Actor-Flower-Mesh-Work: making environments together

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Abstract (200 words max)
In this paper we use an Ingoldian 'meshwork' and a Latournian 'actor network' approach to unpack the complexities of devising and constructing complex situations that combine creativity and technology. To do this, we draw on our experience of creating and exhibiting an interactive installation. We draw on our observations of the interactions, relations and correspondences between the installation, its elements and the people that visited the space.

We develop a discussion of these theories somewhat auto-ethnographically around the artwork *Lichtsuchende*, a group of robots with social behaviours enacted through light. Their trajectories of becoming are not that straightforward, and by looking at the moments of becoming we can delve into understanding the artwork better using two distinctive approaches: Ingold's meshwork and Latour's actor-network. The two approaches enable us to investigate from within and from outside. We seek to understand the ways in which these viewpoints can be applied as methodologies to unpack the factors involved in the creation of an artificial society and the emergence of a shared environment made of human and non-human things.

Keywords (5-15): kinetic sculpture, more than human, actor network theory, non-human actors, meshworks, object oriented ontology, digital creativity, installation

Introduction

In this paper we use an Ingoldian 'meshwork' and a Latournian 'actor network' approach to unpack the complexities of devising and constructing complex situations that combine creativity and technology. To do this, we draw on our experience of creating and exhibiting the interactive installation *Lichtsuchende*, a society of robotic light-seeking flowers. We are interested in how ideas relate to *things,* through the selection and manipulation of materials and the crafting and redesign *of* (and *with*) these *things*. In particular, we draw on our observations of the interactions, relations and correspondences between the installation, its elements and the people that visited the space.

When discussing the making process, the exhibiting of the artwork, the potential of materials and the vitality of *things*, we use Tim Ingold's idea that making is an open process that is composed of a *mesh* of continuous interrelations where people, processes and *things* intertwine. It is at these intersections, and when looking at them from within the *mesh-,* that we can see how things -*work* and where *things* (tangible and digital) dissolve disciplinary boundaries and become *enmeshed*, participating in and co-creating each other's environment.

We use Bruno Latour's theory of actor-networks to analyse certain instances of these relations and investigate how materials, things, and people participate in multiple networks simultaneously. We will examine a selection of actors that participate and play active roles in the artwork, and the relationships these actors establish as they engage with one another. To assist unpacking Latour's Actor-Network-Theory (ANT) we draw on object oriented ontology (OOO) via Graham Harman and their take on post phenomenology and potentiality, the hidden or unexplored qualities that things possess.

We are aware of the tensions between these two approaches, with Ingold's view being that of an embedded and embodied experience of things within environments, while Latour's being (at least in relation to early work, 1988) that of an analytical description of constituent parts and the relations that parts establish at different points in time and depths within networks within networks. However, we believe these two positions are useful to help us analyse creative practices, their technological aspects and how *things* relate with each other. The two approaches enable us to investigate from within and from outside. With Ingold's perspective we are inside, embedded in a *mesh* of interrelations, while with Latour's we are outside, observing how *things* work together and are interrelated from afar.

We develop a discussion of these theories somewhat auto-ethnographically around the artwork *Lichtsuchende,* a group of robots with social behaviours enacted through light. On a basic level, they sleep, search for light, recharge, get excited and go back to sleep. However, their trajectories of becoming are not that straightforward, and by looking at the moments of *becoming* we can delve into understanding the artwork better using two distinctive approaches: Ingold's *meshwork* and Latour's *actor-network.* We seek to understand the ways in which these viewpoints can be applied as methodologies to unpack the factors involved in the creation of an artificial society and the emergence of a shared environment made of human and non-human *things*. We do not attempt to formally divide or reconcile the perspectives. Rather, we use Ingoldian and Latournian insights to inquire into the process of making, the becoming of *things* and the making of the environments in which they perform.

The Lichtsuchende

Lichtsuchende is an interactive installation, consisting of a society of biologically inspired, cybernetic creatures loosely resembling sunflowers (Murray-Rust & Jungenfeld, 2015). Each robot can swivel its head on two axes, tracking bright light with its sensors, and can emit beams of light through a cluster of powerful LEDs (see Fig. 1). The tracking of light is their most distinctive behaviour, as they attempt to focus their gaze on the brightest light source nearby. This is the basis of their socialisation - they quietly look around the space, sending out beams of light in the hope of making contact with others. They follow a Maslovian psychology through internal states, and they find an interactional partner, their mutual gazes lead to a stroboscopic outpouring of joy, followed by exhaustion. The society works autonomously as the robots interact with each other, moving through states of dormancy, exploration, communication and repose, but is open to interacting with humans using torches or other light sources. Visitors can join in with the behaviour of the society through their physical interactions, learning to read the states and responses of the robots through patient and curious interaction.

Technically, each robot is made of a combination of i) a custom circuit board (PCB) that holds a microcontroller with a cluster of LEDs and supports several light sensors (see Fig.2); ii) two servo motors that allow the 'head' of the robot to twist horizontally and vertically; iii) a supporting skeleton made of transparent acrylic. They have been presented in several installations, where a variable number of robots are set up in a darkened space, with some locally sourced material (rocks, bricks) used to ballast the lightweight bodies. The processes involved in their making included (among others) designing circuit diagrams, fabricating PCBs, soldering and assembling components, laser cutting acrylic sheets, coding and uploading. We often encountered vibrant matter, and things and their qualities pushing back, showing us other ways forward (or perhaps sideways), which highlighted to us that *making* is a *mesh* of continuous relations where processes and *things* intertwine and share their environments.

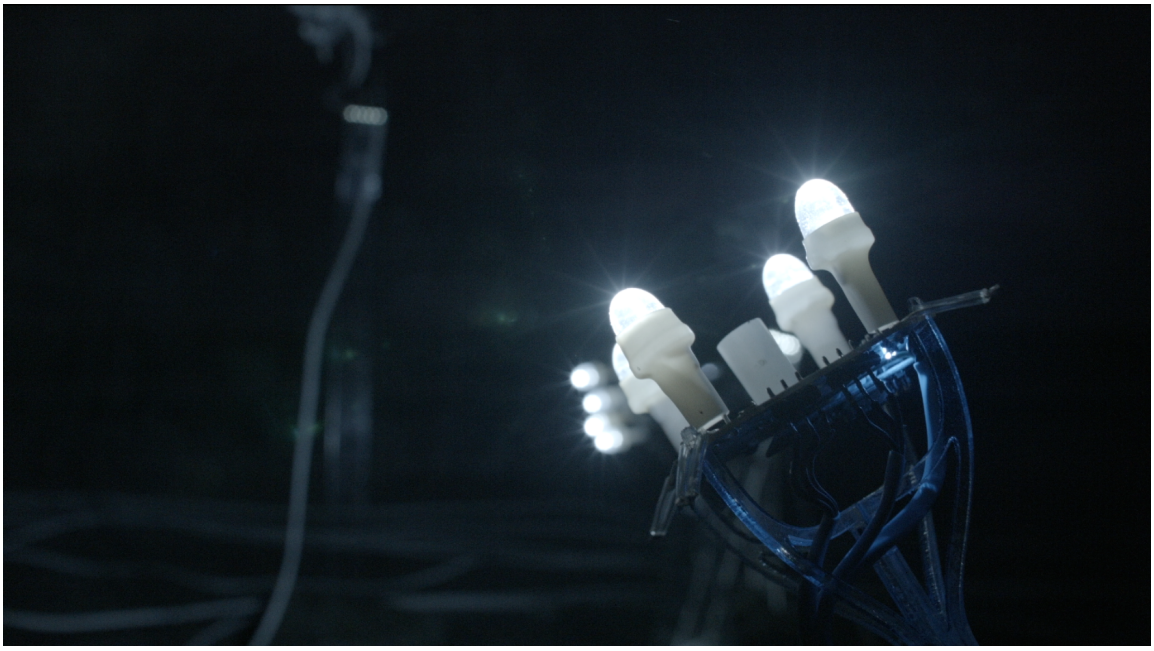

Fig. 1. Lichtsuchende, details of a robot head with lights on; lights of another robot in the background.

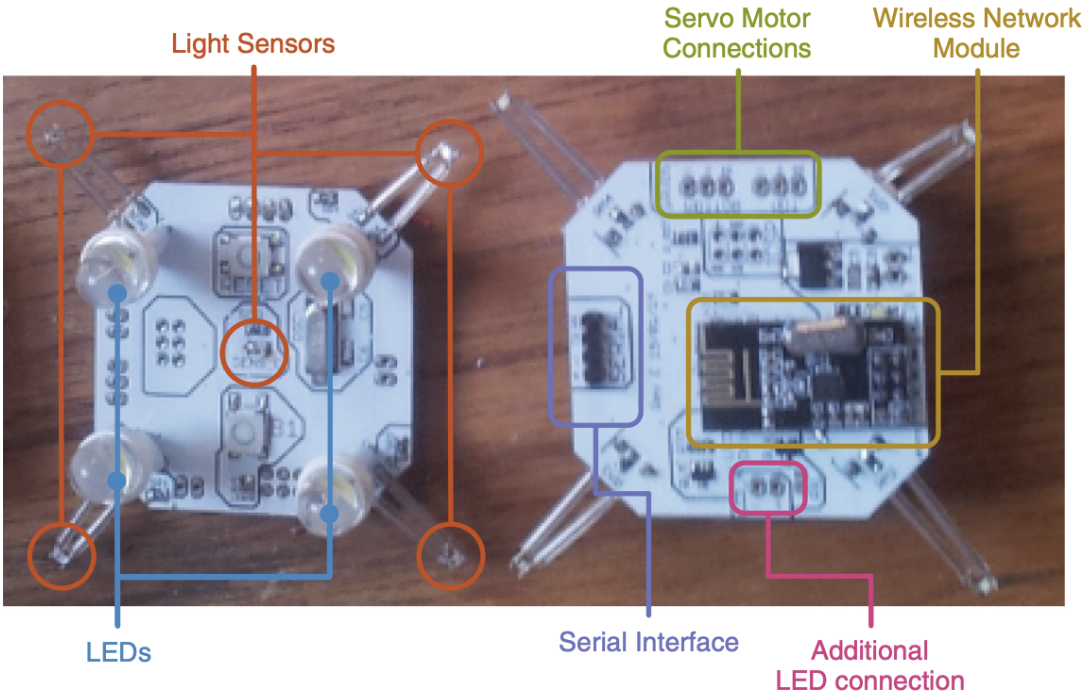

Fig. 2. Printed Circuit Boards (PCBs) showing front and back, featuring layout and components

Starting to make *things*

Interactive works such as *Lichtsuchende* serve to discuss how making is a process through which ideas influence the development of *things* and *things* influence the development of ideas. Here the emphasis is not on whether it is the idea or *thing* that comes first, but on the things that carry from one to the other, and the dynamics established between them in the process of making. Movement between the two is a fluid process, where one is interpreted into the other through materials, senses and algorithms, and this interpretation is revised continuously in the process of making. We refer to making as the process of design and redesign where *things* are made, but also to the process of making as *being*, of participating in the environment and establishing connections within it and with other *things*.

As we make things with our hands, write variables with our fingertips, or build theoretical arguments for our papers, we develop a richer understanding of our relations with the *things* we make, the environments where these *things* are and the technologies which enable us to make them. This idea resonates with Lambros Malafouris' theory of material engagement (2013). Making may be conceived as a process of mutually shaping. The materials we manipulate with our hands, whatever it is, for example dough with its lively yeasty fungus, shapes the bread as much as our kneading along with the humidity and temperature of the room. We have certain control over the bread we want to make, or the code we want to write, for we select the flour, yeast and recipe, or the language, variables and conditions, but in the process of making or writing the materials and the *things* themselves also participate in their own making. The qualities of the materials invite the maker to play, and in this play the making is negotiated. It is not a one-way action, where the maker imposes its will on the materials to shape the *thing* (i.e.

hylomorphism, which Ingold, amongst others, criticises as contrary to process; Ingold 2013, 20-21), but the materials and the *things* themselves push back during the making process and drive the maker to reflect and adjust, in what Donald Schön coined as *reflection-in-action* (1983) although only in the context of human experience, not taking other *things* into account.

Becoming a thing

There is a moment, in the development of a piece like *Lichtsuchende*, when the combined materials become a *thing*. When exactly this *thinging* happens is hard to discern; we have reflected on this elsewhere (Murray-Rust & Jungenfeld 2019). *Thinging* is the action of becoming a thing. It is a denominative verb which defines the moment in which a thing becomes. It would also be possible to use the verb *thinging* to describe how a thing gets tweaked or redesigned over and over in its process of becoming, and then *thinging* applies to the process in which the initial *thing* continues transforming and turns into its thingyness. This idea of converting nouns into verbs reminds us of Bill Watterson's Calvin and Hobbes 25-Jan-1993 vignette: "[Calvin]: verbing weirds language; [Hobbes]: maybe we can eventually make language a complete impediment to understanding" (Watterson 1993). This is not exactly our intention, but we are aware of the challenge to reach understanding through language. *Thinging* as a verb has been previously used to throw light, ontologically speaking, on the issue of what things *are* (Harman 2007, 134 & 145; Ingold 2011, 214). Martin Heidegger in *The Thing* (*Das Ding* 1950) says "The thing things. Thinging gathers" (172) and "The thing things world" (178) which taken out of context may seem bold statements (Heidegger 1975). In the essay, Heidegger uses the example of a jug to discuss the complexity of its *thinging*. The jug is a thing made of clay, but its *thinging* (its potential of containing liquid or other substances) is made of the void where this containing happens. Thus the thing, here the jug, has the capacity of *thinging* (of becoming a thing) and gathering other materials in relation to the world where it *things* (verb).

So, what is this *thing* we are talking about? Is it an object, a material, a program, a thought? Is it physical, can we touch it? Is it visual? Is it responsive? From an object oriented ontology (OOO) point of view (Bryant, Srnicek & Harman 2011) everything is an object, no matter how small or what they are. If we take one of the light-seeking robots as an example, a *thing* is something that has the potential to be active or become activated, or something that has already acquired a place in an environment, enacts its potentialities and participates in and in relation to the environment and those other things around it. Different scholars approach this idea of *thinginess* or *thinghood* differently. For instance, in *Being and Time,* Heidegger states that *things* cannot reach out to the world around them, and objects are mere caricatures of things. A thing is a *Zeug, "etwas um zu…"* (Heidegger 1977 (1927), 92), something for humans to use, to do something with, which is an early take on the question of what things are, and which holds no stance in relation to the *Lichtsuchende.*

Although in German language being-there (*da-sein*) is applicable to people and other things, Heidegger reserves *Dasein,* the possibility of *being there* only to humans (Harman 2007, 3). This is a point which is contested by developments in entanglement theories for instance in Ian Bogost's tiny ontology (2012) or Karen Barad's agential realism amongst others (Frauenberger 2019). In a Latournian sense, things – whether material or immaterial – have agency and any actor has the potential to act. But is giving agency not already an imposed anthropomorphic way of looking at and conceiving of things anyway? Maybe, as Ingold brings up, thinking about the potential of things is more valuable than their agency, an approach which also aligns with Bennett's vitality of materials and Barad's agential realism.

Some *things* may not be able to act by themselves, while they have the possibility of being acted upon and continuing their trajectories of becoming. In our installation, the only action a rock or a brick could perform by itself was balancing on other rocks, bricks or the *Lichtsuchende* bases and continuing with its gravitational pull towards the ground. However, rocks or bricks had the potential of becoming while they pulled their mass towards the ground, no matter where they were, they had potential and participated in the *meshwork*. When the foot of a person kicked the rock or brick, they could suddenly knock other rocks and bricks in their vicinity and the bases of other light-seeking flowers. Drawing on Ingold and also on Bennett, we could call this potential to become the *vitality* of the rock or brick rather than its agency.

Things may be made of materials and computation. Their materials and algorithmic structures are shaped in the process of making. There are some aspects of them which are perhaps temporarily fixed, such as their atomic composition or computational language. Some materials have qualities which are obvious and immediately apprehended, such as the stone is heavy and its surface porous, other qualities are more difficult to grasp or recognize: their trajectories in the environment, their vitality, potentiality, composition. *Things* have the potential to become other things or be part of other *things*, participating in assemblages. So, the heaviness of the rock has the potential of making the rock become a weight that grounds the base of the robot flower firmly to the ground. Its hardness and sharp edges have the potential to become part of another *thing* such as an axe. The malleability of copper gives the material the potential to become a thin thread, its conductivity the potential of becoming a wire or cable. What the material qualities of things are, shape what things are prior to being manipulated by the artist or craftsperson. Their qualities also limit what these materials can be converted into, and whether they can become part of other things, and if so, of their relations of exteriority (DeLanda 2006).

The creation of digital things raises questions about *thingness*, not least because they can be fluid and evasive in ways that matter finds harder. Physically identical hardware running different programs looks the same from the outside, but becomes a very different object. Redstrom and Wiltse's *multi-intentionality* (2018) is a useful concept here, to make sense of the idea that the aspects of a digital object that we (think we) understand can vary wildly; the things we encounter can have different possibilities for meaning, that change over time, and between people.

Material qualities, performances, flows and mattering

As we transform, selected and collated materials into *things,* we engage in the process of making, which is about working with materials and contributing to their transformation, instead of shaping materials into things or imposing ideas onto materials or code (i.e. hylomorphic model). Our work is oriented towards engaging with the potentialities of *things*, bringing to the fore some of their qualities, their *vibrant matter* (Bennett 2010). We conceive of making as a process that requires flexibility from both makers and materials. It is a process in which all participants (people, materials, ideas, environment) are woven, entangled into a fabric which is enmeshed and constantly changing; which is shaped by and shapes others, and resonates with current research in the field of interaction design (Frauenberger 2019). It is unhelpful to consider elements in isolation, we have to consider them in relation to other things. Here, we could talk of making as a textile or fabric, the processes and elements being the threads that compose this fabric, expanding in all directions. This fabric however, is not made of straight lines or vector-like movements, they are tangled, much like sweetpea tendrils, or particles in Brownian motion (see Fig 3, Ingold and Schrödinger). Borrowing the term from Henri Lefebvre, Ingold calls it a *meshwork*

(Ingold 2011, 4; Ingold 2007, 80-2): “the trails along which life is lived” (2007, 81). We propose considering the whole process of making the *Lichtsuchende* and them making their way through the environment, as a *meshwork* where each robotic flower and each of the elements that compose it or have contributed to its making are represented as squiggly lines that are tangled.

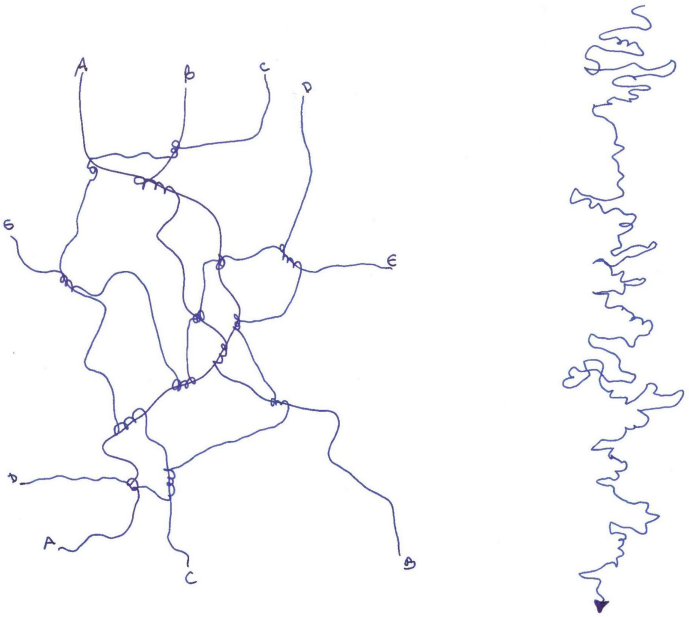

Figure 3 - Drawings based on Ingold (2007, 82) and Schrödinger (1967, 13; first published 1944)

Ingold’s approach to making draws among others on Paul Klee’s *Pedagogical Sketchbook* (1925). There, Klee describes finished forms as dead ends, while he associates the action of giving form as a life-giving exercise (Ingold 2011, 210). This idea of shaping and forming as an action which contributes to the process of life is strongly aligned with our experience of making the *Lichtsuchende*, and therefore we are reluctant to accept that making is a hylomorphic process where matter is transformed and shaped into preconceived, defined forms. There is a bit of preconceiving in making, there is no way of escaping that completely (Murray-Rust & Jungenfeld 2019), but it is part of the idea-development process which changes when *making* takes place. In the case of the *Lichtsuchende, making* cannot be defined as manufacturing, but as a continuous process of exploring and finding ways of bringing things into life. From an industrial design perspective where a prototype has passed all the necessary tests and is sent finally to production, we could say the synthetic polymer (methyl methacrylate) is shaped into different size sheets and transformed into a clearly defined shape. Even in the process when acrylic sheets are industrially manufactured, where quantities are precisely measured and temperature regulated to accurate degrees, each sheet turns out slightly different. In the process of becoming an acrylic sheet the melted methyl methacrylate exposes its melting qualities, its atoms arrange and tangle up in a unique way. When extruded into the mould, the material does not always flow in the same way, its areas not exposed to the room temperature evenly. Similarly, when cutting the acrylic parts using CAD (our templates being similar to those featured in *Oregon Reef,* Beesley 2003, 49), each individually cut shape will have undergone a slightly different shaping process, with the laser cutting through it more or less evenly. Even when the manufacturing process is strictly controlled, the state of the material is in flux.

This idea of materials and processes contributing to the outcome of an artwork is clearly present in Ken Goldberg and Joseph Santarromana's *Telegarden* (1995-2004). In this work, online users instruct a robotic arm to insert seeds, water plants or monitor specific specimens in the garden. The artwork, the garden, is the result of a collaborative making process. The artists had to come up with the idea, work around design issues such as the physical structure of the garden, the mechanics and programming of the robotic arm and the internet platform where people could input actions and interact. This making process involved people, materials and technology, each of which contributed in its own way to the *Telegarden* as a *thing* in its own right. The artists may have contributed to a higher degree, because of their drive to materialise the idea of the piece, but the materials and technology available also played their role in that they shaped what the artists could do with them, which refers back to Malafouris' *How Things Shape the Mind* (2013); the things we create and have around shape the way in which engagement with them is possible, which brings us back to the notion of potentiality. In the *Telegarden,* the robotic arm inserts seeds and nurtures the plants, the plants grow in relation to the input of users which in turn triggers the actions of the robotic arm. Users contribute to the garden and work around what was there: as it forms, dries out or suffers from over watering, vitamin and mineral overdose or deficiencies, plagues. The artwork, now only available online in the form of archived audiovisual documentation, was in a continuous making process for almost a decade, in what Karen Barad calls *mattering* (2007); practised materiality, performed matter.

With *Lichtsuchende*, once the first prototype with glue and toothpicks was developed, a series of more sturdy robots were created. They were made following a template (same materials & program). In principle, all were the same, but they ended up being only similar. Each robot was in a sense unique, displaying the threads that had participated in their process of becoming: robot heads showed signs of the soldering process as marks or burns from the iron and flux. Despite the expectation that the surface mounted components on PCBs were going to speed up our assembly process, that was not always the case. The actions that had happened days before and in another country (China) had an effect on the evening we spent scratching our heads wondering why the PCBs were not working. After much troubleshooting, we realised the LEDs had been originally soldered the wrong way round, and they had to be taken out and replaced. This shows that traces of actions apply even at a distance and across time. The threads that converged that evening (to name a few) involved a bunch of PCBs, a table, soldering irons, a multimeter, hot drinks, tired eyes, pliers, helping-hand stands, zip bags full of components.

The making process of *Lichtsuchende* (2015-2019), its *mattering,* may also be considered as a continuous process which has not finished yet. Despite having spent the last few years in boxes rather than installed, we have plans for its decommissioning, but we have yet to find a clear way of doing this. Surely, this *being-in-the-making* process has not been as lengthy as that of the *Telegarden,* at least not yet. However, the underlying idea that making is an ongoing process is clearly present in both works. When the artwork was installed for the first time in a vault (*Lichtsuchende*) or ready to accept requests from online users (*Telegarden*), its making was not over. The pieces may have needed to be turned on and off, elements within them needed to be taken down, refilled or rearranged, parts repaired, programs fixed. When these types of art-science projects take off in the public domain they are unfinished and continue *mattering* as the projects run their programs, their materials degrade and *things* break (and are sometimes fixed or replaced). The process of making and learning about the materials that compose the *things* we make and the workings of these *things* is endless, because *things* change along with our understanding and the relationships that other *things* initiate towards them. "Despite all claims to the

contrary, crafts hold the key to knowledge" (Latour 1988); *things* learn about making and materials in the processes of making, there is no shortcut to this process of growth (Ingold 2013).

It is interesting to think about how creating digitally engages differently with the flows and vitality of materials. Many aspects are similar: senses of *being-in-the-making*, going through processes of deformation, shaping, structuring, aggregation are just as present with digital materials. Some senses of vitality are enhanced: the replicability of digital materials supports re-use and appropriation of the artefacts created, giving a potential for greater reach but also unintended consequences. Animacy can be more strongly present, as the sensing and reacting capabilities of digital systems can be more vivid and direct than those of the traditional materials of making. However, there is less distinction between the two than might be imagined; Joler's "*Anatomy of an AI"* (2018) shows how far the sociomaterial tendrils of a relatively disembodied digital experience can stretch, through the human labour that supports the creation and processing of data, the rare earth metals embedded in the construction, out to the recycling and landfill centres that are where their *mattering* takes a different form.

Different Things

> "To exist is to differ; difference, in one sense, is the substantial side of things, what they have most in common and what makes them most different (Gabriel Tarde 1895/1999: 73)"
> (Latour 2005, 16)

Although the robots were designed using the same materials, processes and building strategies, each acquired a unique 'robot-al' (instead of 'person-al') quality. Building the robots mostly by hand resulted in individual creatures, with their own graciousness and flaws, similar to Jonnet Middleton's Unity Panda project where components for each panda were knitted separately following a 1946 pattern and later assembled (Middleton 2010); each knitted fabric having its peculiarities: tighter or missing stitches, and each panda having different finishes, seams (alignment), stuffing, eyes, facial expression (see Fig. 4). In theory the robots were identical (following a template), but in practice each creature had its own history and physical singularities which affected its movements, reactions and apparent behaviour. When we observed at the beginning that the robots' movements were too fast and jerky, meaning they could not find each other, we slowed the *Lichtsuchende* down, modifying or adding new parameters to their behaviour. In a sense we bioengineered (in a robot-artificial sense of course) their behaviours, shaping their personality, as well as their physical state, replacing parts (the equivalent of limbs or organs in humans) or improving parts before reinserting them into the robots' live system. The modifications were part of a companionship design process (Murray Rust & Jungenfeld 2019).

Figure 4. Jonnet Middleton's *Unity Panda* project. Image credit: chris+keir (https://www.keir.xyz/work/unity-panda/)

Needing repair meant some *Lichtsuchende* had to enter what we called the 'robot clinic' and be seen by us or a technician (as during GLOBALE: Exo-Evolution exhibition at ZKM, 2015-2016) who after a first assessment would determine the level of injury and set up a recovery plan (e.g. soldering, laser cutting new parts, swapping old servos for new ones, re-programming). This relationship with the robots involved a level of compassion for the creatures, in an ontic sense, it involved caring for them. Having to leave a broken robot in a box labelled 'for repair' was sad, because we had built, looked after, tested, observed, fixed, or reprogrammed it, yet it was suddenly inert, comatose.

When trying to bring them back to life from a vegetative state we could either replace faulty or broken parts (physical) or re-boot their system by reprogramming them completely (psychic). Replacing broken components or acrylic parts was a routine procedure, but we felt reprogramming the creatures was like wiping out their memory with electroshock therapy, as in Michel Gondry's *The Eternal Sunshine of the Spotless mind* (2004). Although the reprogramming therapy involved reinstating a programme which was close to their previous one, it involved deleting any behaviour patterns they may have had. In the process of their *becoming* and us being enmeshed with them, we learned and incorporated that learning into new physical setups or algorithmic rules which the robots would perform.

Again, creating digitally has an interesting relationship with individuality, with the possibility for both more and less variation between pieces. The digital aspects of a piece can be reproduced perfectly, transmitted, shared, copied - all the affordances of digital technology that support idealised multiplication. Indeed, it is relatively impossible to engage with anything digital without making copies, as files are transmitted, stored, cached, displayed, rendered, at each moment occupying a different

substrate while to some extent containing the same information. In the artwork here, the digital aspect of the robots was, barring error, identical, and their differences came mainly from variation of their physical characteristics and histories. However, digital works also provide the seed for individuated pieces, where a single work can have many instantiations for instance: an infinitely repeating series that a participant will experience a different moment of at each time; or a generative work that includes some level of randomness, so it may react differently each time; or a work that allows for a collection of related outputs to be made using different random seeds. However, for us in the *Lichtsuchende*, it was the variability that came from identical programs meeting subtly divergent physical matter that held interest, the constant diffractive tendency of matter to push back, and for objects in the world to acquire their own histories and differences.

Things and Environments

For any making to take place, environments in which to make things have to be available. *Things* do not exist in a vacuum, they inhabit the worlds of which they are part of and which they make with their actions or inactions. Moving past the phenomenological dwelling and *Dasein* (Heidegger 1962), *things* are there and their *being* there contributes to the shared environments they participate in. Since the drive to make things is inherent in humans, and humans live in environments, we could say that living in the environment is also a form of making. This is something that Ingold has extensively discussed in a series of articles about environments (Ingold 2000). As we grow and dwell in the environment we make *things*, and in our interactions with *things* we make the *things* in which and with which we live (a pot, a CAD design, a fire, a machine, a program, a tent); some of these *things* are material, some are not.

Environments may have different qualities and be tangible or immaterial. We can talk about the environments where our imagination plays (our dreamlands), the environments where data flow (digital architectures), the environments where microbiota live (skin tissue). If we accept the premise that environments exist in relation to the *beings* that live in them (Gibson 1979) but also in relation to the *things* that are in them, then artificial lives made of atoms and energy such as the *Licthsuchende,* a group of light-seeking robot flowers, are certainly also in environments. These environments are composed of both non-human and human things, and each is enveloped by what Jacob von Üxküll calls their *Umwelt* (1934), their unique way of understanding the world around them. Although their means to relate to the environment and the world around them are limited to a single physical sense, their ability to change the orientation of their sensory apparatus means the *Lichtsuchende* are able to establish relationships with the environments where they are installed. Environments here are not simply passive, but contain the constellations of other surrounding things. While on a basic level, changes in light levels lead to changes in the robots behaviours, on a more experiential level, creating a social fabric required a delicate tuning of the speeds of response and reaction for the robots. In order to create a *correspondence* between individuals (Ingold 2001, 241) they needed their movements and actions to resonate with the rest of the group. If this was tuned too fast, as in early trials (e.g. at Inspace, Fig. 5), they would appear hyperactive and unable to relate to each other, creating a rather stressed sense of individual isolation. When their sensing and response were working in concert, their *Umwelt* led them to engage fruitfully with others around them.

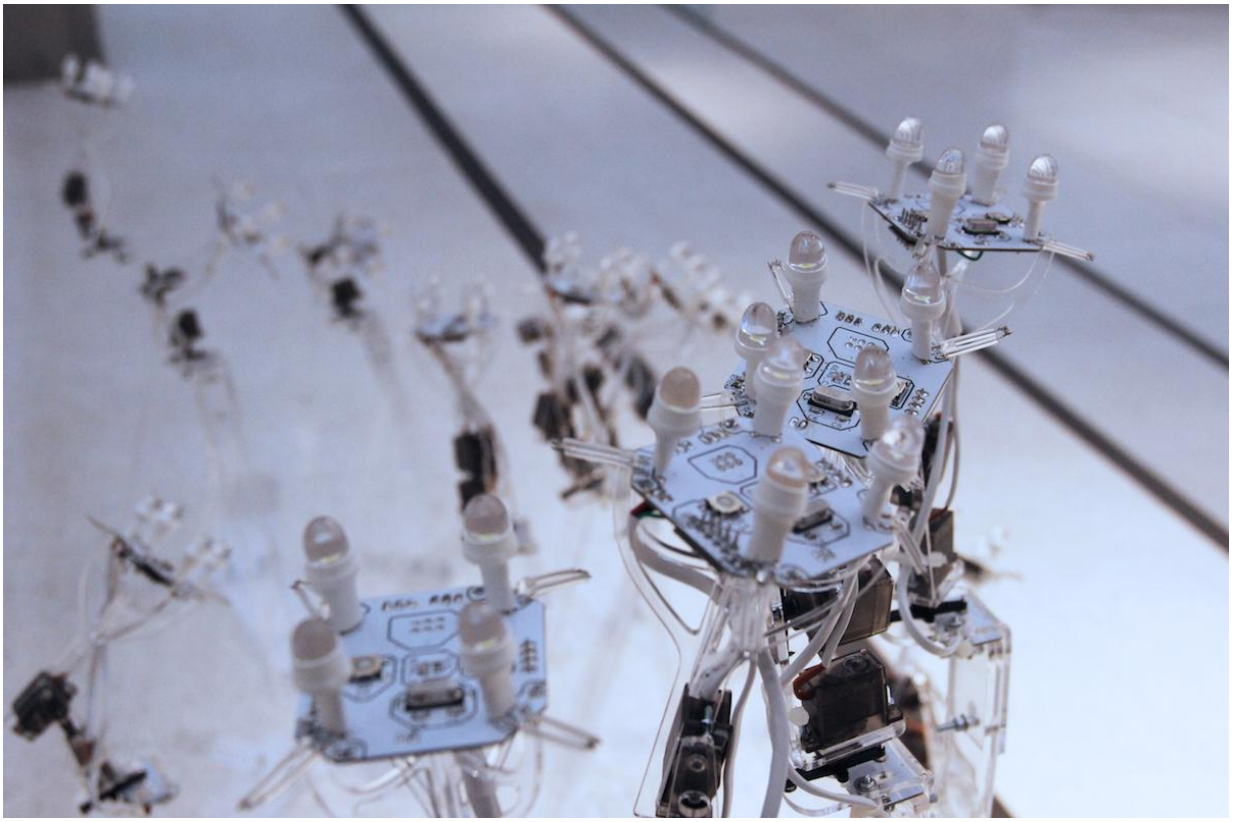

Fig. 5. Lichtsuchende waiting to be installed and tested as a large group for the first time at Inspace, Edinburgh,

The environment where artworks such as Rafael Lozano-Hemmer's *Vectorial Elevation (Relational Architecture #4)* (2000) develop is considerably different. In *Vectorial Elevation*, the environment is two-fold, part of it is directly installed in Mexico City on the roofs of buildings and is projected into the air above the city, while the other part is online (users select vectorial elevations) and on servers (processing of the settings selected through the user interface). The *Lichtsuchende* are closer to Philip Beesley's *Hylozoicground* (2010), living architectures that respond to the movements of people in the environment, sensing their proximity and moving their articulated parts accordingly. In Beesley's artwork, there is no obvious action for people to perform, *Hylozoicground* senses presence, while our robotic creatures can be activated when people point light directly at them using a torch, or reflecting light using their bodies.

In terms of the making and creation involved in the *Lichtsuchende*, as with many other artworks, several different environments were involved, allowing different engagements between the various components, and different interactions. Here we will look at two - the environments where we made the robots, and the ones in which they were let loose to do their roboting.

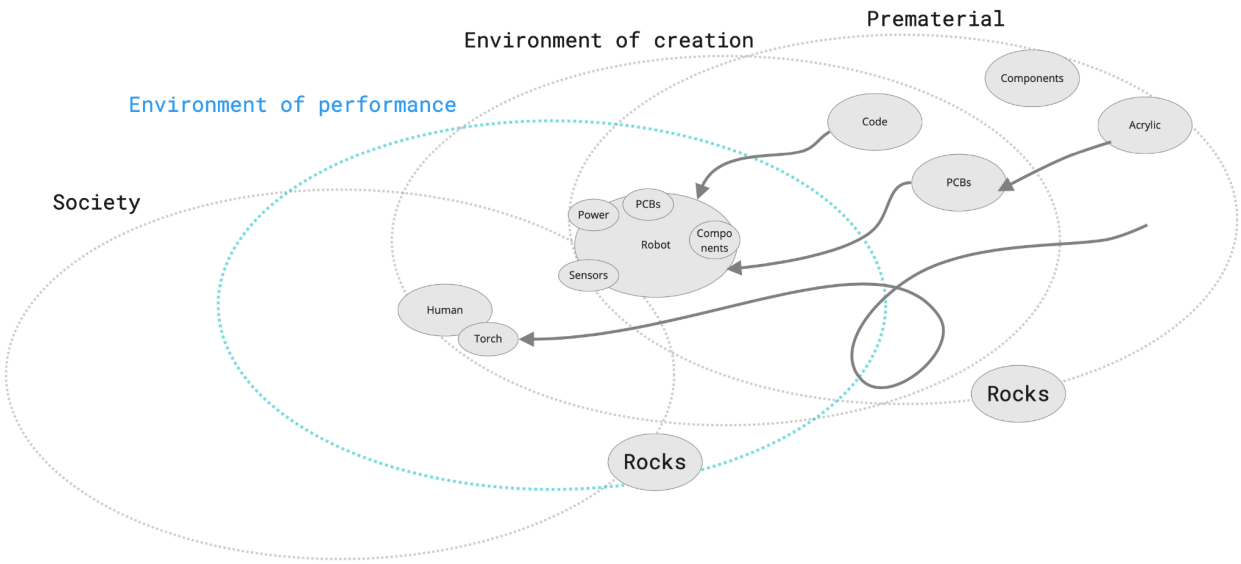

Fig. 6. Material flows through the environment of creation into the environment of performance

The robots were constructed in what we could term the 'environment of creation' (Fig. 6). Here, as LEDs and PCBs flow through the global supply chain and into our workshops, we bring them into relation with shaping and modifying forces - soldering irons, heat guns, lasers, and they begin to take physical form. The animacy and vitality here is generally a physical, mineral, chemical kind - the apparent ways that solder 'knows' where to flow on a well prepared board, the transitions from liquid to solid as cyanoacrylate meets free air or the moment when heated acrylic suddenly becomes fluidly deformable and open to the possibilities of movement. Alongside the physical shaping, a more digital connection to the world starts to take place: the initial *Umwelt* of a microcontroller concerns clock signals from a crystal oscillating and information pushing in on the serial connections, activating receptive structures that allow for the the patterning of its memory with programs. A series of gradually more complex test programs build up first initial possibilities for sensing and action, in terms of voltages that correspond light levels, angles that indicate particular positions to be taken, and the possibility for structured communication with a connected device - sharing information and receiving instruction. As the testing and building progressed, for each device this initial state was built upon to create more refined and actively created parts of the senseworld: as light sensing was combined with movement, the *Umwelt* of the *Lichtsuchende* expands to have a sense of 'brightest' with the attendant possibility of orientation, and a slightly meaningful relation with the world starts to form. However, in this environment, stimulus was degenerate and minimal - moments of input would be interspersed with disassembly; interactions were technical, codified, programmatic, invasive, with little opportunity to relate internal states to environmental happenings, or to connect with others. The environment was oriented towards technical production rather than being supportive of robot activity: there were many bright lights that would draw their attention, physical arrangements were geared towards ergonomics for humans rather than robot socialisation, objects present were designed for testing, probing and evaluating rather than open ended interaction, and minimal thought was given to experience and aesthetics.

After a period in the environment of creation, the robots transitioned to a performance space, where there were more open possibilities. The lighting was carefully controlled to provide the optimum ground for them to communicate without distraction; they were in a space with many other robots, allowing the more social connective aspects of their *Umwelt* to come to the fore, as they formed alliances, corresponded, interacted. There was often a sense of group dynamics, the creation of a social environment within the larger environment of the room, that shaped their actions and behaviours through their sense world. It was this environment that the public were invited into, from the wider context of their daily lives, into a partitioned space, set up more for these light-seeking robots than people, and invited to engage with the objects on their own terms.

Actors at work: ANT briefly unpacked

Bruno: "Oh, I love it. I am a serial redescriber. Now I know who I am. [LAUGHTER]"
Latour et al. 2011, 74

We use Harman's study of ANT as an entry point to help unpack some aspects of Latour's Actor Netowork Theory which are useful in our attempt to better understand the *Lichtsuchende* and their process of becoming. ANT is widely credited as the first comprehensive theory which assigns agency to non-human actors, allowing anything (including the *Lichtsuchende*) to be conceived as actors in the network. Harman (a key OOO scholar) prefers Latour, because he attributes ontic capacities (the ability to care for) to things, unlike Heidegger who attributes it only to people (Latour *et al.* 2011, 26). Do Latour's actors, in our case a bunch of robotic creatures*,* care for the actors around them? That is difficult to discern, but we can look into whether they relate to other things around them; that is more feasible.

At the core of ANT are actors and their relations, and how when combined, they forge a net of actions. According to Harman, ANT is based on irreduction, actors, alliances and translation:

1) **Irreduction** refers to the need to avoid simplification. Things and their relations are complex, irreducible, yet when describing them, we have to reduce them to some degree. The *Lichtsuchende* are made of materials and parts, as well as lines of code and electric current. If we start unpacking these we go deeper (copper, plastic films, functions, solder, resistors, electric charge, to name a few) but end up having to reduce things, else we hit the infinite regression paradox where "each actor is a black box containing other actors ad infinitum" (Latour *et al.* 2011, 27). When considering the *Lichtsuchende* in a particular set up (e.g. Vault 13, see Fig. 7), other things and complex relationships become apparent, yet we still have to reduce them when describing a humid stone-based vault, stones serving as ballast to acrylic bases, robotic heads turning around searching for light, power supplies feeding current to the robots, visitors moving and carrying torches that point at things.

Fig. 7. *Lichtsuchende* @Vault 13, Hidden Door Festival, Edinburgh. Image credit: Chris Scott (@chrisdonia).

2) **Actors** are anything that contribute to a *network*, this includes things and relations. As briefly described in relation to irreductions, actors are of varying sizes, shapes, they come and go, are real or fictional, material or immaterial, made of flesh or other stuff, while also made of other actors, and may be part of larger actors. As Harman states: "all actors are equally real [although not equally strong]" (Latour *et al.* 2011, 27), and when analysing and describing, we have to consider them in terms of their actions, and the effects that these actions have on other actors or the relationships between actors. When looking at an instance as captured in Fig. 7 (long exposure: 1/30 shutter speed, f/8 aperture, EFL 16 focal length, ISO 100), we notice some obvious actors frozen at work: stonewalls, concrete floor, white power cables, light beams, acrylic structures, visitor crouching down / standing / reaching over with their hand, robotic creatures' heads turning and moving, stones acting as ballast. Actors are more than their relationships and as Latour states "a*ny thing* that does modify a state of affairs by making a difference is an actor" (Latour 2005, 71). There are actors at play that are not visible or captured in the image but have left a trace: the torch the visitor holds, the curtain shielding the space from daylight and keeping it relatively dark, the signage installed at the entrance giving guidance to visitors, or the sounds that different actors produced and played in the space.

3) **Alliances** are connections between actors that can be strong or weak. These alliances are defined by where and to which other actors any actor turns to in order to forge connections. Latour's theory is aligned with secular occasionalism; things interact with each other at a local level without the intervention of a top-down figure or idea. As argued elsewhere, horizontality is a more even ground to discuss relations between things (Jungenfeld 2022). All relations require a mediator which, as

mentioned, Harman criticises since if each actor requires a mediator, and every mediator is an actor, then what mediates between mediator and actor? (see earlier discussion of infinite regression paradox) (Latour *et al.* 2011, 35) This is an issue from a metaphysical standpoint, but for Latour each actor is a mediator, what is between them is simply another mediator (Latour *et al.* 2011, 33). For example, two robot flowers are linked to the power socket through a cable, this cable is placed between the flowers and the socket by another actor (technician) who links them and is a tangible ally that acts when plugging things together. Their alliance and connection to other actors remains even after having left the room. Immaterial elements are linked, the program that runs the robot flower is allied to it through a circuit; this circuit has components that are linked by the solder that another ally added to them. The solder is made of the alliances between its metal molecules, and so on and so forth. The program is linked to the exhibition through many actors, all those involved in the set-up of the infrastructure and the organisation of the actors that are at play, along with those unpredictable actors (e.g. visitors) that appear over time (see Fig. 8).

4) **Translation** explains how a thing and its description at any point can never be exactly the same because processes are applied in the translation and therefore the initial thing turns to be another thing (Latour *et al.* 2011, 26-28). Any description or analysis, as we are trying to do here in explaining the *Lichtsuchende,* is a translation. We acknowledge that in attempting to explain things, even when simply describing elements within a *network*, we are translating and reducing (see Fig. 9). It is this simple, we cannot unpack every actor, as each relationship of actions happens as an unrepeatable instance and each action changes the actor in the following action (translation). Actors change with these translations: "everything is in a state of perpetual perishing" (Latour *et al.* 2011, 29). Figure 9 captures the state at a particular moment, in that instance, the arrangement of actors (relations and things) was as pictured, yet after 1/30 second passed, *things* would have changed: the visitor would have moved, robot heads turned, the point in their algorithm at which each robots was would have passed, the configuration of the lights projected into the space by different actors. Some things may seem permanent, i.e. the stones or wall, yet they are also in flux, only that their timescales differ, stones are slower than electric current.

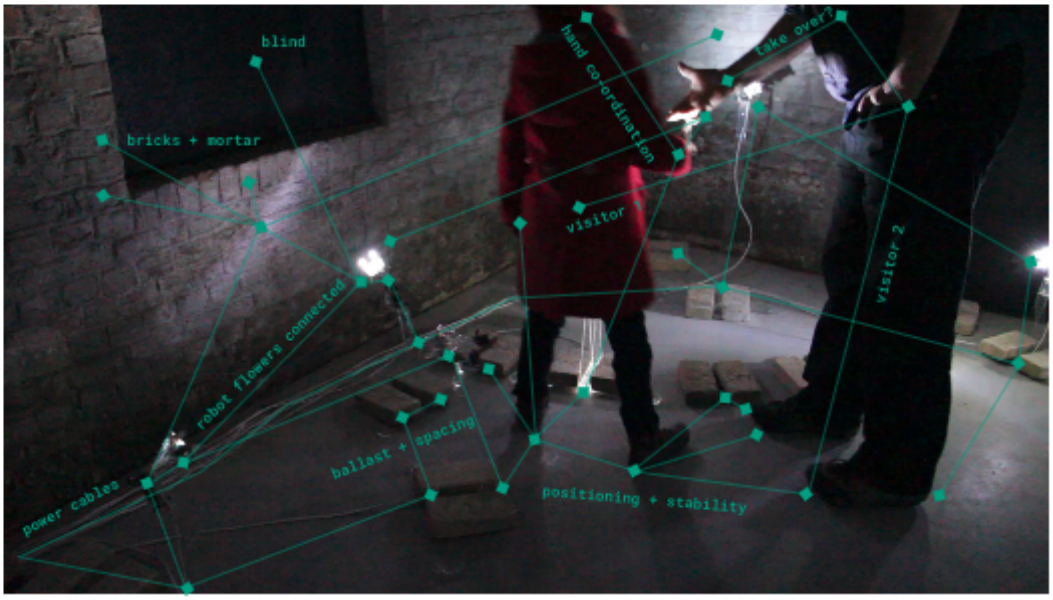

Fig. 8. Some of the key actors in the installation showing their relations

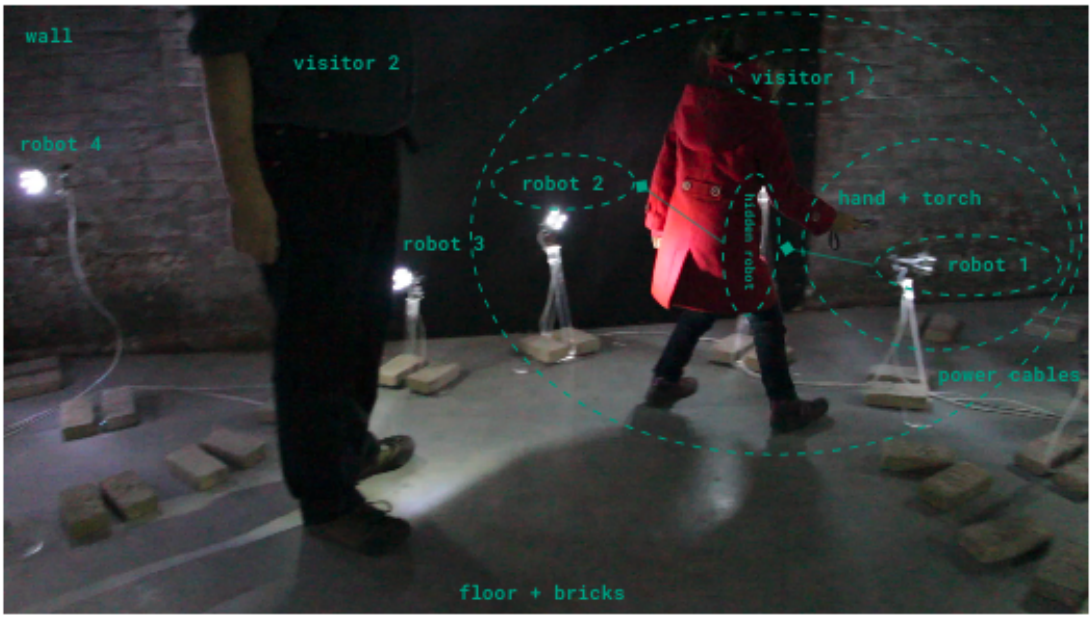

Fig. 9. Key actors and groups showing some of the subgroups and alliances present

For digital works, this broader sense of what can be an actor, and how far to follow relations is important to understanding the socio-cultural embeddings of works and their production. Recognising the agency of programming languages, libraries, datasets, discussion fora, repositories feels increasingly crucial to understanding the acts of creation. In a more local sense, the *Lichtsuchende* highlight the agencies of the various *things* brought together, as torches and spaces shape human behaviour, and interactions with the robots establish various physical and conceptual relationships. The materiality of the digital is easy to read in an agential way, as responses can be coded, interactions scripted, behaviours carefully shaped to enact various forms of 'liveness'.

The active *mesh* at work

Here we bring *meshworks* and actors together to shine light onto things and the threads that help us understand what is at play in the environments that robots and other actors co-produced and shared. For this, we discuss how things and their relations changed over time as the *Licthsuchende* are part of what Ingold (following Deleuze's work) refers to as *lines of becoming* (2011, 83-4) within the *meshwork.*

The environment is unique to each actor; a robot's world (its *Umwelt*) is different to the environment of the torch – that is hitching a lift with the visitor, nonetheless, their environments sometimes overlap (see Fig. 10), particularly when they are performing their *being* in the world in relation to each other. The environment changes depending on the setup and configuration, and how *things* are distributed across space and over time. In relation to the *Licthuschende* every exhibition space offered a relatively different environment where they could be active actors and relate to others, non-humans and humans. There are aspects of the environment which different actors may share, for instance, robot 1 and robot 2 may have shared the power supply, program and floor; or visitors, torch and robots may have shared black-out room and air temperature.

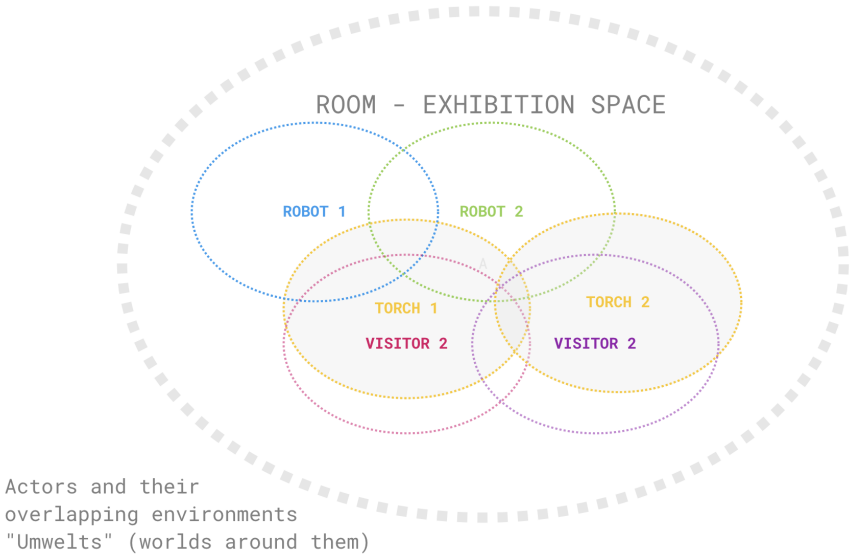

Fig. 10. Diagram showing the overlapping environments of 6 main actors with the *Lichtsuchende* installation.

For some of these actors (i.e. torch) to be able to share the environment and participate in the *mesh* of relations, another crucial actor needed to be at work. Only when visitors hold the torches in their hands, carrying and performing gestures with them, the torches are able to modify the state of the robots and activate something in these other actors, leaving a trace. The non-human and human things, e.g. the torch and hand, merge in *cyborgian intentionality* (based on Ihde 1990, Verbeek 2008), where the robot-torch relationship is mediated by other agents, in this case the human, hand and moving body. Hence, the participation of the torch in the *meshwork* of relations is contingent on them being carried by and *ready-at-hand* (like Heidegger's hammer) with the visitor. The torch cannot activate itself (turn on) nor can it enter a performative state on its own. The torch becomes an active actor when embodied, and only falls back to Heidegger's *present-at-hand* state when the visitor places it back on the table on their way out, or the batteries run out. In relation to the latter, in *Being and Time* (1977 (1927)) Heidegger calls this the "disturbance of reference" which happens when something does not work properly or fails to work at all (Harman 2002, 46; Latour *et al.* 2011, 36). At such a point, the relationship of correspondence between torch, hand, robot and visitor, which Peter-Paul Verbeek coins as having *composite intentionality* – where technological things also have intentionality (2008) – breaks. The gestures that were performed together, their entangled *lines of becoming,* diverge. As Ingold describes in 'The Textility of Making' and in relation to flying kites (2011), the wind, kite, string, and person are "trajectories of movement, responding to one another" (215). Once the correspondence between them is disrupted, the kite loses its ability to fly, the dance of relations falls apart.

A reminder of the importance of potentialities seems appropriate here, since elements in the environment (things, which Harman calls objects) have qualities that are not always included in the network of relations (Latour *et al.* 2011, 36). However, as Harman points out for Latour "alliances are more important than hidden individual essences and potentialities" (Latour *et at.* 2011, 51). In Latour's case, potentialities are secondary, while for Ingold and *vital material* scholars such as Bennett, these are crucial to the *things* themselves because hidden potentialities, although dormant, participate in the *mesh* of relations that develop over time rather than having an effect on a particular instance.

Fig. 11. Robot, torch, hand and child enmeshed in correspondence at Summerhall Edinburgh.

In the *Lichtsuchende* installation, we could refer to the potentiality of robots to shine light at other robots, at the room and torch. When looking at a snapshot of the installation (see Fig. 11) some robots are asleep or taking a break, and their capacity to shine is dormant. Yet this potentiality is vital since without it robots would struggle to find each other and make *alliances*, or enter the *mesh* of relations where correspondence with other actors is possible. Also, the stones of the installation have the hidden potentiality of rolling in the shore and corresponding with the waves, but this capability disappears in the installation where the relations between the stones and other things are based on weight and size. Their rolling capacity is dormant, and only occasionally activated by other actors that may cause them to fall, roll over, knock down other things in their trajectory. In any instance where actors are at work, there are more potential relationships than those appearing to have been established. In Figure 11 we see a robot, torch and child closely engaged and active, while other robots are facing away and have their headlights off. What is happening does not preclude the apparently dormant robots from establishing a connection with other actors, and corresponding with them in a fraction of a second from now. Associations are circumstantial, and increase or decrease depending on the number of actors that are active and at work at any moment, but *things* and their relations exist as threads over time, they are evolving actions within the *mesh*, they converge, correspond and push each other, they are *trajectories of becoming*.

To illustrate this we present two ways of looking at what is happening between the light-seeking robot flowers and other actors: 1.) Ingold's lines in the *meshwork*, and 2.) Latour's actors in the *network*. For this, we review visual documentation of the installation and apply visual analysis methodologies discussed elsewhere (Jungenfeld 2020).

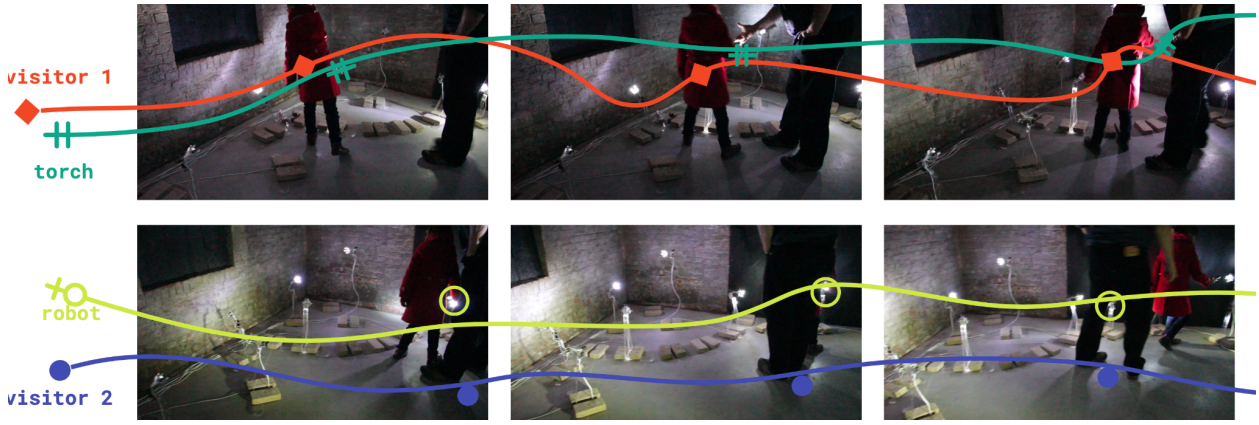

Fig. 12. Sequence showing 4 actors visualised as threads, as trajectories of movement in a meshwork, @Zebrastraat Gent.

Ingold's lines in the meshwork

In Figures 11 and 12, we have a sequence of images extracted from the video documentation showing an area of the installation where a number of actions are being performed. The lines of two visitors, a torch and a flower are overlaid onto the sequences to highlight movement and positioning, as well as points where and when these *things* may have converged:

- **Top sequence:** visitor 1 and torch are drawn together to address *cyborgian intentionality* (Verbeek 2008), and how these two actors are enmeshed, needing each other to have an effect on other actors, particularly on other technological actors (i.e. robot flowers) that are somewhat fixed to the floor. When following those two threads of action we see how they somehow move along together, crossing over, converging, getting entangled and activating other actors. The visitor is occluding our view of how things are being entangled – we cannot see the robots or torch in detail, however even from the back we can see the arm (that holds the torch) moving sideways and rotating, the lights and shadows in the space changing (reflections on walls, floor, fabric, skin). The two threads are at play, together over time.

- **Bottom sequence:** visitor 2 and robot are drawn as moving along temporarily, yet staying somehow apart, their paths not actually converging in the *mesh*. If we had overlaid the threads of visitor 1 (with torch) and robot, we might have observed some convergence, especially at the beginning of sequence where the child wearing a red coat (and torch) is directly engaging with the robot, pointing the torch light at it, and making quick rounded gestures around it. This performative aspect just described, is only visible in the video footage, in the sequence this level of detail (gestures and correspondence) is difficult to identify. The paths (trajectories of *becoming)* of visitor 2 and robot share the space and their environments overlap, in the form of visible light beams, or the movement of visitor 1 and torch.

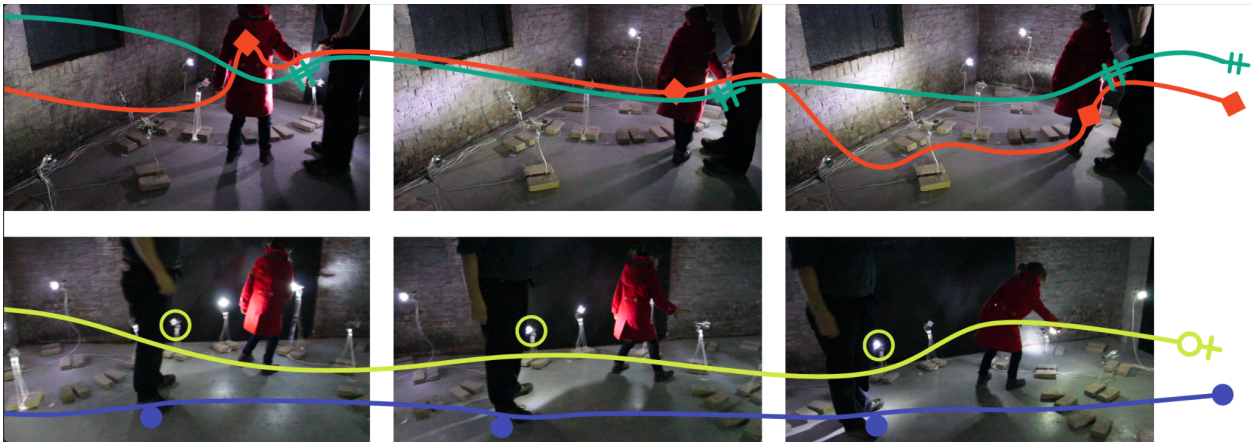

Fig. 13. Continuation of sequence showing 4 actors visualised as threads @Zebrastraat Gent.

Latour's actors in the network

When looking at threads within *meshes,* we struggle to see how things are deeply interrelated, because as we follow movement, the relationships and associations between elements change and dissolve, and we cannot pay close attention to nuanced inter-relations, and mediators between mediators; things simply move too fast; things simply move too fast. Hence we are interested in what happens when we put a *meshwork* analysis approach alongside the in-depth analysis of instances that ANT offers. When discussing ANT earlier, we selected two instances and ways of visualising key actors and their associations. Those images give us additional information about what is going on in the *meshwork* at particular points in time. It is impossible to present all actors or their connections, in the form of a graphical representation, therefore we only present a few. Let us discuss them a bit more in depth here.

The *Lichtsuchende* are robotic creatures fixed to the ground, much like Random International's *Audience* (2008) installation, where little mirror creatures turn towards visitors while their bases are static, grounded. In both installations, the individual robotic creatures have no feet or wheels to move about in space, but can rotate their heads to face and engage with visitors. Each robotic creature is an actor in the *network*, and is interrelated to all other creatures, through a long list of actors: PCB design and assemblage of components, program and algorithmic structure, acrylic sheets from which they were laser cut, power cables that feed current to them, light present in the room, et cetera. These and other associations can be described in relation to the robots, but many other actors and associations were at play, mediating between actors. When looking at these two images side-by-side (see Fig. 14) we can see how some of the strongest actors (i.e. visitors and torch) have moved, and as Latour says drawing on Whitehead, there is a need for "new associations in order to persist in its existence" (Latour, 2005, 218).

In that quote, Latour is referring specifically to society, but we choose also to apply it to groups of actors that are societal in the sense of *being* together and influencing each other. In the left, visitor 2 extends their hand to grab the torch and take control over the gestures and actions that visitor 1 (dressed in a red coat) is performing. That action is counteracted by visitor 1, moving their hand away, continuing their direct connection with the torch and in return with the robotic creatures that they together (visitor 1 ant torch) are engaging and connecting with. The mediating actor here is clearly and strongly the light that is emitted in all possible directions, from different sources and actors within the space. In the right image, we see an instance where new associations have been established between visitor 1, the torch, and the robot that faces towards the right, away from visitor 1. A new association is

being established, yet other actors are also at play, either actively engaged (e.g. robot 2, hidden robot) or ongoingly engaged (e.g. power cables), while visitor 2 is merely standing, refraining from taking direct action, yet with their presence leaving a trace and interjecting the trajectory of different light beams, casting shadows around the space.

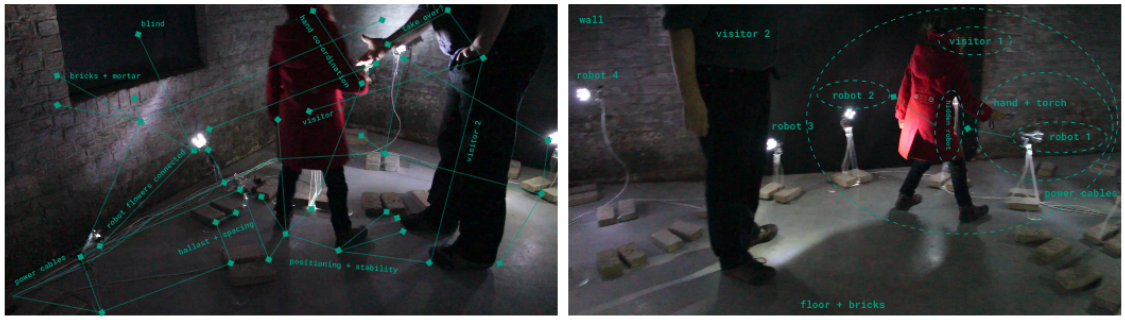

Fig. 14. Different ways of visualising connections between actors in a network.

Other actors at play which may be less obvious in either of these images are the selection process that led to the curated exhibition, the wheelbarrow used to bring the bricks that acted as ballast, or the smell and humidity of the cellar where the *Lichtsuchende* were installed. These weaker actors have left traces, but are neither present in the diagrams nor visually perceivable at first from the images. As Latour discusses: "If no trace is produced, they [objects] offer no information to the observer and will have no visible effect on other agents" (2005, 79). The issue is that the information provided in the images is insufficient for the observer to note the existence of subtle, less active actors. Contextual information and the trajectories of actions – following paths in *meshworks* – are needed. How else could we account for all the actors at work (no matter how weak or strong), when for their traces to be noticed we have to take into account their paths within the *mesh*, their trajectories of becoming? Things are perhaps more than their relations or qualities (Latour *et al.* 2011, 39), because in every attempt to translate them into actors we can never completely unpack them. Thus talking about and taking into account potentialities, and performativity aspects as proposed by agential realism (Barad 2007) may be a better approach to understand how things emerge from and make environments together, how actors in *meshes* work, get entangled and correspond.

Bringing *things* together

In this paper, we have brought together four of the theoretical worlds that underpin an understanding of the ways that people are creating digitally. Heidegger's *thingness* gets into the what it is for something to be a thing in the world, whether physical or digital. Bennet's sense of *vibrant materials* along with DeLanda's *fluid assemblages* and Wiltse's *mult-intentionality* take us into the blurry edges of *thingness*, the ways that they form and reform, coalesce and disperse in their continual *mattering*. Latour's ANT gives a way to read complex situations in terms of their component parts and the relations between them, again extending beyond the immediate to bring in a wide swathe of more than human actors and actants. Finally, Ingold's *meshworks* draw attention to not just the relations between things, but the trajectories and lifeworlds that they follow, the situated and embedded unfoldings that they perform in their constant process of becoming.

These are all joyfully resonant theories in their own rights, pointing at ever more vibrant understandings of the world, that allow us to go beyond any sense of the world as inert clumps of matter occasionally stirred up by human actions. This follows the exhortation that "we need to devise new procedures, technologies and regimes of perception that enable us to consult nonhumans more closely, or to listen and respond more carefully to their outbreaks, objections, testimonies, and propositions." (Bennett 2010, 108). Digital creation is a strange bedfellow with some of these very material, biological, cultural understandings of the universe, as so many of the technologies that support digital works start by setting themselves up along lines of difference from the surrounding world: creating clean spaces for logic to be enacted, built on extractive practices, that offer little space for traditional life to engage. However, as we have discussed, there are many qualities to digital – and especially physical-digital – creations that speak to these questions. The *thinging* of electronic or computational artworks can be vividly apparent, their changes writ larger than the reorganisation of material. *Vitality* is easy to grasp from the first moment of making a light blink with a microcontroller and the sense of working with something at least somewhat autonomous. Every electronic device is a *fluid assemblage*, bringing together code, computation and physicality for a time, changing its identity through software, networking and interaction. Networks carry through to the interdependencies of hardware and software on people, code, structure and connections, the leaky abstractions of concepts, information and hardware that build the foundations for any kind of digital enactment. When we come to *meshworks*, however, the traditional story does not follow the sense of possibility as closely. A network view of relations is very much in keeping with with computer science and the development of digital ideals, as nodes with relations, however complex. To work with a sense that these things have wiggly trajectories, that they entangle and correspond with people's life courses is part of the new frontier of computational thinking, where the fuzziness and politics of computation need to be acknowledged. Every computation runs on a piece of hardware, every piece of data came from a thing in the world, and to see them purely in terms of the relations and abstractions they encode leaves a practice that is unable to engage with humanity, let alone more-than-humanity. Instead, we can look for the mess, for potentialities, the co-dependencies, the *becomings-with* that are the hallmarks of a materially engaged digital practice.

Acknowledgments

TBC

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Authors biographies (short)

Rocio von Jungenfeld is a creative practitioner and media researcher at the University of Kent, working in embodied perception and how media art and technology alter human-non-human interactions in environments. Her creative practice involves collaborative, interdisciplinary, and participatory media production; hybrid/immersive installation environments; outdoor-mobile projections; interaction design; and media art in public space.

Dave Murray-Rust is a researcher at Delft University of Technology, working in human-algorithm interaction - exploring the messy terrain between people, data and things through a combination of making and thinking. In his creative practice he engages with interactions between people and technology. This includes electronic music making, building software for different kinds of musicking and a collection of technology based artworks.