ECOLOGY OF ENCOUNTERS

Meeting spaces for humans and non-humans in media art

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"*How to live a world of difference(s), a world in/as ongoing differentiation, in such ways that the outcome is not ever more separation and antagonism, exclusion and the fear of others, but so that new senses of commonality are envisioned?*"

(Thiele, 2014, p. 202)

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ABSTRACT

The rapid intensification and development of both scientific and technological progress are shaping our world at an unprecedented speed. Our time asks us to re-relate to each other and the others we share our space with. “The human” can no longer be seen as the centre but as part of a comprehensive and complex system. This system consists of humans, animals, plants, fungi, and micro-organisms but also matter and data. This thesis is a practice-based exploration of the encounters between human and nonhuman via sensing technologies in my art practice. Through the lens of agential realism and the methodology of diffraction, I look back on four of my works 1. RHIZA, an interspecies connector between fungi and humans. 2. ZIEN, a collaborative public art project between ministry officials, citizens, and a robot arm. 3. FadingColours, real-time data sculptures that connect ocean data on coral bleaching and the living conditions of the algae. 4. ZOE, a temporary coexistence between reishi mushrooms and a custom-made robotic system. I am questioning whether the philosophy of critical posthumanism and new materialism come to practice in my process of creating media art installations.

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INTRODUCTION

Standing on the stage, I saw the audience sitting in the dark. The rules of theatre dictated that they could not enter the world I was part of. Their role was to sit and watch. Experience the world we created from a certain distance. I left the stage wondering if the same experience could occur if I were not here. What if the audience and the space, matter, and non-matter, came together? Is my human performing body needed as a mediator to bridge between the observed and observer? Or can you be both at the same time?

During my bachelor's in scenography, I started experimenting with what this could be. What would it mean if performativity remains, but the human being no longer has the leading role? Who or what can take the place of the human performer? I kept the principle of staged encounters. I left the fixed positions behind. The influence of one on the other became my starting point.

Through the process in the microcosmos of theatre, I also explored this process outside the theatre. We are part of a world with a quite disturbing political, social and ecological situation. The rapid intensification and development of both scientific and technological progress are shaping our planet at an unprecedented speed.

Our time asks us to re-relate to each other and the others we share our space with. Now that technology and the consequences of our impact on this earth penetrate deeper into our lives, I can no longer see "the human being" as the centre but as

part of a comprehensive and complex system. This system consists of humans, animals, plants, fungi, microorganisms, matter, and data.

Through the theories of posthumanism, new materialism, agential realism and care practices, I came more profoundly into the theoretical realm of this flow of thoughts and theories. Theoretically, theory and practice are the same. In practice, this is only sometimes the case. Take the concept that everything is connected to everything. It sounds great, but it does not resonate with how we experience our world. What matters is how we are connected. We need to be able to understand the specifics of these connections in order to experience them.

This thesis is a practice-based exploration of the encounters between human and nonhuman via sensing technologies in my art practice. Much is written and searched for terminology within media studies that emphasise the relationally between human and nonhuman action. Through the critical post-humanistic lens of agential realism, I look back on the process of four works created in 2021 and 2022.

1. RHIZA (2021)
An interspecies connector between fungi and humans.

2. ZIEN (2022)
A collaborative public art project between me, ministry officials, citizens, and a robot arm.

3. FadingColours (2022)
Real-time data sculptures that connect ocean data on coral bleaching and the living conditions of the algae living in the sculptures.

4. ZOE (2022)
A temporary coexistence between reishi mushrooms and a custom-made robotic system.

I will examine if and how practice and theory come together, by looking back on the process of creating these works and the decisions made in the process via theory of critical posthumanism and the new materialist methodology of diffraction. I know that my installations start from a mindset that wishes to invite one to get to know the unknown other—hoping to create a more empathic and caring connection with others. I question what it means and takes to work from a critical posthumanist stance and how to create encounters between the human and nonhumans, which are experienced as an embodied immersion in the other's zone through sensing technologies.

Inherent to the methodology of critical posthumanism while writing and reading this, I acknowledge and respect the multiple and internally contradictory aspects of our own knowledge practices, where the focus is on collaborative ethics. As I always say about my practice, I focus more on the experience of questions than one clear answer.

THE THEORIES

"*It matters what matters we use to think other matters with;*
it matters what stories we tell to tell other stories with;
it matters what knots knot knots, what thoughts think thoughts,
what descriptions describe descriptions, what ties tie ties.
It matters what stories make worlds, what worlds make stories."

(Haraway, 2016, p. 12)

The theoretical field of posthuman studies does not consist of discrete and neatly delineated areas. Like the worldview they represent, the theories and authors are woven into a rhizomatic network. No thinker belongs to a theory view, and no theory belongs to a single thinker. The abundance of theoretical expressions within posthumanism makes it necessary to delineate some reference points.

In this thesis, I relate my work and thinking to the perspective of critical posthumanist scholarship in the humanities today (2022). Their new schemes of thought address the relationship between contemporary concepts of human/non-human interactions and real-life conditions. This chapter will give an overview of the different critical terms, and leading concepts of posthumanist critical thinking with a focus on agential realism as part of new materialism.

CRITICAL POSTHUMANISM

Posthumanism is a term which is not explained easily. Since the term is used differently by various thinkers, there is a need to clarify whether one is talking about posthumanism or transhumanism.

If we go back in time, the rise of Humanism was between 1400 and 1600. It shifted the worldview from a god-centred society in western Europe to a man-centred one. I specifically say (western) man-centred and not human-centred, given that this perspective did not address the full spectrum of humanity. Around 1900, philosophers and scientists began to question the idea of man as the central point. New ways of thinking need their time. The big push became visible in the last thirty years with the rise of interdisciplinary critical practices within the humanities that called themselves 'studies'.

One can think of studies like media, science and technology, women, gender, queer, postcolonial, cultural and many more. A defining feature of the studies is that they are grounded in and resonate with our world's social and political changes. They combine science, philosophy and the arts in parallel ways and value the knowledge gained in the lived experience without taking an anti-science stance. They activated a way of thinking of 'the other' within the academic world and paved the road for posthumanism. Posthumanism does not exclude humans but includes them from a more holistic perspective.

Keeling and Lehman (2018) define in the Oxford Research Encyclopedias the posthuman perspective as one where humans are:
(a) physically, chemically, and biologically enmeshed and dependent on the environment;

(b) moved to action through interactions that generate affects, habits, and reason; and

(c) possessing no attribute that is uniquely human but is instead made up of a larger evolving ecosystem. There is little consensus in posthumanist scholarship about the degree to which a conscious human subject can actively create change, but the human does participate in change (Keeling & Lehman, 2018, p. 1).

On the other hand, there are transhumanists. Transhumanists and posthumanists are often confused. However, there is a big difference. Transhumanists focus on the improvement of humankind through technology. In their philosophy, the human being remains central, and the focus is on the enhancement of the human being that goes hand in hand with developing new technologies. The term transhumanist was popularised in 1957 by the English biologist and philosopher Julian Huxley in his essay "transhumanism"(Ostberg, 2022).

Posthumanism is a field formed by a broad spectrum of academic disciplines like; comparative literature and cultural studies, ecocriticism, animal studies, environmental studies, science and technology studies, psychoanalysis, quantum physics, cybernetics, feminist studies, postcolonial studies, new media studies and many more fields of studies within the humanities—also, integrating less likely scholars in the academic world as arts, architecture, literature and music.

My thinking and practice resonate most with critical posthumanism, new materialism and agential realism theory. These theories have a similar focus on relational ontologies, a critique of dualisms, and a focus on encounters with non-humans and matter. The critical thinkers are Rosi Braidotti, Donna Haraway, Karen Barad, Marie-Luise Angerer, Jane Bennett, Claire Colebrook and Rick Dolphijn, who have a foundation in the philosophy of Deleuze and Guattari and their vision of monism. Braidotti describes this as the foundation of critical posthumanism - as both material and vital, a monistic ontology offers possibilities of grounding the embodied and embedded posthuman subject in the process (Braidotti, 2006).

They distance themselves from the Cartesian dualism formulated by René Descartes as the dualism between mind and body by focussing on the convergence of body and mind, human and non-human, matter and meaning, nature and culture, subject and object, continuity and discontinuity, and beginning and return.

According to Braidotti, it is a process of redefining one's sense of attachment and connection to a shared world, [...] It expresses multiple ecologies of belonging, while it enacts the transformation of one's sensorial and perceptual coordinates, in order to acknowledge the collective nature and outward-bound direction of what we still call the self (Braidotti, 2013, p. 193).

Critical posthumanism is a theoretical approach which maps and engages with the 'ongoing deconstruction of humanism' (Badmington, 2000). The post prefix in posthumanism is double-sided by expressing the desire, and simultaneously it confirms to go beyond Humanism.

Humanism, and with it, the human being, remains the basis of the body of thought. The addition of “critical” in the expression “critical posthumanism” is to distinguish between the uncritical and popular use of posthumanism in, for example, science fiction and popular use in media and science. The addition of the word critical emphasises the multi-sided approach between the human and posthuman. Like Lyotard’s 1987 notion of a “rewriting of modernity”, (McCaffrey, 2015, p.276) critical posthumanism attempts a ‘rewriting of humanity’.

Critical posthumanism questions our relationship to ourselves and the more than human. What does it mean to be human? Moreover, what does it mean to be ‘posthuman’? Where did the need to become posthuman come from? What causes it in the relationship to the non-human? Think of the living non-human like animals, plants, and microbes, but also the non-living like robots, data and machines. It also questions how it makes us relate to concepts such as god and the Anthropocene.

Within critical posthumanism, a reflective approach to our thinking is essential. It is critical of transhumanism in its desire to transcend and improve humankind through technology. On the other hand, in posthumanism, humankind is so much a part of the whole that humans become sidelined. As a result, no action can really be expected from humans anymore. Whereby no responsibility is taken for our actions either. Janina Loh focuses on this topic of responsibility. She proposes an inclusive understanding of the responsibility that allows us to no longer essentialistically attribute or deny responsibility to individual (human) agents. In this way, responsibility in the context of an inclusive ethics of companionship is a property of successful relations. It only arises in the interaction of human and non-human agents (Loh, 2021).

Posthumanism generally assumes an equal relationship with the non-human. Critical posthumanism further questions the complications of this and the extent to which the proposed relationships do not still primarily serve the human.

Critical posthumanism's main purpose is mainly ethical and motivated on responsibility and care – care for the human and the non-human alike. In this sense, "whoever cares about the humans and their past, present and future might want to critically engage with humanism's anthropocentric ideology" (Herbrechter, 2013, p. 3).

In my practice, critical posthumanism keeps me critical of what kind of relations I have and want to have with the humans and non-humans around me. In many of my works, there is a motive to find ways of living together while being different. I see embracing the differences and working from these different qualities of those involved as a proposal to redefine our own society and the way we live together on our planet. This brings in my practice a notion of responsibility towards the humans and non-humans I collaborate with. Collaborating in a critical posthumanist way requires being caring and taking into account all the qualities and needs. In the following chapter on new materialism, I will focus more extensively on how embracing difference creates the space to collaborate with the non-human.

NEW MATERIALISM

New Materialism shares the interest with critical posthumanism of rethinking and positioning the human and non-human. They rethink critical approaches to difference. From an urgent and challenging manner, they look at how it works, what it is and why it matters.

"New materialism" is a term coined in the 1990s by Rosi Braidotti, Manuel DeLanda and Donna Haraway to describe a theoretical turn away from the persistent dualisms in modern and humanist traditions (Dolphijn & Tuin, 2012). "New materialism opposes the transcendental and humanist (dualist) traditions that are haunting cultural theory. What can be labelled 'new materialism' shifts these dualist structures by allowing for the conceptualisation of the travelling fluxes of nature and culture, matter and mind, and opening up active theory formation" (Dolphijn & Tuin, 2012, p.48).

New materialism turned toward matter from a dissatisfaction with the linguistic turn of the 20th century, where the focus is primarily on language and the users of that language. What is referred to as new materialism, like posthumanism, is not a unified term and consists of many meanings. They share the concept that matter is not inanimate and can generate data or go outside the existing material discourse.

"By rejecting a distinction between the physical world and the social constructs of human thoughts, meanings and desires, new materialism opens up the possibility to explore how each

affects the other, and how things other than humans (for instance, a tool, a technology or a building) can be social 'agents', making things happen. Its post-anthropocentrism displaces humans from the central focus of social inquiry, not only emancipating the affective capacities of the non-human but also establishing an ethics that can engage productively with human culture, with other living things, and with the wider environment of inanimate matter" (Braidotti, 2013, p.60).

Despite the rapid increase of new materialist approaches, Dianna Coole and Samantha Frost describe three main categories in their book; New Materialisms: Ontology, Agency, and Politics (2010): Ontology/Agency, Bioethics/Biopolitics, and Critical Materialism. Ontology/Agency is characterised by exploring the agency of matter. Bioethics/Biopolitics focuses specifically on non-human social justice and geopolitics, whereas Critical materialism focuses primarily on global capitalism in relation to the climate crisis. Critical materialism emerges from Marxist historical materialism. The prominent thinkers are Karen Barad, Jane Bennett, Rosi Braidotti, and Elizabeth Grosz.

One of the essential thinkers of new materialism is Jane Bennett. Like many from the field of posthumanism and new materialism, Bennet is influenced by Deleuze and Guattari. As well as the early twentieth-century critical vitalists to bring together vitalism, affect and materiality. In her book Vibrant Matter (2010), she states that non-human with a focus on non-biological matter has a liveliness that shows in the shared agency by relating and clustering with human and non-human actors. Whereby agency is never intentional and always shared. Her starting point in this book is 'thing-power'; "thing-power gestures toward the strange ability of ordinary, man-made items to exceed their status as

objects and to manifest traces of independence of aliveness, constituting the outside of our own experience" (Bennett, 2010, P. XVII).

Rosi Braidotti began using the term "new materialism" in the second half of the 1990s from her deep interest in materiality and morphology of alterations and focusing on the questioning of dualisms. Her re-reading of Spinoza, Deleuze, and Guattari leads her to formulate Zoe. Braidotti's "Zoe embraces geologically and technologically bound egalitarianism, acknowledging that thinking and the capacity to produce knowledge is not the exclusive prerogative of humans alone, but is distributed across all living matter and throughout self-organising technological networks" (Braidotti, 2019, p. 51). This "non-human, vital force of Life"(Braidotti, 2013 p. 60) may be referred to as Zoe, as opposed to bios or Anthropos (Braidotti, 2006), where "Bios refers to the life of humans organised in society. Zoe refers to the life of all living beings" (Braidotti, 2019, p. 10). Zoe has the capacity for self-assembly or the tendency of all living matter to enter into associations with other material systems. It raises ethical questions on subjectivity since it is neither an individual subject nor a human.

Donna Haraway calls this Nature Culture. A term she introduced in her Companion Species Manifesto (2003). Nature Culture is a concept that emerges from questioning dualisms that are deeply embedded within the traditions of humanities and science (nature and culture, matter and mind, the human and the non-human). The concept of Nature Culture offers us an option to rethink these oppositions so that they do not represent just parts of our world. It rewrites all subversive material practices and gives the possibility for ethical breakthroughs as new materialism is challenging the division between "being" (ontology) and "knowing" (epistemology). Haraway argues that knowing is not separated

from being; therefore, the non-human is implicated in knowledge production. Karen Barad calls this Ethico-onto-epistemology, which highlights the interrelatedness of "ethics, knowing, and being" (Barad, 2007, p. 185).

Karen Barad [they/their][1] is a theoretical physicist and feministic philosopher with a strong background in particle physics and quantum field theory. They advocates a stronger focus on ontology in science. Barad suggests that the physical laws support the experience of reality in an ethical manner by itself. Barad emphasises in their theory of agential realism (2007) the entangled nature of reality, such as the ontological inseparability of objects (matter) from subjects (meaning). The theory of agential realism is a posthumanist performative approach focusing on the process and practice of science rather than the product. It recognises agency as a quality that the subject and object possess. The boundaries between subject and object, observer and observed, are not defined prior to their intra-actions within the theory of agential realism. Intra-actions are the complex co-productions of human and non-human matter, time, and space. Therefore, the human does not act on matter, but rather humans and non-humans are agential actors in the world as it continuously comes into being (Barad,2007).

Barad prefers to use the term intra-action instead of interaction to describe the relationship between the human and non-human participating. Barad argues that "'intra-action' signifies the mutual constitution of entangled agencies. That is in contrast to the usual 'interaction,' which assumes that there are separate individual agencies that precede their interaction, the notion of intra-action recognises that distinct agencies do not precede,

1 They/Their are the preferred pronouns of Karen Barad

but rather emerge through, their intra-action" (Barad, 2007, p.33). Through intra-actions the boundaries of phenomena are established. Barad refers to these boundaries as agential cuts. These agential cuts are the products of agential acts that produce these separations. These agential acts make the agential cuts more than socially constructed distinctions between material objects such as human-nonhuman. These cuts shape the materiality of what they bring into being, which makes them simultaneously discursive and material. (Barad, 2007).

Karen Barad focuses with their theory on how we take part in the world in a way that we are not bystanders, observing the world from an outside perspective. According to Barad, understanding ethics needs to be accessible for humans to respond to them. In order to act responsibly, Barad focuses on the material entanglements and how they reconfigure through intra-actions. "Ethics is not simply about the subsequent consequences of our ways of interacting with the world, as if effect followed cause in a linear chain of events. Ethics is about mattering, about taking account of the entangled materialisations of which we are part, including new configurations, new subjectivities, new possibilities – even the smallest cuts matter" (Barad, 2007, p. 384).

Entanglement is one of the key parts of Barad's agential realism theory. "Entanglements are not a name for the interconnectedness of all being as one, but rather specific material relations of the ongoing differentiating of the world" (Barad, 2010, p. 265). "To be entangled is not simply to be intertwined with another, as in the joining of separate entities, but to lack an independent, self-contained existence. Existence is not an individual affair. Individuals do not preexist their interactions; rather, individuals emerge through and as part of their entangled

intra-relating. Which is not to say that emergence happens once and for all, as an event or as a process that takes place according to some external measure of space and of time. But rather that time and space, like matter and meaning, come into existence, are iteratively reconfigured through each intra-action, thereby making it impossible to differentiate in any absolute sense between creation and renewal, beginning and returning, continuity and discontinuity, here and there, past and future." (Barad, 2007, p. IX)

In order to bring agential realism into practice, Barad notes that the practices of knowing and being are mutually implicated and not isolable. In Barads words, "we do not obtain knowledge by standing outside the world; we know because we are of the world. We are part of the world in its differential becoming. The separation of epistemology from ontology is a reverberation of a metaphysics that assumes an inherent difference between human and non-human, subject and object, mind and body, matter and discourse" (Barad, 2007, p. 185). As a methodology, Barad proposes diffraction. Diffraction is used as a metaphor to read insights "through one another in attending to and responding to the details and specificities of relations of difference and how they matter" (Barad, 2007, p.71). Barad's diffraction methodology draws on Haraway's diffraction methodology (Haraway, 1991) and the principle of diffraction in physics, as shown by quantum physicists Niels Bohr and Werner Heisenberg in 1920. Haraway proposes diffraction instead of reflection as she sees reflexivity as a recommended critical practice but Haraway states that her "suspicion is that reflexivity, like reflection, only displaces the same elsewhere, setting up worries about copy and original and the search for authentic and really real" (Haraway, 1991, p. 16). Haraway states that "diffraction does not produce 'the same' displaced, as reflection and refraction do.

Diffraction is a mapping of interference, not of replication, reflection or reproduction. A diffraction pattern does not map where differences appear, but rather maps where the effects of differences appear" (Weinstock, 2020, p. 300). The agential realist approach differs from Haraway's diffraction regarding reliance upon representation. Barad argues that the idea that representations reflect the social and natural world is distinct from that they pursue to represent, which maintains the humanist fallacy of "holding the world at a distance" (Barad, 2007, p. 87).

Kaiser and Thiele commented in their article Diffraction: Onto-Epistemology, Quantum Physics and the Critical Humanities on Barad's vision of diffraction that "diffraction highlights the systemic intra-actions and unavoidable 'agential cuts' that co-constitute subjects, objects and the ongoing pattern-formations in which they/we participate"(Kaiser & Thiele, 2014, p. 166).

Barad calls this process of knowledge-making posthumanist performativity, where diffraction is not a way of seeing the world differently as we observe it from the outside. It is a way of direct engagement with the world through responsible participation. We are constantly making ethical choices by choosing particular areas to focus on and not on others, which asks us to take responsibility and be more attuned to how we intervene in every action and moment to the critical possibilities available.

These new materialist theories and views are, of course, not without criticism. Slavoj Žižek gives an interesting critique of this theoretical turn. He argues in Absolute Recoil: Towards a New Foundation of Dialectical Materialism (2015) that the new materialistic attempt to undermine the subject/object distinction and the attempt to dismantle traditional humanist thinking, new materialists are rendering the human values as capacities of all things

as (deficient) versions of human subjectivity. (Žižek, 2015). Žižek criticises that New Materialism projects subjectivity and a form of anthropomorphism on the material world. What he oversteps here is the focus in New Materialism on the capacities or qualities of the actors in the new materialistic thought, which focuses on understanding them in terms of what they are capable of and what they are instead of projecting human subjectivity on them.

The variety of interdisciplinary methodologies proposed by the new materialisms allows one to approach ontological questions from different perspectives. New Materialism has considerable added value regarding the possibilities of interdisciplinary collaboration within various sciences and knowledge production. Agential realism requires me to think of how I am accountable and responsible for the worlds my actions contribute to materialising—working on my installations in intra-action with the many entanglements of the people, the technique and sensors used, and the context and qualities of the non-human involved. This new materialistic approach is about being in between. It is messy but gives us a greater sensitivity towards the ethics and effects of the knowledge-making process and how to work from a critical post-humanist approach. As diffraction is used as a methodology in HCI (Human-Computer Interaction) and design research, I will describe in the next chapter how this methodology comes into practice to see if I can apply this to my artistic practice.

METHODOLOGY OF DIFFRACTION

In the light of critical posthumanism, new materialism and the methodology of diffraction, there are not many examples regarding (new) media art installations. However, multiple publications have been written on HCI and design research relating to diffraction and new materialism in light of the international Human-Computer Interaction – CHI Conference on Human Factors in Computing Systems (2020, 2021, 2022). Agential realism has been proposed in HCI and as an option to design with data in design research. They are considering a world where bodies and technology are getting more entangled—questioning the agency and autonomy of cyber-physical systems, AI, extended realities and others who question the notions of agency and limits of human-machine boundaries (Frauenberger, 2020). Which also addresses questions about the context of people's feelings and experiences in affective and multisensory environments.

An essential part of my practice is the use of data and the experience of it. I see data as an opportunity to bridge human-human, human-nonhuman, and nonhuman-nonhuman. Data gives the possibility of experiencing the invisible and unknown of the other. I am interested in making existing data tangible and taking it out of abstraction. On the other hand, I like to explore the unknown in the data from the sensing technologies I use in my installations. As Gaver (2012) already mentioned ten years ago, there is potential to re-imagine alternatives for interaction design and the use of data.

Using an example of the methodology of diffraction in HCI and design research shows us in this chapter how this methodology comes into practice and could be used in (new) media arts that use sensing technologies and data to create encounters between the human and non-human.

As already mentioned, Karen Barad and Donna Haraway use diffraction as a methodology that focuses on the details and specificities of relations of difference and how they matter, which asks one to have a close eye on the different elements that may interfere with each other in the ongoing process. Sauzet describes that "diffraction creates a greater sensitivity than reflection, which is a common metaphor for analysis that invites images of mirroring." (Sauzet, 2019, p. 2) Diffraction is the process of ongoing differences. Sauzet sees it as a thinking tool for analysis, diffraction attunes us to the differences generated by our knowledge-making practices and the effects these practices have on the world (Sauzet, 2015).

Barad's concept of intra-action focuses on interconnectedness with attention to materiality. It shifts attention from an individual subject/object to the performativity of emergent phenomena. Phenomena are, in agential realism, the smallest ontological unit to analyse. These phenomena require a sensibility to distinguish between the subject and the object. This distinction-making is seen as an active choice that Barad calls the already mentioned "agential cut" (Barad, 2014).

Karen Barad's theory of agential realism gives the possibility to rethink interaction design as the ongoing phenomenon of intra-actions across agential cuts. These agential cuts also ask one to explore the question of agency. Barad sees agency not as an individual property (Barad, 2003).

Barad says that “agency is a matter of intra-acting; it is an enactment, not something that someone or something has. Agency is doing/being in its intra-activity” (Barad, 2007, p. 235). In other words, it is the question of who and what acts, as Barad describes it as cutting together/apart of the agential qualities of the phenomena. One can recognise agency as relations, feelings, things, silences, distances, and structures but also things or architecture. When one detects cuts, one is making them and making cuts is performing phenomena by diffracting different types of agencies.

Design research has been refining and approaching data in recent years as a design material. In HCI, this is applied as a form of new materials combining physical materials with interactivity or immaterial materials such as electrical signals or algorithms (Belenguer et al., 2012).

The paper Difraction-in-action: Designerly Explorations of Agential Realism Through Lived Data (Sanches et al., 2022) presented during CHI 2022 shows examples of how diffraction comes to action when working with ‘lived data’. Lived data considers different ways and purposes of living with data. The paper focuses on five examples of how design researchers can create knowledge by engaging diffractively with the data they gain from human bodies and behaviour. In their first case study, “Exploring Breathing Through Biosensing,” the researchers look back on the process of creating the “Breathing Shell” (2018). “Breathing Shell” is an artefact that captures breathing data created by a team of designers, engineers and a classical singer who is an expert in breathing exercises. To design the “Breathing Shell”, the team created an adjustable corset for different body types in order to capture the biodata with biosensors such as an elastic stretch belt, muscle tension sensors, and accelerometers.

The biodata was then visualised or sonifed to make them perceptible when doing the breathing exercises.

The researchers highlight in this example diffraction in the design process of the biosensors through the adjustable corset by working diffractive it made the design with and for breathing. Because the team actively participated in the design process by doing breathing exercises, they could engage diffractive with the data throughout the design process, which led them to recognise different agential cuts that were created between the ongoing phenomenon of breathing and the measurements of the sensors. This process helped them to move away from just representing breathing and instead focus on the phenomenon of how bodies move and breathe while keeping an eye on the differences between bodies. As Sanches noted, "the phenomena of what breathing is and what it does to the researchers' bodies was shifted, they hacked existing sensors to measure their—gradually changing—understanding of what breathing is, and how it can be sensed. [...] This research process highlights that capturing breathing data is not stable and thus should not be taken for granted. [...] Rather than being just a sensor measuring breathing, the pillows also provided a tactile feeling as they inflated and deflated in tandem with the breathing. This caused some wearers to experience a blurring of the boundaries between themselves and the corset (Karpashevich et al., 2022), representing another agential cut between body and measuring apparatus"(Sanches et al., 2022, p. 6).

In this example, data through the lens of agential realism is not a measurement or representation of the world. It is an ongoing process that I recognise in my process where I experience data as never finished nor immaterial but the entanglement of

many factors, such as the context, the technologies and sensors used, the human and non-human, and the use and display of the data in my work.

In the article (Dis)entangling Barad: Materialisms and ethics (Hollin et al., 2017), agential realism is presented as a proposal for producing a new and more ethical form of data through other forms of description, contemplation and assemblages. Stating that we are responsible as humans who decide what we make visible and what we choose to leave invisible. “There is, thus, both an ethics of inclusion and an ethics of exclusion inherent in Barad’s work” (Hollin et al., 2017, p 5). In other words, performing an agential cut is an act of responsibility. It resonates for me with the notion of responsibility that critical posthumanism places on how we take place as humans in this world.

With this methodology of diffraction in mind, I will look back in the next part of this thesis called My Experience at the processes of the four works made in the last year and a half. I use ethnographic fieldwork such as observation and conversations done during the process and presentations of the works to determine whether these diffractive moments arise in my process.

The difference between my practice and the design examples is that my installations do not have any purpose of being an artefact that has to be useful as an object or solve anything. My work focuses less on the human experience and how to extend these through ‘living data’, which is the case in the case studies of Difraction-in-action: Designerly Explorations of Agential Realism Through Lived Data (Sanches et al., 2022). My practice focuses on making the invisible and unseen tangible through sensing technologies. The data is, for me, an opening to encounter each other and not to solve anything.

MY EXPERIENCE

"Recognising the positive difference caused by connections and relations within and between different bodies, affecting each other and being affected. In the end, humans and non-humans go through a transformation as a result of the intra-actions between them that is better understood if we live outside of "I" "

(Buchynski & Lang, 2021, p. 1)

The words of these thinkers propose a world, a way of living and relating that sounds to me like the kind of world I want to be part of. The type of world I like to contribute to. Even one I aim to create. They feel like coming home. Nevertheless, when facing reality, I wonder if it is possible. Is it not just a nice philosophy that is too complex to implement? Can I create anything, being constantly aware of how we are in a constant flux of moving and relating to one another?

Rosi Braidotti says that "the transformation towards the posthuman is neither linear nor one directional but is rather a multi-faceted experimentation with what 'we' are capable of becoming. It is undeniable that the combined impact of the Fourth Industrial Revolution and the Sixth Extinction is altering the terms of our embodied existence, as well as our self-understanding, but changes and adjustments on this scale are both gradual and constant. We are not in a position yet to fully grasp the complexity of these internally contradictory phenomena. We need much more research on the material aspects that compose those phenomena, on their assumptions and implications. The material aspects refer to Zoe, but also to the geological and technological aspects of transformation." (Braidotti, 2019, p.44)

With 'we', Braidotti is searching for a new collective subject. She calls this: "'we-are-(all)-in-this-together-but-we-are-not-one-and-the-same' kind of subject" (Braidotti, 2019, p.55).

This new 'we' is what I hope to create when working on encounters between humans and non-humans. It raises many questions about what it means to create a new 'we'. What am I in 'we'? What are the others in 'we'? How to understand being different and, simultaneously, part of something together? What is this something? How to define each other when we do not think linearly or in binaries? Is that even possible?

Within posthumanist thinking and related theories, specific terminology has emerged and is still developing. This is due to the methodological challenge of theoretically representing the profound interconnections between humans and non-human factors and agents. I think words are a way to create a 'we', but with just words, it stays pretty abstract. Having in mind that we as 'humans' are the dominant category in the world at present and have to come to terms with the structural inequalities. If we embrace the idea of a nonhuman-centred worldview, we must redefine our very idiom of nature-culture and human/non-human interrelationships. Maybe we also must redefine how we create and collaborate when making art from this perspective.

Multiple artists are already working on these same themes from a posthumanist approach. Robertina Šebjanič focuses with the work Aurelia 1+Hz/Proto Viva Sonification on how we understand jellyfish and how to enhance the relationship between humans and other marine species. She created this audio-visual performance with a living system that includes living moon jellyfish to explore the phenomena of interspecies communication. It sonifactes the environment of the underwater acoustic/ bioacoustics.

The moon jellyfish (Aurelia Aurita) create live sound in this interactive performance. What is very visible in the work of Robertina is her care for the non-humans she is working with. The moon jellyfish she works with are in aquariums, giving them the best possible environment and experience while in the artwork
(Šebjanič, n.d.). (Fig. 1)

Špela Petrič focuses in her series the PLANT-MACHINE on the possibilities of post-anthropocentric cognition. She investigates alternative relationships with plants through machine learning. In the work PL'AI, part of this series, she focuses on the notion of play as an ontological condition of bodies. Whereby it not only focuses on the human body. Creating the metaphor of 'play' instead of having a 'purpose', she sees this as an existential condition for our more than human bodies since this will allow bodies to thrive (Petrič, n.d.). (Fig. 2)

Saša Spačal created the work Myconnect a symbiotic interspecies connector. A circuit with signals and impulses that are generated and translated by biological organisms and technologicalm organisms. It creates an immersive experience of symbiotic interdependence. She says her "artistic practice focuses on entanglements of environment-culture continuum and planetary metabolisms. By developing technological interfaces and relations with organic and mineral soil agents, I try to address the posthuman condition that involves mechanical, digital and organic logic within biopolitics and necropolitics of our times."(Spačal, n.d.) (Fig. 3)

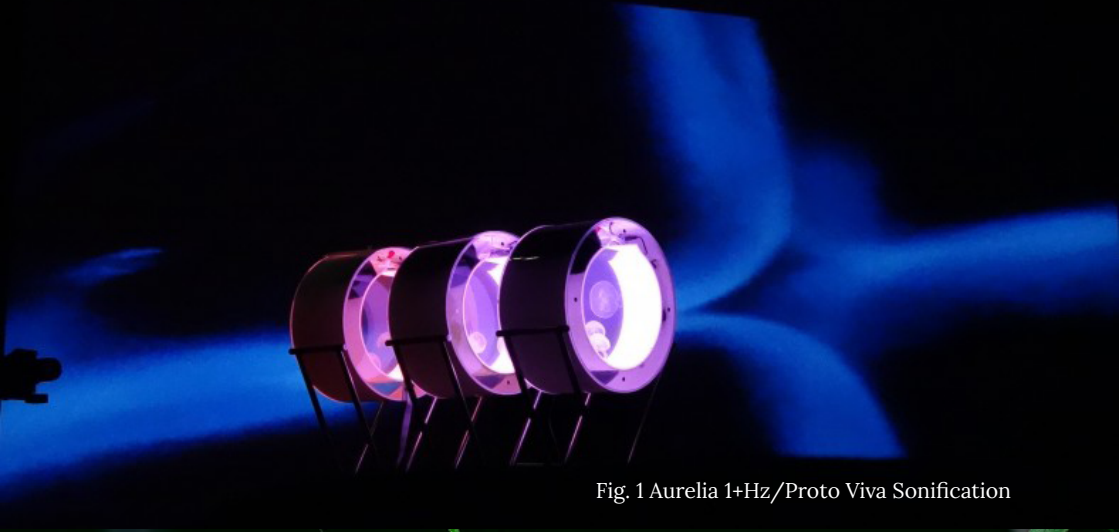


Fig. 1 Aurelia 1+Hz/Proto Viva Sonification

Fig. 2 PL'AI

Fig. 3 Myconnect

I aim to create in my work a space where the biological, cognitive, and technical processes come together. Co-shaping of human, non-human, matter, and environment constantly encounter and mutually affect each other.

In this chapter, I look back on the process of creating four of my works through the proposed methodology of diffraction and the theory of agential realism.

1. RHIZA, an interspecies connector between fungi and humans.

2. ZIEN, a collaboration between ministry officials, citizens, and a robot arm.

3. FadingColours, real-time data sculptures that connect ocean data on coral bleaching and the living conditions of the algae.

4. ZOE, A temporary coexistence between reishi mushrooms and a custom-made robotic system.

I describe the concept, process, installation and care for each artwork. Based on my experiences and observations, I examine whether the theories and the practical application experience align in these art installations.

RHIZA

‘RHIZA’ is an interspecies connector that invites one to become part of the communication between its mycelium and oyster mushrooms. The oyster mushrooms and mycelium continuously exchange biodata through electrical signals. The biosensors pick up these electrical signals and translate them into vibrations one can feel by standing bare feet on the mycelium floor pads. ‘RHIZA’ was exhibited during Ars Electronica 2021 Linz, festival X in Dubai 2022 and won the YouFab Global Creative Student Award 2021.

Fig. 4 RHIZA

Ars Electronica Festival 21

CONCEPT

'RHIZA' is inspired by the interaction within mycorrhizal networks. This underground network of fungal connections exchanges not only back and forth between fungi and one plant but also between neighbouring plants, using fungi as a thoroughfare. As the fungal threads spread, they can link to multiple plants, creating webs known as 'common mycorrhizal networks'. Through these networks, plants and fungi can exchange sugars, nutrients, water and more. These shared mycorrhizal networks embody ecology's most basic principle: the relationship between organisms.

I am intrigued by the recognition, understanding, and interaction with other species. Within this installation, I am researching the possibilities of creating an empathic relationship between humans and nature. 'RHIZA' aims to create an awareness of being part of a bigger network and creating a possibility for humans to be aware of the communication and sharing of information outside the human realm. It is essential to no longer see "the human being" as the centre but as part of a comprehensive and complex system. This system consists of humans, animals, and plants, but also matter and other entities. COVID-19 has highlighted once again that we need to start living in coexistence and symbiosis with natural landscapes rather than dominating or exploiting them, as is common in many western societies. What impacts nature also impacts us humans.

'RHIZA' is an interspecies connector that emerged as an aspiration to enable human beings to transgress their own species and

Fig. 5 RHIZA - Festival X Dubai

connect with otherness in a multiplicity by experiencing their connectedness. The visitor will experience the so-called mycorrhiza on the level of perceptive and physiological. Mycorrhiza is a form of cohabitation between roots and fungi. In 'RHIZA', which means roots, the visitors will be integrated into the human-mycelium-mushroom interface by means of their own roots- their bare feet.

In other words, our skin connects with the mycelium's oscillations produced by electrical resistance. This hybrid sensation of electric resistance and pulse is then transferred back to the human body via tactile sensory impulses. Such symbiotic connections are an embodied way to integrate human beings into the network of their environment through their kinesthetic empathies.

Through my work, I want to offer space to reflect and experience what these emergent systems entail. With 'RHIZA', I like to create space to think, feel and experience what it means to be part of the complex network we live in and that we can also listen to other systems instead of taking them over.

The profound restrictions imposed by the pandemic on social interactions and physical movement are causing a shift to the online domain when it comes to arts, education and research, which is why it is necessary to re-examine our essential relationships with the material and embodied world we live in.

Experiencing the complexity of the mycorrhizal network with their subtle blend of cooperation and conflict can be seen as a metaphor for how we relate with each other and our social systems. Like human society, this society is characterised by variety, with its capacity to help, hinder, cooperate, and exploit.

Fig. 6 RHIZA close-up

PROCESS

As a child, my number one role model was Jane Goodall. She intrigued me because she managed to get so close to chimpanzees without perceiving her as disturbing or dangerous. After months of observing, she came out of the woods and introduced us to the remarkable world of these chimpanzees. Like Jane Goodall, I wanted to go into the woods to learn about other species, not to do anything with them but to watch and experience their lives.

During the pandemic in the winter of 2020-2021, I read Merlyn Sheldrake's book Entangled Life – how fungi make our worlds, change our minds and shape our futures (2020). For the first time since my fascination with monkeys as a child, I felt a similar fascination for this strange organism called fungi. Sheldrake describes the fungi so beautifully on their own terms. How understanding them changes our understanding of life. They are a whole kingdom by themselves incomparable to animals, plants, insects or humans and closer to us than to plants. The kingdom of fungi has not yet been researched much. Mycology, as it is called, was, until now, a field of science that did not even have a proper place within universities. What especially fascinates me is the mycorhizal network, often called the wood wide web —a whole society communicating and exchanging with each other and even hosting communication for other species like trees. I wanted to experience this communication, but how?

One of the very first ideas was to mimic this network. I thought of the roots of sharing communication and spreading their information over the network.

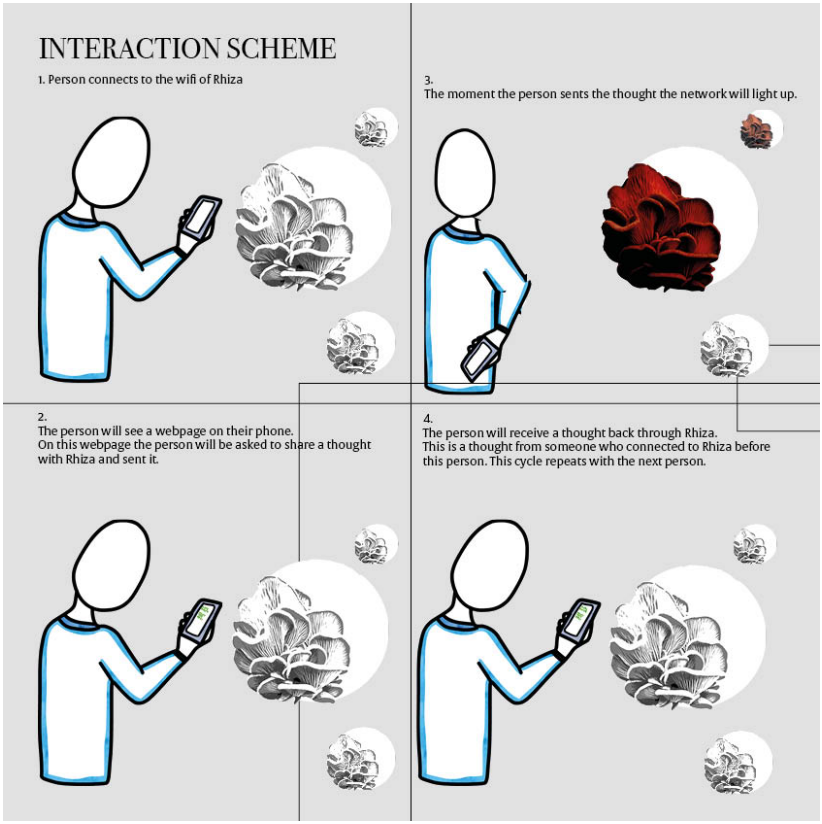


Fig. 7 First sketch interaction RHIZA

Thinking back, I worked in an earlier work with the principle of sharing and leaving something behind for the next person.

What I did not like about this first idea for this installation is that it mimics while there is actual communication going on. Moreover, it completely excluded the mushrooms and just showed a form of communication through a network where there is a form of knowledge sharing. It had nothing to do with the fungi and was only inspired by them. On top of that, it felt not good to use them for aesthetic reasons to be in the installation without acknowledging them.

To not make this work about humans, I had to get to know fungi. Apart from the mushrooms I eat or see in the wild, I had no experience with them. I started to watch documentaries and read more about fungi to understand what we know about them and which research is done on the communication of fungi. Knowing that I wanted something with this network that communicates, I decided to try to make this communication perceivable. There were multiple examples of people translating the communication of mushrooms into sound. One of the things that bothered me is that I often saw that they captured this in the mushroom caps. This way of measuring the activity is questionable since the caps are so humid that there is a high chance of only measuring the oxidation. It is still being determined where and if these signals reach the fruiting bodies. Also, we do not know if they make a sound. I understand why people translate it into sound, as it is the preferred way we communicate. I was looking for a way of experiencing this communication in a manner that would take us out of the comfort zone of our preferred communication. I imagine this communication as something the mushrooms and plants experience as vibrations, which we do not give meaning to as quickly as

sound. It felt to me like the way to listen to something without filling it in.

Arriving at these thoughts raised two issues;

1. I needed to get to know the fungi. How do they grow? What do they need?
2. I had to look for sensors that could sense the signals in the mycelium.

Luckily nowadays, people have many options for growing mushrooms at home. I ordered a growing kit and started experimenting. I ordered the growing kit for the pink oyster mushroom on the coffee ground. Of course, I was impatient and did not start from the basics of growing them in the provided box, but I tried it directly in different shapes.

Fig. 8 First tests growing pink oyster mushrooms on coffee ground 11-04-2021

Fig. 9 First tests growing pink oyster mushrooms on coffee ground 11-04-2021

Looking back on what I know now about growing mushrooms, I was fortunate that I started to see mycelium growing within two weeks. (Fig. 10, 11, 12) Not much later, the first signs of fruiting bodies were there. (Fig. 13, 14)

Fig. 10 Close-up mycelium growing 26-04-2021

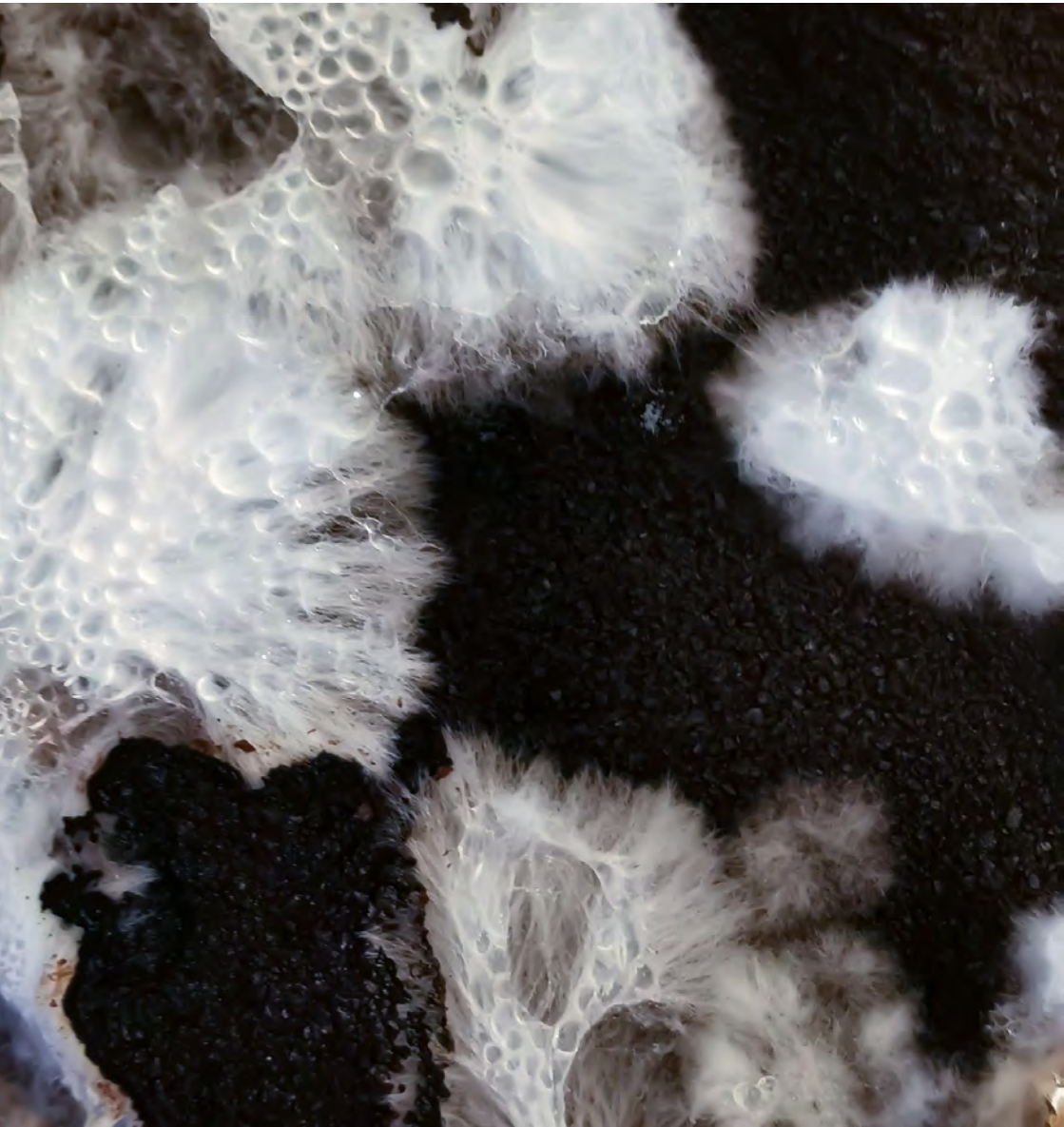


Fig. 11 Mycelium growing in sphere 26-04-2021

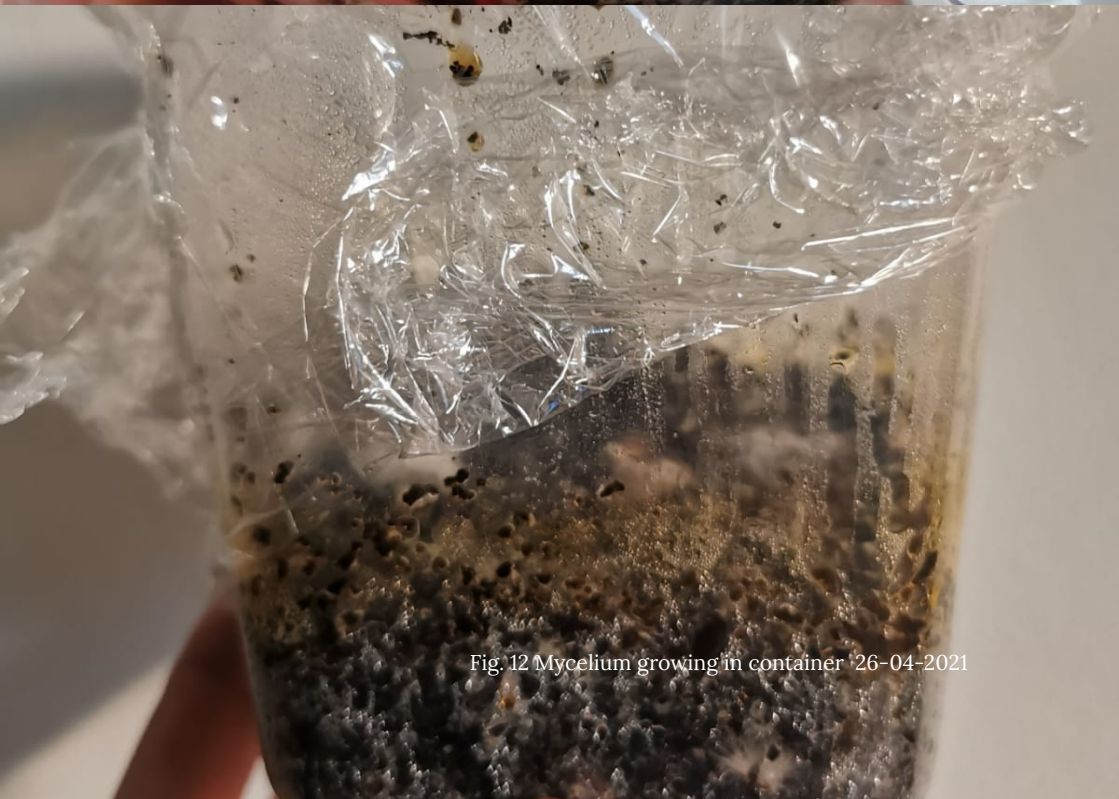


Fig. 12 Mycelium growing in container 26-04-2021

Fig. 13 First sign of fruiting bodies sphere 02-05-2021

Fig. 14 First sign of fruiting bodies Petri 02-05-2021

The fact that I could grow it in spheres inspired me to come up with the first sketches of how this installation could look. In this sketch I am still thinking of the combination of pink oyster mushrooms and lionsmane. (Fig. 15)

From the concept of sensing these signals through vibrations, I wanted people to relate to the materiality of the mycelium. I noticed that there were already packing materials made out of mycelium. This made me wonder if it is possible to experience these vibrations via the same material as it produces the signals.

Looking into these mycelium products, I noticed that there are different substrates the mushrooms are growing on. It looked like most products using mycelium as a base, were from wood or straw-like material. Inspired by this, I tried to create a floor with a white button grow kit, combining it with pasteurised straw. (Fig. 16, 17)

Taking into account also the financial part of growing many spheres and floor parts made me look into the other possibilities of growing mushrooms myself without the help of a growing kit. (Fig. 18, 19, 20 21)

Fig. 15 Sketch RHIZA April 2021

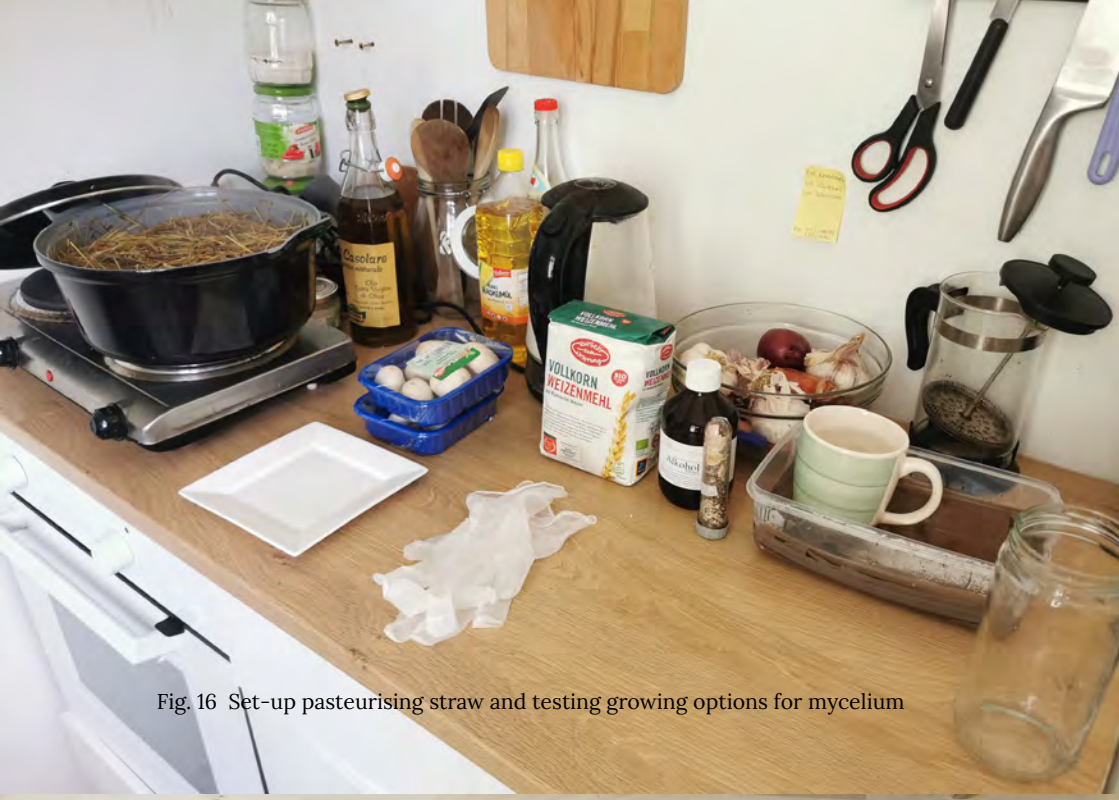


Fig. 16 Set-up pasteurising straw and testing growing options for mycelium

Fig. 17 Set-up floor pad out of white button grow kit combined with pasteurised straw

Fig. 18 Test wheat flour + straw + mycelium grow kit

Fig. 19 Test straw + coffee ground + mushroom

Fig. 20 Test straw + wheat flour+ white mushroom

Fig. 21 Test straw + white mushroom

Apart from these tests, there were also a few cardboard tests. After two weeks, there was some mycelium growth. Nevertheless, this experiment failed just as all the other experiments of growing mycelium myself.

The earlier experiments with the pink oyster mushrooms went well in the container, so I saw some actual growth. Having the first real fruiting bodies made me focus on the different possibilities of capturing these signals exchanged through the mycelium. On the other hand, the petri dish and bowls did not manage to make bigger fruiting bodies.

Fig. 22 Fruiting bodies pink oyster mushroom in container 1

Fig. 23 Fruiting bodies pink oyster mushroom in container 2

Based on Electromyography (EMG), I started looking into the option for sensors. EMG measures muscle response or the electrical activity that responds to a nerve's muscle stimulation. The electrical activity captured by the electrodes is generally displayed on an oscilloscope. Human muscles have no electrical activity at rest. Only during contraction it is present. I saw several examples of people using EMG sensors to capture these signals in the manner described earlier. I ordered a myroware EMG sensor to have a starting point.

It was clear that the electrodes usually placed on the skin would not work for me. I decided to replace them with needles which have to be inserted into the mycelium. I had to find needles that would do the most minor damage to the tissue of the mycelium and mushroom and where there would also be the slightest chance of oxidation to avoid getting noise in the data. I ended up using gold acupuncture needles. Since I had not constantly mushrooms available, I did a lot of the first testing on plants. I knew that people had already achieved measuring their activity with EMG.

I tried this sensor on the little fruiting bodies in the container and on this plant. However, I had no results. By this time, I needed to ask someone with experience. I consulted Laurent Mignonneau, Interface Cultures professor, who taught me the course sensors and microcontrollers. Laurent and I experimented with different possibilities of EMG and EEG sensors. I was building different types of circuits. So far, without success. Nothing was working.

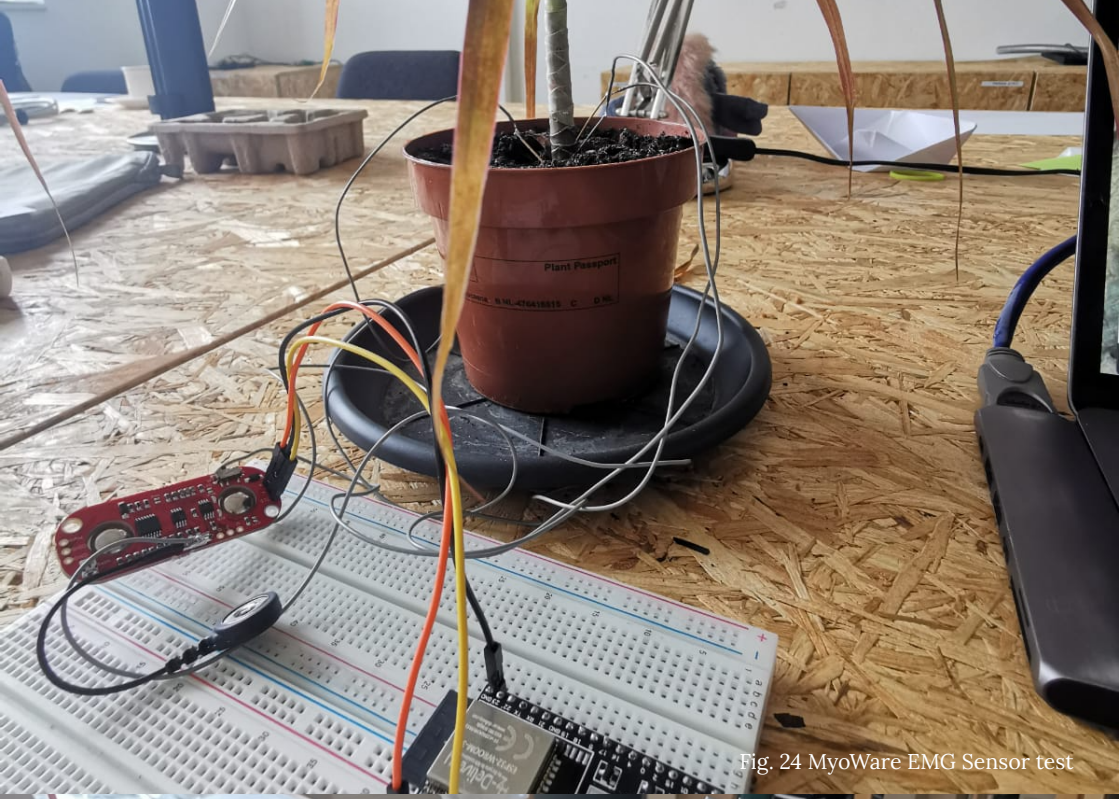


Fig. 24 MyoWare EMG Sensor test

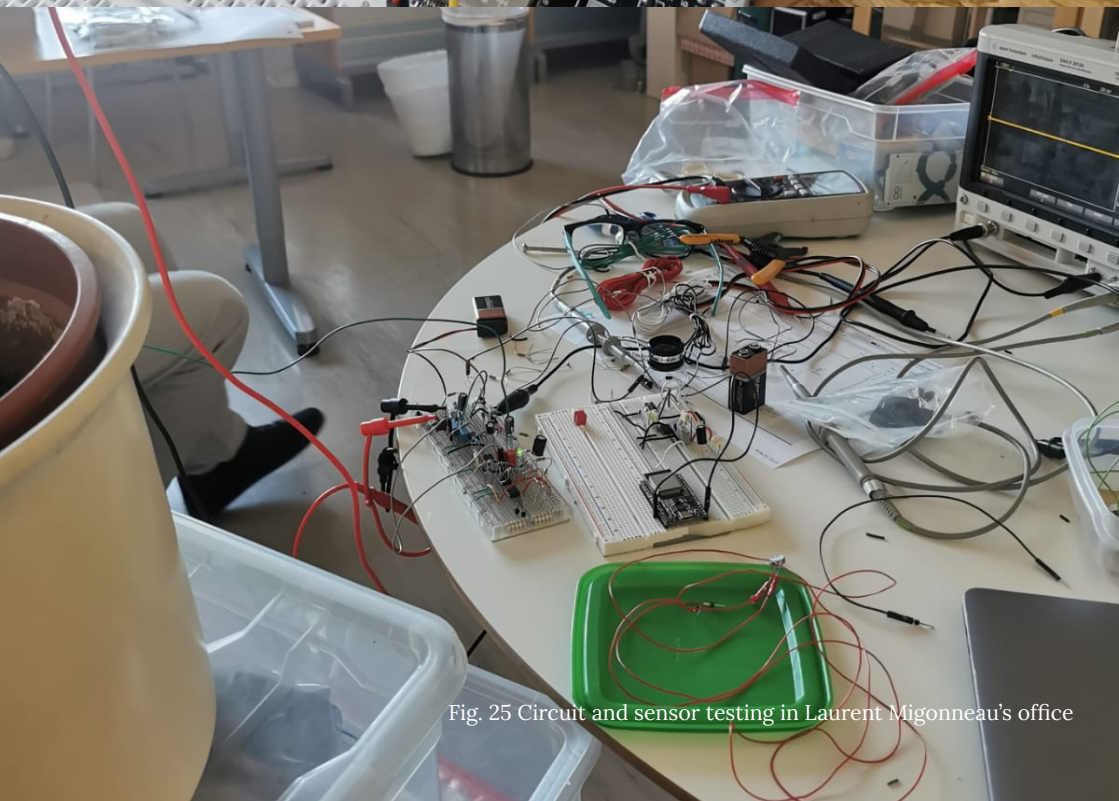


Fig. 25 Circuit and sensor testing in Laurent Migonneau's office

In parallel, I was still working and experimenting with mushroom growth. I needed to gain more knowledge about them and hoped by trial and error to achieve growing proper mushrooms. I started to have a feeling for the needs in terms of hygiene for mushrooms and that they needed holes to grow out. I experimented with growing them in bigger spheres after growing them in small spheres and considering my idea for the installation.

Fig. 26 Glass spheres prepared with holes for mushroom growth

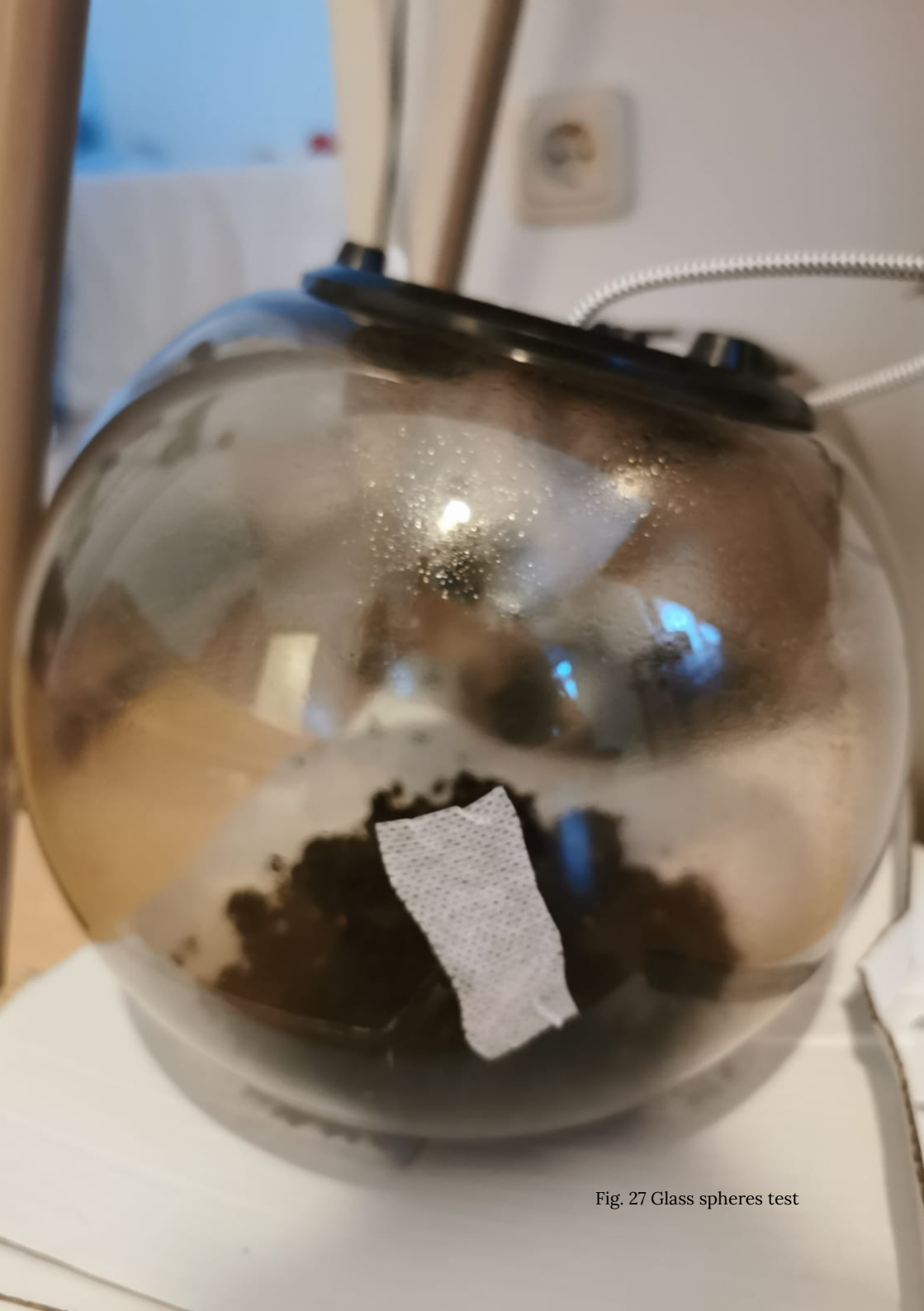


Fig. 27 Glass spheres test

Since this installation was proposed for Ars Electronica 2021, I felt a little overwhelmed by all the parts that were not working. I was unable to grow big healthy mushrooms, did not manage to grow mycelium, and the sensors were not working. There was nothing more than me enjoying trying out these things. Knowing fungi so well that I could work with them would need more time.
I needed to ask for help. Like the sensors part, I needed someone with more experience.

I found a very active node of the mycelium network society in Linz based in STWST. On top of that, I found in the Netherlands company GrownBio who is specialised in growing mycelium objects and selling growing kits to do this yourself. After reaching out to both of them, the growing mushrooms and floorplates gained momentum.
With Taro on my side from the mycelium network society guiding me through the process and opening his mushroom lab to me was a fantastic opportunity to learn the process of growing mushrooms from someone else.

At the same time, the growing kits for growing the floor plates arrived. I started growing the floorplates in my bathroom. The process of growing these floorplates taught me a lot about the humidity and temperature that mycelium needs to be able to grow.

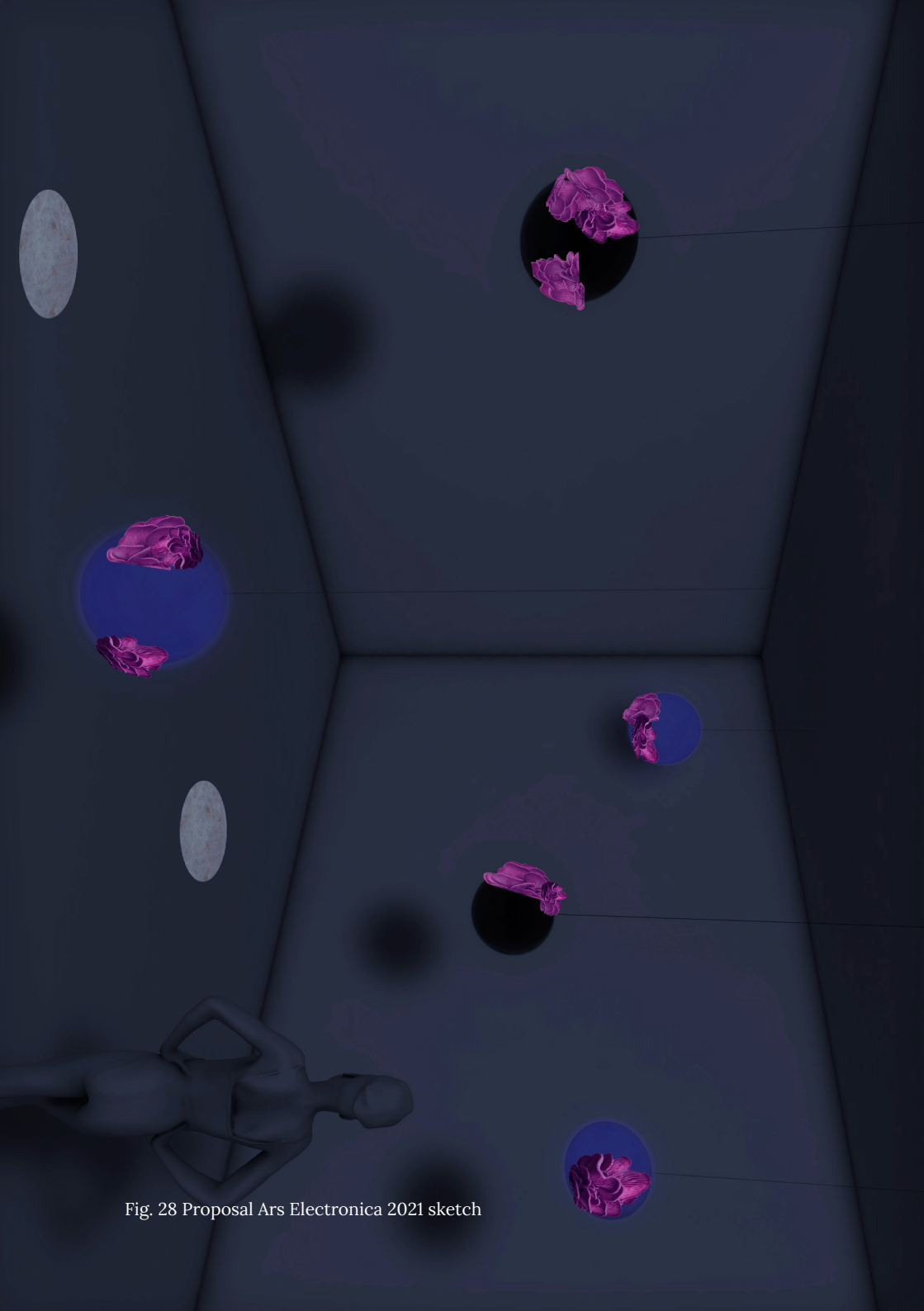


Fig. 28 Proposal Ars Electronica 2021 sketch

Fig. 29 Taro's growing room

Fig. 30 GrownBio growkit mycelium in fridge

Fig. 31 Growing floorplates in bathroom

I had finally achieved one goal. I grew the floor pads and also experimented with growing mycelium in other forms and with different qualities.

Fig. 32 mycelium bowl glow in the dark

Fig. 33 glowing mycelium bowl

This made me start on the idea of making them vibrate. At this point, I thought that the installation should work as shown in Fig. 34,35,36.

Fig. 34 Sketch RHIZA sphere pratical

Fig. 35 Sketch RHIZA floorplate pratical

Fig. 36 Sketch RHIZA practical

After testing the idea with the vibration motors, I noticed they lacked the power and capability to go through waves. Also, when using multiple vibration motors.

Fig. 37 Mini vibration motor in mycelium

Fig. 38 Testing experience of mini vibration motor in mycelium

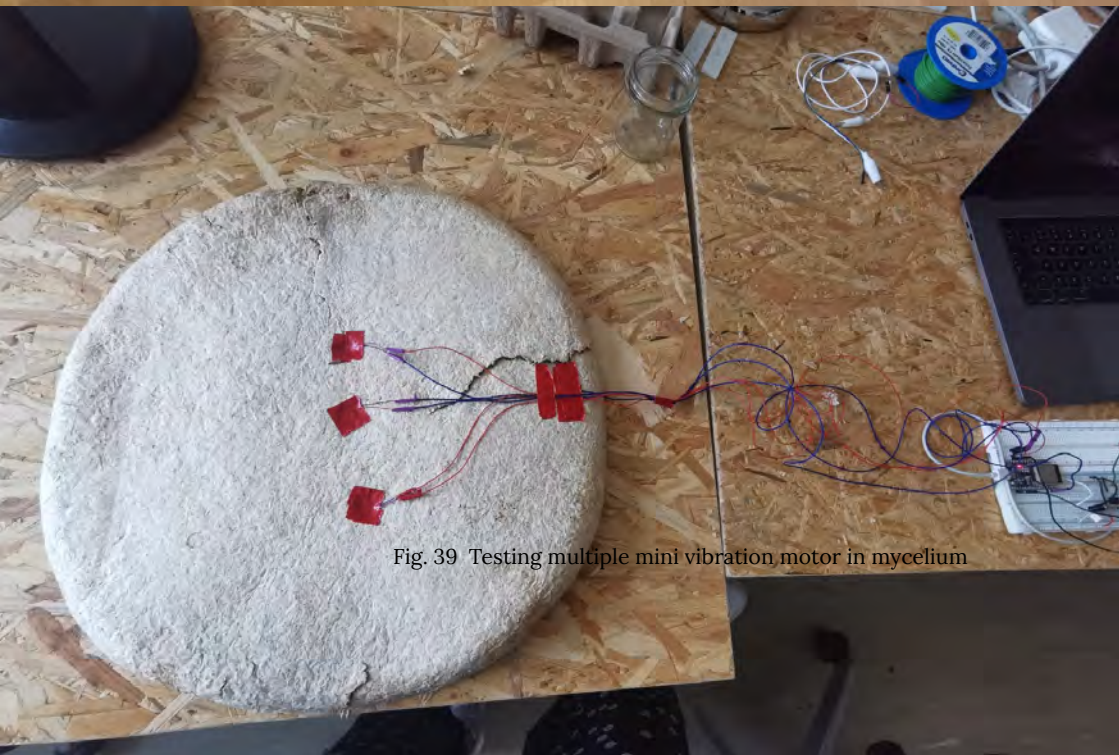


Fig. 39 Testing multiple mini vibration motor in mycelium

It turned out that there were too many obstacles to grow the mushrooms in glass spheres that would be hung from the ceiling. It felt to me like there was too much going on. I wanted to focus on the mushrooms and how they were growing and the mycelium to be visible. Therefore I changed the idea from glass spheres to a transparent tower which they would grow from.

I laser cutted and built eight segments of 20x20x50cm out of plexiglass. The tower is split up into segments so I can replace parts of it when it is not growing or has contamination. I built eight segments and not four, so I would always have a backup in case segments were not healthy or growing. Furthermore, this is the most feasible way to grow and transport a tower of 200cm.

Around the same time, I came across the open-source work of Sam Cusumano, who works on the sonification of biodata. After being in touch with him, I went with his work to Laurent. We finally managed a circuit that could measure the signal on two points in the mycelium and measure the difference between them. With the sensors there, I still needed to translate the data into vibrations since the mini-vibration motors had no effect. I switched to bass shakers, typically used in cars to experience the low frequencies of music in the body.

In the meantime, I kept growing mushrooms with grow kits to test the sensors and experience the vibrations. It made me realise how patient I had to be in this process. Mushrooms need their time to grow and have a specific life span, so I had to work with their rhythm. Realising this made me think of the exhibition. It was a risk to work with them together. I learned now that so many factors had to be right for them to grow. They are way less consistent than house plants.

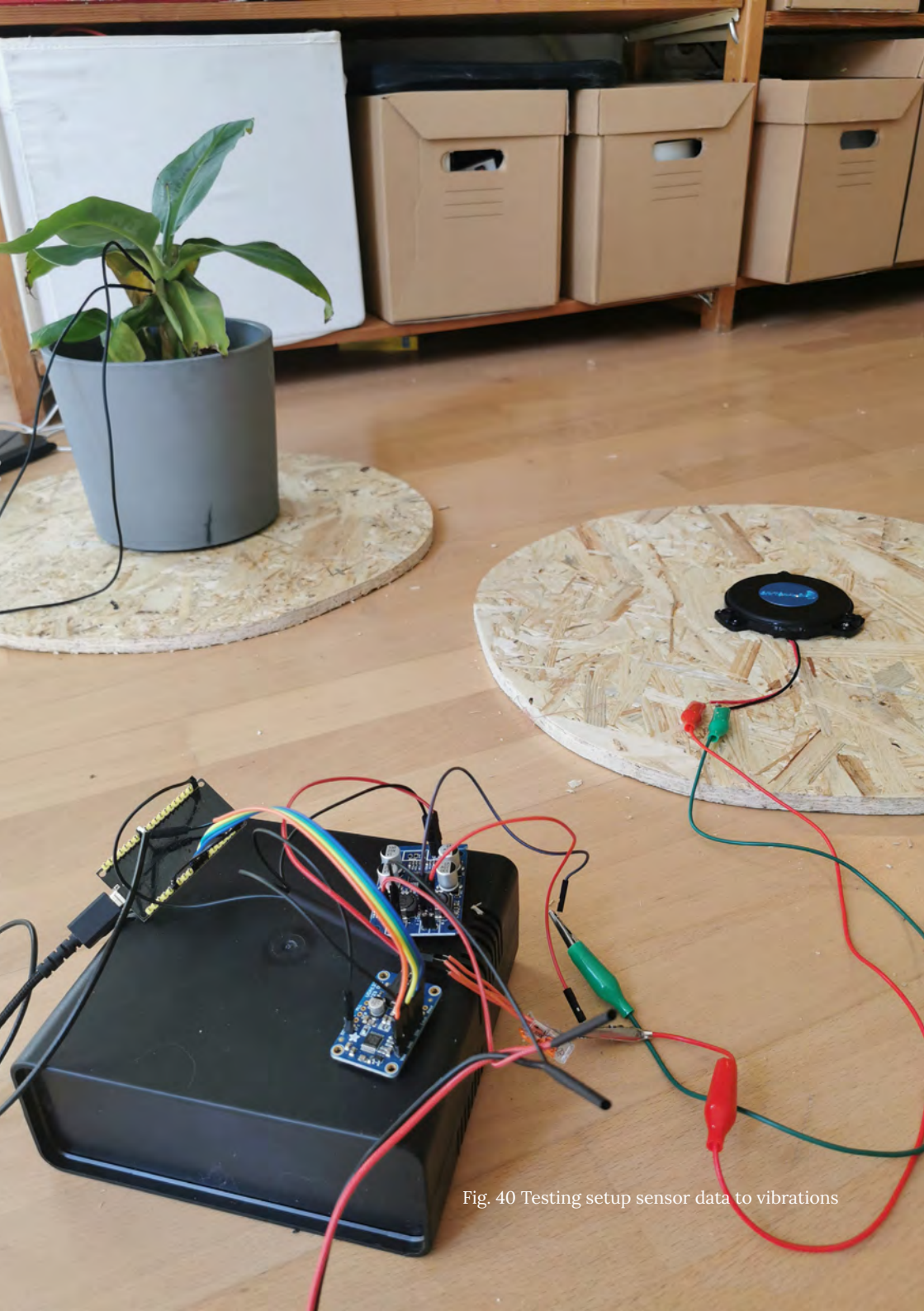


Fig. 40 Testing setup sensor data to vibrations

To start with hygiene and the risk of contamination when creating their environment. They are susceptible to the temperature, humidity, light and what they are growing on as substrate. My initial idea of having this installation with artificial light in the dark made no sense. This type of mushroom likes light. They fruit because of the light. In other words, if I want them to show up in the exhibition, I have to make sure that I create the situation they like and work in their rhythm.

With the first moment for 'RHIZA' to be exhibited around the corner, Taro and I started growing the tower. Based on his experience and the information from the so-called 'bible' of mushroom growing, "Growing gourmet and medicinal mushrooms" (Stamets, 2000). I could only hope we have the timing right.

Fig. 41 Filling the segments

Fig. 42 Growing the segments

It turned out that it worked. During Ars Electronica 2021 'RHIZA' grew over the five days of the exhibition. After this exhibition, 'RHIZA' has been in different places for the last one and a half years. The work of growing the oyster mushrooms still is a work in progress. I am growing the mushrooms depending on the location of where 'RHIZA' will be exhibited. This means that apart from learning how to grow pink oyster mushrooms myself, I also have to work with mushroom farms in different places worldwide. It asks me to explain the process of growing pink oyster mushrooms for 'RHIZA' in relation to the place where the installation will be exhibited. Furthermore, the floorplates made from dried mycelium are damaged easily. Therefore I keep researching, changing and improving parts of this installation.

Fig. 43 RHIZA top part of the tower

INSTALLATION

The work ‘RHIZA’ has a flexible presentation format, allowing it to adapt to different contexts. It can be presented as a full tower or in a smaller version. Since ‘RHIZA’ consist of living mushrooms/ mycelium, it requires care and environmental conditions. It needs daylight, temperature between 22 - 28 °C and humidity above 80%. Indoor presentation is preferred. The mushrooms grow during the exhibition, so the tower does not always have the same appearance.

‘RHIZA’ exist out of one transparent plexiglass tower of 220cm. The tower is divided into four segments 50 cm high filled with the mycelium of the pink oyster mushroom. The lowest segment is smaller and contains the electronics and sensors for ‘RHIZA’. Around ‘RHIZA’, depending on the version, floor pads are made of dried mycelium. These floor pads are connected to the tower and make the signals picked up by the sensors, which are inserted in the mycelium, tangible through vibrations.

Fig. 44 RHIZA day 1

Fig. 45 RHIZA day 5

Dimensions

First version RHIZA

Tower 20x20x220cm

4x plexiglas mycelium segment 20x20x50cm

1x plexiglas sensor segment 20x20x20cm

3x Floorpads 45⌀

Hollow bench 45x50x45cm

Second version RHIZA (in development)

Tower 20x20x220cm

4x plexiglas mycelium segment 20x20x50cm

1x plexiglas sensor segment 20x20x20cm

2x Floorpads 34x40cm

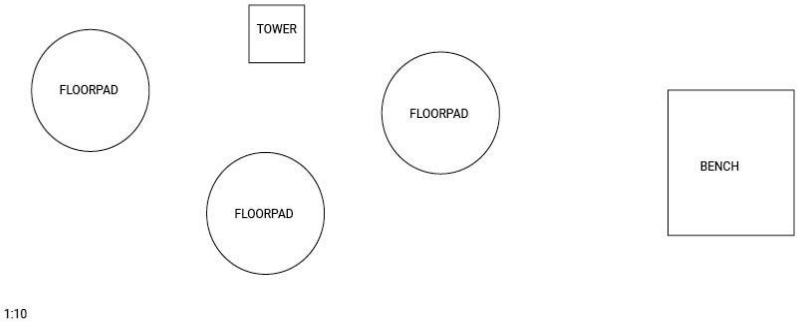


Fig. 46 Topview Setup RHIZA

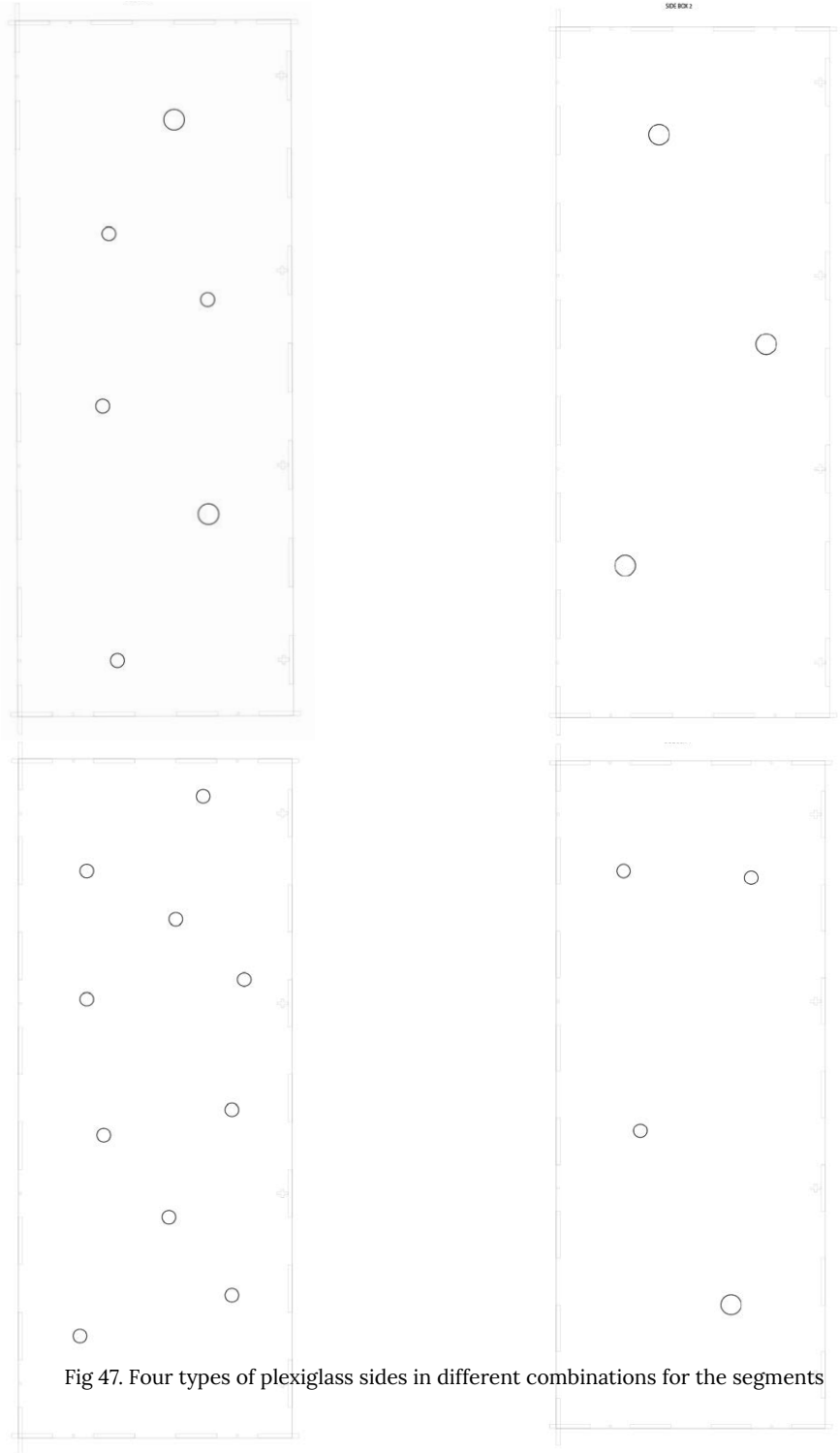


Fig 47. Four types of plexiglass sides in different combinations for the segments

CARE

I noticed that 'RHIZA' needed a lot of care and attention during the exhibition. It made me think of what it means to care for something and work together with something other than a human being in an environment like an exhibition space. As the artist, a work that is alive asks me to bridge the needs of the mushrooms I am working with and the possibilities of the places that are interested in hosting them.

Therefore I decided to write a technical rider and a care rider for 'RHIZA'. I noticed that for people to understand and take the needs seriously, they must also get to know the mushroom.

In practice, it comes down to me clearly communicating that this work is alive. That the mushrooms need care and that it is a work that is changeable through time and responding to its environment. This includes the understanding that there is a preparation time for growing the pink oyster mushrooms before exhibiting. Sometimes, people wonder if we cannot develop a faster way, a shortcut to a quick fix. Observing this behaviour is interesting because I recognise it from my process—the difficulty of tuning into the needs and rhythms of another species. It is the human trait of wanting to bend things to our will and being used to it working this way.

When I sense that the person who wants to invite 'RHIZA' understands what is needed, I take them through the process of growing and caring for the pink oyster mushroom in detail. Planning is one of the most challenging parts of caring for mushrooms that must perform at a certain point.

Based on my experience, I made a schedule including the needed circumstances that provide the most significant collaboration change from the pink oyster mushrooms. The planning in Fig. 48 is the optimal growing plan for exhibiting 'RHIZA' for 5-7 days.
If 'RHIZA' needs to be visible more extended, six additional segments are required per 5-7 days.

It asks for much communication with the exhibiting partner and the mushroom farm growing the mushrooms. Because growing mushrooms in these segments needing to be on time is often a challenge for mushroom farms, they usually only produce mushrooms as a food source. It requires from their side an understanding of the necessity of growing them at the right time and preparing them in the recommended way. On the other hand, as I already discussed, the exhibiting partner must understand the time and resources the mushroom farm needs to grow mushrooms. Mushrooms are not flexible when it comes to planning or rescheduling.

The second challenge is their environment. This is in all stages of the work.
First is the growing and filling process of the pink oyster mushrooms in the segments. I prefer working with a mushroom farm near where 'RHIZA' will be exhibited. It keeps the amount of travelling for the mushrooms the lowest, and farms already have the environment for taking care of them in their most vulnerable state. A side note is that I like that they grow on a substrate available in the country they are exhibited in.

When the mushrooms arrive at where they will be exhibited, they have a day and night schedule. I adjust the recommended care depending on the environment where they are shown.

Day	**What**	**Amount of segment**	**Temperature**	**Light**	**Humidity**
8 weeks prior	Ordering substrate				
4 weeks prior	Manufacturing or receiving&building segments				
Filing segments					
Day 1	Phase 1: Mycelium growth	2 (1backup)	24 - 30 °C	Dark	95 - 100 %*
Day 2	Phase 1: Mycelium growth	2 (1backup)	24 - 30 °C	Dark	95 - 100 %*
Day 3	Phase 1: Mycelium growth	2	24 - 30 °C	Dark	95 - 100 %*
Day 4	Shipping if filling of segments is not on location*		20 - 30 °C		
Growing **					
Day 11	Phase 2: Fruiting initiation	2 (1backup)	18 - 25 °C	Daylight	90%
Day 12	Phase 2: Fruiting initiation	2 (1backup)	18 - 25 °C	Daylight	90%
Day 13 - **Set-up RHIZA*****	Phase 2: Fruiting initiation	2	18 - 25 °C	Daylight	90%
	Phase 3: Fruiting bodies day 11	2 (1backup)	20 - 30°C	Daylight	85%
Day 14 **- Opening expo**	Phase 3: Fruiting bodies day 12	2 (1backup)	20 - 30°C	Daylight	85%
Day 15	Phase 3: Fruiting bodies day 13	2	20 - 30°C	Daylight	85%

**Express shipping as fast as possible and/or filling of the segments on the location During this phase, the segments are in trash bags, which keeps the humidity high*

*** Open once a day for 10 minutes the bags of the segments to refresh the air for the mushrooms and spray them with water*

**** When we take the segments out of their bags, phase 3 is initiated.*

Tabel 1 Planning RHIZA

The mushrooms need to be moist to keep them healthy. The way to do this is by spraying them with water during the exhibition's opening times. Outside opening hours, with an electric humidifier (Fig. 48) They also should not become too cold or warm as this will influence their growth.

The most important skill to know if mushrooms are doing well is observing them and looking for signs of how the growth is going.

Is there any mould?

Is the mycelium overgrowing the substrate?

How do the fruiting bodies look?

In most phases, I am there to take care of this, or I am in close contact with the person growing or taking care of them. For the people taking care of the mushrooms during an exhibition, I include visual references, so they know what to look for.

Fig. 48 Humidifying RHIZA

Fig. 49 Healthy sprouting mushroom

Fig. 50 Unhealthy sprouting mushroom (too dry)

Fig. 51 Developing mushroom

Fig. 52 Healthy grown mushroom with open caps

Fig. 53 Healthy older mushroom - After this phase they will die

Fig. 54 RHIZA segments from young to older

Fig. 55 Young mushroom with sensor

Fig. 56 Older mushroom with sensor

Fig. 57 Pink Oyster Mushroom

On the notion of taking care of their environment, I learned during the first time of showing 'RHIZA' that visitors behave differently toward a mushroom than they do toward a work of art that does not consist of a species they may also recognise as nature or food. By recognising the mushroom, people tend to touch it or even pick it from the tower and take it with them. Therefore, apart from the one-line instruction to take off the shoes, I also instruct not to touch them to ensure the mushrooms grow in peace.

It is essential that the fungi have the possibility of making their complete life cycle and are not being wasted. If segments are over after the exhibition and still growing, I always try to look for a place where they can finish their cycle.

I like to collect the grown mushrooms and cook for all those involved with 'RHIZA' to complete the circle between the human who cared for the mushroom and the mushroom that nourishes the human.

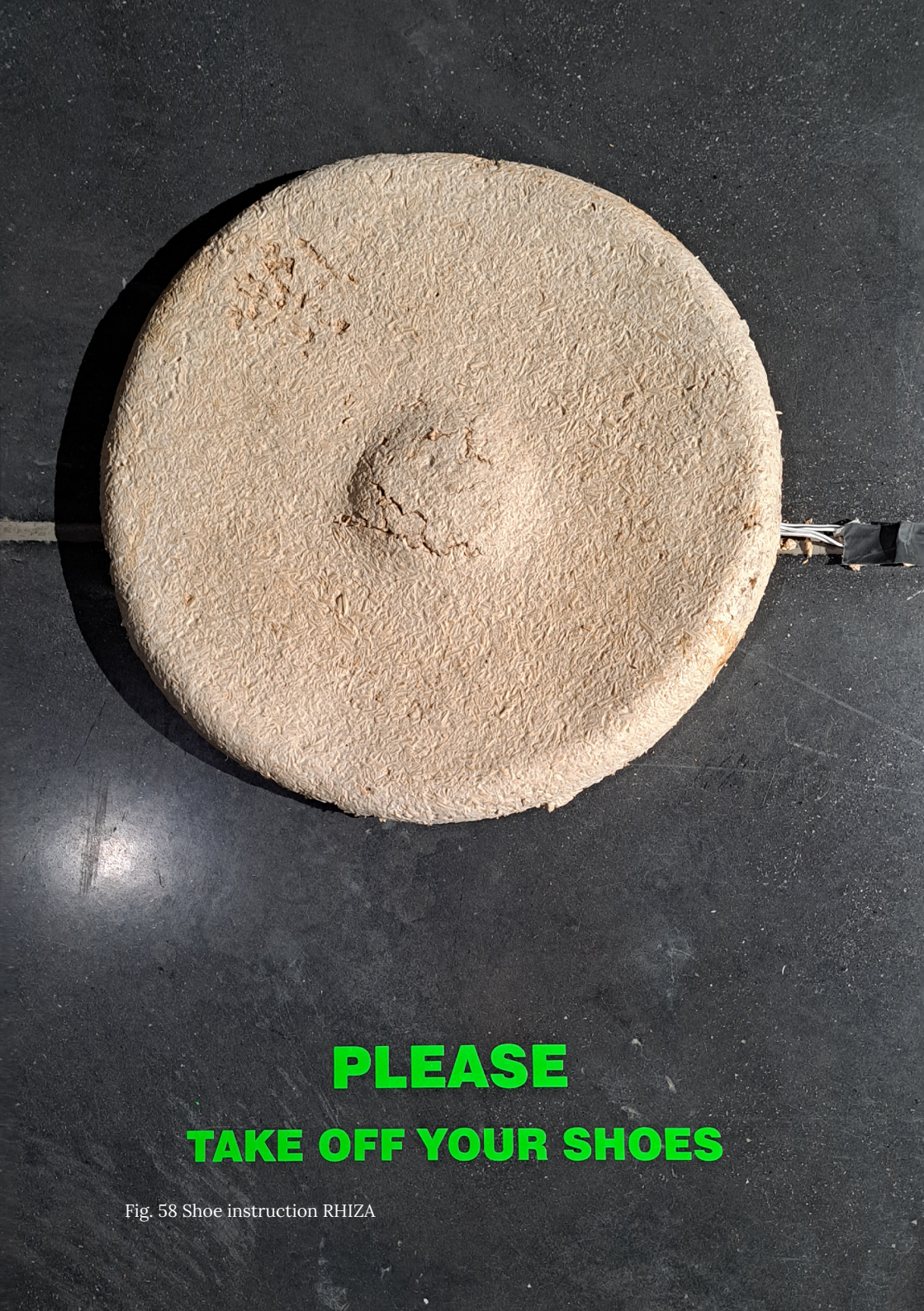


Fig. 58 Shoe instruction RHIZA

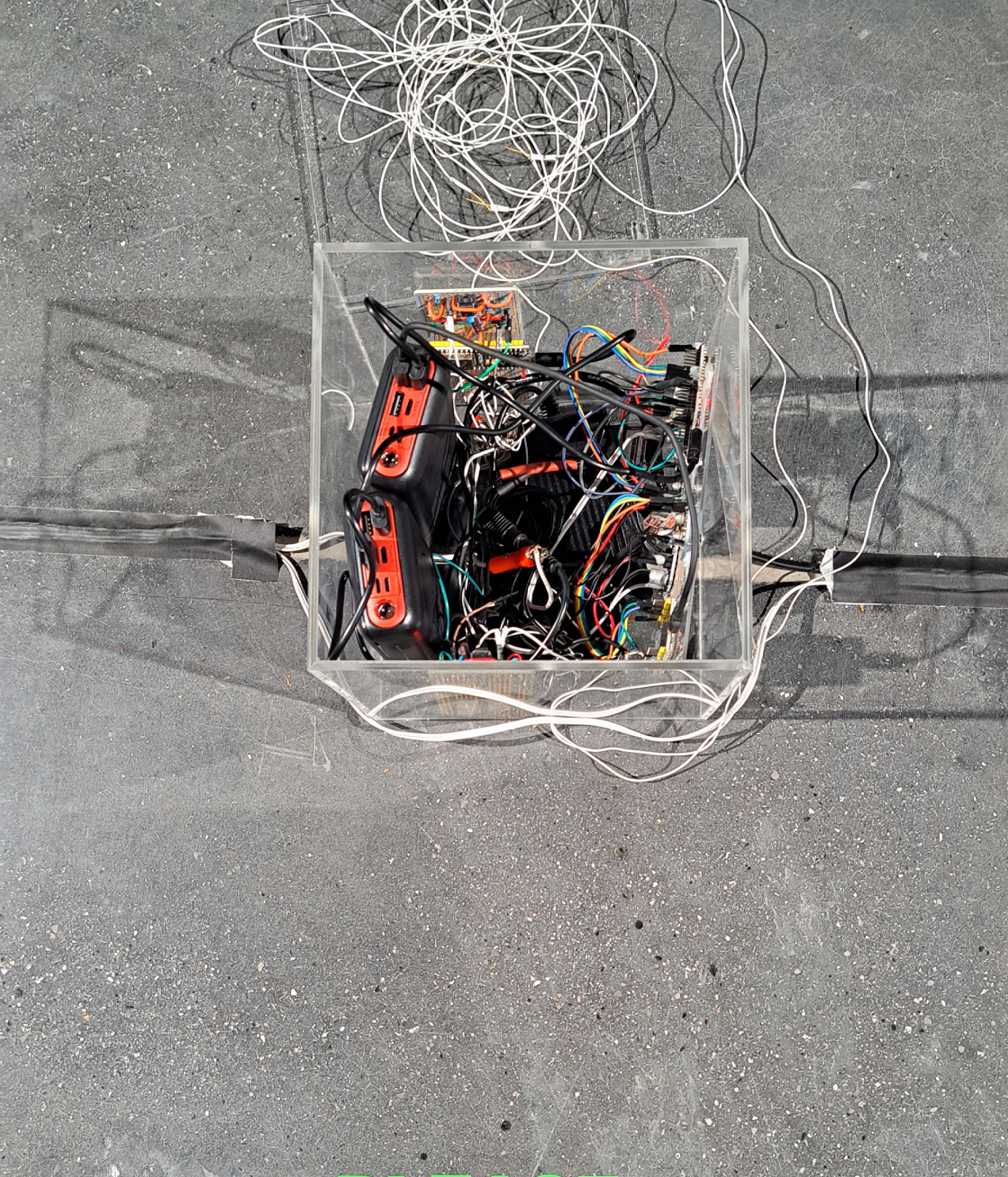


Fig. 59 Tower instruction RHIZA

Fig. 60 RHIZA at Festival X with instructions on the floor

ZIEN

‘ZIEN’ is a participatory art project created in the spring of 2022, a light installation in front of the Dutch Ministry of Finance- Den Haag. ‘ZIEN’ is created in five days from the cooperation between the robot arm IIWA[1] and humans. The robot engraves portraits of interested passers-by in mirrors on the square in front of the Ministry of Finance. These portraits are used to build the installation on the spot. ‘ZIEN’ examines the relationship we, as a society, want to have with technology. It created a collective visual reminder to stay out of the abstract.

1 LBR IIWA is KUKA’s lightweight cobots specialized in delicate assembly work. The LBR iiwa is the world’s first series-produced sensitive, and therefore a human-robot collaboration compatible robot. LBR stands for “Leichtbauroboter” (German for lightweight robot), and iiwa for “intelligent industrial work assistant”. With the LBR iiwa, humans and robots can work together on highly sensitive tasks in close cooperation. (LBR Iiwa, n.d.).

Fig. 61 ZIEN

CONCEPT

A ministry is a place that quickly becomes an abstraction to the outside world: a building, an institute, an envelope, a name. In the same way, the outside world is abstracted within the walls of the ministry.

Throughout my year being an artist in residence of the Ministry of Finance, I heard a need to be seen and heard within the bigger picture, especially concerning the introduction and use of technology. The need for this is not only outside but also a huge topic for the civil officers working in the ministry.

As a citizen of the Netherlands, I am very aware of the Dutch childcare benefits scandal. This scandal started in 2018 but is, until today, a major political scandal in the Netherlands. The Tax and Customs Administration (part of the Ministry of Finance) made false allegations of fraud while attempting to regulate childcare benefits for families (Toeslagenaffaire, n.d.). Due to this scandal, we became painfully aware of how things can go wrong when we lose sight of how technology is applied.

Still, I notice within the ministry that the application of technologies is seen as something they have no influence on. It is something above them that they can not control. People find it hard to keep in touch with themselves, their sense of responsibility, and critical ethical thinking when working with a system. Therefore I like to create an artwork focused on the process rather than the result. With 'ZIEN', I provide a way to meet with each other and technology outside the walls of the ministry.

Fig. 62 Opening ZIEN first phase

I show the process openly. The mess it brings. The constant need to adapt to the process due to the circumstances and the sensitivity of the technology we are working with. The work has to demystify an artist's work and the work with technology.

I want people to be and feel needed in order to create this work. Via 'ZIEN', the possibility is created to meet the other, opening up the conversations around these themes from connection rather than opposition. Where we leave as a collective force, a very visible and tangible trace in front of the ministry's main entrance reminds the inside and outside world of the Ministry of Finance that both sides are humans with a face and a life that needs to be considered and seen.

PROCESS

This installation is the outcome of my artist residency at the Ministry of Finance in the Netherlands. The Kunstcommisie of the Ministry of Finance asked me to develop a work based on my experiences within and in relation to the Ministry of Finance. It became a critical reflection on the current situation with an invitation to the future.

When I got the opportunity to be an artist in residence at the Ministry of Finance in 2021, I considered it an intriguing place because of the controversy surrounding it. It is a place that is not immediately very popular or for which there are many warm feelings. However, it is also a place with a massive impact on the country. We cannot deny that money is a determining factor in our societies. There is also little trust in the Netherlands regarding this ministry. As I mentioned before one of the reasons was the childcare benefits scandal.

This scandal led in 2021 to the fall of the Dutch Cabinet. Until today it is a political scandal in the Netherlands. The situation was so prejudicial that on Oct. 25, 2021, Amnesty International released a report called “Xenophobic machines: Discrimination through unregulated use of algorithms in the Dutch childcare benefits scandal” (Amnesty International, 2021). The report makes no secret of the situation “Thousands of lives are ruined by a disgraceful process which included a xenophobic algorithm based on racial profiling. The Dutch authorities risk

Fig. 63 Impression Ministry Finance during research phase

repeating these catastrophic mistakes as human rights protections are still lacking in the use of algorithmic systems," states Merel Koning, Senior Advisor on Technology and Human Rights at Amnesty International (Dutch Childcare Benefit Scandal an Urgent Wake-up Call to Ban Racist Algorithms, 2021).

Governments around the world are rushing to automate the delivery of public services, but it is the most marginalized in a society that are paying the highest price. [...] The black box system resulted in a black hole of accountability, with the Dutch tax authorities trusting an algorithm to help in decision-making without proper oversight (Dutch Childcare Benefit Scandal an Urgent Wake-up Call to Ban Racist Algorithms, 2021).

Knowing all this, I was uncertain whether this was a place I was willing to commit to. On the other hand, it is easy to be critical from the outside with little knowledge of the situation. I do not have the impression that I need to solve or foresee anything through art. However, I did see the problem of an abstraction taking place. Similar to the type of abstractions in science that I find interesting to research and make experienceable.

I decided to do this under the conditions that I could be critical. During my residency's first period, I wandered through the ministry. They introduced me to the various departments and showed me what they do. I decided to listen like a fly on the wall to the snippets of conversations I heard passing by. The gossip, frustrations and victories shared at the coffee machine. As it turned out, it was not at all that unified. Each department has its own corridor of flex spaces where everyone still has a personal favourite spot. They hardly know each other as soon as it is outside their area. Added to that, I must say it was a difficult period to observe because there was also corona.

The pandemic made that only a minimal number of employees were there daily. Everyone had certain days they were allowed to come to the office. One of the first observations was that finding someone to take responsibility for a decision whenever I wanted something was challenging. There was always someone else who might also have to make that decision.

The Art Commission of the Ministry of Finance aims to inspire, connect and keep the dialogue alive. The finance ministry has developed themes for itself they want to work on. One is environmental awareness and transparency. Out of everything I came across, I found it interesting that they have this as a top priority. If there was anything I needed to see more effort for was the accessibility, transparency or environmental awareness of the ministry. There are very few places where the outside world felt as distant to me as inside the ministry. The civil servants also have a considerable distance from each other. Meanwhile, outside the walls, I also gauged the mood around the ministry. I mainly felt distance, distrust and criticism.

Enough forces are going on around the ministry regarding criticism and points of improvement. I do not see myself as the right person to contribute anything meaningful. I wanted to find a way to bridge these distances, the distance to each other and to take responsibility. I wanted a work that brings the outside world in and the ministry out. After a month of observation, I proposed to create a work outside on the ministry square. Immediately it became clear that the ministry had never done anything out in public space for fear of criticism. Therefore I noticed an enormous cautiousness to do anything related to the outside world. I was surprised by this because it seemed like a contradiction to the ministry's top priority: to create transparency and contact with the outside world.

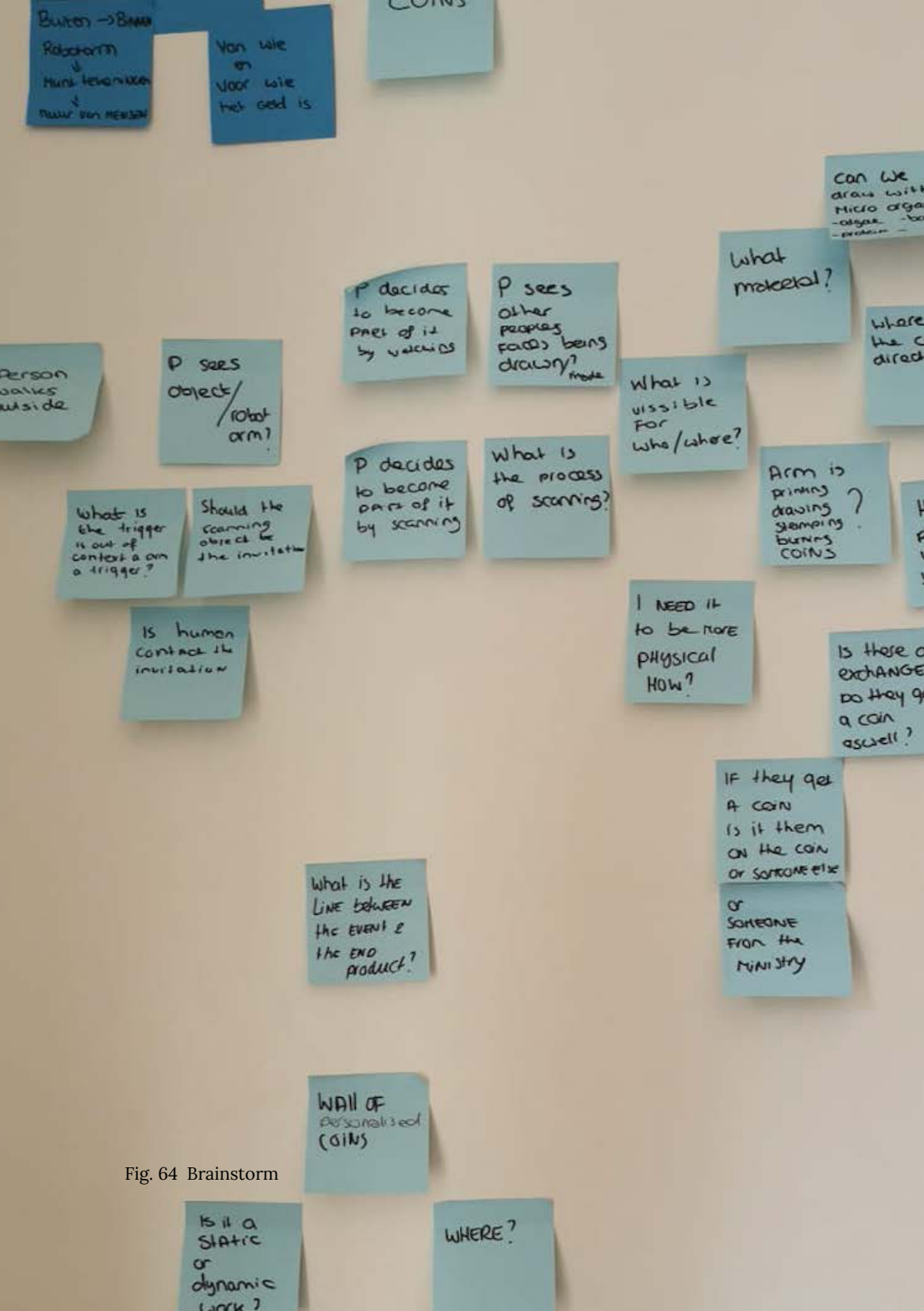


Fig. 64 Brainstorm

The aversion and ignorance of new technology within the ministry are alarming. People do what they are asked to do and assume it is correct. At the same time, I also found it difficult to blame them. I can understand that when there is absolutely no knowledge of artificial intelligence or the ethical issues surrounding new technologies, you do not engage in those and trust your employer to let you work with something right. However, try to find the person who, in that vast network of ministry, sees themself as the person in charge.

It was a quest as to what I could do. What did I want to make in this environment? I felt the work had to be something that is accessible. The audience is not an experienced art audience. A considerable part has little to no experience with art. In addition, I wanted to place it in the public space and was looking for a connection. So it could not be a work so abstract that the man from the fish stand next to the ministry could not relate to it at all. Nor did I want to make a work that was not critical of the ministry's situation regarding the use of technology and the enormous separation it causes in society. The concept developed into a robotic arm that engraves portraits on the ministry's square. A tangible form of technology that can make visible how much care and human attention is needed to make it work properly.

A robotic arm is programmed to make an effort to capture and engrave you. Through the robotic arm, the person being portrayed works with me to create a final work. Each of us is needed in this process to create the work.

The way these portraits would look and come together went between being enormous and demanding one's attention to something very subtle and requiring your attention to look carefully. I ended up with the subtle version because I like it when people have to put in the effort and take their time.

Fig. 65 First sketch of possible robot interaction with the public

Fig. 66 Sketch portraits at the entrance

Fig. 67 Sketch portraits on the main square inside but not available for public

Fig. 68 First proposal to have the portraits on the outside wall of the building next to the entrance

Fig. 69 Sketch big maze outside with portraits on the inside

Fig. 70 Sketch option of walkthrough

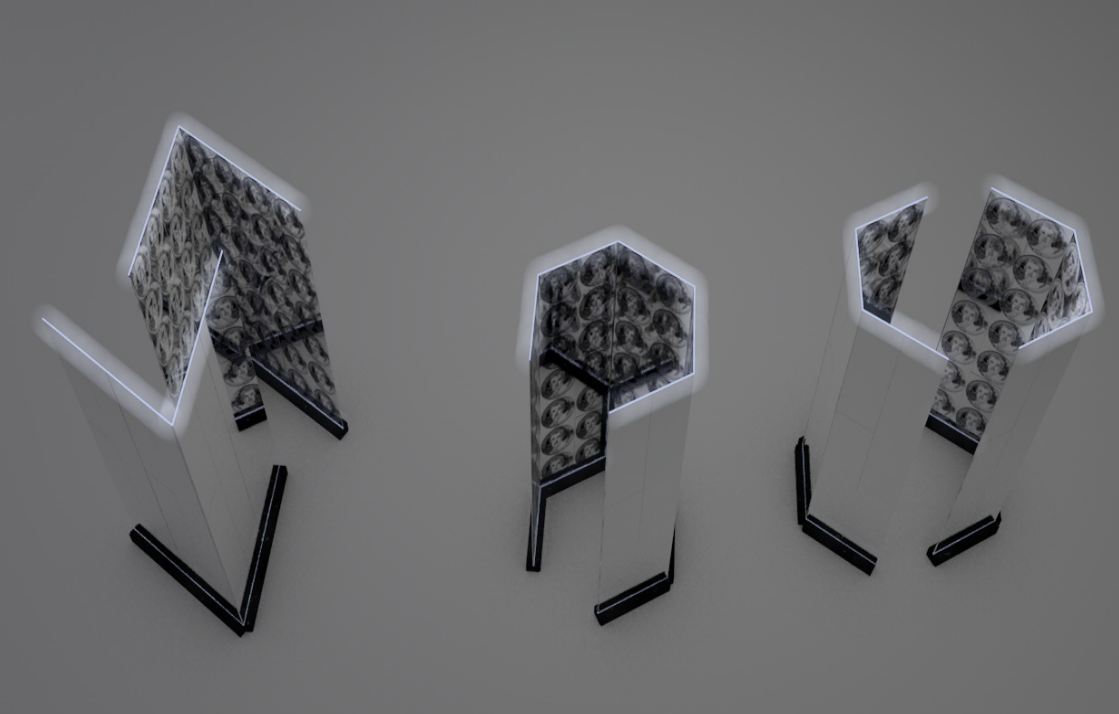


Fig. 71 Form studies on the shapes for outside

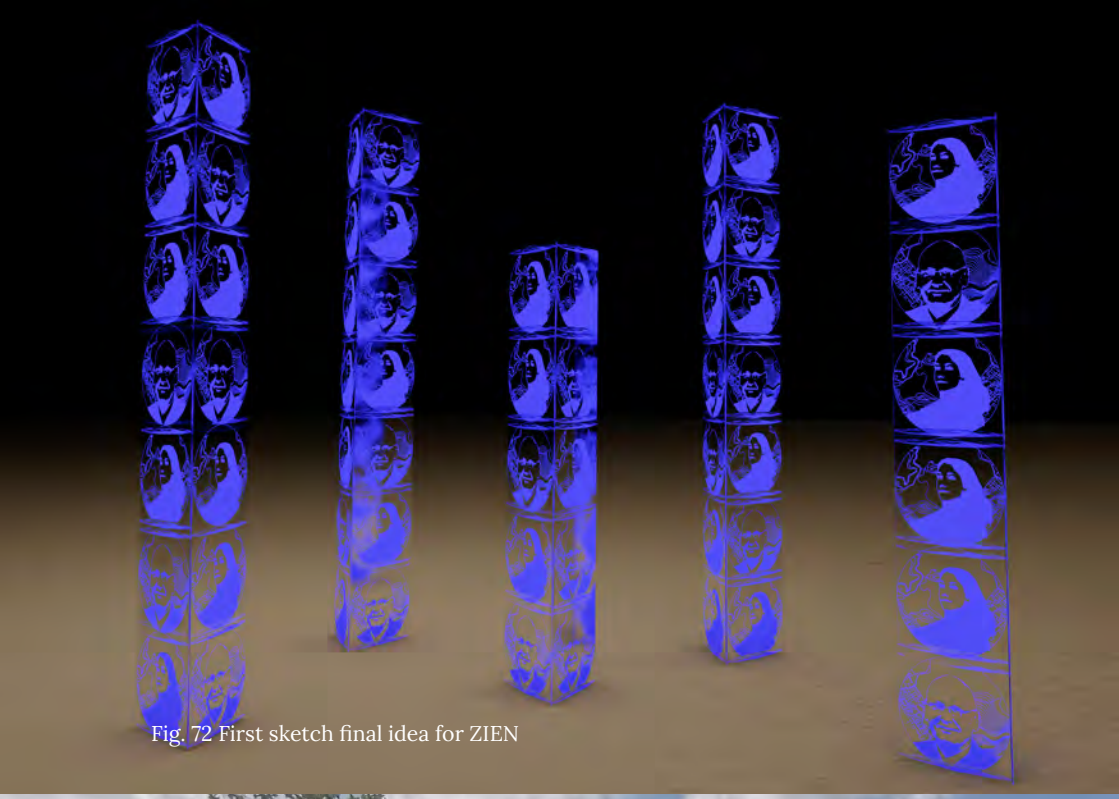


Fig. 72 First sketch final idea for ZIEN

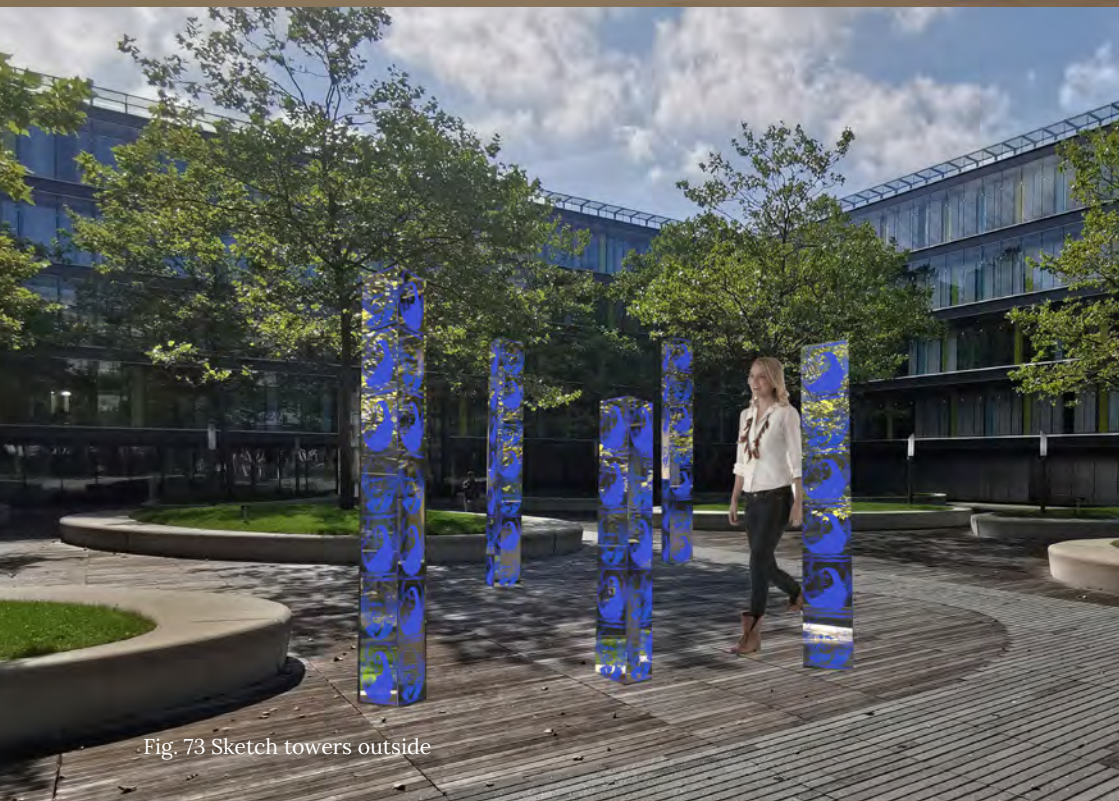


Fig. 73 Sketch towers outside

The idea I proposed resonated with the art committee. I was the very first artist ever to create a work within the walls of the ministry, I did not expected the enormous struggle that needed to be made to get everyone to agree that this work could be there. I had to take my plan to the top of the ministry to explain what I would do and why it was important. Making it clear to them that the nerves they felt about going public were the very reason to do it if they really wanted contact. In the months of this process, I had never experienced this sluggishness. I thought the pink oyster mushrooms were slow. They were swift and predictable compared to the process of a Ministry.

It initially discouraged me until I thought about how Christo compared his process and the complexity of getting authorities to go along with it to playing poker. Where the process is already part of your work, I could slowly see the process of 'ZIEN' as the space that needed to be claimed-to break literally through the walls of ministry.

The struggle I faced within the ministry was so intense that I could not do this alone. I collaborated with Bashir Bastani to design the background for the portraits. I was looking for a visual with a slight hint of coins focusing on the connecting factors within the Netherlands. Between water and land. Nature and technology. Man-made and Nature Force. From the different designs, we finally arrived at a design inspired by the seafloor and the Netherlands' road network.(Fig. 75,Fig, 76, Fig. 77)

Fig. 74 One of the many interaction explanations of the work
this one was particularly for the legal department

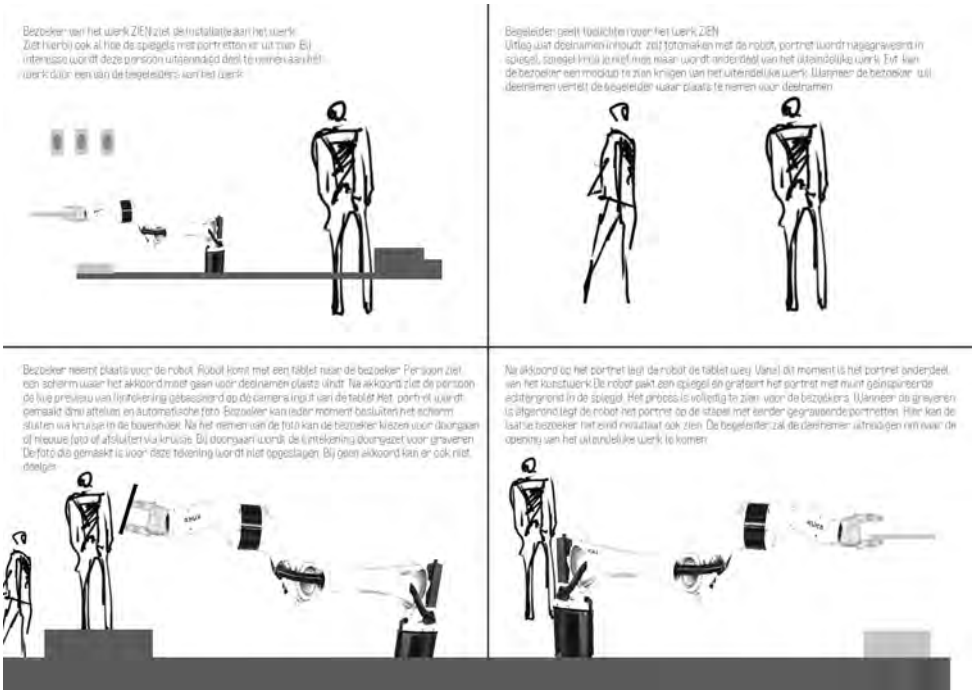


Fig. 75 Coin design 1 Bashir Bastan

Fig. 76 Coin design 2 Bashir Bastan

Fig. 77 Coin design 2 Bashir Bastan

I worked with Amir Bastani from the Creative Robotics lab at the Art University Linz on the interaction and engraving with the robot arm. Bit by bit, the work came together on the conceptual and creative side as well as on the productional and practical side of the ministry. It was a process of getting to know the quality of the material of the mirrors and finding out what kind of laser engraver would work with what settings. Could we do the movement with the robotic arm, or did we have to find a laser engraver with the movement within itself? IIWA turned out not to be fast enough to engrave. Therefore we decided to work with a laser engraver that IIWA kept in place. This process of researching the materials and technology you are working with was also something that made the people from the ministry feel insecure. They wanted clear answers on how something would work, which forced me to find the balance between technology and human expectation. I needed time to find out what IIWA was capable of. I also needed time to determine what the laser engraver could or could not do. I explained to process and what it means to work with the uncertainty of not being sure what will come out. I noticed that making them part of the little steps did not take away any concerns from them. Therefore I decided that this is just something they have to deal with. I am dealing with it, and I asked them to do the same and to dare to trust the process.

Six months later than planned, we finally placed IIWA, the robotic arm, in front of the Ministry of Finance to start working on 'ZIEN'. 'ZIEN' is created in five days from the cooperation between the robot arm IIWA and humans. The robot engraves portraits of interested passers-by in mirrors on the square in front of the Ministry of Finance. I used these portraits to build the installation on the spot.

Fig. 78 Testing the laser engraving and light

Fig. 79 Testing engraving set-up IIWA

Fig. 80 Building ZIEN at Ministry of Finance

Fig. 81 Amir programming IIWA

I wanted to make the participants and bypassers feel the process of 'ZIEN'. Therefore, Amir and I worked on the patch of 'ZIEN' during these five days on the spot in the hybrid visual/textual live-programming environment called VVVV.

Working with technology such as a robotic arm and a laser engraver requires an awareness of safety. Even the photos we took of participants had to be done in an ethical way where we could guarantee them that their data would be removed immediately after engraving. This safety and human oversight is key to working with technology and the concept behind 'ZIEN'. 'ZIEN' examines the relationship we, as individuals and as a society, want to have with technology.

Working with IIWA outside gave me an insight into the sensitivity of technology. For the safety of the arm, we brought it inside every day. This made us have to calibrate IIWA every day. Even though the basics were the same, we could never assume that without testing it and ensuring it would work. Factors such as an uneven surface and constantly changing light affected the process of engraving a proper portrait.

This week, we had multiple people coming by on various days to see how the process was going and also noticing the small changes we were making in engraving and building the towers.

After five days, the towers were finished. The work will remain on the square in front of the Ministry of Finance until early 2023. I am developing a side program with WAAG Society to keep using the space created by 'ZIEN'. This will take place in early 2023.

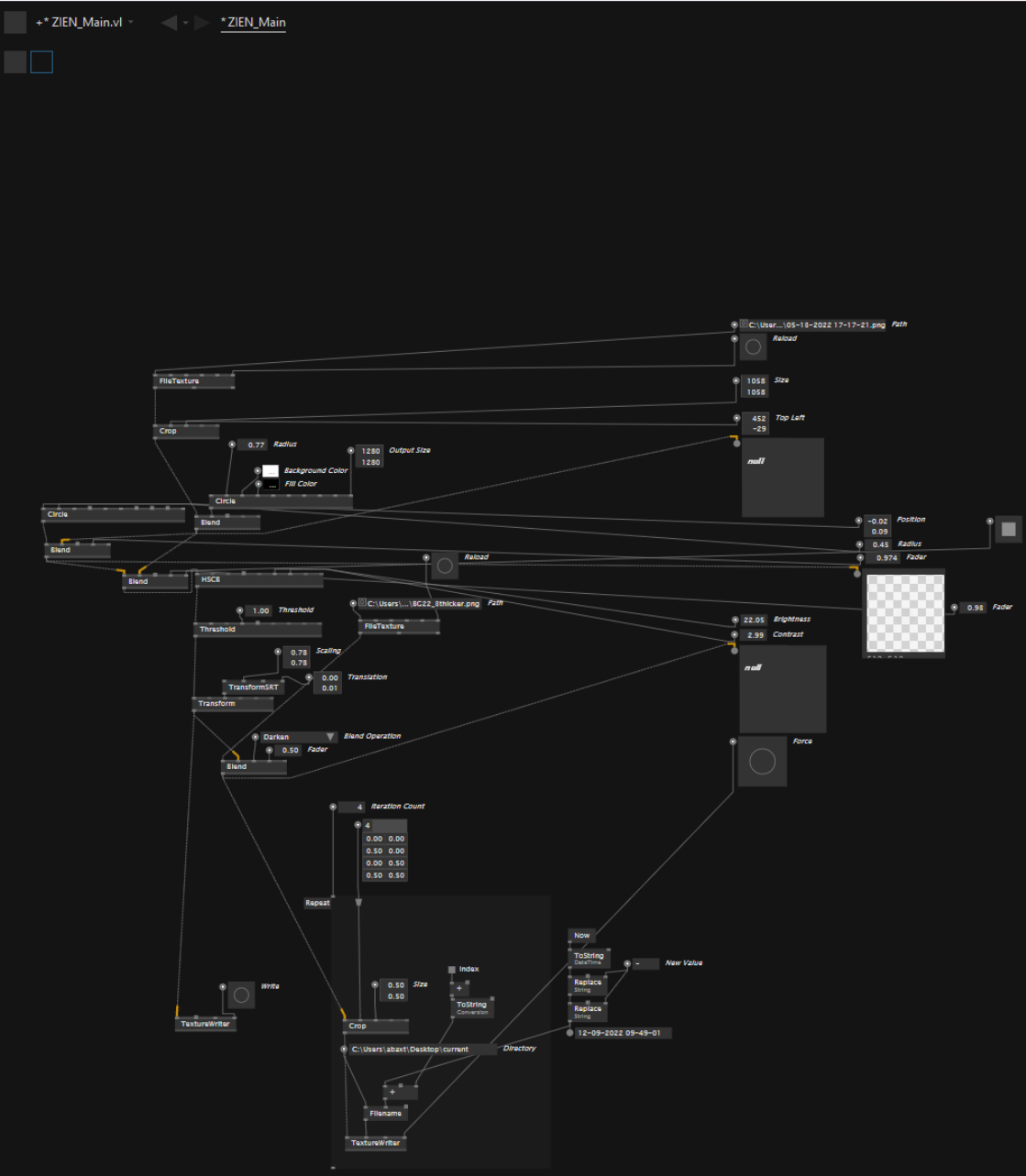


Fig. 82 Part of ZIEN patch in VVVV gamma

Fig. 83 Working with Amir Bastani outside during ZIEN

Fig. 84 Side view ZIEN

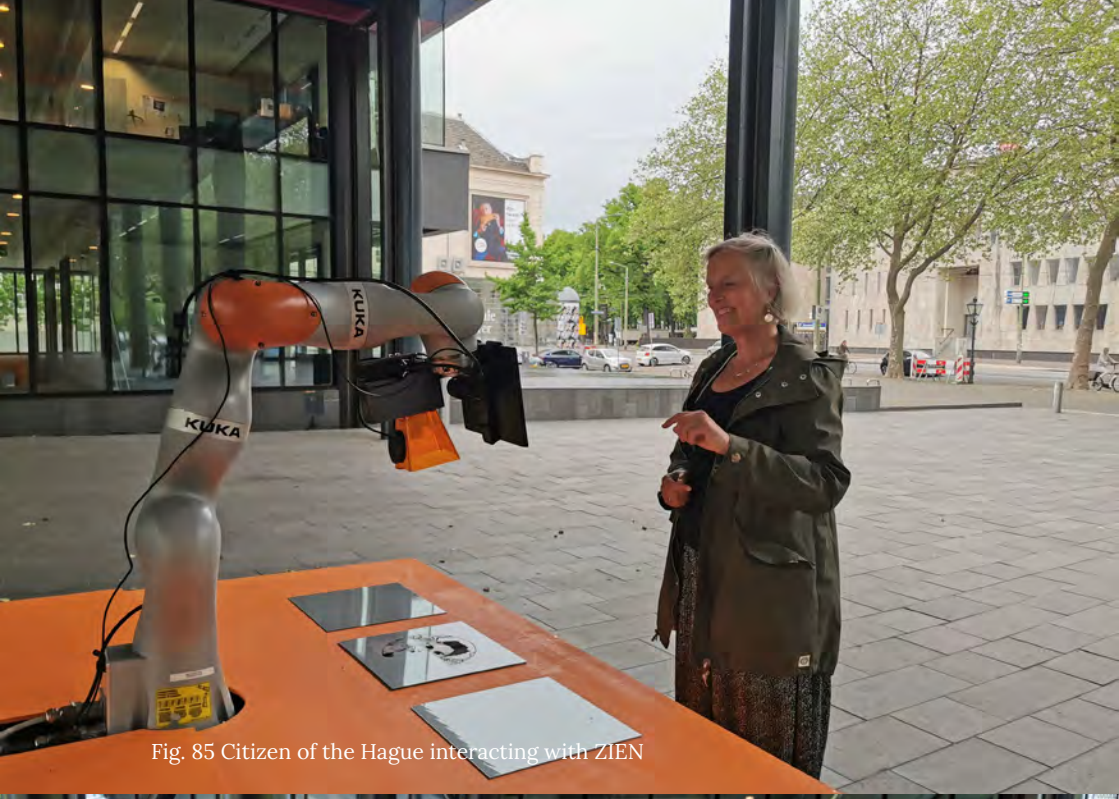


Fig. 85 Citizen of the Hague interacting with ZIEN

Fig. 86 Cleaning station ZIEN

Fig. 87 ZIEN front view

Fig. 88 Warning instruction ZIEN

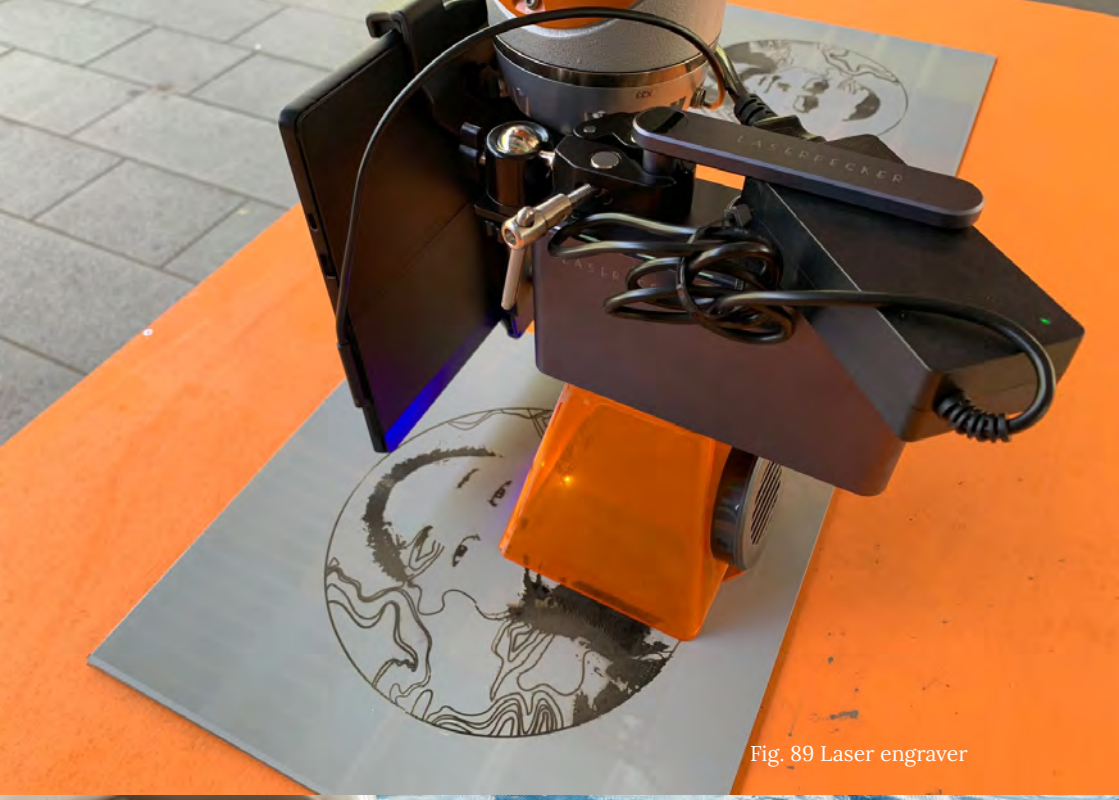


Fig. 89 Laser engraver

Fig. 90 Portraits to be cleaned

Fig. 91 Taking the picture for a portrait

Fig. 92 Cleaning the portraits

Fig. 93 Building the towers

The concept proposal by Thais Costa from WAAG Society is 'Maken om te zien' (Making in order to see), a side program composed of a series of four public events. The program brings together diverse groups of people to collaboratively reflect on their role as citizens and their place in society. This includes participants from diverse backgrounds working in the Dutch Ministries and the general public.

The activities make space to experiment and share perspectives regarding the systems that rule society, such as technologies, governmental bodies and ruling laws. The side program seeks to answer "how might we bridge existing communication gaps between citizens and government and bring in new perspectives on the role of technology in society?"

The program explores critical making and co-creative approaches to engage citizens of the Netherlands in makership while critically reflecting on and discussing contemporary social issues. Critical making is an approach based on the maker culture. It aims to understand how art, design and technology can fulfil a critical and reflective role in society, including the possibility of revealing and challenging power relations. Thus, making is an important resource for discussing difficult topics in an approachable and safe way:

1. It enables people to concretise and contextualise ideas as well as understand their own perspective on a subject.
2. When making things concrete, people are able to discuss different opinions and speak more confidently about conflicting ideas when presenting them through an object or concept at hand.
3. Making together is a valuable process that supports human connection by experimenting, experiencing and ideating together..

The makership practices that we will explore address the intersection of art, technology and society. Critical making involves using technological tools to reflect on the role of technology in our current systems and imagining a future that is open, fair and inclusive. A future that rethinks our position in society as citizens that share common goals of justice and fair opportunities for all. Making together is an enriching process that brings in new ways of looking at these topics and provides an opportunity to bridge the gap between different target groups and diverse opinions.

I hope 'ZIEN' is an invitation to reflect and take responsibility. To keep seeing yourself and others. Sometimes it may seem that you are absorbed in the vastness of the bigger whole. By keeping an eye on the details, you are able to remain seeing.

Fig. 94 Opening ZIEN by Jan van Zanen, Mayor of The Hague and Han van Gelder, Deputy Secretary-General of the Ministry of Finance

Fig. 95 ZIEN during opening

INSTALLATION

The work ‘ZIEN’ consists of two phases. Phase one is creating the work ‘ZIEN’ with a robotic arm IIWA during a specific period. Phase two is the final work of multiple towers with portraits engraved on mirrors that has light from the inside. When presenting the work, it has to be decided to repeat the whole process or exhibit the towers created in May 2022. It can be presented indoors and outdoors. When shown outside, the environmental conditions should be kept in mind.

Dimensions

1 tower with mirrors 30x30x152 cm
2 towers with mirrors 30x30x182 cm
2 towers with mirrors 30x30x212 cm
2 waterproof electricity safety boxes

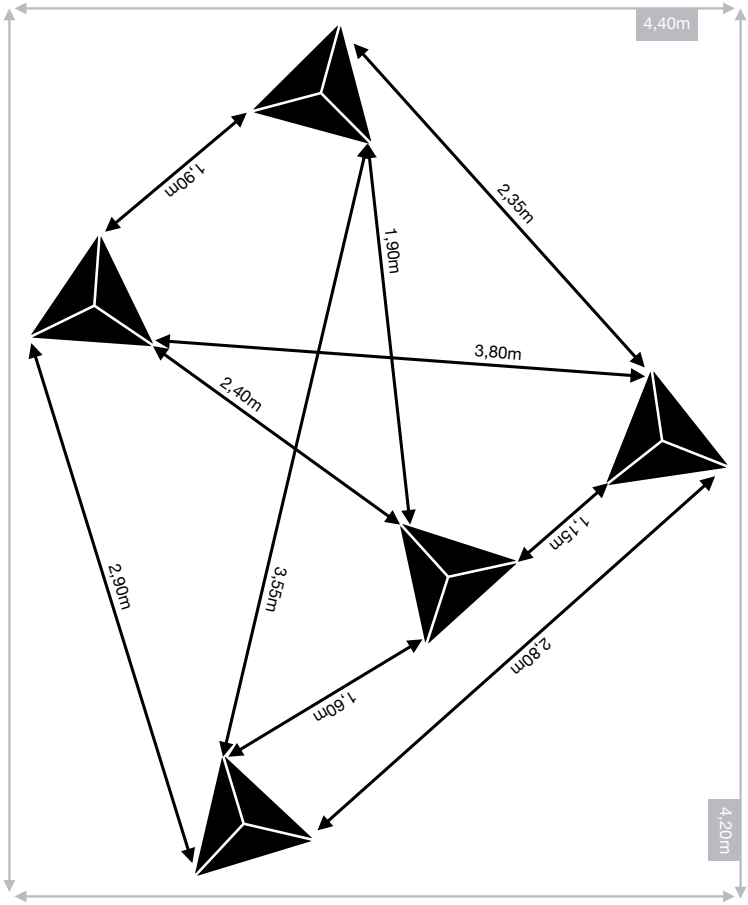


Fig. 96 Topview placing towers of ZIEN at Ministry of Finance

CARE

On the topic of care 'ZIEN' asked for a very different type of care. The care needed from my side on the technical part was mostly on safety. Safety for the people who were interacting with the work. Physically but also with their data. It was for me, being aware of the sensitivities of the ministry, important to be extremely careful with this and ensure that the experience was safe.

The physical safety of working with a robot and laser engraver asks for a constant awareness of the environment. It was essential to create indirect indications and direct instructions for people on how they behave around the robot. Amir and I agreed that one of us was behind the computer and consol of IIWA. We could stop the robot arm and the laser engraver if anything goes wrong.

Another part to consider was that we were working outside and that the final work would stay outside—this required extra caution regarding the design and placement of the various components. Because the work is outdoors, it is subject to the weather. As a result, the work gets dirty quickly. The ministry now includes the work in their weekly cleaning. The impact of weather and long days working outside also had a massive impact on the team that made 'ZIEN'. It should not be underestimated how well you have to take care of yourself when you are constantly in a public process like this.

I did not expect this project to make me so aware of the urgency of taking care of myself, my process and also the human and non-human with whom I work.

How do I stay close to myself and what I stand for? It meant I had to stay true to what I wanted to create within a ministry with many agendas. I was tossed back and forth between how they envisioned the work and what I wanted it to be. Something I also described earlier was the space you need as an artist to experiment. Get to know the material and technology you are working with. The choice to have 'ZIEN' focus so much on the process is also a response to how little space I felt for process and development within the ministry. I observed this in how they interacted with me as well as how they handled their own work.

This work now belongs to the Ministry of Finance, which means that I no longer directly take care of the work and what happens to it. I wrote a very extended technical and care rider for this work so they can adequately take care of it. Despite this, in the background, I do of course remain involved with the condition of the work and, when and how it will be exhibited in other places.

Fig. 97 Close-up portrait ZIEN on the tower when light is off

Fig. 98 Close-up portrait ZIEN on the tower when light is on

FadingColours

‘FadingColours’ intertwines living algae and almost real-time coral bleaching data. In this partly interactive installation, the living conditions of the algae are influenced by the almost real-time data on coral bleaching. The five living data sculptures are connected to National Oceanic and Atmospheric Association (NOAA) Coral Reef Watch, which is used to observe and research coral reefs worldwide. The algae create a tangible reflection of the situation of their species and the corals under the sea surface. ‘FadingColours’ is exhibited at Ars Electronica 2022 - Linz, Welcome to Our Guesthouse 2022 - Rotterdam and WIP festival 2022 - Nicosia.

Fig. 99 FadingColours - Welcome to Our Guesthouse, Rotterdam

CONCEPT

Coral reefs are one of the most vulnerable ecosystems on the planet. They are also called the "rainforests of the sea" because of their rich biodiversity that significantly benefits our planet and humankind. Corals remain a mystery to many, who may not know they are living organisms. Environmental stresses, like higher water temperatures, can cause coral bleaching. Although corals are animals, they also contain single-cell organisms called zooxanthellae that can photosynthesise, enabling the corals to share in energy captured directly from the sun. Coral bleaching is one of the most visible signs that the reefs are in trouble. Pushing out their beneficial algae, the corals begin to starve.

Our world is literally losing colour with the bleaching and disappearance of our corals. Conservationists have sounded the alarms about the death of coral reefs for decades. However, most people are still determining what a coral is and what these warnings actually mean. How can we expect to get someone to care about the coral reefs when it is an abstract thing they can barely relate to? If they do not understand what a coral is or what the data about them tells us. How can we expect people to care about saving them?

As Thom van Dooren states in his book 'Flight ways: life and loss at the edge of extinction', "the brand of holist ecological philosophy that emphasises that 'everything is connected to everything' will not help us here. Rather, everything is connected to something, which is connected to something else.

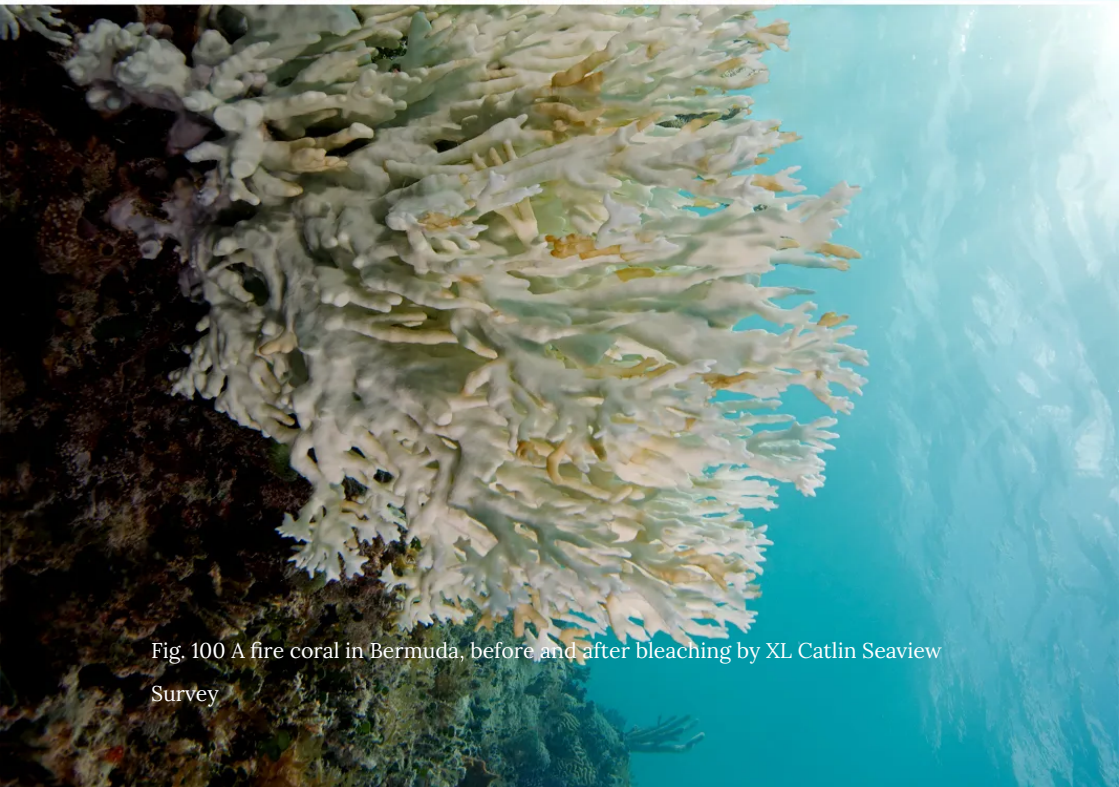


Fig. 100 A fire coral in Bermuda, before and after bleaching by XL Catlin Seaview Survey

While we may all ultimately be connected to one another, the specificity and proximity of connections matters—who we are bound up with and in what ways. Life and death happen inside these relationships. And so, we need to understand how particular human communities, as well as those of other living beings, are entangled, and how these entanglements are implicated in the production of both extinctions and their accompanying patterns of amplified death." (Van Dooren, 2016, p.60)

'FadingColours' is an interactive installation that intertwines living algae and coral bleaching data. Based on the technologies and data used to observe, care and understand corals and algae. In these sculptures, I grow living algae. Each of the sculptures connects to a coral reef around the world via NOAA's Coral Reef Watch. The algae environment is directly linked to the reef data they represent. The data influences their environment in order to create living sculptures that reflect in their colour and light the state of the coral and their algae in the ocean. Behind the statues is a screen with a rotary device. One can rotate the black disk under the screen to explore the situation of all the reefs connected to NOAA's Coral Reef Watch.

We can learn to listen to the signs of other systems instead of taking them over or leaving them behind, especially with natural systems that live in such a different environment than we do.
'FadingColours' is creating an ecosystem of tangible data sculptures to tell a coral-algae narrative about our world. It aims to blend the digital and the natural to show us the fragile balance of the symbiotic relationship between coral and algae through a tangible living and digital representation of their living situation in the present moment. In order to give one a more intimate and direct opportunity to get to know them.

Fig. 101 Living data sculpture connected to a reef with no stress

PROCESS

I have always been drawn to the ocean. One of my big passions is scuba diving. Scuba diving allows you to enter a world we do not belong to. Being dependent on your air tank, mask, and other equipment is a constant reminder that this is not an environment where we are supposed to be. It is magical that we can be underwater despite this. You must slow down when you descend to allow your body to adapt. You breathe in and out as calmly as you can. Never hold your breath. Your body cannot tolerate this underwater. The slower you move and breathe, the longer you can stay down. It is dangerous underwater, so you can never be alone. You keep an eye on each other. If anything goes wrong, it may endanger your life. The underwater world is one of the places where you remember how fragile our lives are.

One can think why to take all those risks and all the hassle. Once you are there, it is like being on another planet, another universe. You cannot talk. Just watch. You hold your arms tightly and minimise any movement that might accidentally damage anything. Then you can get so close to underwater life. They swim all around you. They shoot away when you see them. They come to you to see what you are. The more you know about them, the more fascinating your encounters become. The intelligence of octopuses, the force of the water, and the colours and textures of corals and seaweeds. When you dive, you almost always visit a coral reef. Coral reefs are like the cities of the ocean. When diving, you will almost certainly visit a coral reef. Coral reefs are like the cities of the sea.

Fig. 102 Noor diving

So many species congregate here. They nourish, and they reproduce. They hunt and find protection; the foundation of it is the corals themselves. The little animals are often mistaken for plants. When you get out there, you see the beauty and the painful reality. Coral reefs that have lost all their colour. Coral bleaching happens when sea temperatures become too high or low. These little temperature changes can cause coral to drive out their algae. Coral polyps live in a symbiotic relationship with algae called zooxanthellae- they live inside the coral and provide 90% of the food corals need. Zooxanthellae are also responsible for their bright colours.

Once you encounter a reef like this, you immediately notice the difference. The liveliness is not there. Once you surface again, the underwater world feels like a dream you have visited.

Obviously, there have been alarming reports about the situation of the coral reefs for years. Even though you have been there - what is told about coral bleaching can still feel hard to grasp. I have little feeling for numbers or graphs. I understand them but do not feel them. So I wondered, isn't there a way to make the data tangible? After all, data tells a story. Data relates and is constantly changing.

In order to find a more specific connection between us and the corals and algae living so far away from us, I want to bridge humans towards the coral-algae narrative through Donna Haraway's tentacular thinking. Tentacular thinking is the ability to perceive the world by touching, feeling and experiencing things. Humans can use it to gain new knowledge, understanding and experience of the other and the unknown in a different way (Haraway, 2016).

What materialised strategies can we use to relate to this abstract species? Can we use the combination of the technologies used to observe, care and understand corals and algae as well for

us to create an understanding and connection to them?

The idea for this installation started with three pieces of research in parallel. First, I wanted algae or corals to tell the story of their situation. I looked into the possibilities of working with corals, but this was so complex that I decided to move on with the algae. From my experience with mushrooms, I knew that it takes a while to get to know the behaviour and preferences of a species. So my first step was to decide on a type of algae I wanted to work with and to get them.

I ordered a little bottle of spirulina algae from Sweden. They are not the same as living in corals, but they can survive independently, and there is enough information available on how to feed them.

I knew I wanted to influence the living conditions of these algae and that I wanted them in a larger amount than the 100ml I had from Sweden.

I started my own spirulina farm to increase the amount of spirulina. For months I started observing their natural behaviour in the water tanks. I started experimenting with the amount of air, movement, type of light, and temperature.

Fig. 103 Preparing food for the algae

Fig. 104 Algaefarm

Fig. 105 Test setup

Fig. 106 Test setup difference in movement

Fig. 107 Light and temperature test algae

Fig. 108 Air, light and temperatur

Fig. 109 Air test algae

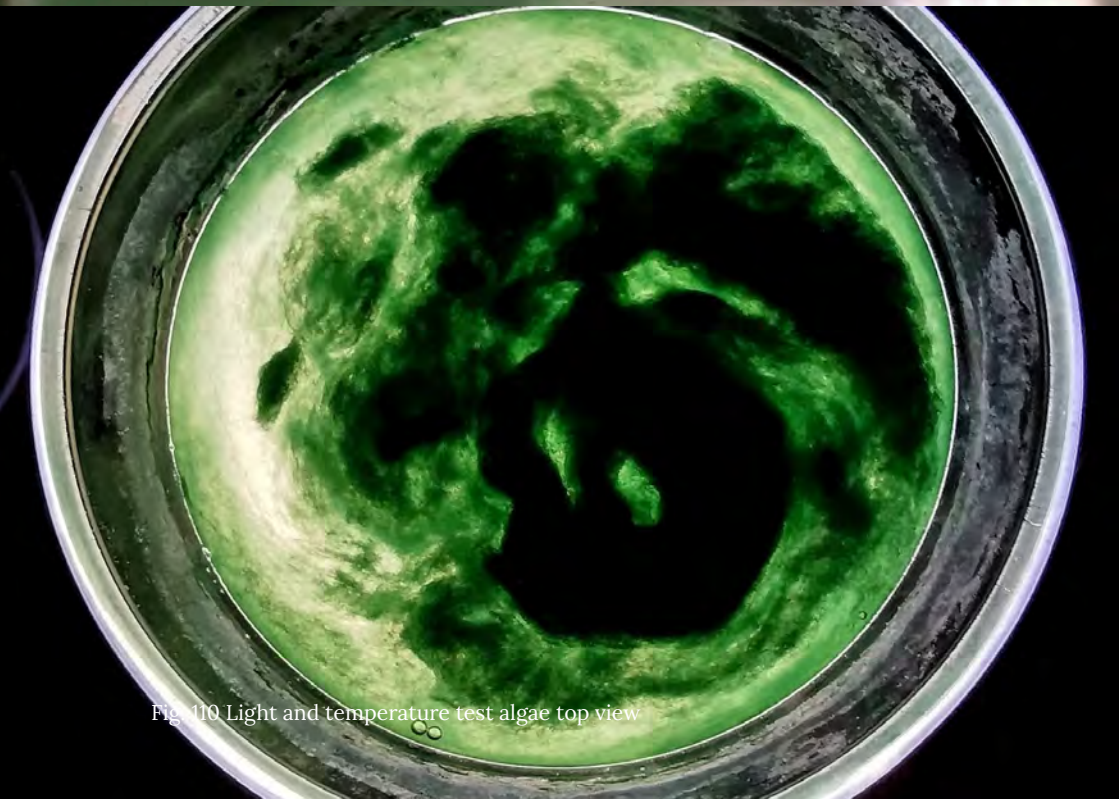


Fig. 110 Light and temperature test algae top view

I noticed that the algae react to movement, light and temperature change and that I could make them float to the top of the water they live in without them dying or damaging. For me, this behaviour had a similar quality as the bleaching since the appearance of their environment changed from deep green to yellow and eventually transparent water.

Next to this, I was researching the textures of corals. Initially, my idea was to create sculptures with a similar texture as the corals since I was already working with the algae. For this part, I was in contact with the Functional Reef Ecology Lab based at the Institute of Oceanography (NTU, Taiwan) and using the open-access archive of Corallum Fabrica. An open-science project dedicated to the 3D structure of coral skeletons involving designers and scientists. Coral samples have been imaged using x-ray tomography, and high-resolution 3D models of their structures have been elaborated. The generated data form the core of this open-access archive of coral structures and can be used for research purposes and scientific mediation to a broad audience (CorallumFabrica, n.d.). I wanted to use these 3D scans to 3D print sculptures for the algae to live in.

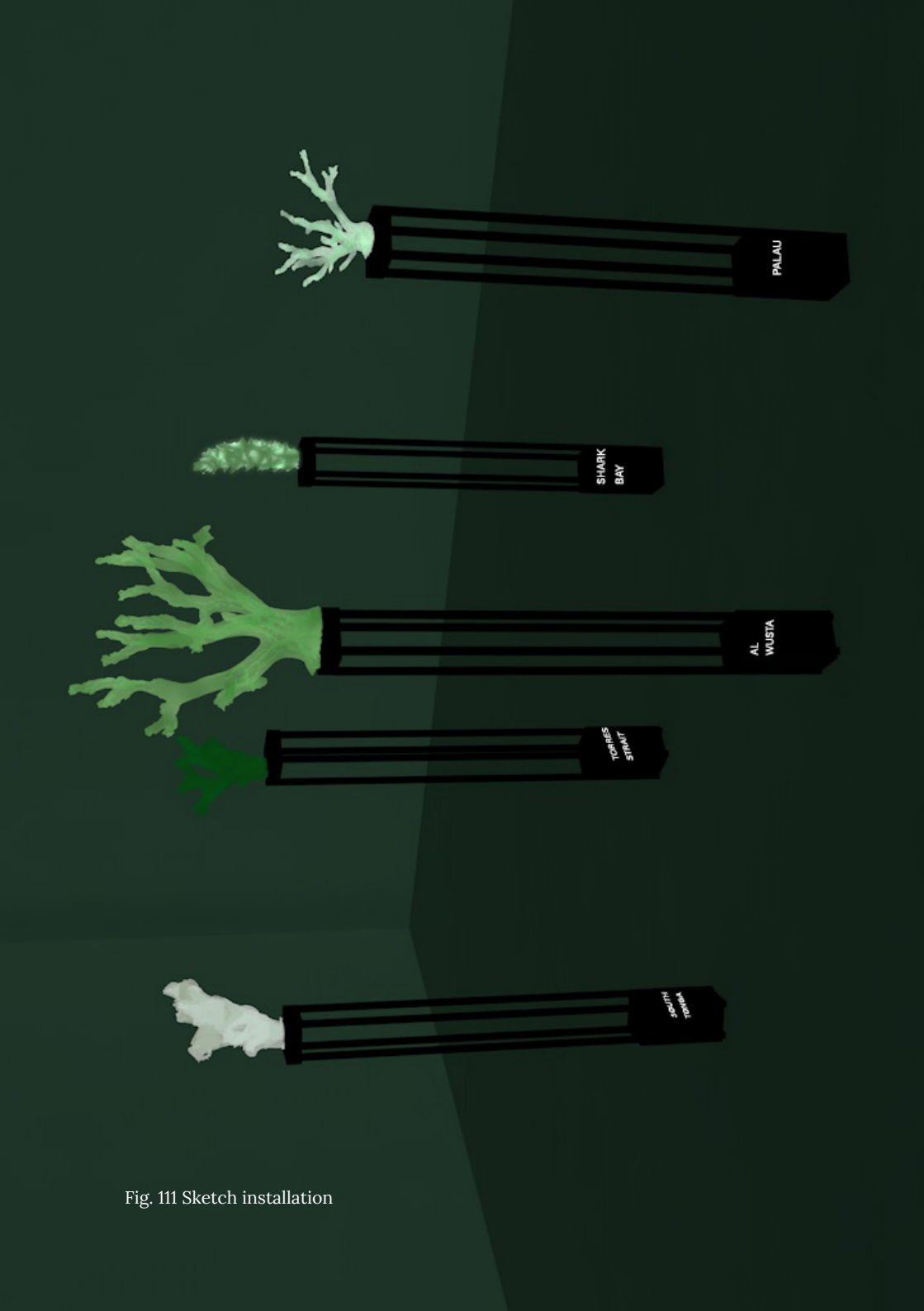


Fig. 111 Sketch installation

I had several 3-D scans of different corals. From these scans, I made 3D objects to 3D print. However, the structures of the corals turned out to be so complicated that it appeared impossible to print them watertight within the possibilities I had available. While doing so, I felt I was translating too directly using printed corals with algae. I was afraid that the focus would disappear to the sculptures' shapes and textures rather than the process of the algae being influenced by the data. I wanted to make visible the process that takes place inside the coral and not again the beauty of the outside. Taking these thoughts into account, I decided to do the complete opposite visually of the complex structures of corals. I chose to show the algae in 1000ml glass carafes. This also gave me the liberty that the coral sculpture did not have to match the reef it was connected to.

3D SCAN CORAL

Fig. 112 3D scan coral

Fig. 113 3D model coral

The last part was the data on coral bleaching. The core of the story this work has to tell. I found the NOAA Coral Reef Watch. This free online tool provides a global analysis of sea surface temperature (SST) and outlooks to identify coral reefs at risk of bleaching. NOAA uses near-real-time and historical satellite SST measurements to determine the global temperature threshold of coral reefs (NOAA Coral Reef Watch Daily 5km Regional Virtual Stations, n.d.). Erick Geiger, one of NOAA Coral Reef Watch Scientists, helped me access the API of their website, where they update this data almost daily.

With access to their data, I worked with Amir Bastani on developing a VVVV patch for receiving this data, translating it into actions for the sculptures and sending it via MQTT[1] to the ESPS32 microcontroller in the five sculptures. Simultaneously, the information is also visible on the screen behind the work so visitors can explore all the 214 reef stations by rotating a disk under the screen. The following are the five states that a coral reef can be in and the implementation in the sculptures.

1 MQTT is the most commonly used messaging protocol for the Internet of Things (IoT).A protocol is a set of rules that defines how IoT devices can publish and subscribe to data over the Internet. The sender (Publisher) and the receiver (Subscriber) communicate via Topics and are decoupled from each other. The MQTT broker handles the connection between them. The MQTT broker filters all incoming messages and distributes them correctly to the Subscribers. (MQTT Essential Series | HiveMQ | All Core MQTT Concepts Explained, n.d.)

Alert level	Effect	Translation in FC
No Stress	No bleaching	Algae are moving, and bright green
Bleaching Watch	Low chance of bleaching	Algae are getting less light but still, enough movement to stay green
Bleaching Warning	Possible bleaching	Algae are getting more yellow light and irregular movement. Creating less dense green sculptures.
Bleaching alert 1	Significant bleaching likely	Algae are getting no movement and more blue light. Algae start hovering in the sculpture in clumps.
Bleaching alert 2	Servere bleaching and significant mortality likely	Algae are getting no movement and just bright light which raises the temperature slightly. They start floating on top of the sculpture. Creating transparent water.

Tabel 2 Coral Reef states

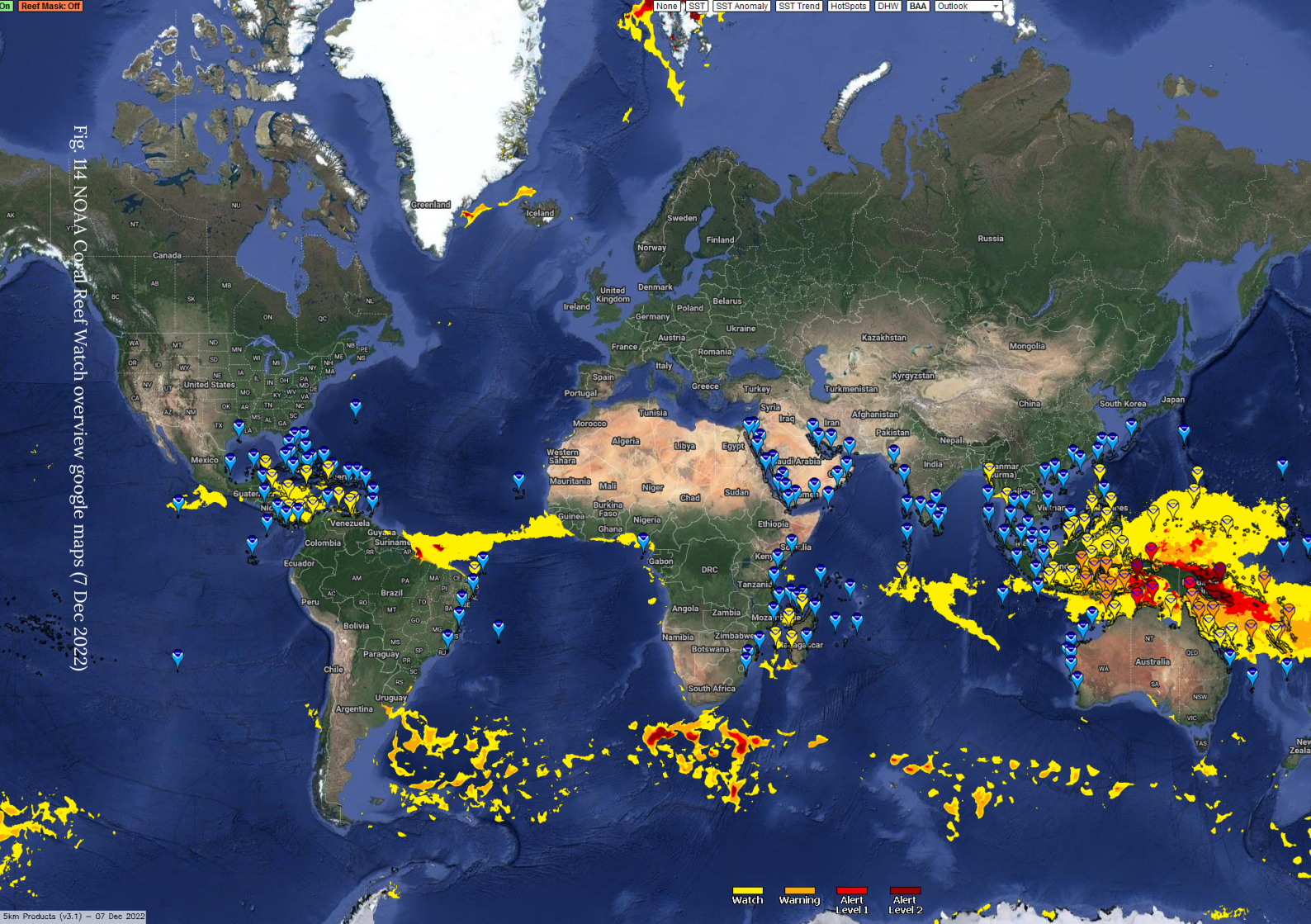


Fig. 114 NOAA Coral Reef Watch overview google maps (7 Dec 2022)

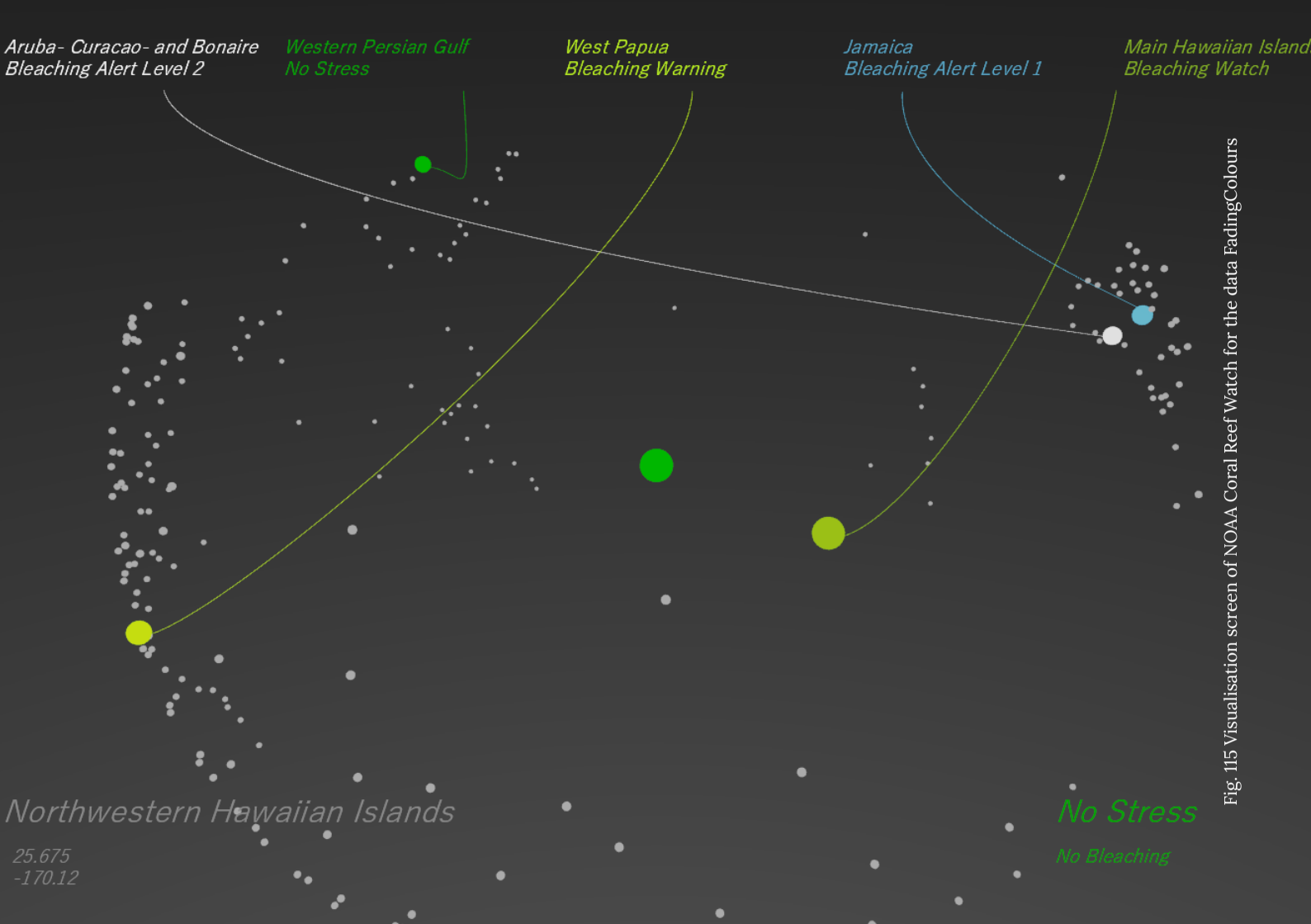


Fig. 115 Visualisation screen of NOAA Coral Reef Watch for the data FadingColours

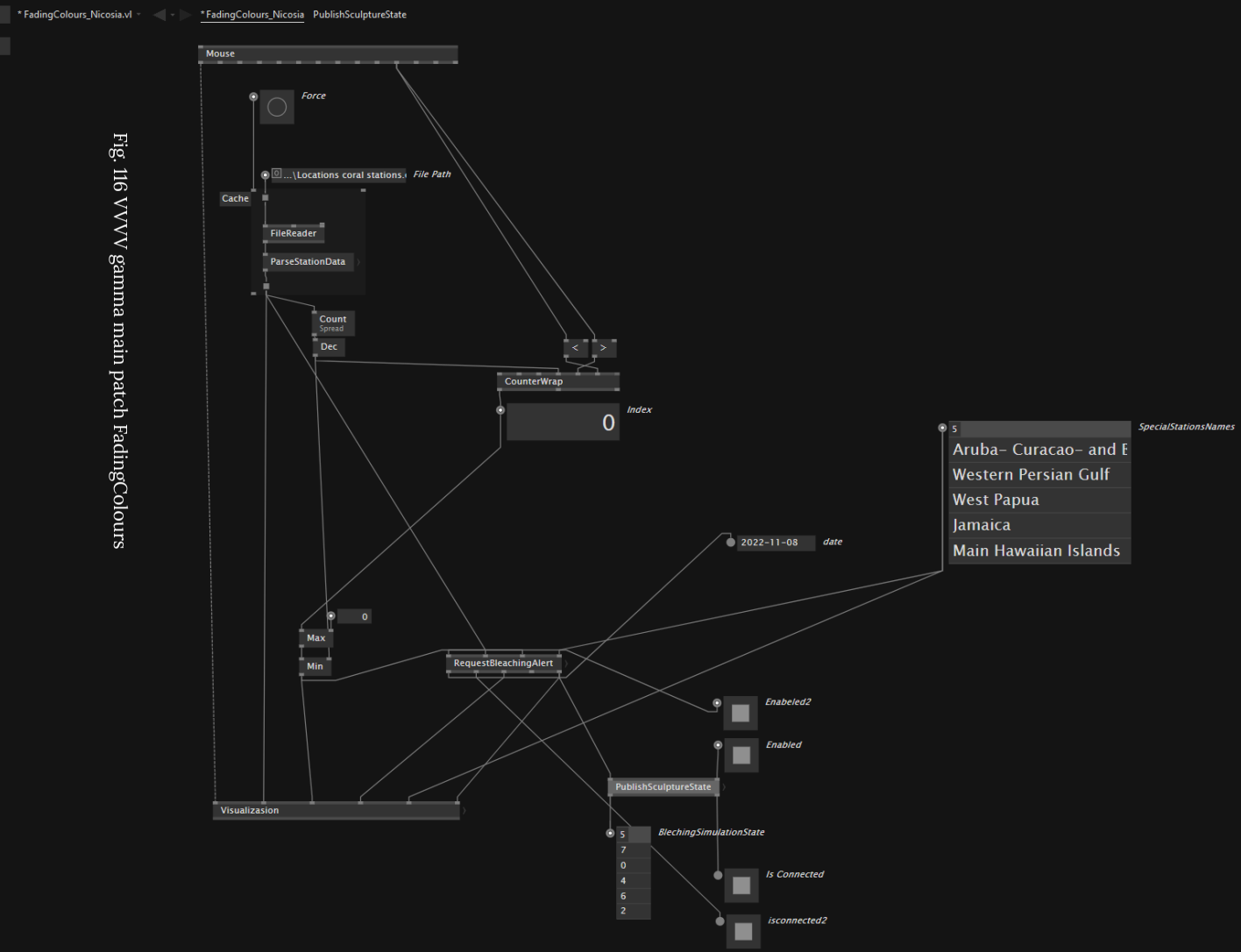


Fig. 116 VVVV gamma main patch FadingColours

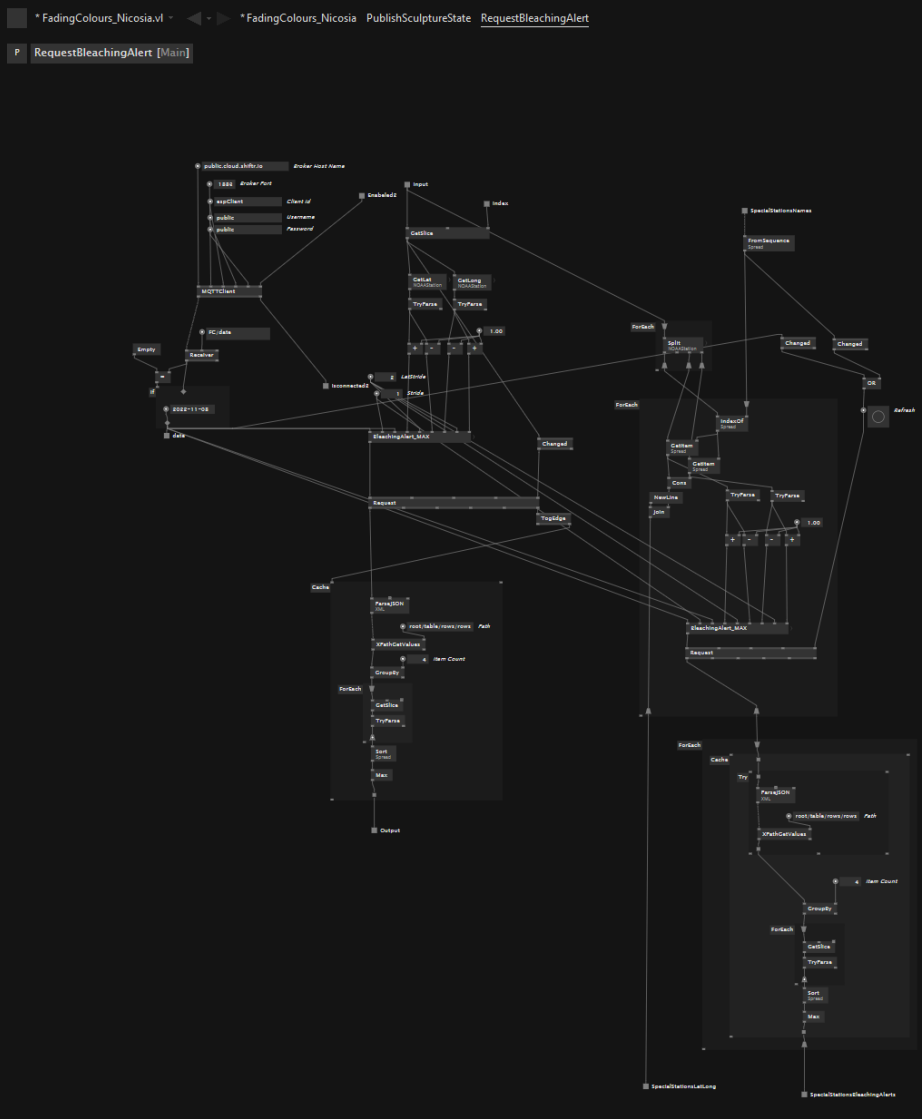


Fig. 117 VVVV gamma receiving data FadingColours

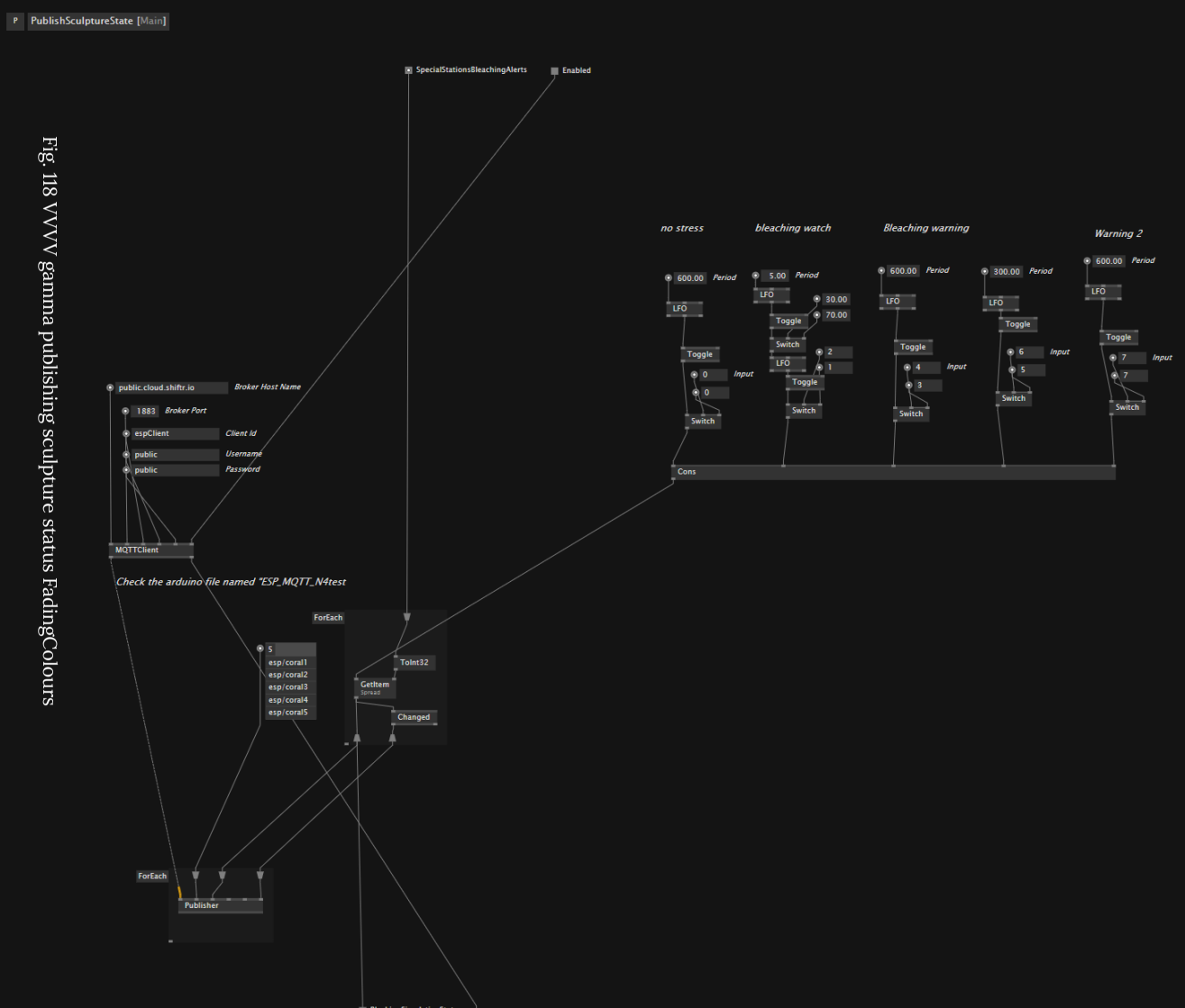


Fig. 118 VVVV gamma publishing sculpture status FadingColours

Fig. 119 Livingdata sculpture bleaching alert 1 and screen with visualisation

Fig. 120 Visitors explore data visualisation screen

I noticed while working on 'FadingColours' that when I was talking with people about this work, they always came up with ideas of how to make the installation more interactive for humans. I wanted this precisely not because it is about the interactivity between the data and the algae. It is not about being able to directly do an action yourself and then see the consequence in the algae. On the contrary, I wanted the visitor to experience a different rhythm once again. I got the comment that this data might be too slow to see the difference. That is right - you cannot see the difference in a day. Nor do you have to. I am not trying to provide you with quick access to information. I want you to make an effort to explore who they are. What they can show you.

At the same time, I did realise that this is a work that needs background knowledge about the relationship between coral and algae. Furthermore, it requires the opportunity for humans to explore what the sculptures are related to. That is why I eventually included the visualisation screen.

At the top of the screen, you see the locations of the five sculptures in the same order they are exhibited. Below that, you see the state of the reef, and via a line in the colour corresponding to the sculpture's colour, you see where this reef is located. Below the screen is a rotating disk that allows the visitor to view the other reefs. These reefs' names and states appear at the bottom of the screen. Thus, a visitor cannot change the state of the sculptures. Only the coral reefs can.

Fig. 121 FadingColours interaction

Fig. 122 FadingColours close-up

Fig. 123 FadingColours interaction with visitor Ars Electronica 2022

Fig. 124 FadingColours screen and sculpture Ars Electronica 2022

INSTALLATION

'FadingColours' host living algae. In order to keep them alive and healthy, this installation requires extra attention to the algae situation during the exhibition. The temperature in the room can, therefore, not be under 18 °C. In order to see algae behaviour, the best indoor presentation is preferred in a dark or twilight environment.

'FadingColours' exist out of five living data sculptures of 120cm high. Each sculpture consists of one metal frame, one metal bucket with inside one ESP32 microcontroller, one air pump, one light ring and one power bank. The bucket has a plastic lid with the light ring built in. On top of this lid is a 20cm high glass vase which is ⅓ filled with living algae. The ESP32 in the bucket is connected to the wifi (2.4ghz bandwidth). This is how each sculpture receives its information. The five sculptures are placed in a triangular shape within the centre behind them, a 43-inch monitor. Under this monitor is a black rotary device mounted. This monitor is connected to a computer that runs VVVV Gamma version 2021.4.10 and is connected to the wifi.

The websites public.cloud.shiftr.io and port 1883 should be excluded from the firewall for 'FadingColours' to connect and send the data of NOAA's Coral Reef Watch.

Dimensions

5x black metal pedestal 23x23x100cm

5x glass vases 1000ml

5x metal bucket

5x plastic lid with light ring

5x esp32

5x airpump

1x 43 inch monitor

1x windows computer

1x black rotary device 15⌀

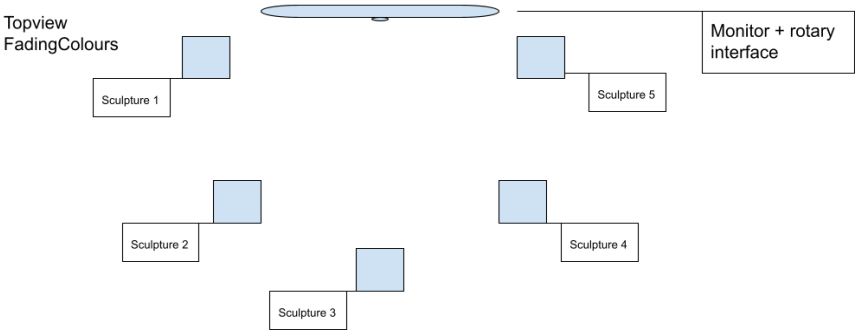


Fig. 125 Topview Setup FadingColours

Fig. 126 Overview Setup FadingColours

CARE

The care for 'FadingColours' is very different from 'RHIZA's'. In comparison, pink oyster mushrooms need constant care and particular conditions. For the spirulina algae, it is essential that the water they reside in has the right amount of nutrition and PH values.

This makes exhibiting algae a lot easier than mushrooms. When the algae are planned to be shown in 'FadingColours'. I extract a small amount of spirulina from the algae farm. These algae are given fresh water and new nutrition, which causes them to multiply by not exhibiting them directly from the farm that already has a balanced ratio of water-food to algae. I transport them with a wider ratio of water-food to algae. This allows them to live longer in this environment without needing extra care. The sculptures work on power banks, therefore the bucket must be opened every evening to take them out and recharge. This also creates a moment when all the vases with algae get movement. If the algae associated with a coral reef that is in a critical situation have no movement during the day, This can cause some of the algae to die off in the long run. Hence, intermediate movement is vital for all sculptures to remain healthy.

To continue exhibiting this work, I have a spirulina farm in my house for the time being. I have to feed and change weekly to ensure the algae stay healthy. It is quite a commitment to have a constant care factor in your daily life for your artwork. At the same time, I still enjoy experimenting with them and seeing what else we can do together. 'FadingColours' is relatively easy to take care of for others. There is no need for specific knowledge or skills for the exhibiting partner to exhibit 'FadingColours'.

ZOE

‘ZOE’ is a temporary co-existence between the reishi mushrooms and a custom-made robotic system. ‘ZOE’ explores the possibilities of internal communication between its robotic system and reishi. Within this seeming paradox between nature and technology an ecosystem occurs that cares for and affects each other through sensing technologies. A tactile space of data visualisations is created around ‘ZOE’ in which visitors can explore ‘ZOE’s’ outcome. ‘ZOE’ is created during the one-month residency Welcome to Our Guesthouse 2022 at theatre Rotterdam as part of ACT.

Fig. 127 ZOE - Welcome to Our Guesthouse, Rotterdam

CONCEPT

‘ZOE’ is a temporary co-existence between the reishi mushrooms and a custom-made robotic system. Noor Stenfert Kroese and Amir Bastani explore with ‘ZOE’ the possibilities of internal communication between its robotic system and reishi. Within this seeming paradox between nature and technology, an ecosystem occurs that cares for and affects each other through sensing technologies.

Our future can not be one where technology is in opposition to or a destruction of the natural environment. Without claiming that we know what nature wants or needs. ‘ZOE’ creates a possibility of unknowns coming together. It continues onto the research of the interaction within fungal mycelia networks. Scientists discovered that fungi transmit information through their network using electrical impulses. To this day, they do not know what this communication entails. It is the curiosity of what happens when we do not assume the outcome or interpret it through thinking but give it space to be with and experience it.

‘ZOE’ is inspired by philosopher Rosi Braidotti (2017). Simplified, the suggestion is to replace the idea of life understood as ‘bios’-- human life with ‘Zoe’ – all forms of life, which questions us about repositioning our way of taking part in this world. Instead, from the perspective of us humans being on the outside looking to the rest as if we are not part of it, ‘Zoe’ places everything, including us, in relation with the others as being part of it. For ‘Zoe’ to happen, we must search for a new ‘we’.

What kind of new ‘we’ do we experience when it is not about us? ‘ZOE’ shifts the attention to the relationality of all that is involved. ‘ZOE’ creates around itself a space of sensory data visualisations. It opens up a way to relate to the unknown mushroom communication in ‘ZOE’. Visually, auditory and tactile translations of the data flowing out of ‘ZOE’s’ temporary co-existence are there for the visitor to explore.

‘ZOE’ is part of ACT: Art, Climate, Transition, a European cooperation project on ecology, climate change and social transition. In an era of climate breakdown, pandemics, mass extinction and growing inequalities, we join our forces in a project on hope: connecting broad perspectives with specific, localised possibilities, ones that invite or demand that we ACT.

PROCESS

'ZOE' started as a shower thought – could there be an internal communication between fungi and a robot?

Knowing that fungi communicate through electrical signals, it made sense to me that it should be possible to connect that to another network that also uses information and electric signals to operate. It was like RHIZA, ZIEN, and FadingColours came together in my head. The fungi with their signals, the amount of care and attention they need and the precision of the robotic arm, the possibility of repetition and constant attention. Furthermore, later in the process, the storytelling and tangible experience of data showed up as in FadingColours.

At the same time, I wanted to improve my knowledge and skills in mycelium and mushroom growing. I reached out to the Mushroom Research Center Austra (MrcA) to ask if they could help me learn low-tech ways of growing oyster mushrooms and get to know more types of mushrooms, their qualities and how to grow them. They agreed, and in June 2022, I went for a three-day crash course on mushroom growing in Innsbruck.

Before going there, I got the question from Theater Rotterdam if I wanted to participate in their residency Welcome to Our Guesthouse. A one-month residency where I would get the space and time to work on a research project. It was a good place to start my research into the possibility of creating this internal communication.

Fig. 128 MRCA autoclave

Fig. 129 MRCA growing room

Having this in mind, I searched for the type of mushroom that would suit this experiment. I wanted one that had a longer life span than the 5-7 days of the oyster mushroom. Then I got to know the reishi mushroom, a light-sensitive mushroom that grows slowly over time. It is quite sturdy and alien like beautiful. Another name for them is Ganoderma, a species of Basidiomycota mushrooms. They grow on dead trees all over the world. Ganoderma means Ganno - shinning Derma - skin. They are probably named like this because of their beautiful shiny brown-yellow skin.

Fig. 130 Mycelium on agar plate MRCA

Fig. 131 Reishi in ZOE

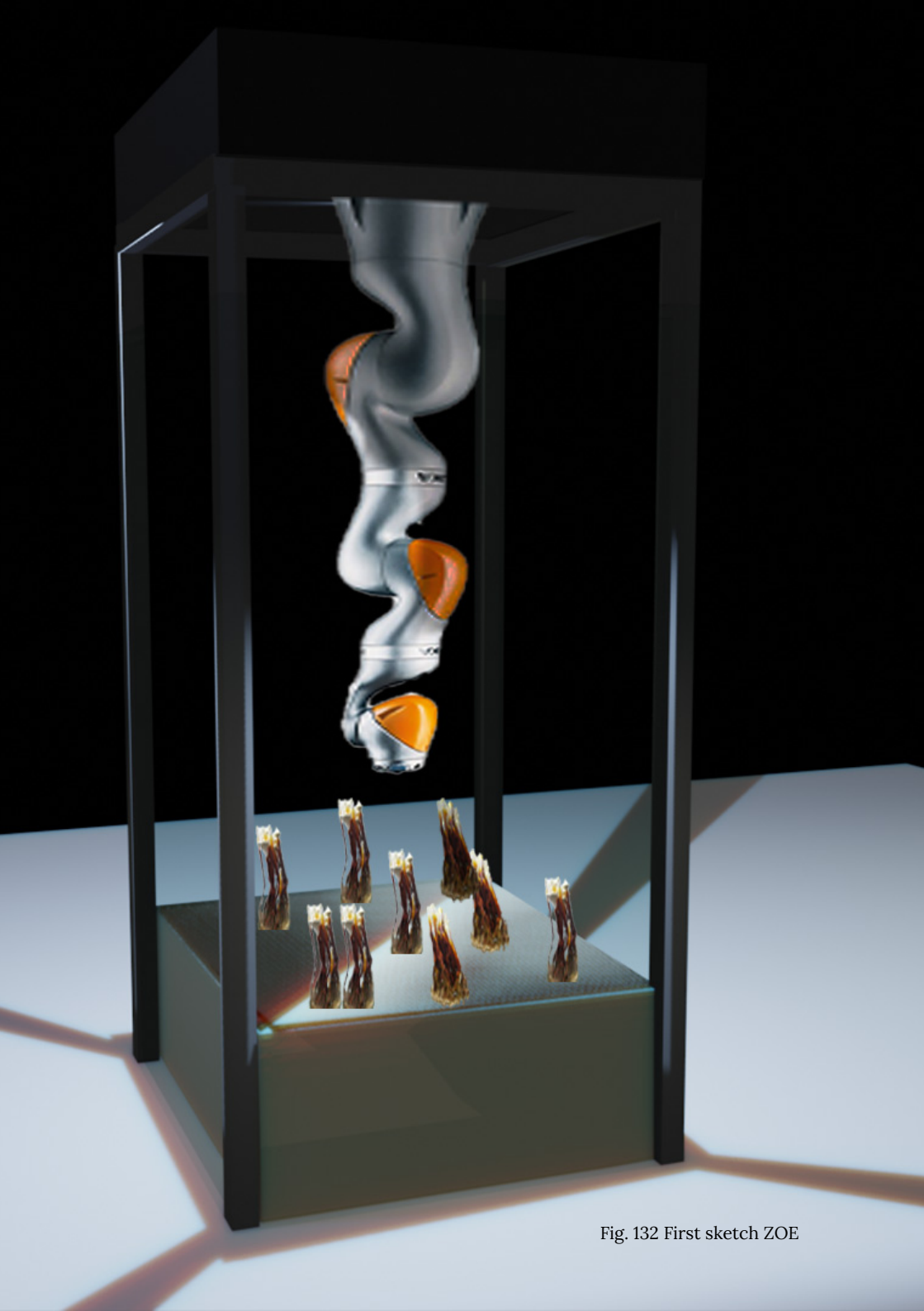


Fig. 132 First sketch ZOE

The title I used as the working title was A.S. – Artificial Symbiose. Symbiosis is a term used to describe any relationship or interaction between two dissimilar organisms. For me, symbiosis can be seen as the art of living together.

How to bring these together? What kind of robot had to take care of them? Should it move the mushrooms around? Should it move between the mushroom? To the mushrooms? Above? Is it a moving platform, a quadroped robot or a robotic arm?

Amir Bastani and I thought of many options for what type of robot the mushrooms would need to take care of them. I wanted the robotic system and mushrooms to envision the possibility of harmonious flowing together of technological media and organic material. So it had to make sense to the needs of the reishi. We knew the reishi needed a closed environment with a very high CO_2 and humidity level to grow as antlers. Therefore it made sense that the robot had to be in the same environment as the reishi if it wanted to be a genuine part of the ecosystem. It also raised the question of what the robot had to be able to do. What kind of actions and what could it provide? Soon it became clear that this was more than just a robotic arm we needed. We had to build a custom-made robotic system for this idea.

A robotic system needs input to know what to do and when. So we had to make sure we would gather enough data from the environment of 'ZOE' to create a relation between what was going on in the mushrooms, in the environment of the mushrooms and what the robotic system would do. The aim was not just to create a system that would observe the mushrooms but also influence them based on the input of the mushrooms themselves.

I designed a system that would measure the activity of the signals of the reishi and the environmental factors for reishi growth: CO_2, temperature and humidity.

The sensors used to measure the activity of the reishi are an updated version of the ones used in RHIZA. To do this, I consulted Prof. Andrew Adamatzky, director of the Unconventional Computing Laboratory at the University of the West of England. He published in early 2022 a paper called “the Language of fungi derived from their electrical spiking activity” (Adamatzky, n.d.). We were in contact, and he explained how they measured these signals and updated mine accordingly.

The robotic system had to be a closed environment with two fans to let the air in and out to regulate the CO_2. Ceramic infrared heat lamps would go on and off to keep the temperature inside ‘ZOE’ around 25 °C. A humidifier to make sure the humidity stays high enough. The sensor I used to measure the environment is the SEK-SCD41-sensor by SENSIRION. The robotic arm IIWA is hung from the centre of the big cube, mounted on IIWA a camera, light, and the humidifier’s end. This was the base of the robotic system with which we would start our residency at Theatre Rotterdam.

Fig. 133 Updating the bio sensors

Fig. 134 Sketch ZOE space

Fig. 135 Sketch ZOE big cube

Fig. 136 Growing test reishi vase in bio lab Ars Electronica Center

After trying out the possibilities of working with reishi by growing one vase of reishi in the bio lab of Ars Electronica, I grew with the help of MrcA 20 glass cubes with two types of reishi. The Hungarian and Chinese reishi. The Chinese reishi is more light-sensitive, and the Hungarian is slightly less sensitive.

I arrived in Rotterdam with IIWA and the 20 reishi cubes. They had already built the big cube. Our first task was integrating IIWA, the sensors and all the other parts of the robotic system. This system was something no one could know if it would work. I made it up based on my experience with mushrooms and robotics. I was asking for the expertise of the MrcA and the Creative Robotics lab in Linz, but of course, they could only partially oversee the complications of this system.

Reishi's are just like all fungi, very sensitive to their environment. The most significant danger for them is contamination or getting dry or cold. On the other hand, was it the question if the robotic system would be able to actually take care of the environment as envisioned. Furthermore, how to make sure all the parts of the robotic system would be able to function within this very humid environment. We had just one take on this. It would either work or fail.

The first week of the residency was building up this environment and focussing entirely on the technology. We knew that when we closed the big cube, we would hardly be able to get in there again. After finalising the technical part, we had to build a tent around the big cube to ensure its environment was as clean as possible.

Take off the little cubes' covers and place them in the big one. Closing it, and then it was a matter of waiting. Would the reishi accept their environment? Hoping we had moved without harming them in their big cube. Hoping the technology holds up. Even though we had given IIWA a custom-made raincoat and taken the necessary precautions with the other parts to make them resilient to the conditions, it was still unnerving in this humid environment.

Fig. 137 Building ZOE

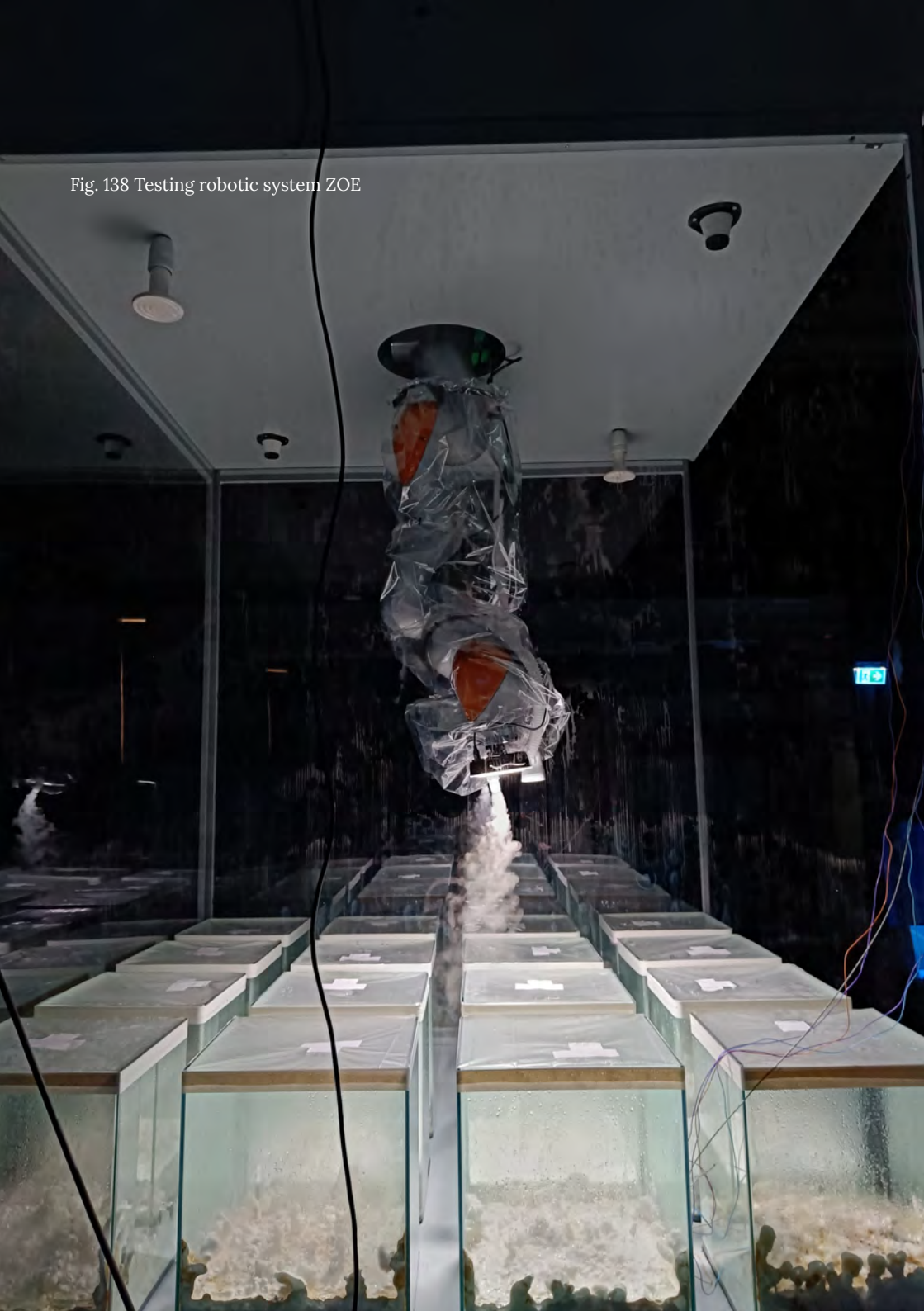


Fig. 138 Testing robotic system ZOE

Fig. 139 Testing IIWA in ZOE

Fig. 140 Improvised cleanroom for removing the covers of the reishi

Fig. 141 Programming ZOE

Fig. 142 Monitoring reishi growth ZOE

Luckily, it worked out. The reishi started growing without any mould. The robotic system kept working, and the data started coming in. It was the first time that we saw all the data coming in. Besides some tweaking on the minimals and maximals of the environmental situation, the big question was how to explore this possibility of internal communication between the reishi and the robotic system.

Fig. 143 Sprouting reishi

Fig. 144
Observing reishi growth

We had some ideas on what would make sense to bring them together. However, seeing the actual situation made us wonder if it makes sense to connect this data of reishi signals to specific actions. Our initial idea was to connect the reishi's signals to the robotic arm's movement. This idea made sense when we still thought that the big cube would consist of one big field of mycelium. Due to practicalities and concerns from MrcA about how to grow mycelium in such a large environment, we decided on the little cubes. When we saw all these signals coming in, we faced the reality of having no clue what would happen based on these signals from these two cubes. Therefore it made no sense anymore to connect the data of two separated mycelium fields as the input for the whole environment.

The goal was still to make the activity of the reishi the input of the system. We had to find another input from the mushrooms. Therefore we made IIWA take pictures every half hour from each cube with reishi. In the period that followed, we compared the images to see if there was any way we could measure from the pictures how the mushrooms were doing. We found a way to compare them over time to see the difference in the amount and size of the reishis. We told the system that if this difference is significant, there has been a lot of growing activity. Assuming that if they thrive, they grow. Based on this information, the robotic system would decide which cube had the least activity and focus its attention on it by giving it the most optimal amount of light. Also, this cube is the first to receive extra humidity when the humidity is low.

Fig. 145 Reishi with sensor

Fig. 146 Creating pointcloud of the reishi in order to try to measure their growth

Fig. 147 Research into comparison between all the reishi cubes up 26-10-2022 down 27-10-2022

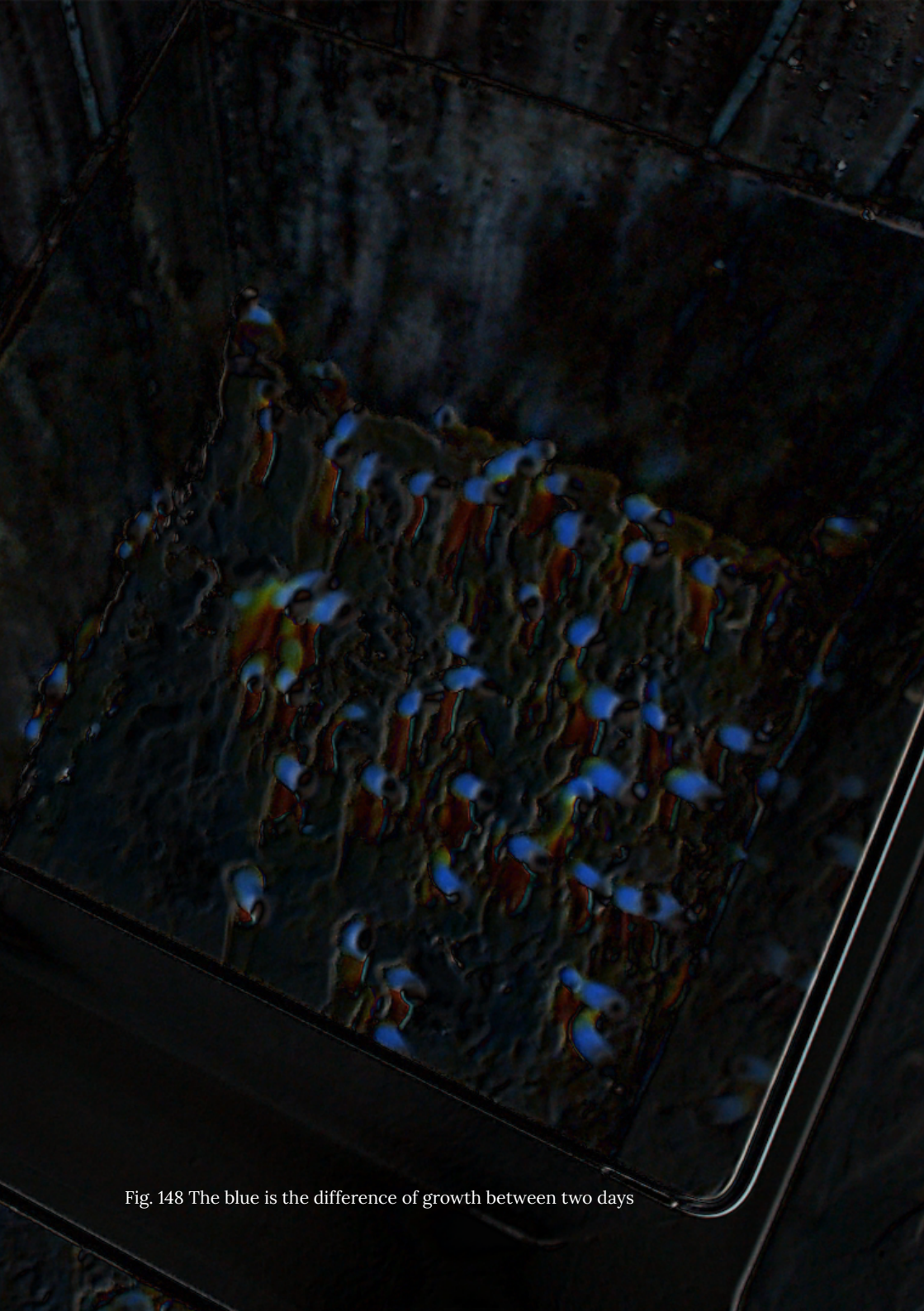


Fig. 148 The blue is the difference of growth between two days

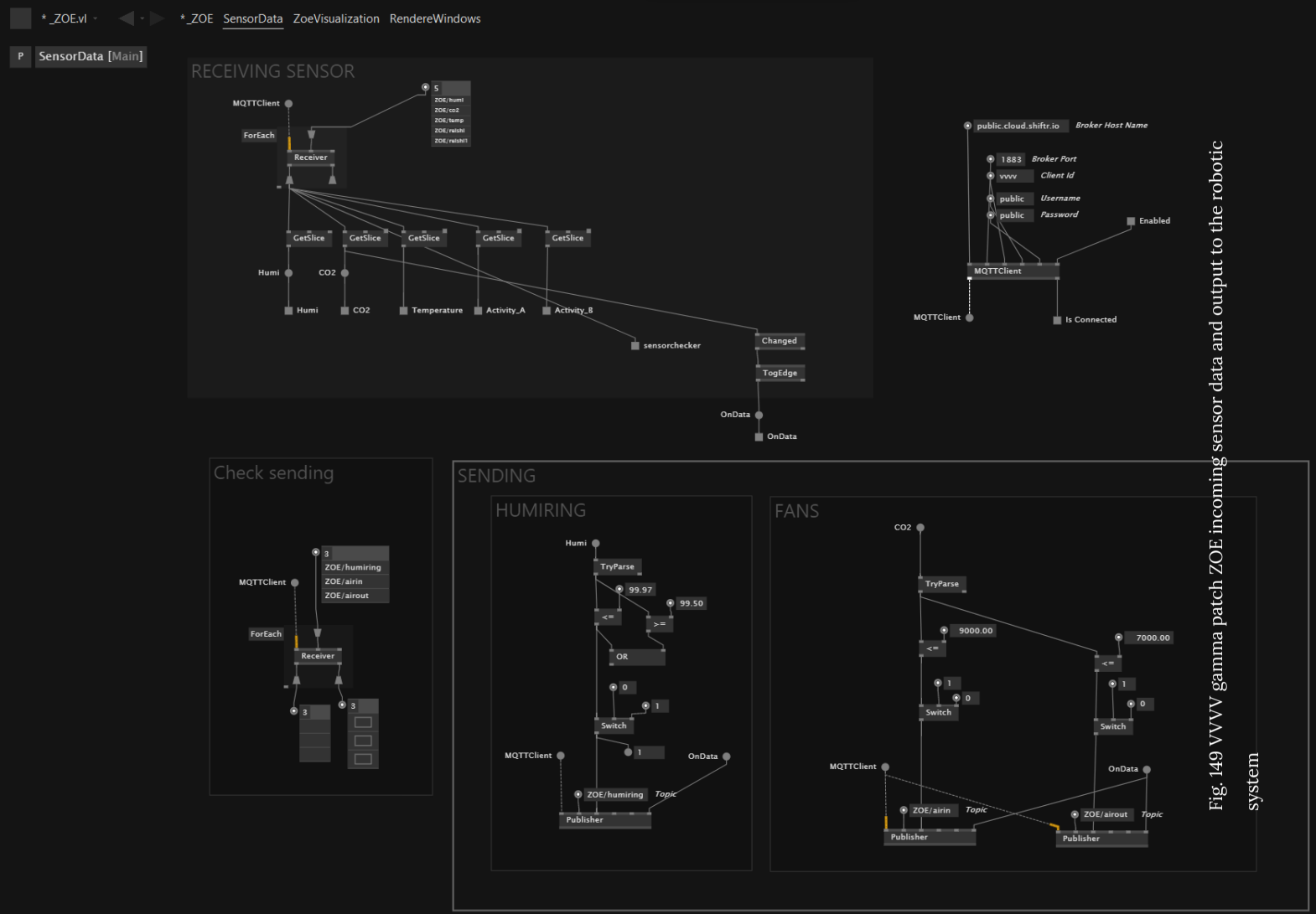
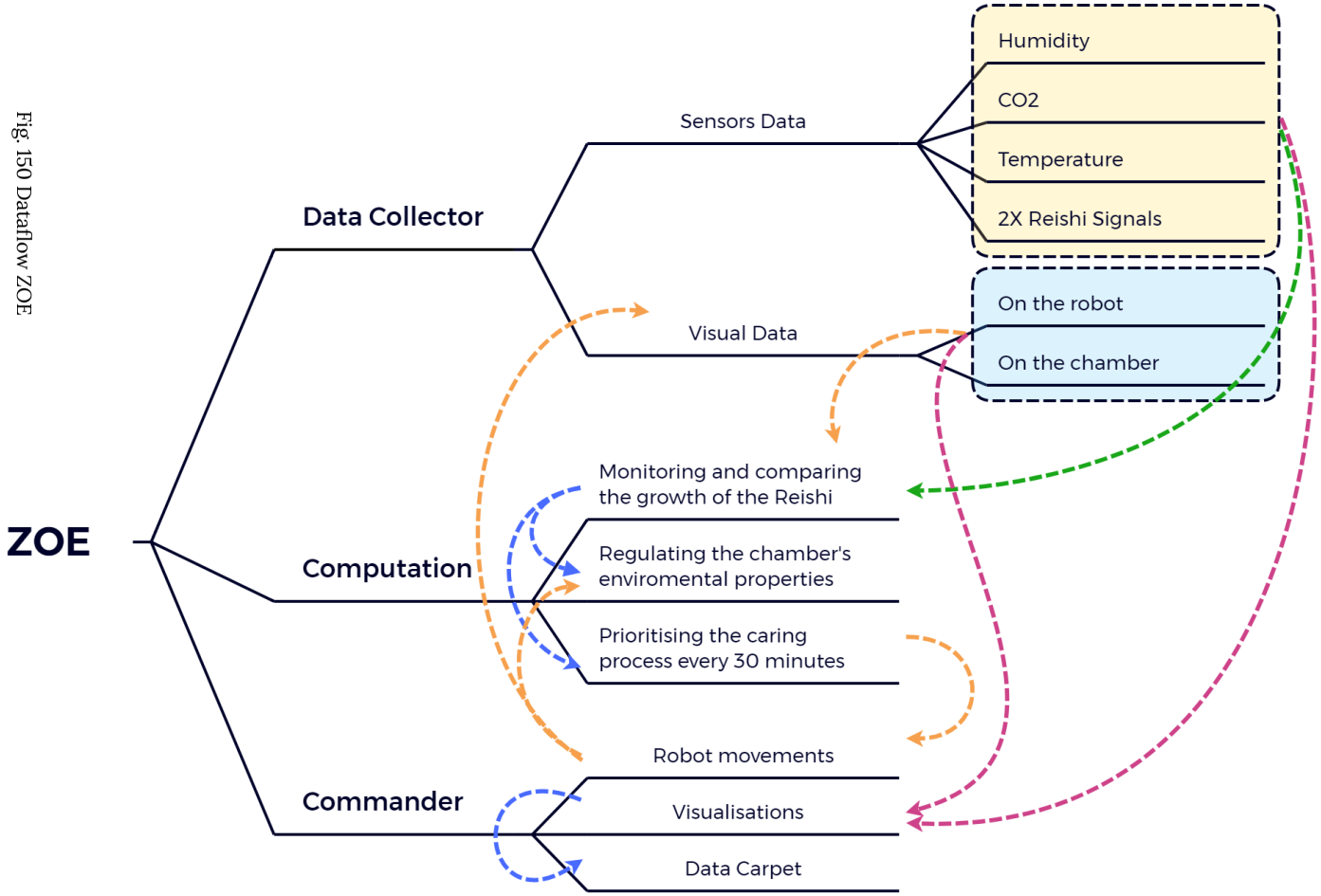


Fig. 149 VVVV gamma patch ZOE incoming sensor data and output to the robotic system

Fig. 150 Dataflow ZOE



As IIWA puts its light source above the reishi, which is seen as the one that needs extra care, it also triggers the other reishi in their behaviour. Reishi is light-sensitive, and they are growing towards the light. This means that the reishi grows towards the other reishi that needs extra care. Over time this created a reflection in the shape of the fruiting bodies of the reishi of how the other reishi were doing in relation to this reishi.

Besides that, we noticed that for all the reishi, it is essential that the humidity is spread well over all the cubes. Therefore we linked the action of adding humidity to 'ZOE' to a hovering state of the robotic arm above all the reishi. Humidity spreads this way throughout the whole space when the humidifier is turned on.

Since we could observe the data coming out of the reishi's environment and access the signals exchanged within their mycelium, I wanted to know if there would be any visible relation. I did not just want to visualise it and then look at and compare it to come to a conclusion. I tried to relate to it. I wanted to put effort and time into experiencing what would come from this. I needed it to grow and to slow me down. So I decided to make carpets out of it. Tufting carpets felt to me like a growing force which resembles that of fungi. Doing this asked me to be present in the 'ZOE' space and participate in the system. It felt repetitive, and I had to be precise, like the robot's work. It made me physically and mentally entirely focus on this data. This data is full of unknowns. I had no idea what would come out. Maybe every day was the same, maybe not.

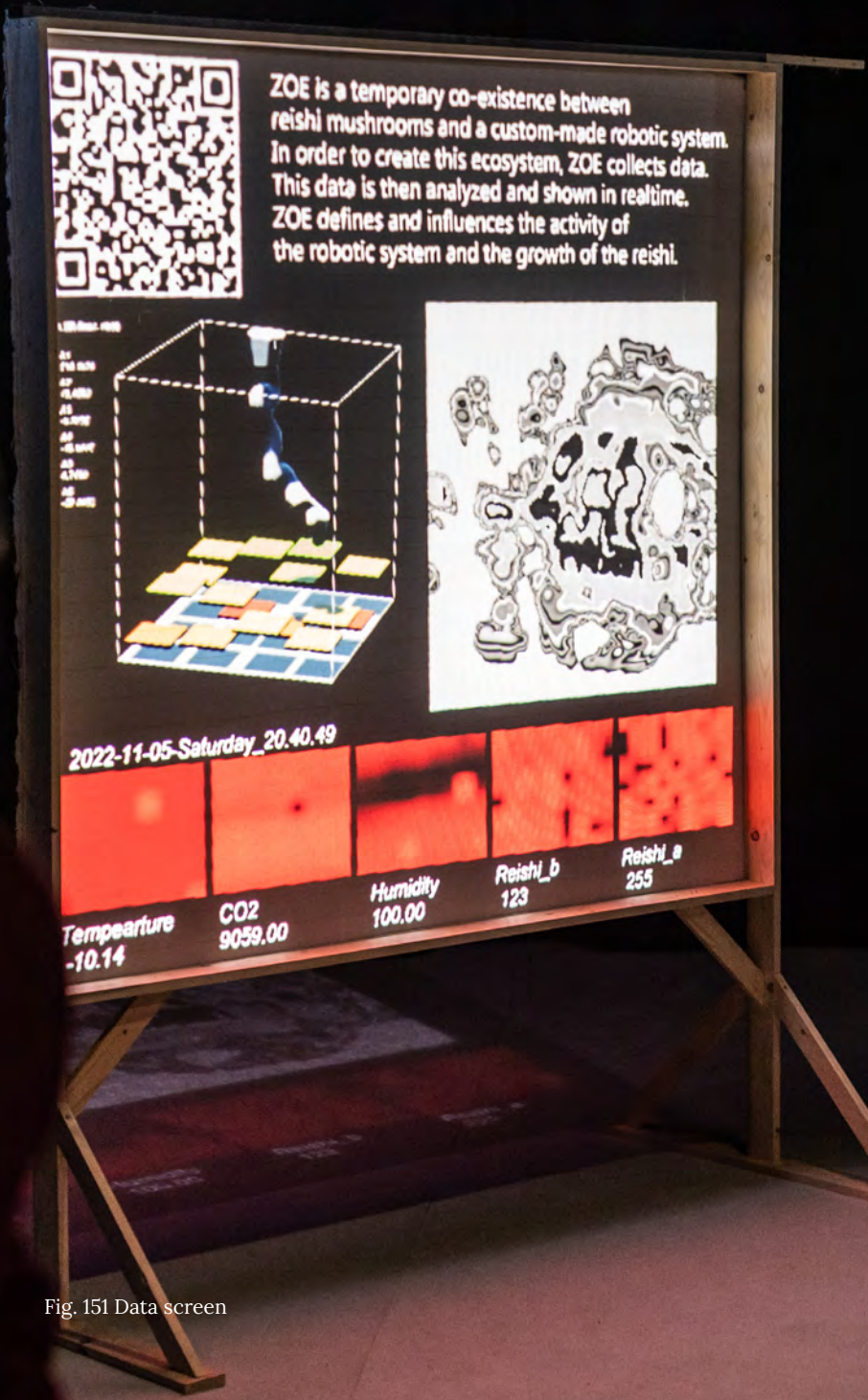


Fig. 151 Data screen

In the space around the big cube was on every corner a tufting frame. On these frames, I wanted to work on the carpets. Knowing they also needed time to dry, I had multiple frames to keep the process of making carpets going. I noticed that I needed two frames a day—one for making a carpet and one for the carpet that is drying. On the other two, I wanted to make the invisible parts of 'ZOE' visible. One screen became the live view of the camera inside 'ZOE'. The other screen became our data screen. (Fig. 151)

The data screen showed the following visualisations:

In the left corner is a QR code. This leads to the live stream on youtube, where people could watch 24/7 inside 'ZOE' and see the same data visualisations as on this screen.

On the left, under the QR, is the visualisation of IIWA and tiles representing the smaller cubes with reishi. The visualisation of IIWA is in real-time and shows its position. The tiles visualise the data from the comparison of the pictures that are taken every half hour. If a cube has a high growth rate, it turns green and floats higher. If there is a low amount of growth, it turns red and stays lower. This visualisation represents the decision-making to which cube IIWA gives extra attention.

Next to this visualisation is the data we are getting from the reishi in relation to their environment. Each ring is connected to one part of the data: Reishi activity a and b, humidity, temperature and CO_2. The rings get distorted in ratio to the activity of the data, how often this date comes in and how much it differs from the minimum and maximum calculated daily.

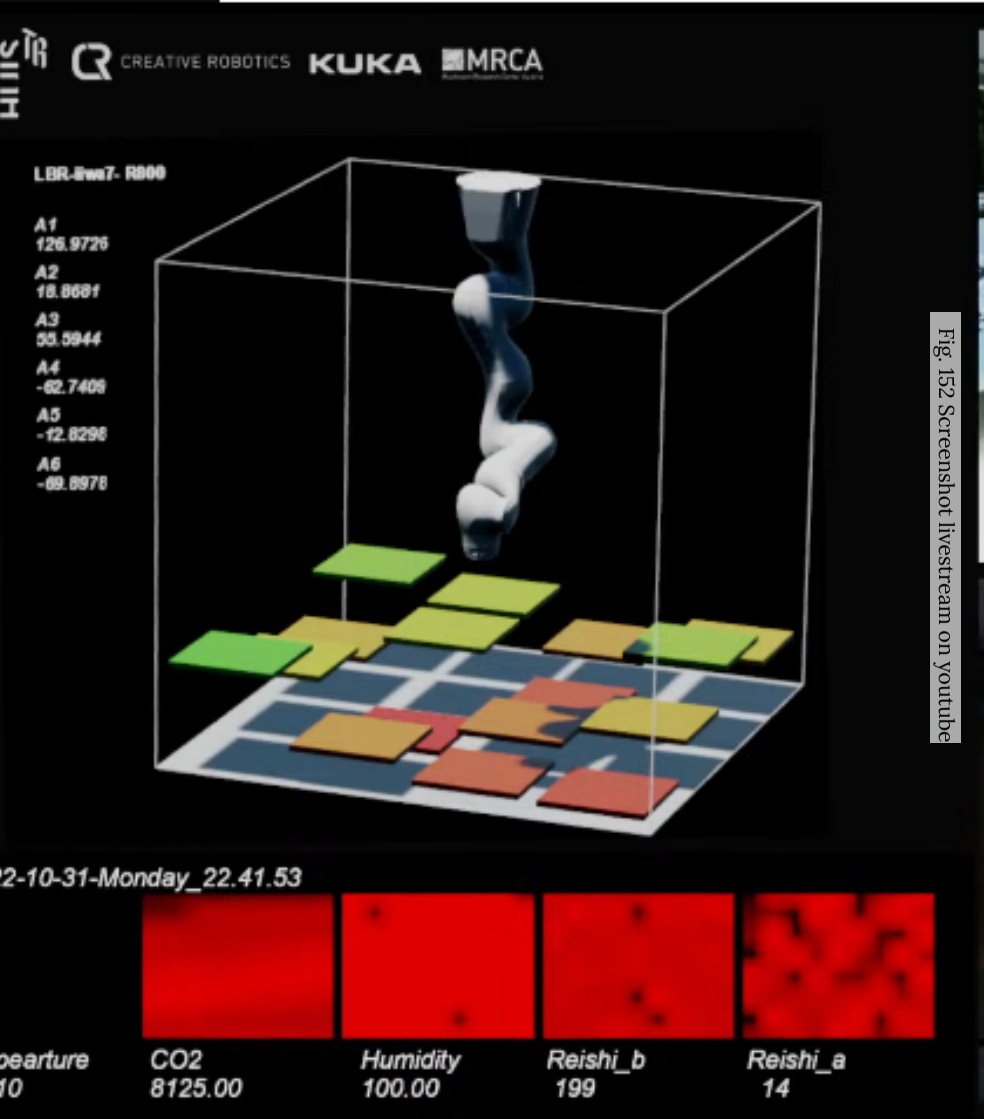


Fig. 152 Screenshot livestream on youtube

Each data coming in is also visualised at the bottom of the screen. These read tiles are the data converted to pixels. Each tile is a single channel texture with ten by ten pixels that change their position and colour depending on the incoming amount of data. Each pixel relates to the amount it is changed. For example, the lower the temperature, the darker the pixel gets. The higher the temperature, the brighter red it becomes. Each tile represents in real-time the data coming out of 'ZOE'.

Since I also wanted to create a more tactical outcome of the data we were getting from 'ZOE' in the form of data carpets. We collected all the data on a daily base as input for these data-carpet visualisations. These data-carpet visualisations work the same as the real-time visualisation of the reishi activity in relation to their environment. I projected these on the tufting frames and tufted carpets from them. The colours of fungi and moulds inspire the colours of the carpets.

In the last period of the residency, we started making these data carpets. Which also were placed on the floor for visitors to experience as tactile data visualisation. Since there was the sound of the carpets' tufting, I also wanted the sound of the rest of 'ZOE' in the space. Hearing the data could help to make an intangible relation in the space between the four screens and the big cube in the middle.

Fig. 153 Amir tufting

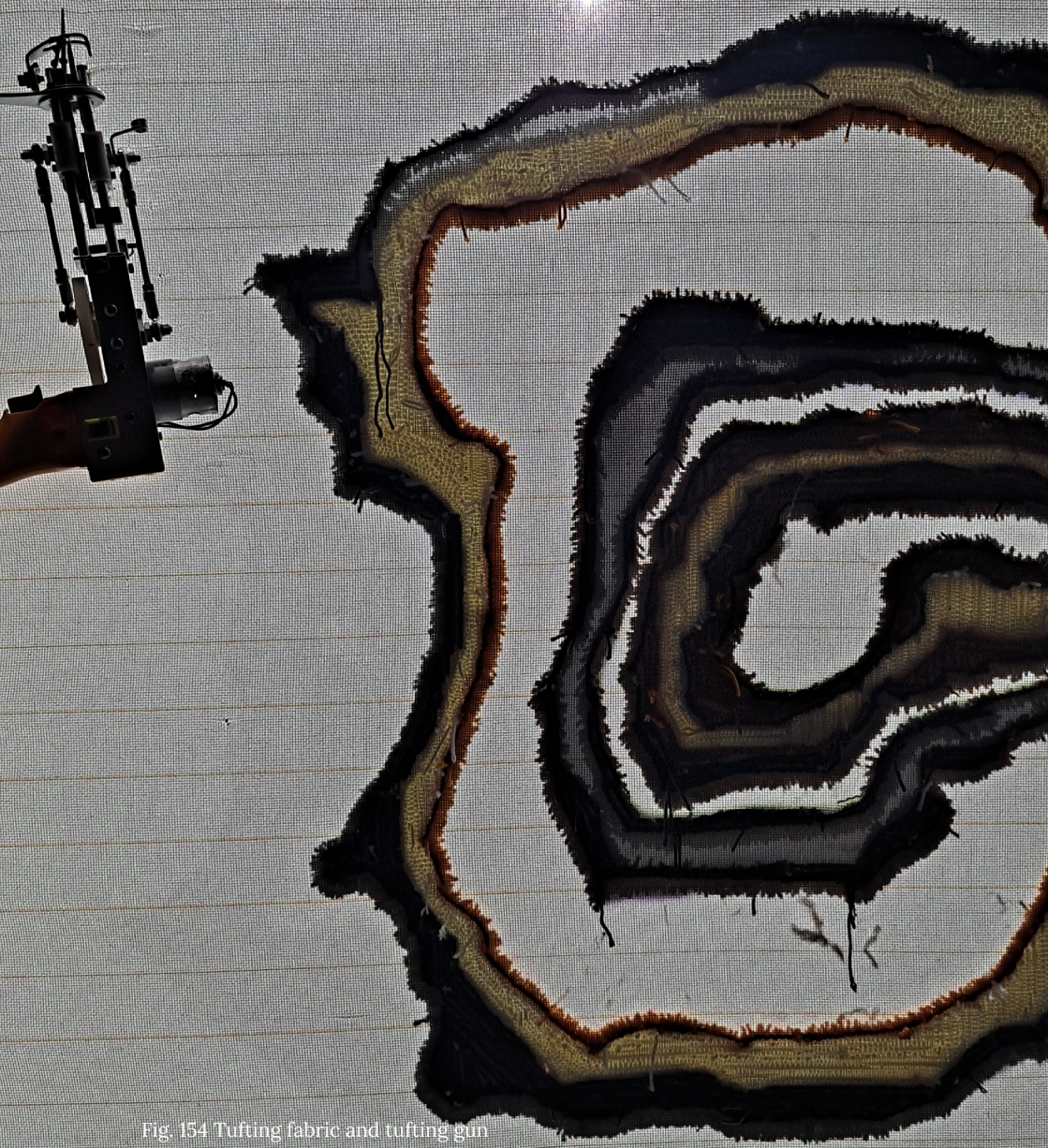


Fig. 154 Tufting fabric and tufting gun

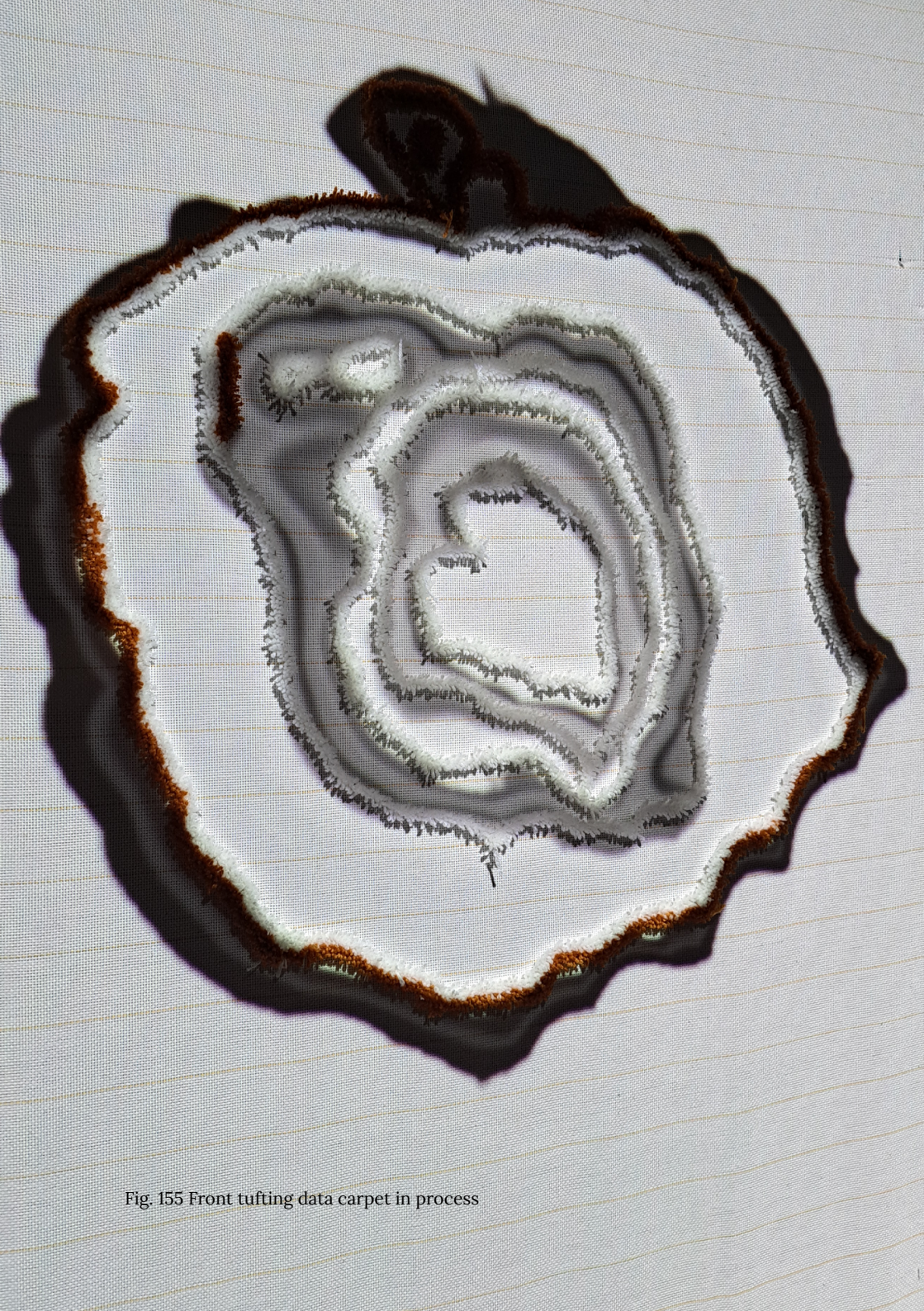


Fig. 155 Front tufting data carpet in process

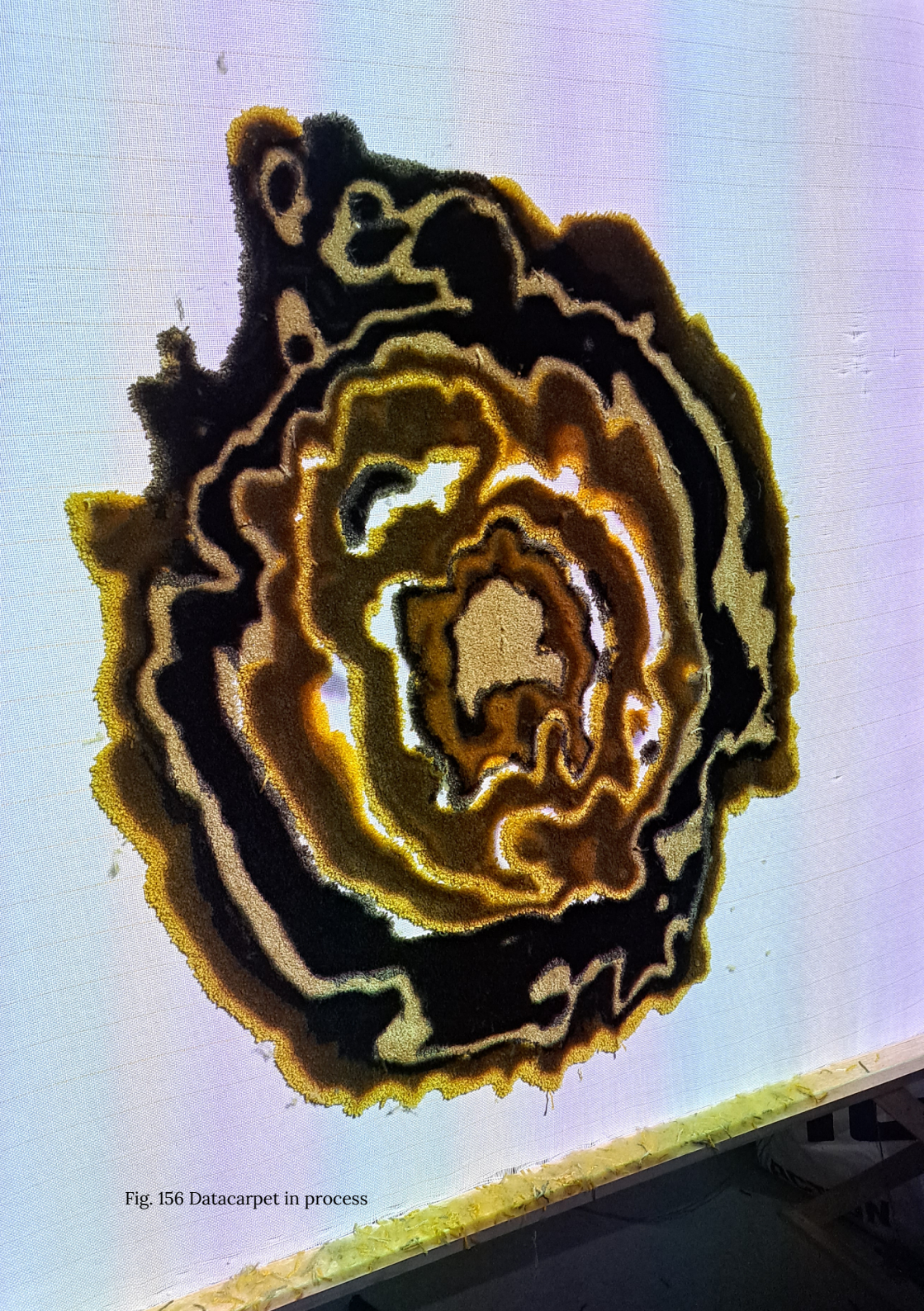


Fig. 156 Datacarpet in process

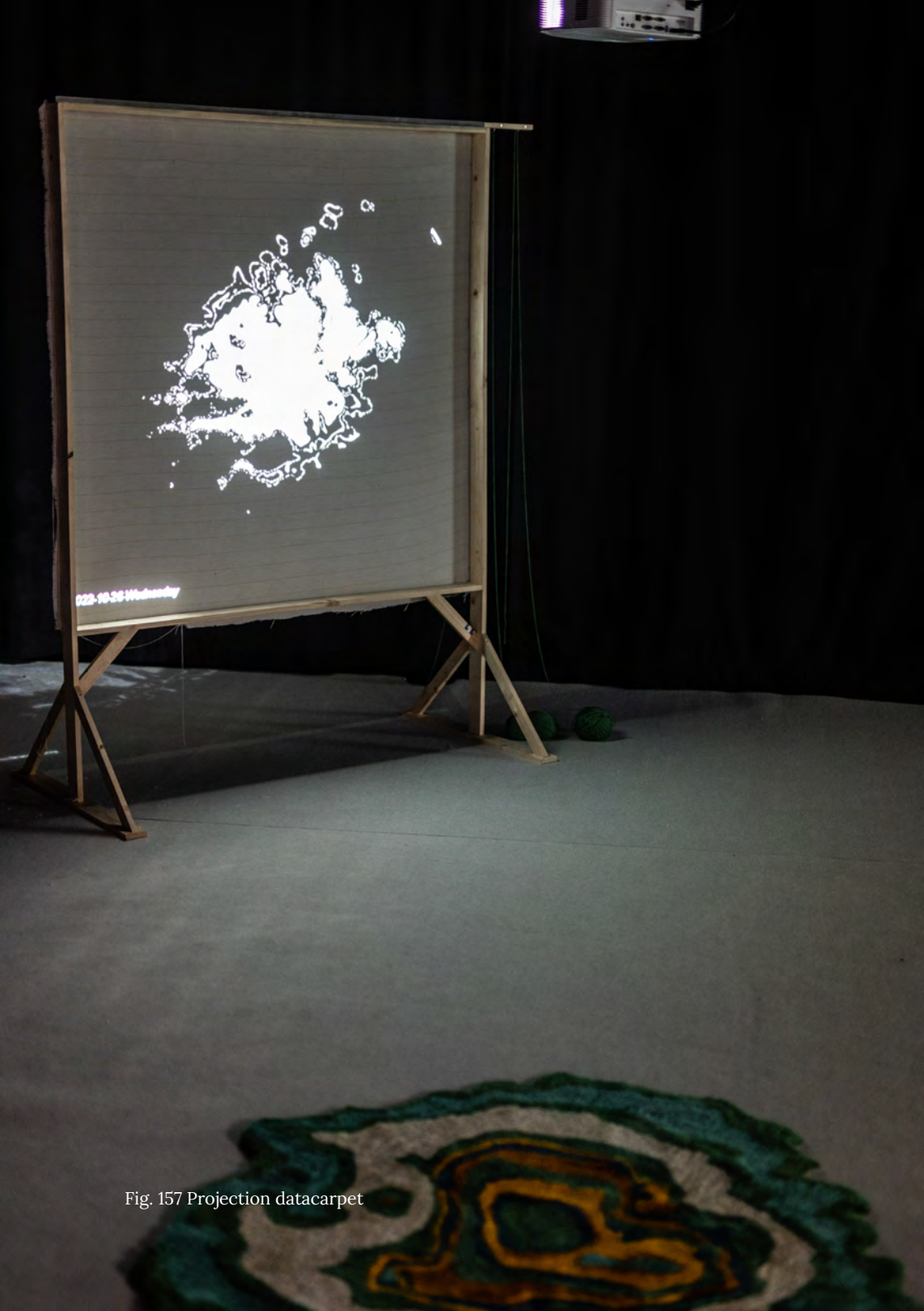


Fig. 157 Projection datacarpet

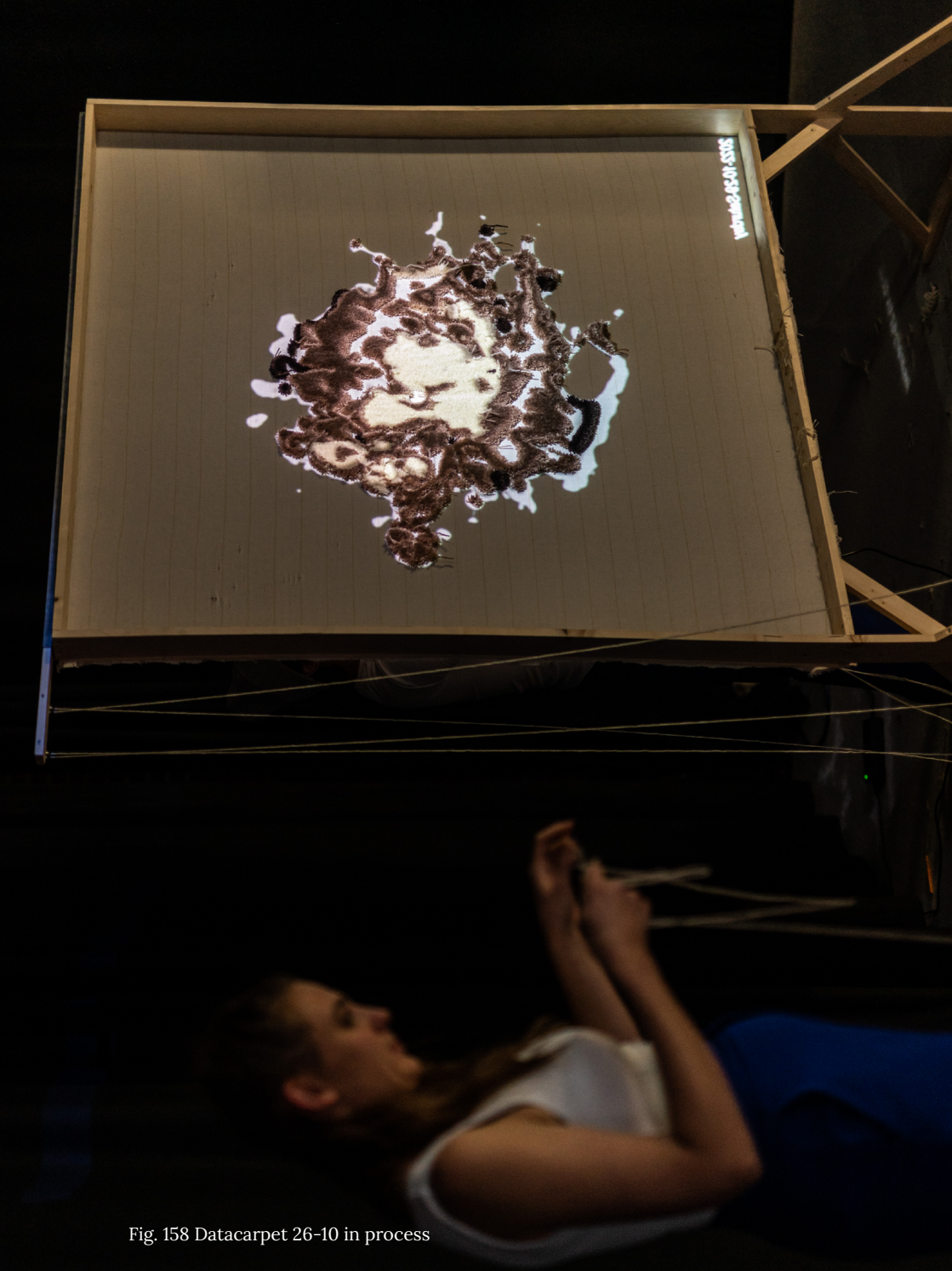


Fig. 158 Datacarpet 26-10 in process

There were many ways to tune in on the different actors of the little ecosystem we were building. I noted that people who came into 'ZOE' slowed down when they knew what it was. On the other hand, people who visited for the first time had a certain amount of restlessness. As one of the visitors said, "Even though this is not about me, I feel it matters that I am here. I want to contribute something as I feel so many things are going on."

A certain amount of not knowing what to do is acceptable. A visitor needs time to relate to the work and accept that, in this case, they are just here to experience it, and you do not have to contribute in an active form. It is about your attention to the other. They are getting to know something or someone else who is very different from you—but being able to do this as a human requires feeling a certain amount of safety and understanding where you are.

Since people are so different from each other, they also need different ways to find a point of entry into an artwork. It is common for an artwork to have a description close by where the visitor can read about the work. As I noted with FadingColours, when a piece has complexity in how it works and what it is based on, people tend to lose their attention very fast when it is written. We decided to keep our desk in the space of 'ZOE' as we (Amir and Noor) are also part of this system. It was clear to me that we were the last thing someone should be able to tune into in this space. Therefore, we made a recording where we explained 'ZOE'. It created the last needed entry point into this work. I noted during the time 'ZOE' was exhibited that it worked for many people to choose in which order they wanted which information and even if they wanted the information.

Fig. 159 Recoding voice-over ZOE

For those who came in with a need to cling to something, it helped the headphones guide them through the work. What I liked about this is that you do not have to separate yourself into first getting the information and then watching the work. Combining it and taking the time for the recording helped people to overcome this restlessness of the urge to receive fast information. It also helped that this installation was in a theatre context, which prepared people to take their time to receive the whole story.

'ZOE' was exhibited from 2 to 5 November 2022 in Theatre Rotterdam as part of Welcome to Our Guesthouse. During the residency period and the festival, we created seven data carpets. I am still working on the data carpets from the remaining days of 'ZOE'.

Fig. 160 Close-up ZOE

Fig. 161 Visitor with ZOE day 1

Fig. 162 Visitors with ZOE day 5

Fig. 163 ZOE humidifying

Fig. 164 Reishi in ZOE

Fig. 165 Datacarpets

Fig. 166 Data carpet in process during ZOE

Fig. 167 ZOE small cubes in the big cube

Fig. 168 Reishi

Fig. 169 Audience in ZOE

Fig. 170 Audience in ZOE with data screen

Fig. 171 Comic about ZOE by Flo de Goede

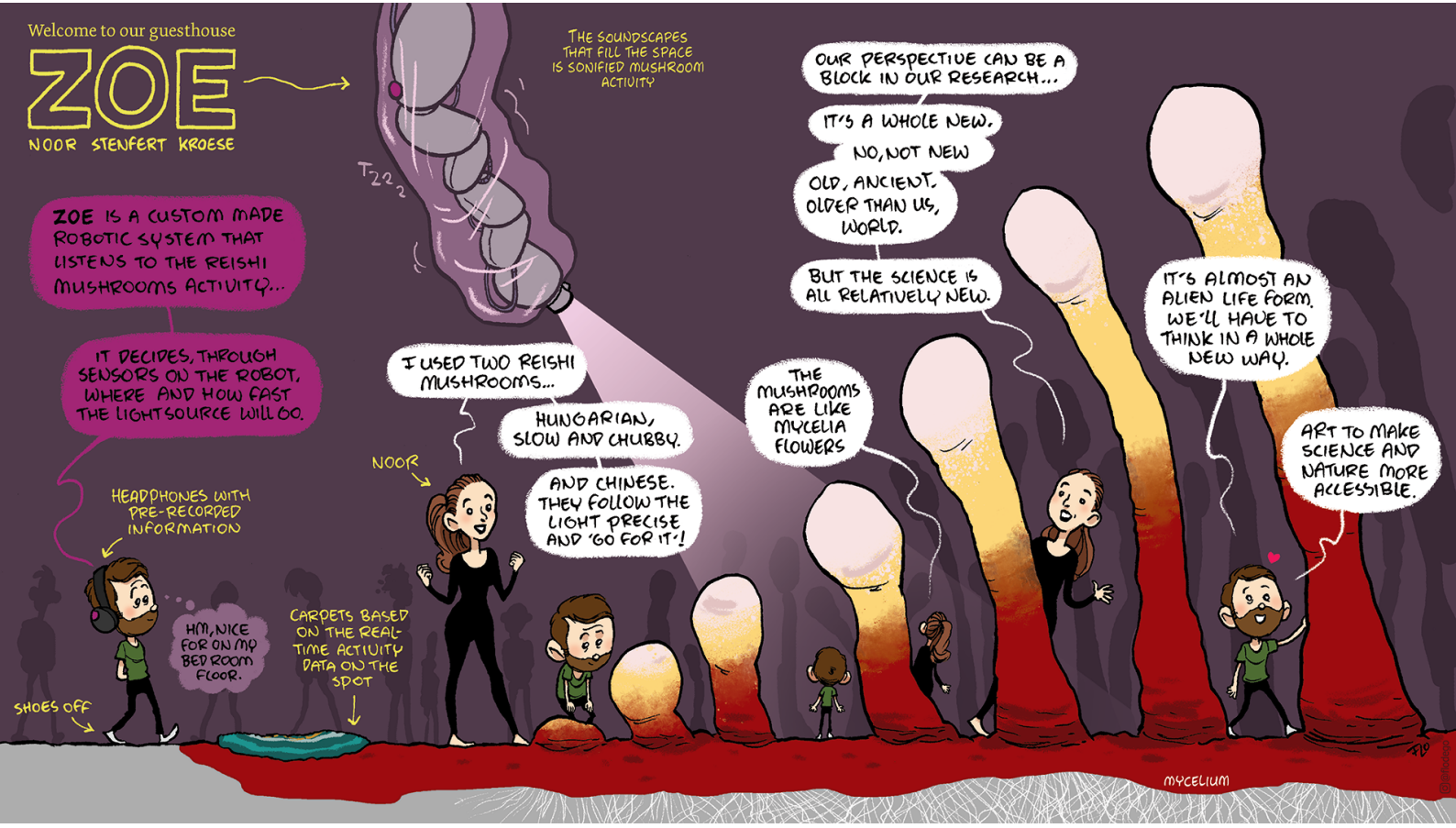


Fig. 172 Comic by Flo de Goede talk between Dr. Adamatzky and Noor in ZOE

Fig. 173 Overview space ZOE

Fig. 174 Datacarpet 24-10-2022

Fig. 175 Datacarpet 23-10-2022

Fig. 176 Datacarpet 22-10-2022

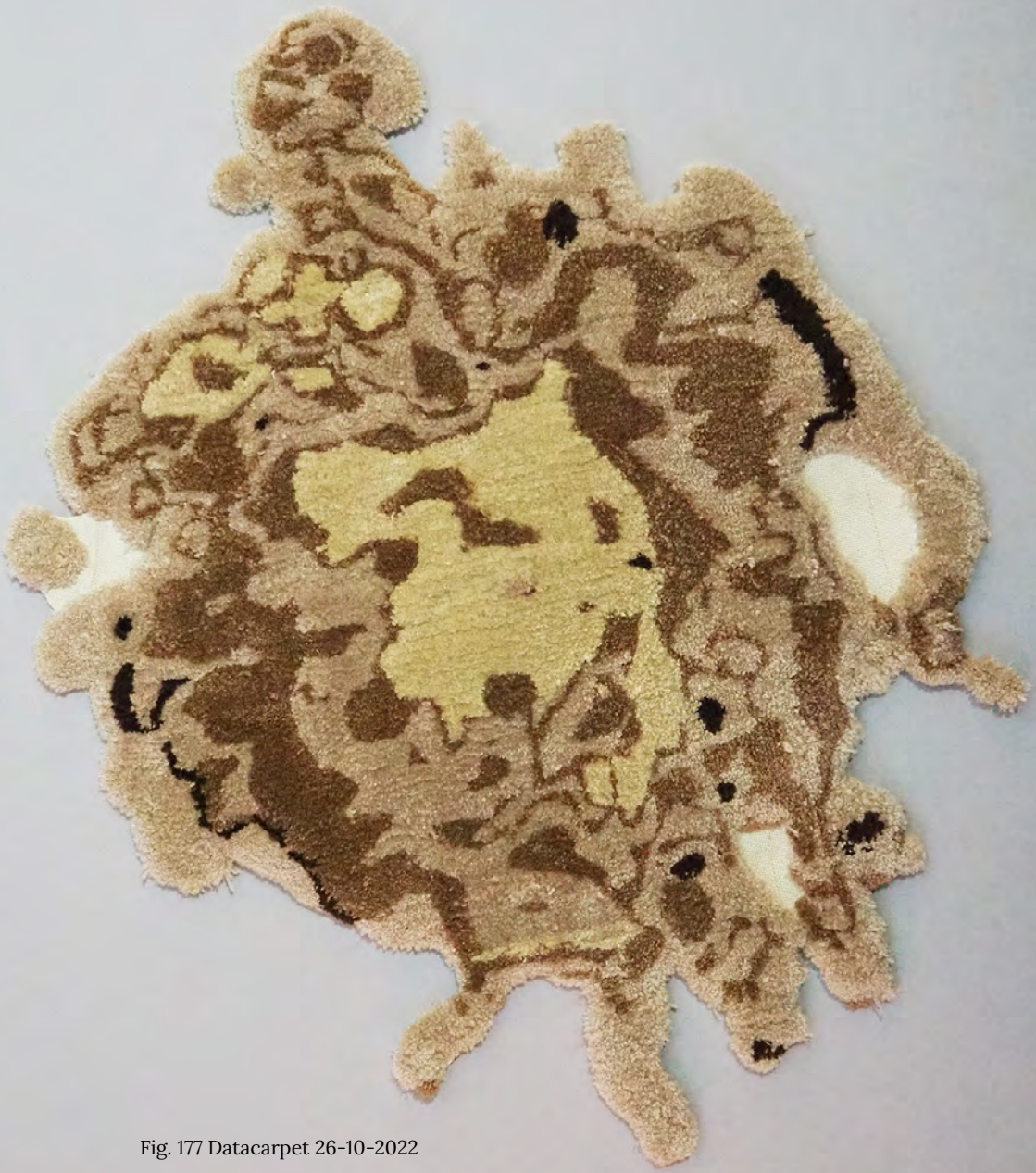


Fig. 177 Datacarpet 26-10-2022

Fig. 178 Datacarpet 29-10-2022

Fig. 178 Datacarpet 02-11-2022

Fig. 179 Datacarpet 03-11-2022

INSTALLATION

'ZOE' exist out of one big cube in the centre of the space of 150x150x320cm. This cube is the living environment for the reishi mushroom and the custom-made robotic system. This environment has a temperature of 24-28 °C, humidity above 85%, and the CO_2 has to be higher than 8500 ppm.

The reishi mushroom is in 16 separate glass cubes of 30x30x35cm. 'ZOE' collects data through sensors in the environment and the mycelium of the reishi. 'ZOE' also collects data through observation with a camera. 'ZOE' uses this data to create an internal communication between the reishi and the robotic system. The data are also used in the space to sensory experience the activity in 'ZOE'.

At a distance of 5 meters from each corner is a tufting frame. These frames are used as projection screens for the data visualisations, live stream from the camera on IIWA, and to tuft the carpets. While 'ZOE' is exhibited, data carpets are made from the data coming from 'ZOE'. Therefore the space around 'ZOE' is constantly changing, and carpets will be added to the environment.

Dimensions

Space
Total cube 150x150x320cm
20x glass cubes 30x30x35cm
20 liters reishi mycelium
4x tufting frames 150x150x200cm
144m2 Light grey carpet on the floor
4 beamers

12 theater led lights + light table
Soundsystem

Robotic system
1x IIWA (robotic arm KUKA)
1x A custom-made software which connects and controls the hardware
2x fans
1x humidifier
1x waterproof dive light
2x ceramic infrared heat lamp
1x SENSIRION SEK-SCD41-Sensor
2x Bio sensors fungi signals
1x Kinect
1x logi webcam full HD
2x HEPA filters

Data carpets (amount depending on time span ZOE)
Tufting fabric
Wool
Tufting gun
Latex
Carpet trimmer
Tufting tools

Reishi safety
1x air purifier with HEPA filter
1L Bacillol AF
Disposable latex gloves
Paper towels
Plastic cover foil 20m2

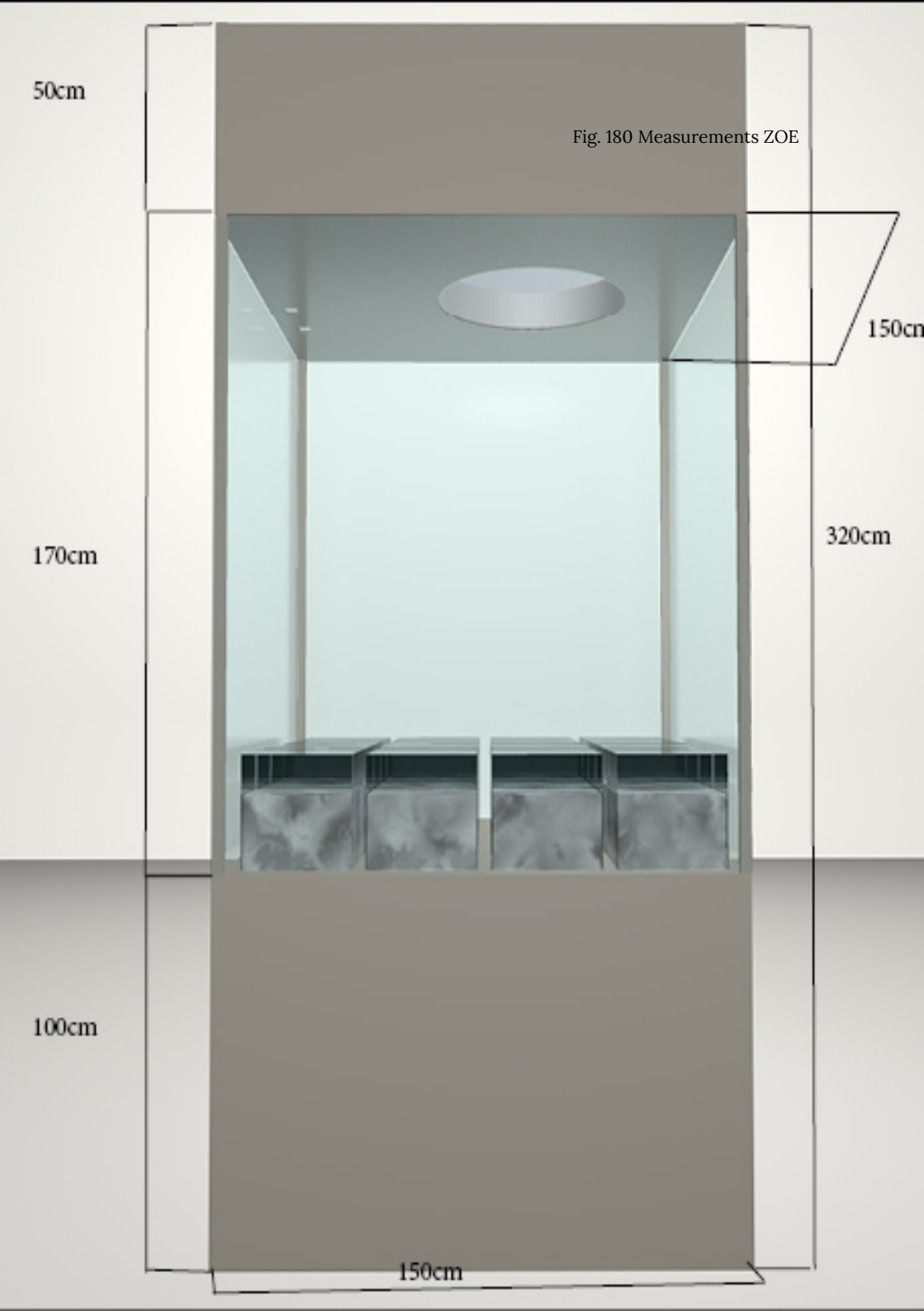
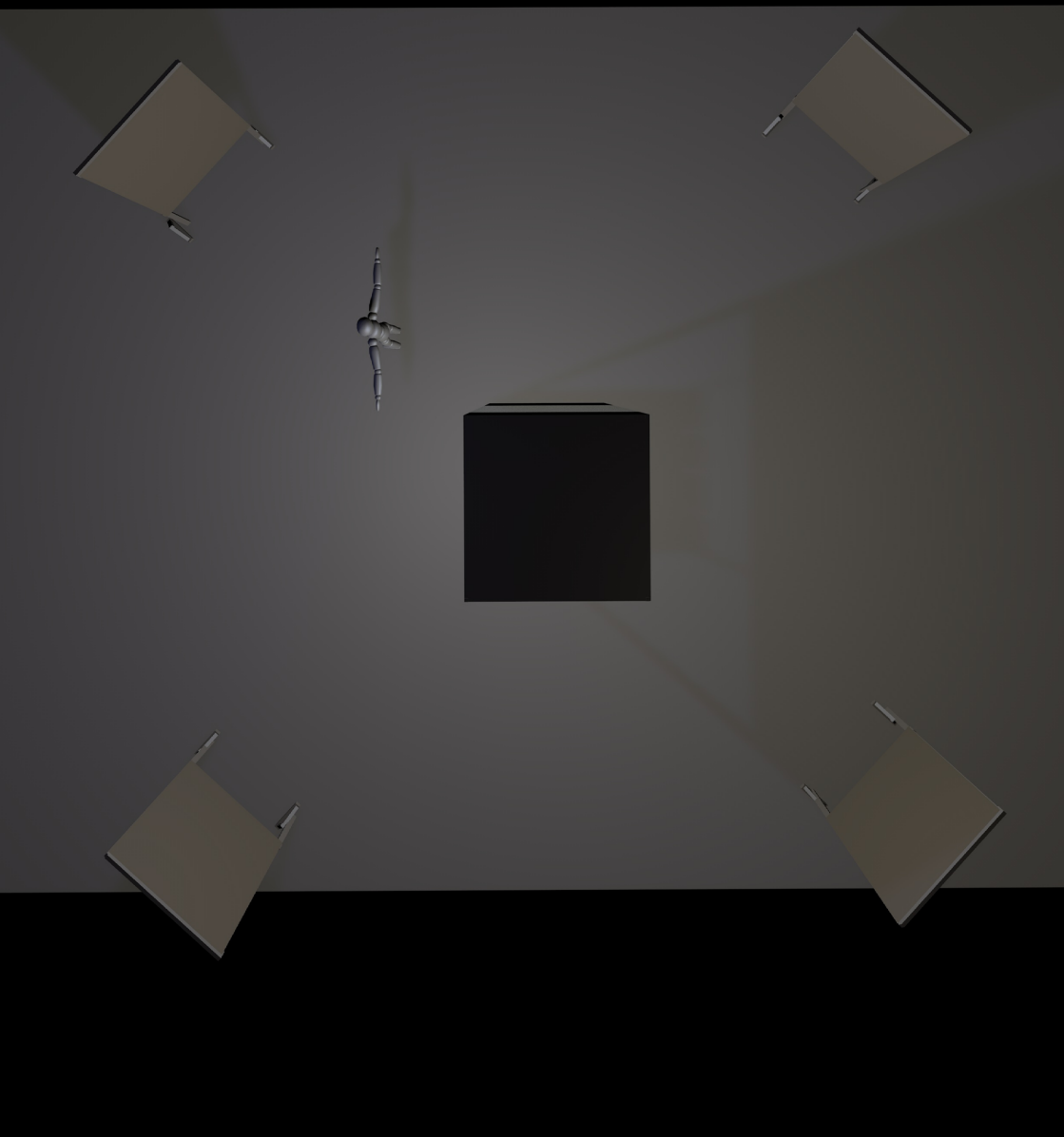


Fig. 180 Measurements ZOE

Fig. 181 Topview ZOE



CARE

One of 'ZOE's' core principles is that of care. The work revolves around the care of the robotic system for the needs of the reishi indicated by the reishi. This also gives the robotic system a purpose. Without any input, it is nothing more than just hardware.

Based on the experience of 'RHIZA' and 'ZIEN', I worked in 'ZOE' directly from the mindset of what is needed for IIWA as well as the reishi. For the reishi, the focus is on the environmental hygiene, and for IIWA on environmental safety, which involves the safety of both IIWA and the reishi, the team and the visitors in relation to IIWA.

Because of this, the greatest emphasis in the preparation work was on ensuring both. The process was a continuous balancing between what was possible for the technology that was part of the robotic system and the possibilities that the reishi could live with. Because this system would come together for the first time in the installation, it was essential that we immediately had the correct setup and safety agreements in place. For example, hanging IIWA in the cube and ensuring it would not be damaged because of the humidity.

Due to the fact that IIWA needed, in our case, supervision, the presence of myself and amir was an immediate requirement, which was conceptually consistent for us. We did not want to pretend that this system had no human influence. We have a responsibility - and we are part of it, although it is not about us.

The reishi also have many requirements. First, the conditions had to be right regarding temperature, light, CO_2 and humidity. Initially, the idea was to adjust the temperature in the whole room to the reishi. Soon we concluded that this is not a space where humans like to be. It is too warm. Nor is it particularly climate-friendly to heat a theatre studio to 25 °C for a month. The safest choice was an enclosed space to bring together all the different needs. It also provides the most satisfactory environment for both.

The process of growing mycelium is a precarious one. This made it impossible to fill the entire cube with mycelium at once. Hence, we chose to grow them in individual glass cubes. This allowed us to give them time to grow a bit and thus gain more resistance before they had to go through the move to the large cube. An added benefit was that by keeping them fragmented that we had the ability to replace them if they had contamination or did not grow. 'ZOE', therefore, had four backup cubes. The sixteen healthiest ones went in initially. We did not need to use the four backups.

I also wanted to take care of the space around 'ZOE' for the human visiting. 'ZOE' had to be a soft space. I wanted it to be safe enough to be with what we did not know, where you can experience what is happening in this temporary ecosystem in different ways—feeling the different rhythms of all the things taking part. Therefore I changed the theatre floor to a light grey carpet, the same colour as the big cube in the centre. I asked people to take off their shoes when they entered the space—hoping to give them this assurance of being comfortable and safe.

As in 'FadingColours' and 'RHIZA', the reishi survives longer than the duration of the installation. Like the pink oyster mushrooms, I let the reishi complete their life cycle. Where oyster mushrooms are edible, this is not directly applicable to reishi.

This can be done but is complex and requires the necessary know-how because it is only used in pulverised form as tea or medicine. Together with the data carpets, the reishi that has grown form a tangible legacy of 'ZOE'. They can also be exhibited individually from 'ZOE' when the space does not allow 'ZOE' to take place again. In this way, they are not being wasted, and the concept of 'ZOE' can be told and experienced in a smaller form.

Fig. 182 ZOE's reishi

CONCLUSION

This thesis is not to establish a practical how or why. It is, for me, a story about how things come together. I am finding my way through these philosophies and methodologies with my practice. Curious whether they naturally appeared in the process and if it is possible to track them down.

The four works I am looking back on all use sensing technologies that produce data. This biodata can be the data about the human they are capturing, the fungi it is measuring, or the corals it observes. I try to bridge the abstraction of the data into the experience of the story they can tell. I think using these data gives me the possibility of having a better insight into "the entanglement of the apparatuses of production" (Barad, 2007, p. 30).

A process of emergent data collection emerges through my lived experiences of collecting and trying out these sensors and technologies. It provides progressive insights into the data collected and how it can be interpreted and used as material for my work. This can be seen as a diffractive approach to engaging with data. It focuses on engaging and attending to differences instead of expecting data to reflect reality in a straightforward, representational way (Rowley, 2007).

I experience in my process that engaging with the different factors I am working with, namely the organism, technologies and humans, these processes are slow, and all of them have different rhythms. The data gathered as material to bridge between humans and non-humans is a process I can not predefine. It asks me to protect my process to not slip into efficiency.

The final artwork and the process are equally important.
I need time to explore the different possibilities with these technologies and data. I need to hold space for the messiness and contradictions that emerge from my practice in order to see the options for multiple interpretations and translations into experiences.

As noted, unlike the many design examples using this methodology, my work does not result in a product or service. Nevertheless, looking at my work through the lens of agential realism, this methodology can be applied in my practice as it is in design research. In all my works, one can find agential cuts and moments of diffraction. For example, "RHIZA's" haptic experience of mushrooms is in co-creation by phenomena of intra-acting bio-sensors, skin, electrical signals, digital signals, software, power delivery to the bass shakers, the growth of the mushrooms over time, and experience of this work. Every moment of haptic translation between skin and fungi occurs through an agential cut.

The bio-sensors are the measurement apparatus of 'RHIZA'. They draw an agential cut between the mycelium's substrate and the electrical fluctuations generated in their network. Another agential cut is between the analogue signal of these electrical signals and the translation into the frequency of the vibrations in the bass shakers made by the amplifier. The parts are individually separable through agential cuts but are inseparably interconnected as phenomena. 'RHIZA' calls for careful attention to the intra-actions between what is measured in the tower and how that is transformed into the vibrations. Exploration of these signals is perceived as a lived experience, not a display of these signals.

Another example is 'ZOE', the way the work engages with sensing technology diffractively by attending to the differences between reishi and the different ways of defining what reishi activity

is and consequently designing a custom-made robotic system with and for the reishi mushrooms. Engaging with data diffractively throughout the process led to recognising the different agential cuts created between the ongoing phenomenon of reishi activity and the data collected by the sensing technologies. This helped in moving away from simply representing reishi activity. Instead, it engages the phenomena of reishi activity in the mycelium, their growth and environmental conditions while staying with the differences of the reishi.

Using sensing technologies and data as material to create encounters between humans and non-humans requires a responsible and careful process regarding the non-humans creating, providing and representing this data. It constantly asks to be aware of the other, human and non-human. As mentioned, Braidotti describes the transformation to the posthuman as "neither linear nor one-directional but is rather a multi-faceted experimentation with what 'we' are capable of becoming" (Braidotti, 2019, p.44).

Becoming is taking place in the practice of care and responsibility. It matters to care for yourself and the other to be together. It matters how one takes responsibility for the process, the species one is working with, the technology, the space, the time, the material and immaterial, and the humans one works with and are visiting the work. It all requires respectful care and attention to their capabilities and needs. It is through them and their intra-actions that these works can exist. In that sense brings critical posthumanism, new materialism and the methodology of diffraction to an awareness of the process of media works involving human and non-human encounters. The requirements that are needed to take a responsible position and caring position where one is not just using the other but collaborating with respect to the differences.

In ‘ZOE’, I create an interactive work between two non-humans while also creating a space for humans to experience sensoriality and diffraction. This work explores the possibilities of creating a new ‘we’, as Braidotti calls it. I believe we have to reposition ourselves in relation to the other entities around us. We have to start asking ourselves what it means to take responsibility. Can humans give space to non-human entities to claim a part of the new ‘we’? What does it mean to care for the other? How can we be different and one at the same time? So many questions need the space to be experimented on, experienced with and elaborated on.

In line with this thesis and these works, I plan to keep working with biological and technological non-humans. I will keep bringing them together in interactive artworks through sensing technologies. The data coming out of this allows me to create encounters between humans and non-humans which can be experienced as embodied immersions into the zone of the other to explore these questions of creating a new ‘we’.

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Adamatzky, A. (n.d.). Language of fungi derived from their electrical spiking activity. Royal Society Open Science, 9(4), 211926. https://doi.org/10.1098/rsos.211926.

Aloi, G., & McHugh, S. (Eds.). (2021). Posthumanism in art and science: A reader. Columbia University Press.

Amnesty International. (2021). Xenophobic machines: Discrimination through unregulated use of algorithms in the Dutch childcare benefits scandal (EUR 35/4686/202; p. 41). Amnesty International. https://www.amnesty.org/en/documents/eur35/4686/2021/en/.

Angerer, M.-L. (2015). Desire after affect. Rowman & Littlefield International.

Angerer, M.-L. (2017). Ecology of affect: Intensive milieus and contingent encounters (G. Jackson, Trans.). Meson Press.

Badmington, N. (Ed.). (2000). Posthumanism. Palgrave.

Barad, K. (2010). Quantum Entanglements and Hauntological Relations of Inheritance: Dis/continuities, SpaceTime Enfoldings, and Justice-to-Come. Derrida Today, 3(2), 240–268. https://doi.org/10.3366/drt.2010.0206.

Barad, K. (2014). Diffracting Diffraction: Cutting Together-Apart. Parallax, 20(3), 168–187. https://doi.org/10.1080/13534645.2014.927623.

Barad, K. M. (2007). Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning. Duke University Press.

Belenguer, J. S., Lundén, M., Laaksolhati, J., & Sundström, P. (2012). Immaterial materials: Designing with radio. Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction, 205–212. https://doi.org/10.1145/2148131.2148177.

Bennett, J. (2010). Vibrant matter: A political ecology of things. Duke University Press.

Blackman, L. (2012). Immaterial bodies: Affect, embodiment, mediation. SAGE.

Boucher, M.-P., Helmreich, S., Kinney, L. W., Tibbits, S., Uchill, R., Ziporyn, E., & Massachusetts Institute of Technology (Eds.). (2019). Being material. The MIT Press.

Bozalek, V., Braidotti, R., Shefer, T., & Zembylas, M. (Eds.). (2018). Socially just pedagogies: Posthumanist, feminist and materialist perspectives in higher education. Bloomsbury Academic.

Braidotti, R. (2006). Posthuman, All Too Human: Towards a New Process Ontology. Theory, Culture & Society, 23(7–8), 197–208. https://doi.org/10.1177/0263276406069232.

Braidotti, R. (2013). The posthuman. Polity Press.

Braidotti, R. (2019). Posthuman knowledge. Polity.

Braidotti, R. (2022). Posthuman knowledge and the critical Posthumanities. STERNBERG PR.

Braidotti, R., & Hlavajova, M. (2018). Posthuman glossary. Bloomsbury academic.

Buchynski, A., & Lang, M. (2021). Karen Barad and Their Influence. https://openeducationalberta.ca/curriculuminfluences/chapter/barad/

Celan, P., & Joris, P. (2014). Breathturn into timestead: The collected later poetry : a bilingual edition. https://www.overdrive.com/search?q=F2F27E0F-A163-48F0-8CC7-029274715E2D.

Christo | TateShots. (n.d.). Retrieved December 8, 2022, from https://www.youtube.com/watch?v=oY-YVR4_aEc.

Clough, P. T., & Halley, J. O. (Eds.). (2007). The affective turn: Theorizing the social. Duke University Press.

Coccia, E. (2018). The life of plants: A metaphysics of mixture. Polity.

Connolly, W. E. (2013). The 'New Materialism' and the Fragility of Things. Millennium: Journal of International Studies, 41(3), 399–412. https://doi.org/10.1177/0305829813486849.

Coole, D. H., & Frost, S. (Eds.). (2010). New materialisms: Ontology, agency, and politics. Duke University Press.

Coral Reefs: Strategies for Ecosystems on the Edge. (n.d.). International Institute for Sustainable Development. Retrieved December 9, 2022, from https://www.iisd.org/articles/deep-dive/coral-reefs-strategies-ecosystems-edge.

CorallumFabrica. (n.d.). Retrieved December 9, 2022, from https://corallumfabrica.laas.fr/3dlibrary.

Devendorf, L., Andersen, K., & Kelliher, A. (2020). Making Design Memoirs: Understanding and Honoring Difficult Experiences. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, 1–12. https://doi.org/10.1145/3313831.3376345.

Dolphijn, R., & Tuin, I. van der. (2012). New Materialism: Interviews & Cartographies. Open Humanities Press. https://doi.org/10.3998/ohp.11515701.0001.001.

Dutch childcare benefit scandal an urgent wake-up call to ban racist algorithms. (2021, October 25). Amnesty International. https://www.amnesty.org/en/latest/news/2021/10/xenophobic-machines-dutch-child-benefit-scandal/.

Feinberg, M. (2017). A Design Perspective on Data. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, 2952–2963. https://doi.org/10.1145/3025453.3025837.

Fox, N. J., & Alldred, P. (2021). Doing new materialist data analysis: A Spinozo-Deleuzian ethological toolkit. International Journal of Social Research Methodology, 1–14. https://doi.org/10.1080/13645579.2021.1933070.

Frauenberger, C. (2020). Entanglement HCI The Next Wave? ACM Transactions on Computer-Human Interaction, 27(1), 1–27. https://doi.org/10.1145/3364998.

Frontiers | Detection of Coral Reef Bleaching Based on Sentinel-2 Multi-Temporal Imagery: Simulation and Case Study | Marine Science. (n.d.). Retrieved January 28, 2022, from https://www.frontiersin.org/articles/10.3389/fmars.2021.584263/full.

Gaver, W. (2012). What should we expect from research through design? Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 937–946. https://doi.org/10.1145/2207676.2208538.

Gitelman, L. (Ed.). (2013). "Raw Data" Is an Oxymoron. The MIT Press. https://doi.org/10.7551/mitpress/9302.001.0001.

Given, L. (2008). The SAGE Encyclopedia of Qualitative Research Methods. SAGE Publications, Inc. https://doi.org/10.4135/9781412963909.

Godfrey-Smith, P. (2018). Other minds: The octopus and the evolution of intelligent life (Paperback edition). William Collins.

Gregg, M., & Seigworth, G. J. (Eds.). (2010). The affect theory reader. Duke University Press.

Grossberg, L., Nelson, C., & Treichler, P. A. (1992). Cultural studies. Routledge.

Guidi, Lionel, Fernàndez-Guerra, Antonio, Bakker, Dorothee, Canchaya, Carlos, Curry, Edward, Foglini, Federica, Irission, Jean-Olivier, Malde, Ketil, Marshall, C. Tara, Obst, Matthias, Ribeiro, Rita P., & Tjiputra, Jerry. (2020). Big Data in Marine Science. Zenodo. https://doi.org/10.5281/ZENODO.3755793.

Haraway, D. (2013). Simians, Cyborgs, and Women (0 ed.). Routledge. https://doi.org/10.4324/9780203873106.

Haraway, D. (2016). Tentacular Thinking: Anthropocene, Capitalocene, Chthulucene. 17.

Haraway, D. J. (1997). Modest–Witness@Second–Millennium. Femaleman–Meets–Oncomouse: Feminism and Technoscience (Vol. 30, Issue 3, pp. 494–497). Routledge.

Haraway, D. J. (2008). When species meet. University of Minnesota Press.

Haraway, D. J. (2016). Staying with the trouble: Making kin in the Chthulucene. Duke University Press.

Harris, D. (2021). Karen Barad's feminist materialism: Intra-action and diffraction.

Herbrechter, S. (2013). Posthumanism: A critical analysis. Bloomsbury.

Hinton, P., & Treusch, P. (Eds.). (2015). Teaching with feminist materialisms: Teaching with gender. European women's studies in international and interdisciplinary classrooms. ATGENDER.

Hollin, G., Forsyth, I., Giraud, E., & Potts, T. (2017). (Dis)entangling Barad: Materialisms and ethics. Social Studies of Science, 47(6), 918–941. https://doi.org/10.1177/0306312717728344.

Homewood, S., Hedemyr, M., Fagerberg Ranten, M., & Kozel, S. (2021). Tracing Conceptions of the Body in HCI: From User to More-Than-Human. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1–12. https://doi.org/10.1145/3411764.3445656.

Hultman, K., & Lenz Taguchi, H. (2010). Challenging anthropocentric analysis of visual data: A relational materialist methodological approach to educational research. International Journal of Qualitative Studies in Education, 23(5), 525–542. https://doi.org/10.1080/09518398.2010.500628.

Jenkins, N., Ritchie, L., & Quinn, S. (2021). From reflection to diffraction: Exploring the use of vignettes within post-humanist and multi-species research. Qualitative Research, 21(6), 975–989. https://doi.org/10.1177/1468794120920258.

Kaiser, B. M., & Thiele, K. (2014). Diffraction: Onto-Epistemology, Quantum Physics and the Critical Humanities. Parallax, 20(3), 165–167. https://doi.org/10.1080/13534645.2014.927621.

Karpashevich, P., Sanches, P., Garrett, R., Luft, Y., Cotton, K., Tsaknaki, V., & Höök, K. (2022). Touching Our Breathing through Shape-Change: Monster, Organic Other, or Twisted Mirror. ACM Transactions on Computer-Human Interaction, 29(3), 1–40. https://doi.org/10.1145/3490498.

Keeling, D. M., & Lehman, M. N. (2018). Posthumanism. Oxford University Press. https://doi.org/10.1093/acrefore/9780190228613.013.627.

LBR iiwa. (n.d.). KUKA AG. Retrieved December 20, 2022, from https://www.kuka.com/en-at/products/robotics-systems/industrial-robots/lbr-iiwa.

Lemke, T. (2015). New Materialisms: Foucault and the 'Government of Things.' Theory, Culture & Society, 32(4), 3–25. https://doi.org/10.1177/0263276413519340.

Loh, J. (2021). Verantwortung / Responsibility – Janina Loh. https://janinaloh.de/beispiel-seite/verantwortung-responsibility/.

Lyotard, J.-F. (1991). The inhuman: Reflections on time. Stanford University Press.

McCaffrey, E. (2015). Rewriting Modernity. Cultural Politics, 11(2), 275–292. https://doi.org/10.1215/17432197-2895831.

Mondloch, K. (2018). A Capsule Aesthetic: Feminist Materialisms in New Media Art. University of Minnesota Press. https://doi.org/10.5749/j.ctt1zgb3fb.

Morton, T. (2017). Humankind: Solidarity with nonhuman people. Verso.

MQTT Essential Series | HiveMQ | All Core MQTT Concepts Explained. (n.d.). Retrieved December 20, 2022, from https://info.hivemq.com/mqtt-essentials.

NOAA Coral Reef Watch Daily 5km Regional Virtual Stations. (n.d.). Retrieved January 28, 2022, from https://coralreefwatch.noaa.gov/product/vs/map.php.

Orlowski, J. (Director). (2017, July). Chasing Coral [Documentary film]. Netflix.

Ostberg, R. (2022, March 11). Transhumanism | Definition, History, Ethics, Philosophy, & Facts | Britannica. https://www.britannica.com/topic/transhumanism.

Parikka, J. (2012). New Materialism as Media Theory: Medianatures and Dirty Matter. Communication and Critical/Cultural Studies, 9(1), 95–100. https://doi.org/10.1080/14791420.2011.626252.

Petrič, Š. (n.d.). PL'AI. Špela Petrič. Retrieved December 10, 2022, from https://www.spelapetric.org/plai.

Pierce, J. (2021). In Tension with Progression: Grasping the Frictional Tendencies of Speculative, Critical, and other Alternative Designs. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1–19. https://doi.org/10.1145/3411764.3445406.

Puig de la Bellacasa, M. (2017). Matters of care: Speculative ethics in more than human worlds. University of Minnesota Press..

Radio ·, C. B. C. (2021, December 1). Scientists are mapping the world's underground fungi network to fight climate change | CBC Radio. CBC. https://www.cbc.ca/radio/asithappens/as-it-happens-the-wednesday-edition-1.6269628/scientists-are-mapping-the-world-s-underground-fungi-network-to-fight-climate-change-1.6269630.

Rowley, J. (2007). The wisdom hierarchy: Representations of the DIKW hierarchy. Journal of Information Science, 33(2), 163–180. https://doi.org/10.1177/0165551506070706.

Sanches, P., Howell, N., Tsaknaki, V., Jenkins, T., & Helms, K. (2022). Diffraction-in-action: Designerly Explorations of Agential Realism Through Lived Data. CHI Conference on Human Factors in Computing Systems, 1–18. https://doi.org/10.1145/3491102.3502029.

Sauzet, S. (2015). Thinking through picturing. In Teaching with feminist materialisms (pp. 37–51).

Sauzet, S. (2019). Phenomena—Agential Realism.

Schwartzberg, L. (Director). (2019, October 11). Fantastic Fungi [Documentary film]. Moving Art.

Šebjanič, R. (n.d.). Aurelia 1+Hz / Proto Viva Sonification ||| audio – visual performance with living system | Robertina Šebjanič. Retrieved December 10, 2022, from https://robertina.net/aurelia-1hz-proto-viva-sonification/.

Sheldrake, M. (2020). Entangled life: How fungi make our worlds, change our minds and shape our futures. The Bodley Head.

Somerville, M. (2016). The post-human I: Encountering 'data' in new materialism. International Journal of Qualitative Studies in Education, 29(9), 1161–1172. https://doi.org/10.1080/09518398.2016.1201611.

Spačal, S. (n.d.). Agapea Saša Spačal. Retrieved December 10, 2022, from https://www.agapea.si/en/.

Stamets, P. (2000). Growing gourmet and medicinal mushrooms (3rd ed). Ten Speed Press.

Sundström, P., Taylor, A., Grufberg, K., Wirström, N., Solsona Belenguer, J., & Lundén, M. (2011). Inspirational bits: Towards a shared understanding of the digital material. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 1561–1570. https://doi.org/10.1145/1978942.1979170.

Thiele, K. (2014). Ethos of Diffraction: New Paradigms for a (Post) humanist Ethics. Parallax, 20(3), 202–216. https://doi.org/10.1080/13534645.2014.927627.

Toeslagenaffaire. (n.d.). Trouw. Retrieved December 20, 2022, from https://www.trouw.nl/internal/dossier/kinderopvangtoeslag.

Tuin, R. D. and I. van der. (2012). New Materialism: Interviews & Cartographies. New Metaphysics. https://doi.org/10.3998/ohp.11515701.0001.001.

Van Dooren, T. (2016). Flight ways: Life and loss at the edge of extinction (Paperback edition). Columbia University Press.

Weinstein, J. (Ed.). (2017). Posthumous life: Theorizing beyond the posthuman. Columbia University Press.

Weinstock, J. A. (Ed.). (2020a). A monster theory reader. University of Minnesota Press.

Weinstock, J. A. (Ed.). (2020b). The Monster Theory Reader. University of Minnesota Press. https://doi.org/10.5749/j.ctvtv937f.

XL Catlin Seaview Survey. (n.d.). XL Catlin Seaview Survey. Retrieved December 10, 2022, from https://www.catlinseaviewsurvey.com.

Žižek, S. (2015). Absolute recoil: Towards a new foundation of dialectical materialism. Verso.

APPENDIX

Transcript voice over on headphones in ZOE

Noor: [00:00:00.24] I don't know how much you already know about mushrooms. But for now, let's start at the beginning. If I say mycelium, do you know what I mean? Okay. Come with me. We go to the Reishi, stand up and walk to the big cube in the middle. The reishi are the mushrooms that are growing in Zoe. If you're close to them, you see, they grow from a white substance. This is mycelium. Sometimes you also see it on the glass. It looks like little threats. Do you also see the reishi? They are now brown, yellow and white. The white part is still growing, and the brown-yellow is their skin. When they grow on the glass, they don't make a skin. So you can see if you look very closely how they grow slowly over time. If you find one and you maybe see that they make little lines, I think they make these lines every day that they grow just like trees. But that is my observation. It's nothing scientific.

Maybe you have heard about the Wood Wide Web or that trees can talk with each other. Well, it's actually the mycelium that they are connected to that can transmit these signals. And mushrooms are the fruiting bodies. Or see it as flowers of the mycelium. Mycelium and their mushrooms constantly exchange little electrical signals. It is quite recent that we found out that they communicate. And until today, we have no idea what this communication exactly is. We only know that they do and that they transfer nutrients and information to the network and that other plants and trees can connect to it. If you look at the door where you came in. And you stand with your back to it on the left side and the back

side of the big cube, you see cables, blue, orange and purple cables go to that corner. Do you see that these cables go inside the reishi? These are the sensors that are picking up this communication. It is the same kind of sensor that we use to pick up our brain signals. We only know that these signals are here, but we don't know what they mean.

Amir: [00:02:55.88] Now if you're somewhere close to the big cube. I want you to look at the door where you come in. There's a screen next to that. That is our data screen. Walk towards it and stand in front of it. So you see a text, a QR code. And some visualisations. Let's talk about the one in the middle - right. You might see a few circles that sometimes they are jittery and distorted and sometimes they are more calm. They are the visualisation or the production of the data we are getting from the mushrooms. If you look below the screen, you see a few tiles. Each of them has its own tag. So how it works. We are collecting a lot of data from the big cube, two of which coming directly from the mushrooms. The rest are the temperature, humidity and the CO_2 amount. If you want to be notified or if you want to convert this data to something human-readable or human noticeable, what we need to do is either visualise them or sonify them. The way that it works is we convert this data, this signal, to textures, to pixels. Each tile. Has a few pixels that they change their position an their color according to the coming amount of data. For example, let's talk about the temperature. In a given time. Each pixel is looking for the amount of temperature that is being changed. The colder. It gets black. The warmer, It gets brighter and the same applies for the other tiles. So what do we do with those? Then we convert each of them to a few rings. And each ring. It's getting distorted. In ratio of the activity or how often this data coming in and how much they are different

from the minimum and maximum that they are calculated every day.

Amir: [00:05:42.89] If this threshold is high, you will see that this circles are getting distorted. If this threshold is low, you see them more calm and steady. And this is just for us to be able to somehow visualise these activities that they are happening inside the big cube. Okay,what is the one on the left? You see the visualization of a robot and a few tiles that are floating in the air. Each float is basically representing the smaller cubes where the mushrooms are there. Those are there to represent the growing amount of each cube. So if you notice on the robot, which is inside the cube, there is a camera there. So what we do is every half an hour the robot goes over every single cube and takes a picture. Then we compared those pictures to the one from yesterday and the day before and the day before and the day before. And then we discover or we can analyse the different amount or different size of each mushroom. If this amount is high, it means mushrooms are growing. If this amount is low, it means that the mushrooms are growing less than the others. Those that are growing more. That representative tile becomes more towards green and it stands higher. And those that they are growing less. Their representative tile gets red and stays below. And now this is the decision of the system to hover the robot. Over the one that it was growing less to give them more light as it needs.

Noor: [00:07:35.02] And the interesting thing is that reishi are light sensitive. So that means that reishi grows towards the light. And by creating a system where we decided, okay, you observe and you go to the reishi that needs more attention, makes that all the other reishi grow also towards the box with the reishi that needs more attention because they grow to the light that is

above this box. So if you look closely, you see that they sometimes go more left, right, more up, and that is really depending on where the light has been in the time they were growing. And did you know that mushrooms are closer to us and animals than to plants because they breath? So that is also when we try to make this temporary coexistence in Zoe that we have to measure the CO_2 ,temperature and humidity with sensors to give this information back to the to their ecosystem. So the robotic system knows what to do, what they need.

Amir: [00:08:39.39] So what do we mean when we talk about the robotic system? So you already noticed that there is a robotic arm hanging from the ceiling of the big pixel or the big cube. Well, that part itself is just one part of a robotic system. The robotic system here really is everything that let us observe and monitor the activities that is happening inside this cube and everything that decides and calculates this information and creates behavior for all the other parts of this big cube. For example, when we collect the humidity data, there is a humidifier that it knows when it should start working. So there is a condition. If the humidity is low, the robot moves around and the humidifier starts putting steam inside the big cube. Also, when the CO_2 two is going.. going up and down, we know how to regulate that with turning on and off the fans that they are mounted on the ceiling. You see two filters on each corner. Also on the ceiling, there are two mosaic lamps that they are providing heating, providing temperature control for these big pixels for this cube. And of course, you have noticed already the light mounted on the robot. So we know that mushrooms need light, right? So I already said that we see and observe which pixel needs more light to grow better. Then the robot moves to the position of that pixel and hovers.

Amir: [00:10:17.95] And what we call a cruise mode. Cruise mode that the robot is slowly moves around and make sure that every single mushroom in this mycelium box gets enough light. And also there's a camera mounted on the robot. This is the one that collects these pictures. So all together, they are connected to a laptop that is up there. And this laptop basically has a program. We wrote this program together that it collects all this data. It analyses this data and it makes a decision. Um. What should happen in this pixel? Do we need more temperature? Do we need, um, more humidity or less humidity? Do we need to regulate the CO_2? CO_2? Where should the light be? And we are the one who wrote and created this robotic system. There are certain rules that we put there, and this robotic system follows these rules and does the rest of the things by itself. But of course, we are learning from this process. We are observing that how these rules and how this process is good or beneficial or not beneficial for the whole ecosystem. And of course, we can influence that by changing some values, by tweaking some parts of these rules. This is also our part that we are learning from creating this robotic system for this ecosystem.

Noor: [00:11:48.52] I think the interesting thing for us is also to play with it, like, what do we decide and when do we let the system decide? Or the system is then like Zoe and the robotic together so their network. So if these reishi are not growing so fast and we say, okay, you go where the reishi are not growing so fast, that means that the whole shape they're growing in is basically decided by them or by us or by both of us. I think what is so fascinating is that this whole other society of mushrooms and mycelium is so different than us and so much longer here on earth. And I think we could learn a lot from them in their different way of being together. And if you work with these things like mushrooms,

technology, data, or us as humans as well, we all have a different speed, a different rhythm in time. And when I started working with these non-humans, I realized that I had to learn to adjust my speed to be able to see if you're still standing. Maybe find a data carpet and lay down for a bit.....Did you already find one? If there are other people also laying there.

Noor: [00:13:09.76] Just. Just go with it. You can be together here. It's not. It's not a problem. Just lay down. Relax. If you don't want to be on the carpet, lay somewhere else. These data carpets are made every day from the data that we collect from the reishi signals and their environmental data. And we're just told you about we collect it over the whole day and we visualize at the end of the day, a final visualization of how the signals and the environment related to each other that day. And I make carpets out of them to find a way of understanding them, because as long as we do not know what they say, I try to find another way to experience what their relation could be between their communication and their environment. And did you also hear the sound in space? I already said it. We also sonify it. We don't know so far if mushrooms make sounds, but we gave them some sound. It is their signals in this moment that you can hear. So. When you're ready, take your time to see them, hear them, and feel them through the carpets.