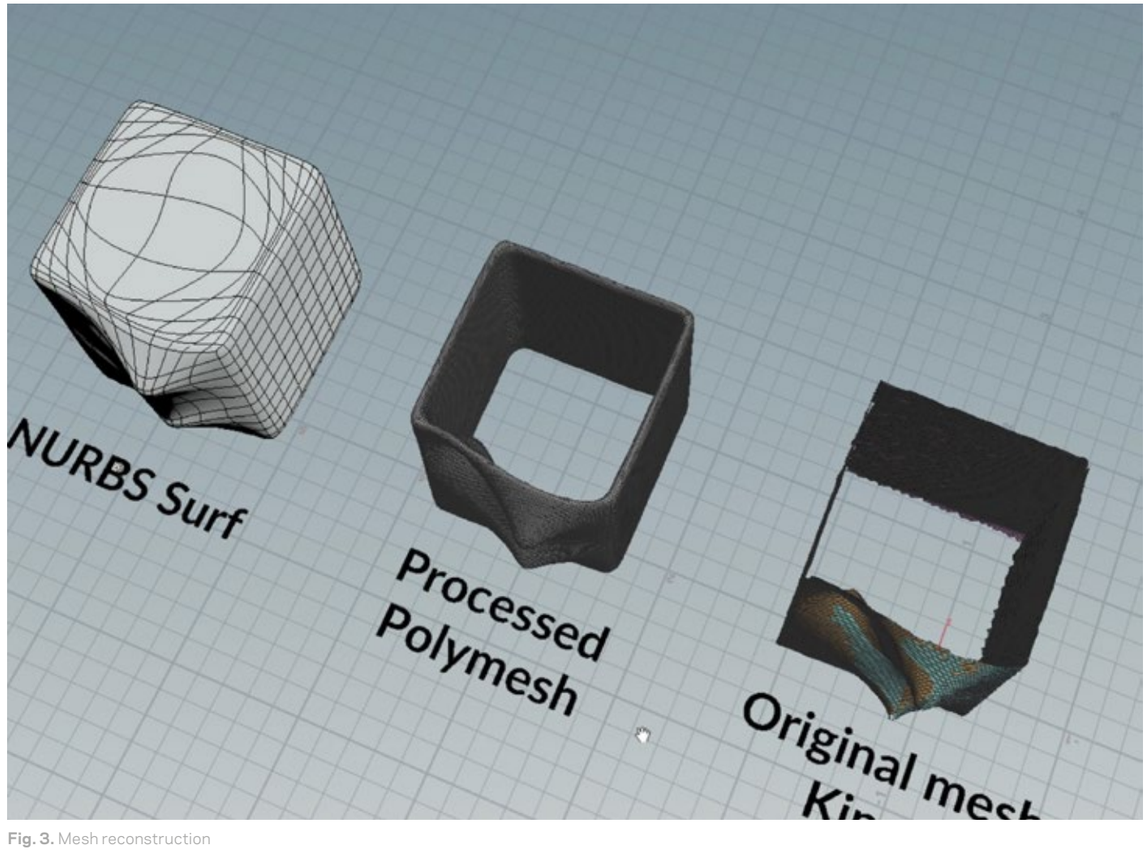


Fig. 3. Mesh reconstruction

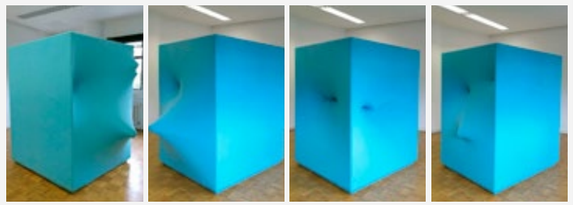
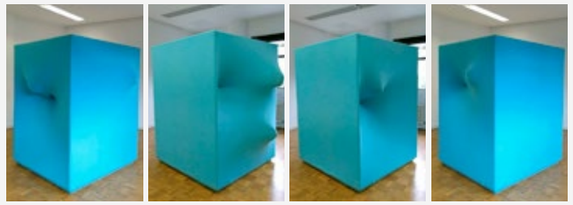
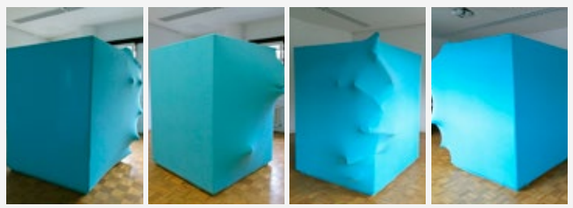
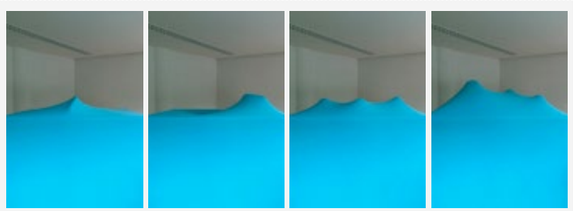
Form-giving process of the textile-body ontology		
	Choreographic Sequences	**Form Qualities**
1. Dot Patterns		The dancers pushed the fabric with their fingers as instructed by the choreographer, first with one finger then with several. A sequence of relief dots moving up and down could be observed, creating abstract and subtle geometric patterns.
2. Spherical Volumes		Heads and knees were used to deform the textile by pushing it forward. As heads are not pointed like fingers, forms were more rounded and more predominant as they occupied more surface area.
3. Convex and Surface Indentation		Hand movements deformed the textile inwards, creating convex volumes that made the edges of the interface more evident. By grabbing the textile and pulling it inwards, different degrees of indentation were created.
4. Convex / Concave Forms		Combining the movement of heads and knees pushing the textile forward with hand movements to grab the textile inwards created great tension that resulted in more prominent forms.
5. Sharp Surfaces		Interacting with arms and legs offered the sharpest forms as the textile was under very high tension.
6. Smooth Contours		On the contrary, the top view offers softer shapes as that view allows perceiving the transition in height from the flat to the deformed surface of the textile. To facilitate recording data from the top view, the soft interface was turned around to stand on a shorter height.

Table 1. Form-Giving Process

Participants	**Choreographer**	**Dancer**	**Author 1**	**Author 2**
Topics				
1. Soft interface	By keeping the body hidden, a new organism appears, it is a new identity.	Interesting setup in relation to material elasticity. Preference for close interactions as it enables creating more abstract shapes.	Its size and constrains helped reflection on the explorations to be more specific.	It has potential as a design tool. The augmented scale between user and material makes it easier to explore form.
2. Differences in ways of working	Not seeing the body. Felt like using 3D software instead.	Not having a full picture of what was being created.	Combining physical and digital materials within the design process enables creating dynamic systems that open new possibilities for design across different scales.	A textile interface as a time-based modelling tool.
3. Relevant insights for each one's practice	Body form-giving process instead of choreography.	Having an extra element (soft interface) as a collaborator for shaping the body.	The combination of an embodied approach to design and computational thinking offer an immediate response about the results of the prototypes being tested.	To design in a continuum space and its transition from one state to the other.
4. Outcomes evaluation	When the interface starts becoming irrecognizable. Dot pattern as the most interesting one.	Individual movements are less important, collaboration becomes essential in order to affect the space.	The new entity created by the textile-body ontology blurs the notion of clothing, expanding its meaning towards spatial configuration of embodied soft surfaces.	Still incipient. Its main value relies on its potential as a form-giving tool based on analogue inputs.
5. Collaborative aspect	It is interesting as it invites thinking in a different way.	As an observer, the anonimity of the exploration is interesting, especially when all dancers sync up as it gave the feeling of a whole unit instead of an interface and 3 separate humans inside.	An embodied approach to design through collaboration creates a shared experience that allows reflecting upon body-material / body-space / body-body relationships in an early stage of the design process across different disciplines.	I see value in collaborating with others as it brings new ways of working and new aesthetics.

Table 2. Analysing the value of using a collaborative and embodied approach to soft architecture

the outside, creating dynamic interactions between users and space.

2) Adaptability. The material's elasticity adapts to different volumes and forms, offering very defined shapes when the body activates the soft interface. Its adaptability allows users to modify the space according to their needs, taking up room when needed or using the minimum space otherwise.

3) Tensity. The soft interface operates as a pre-tensed envelope, allowing users to experience how it feels to be held by a soft and elastic wall, eventually performing counterbalanced movements through different thresholds of elasticity.

As a result of the co-shaping process, a collection of morphologies was created. Table 1 shows a selection of the choreographic sequences performed by the dancers, as well as a brief description of the resultant form expressions. The dancers, in dialogue with the choreographer, performed six different choreographic sequences using different parts of their bodies, indicated in the description of each of the form expressions: 1. Dot Patterns, 2. Spherical Volumes, 3. Convex and Surface Indentation, 4. Convex/Concave Forms, 5. Sharp Surfaces, 6. Smooth Contours.

The dancers started by first performing a more localised movement with their fingers, continuing by gradually integrating other parts of their bodies to have a more significant impact on the walls of the elastic interface. Intuitively, they began to help each other to gain more control in deforming the walls. As Figure 2 shows, dancers made use of the rigid frame to hold themselves when stretching the walls. A GoPro camera was placed inside the elastic cube, and a video-recording camera outside of it in order to capture the dancers' movements and document both inside and outside perspectives (Figure 2).

Three Kinect sensors were triangulated to get a 360-degree capture of the explorations. Brekel multi-Kinect software was used to record raw data retrieved from the Kinect cameras which were later imported into SideFX Houdini software to join the three different meshes of each position into one single object and perform a subsequent reconstruction of this joined mesh. Once the mesh was cleaned, the still frame geometry was exported as a *.obj file, and imported in Rhino3D to manipulate it within a Grasshopper environment.

The improvements in the physical-digital setup mentioned above responded to the following: the need to obtain a smaller amount of data that was more precise, a physical space with certain constraints (related to dimensions and material properties) that allows the participants to be more specific in relation to the findings, and finally a more interesting dialogue between physical and digital spaces, in this case, triggered by the elastic property of the material (a matter-form relationship). The data captured by the Kinect sensors enables different perspectives on the soft elastic interface, as Figure 3 shows. By handling data that is based on transformation processes, certain random events emerge, such a glitch, that in the context of computing refers to a malfunction in a programme or interface; sometimes these errors are manifested in a visual way. Regarding the captures that are presented here, they turned into unexpected forms and deformations of the soft and elastic interface. By capturing the choreographic explorations with three Kinect sensors, a raw mesh is created, allowing the designer to re-construct it and project different conditions and criteria to obtain specific outputs (Figure 3).

The forms created by the textile-body ontology hold certain qualities of plasticity and dynamism that make them interesting and powerful in relation to design expressions, in both the physical and the digital realm. The present set-up allows an understanding of the singularities of a soft and elastic space and its expressive qualities as a system, as a new ontology that generates a distinct form-giving process.

The behaviour of the soft interface is determined by the combination of the fabric material properties and the restrictions imposed by the aluminium frame, thus in an elastic yet stable combination. Subsequently, the capacity to be stretched out by the body creates a volume that results in a specific form, in a temporary event that modifies one side of the interface from being a plane to becoming a three-dimensional surface. The data captured by the Kinect sensors changes over time, introducing a 4D aspect that makes this data significantly different from the one that results from a static body, creating a temporal aspect and generating data that updates constantly. Moreover, by examining the data with the procedural modelling software, hidden spaces that are not visible within the physical realm can be discovered, as the Kinect sensors reconstruct some of the parts that are not visible, creating new possibilities of spatial configuration. Within a soft architecture context, different ideas of potential applications emerged, such as, for example, the idea of a soft space inside a built space, a soft wall or soft window that could mediate as an interstitial space between the facade and the interior of a building, modifying natural light conditions and spatial conditions by interacting with the textile and pushing it outwards: a similar concept to the recently built Guelmim airport, in Morocco, by Groupe 3 architects. They wrapped the building with a metal mesh skin, creating a light-filtering facade, mediating the relationship between inside and outside. The results obtained from our elastic interface could drive similar operations. Figure 4 shows how the dynamic quality of transparency is translated into a colour gradient map and applied to the reconstructed mesh. In this way, some graded distributed areas of transparency are created, making it possible to evaluate the distances between the face centres of an initial state of the mesh and the manipulated one.

Figure 5 shows some of the captures that were reconstructed with Grasshopper tools and visualized in Rhino3D, addressing the curvatures of the soft surface. Figure 5 shows a Soft form vocabulary that further elaborates design possibilities, offering a visualisation of a speculative urban scenario in which certain parts of a building's skin could behave in a soft and elastic way.

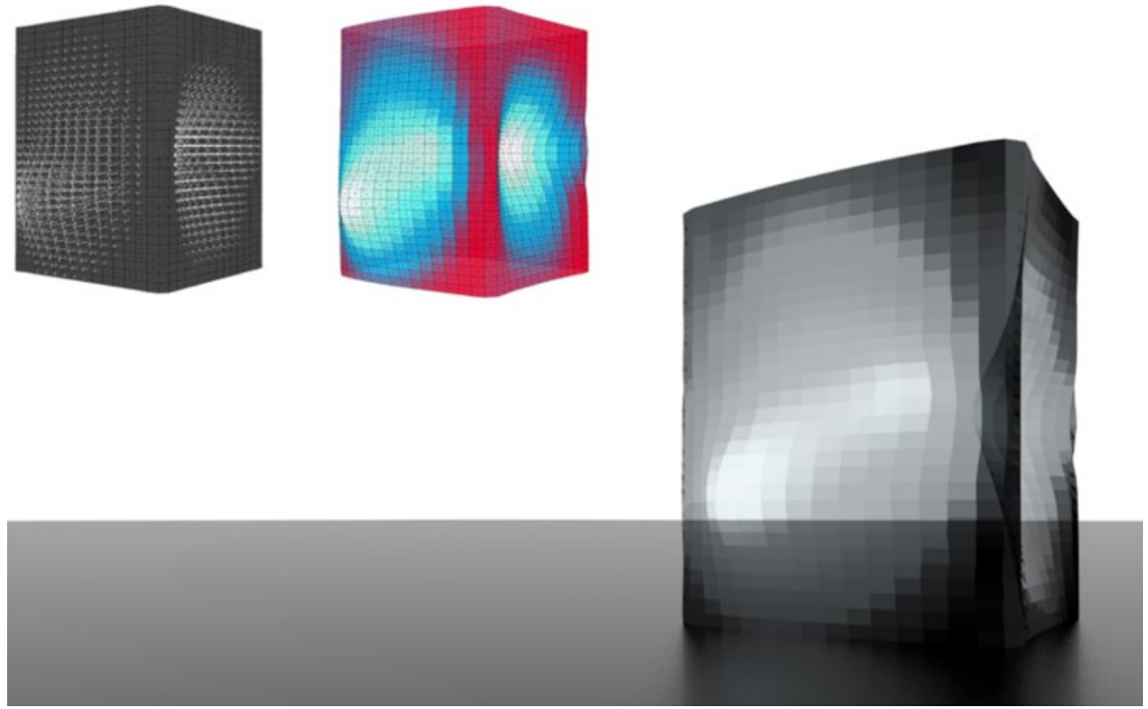


Fig. 4. Interpreting transparency

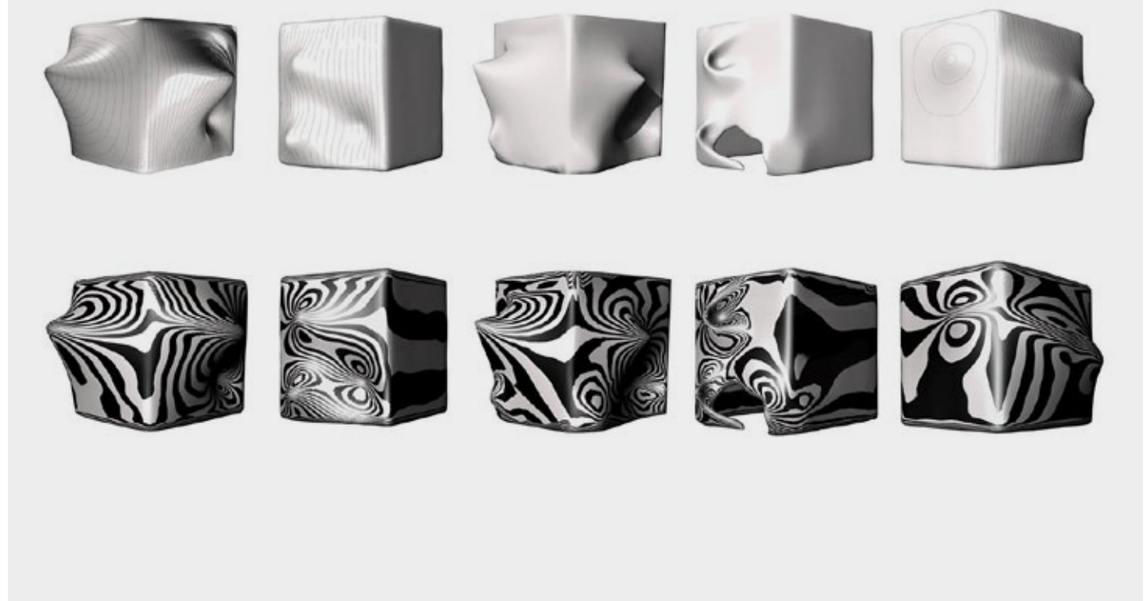


Fig. 5. Pictures showing curvature analysis on soft surfaces using zebra striping diagnostic in Rhino3d

5
ANALYSING THE VALUE OF DESIGNING SOFT ARCHITECTURE THROUGH EMBODIED INTERACTION AND MOTION CAPTURE TECHNOLOGY

In order to assess the value of the collaboration, an open coding process used in Grounded Theory (Flynn and Korcuska 2018) was used to analyse and identify commonalities by comparing feedback from all participants.

Both authors, the choreographer and one of the dancers answered a brief questionnaire to extract the most interesting aspects from the collaboration. The questionnaire focuses on five topics: 1) The design of the soft interface 2) Differences in ways of working 3) Relevant insights for each participant's practice 4) Outcomes evaluation, and 5) The collaborative aspect.

1. The soft interface
What do you think of the soft interface?

For the choreographer, this exploration connects with his idea of architectural dance, as it is a very architectural way of composing with the body. 'By keeping the bodies hidden, a complete organism appears, it is a new identity'. Dancers and the soft interface together defined a new body, creating architectures of movement in the space.

The dancer found the set-up interesting and enjoyed interacting with the elastic properties of the material. She preferred the interactions that happen closer to each other: 'I felt we were able to create more shapes that were more abstract'. For her, the dimensions of the interface determined how much the dancers could affect its shape.

Author 1 found that the dimensions and the form of the soft interface helped to narrow down the scope of the research and therefore enabled more specificity in the results and the findings. 'The idea of focusing on a bespoke space as a module facilitates the process of digitally speculating on a more complex application by grouping together different formal qualities and growing them in scale accordingly'. In terms of how the interface could be improved, by increasing the numbers of soft interfaces and dancers, more complex spatial configurations would be created.

Author 2 sees potential in the soft interface as a design tool: 'in this augmented relational scale between user and material it is easier to explore and to sculpt form while one experiences in the first person how material behaves'.

2. Differences in ways of working
What did you find different from your usual way of working?

According to the choreographer, movement was mainly led by the soft interface as he tried to achieve what he had in mind, but the interface behaved quite differently from how he expected it to, so he decided to improvise by relying upon the immediate outputs. During the explorations he felt that 'the dancers and the interface defined a new body that creates architecture of movements in the space'. In his opinion, an invisible machine with different elements that work together was created inside the interface, revealing only minimal details of shape that were pure and clean.

The dancer said they relied very much on the directions that the choreographer was giving to them, based on how visually interesting the movements were. She also mentioned that it was impossible for her to understand the results of the movements performed as it was a collective act. 'I felt the interface was the performer and we were the puppeteer or manipulator'.

Author 1 found that the temporary aspect of the physical-digital nature of the set-up was the least familiar to her. In this sense, the act of 'combining physical and digital materials within the design process allows the creation of dynamic systems that open up new possibilities for design across different scales'.

Author 2 found it interesting to use the textile as a 3D modelling tool like the ones used in computer software, to see the difference between them. He also felt that 'it is a time-based modelling tool that captures many potential solutions within the same model, in contrast with regular models which only hold particular states of form'.

Regarding the digital toolset, he thinks a higher number of sensors would help to get a complete form, without the need to re-construct the mesh that is obtained.

3. Relevant insights for each participant's practice
What did you find interesting/useful from your perspective?

The choreographer found it quite challenging to create movement with the constraints of the soft interface, as he could not see the dancer's body: 'You can't think of dance any more. I felt more as if I were using a 3D software'. However, he thought it was inspiring as a way to get into choreography from a different point of view.

For the dancer, the interface operated as a sort of shield. 'I was no longer visually exposed, so my movements or the way I looked were not that important any more'. In order to have more impact on the surface of the interface, they intuitively started to help one another by acting as counter-balances.

What Author 1 found most interesting was the fact that by working motion capture technology, the variety of possibilities was very exciting in terms of the digital visualisations and speculation that this way of working offers. 'Both an embodied approach to design and motion capture technology offer an immediate response to the results of the prototypes being tested'.

Author 2 sees the potential in 'designing a continuum space and having the opportunity to explore in the computer not only interesting forms but also transitions from one state to another'.

4. Outcomes evaluation
What is your opinion regarding the outcomes of the exploration?

The choreographer found it particularly interesting that 'the interface becomes unrecognizable as the dancers deform the corners of it', and that by adding more dancers the whole interface could be blurred. For him, the dot patterns were most interesting and elegant.

The dancer found the anonymity of the exploration very interesting, seeing shapes appear and disappear without knowing who or what they were, e.g. heads coming in and out of the interface. For her, the patterns generated by the synchronized movements of each dancer's fingers were the most interesting, as 'it gives a feeling that the interface is one object rather than three separate humans inside'.

Author 1 thinks that both the physical and the digital results are relevant in the sense that they work as a physical hypothesis to reflect upon the relationship between body and spaces in terms of experience and the relationship between form and matter. From the point of view of the textile design, 'the image of several bodies interacting inside an elastic space blurs the notion of clothing, expanding its meaning towards a spatial configuration of bodies and soft surfaces in which one becomes the other, making them inseparable'.

Author 2 believes that they are still at an early stage, but that they present many possibilities through the variety of parameters that can be modified according to a specific design task. Potential translations into architecture include the structural performance of a particular material, its qualities or other rendered properties. 'The principal value of this toolset is as a form-generation or form-giving process similar to a sort of explicit modelling tool, but in this case mediated by analogue inputs'.

5. Collaborative aspect
What do you think about the collaborative aspect of the project?

The choreographer considers the collaboration as an 'invitation to think differently, e.g. to imagine a wall based on body instructions which brings a very interesting aesthetic. You can arrive at the conclusion of having a wall with dots'. The dancer noted that 'working with an interface that manipulates the shape of the body' was interesting to her, as dance is related very much to the shape of the body. She also mentioned that the collaborative aspect also affected their understanding of the space, as it became more relevant by being defined by the interface.

Author 1 considers the collaborative aspect to be essential when it comes to bridging two disciplines, and that in the case under discussion in this paper, 'the collaborative aspect becomes not only a co-shape process involving different stakeholders, but also the material'.

Author 2 sees value in collaborating with other disciplines, as 'different perspectives and ways of working convey in a specific research motivation, contributing to creating new ways of working and new aesthetics'.

In the next section, a brief analysis of the main findings based on participants' feedback is provided. Table 2 offers a more precise picture of the main feedback from each participant in order to compare and identify the common points in relation to the topics.

The following commonalities were identified:

a) Both the choreographer and the dancer found the fact of not seeing the body/outside challenging, as their interaction was mediated by the soft interface (Topic 2). From the point of view of the choreographer and the dancer, not seeing each other while performing forced them to find other ways of communicating, through an external element (soft interface) that simultaneously shaped the way the dancers interacted with each other.

b) The choreographer (Topic 1), the dancer (Topic 5) and Author 1 (Topic 4) coincide in their opinion that the soft interface, when interacting with the bodies, becomes a whole new entity.
Whilst the choreographer and the dancer identified this new entity by relating to it through body and movement, Author 1 observed that by seeing it as an extension of clothing, a transitional state between clothing and architecture creates a new ontology.

c) The choreographer (Topics 2 and 3) and Author 2 (Topics 1 and 2) agreed on the potential of the soft interface as a body form-giving process.
Interestingly, both the choreographer and Author 2 saw the interactions between the soft interface and the dancers as a 3D modelling tool.

d) Author 1 (Topic 2) and Author 2 (Topic 2 and 3) consider the particularities of the physical-digital set-up especially relevant as a tool that opens up new design possibilities.
For Author 1, the physical and digital set-up brings a new design space for exploring the materiality of textiles on different scales.

e) All participants perceived that there is value in working across different disciplines as it provides a different way of thinking about one's own practice, as well as news methods and aesthetics (Topic 5 and Topic 3, dancer).

6
CHOREOGRAPHED MORPHOLOGIES: TOWARDS A HYBRID METHOD FOR SOFT ARCHITECTURE

The motivation for this research was to explore other ways of designing soft architecture based on direct experience with the material through embodied interaction and motion capture technology. When looking at the existing methods that have been used in architectural design based on a physical-digital set-up, the majority of them use the body as an interface to produce a form or interactive spatial experiences, often using static and rigid materials. Thus, they do not contemplate a soft and elastic material engagement through embodied interaction as a system that is able to inform the design of space. Consequently, knowledge relating to the spatial experience of a soft space is somewhat limited. Through a case study, this research has demonstrated how an embodied approach to soft architecture contributes to gaining material and spatial knowledge at different levels (body-material, material-space and body-body) across disciplines through a collaborative process that uses the expertise of dancers, textile designers and architects. The property of the material that this research explored is that of elasticity. The findings show

that when one is confronted with that property in a direct spatial experience, its materiality is revealed the moment the textile changes its state from relative relaxation (pre-tensed) to maximum tension triggered by the body, creating a space. This encounter enables making meaning from the value of the dynamic qualities of the textile-body ontology in relation to the spatial experience (inside) and to the form expressions in a very immediate way, thus facilitating processes of creative ideation and speculation, as one can immediately reflect on potential applications for architecture. The main findings that the authors identified are as follows:

1) The combined approach of choreography and motion capture technology offers a co-shaping process in which space is shaped by the direct experience with the material, both in the physical and the digital realm.
2) The use of a physical-digital method offers a set of physical and digital morphologies (the form-giving process), enabling the exploration of a new soft form vocabulary.
3) The use of an embodied approach offers the opportunity to grasp the dynamic and spatial qualities of the body-material interactions. It enables an immediate understanding of the materiality of the textile with regard to the creation of space (inside-outside) and the relationship to others that share the same space (the meaning-making process).
4) Working collaboratively enables new perspectives to be brought from other research fields. In the case presented in this paper, working with dancers as experts on body movement contributed to the generation of more precise outcomes of the form expressions as well as feedback from first-hand experience (possible future users).

Choreographed morphologies aimed to offer a new method for designing soft architecture by re-connecting the body with space by means of an embodied experience. Although the outcomes of the method presented in this paper are not definitive, they prove the method's potential as a way to open up new design processes and new ways of interacting within a soft space. It brings a new perspective on how the dynamic qualities of a soft and elastic material can be used to inform the early stages of an architectural design process. Thus, the resultant space would also affect the way users interact within the space and with others. It would allow them to have a more personalised spatial experience, enabling them to modify parts of the walls, windows, facades or other architectural elements according to their needs or motivations.

Involving a larger group of participants, and using larger hard and soft material systems, would allow the project to grow in scale and to further elaborate the body-material interaction in both the physical and the digital realms. Including architects, dancers, embodied interaction design experts, textile designers and users during the design process would enrich the insights into designing soft architecture and would open up a co-design process for soft architecture design.

ACKNOWLEDGEMENTS

We would like to thank the Salvatore Siciliano company, Dr Oscar Tomico from Elisava Barcelona School of Design and Engineering, Dr Norbert Palz from Universität der Künste Berlin, Dr Delia Dumitrescu from The Swedish School of Textiles, University of Borås, and Professor Clare Johnston from the Royal College of Art for supporting this research project. This work was supported by the Marie Curie, Horizon 2020, Research Grant Scheme, grant No. 642328, ArcInTexETN.

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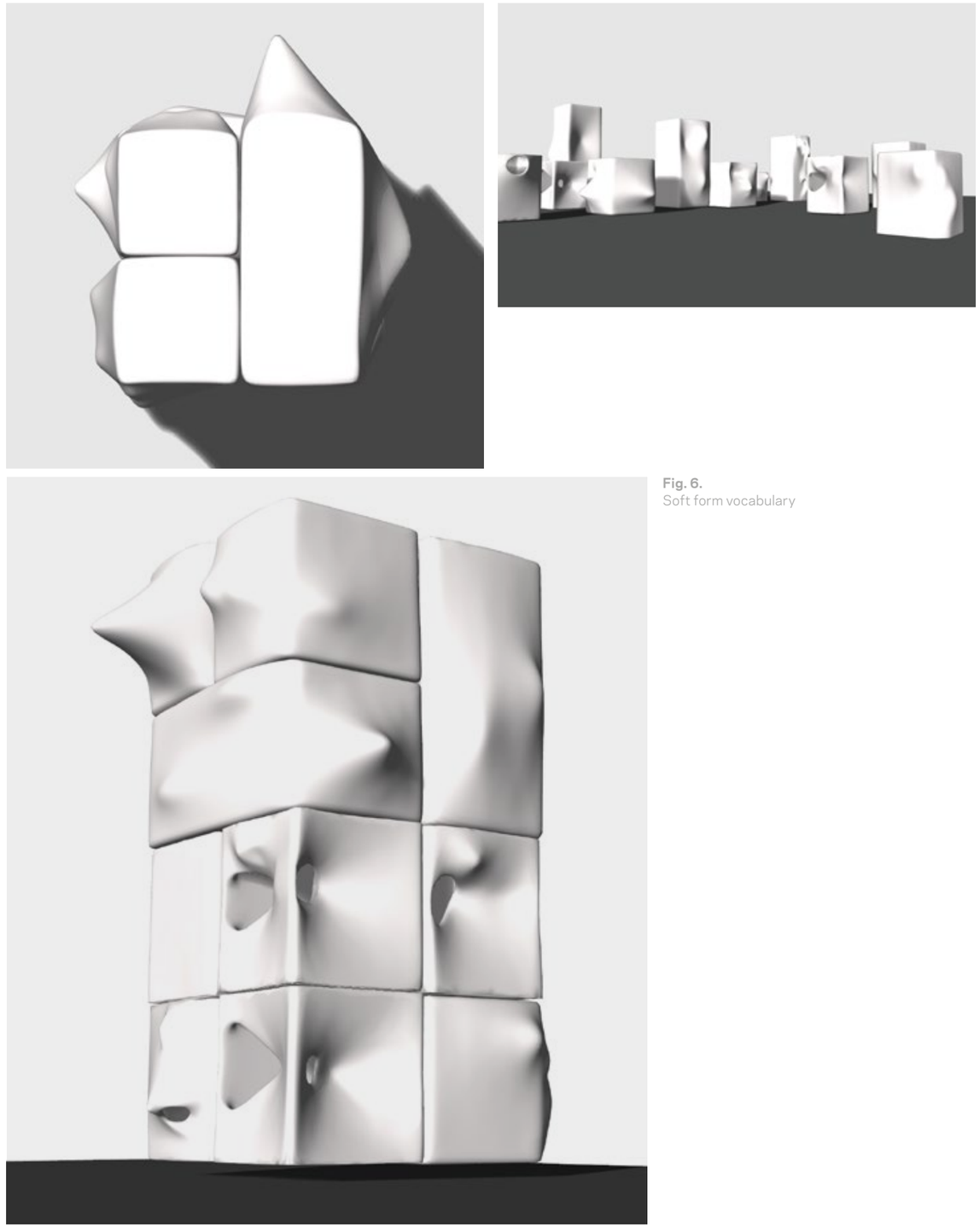

Fig. 6.
Soft form vocabulary