Algorithmic Bodies

The Movement of Surface Structures

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ABSTRACT

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Algorithmic bodies, by means of additive fabrication, is expressed through the interaction of body and material. This work articulates the interdependence of body and material to shape formwork responsive to our sensory experiences. Therefore, having more sustainable methods to making machines and devices we work with every day.

In this work I attempt to establish language, methods and processes through which sensory experiences inform the way we work with tools and material. This results in the production of a series of iterative (repeating) algorithmic generated formwork that express the relationship between body, movement and material. The formwork comprises yarn, wood and plastic by the application of crochet and the assembly of geometric forms.

The interdependence of body-material is explored through artistic algorithmic applications and methodologies of crochet. The body becomes an additive printer or knitting machine through consistent repeating body movements, resulting in material algorithmic models. The body moves the hook and yarn into slip knots, chains, and stitches to produce textile. While each chain or stitch appears discrete (a single unit), it is always in continuous relationship to the previous and subsequent loops. Mathematics often demands discrete quantified splitting of experiences. However, like crochet, these experiences are always in a state of continuity, relationship and interdependence. As with written words, breathe and sound are split into letters. Through typed and printed text, we partition continuity into discrete units.

However, the body is a sensory-based responsive organism in constant relationship with its immediate environment. Continuously, it seamlessly internalises externalities and externalises internalities. The environment, in which the body is situated, is made up of material. Through crochet, iterative patterns and material, body knowledge is acquired through living experiences — in a given time and place, i.e., the immediate environment.

This work is situated within a living community; thus, it was essential to reach out to people in my local and global communities to discuss textile, mathematics and art through crochet and additive fabrication. Outreach has been in the form of social crochet get-togethers to share body knowledge through body-material interaction. From here we can establish language and autobiographical methodologies to inform the way we make our daily essentials.

CONTENTS

1 INTRODUCTION

Making bodies from algorithms is an interactive process by means of motion, body, material and entrainment. Through motion, the body formulates what happens. Simultaneously, the interdependencies and limits of body and material are what inform affordances. Relationship in our immediate environment informs what we do and the materials to do them with. Our own bodies inform the movements and limits of the work, in this case, the formwork. However, the relationship between a designer and a programmer is often about the tension of desire and function: the designer attends to what could be and the programmer attends to what is functionally possible. However, we can merge this relationship in the body and resolve the tension by attending to our own sensory experiences in relation to material.

To put this more simply our bodies are always responding to what is around us. This could be atmosphere, material and people. The things we make are always in relationship with ourselves, with our environment and with our communities, as well as a response to the materials our bodies interact with. Therefore, the techniques we apply to make the things we need every day are culturally and viscerally embedded in what we do. And what we feel we need is also an expression of our values, and what we do with our time and what we make with our time are also expressions of our values.

The tension between the designer and the programmer is a form of resistance. So, what if, the programmer no longer resisted what could be, and the designer no longer resisted what functioned. And instead, they would experience 'what is' through sensory experiences by listening to each other while being aware of their own internal sensations. By listening carefully to ourselves and each other we can acknowledge these tensions and work through them to achieve more complete and comprehensive outcomes.

Therefore, this work explores the affordances and limits of material and algorithms, while also establishing relationships through outreach in local community. The algorithmic artworks submitted in 2020 (5 Publications) are explorations of material through mathematical and physical language. Here the aim is to find language in these academic cultures that are typically removed from our everyday (non-academic) experiences and relationships. Meanwhile I also established local events and get togethers to discuss these same forms through everyday local interaction. Both of these communities need more opportunities to intermingle, such as through everyday encounters and shared spaces. These moments become the glue to enmesh our everyday with academic pursuits, while simultaneously sustaining an awareness and relationship to our immediate environment. That being said, it is extremely difficult to dismantle an ivory tower whose existence feels very far removed from everyday reality, our environment and essential bodily needs.

I seek to transform mathematical and physical constructs in academia into everyday realities through shape, form, clay and fibre sculpting, drawing, artwork, get-togethers, and everyday encounters. To make these privileged and detached academic structures and language more everyday, I reach out and share my experiences with people in my immediate local community as well as my global online communities. While it is important to explore different ways of thinking and expressing, I feel quite isolated and detached

when I do not integrate these experiences into my everyday. Some of the ways I have shared algorithmic crochet in my immediate and extended communities is in section 4 Outreach & Participation. This section includes different types of outreach: presentations, one-on-one and group meetings, attending exhibitions, and arranging local and online get-togethers.

2 SENSORY EXPERIENCES

The fields of physics and mathematics uphold beliefs, perspectives and performances of objectivity, omitting other ways of expression from their work. This space is where the study of electricity and algorithms happen. Moreover, when these themes are being applied in formal institutional and industrial environments, there is a severe lack of sensory experiences, which in turn, impacts the work and the outcomes:

"The bodiedness of people gets lost, especially in a sedentary workplace dotted with scores of chairs, where human labour is imagined not as flesh and muscle but as measurable economic deliverables, organised by roles and tasks." (Sara Hendren 2020).

The culture of a workplace informs the values and investments of the organisation. And the affordances of the workplace inform the permissible movements in that environment:

"a culture is similar to a corporation in that it's a culture's best interest to perpetuate itself…because we are part of this culture, we are really unaware of the ways that we perpetuate sedentary behaviour." (Katy Bowman 2016).

By involving bodily expression during these working processes, we also attain understanding of them through bodily processes, thus cognitive knowledge becomes emotionally and physiologically integrated. Where the body informs the mind about the world, not solely the mind convincing the body to change, nor move from cognition of visual stimulus nor verbal/textual instruction.

The mechanistic approach to the body, i.e., body mechanics, demands that we cognitively comprehend movement. This is instead of experiencing bodily sensations that move the body towards responsive movements. Additionally, in literary cultures, central vision has primacy over peripheral vision (not to even mention the other senses and modalities). Bodily ways of knowing go unrecognised, belittled and undervalued. The written word becomes law and meaning is deciphered from "between the lines" that are approved of by top-down hierarchies: where the head rules the body.

In this work, we move towards an appreciation and regard of the body and sensory experiences through the relationship with material. This process also works towards dialogues through non-binary language and non-linear approaches that value sensory experiences. It also recognises the broad and diverse spectrum in which sensory experiences are internalised, then in turn articulated through cognitive processes, gestures and movement.

Boolean and other binary logics afford two states: yes/no, true/false, and male/female. "Although it takes two to make a binary (and set up the heterosexist paradigm), clearly inequalities are expressed in the tendency to privilege one side of the equation over the other - with positive and negative attributes accordingly." (Winnie Soon 2018). Some challenges come from binary memory of 1 and 0, or on and off, as well as in electronics where connectors are male-centric and heterosexist binary of male (primary, 1) and female (secondary, 0). Binary dualism is the default for logic processes, where digital pathways are typically split up into true or false, or yes or no.

> The zeros and ones of the machine code seem to offer themselves as perfect symbols of the orders of Western reality, the ancient logical codes which make the difference between on and off, right and left, light and dark, form and matter, mind and body, white and black, good and evil, right and wrong, life and death, something and nothing, this and that, here and there, inside and out, active and passive, true and false, yes and no, sanity and madness, health and sickness, up and down, sense and nonsense, west and east, north and south. (Sadie Plant 1997, 34.)

Upon the examination of the binary dualism construct, we can explore notions of energy and power in the sociotechnical digital world we presently live in, for example, electronically, computationally, or relationally between people. Points of connection are reduced to detached reproductive causal mechanics that have little or nothing to do with the fluid interdependencies of emotions, relationship and community: which are more akin to fuzzy logics, probabilities and intersections.

The way we internalise knowledge and know-how influence our perspective of our environment and the people around us. Therefore, our electronic and computational paradigms and metaphors need to respond to the way we feel and relate to each other, and not the mechanised functionality of human reproduction. Moreover, these conventional stories told about the mechanics of electricity also excludes people in our communities who do not experience the world in binary states and relationships. Fuzzy logic, a logic system based on probabilities or percentages, can stand in as an alternative to binary states: one and zero. Fuzzy logic also affords interrelational states, overlapping ranges and intersectional occurrences, which can be visualised in Venn diagrams through overlapping intersections: $\cap$.
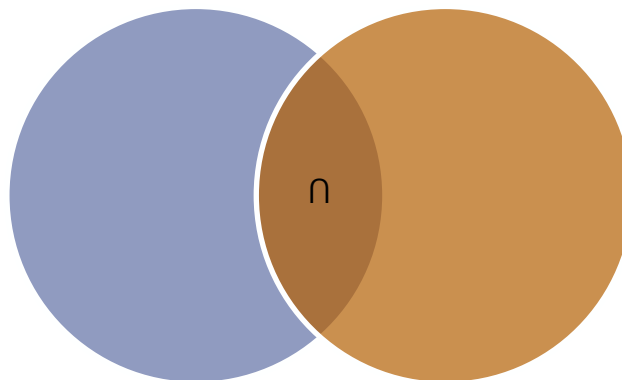
FIGURE 1. Intersection of two groups.

As we migrate away from binary logics, we can explore alternatives such as fuzzy logic, ternary logic gates and other non-binary logics, states, relationships, and systems — which better represent the continuous sensory experience in relationship with the immediate environment.

In the following sub-sections in this chapter, we explore the body-material journey by beginning with body-knowledge, followed by emotional detachment, then ending with the interdependent relationships of beings, material and space. The first sub-section is Body Knowledge, here we explore different ways of attaining knowledge and how affect (bodily expression) is the externality of our internal experience, then how that might be internalised by those we share space with. After which is 2.1.1 Objectivity and Melancholy, where

perception and values of objectivity are interrogated. This is followed by 2.1.2 From Discrete to Continuous, where the migration from discrete (individual pieces or particles) become one seamless continuous form. Then at the end with 0

Sharing Breath, where we tell our stories on our own terms by sharing breath, not through objectivity, nor measurement of discrete units, but with our continuous breath in synchronicity with voice and being.

2.1 Body Knowledge

To start with one's own place, experience and skin. To be in the world as you are. Then reach out from there by attending to one's own sensory experience. From here, we can cultivate an awareness of our material environment through, for example, somaesthetic methodologies and practices. Sensory experiences can be described as our senses. In this work, exteroceptive sensory experiences are those that happen outside the body, while interoceptive sensory experiences are those that happen inside the body, i.e., within and including the skin.

However, in scientific studies when people observe people, the affect (*expression*) of researchers conducting studies can be emotionally distant or detached (as though the researcher detaches their own living experience from the research environment). The question here is then, what are the causal implications of emotional detachment in research, particularly when people observe people. The way bodies interact and share space indicate the affordances of that space and situation, whether these bodies are people, furniture, textiles, trees, stones or any other body or material. The reason this is important to this work, is that if we are making things for ourselves and each other, we need to understand how our current methods are disruptive to seamless body-material relationships.

One example could be, haptic transference, which can be described as the transferring of sensory experiences to the body through various receptors in the skin, the proprioceptive sense (awareness of limbs/body in space) and the interoceptive sense (awareness of internal body sensations, e.g., digestion or heartbeat). The haptic transference between our material living environment is constant. We are always receiving sensory input through this mechanism. Another example of seamless body-material relationship is our microbiota. These microorganisms live on our skin and in our gut and we pass them on and pick them up from everything in our environment. The equilibrium of these microbes is dependent on our environment.

Our senses respond to the body's interoceptive (internal) and exteroceptive (external) experiences, through seamless reception. The resulting feelings collectively comprise our experience of, for example, working, playing or socialising in a given space. Such experiences, in turn, inform our behaviour, moving our interactions with each other and material in the environment. Through visceral responses, these experiences seamlessly shape the forms we draw and sculpt, which, in turn, inform the choices we make. Thus, the influential role of experience in our daily interactions suggests adopting co-making approaches that integrate the body-material experience. In the absence of real-time responsiveness, (industrial) design attempts to anticipate behaviours and functional objectives through detached processes, e.g., geometric computer modelling. In short, if we care about experience, which informs our movement, behaviour and culture, we need our daily experiences to inform the co-making of things we use everyday.

Because these situational experiences are internalised into the self, which become bodily expressions of the system in which we inhabit, participate in and express. "The notion of decolonisation dissolves the boundaries between self and collectivity, between the individual and the system." (Roxana Ng 2011; Roxana Ng 2018). Through crochet, this work explores the relationship of body-material, which can also be expressed as the relationship of the self and the system. The crochet works, i.e., the material, are the system, while the body is the self. Through the process of making the body makes and moves the material by means of the material affordances. This means that the body moves as a response to the attributes of the material.

2.1.1 Objectivity and Melancholy

Observation is about perception, even extremes such as neutrality or objectivity are forms of perception, and all are coming from the body. Instead, my aspired perception is through a feeling of consistency, a feeling of resonance with the environment I inhabit. As well as with an internal awareness of emotion. But how does one find or express this sustainable feeling of being in one's own skin.

Explorations of my own emotions and feelings informed my research direction towards Silvie Pic's work on geometrical structures of melancholy (1990; 1998; 2005). Her illustrations of the torus expressed meaning of breath and breathing. I understood it to represent the seemingly *negative space* under the diaphragm where digestive organs reside. Negative space can be interpreted as the inhale of breathing, i.e. the production of vacuum and negative pressure from the nose to the toes. The cyclic rhythm of inhalation and exhalation coordinate the muscles required to breathe in whole-body synchronicity. The torus is also the doughnut-shaped flotation device that keeps you afloat: 'lifesaver' or 'swim ring', elevating the body on every deep inhale.

Silvie's structures are toroidal, curved and round on the outside, yet their internal structures are rigid, square, orthogonal, like the rooms in a building. It is the hidden patterns of our breath that are the bodily expressions of living in rectangular buildings, and orthogonally constructed spaces — as those in cities and urban areas. Every right angle and straight line is an interruption of the torus' wholeness.
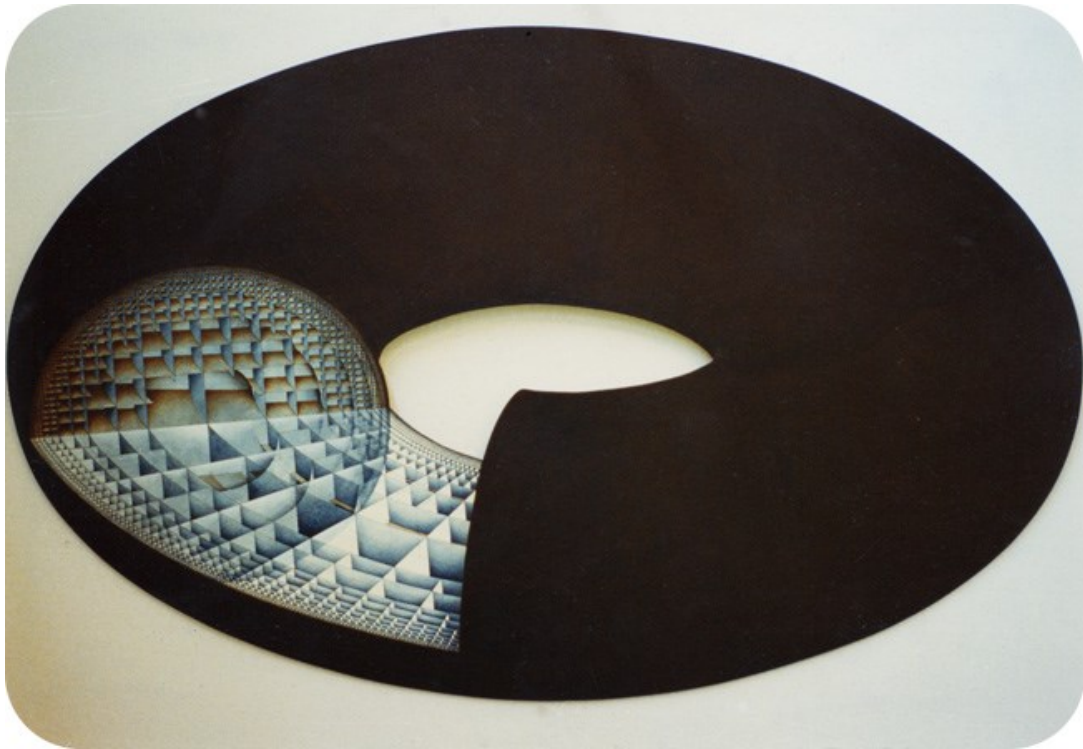
PICTURE 1. Tore I, Silvie Pic, 1990.
Reproduced with permission. http://www.documentsdartistes.org/artistes/pic/repro2.html

Cells, however, are round and form circle-packing structures or dendritic networks, not square grids like our cities. Yet we live and breathe our cities, buildings and rooms. In Silvie's "The Anatomy of Melancholy" (2005), she comes from a place of spatial intuition which she defines as an "intermediary between the vague visual image and a sensation, the sketch of a movement". She continues describing her process as:

"The spatial pattern and the sketch of movement—original, still incomplete—are those of a space or a force that, from a dense and dark centre tries to extend in six directions of space but that, almost immediately, curves and comes back over itself." (Silvie Pic 2005).
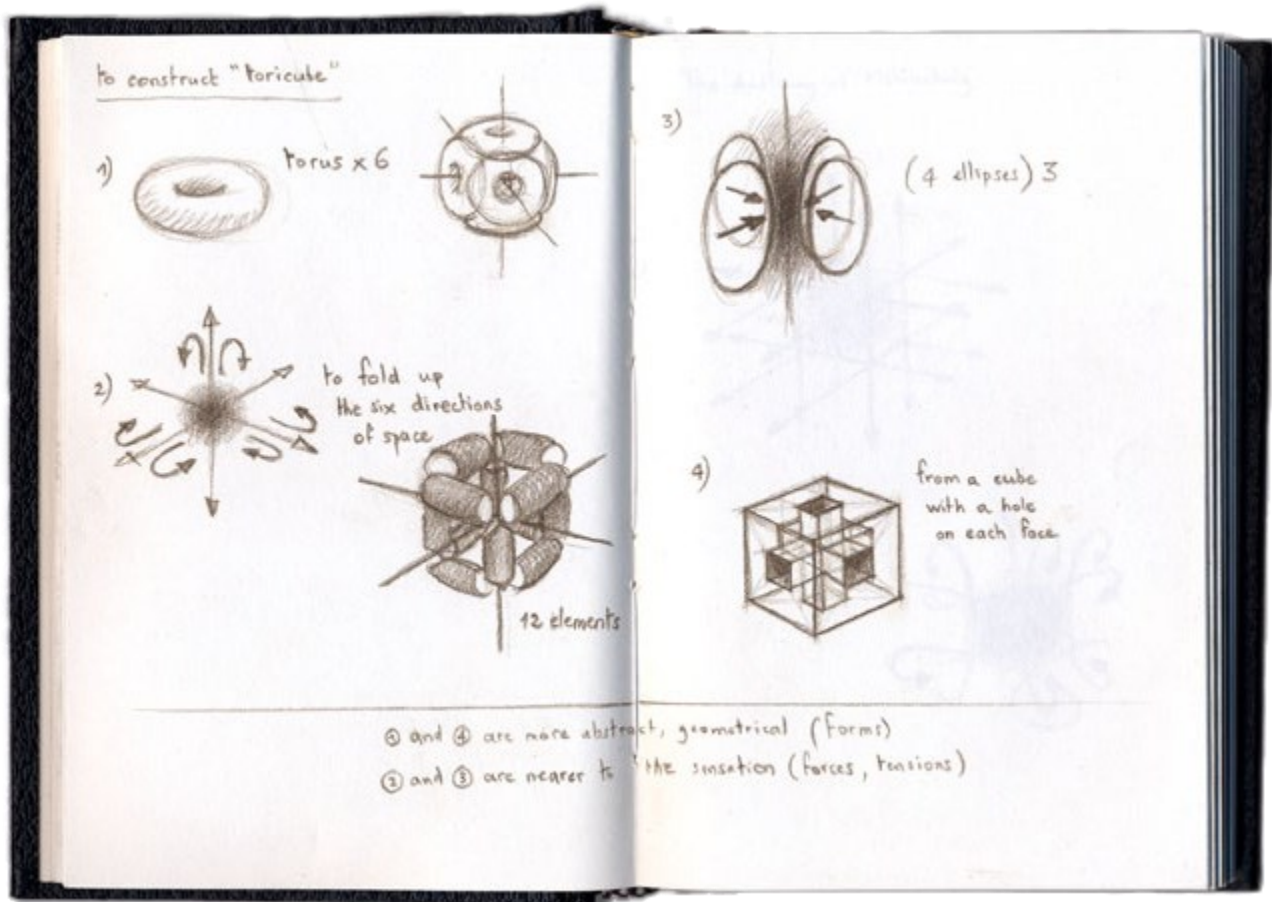
PICTURE 2. How to construct a toricube (Crayons de couleurs sur papier, 21 x 15 cm).
Silvie Pic, 1998.

It is here where melancholy begins to transform into gravity. Then further exploration of melancholy with the shape *toricube*:

> The geometrical structure is the overlapping of six tori with diametrical plans situated on the six faces of a cube (each big circle being inscribed within a square). (Silvie Pic 2005.)

The cubic structure of breath and breathing in this *toricube* encases breathing until our existence, movement and rhythm is square and rigid. Much like the rigid, stiff movements of frustration and mechanical automation, without mind nor heart. Even though our bodies are more water-like, with limbs that sway like young branches of trees, the patterns we follow in our cities take sharp 90° angles every time we turn a corner. This habit of squareness in the structures of our daily living is generated by the formation and resistance of the square. Thus, making our existence equally square, and ultimately making our breathing shallow and tense, restricting flow of emotions and movements in the body to certain prescriptive and approved norms.

How does one then traverse from melancholy to sustainability, from a recluse inner depth to a harmonious existence with the environment and the spaces and communities we inhabit. Returning to the "six directions of space" and where the line "almost immediately, curves and comes back over itself", we can observe our own activity of breath in space,

and instead of being boxed into a cube, finding a sense of synchronicity. Discovering an internal rhythm through breathing and heartbeat, following the cycles of air and (what should be) the involuntary muscles for breathing, this rhythm of breath is what resonates speech, and constant and consistent motion in the body.

This feeling of synchronicity is in the waves and spiral motions of the Earth, these shapes create a sense of joy, happiness, contentment, elation and wonder. Shapes such as the stars on a cloudless night, six pointed snowflakes that fall on winter gloves, the first winter frost that glitters in the streetlight, cumulus clouds that journey overhead, and above all the ribbon-like polar lights waving in the dark sky. It almost becomes a recipe for life to gather feelings and maintain an equilibrium. Because the way feelings are internalised ultimately change the perception of experience, and to observe in a balanced manner requires an embodied state of equilibrium.

The violence of objectivity upon the subjective (R. Danielle Egan 2004), imposes a dualism of mutual exclusivity. Generating contrast and polar opposites, the positive and the negative, the objective and the subjective, just like the binary of 1 and 0, or on and off. This process lacks wholeness, or the awareness of body knowledge and its relationship to its environment: a form of detachment or nonattachment. "An attitude of detachment is characterised by the absence of emotion when we are presented or confronted with something." (Roxana Ng 2018). In other words, emotional detachment is to hide from, or avoid, experiencing. Therefore, one of the goals of this work was to attend to my own body and feelings while observing others. In phenomenological terms, a prereflexive state (Susan Kozel 2008), being present in and aware of my body while engaging with and observing my participants. Hereby learning how my modes of being are changed through my perception, view and standpoint (Mary Evans 2003), and in turn influence my choices, decisions and behaviours. Prereflexivity is an embodied awareness of one's own internal sensations of proprioception and interoception through connective tissues and the fluid nature of motion. This affords the body to be in place and in synchronicity, present and aware, and able to express. Here observations are emotionally internalised.

2.1.2 From Discrete to Continuous

The interdependence of body and material can be demonstrated by the affordances of yarn. The lengths of material offer discrete repetition in continuous motion. The yarn establishes pathways, while the movement results in the shape, or here, the stitch.

Algorithmic surface structures express the incremental, and sometimes incomplete, process of crochet. This procedural work applies various yarns, and some acrylic paint, to grow spheres, hyperbolic planes and hexagonal tessellations. Each demonstrate properties of surface area and structure: spheres have minimum surface area to maximum volume; hyperbolic planes have maximum surface area to minimum volume; while hexagons make regular tessellations which are flat, thus no curvature, unless it lays upon an unflat form. The tessellating regular hexagon also has maximum area with minimum perimeter—much like bubbles packed together. Cell-by-cell, or here, stitch-by-stitch, we appreciate the incremental and entwined process of growth and becoming.

Hexagon pseudocode:

```
function slipknot
function magic_circle
function row_1: {var i=0, while i<=6:
            corner(dbl_stitch), i+=1}
function row_2: {var i=0, while i<=6:
            corner(sgl_stitch), i+=1;
            var j=0, while j<=2:

            edge(sgl_stitch), j+=1}
function row_3: {var i=0, while i<=6:
            corner(dbl_stitch);
            var j=0, while j<=4:

            edge(dbl_stitch), j+=1}
function end
call slipknot
call magic_circle
call row_1
call row_2
call row_3
call end
```


PICTURE 3. Pseudocode for a crochet hexagon.

PICTURE 4. Joining hexagons with seams

PICTURE 5. Seamless joining of hexagons with Join-As-You-Go (JAYG) stitch.

2.1.3 Sharing Breath

> The opportunity to explore my place in the world and to share my story through breath and body in an oral performance strengthened my inner voice and ignited within me a burning desire to continue expressing myself through orality and embodied ways of writing. (Candace Brunette-Debassige 2018.)

The sharing of breath can be understood as bodily expression. The way of being in the world as we are at any given moment. The breath is a requirement of the living body, something in constant motion. By means of nutritional motion the body inhales nutrients, and exhales energy converted to carbon. Our stories are equally thus. Though beyond the particles of input and output, we come to the exchange of energy and touch. This in-between space where we can zoom into the space between our bodies and the material around us:

> How we meet the built environment depends on both bodies and worlds. There's no custom-fit solution arriving for any of us, but if you could zero in on that movement of body-meets-stuff—flesh up against metal or concrete or plastics—if you could slow down the tape right at the instant of connection, you'd see it packed with information. (Sara Hendren 2020.)

In this space the material meets immaterial. It is in the way we experience space, each other and our feelings, informing the movements of our stories of what we need, as well as how and what we make. In the academy the immaterial is locked in the studies of theology:

> …the spirit, which is relegated to the domain of religion. The spirit 'belongs' to theology and religious studies, not to other disciplines; this indicates the depth to which our thinking is circumscribed by existing disciplinary boundaries. Much of critical teaching is implicated in the mind-intellect versus body-spirit divide. (Roxana Ng 2011; Roxana Ng 2018.)

This in-between space where body-meets-world is a very real and visceral experience, while also being ubiquitous and invisible. However, in the spaces where industrial design happens, the design of the things we need and interact with everyday, detach our bodily experience from the design process. Therefore, what body paradigms do we bring to a space and to the things we need everyday? What are the affordances of a space or community? And what stories do we feel safe or confident enough to articulate? And, perhaps more importantly, which stories or experiences are silenced or not permitted in our design spaces?

An expression of storytelling is relived through our retelling of it. The production of storytelling is a living breathing sharing experience; it requires a listener and a teller. The telling is always in response to the environment and the listener. The internal experience of the teller informs the story. This is not like reading a book where the words are prescribed, and tone is encoded. Storytelling is a living breathing shared experience. The

production of words through unmemorised hand gestures or speech is immediate and present, the mechanisms the movements and expressions are responsive to that moment in time and place. Therefore, they require attention, attendance and practice in our everyday. We internalise the expression of stories from those around us. If those stories are in conflict with our internal realities, this creates discord and internal dissonance. To live and breathe one's own story, requires time, a receptive community, some solitude and a healthy dose of courage. A community that can listen and acknowledge individual experiences afford the voices in our communities that are not mainstream nor popular. They can attend to our lived stories as living experiences and accept them as such. Such an interdependent relationship establishes culture and community where one's own story on one's own terms is valued and heard. Our stories are alive, they are not static tomes of prescribed text locked in institutions, recorded in encyclopaedias, or other objectively recorded or memorised prescriptions. They become stories through our interaction with them. For a story to be alive, it must be imagined, articulated and expressed; otherwise, it is dead, preserved in a tomb.

The articulation of stories is situated in the body. And, importantly, identifying whose bodies are articulating the stories of experience, self and system through body expression. "As part of the institutional structure created historically to preserve the privilege of certain classes of men, the academy is no exception to the entrenchment of white male privilege, values, and knowledge based on men's experience of the world." (Roxana Ng 2018). Therefore, here we participate in challenging privileged "white, male assumptions" (Roxana Ng 2018). Then if we look at our cities and built environments, we need to consider where the data to design these spaces, Sara Hendren (2020) reads from Viktor Papanek's book "Design for the Real World": "Most human factors design data, also unfortunately, are based on white males between the ages of eighteen and twenty-five. The data has been gathered almost entirely from draftees inducted into the military branches.".

The way we tell the stories of computers, electronics and energy, as well as other topics such as physics and mathematics, inform what we believe about ourselves and each other. They also inform the mechanisms we see, observe and make. Therefore, if connection is articulated as a reproductive causal mechanism, our connections in computing and electronics are limited to these binaries. Instead, the inquiry into The Space Between (Joanna Brouk 1981), we can ask about how to situate our stories to place, and not in alignment with imaginary constructs of space. Through these stories we can articulate our immediate experiences and respond accordingly to our immediate environment.

2.2 Algorithmic Modalmedia

The algorithm is the method, the modalities are the sensory affordances, and media is the way information is delivered. Crochet is a way to generate touch, haptic, interoceptive, proprioceptive, and visual information through an iterative algorithmic expression. Through the bodily affordances of receiving information, the body can inform the mind through bodily awareness. "As neuroscience now appreciates that the brain is in a body and the

body is in the world." (Patrice Duquette 2017). This way, the body is the mind, and the entire nervous system is the brain. Through these pathways the body experiences the immediate environment, which is always in immediate relationship with the body.

A lived experience is all anyone knows. Beyond that is speculation, myth and tale. Stories are a vital part of human existence. And each individual has a their own. However, for a long time, only a few certain types of stories were given voice, and if anyone strayed from those stories, they were persecuted. This leaves a disconnect between the stories of local cultures and communities that belong to place. Stories that come from place are the stories we tell that connect us to where we live, how we live and how to live from the land in which we inhabit. Without these stories, we lose our sense of belonging, the feeling of being home.

In present day, many of us, especially those living in urban and city environments suffer from depression, or living with a constant feeling of emptiness and melancholy. Moreover, through media, including social media, there is a lack of everyday, and instead it is smothered by dominance, aggression and positivism. Ultimately, media only approves of the expression of a select few who generally look the same, speak the same and act the same. The algorithms behind the media of popular culture are not *true*, instead "Algorithms are opinions embedded in code." (Cathy O'Niel 2017).

Self-similarity and symmetry of fractals, like snowflakes, are beautiful. Fractals repeat, over and over, the same or similar pattern repeats. However, for our communities, what we repeat becomes who we are. What we value is what we repeat. Therefore, it is up to us to decide what it is we iterate, what it is we want to bring into this world and what we want our world to feel like to live in. It is the variation in pressure which is what makes each snowflake different. This variation in pressure is also what forms the roughness of coastlines, mountains and valleys. Without these, life would not exist, and the land would be a very smooth flat (boring) uninhabitable spheroid.

This lack of continuity and stories from home is symptomatic of the emptiness of media, its lack of immediacy with the everyday needs of self and mutual care. We need a shared space that affords everyday lived experiences and ways to share these meaningful ways of knowing. The system needs greater variation, diversity and inclusion, and particularly, the willingness to listen to non-prescriptive narratives. Only then will we appreciate the lived experiences of each other on our own terms.

Computer science consists of coding, artificial intelligence (AI), machine learning and electronics, with conceptual origins in symbolic logic and mathematics. Programming has for the most part been considered to be "women's work" until around the 1950s, as the work was tedious, repetitive and required a high degree of precision. The first programmer or computer scientist (in recorded English history) was Ada Lovelace. However, around the 1960s it shifted, and this work was then taken over by male people. "Programmers are crazy about puzzles, tend to like research applications and risk-taking, and don't like people." (William M. Cannon & Dallis K. Perry 1966). These kinds of people were recruited by IT and TECH companies. Over time this work was incentivised, hiring good programmers became highly competitive. It was no longer tedium and precision; it was a

fast-paced agile lean mean programming machine. Turning the working environment into aggressive, toxic places as people clamour, posture and dominate space to get points, profits or raises, i.e., the proverbial mountain top.

Searching for satisfying experiences feels very difficult in a world with toxic working cultures, or where some resort to staring into their devices instead of engaging with each other. And when discussions feel draining, exhausting and manipulative, as the inherent system of the working culture is played out through internalised hierarchies. It is then no wonder many of us feel more comfortable with our heads in our phones and not sharing space and engaging with each other. The undercurrents of our social interactions are filled with emotional turbulence and unease. However, instead of seeking connectivity and balance, our current working office spaces generate discord, dissonance and social isolation. Where emotional unloading is directed towards the most vulnerable in our communities, forcing them to do other people's emotional labour.

So how do we go from emotional labour to code, in theory, programming is for the most part: not participating in emotional labour. It is avoiding it all together. Because it is easier to speak to a computer than participate in emotional discourse. Therefore, code is not just code, but rather the construct of culture, social interactions and accessibility that suits only certain kinds of people. We need to evaluate the community where coding happens and who is doing it and how. Code comes with the kinds of people that code, their social mannerisms and behaviours, and their human emotional output. Moreover, the more diversity we have in the coding community the more accessible coding is, and more of us will have access to coding, engineering, physics, mathematics and all those priestly topics that have been long hidden away in cloisters. Most importantly, different bodies and experiences are also needed, because different bodies will bring different stories, and this needs to be explicitly valued and articulated.

In the English speaking world, the physics prescribed today is based on the physical experiences of European males of the last 1000+ years, and their beliefs come from that cloistered monoculture. Their proofs come from their way of thinking and living, and are based on the limitations and affordances of that experience. To broaden physics to be open to other ways of talking and writing about physics, we need to recognise and acknowledge experiences of more kinds of bodies. Because our physics knowledge is only as diverse as the kinds of people, and thus bodies, that do physics. Physics comes from movement, or lack of, it is an artform that expresses events in space through symbolism. Symbolism is a very human activity, it helps to condense a feeling, thought or idea, much like words, but in written or drawn form. Therefore, the expression of physics can be opened up to all of us who experience life and wish to communicate our experiences with others through symbolism.

The embodiment of breathing and our rhythm of breathing is one in the same. It is also what cultivates our shape, our form. Breathing requires the synchronicity of the muscles in our torso in time to our environment. This is also what regulates and stabilises the metabolism. As we breathe in, we take in air, the air is combined with nutrients to generate energy, we use this energy to tell our story, to tell of our lived experience. When breathing

out we expel carbon dioxide, the metabolised energy. Just like a petrol-based car, we humans produce fumes with every breath, and how much depends on what goes in. The more we need to burn to maintain our system the more carbon dioxide each one of us expels. The more intuitive our tools, the less energy we need to use them, and the less fumes we produce.

In Susan Kozel's book "Closer: Performance, Technologies, Phenomenology" (2008), she discusses the role of embodiment and sensory experience in a technological context. "Physical interfaces, embodied philosophies, sensory engagement with the world and with others, embodied imagination, the politics of bodies reflected through cities, and even the act of writing: at the center of it are all bodies." (2008). The body often feels missing in the design of interfaces, with so much focus placed on symmetry, form and function.

2.2.1 Co-Evolution and the Geometry of Space

A non-Euclidean space, one of turbulence, complexity and diffusion. Here spacetime bends with perception, with the hyperbolic curvature of chanterelle mushrooms, curly leaf lettuce, or corals: maximising surface area into minimum volume (Margaret Wertheim 2009; Daina Taimina 2012).

> Without any theory nature has figured out how to fit maximum surface
> area into minimal volume. (Daina Tamina 2012.)

Atmosphere and ambiance in an environment can make the space feel greater or smaller, much like hyperbolic planes that allow for more area than the space given. Or feeling bigger on the inside than appearing on the outside, this is much like the Tardis in BBC's Doctor Who series; or the holodeck found on starships the Star Trek™ universe. These imaginary futurisms allow us to explore possibilities of what could be. The turbulent spiral forms found in the air also generate such multidimensionality of space, as we breathe in the air, we become a body in and among this hyperbolic space. Our perception can make us feel larger than life, miniature, or invisible, these feelings can change the atmosphere of the space in which we inhabit, as we take over the room or vanish into the furniture (Brigid M. Costello 2018, 25). Our presence alters our perceptions of space and time, as well as those we might be sharing space with. The gradients of material and bodies in space alter movement and interoceptive balance.

With this in mind, I will discuss my position within the context of interacting and interfacing with material. Through this context I acknowledge sensory modalities and non-visual experiences. However, while crochet can have highly visual demands the movements progress relationally, though linearly. The body moves in relation to the hook and yarn, pushing through voids (e.g., negative space) and pulling through yarn, all while moving linearly along with the length of yarn. The path is defined by the yarn, while the movement is directed by the intention to produce the desired stitch. The ins and outs of crochet fill voids while also generating them, both within the mesh-like material and the space around it. The encoding of algorithms informs the fractal voids (or fractional dimensions of space) as well as hyperbolic voids.

Through body-material study of space, thus voids, we find gradients of space, e.g., the space of water, space with air and gravity, and the space with air and no to low gravity. Gravity offers degrees of viscosity in space: the more gravity, or attraction to the planetary body the greater the viscosity in the void. Each space (or void) with their own degrees of viscosity (or the ability for a body to move through it). Our internal sensations, e.g., interoceptive and proprioceptive sensations, also inform the affordance of movement through a void, that is, in relation to the void's quality, e.g., atmosphere. The atmosphere, form and sensory modalities inform how bodies move through the geometry of space.

Our sensory modalities make up our bodily experience through sensations that respond to the environment and our internal experience. I attribute this to the place where hearing and touch converge, a place where vibration meets sensation and bioelectrical energy. The ear is intimately entwined with the movement of whole body breathing, an experience often held when meditating and/or chanting, where breathing (and sound) is in synchronicity. The outer ear is a spiral helicoidal hyperbolic form that affords the vibration of particles in space to traverse into the ear which resonates in the head. It is a form that expresses the continuous rhythms of breathing through its folds.

If we look at the gills of fish, they are in the same place as our ears in relation to the mouth. When breathing in, muscles pull back towards the ears to draw air in through the nose or mouth, then release when breathing out. While fish take in water through their mouth, which traverses out through their gills, the human body can afford breathing in and out through both the nose and mouth. In addition to breathing, the muscles at the back of our jaw near the ears also support speech, eating, and drinking: muscles also often exercised during social interaction. The coordination of breathing by drawing air in and releasing is an inherent autonomic function. However, this autonomic coordination can be disturbed in environments that are disruptive to our autonomic bioelectrical systems and impose restrictive mechanistic movement.

The body's relationship to space is co-evolutional, we interact with spaces, build them and re-make them, all the while living in and with these spaces. Over time these spaces shape us through the way we navigate and respond to place.

2.2.2   A Mathematical and Physical Phenomenology

The phenomenon of symbolic thinking is not unique to mathematics. Ultimately mathematics is one of many ways to imagine. Crochet and other textile art forms use symbolism to define and demonstrate pattern making. The origins of computing lie in these symbols of fabric making, including weaving, knitting and crochet, e.g., the Jacquard loom, as well as music notation, e.g., the piano player. The formulation of academic pattern making were derived from predominantly male bodies and cloistered religious organisations. Thus, the discoveries and definitions of mathematics have, for the most part, excluded bodies considered to be "not male". The religious undertones of mathematics still linger in academic circles, because it is quite difficult to obliterate thousands of years of superficial gender-based cloistering. Therefore, we need to criticise how mathematics is done and developed, and fields that require approved mathematical

expression, such as computer science, physics and just about all the natural sciences, as well as statistics and data analysis. Not all areas of mathematics are as clear cut as arithmetic, and even arithmetic gets fuzzy when we explore its meaning and symbolism. In short, it comes down to representation of symbols, and it is up to the user to define what the symbols represent. As a tool, mathematics has its usefulness. But when mathematics is taught as a truth, much in the same vein as religions proclaim notions of truth, therein lies the problem.

Because mathematics can be a bit of a fuzzy subject with misleading illusions of certainty. Not to mention the fact that often mathematics needs to be translated into an applied reality, such as code, spreadsheet formula, a measurement or quantity of a material, and real distances change depending on the resolution or scaling ratios. Mathematics is great at drawing lines and curves, but can only estimate a real wave in the sea or a real snowflake falling from the sky.

However, if mathematics is more of an art form, there can be an unlimited form of expression, here it does not matter if it "works" or not. Perhaps a formula or equation is just pleasing to perceive or imagine. Alternatively, the proprioceptive experience of drawing the equation is extremely satisfying. We can learn equations through the illustration of the characters, and develop experiential understanding through interaction with mathematical drawings, formwork, equations and artwork.

I imagine the expression of touch is much like waves through dendritic branching. A wave of energy that traverses skin, flesh and bone. Though when we see, look or gaze, we feel through our eyes. The view informs us, as well as the atmosphere around us, both intimately interweaved. From the waves and temperatures of air pressures, turbulence from motion, or the stillness of stagnation, we feel, and thus experience, atmosphere. Gravitational waves, such as the pull of the moon and sun on the water on our Earth, it ebbs and flows the tides, drawing in and releasing out, much like autonomic breathing. The difference in pressure is the body in constant divergent motion, perhaps: $\Delta p = C \nabla$ (Δ = difference, p = pressure, C = constant, ∇ = divergence).

The pressure is much like the social pressures we feel, or perhaps utterly unaware of, a form of dark matter, intangible, yet ever present. They produce tensions in the body and direct motion, unless we become aware of embodied feelings.

> By learning to be in my own presence and sit with difficult emotions, I began to understand and disassociate from the colonial messages I had internalised and the years of tension absorbed by my body unravelled. (Candace Brunette-Debassige 2018.)

A phenomenology of computer science would reveal hidden misconceptions about electronics and, thus, code. Software and hardware have an intimate relationship and the line is often blurry, much in the same way our bodies are intertwined with our technology. The integration of body, software and hardware is very much in parallel with body, mind and stone. As we approach data-driven technologies through the data produced by our modalities, we need to explore how we feel about this. The stone is our first technology,

along with plant fibre and wood. We become like the material we work with, and the peoples who are still living to the rhythms and spin of the earth and who sustain the ever present feeling of continuity to their environment: there is a wisdom found in stones.

> …stones were the most perfect beings because they were self-contained entities that had resolved their social relationships and possessed great knowledge about how every other entity should live (Vine Deloria 1999.)

Stones help us find a place of calm, because to work effectively with stone, one must be in a state of emotional equilibrium and wholeness, otherwise you may cause harm.

2.2.3 The Feel of the Algorithm

> You let the material tell you where to go, and it tells you at every step what the next has to be because you're integrating with an overall brand new pattern in mind. (Evelyn Fox Keller 1983, 125.)

Picking up the crochet hook, I feel the coldness of the metal hook, it is encased in a plastic handle which has an almost rubber- or hard silicon-feel affording a softer grip, making it more comfortable to use. I take one end of the yarn and make a loop. The yarn is smooth or rough pending on fabric that I want to use whether it is wool-silk, cotton or course wool. To make an iterative pattern is a repetitive process, almost meditative. In the loop I make the one chain stitch, then I continue with six more chain stitches. I go over them with single stitches, one in each chain then two in the loop. I join the next stitch to the other end beginning the spiral. I continue the same pattern seven single stitches then two single stitches in the eighth stitch. I iterate this pattern over and over and over again. A conical form takes shape, as it gets wider and wider until it plateaus, flattening out, circular like. After several spiral rows around the conical centre, hyperbolic frills emerge, i.e., negative curvature, similar to curly lettuce or chanterelle mushrooms. This form is called a hyperbolic pseudosphere.

This iterative process requires attention, breathing, movement, and counting. The tension between my fingers and the yarn informs the tension within the stitches. The tension in each stitch can be representational of my feeling for the algorithm. For example: the more tense I feel, the tighter the stitch; the more relaxed I feel, the looser the stitch. There is evidence of my feeling in the formwork — even though every stitch is counted the whole is continuous. This pattern of nine stitches for every eight was entrained through which I internalised this formwork. It was me who was counting every stitch and checking if I forgot my place. Checking in with myself established a sense of self responsibility, as it was my responsibility to count every stitch to ensure I was following the pattern. Ultimately, this formwork with my choice, it was my choice to choose nine for every eight stitches. And I knew if I wanted this hyperbolic form, I would need to ensure there was always an increment so that there were more stitches in every cycle of the spiral.

> Both for brevity and for distinctness, a recurring group is called a cycle. A cycle of operations, then, must be understood to signify any set of

operations which is repeated more than once. It is equally a cycle, whether it be repeated twice only, or an indefinite number of times; for it is the fact of a repetition occurring at all that constitutes it such. In many cases of analysis there is a recurring group of one or more cycles; that is, a cycle of a cycle, or a cycle of cycles . . . (Ada Lovelace 1842, 44.)

Through this process my feelings counted, rather than being counted. My feelings mattered as they became something, as my experience was recorded in every stitch of the hyperbolic pseudosphere. It was not a machine, it was not a program; I was the machine, I was the program. By attending to my feelings, the hook and the yarn, my experience was infused in the formwork. However, when we work with computers where do the feelings go. This is quite different from working with yarn, clay, or paint.

From my experience with coding and typing, the feelings go into decisions they go into the desire to instruct. Code is an instruction for the computer. It informs the computer what is required. For the most part basic code can produce reliable outcomes which is why we use it to store important information and to do calculations. For example, binary computers can reliably do arithmetic: plus, minus, multiplication, division, among other quantifiable (discrete) calculations. The decision of what instruction to give the computer is an opinion, and regardless of what that decision is based on it is always a choice, i.e. an opinion. The data structures behind the code are also opinions, usually based on opinions that informed what data to collect. These opinions are inherently cultural and representative of the groups who have them, just as code and data structures are representative of the groups and their respective cultures. They tell us the affordances of these groups and cultures, as well as their values, beliefs, and what they allow to rise to the surface. Because we can only make what we are, and we become what we make.

In order to make something unlike ourselves, we need to bring in people who are unlike ourselves. We need to involve those who experience the world differently to ourselves; these people, when welcomed and involved in our everyday, will share their values, stories and beliefs, which in turn transform who we are together. We become remade through the process of involvement.

The programming of algorithms is no different. More diverse peoples need to be involved in the process of making algorithms from the very beginning, particularly those algorithms that inform our choices daily. Some questions that have arisen from this work are:

- What can we express with algorithms?
- What are our dreams and nightmares around AI and algorithms?
- How do we imagine what algorithms look and feel like?
- What is the body of an algorithm?
- How do algorithms shape us?
- How do we shape algorithms?
- How do our values, stories and beliefs inform the programming of algorithms?

3   ALGORITHMIC FORMWORK

Algorithmic formwork is a process of generating pattern into form. It is a form that the body can interact with through movement. Algorithmic bodies produced from algorithmic formwork are material interfaces that have enmeshed segments (or cells) in relationship with the whole. The whole is not only the resulting material composition, but also the processes in which the formwork emerged from. "In the organic and living unfolding of the world, wholes are generated by and out of other wholes, and the parts we observe are very often descended from the elaboration and internal differentiation of a whole whose existence precedes them." (Joe Norman 2019). This in contrast to the industrialised constructed *wholes* assembled from *parts*: "That is, a whole is generated by gathering the necessary parts (which, crucially, already exist) and putting them together in some way such that a thing is made from the parts." (Joe Norman 2019).

Crochet is not constructed in this sense of parts, it is a process that requires the whole of a body with the experience of knowing the processes of crochet, it also needs all the pathways to bring the yarn to that body, as well as the hook and all those before who made the hook and made it possible to bring the hook to the same place. All those pathways are integrated into every piece of crochet formwork. The algorithms, to make the formwork, came through the internet, and it was Daina Taimina who had the insight to see exponential growth and hyperbolic forms as crochet stitches. She, like many other people know crochet, but she was the one sitting in a mathematics lecture who made the connection. Then through academic, art and social pathways she shared this technique with communities around the globe by means of journal articles, art exhibitions, talks and presentations, and on social media on the internet.

Her living story tells of the interdisciplinary work that exists in each individual. We each have numerous interests, needs and skills, all which can have interdependencies with mathematics. Because mathematics is not only about discrete counting, measuring and plotting dots in two- or three-dimensions of space. Mathematics can be a way to formulate and share what we imagine. And algorithmic formwork explores the in-between space of continuous fractional dimensions by generating algorithmic bodies. The space between the discrete "square" mathematical framework is where mathematics lives in our everyday. And the crochet formwork is one way to touch and interact with mathematics.

3.1 Formwork

By articulating geometric forms through algorithmic expression, we can eliminate the need for the three physical dimensions of space to locate and produce form. This way the forms are made through relationships of particles, or here: stitches. It is in the relational distance and angle of one stitch to the other, or the affordance of material that informs the resulting geometry. While this work mainly expresses hyperbolic forms through crochet (TABLE 1, 26**Error! Reference source not found.**), this work has briefly explored ridged bodies to begin to figure out what kind of rigid or semi-rigid forms can produce negative curvature.

TABLE 1. Seven bodies of crochet.

SPHERE YARN: REUSED FABRIC COTTON + ELASTAIN BRAND: KEHRA (LINDA)	HYPERBOLIC DISC YARN: 85% RECYCLED COTTON + 15% POLYESTER BRAND: NOVITA (REIPAS)	HYPERBOLIC PSEUDOSPHERE YARN: MERINO WOOL BLEND SHOP: WOOL FOR EWE, ABERDEEN
HEXAGONAL PLANE YARN: MERINO WOOL + BAMBOO PRODUCER: EIJAN KUDONTAPUTIIKKI	BUBBLE PLANE YARN: FINNISH WOOL PRODUCER: TUKUWOOL	TWO SPHERES, ONE COATED WITH ACRYLIC PAINT YARN: MERINO WOOL + BAMBU PRODUCER: EIJAN KUDONTAPUTIIKKI

These seven crochet models are selected as representations of algorithmic space. The spheres represent positive curvature and whole elements to hold; the small painted sphere (TABLE 1, bottom right) integrates all the stitches with the acrylic coating with no holes in-between. The hyperbolic disc and pseudosphere are planes of negative curvature, thus maximising surface area in relation to its total volume. The hyperbolic pseudosphere is made from an incremental and iterative expansive algorithm with a ratio of 8:9 (nine stitches for every eight). The hexagonal lattice is also a plane, but with no curvature; it is made from hexagonal pieces that are seamlessly stitched together with join-as-you-go (JAYG) stitches. Bubble plane is made with bobble stitch, its texture is not flat as each bobble is raised. These seven pieces explore the interdependent properties of spheres, cones, discs (circles), hexagons and bubbles. The emergent integration of yarn as cell-like forms expresses the seamless wholeness of becoming.

However, when we begin to explore rigid or semi-rigid bodies and materials, we need an approach that responds to the ways hard materials limit our soft bodies. One approach is to begin with straight lines, i.e., sides or edges. A ball or sphere, which has positive curvature, can be made with twelve pentagons and five hexagons around each pentagon,

i.e., a truncated icosahedron. To produce negative curvature, replace the pentagon with a heptagon (seven-sided polygon) and place seven hexagons around it (PICTURE 6, 27; PICTURE 7, 28). The number of sides of the central cell, relative to the number of sides of the surrounding cells informs whether curvature is positive, negative or null (flat). If a hexagon is in the centre, the form is flat, making a regular tessellation. Briefly, if you increase the number of sides of the centre cell (relative to the surrounding cells), the form has negative curvature, and if you decrease, it has positive curvature. From there, we also need to look at cell area and side lengths which also impacts the degree of curvature.

PICTURE 6. Wooden hyperbolic formwork.

Material properties of wood through hyperbolic rigid-body formwork. In the context of algorithms and geometry. The images to laser cutting the forms were made by Simon Nielsen: https://jim1000sprog.dk/. Simon also gave me an introduction to the laser cutting machine for the first large model. Producing formwork through rigid bodies provides material limitations due to the tools and material properties of hard materials. Intersections and connections require geometries that respond to the hardness of the material. This also requires different modalities of movement as well as a skillset to cut rigid materials. Yarn and textiles are pliable and compliant and can be bent, twisted and looped, however yarn does not readily hold its shape unless it is entwined and stitched. In contrast, rigid materials, such as wood, stone and metal readily hold their shape; though this depends on their composition, metal wire has properties like yarn and can be knitted or crocheted.

The innovation process to make cell-like forms from 4mm plywood required the following steps:

1. Studying geometrical forms to produce hyperbolic formwork.
2. Figuring out how to join the rigid-bodies.
3. Making digital vector images of the puzzle pieces.
4. Lasercutting the plywood.

5. Soaking the wood in hot water.
6. Putting them together while wet.
7. Coating the wood with PVA glue to keep the parts together.

Producing formwork with rigid materials required to think in terms of cutting and placement, including the plotting, measurement and angles of lines. While working with yarn required counting stitches and expressing a series of movements to produce the stitches. The task of crochet is meditative through its recurring and iterative processes, which is more like the tasks a computer does. While the tasks required to produce rigid-body formwork is comparable to the work of software developers and designers.

The cell-like forms (hexagons and heptagons) of the wooden hyperbolic plane (PICTURE 6, 27) are like each stitch, but on a larger scale. The next step was to work with a material that had the compliant properties of yarn and textile, but some of the rigid properties of wood.
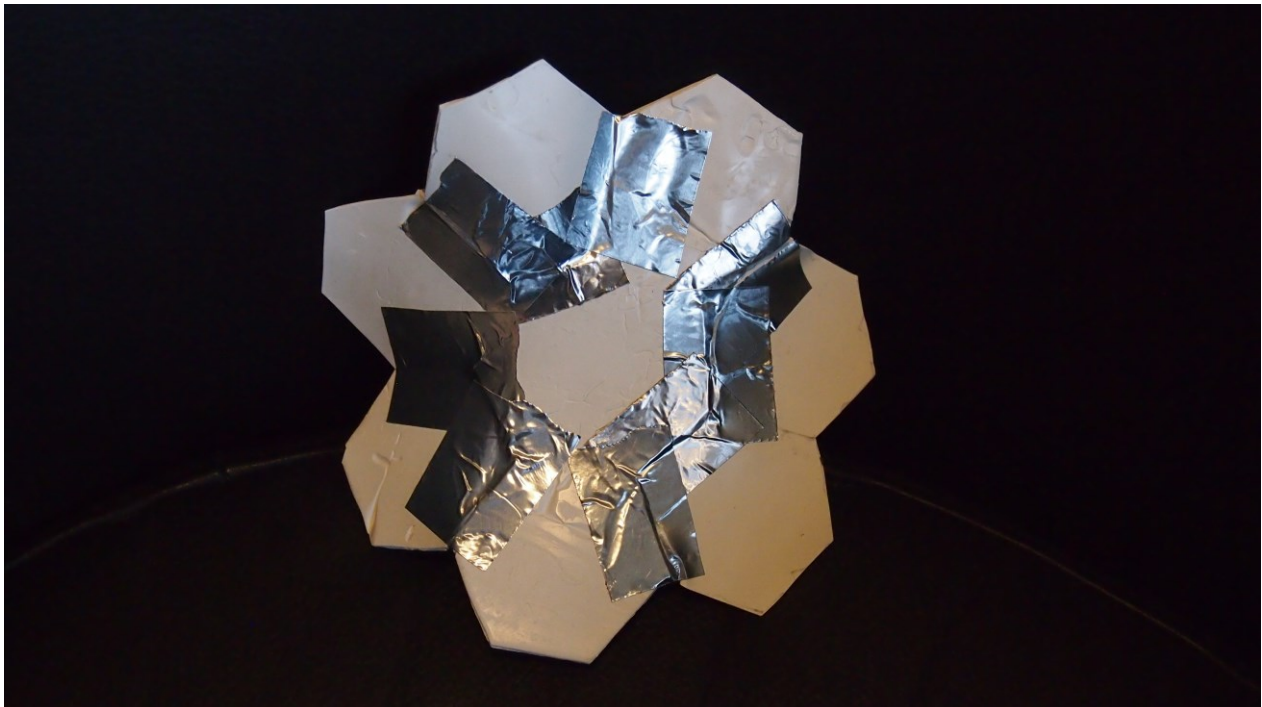
PICTURE 7. Compliant hyperbolic formwork.

Here I began to explore with plastic, specifically: dried pieces of acrylic paint. Instead of needing a digital software or a laser cutter, I used dried paint, pencil, aluminium tape and scissors. To make the cells, I drew an outline of the hexagon and heptagon from leftover pieces of the wooden formwork. Then taped them together with the aluminium tape. The cells joined together seamlessly with the tape. There were no gaps between the cells, as in both the yarn and rigid-bodies. It was more like a skin or membrane, offering the space to explore and study compliant materials. Compliant materials offer plasticity and adaptability to stresses, strains and loads. This formwork (PICTURE 7, 28) is situated in the application of algorithms and geometry while responding to material limits and expressions of dried plastic.

From plastics we return to yarn. However, this yarn is made from strips of fabric resulting in recycled yarn. The recycled yarn is thicker than spun yarn, and when stitched it has rigid-like properties because of its thickness. Each stitch is like a triangle, though more flexible than a rigid-body. And instead of being taped together like compliant dried acrylic paint, it has a mesh structure with gaps between the yarn.

PICTURE 8. Crochet as hyperbolic tracing.

The number of points on a polygon inform the number of curves in a hyperbolic form. This hyperbolic crochet sculpture, made with recycled cotton ribbon yarn, began with a triangle, then continued around the triangle with a 5:6 ratio (six stitches for every five). However, this is different from a hyperbolic triangle which is derived from a saddle-shaped surface. This textile formwork is a precursor to the integration of rigid bodies, such as wooden polygons, with yarn. The rigid polygon becomes the kernel that informs the incremental continuous process of fibre formwork. In other words, the triangle evolves "through the application of exponential loops into hyperbolic versions where the base geometry is coded into the final product." (Alexander Worden 2018). Every crochet trace around the kernel (base geometry) encodes the resulting formwork. Algorithms and geometry are always responsive to and limited by the bodies and materials they are applied to.

4   OUTREACH & PARTICIPATION

Outreach and participation are the processes which involve our immediate and extended communities, i.e., the people in and beyond the spaces we inhabit and move through. It is about sharing and bringing about awareness through exposure and immersion. In this context, the discussions and activities explore intersections of thought and activity that, in our education institutions and day-to-day living, are typically isolated: crochet, art and mathematics. The opportunity to share unlikely or unexplored combinations can provide alternative directions to present day challenges and problems. Just as Kate Stone brought together electronics and the printing press to create printed electronics (Kate Stone 2013), here we can have a shared space to put together more unlikely partnerships.

Several meetings with Professor Tarja Rautiainen-Keskustalo (from March 2019 to October 2020) brought about an interest in sound, textures, textiles and wayfinding. These meetings on materiality, sound and mathematics established pathways to bring the material into technology. Material is both a quality and an artifact (or thing), it is something to hold, touch or experience. In October 2019, I presented to Tarja the works of crochet (TABLE 1, 26). Here we ideated the potential in how textiles can be models of sound waves, or formwork for an electroacoustic transducer (e.g., loudspeaker); as the forms of hyperbolic crochet can model sound waves, which is afforded by the incremental processes of algorithmic crochet modelling. This was the first of many conversations regarding the application of crochet algorithmic modelling.

PICTURE 9. Introducing algorithmic modelling in the Math Coffee (MTT-TIE -kahvit / MTT-TIE coffee) Tampere University, on Tuesday 1.10.2019 at 13.15 Olohuone B1029-20. From this point, I began my journey to reach out to share my experiences with my extended communities, first within the university presenting at various meetings (

TABLE 2, 33) and courses, and through small group meetings. Then later in a meeting at Työvaenmuseo Werstas arranged by Tarja Rautiainen-Keskustalo. In March, I attended Niina Hiltunen's Wool Works exhibition, and from August 2020 I arranged a series of crochet get-togethers online, at friends' homes, or small groups in local pubs and cafes (

TABLE 2, 33).

Also, I presented the algorithmic crochet in Tarja Rautiainen-Keskustalo Media Studies course, in an email Tarja Rautiainen-Keskustalo (2020) described the course as follows: "The methodology course is part of Mediatutkimus Master's Programme and it is in Finnish. The focus is on so-called material media studies and critical, material, approach to code, coding, and algorithmic culture is an essential part of it."

While the content of the presentation was not directly related to the students' studies, it was our hope that the students could look at the crafts they do, and how that can inform their body-mind experiences in a sociotechnical digital context. As our technologies have, for the most part, paralysed our movement, it is critical that thoughtful and careful understanding of these technologies are applied. Some areas to consider are: algorithms, spaces where we work with technology, our participation in media, and our sensory experiences through media. Discussion around these themes and more can bring about awareness our technologies, which are now a very real and everyday aspect of our lives and cultures. This is vital, not only as producers of technology, but more importantly as consumers we make environmental and cultural choices with the technologies we purchase and use. Our choices impact our environment and our communities in very real and tangible ways.

TABLE 2. Timeline of outreach events, including attendance of meetings, exhibitions and get-togethers in Tampere, Suomi.

Event	Venue	Date/Time/Duration
Presentation at 'Math Coffee' at Tampere University	Tampere University Olohuone B1029-20	1.10.2019 @ 13.15-14:45 (15min presentation)
One-on-One Meeting	Café ja Aula Toivo, 2krs päätalo, Keskuskampus, Tampereen Yliopisto	13.11.2019 @ 12:00 (1 hr)
Algorithmic Crochet Meeting	Tampere University Olohuone B1029-20	16.12.2019 @ 13:00 (2 hrs)
Meeting at Työvaenmuseo Werstas	Työvaenmuseo Werstas	24.01.2020 @ 13:00 (1 hr)
Presentation in Media Studies Course	Tampere University E 326, Main Building	2.03.2020 14:00-16:00 (15min presentation)
Visited Wool Works exhibition	Tampere Finlayson Area	15-16.03.2020 12:30 (attended for 1 hr on the 15th)
Viski&Virkkaus (private get-together)	Get-togethers online or at someone's home	Online: 22.03.2020 @ 17:00 (2 hrs) Home: 5.09.2020 @ 19:00 (2 hrs) Online: 29.08.2020 @ 19:00 (2 hrs) Home: 10.11.2020 @ 18:00 (3 hrs)
Viski& Virkkaus (open get-together)	Pub Simon Metsonkulma Bar & Café Lategame	10.10.2020 @ 18:00 (2 hrs) 7.11.2020 @ 18:00 (2 hrs) 12.12.2020 @ 18:00 (2 hrs)

4.1 Local Get-Togethers

I wanted to set up an event that can fit in local cafes, bars and pubs. Viski&Virkkaus (in English: Whiskey&Crochet) became a small informal get-together to talk about recent and upcoming events, and exchange knowhow on hand-crafted textile fabrication. Every event is different, depending on who shows up, with each attendee sharing their experiences in their own way. Viski&Virkkaus, started with just myself and a friend, which we did online or at either of our homes. Both worked fine for one-on-one get-togethers, which we still arrange every couple of months.

However, to open it up to more people, we needed a local central venue. The first one we tried at Pub Simon, then at Café Metsonkulma, followed by Bar & Café Lategame (PICTURE 10, 34). The atmosphere needed to be cosy, with low music, so we can hear each other without having to compete with the music. So far, we have only been running

on-site events because setting up a welcoming hybrid event requires teleconferencing hardware. Later we would like to explore a hybrid event that is both online and on-site. One possible setup could include a lightweight laptop or device (that can handle teleconferencing) with a webcam and can be connected to a portable speakerphone with a 360-degree omnidirectional microphone.

4.2 Outcomes

The discussion, attendance and thought from the various events and meetings became the motion that brought ideas into fruition. Without the communal involvement and engagement, the notions of algorithmic crochet and the works of crochet would have been isolated and unresponsive to the communities I belong to and inhabit. This unlikely theme of mathematics, fibre art and algorithms brought together individuals who were willing to entertain thematic intersections. Through the medium of crochet, we were able to explore these intersections through practise, expression and ideation.

In order to bring about innovative partnerships, groupings and connections, we need to be willing to reach out to find these individuals who are inclined to explore the unlikely and the impossible. Innovative outcomes come from alternative blends, recipes and variations. Regularly mixing up unlikely combinations will help us to re-innovate the wheel again and again and again. And each generation will re-innovate by means of what is accessible and available to them.

PICTURE 10. Social Media images for local open Viski&Virkkaus events in Tampere, Suomi.

5 PUBLICATIONS

This exploration of algorithmic crochet has a place in the academy. From this work two artworks were submitted: one in Bridges 2020 and the other in the Joint Mathematics Meeting 2021. The first paper outlines 'Surface Structures', in this work surface is expressed as a structure. It is able to hold itself in place due to the material properties of the yarn, tension of the loops, and curvature of the form. This especially applies to hyperbolic formwork. The second paper 'An Expression of Gravity: Body makes wave' expands on this, focusing on the algorithmic process of a hyperbolic pseudosphere. In this work, the iterative and incremental process of a spiral is an expression of the interdependent movement of body and material.

5.1 Surface Structures

With crochet elements of surface area, we learn the properties of spheres, hexagonal tessellations and hyperbolic planes. This exploration is through the medium of yarn, paint and the technique of crochet.

> This allows the designer to pay attention to the specificity of each particle/component individually, yet produce a complex overall structure. (Gisela Baurmann & Daina Taimina 2012.)

Spheres have minimum surface area and maximum volume, while hyperbolic planes are the opposite: maximum surface area and minimum volume. Hexagonal tessellations are flat, while each hexagon has minimum perimeter for maximum area, and each hexagon fits together with no space in between. This is unlike circles or spheres, which have space in between when circle packing. Though bubbles or cells join together making tightly packed polygons, though usually hexagonal. They become the form in which they inhabit.

Understanding surfaces through crochet and yarn acknowledges bodily knowledge. In the Algorithmic Crochet Meeting at Tampere University (2019) (

TABLE 2, 33, and in 10 Appendices), Ju-Yi Chou (PhD of Science and Technology Studies) described the stitching process in a crochet as the modelling of "cell-by-cell" growth structures. Another attendee expressed that they do crafting because it feels good and because it is who they are. Here the textiles become more than the flexible, soft and colourful material properties, but rather the interdependent affordances and relationship of body, movement and material. Through responsive attendance to the moment, we can explore shapes, forms and planes through soma aesthetics, as well as rhythms, algorithms and patterns. Here, we can appreciate the stitch-by-stitch incremental process of growth and becoming — each stitch becoming the form yet to be.

The direction of this work is to learn about and inform new ways to make clothing and shelter through local additive fabrication. For the last 100 years or so, it has been possible to make clothes with knitting machines. In architecture, textile-reinforced concrete, such as KnitCrete, is a viable construction material. This was applied in the work KnitCandela, a concrete shell made on a structure of ultra-lightweight knitted formwork. The knitted formwork was made with a Stieger knitting machine in Switzerland, then transported in suitcases to be assembled and constructed in Mexico. Both clothing and buildings can be achieved with knitting machines.

> The radical possibilities of 'crochet thinking' in architecture and urbanism
> lie in its ability to seamlessly shift between increase and decrease of units
> in the overall fabric, while thinking through the generation of each local
> constituent progressively. (Gisela Baurmann & Daina Taimina 2012.)

Crochet, knitting and other textile handwork has been done for thousands of years. It involves movement intimately responsive to our breathing and seasonal habits and cultures. Weaving looms have been the stepping-stone towards machine textile fabrication, with the Jacquard Loom producing complex weaves by means of programmed patterns on punch cards. Local scale knitting machines were also programmed with punch cards from around the 1970s. This was the same time punch cards were used to programme early electronic computers in the 1970s and 1980s. Today electronic knitting machines, such as Kniterate, Shima Seiki, Wknits, Stolle, and Stieger. Though most of these are for large scale production or design studios. Hacker projects such as Becky Stern's Electro-knit (Becky Stern 2012.), can make it accessible to hackers or hackerspaces, but not for non-tech or low tech individuals or communities.

Exploring surface structures through textile handwork can be one of many ways to study algorithms. Responsive material-body relationships can bring about bodily awareness of interactions with algorithms and other technologies.

5.1.1 Algorithmic Surface Structures

Janna Lumiruusu (2020). Algorithmic Surface Structures. Bridges 2020 Virtual Conference. http://gallery.bridgesmathart.org/exhibitions/2020-bridges-conference/lumiruusu

Crochet is a technique and a technology to make tangible algorithmic bodies of geometries. This work is through a body-material interaction of crocheting various yarns into surface structures, or algorithmic bodies. "This allows the designer to pay attention to the specificity of each particle/component individually, yet produce a complex overall structure." (Gisela Baurmann & Daina Taimina 2012.). The process of making surface structures by crocheting and yarn requires body knowledge. Through iterative algorithms, the body responds in dialogue to the flexible, soft and colourful properties of yarn and textile. These soma sensory experiences of tensions, rhythms and patterns generate algorithmic bodies.

PICTURE 11. Algorithmic Surface Structures (Photo Editor: Nancy Nilsson)
50 x 50 x 50 cm
Wool, wool/bamboo, wool/silk, reused cotton/elastane, recycled cotton/polyester, acrylic paint
2019

Algorithmic surface structures express the incremental, and sometimes incomplete, process of crochet. This procedural work applies various yarns, and some acrylic paint, to grow spheres, hyperbolic planes and hexagonal tessellations. Each demonstrate properties of surface area and structure: spheres have minimum surface area and maximum volume; hyperbolic planes have maximum surface area and minimum volume; while hexagons make regular tessellations which are flat, thus no curvature, unless it lays upon an unflat form. Additionally, each hexagon has a minimum perimeter for maximum area — much like bubbles packed together. Cell-by-cell, or here, stitch-by-stitch, we appreciate the incremental and entwined process of growth and becoming.

5.2 Modelling Movement

The infinite nature of the spiral draws us inwards and extends outwards. By producing a hyperbolic pseudosphere in crochet, we work through the process of iterative increments. The crochet hyperbolic pseudosphere made from a wool-silk blend is a bodied metaphor

articulating the patterns, causality and mechanisms of gravity. The repeating pattern, increasing by one every *n* stitches in the form of a spiral, forms waves:

$$(n + 1) \infty$$

This emergent pattern is the way populations grow, and the outcome is the body that emerges: much like a mushroom that emerges into the air from the mycelium network in the soil below. The spiral form also represents balance, though not through invariant symmetry as a snowflake, hexagonal tiling, a hexagon nor square. In other words, it is not invariantly symmetric through transformation processes such as: reflection, translation, rotation and scaling. Instead, it in itself expresses the process of balance, i.e., the constant work of living to strive for balance. This ongoing nature of living is the work of balancing.

To model balancing and symmetry of movement, is not with mathematical tools, but rather with the motion of producing ongoing formwork that offer the possibility to adapt through incompleteness. An incomplete form offers space to modify and adapt to the current environment and the beings living in and among the environment.

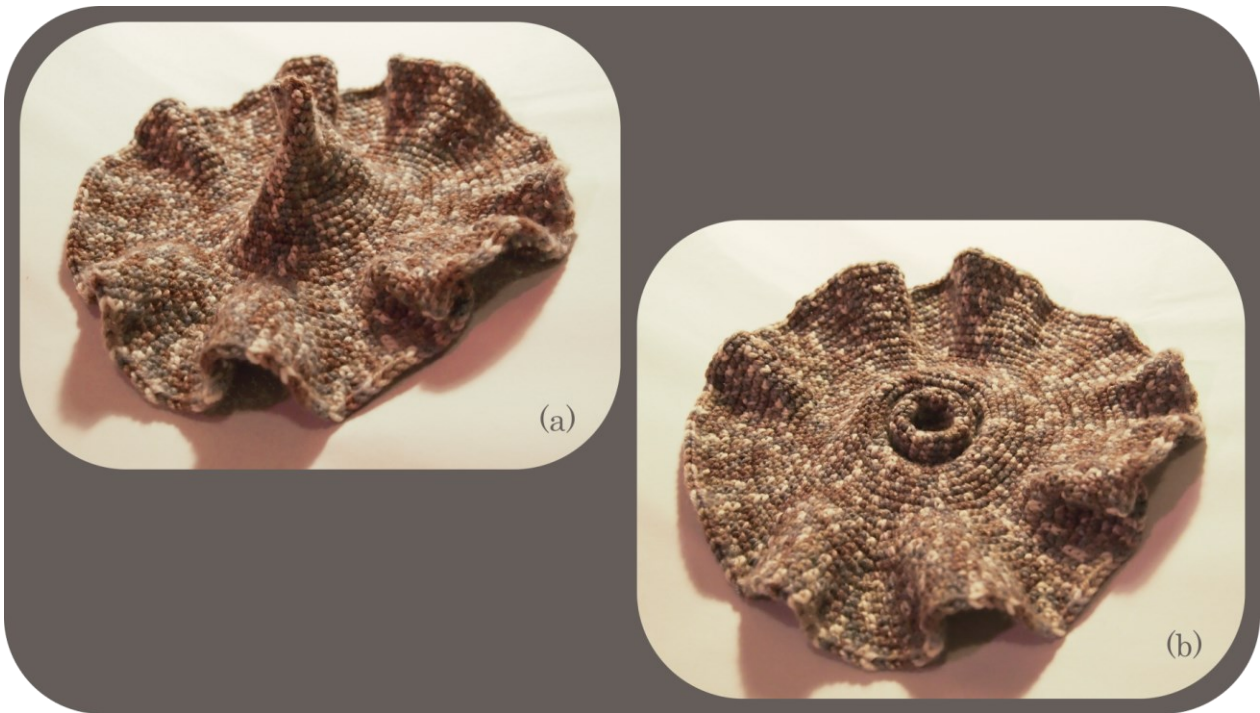### 5.2.1 An Expression of Gravity: Body makes wave

Janna Lumiruusu (2021). An Expression of Gravity: Body makes wave. Joint Mathematics Meeting 2021 Virtual Conference. http://gallery.bridgesmathart.org/exhibitions/2021-joint-mathematics-meetings/lumiruusu

This work of crochet is an exploration of movement and gravity through iterative algorithmic expression. The incremental steps of making each stitch brought about an understanding of how bodies move to generate spin. As my body breathed and pulsed, while moving my hands and arms, looking with my eyes and fingers to check each stitch in place. This relationship of discrete counting, continuous bodily interaction with material, the cold crochet hook, and the tension of the yarn afforded simultaneously a continuous and discrete bodily understanding of matter, space and motion. As I counted each stitch, verifying the number of each iteration, I internalised this process of nine stitches in every eight.

PICTURE 12. An Expression of Gravity: Body makes wave.
5 x 21 x 21 cm
wool-silk blend
2018

The hyperbolic pseudosphere is a representational model of gravity, or gravitational waves. It is in spiral revolution around and away from the centre with nine for every eight single crochet stitches. By increasing every eighth stitch by one (two stitches in one loop), negative curvature is generated. Each stitch represents a moment of spin from a planet-like, or spherical body, in space. The gravity well is formed from the conical centre of the pseudosphere by folding it in on itself two times to make the well and two ring-waves around it. The cyclical stitch-pattern results in the spiral formation, making waves in the frill-like edges of the hyperbolic form — reaching out into space.

PICTURE 13. Supplement photos of 'An Expression of Gravity: Body makes wave' to demonstrate the wave forms expressed in a hyperbolic pseudosphere. This figure was not published in JMM 2021, but instead it is here to show how the cone makes a well with two ring-waves: (a) is the hyperbolic pseudosphere with the conical centre extended, and (b) has the conical centre pressed in and folded to make two ring-waves.

6 DISCUSSION

Emergence is the movement of becoming; like a mushroom, pushing up into the air from within the earth.

> I stumbled upon it in a book by the Anishinaabe ethnobotanist Keewaydinoquay, in a treatise on the traditional uses of fungi by our people. Puhpowee, she explained, translates as 'the force which causes mushrooms to push up from the earth overnight.' (Robin Wall Kimmerer 2013.)

The mycelium network, the interweaving pathways, that connects all the mushrooms to all the other lifeforms in the earth — much like our sensory system and digital networks. Not with words, text or images, but with biological signals: feelings. New media and technology emerge from what has been, it is made from the pathways of existing technology. What exists today informs and participates in the emergence of new technology. What comes after is made of what has been. Yet, there is often a hunger for the new, for the hope of a new technology to solve all the problems in the world today. This uncertain turbulent feeling that is very present can be a very powerful force to bring about new technology. At the same time, we can only make from what has been and the material affordances of what is.

In times of uncertainty, we need to start with what we can do from where we are immediately situated. For example, sitting and making a hyperbolic pseudosphere by crochet. Each stitch is like a breath, a moment in time, and intertwined with the stitch and breath that came before and will come after. Breathing and stitching in synchronicity, producing an *ongrowing* cloth that begins in the centre and spirals outwards. However, the resilience of the piece is dependent on the material qualities of the yarn. A piece of crochet can be unravelled with the pull of the end of the yarn. However, if the piece is painted, or made with a rough wool that can be felted, the relationship of the stitches becomes non-linear. When felted, the fibres are enmeshed into the neighbouring stitches. While a crochet piece that is not painted nor felted can be undone and made anew.

In this relationship, emergence becomes responsive to the materials in our environment, while also attending to what is needed or lacking. In an open terrestrial landscape, we can seek out something edible, something nourishing, as well as material for clothing and tools. Both of which are integral to human connection to place and livelihood. Like a good season of mushrooms that follows several bad years: the mushrooms will emerge when the environment is suitable and sufficient nutrients are present in the soil. The same applies to edible greens, berries, fruit and nuts. Our interaction with these spaces, e.g., forests, are non-linear interdependent ecosystems. Movement within these spaces are also non-linear, they are spaces that require us to weave between rocks, trees, and shrubs, and not move in straight lines.

The fractional space, the space between, and affordances of algorithmic surface structures are much like the forest or other open terrestrial landscapes. The forms afforded by crochet are responsive to the place in which they are situated, this includes the choice of

form, the material, and the movement informed by both the material and form. Much like in manual data entry or arithmetic, the process is slow and incremental — one stitch at a time. This affords attention to the moment, the moment required to make one stitch. In the space between, we can zoom into the space where one stitch ends, and the next stitch begins. In this space we find a loop, the moment of interdependence, as one stitch follows the next on the same length of yarn. In this space, the discrete meets continuous.

The air has substance of pressure variation, the land beneath us responds to our tread leaving footprints in the earth or snow, we weave between others who inhabit these landscapes. To navigate these areas, we must move with and among other who live there. There is no negative nor positive space, there is no void nor solid, there is only the affordance of movement, material, and our responses to internal sensory experiences. Our decisions come from our visceral experiences through emotional triggers, prompts and cues, which come from the experiences we have had and stories we have internalised.

The space requires that we attend to the environment as we navigate through the landscape. Movement, awareness and sensory attention is necessary as nutrients are gathered. Moreover, these spaces afford movement, awareness and sensory attention. There are no demanding loud vehicles, construction or musical sounds that assault our bodies and draw our attention away from our internal sensory experience (interoception) in relationship with our environment.

The environment in which we inhabit informs our movements and affords degrees of sensory awareness and attention. Our technologies and materials too, afford movements by our responses and interactions with them. When making digital environments and tools, we need to consider our bodily requirements, and are we even able to attend to our interdependent sensory experiences while working with our digital tools, or is our attention constantly being demanded of. The awareness of ourselves in a forest or open terrestrial landscape is very different to sensations we have in city centres. "Brains evolved to regulate a body so that it could move around the world efficiently." (Kim Armstrong 2019; Lisa Feldman Barrett 2019). But do our present day technologies make demands on our attention, interfere with breathing, and drawing our gaze outward, away from internal equilibrium, thus making it more difficult for our brains to sustain allostasis.

> …the living body can and must consider itself as an interaction of organs situated inside it, where each organ has its own rhythm but is subject to a spatio-temporal whole [globalité]. Furthermore, this human body is the site and place of interaction between the biological, the physiological (nature) and the social (often called the cultural), where each of these levels, each of these dimensions, has its own specificity, therefore its space-time: its rhythm. Whence the inevitable shocks (stresses), disruptions and disturbances in this ensemble whose stability is absolutely never guaranteed. (Henri Lefebvre & Cathrine Régulier 2004, 81.)

Meanwhile we also need to consider human movement (and stillness) as work and labour, and valuing the effort of our bodies. This effort is not artificial, it is imbued with body-meaning. After all, "Your body is part of your mind, not in some gauzy mystical way, but in

a very real biological way. This means there is a piece of your body in every concept that you make, even in states that we think of as cold cognition." (Kim Armstrong 2019; Lisa Feldman Barrett 2019). The relationship with body and material, and now more specifically, body and machine, influences or compels our movement. In the case of computers, the choice of buttons on a screen directs the movement of our finger on a touchscreen or the movement of a mouse. The interdependence of form, shape and placement all inform the way we move, just as the choice of stitch informs the way the body moves yarn and the crochet hook.

Therefore, when making surfaces, algorithms, machines and digital interfaces, the interdependent relationship of body-material needs to be attended to. The integrated processes of movement with body-mind attention with material in our environment is constant. Algorithms, through the options they make available to us, move our bodies through the digital interfaces we interact with. While we can see and respond to devices and digital interfaces, algorithms feel, for the most part, invisible. The algorithmic processes embedded in our digital interfaces and environments become a feeling, it is infused in the way we interact with technology.

> Thinking about extraction requires thinking about labor, resources, and data together. This presents a challenge to critical and popular understandings of artificial intelligence: it is hard to 'see' any of these processes individually, let alone collectively. Hence the need for a visualization that can bring these connected, but globally dispersed processes into a single map. (Kate Crawford & Vladan Joler 2018.)

Then how do we make the invisible, visible? In order to make an algorithm visible we need to see how it moves us. This can take shape through, for example, the opportunities presented to us, the relationships we migrate towards, and products and images made available to us. Algorithms are not only on the internet, instead, they can also be understood as culture: invisible threads embedded in our communities. The formwork of crochet is a study of iterative patterns, much like the recurring patterns of our cultures and the algorithms built from repeating code. These forms of tactile code, may offer pathways to recognise the invisible threads in our digital environments. By participating in the processes of co-making algorithms results the living forms and expressions of our cultures.

7 CONCLUSION

Interdependencies of Bodies

The workshops and presentations shared this exploration of algorithms through crochet formwork. The conversations and shared experiences informed its progression and emergence. The multidisciplinary nature of this work can bring together people of many fields and interests. In this point of intersection, conversations, themes and topics can diverge and return. Crochet, as a technique and formwork, can be a method to explore and ideate algorithms, 3D printing, fibre sculpting, and architecture, among others. It can also alleviate social pressure and discomfort by having something to do together that does not require talking. Crochet offers pathways to explore metaphors and paradigms through the study of its material properties, affordances and sensory experiences. Because in the end, it is our body that informs us of the world and our environment.

Body is of material. Movement is a sensory experience with material in environment. The space between is also of material, where void and negative space too are material. The fractal (or fractional) dimensions of space, between 0 and 1, 1 and 2 or 2 and 3, where lines and gaps are filled with material and their corresponding qualities and affordances. When materials are experienced as gradients and affordances, the binary of Void and Solid, or Zeros and Ones, become fuzzy as the affordances of bodies are expressed through their material quality.

Material is situated in an environment and the bodies that inhabit the immediate environment. The gradients, viscosity and pressures within or between materials make up an environment. The relational attributes of materials inform their mutual affordances. Thus, from here we can eliminate or reimagine the void — what is the void when everything is material? From this continuous sensory experience with the immediate environment, we are simultaneously in relationship with the environment, and not a binary of them and us.

Bubbles and stitches are interdependent. Their place and form are interdependent with their neighbours. While both, a bubble and stitch, can exist in isolation, when they form a group with their neighbours, they become complex structures. Their form is much like swarms of bees, flocks of birds and schools of fish. Each with their own identity, yet in interdependent relationship with their neighbours. Each individual is limited by the affordances of their body, the bodies around them and the immediate environment, which in turn is limited by the extended environment it inhabits or neighbours.

The stitch in crochet is always in relationship with the stitches around it, and by the crochet hook and body that makes the stitch. The integrity of a crochet piece relies on the interdependence of each stitch. In other words, if the yarn is not knotted nor tied off at the end, or if the yarn gets cut (and is not repaired) the whole piece unravels. Unless it is painted or it is made of a felting yarn, enmeshing each stitch with its neighbours, making it not only integrated but resilient as well.

The discrete meets continuous in the space between stitches. Space between is also the fractional dimensions of crochet formwork, as there is always a hole from which the hook

pulled through a loop. Here we find the spaces between the typical first, second and third dimensions of space. And yet, this technique offers a possible merging of rigid bodies and fibre formwork. By tracing rigid bodies, we can bring together the hard materials with their three dimensions of space with the fractional dimensions of algorithmic fibre formwork. We can bring breath and breathing of crochet to the work of hard materials, such as wood, stone and metal.
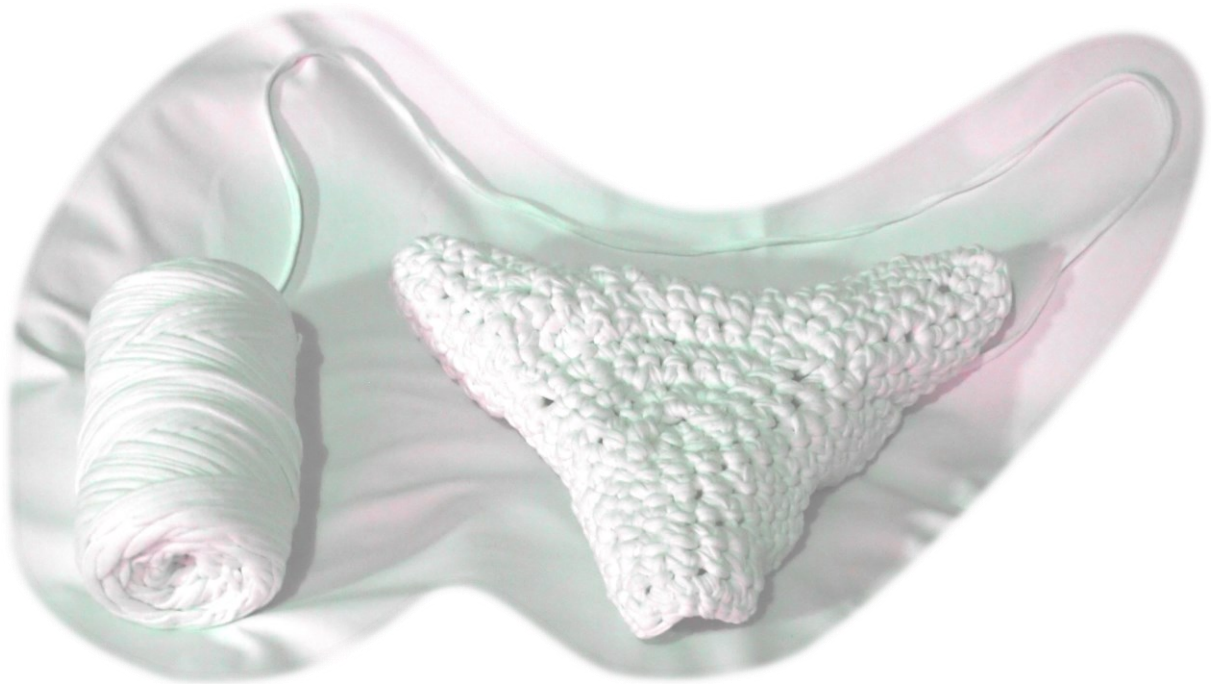
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9 ADDITIONAL LINKS

These are some online resources, places and events I have been introduced to and have come across during the process of this work. They are sites of interest and relevance to the exploratory study of formwork, fibre sculpting, mathematics and algorithms.

Bridges Math Art

http://bridgesmathart.org/

Helsinki Biennaali

HELSINKI https://helsinkibiennaali.fi/en/

CORAL REEF CROCHET Margaret and Christine Wertheim: https://helsinkibiennaali.fi/en/artist/margaret-christine-wertheim/

Tampere Hacklab

https://tampere.hacklab.fi/

Artists, artworks, and *art*chitectures

Rachel Whiteread (Artwork: Ghost): domestic spaces; positive/negative; private/public: https://hero-magazine.com/article/172782/rachel-whiteread/

Anish Kapoor (Artwork: Void Field): https://anishkapoor.com/73/void-field

Henry Spencer Moore (Reclining Figure: External Form)

Riikka Latva-Somppi (Artwork: Minä Kuulen): http://www.latvasomppi.com/

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In Between

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The Void

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Marina Abramovic, Holding Emptiness, 2012: https://www.jmcohen.com/artist/Marina_Abramovic/works/436

Tiina Pyykkinen, Silence has long shadows, 2015-2017 https://www.tiinapyykkinen.com/galleria-forum-box-2016https://www.finnishartagency.com/tiina-pyykkinens-new-installation-at-jyvaskyla-art-museum/

10 APPENDICES

Outreach within Tampere University

One-on-One Meeting (2019)

Hyperbolic algorithms
When: Wednesday 13.11.2019 12:00-13:00
Where: Café ja Aula Toivo, 2krs päätalo, Keskuskampus, Tampereen Yliopisto

Here we will explore the generative patterns of hyperbolic forms through crochet.
Please bring your own yarn and crochet hook.
If you wish to do some multimedia study before the meeting here are some links:
Daina Taimina ~ University Webpage ~ Personal Website ~ Researchgate
Crocheting the Hyperbolic Plane (with David Henderson)
https://www.researchgate.net/publication/225135318_Crocheting_the_hyperbolic_plane

Crocheting Hyperbolic Planes: Daina Taimiņa at TEDxRiga
https://www.youtube.com/watch?v=w1TBZhd-sN0
Daina Taimina: "Study mathematics and.become an artist?" - Lecture 16.5.2017 at Aalto
University, Helsinki https://www.youtube.com/watch?v=rY8Uo6rSnZc
Margaret Wertheim AEON and Christine Wertheim > Crochet Coral Reef
Margaret Wertheim: The beautiful math of coral (and crochet)
https://www.youtube.com/watch?v=zGEDHMF4rLIs
Biennale Arte 2019 - Margaret Wertheim, Christine Wertheim
https://www.youtube.com/watch?v=jh386wyGE7M

Algorithmic Crochet Meeting (2019)

Algorithmic Crochet
When: Monday, 16 December 2019 13:00 - 15:00
Where: Olohuone, Pinni B 1029-30, Kalevankatu 4 (Keskustakampus)

Welcome to join me to try some hyperbolic crochet on Monday 16th of December 13-15. Here we can discuss the relationship between crochet, coding, algorithms, geometry and modelling. If you would like to know more, I suggest looking up Daina Taimina, Christine and Margaret Wertheim, and Gisela Baurmann's works.

Bring your own crochet hook and yarn. If you know someone who might be interested, bring them along or they may email me: janna.lumiruusu@tuni.fi.

Presentation in Media Studies Course (2019)

INVITATION
Welcome to Algorithmic Crochet to discuss and perhaps do some hyperbolic crochet. Here we will discuss the relationship between crochet, coding, algorithms, geometry and modelling. If you would like to know more, I suggest looking up Daina Taimina, Christine and Margaret Wertheim, Alex Worden, and Gisela Baurmann's works.
Date and place are still being arranged via this Doodle, please add your availability: https://doodle.com/poll/r8kkvvvifvxcrvqf
Bring your own crochet hook and yarn. If you know someone who might be interested, send them the Doodle link.
ONBOARDING
If you want to try out some crochet (virkkaus) videos before the meeting I suggest searching for these terms:
- Aloitussilmukka / Slip Knot
- Taikarengas / Magic circle : https://johkunlainen.blogspot.com/2012/05/amigurumi-vinkki-osa-2-taikarengas.html
- Ketjusilmukka / Chain stitch
- Vinkki / Single stitch
- Pylväs / Double stitch
You can find both left- or right-handed videos for these techniques, if you are ambidextrous, you might like to alternate. This is a very nicely illustrated page that shows the chains and stitches: https://www.novitaknits.com/fi/fi/tutorials/virkkaus/novita-perussilmukat-virkkaus
For those who are feeling a bit adventurous, I have just come across this 3D drawing tool to make things to 3D print: http://beetleblocks.com/. It uses visual-based coding, so you have a coding menu available for you to select and try out.

Outreach to Työväenmuseo Westas (2019)

Hei,

Otan yhteyttä mahdollisen hankkeen tiimoilta: monen mutkan kautta olen päätynyt opettamaan yliopistolla moniaistisuutta mm. HTI (human technology interaction)-opiskelijoille ja muutama vuosi sitten kurssille osallistui opiskelija, jonka kanssa aiheesta on keskusteltu moneen otteeseen. Hänellä (Janna Lumiruusu) on tausta insinööritieteissä, mutta hän suhtautuu varsin kriittisesti mainstream -teknologiaan ja ylipäänsä haluaisi ravistella tietyntyyppistä teknologia-uskovaisuutta (ja esim. teknologiaan liittyviä sukupuolistettuja käytäntöjä). Syksyllä hän järjesti "ompeluseuroja", jossa virkkasimme algoritmejä ja puhuimme teknologian materiaalisuudesta, kehollisuudesta, käsityöläisyydestä. Monin paikoin mieleeni tuli monet Tim Ingoldin ajatukset.
Janna on puhunut myös siitä, että hän haluaisi tehdä jotain Tampereen teollisuushistoriaan (kutomoihin) liittyen samassa hengessä, eli jos osaan häntä oikein tulkita, innovoida kutomakonetta tämän päivän haasteiden näkökulmasta (kierrätys, kestävä kehitys, yhteisöllisyys). Tähän liittyy myös älykangas, mutta siinä kohden olen tipahtanut kyydistä.
Olen kovasti innostunut ajatuksesta ja jos vain suinkin teema tuntuu kiinnostavalta, voisin tulla Jannan kanssa jossain vaiheessa puhumaan aiheesta. Hanke on todella ideavaiheessa, mutta kenties jalostuu eteenpäin.

Ystävällisin terveisin
Tarja R-K

Tarja Rautiainen-Keskustalo
Professor (Sound & audio cultures)
Tampere University, Faculty of Information Technology and Communication Sciences
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Permission received from Tarja Rautiainen-Keskustalo to publish this correspondence.

Informing invitees of the Algorithmic Crochet Meeting (2019)

From: Janna Lumiruusu
Sent: Monday, 16 December 2019 19:56
Subject: Algorithmic Crochet

Hi Everyone,

Algorithmic Crochet became a small talking event where I showed some of the crochet pieces I have been working on and the materials and tools I use. The attendees today were Ju-Yi Chou, [attendee 2], Tarja Rautiainen-Keskustalo, and myself. Here we discussed issues in relation to technology that were important to us as individuals and as a group:

Exploring possible collaboration with **Näpsä**: https://www.taitopirkanmaa.fi/Naepsae-kaesityoekoulu

Discussing a happening or exhibition at **Werstas** in the Finlayson area: http://www.werstas.fi/

Our perception is limited by our awareness of our internal sensations through our immediate experiences and environments (Tarja Rautiainen-Keskustalo, Algorithmic Crochet, 2019)

Crafting because it feels good and because it is who I am ([attendee 2], Algorithmic Crochet, 2019)

Modelling through cell-by-cell growth structures (Ju-Yi Chou, Algorithmic Crochet, 2019), i.e. increasing/decreasing of units to make complete organisms "This allows the designer to pay attention to the specificity of each particle/component individually, yet produce a complex overall structure." (Crocheting Algorithms, 2012)

Come up with **new language around coding** and to change the problematic language in electronics and coding: e.g. master/slave, parent/child, male/female, and void, and all the unhelpful and non-inclusive associations and mental images associated with those terms

Challenges with Euclidean space and cartesian coordinates (x,y,z) and how that limits or omits **emotional interactions** and making through a need to make for ourselves and each other

Sustainable crafting, digital systems and electronics

Micromining ---> extracting minerals from (a) used or broken devices and (b) stones around Tampere: harvesting stones like berries are harvested but with similar regulations as to hunting

Reused, recycled and sustainably gathered natural materials for modelling and artwork

Conductive textiles and yarns, here are some links to explore further:

https://www.swicofil.com/consult/innovations/conductivity
https://www.wools.co.uk/conductive-yarn.html
https://www.electro-yarn.com/

Play and crafting with electronics

https://chibitronics.myshopify.com/ ---> https://www.adafruit.com/category/283 or
https://www.robotshop.com/
http://bareconductive.com/
https://www.adafruit.com/category/65

If any attendees feel I have missed something, please respond to the group with your contributions.

I wish you all a happy winter solstice and new year this Saturday to Sunday, enjoy the long night ahead. And I look forward to arranging another Algorithmic Crochet event in January.

Ystävällisesti/Best,

Janna