Chalmers School of Architecture
Department of Architecture & Civil Engineering
2026

Dancing with Space

DANCING WITH SPACE:
Towards a Performative Model of Interactive Architecture

Tereza Táborská

Examiner: Jonas Lundberg
Supervisor: Kengo Skorick

DANCING WITH SPACE:
TOWARDS A PERFORMATIVE MODEL OF INTERACTIVE ARCHITECTURE

TEREZA TÁBORSKÁ
2026

CHALMERS
UNIVERSITY OF TECHNOLOGY

CHALMERS UNIVERSITY OF TECHNOLOGY
CHALMERS SCHOOL OF ARCHITECTURE
DEPARTMENT OF ARCHITECTURE & CIVIL ENGINEERING
MASTER'S PROGRAMME IN ARCHITECTURE AND URBAN DESIGN (MPARC)

PROFILE:
ARCHITECTURAL EXPERIMENTATION
MATTER & MEDIA

EXAMINER: JONAS LUNDBERG
SUPERVISOR: KENGO SKORICK

Statement on the Use of Generative AI

In preparing this thesis, I used Grammarly for grammar and style correction, DeepL for translation, ChatGPT (OpenAI) for phrasing, structure revision, improving textual coherence, and for assistance in writing and debugging scripts in TouchDesigner and Arduino IDE. I also used NotebookLM (Google) to organise and narrow the list of relevant references. All AI-assisted outputs were critically reviewed, verified, and edited by me, and no AI system was used to generate original ideas, data, or analytical results.

CONTENT LIST

THE BODY IS OUR GENERAL MEDIUM FOR HAVING A WORLD.

— MAURICE MERLEAU-PONTY
(PHENOMENOLOGY OF PERCEPTION)

Architecture is not a stage. It is a performer. Instead of simply containing the body, it listens, responds, and transforms with it.

ABSTRACT

This thesis investigates how an interactive architectural space can respond in real time to the qualitative nuances of human movement, with dance as a primary model of embodied and expressive interaction. The research addresses the limitations of static architectural space and conventional reactive systems by proposing a spatial environment that actively participates in a dialogue and exhibits autonomous behavioural expression, positioning architecture as a co-creative participant rather than a passive container.

The theoretical anchoring draws on performative architecture, embodied interaction, cybernetic theory, and spatial atmosphere, reframing architecture as action rather than an object and shifting the Cartesian paradigm toward experiential knowledge "I experience, therefore I am" (Simanowski, 2011). Interactive spaces are interpreted as cybernetic systems that, through sensing, interpretation, and spatial response, form a continuous feedback loop between the human body and its surroundings. Sensory congruency is examined as a key condition for atmospheric coherence across individual sensory modalities (light, sound, texture) to produce a fluid, positive experience (Spence, 2020). Projects, including Mapped Empathies (Requena, 2018), No One is an Island (Random International and Studio Wayne McGregor, 2020), Messa di Voce (Levin and Lieberman, 2004), Shylight (Studio Drift, 2014), and Sky Symphony (Skyform Studio, n.d.), inform both conceptual and technical development.

This work, using the presented theoretical foundations, proposes a conceptual model of interactive architecture organised into three interdependent layers: sensory, cognitive, and expressive. It describes how sensory technologies record human movement, how computational processes interpret the qualitative aspects of movement, and how spatial responses are realised through light, sound, or kinetic transformation.

Methodologically, the research applies practice-based design experimentation, combining motion capture technologies (Kinect and MediaPipe), real-time data interpretation within TouchDesigner, and iterative prototyping of individual responses. These investigations explore how movement can be translated into spatial, visual, and auditory responses through cyclical interactions.

The thesis demonstrates how strategies such as "imperfection to emergence" (Mun, 2023) can foster discovery and co-creation by introducing controlled uncertainty into interactive systems. The final prototype and installation design contribute to the contemporary discourse on interactive architecture by advancing models of embodied spatial experience that integrate technological response, architectural agency, and human perception.

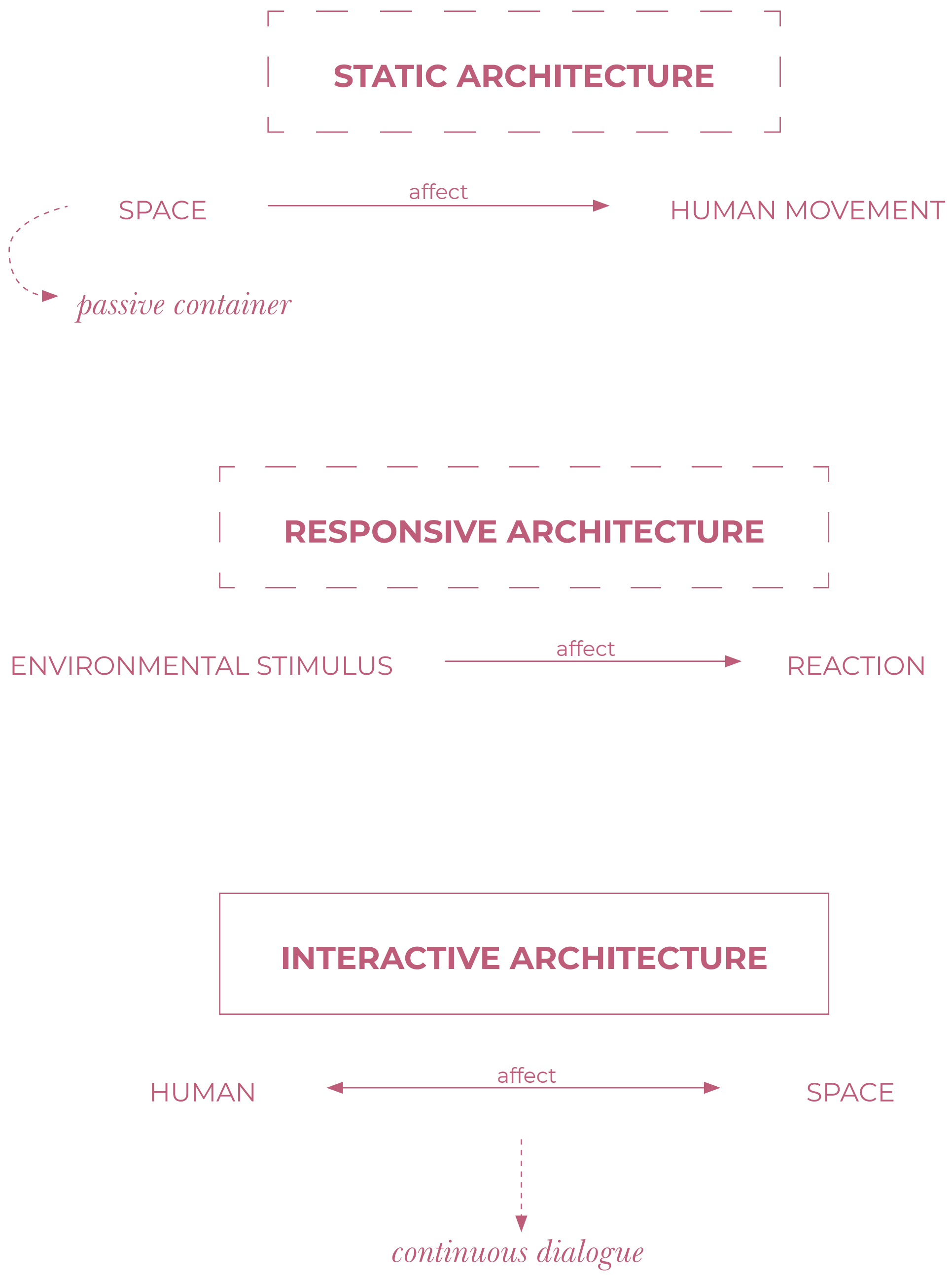


Figure 1.:Static, Responsive, and Interactive Architecture Diagram (Author, 2026)

PROLOGUE

Architecture has long been seen as a stable framework, a static background for everyday human life, a fixed scene, a stage where movement takes place. However, contemporary technological and theoretical developments challenge this perception of still space. As environments increasingly acquire the ability to sense, process, and respond, architecture increasingly adopts a position somewhere between object and actor, matter and behaviour.

Within this perspective, architecture shifts from permanence to process, from object to interaction. Such transformation raises a fundamental question: what happens when space no longer remains neutral but begins to participate? Rather than approaching interaction as a technical exchange between input and output, the research sees it as a shared dialogue, where movement carries qualitative meaning and space responds with its own expressiveness. Architecture enables engagement with the body, reacts to its presence, and influences its actions. This view changes architecture from static materiality to relational experience, where meaning emerges through interaction rather than through form alone.

Human movement plays a central role in this shift. The body is not only a physical entity occupying space but also a carrier of intention, rhythm, and emotion. Movement reveals qualities that go beyond measurable coordinates. It communicates through direction, speed, variation and intensity. When space can perceive and respond to these nuances, it enters the realm of dialogue beyond pragmatic technical function.

Dance offers a clear way to explore this relationship. Unlike everyday movement, dance intentionally amplifies expression, making the emotional and cognitive dimensions of bodily action visible. Creating conditions for effective reciprocal exchange where the body moves, space responds, and the response influences further movement. The boundary between performer and environment becomes blurred, leading to a new understanding of architectural experience as collectively created and continuously evolving.

This understanding positions the project at the crossroads of architecture, technology, and performance. It suggests that meaningful interaction does not arise from perfect control, but from mutual exchange, interpretation, and moments of unpredictability. Through iterative experimentation and prototyping, the research investigates how movement qualities can be sensed, interpreted, and transformed into visual, auditory, and kinetic responses, allowing architecture to behave less as a machine and more as a co-performer.

Ultimately, this work proposes an expanded understanding of architectural space, moving beyond a static, passive environment toward a relational, performative spatial presence. It aims to contribute to ongoing discourse on interactive architecture by exploring how embodied experience can inform the design of environments that not only react, but participate.

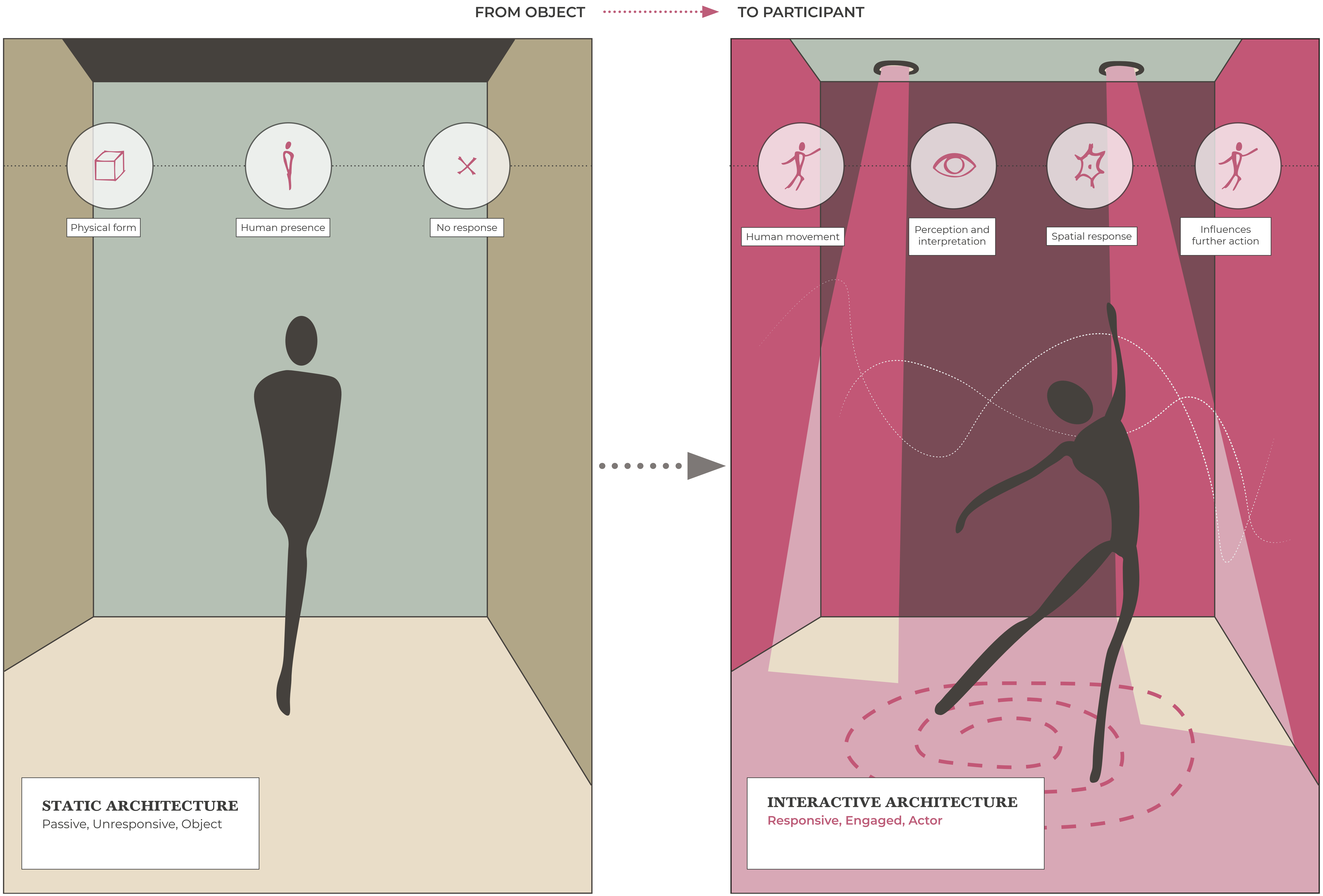


Figure 2.:From Object To Participant (Author, 2026)

PURPOSE AND POSITIONING

The purpose of this thesis is to investigate how architectural space can actively engage with human movement. Although recent advances in digital technologies have enabled complex, dynamic reactions to external stimuli, many contemporary interactive systems remain mainly reactive and work primarily in a linear input-output logic. Despite progress in computational design and smart environments, a gap remains between technical responsiveness and meaningful embodied interaction. This research addresses that gap by examining how architecture might move beyond mere responsiveness. It seeks to understand forms of interaction that are cyclical, interpretative, and relational, in which both human and spatial behaviours influence each other.

Continuous development of Information and Communication Technology (ICT) has shifted architectural capacity to sense, process, and adapt to human presence through computational feedback systems (Lee et al., 2021). These developments open the possibility for architecture to behave rather than merely exist as form. However, the presence of technology alone does not ensure experiential depth or meaningful interaction. Accordingly, this research situates itself within a wider discussion about how interactive systems can foster relational experience, autonomy, and co-creation rather than functioning as deterministic mechanisms.

The concept of embodiment is crucial to the thesis investigation. Humans interact with space through bodily, experiential processes using their bodies' movement, perception, and sensory experience, rather than relying solely on abstract command-based control. Dance is adopted as a focused research context for its complex qualities, including rhythm, emotional expression, personalisation or intentionality, that exceed plain functional motion. In this context, the thesis looks at movement not just as data points but as rich phenomena that carry qualitative meaning and can shape the spatial atmosphere. The body is thus framed as an active co-creator of spatial dialogue and experience, rather than a passive occupant of space.

Integrating motion-tracking technologies provides a conversion interface that translates bodily movement into real-time spatial responses, establishing feedback loops between the participant and the environment. Within this framework, architecture is explored as a partner that registers, interprets, and responds to the nuances of movement. The objective is not to produce fixed or predictable reactions but to investigate how autonomy and controlled unpredictability may encourage exploration, interpretation, and personal agency within interaction (Mun, 2023). Meaningful interaction is conceptualised as an ongoing operation, in which spatial design and atmosphere emerge through information exchange rather than pre-programmed sequences.

Simultaneously, this research acknowledges that the experience is cognitively processed through multiple senses. Human responses arise from the integration of various sensory modalities, indicating interactive installation's need for coherence across visual, auditory, and kinetic outputs to create unique atmospheric experiences that strongly affect emotional and psychological reactions to space (Spence, 2020). Additionally, the intuitiveness of interaction directly aligns with natural cognitive patterns, which people use for behavioural and spatial interpretation (Pitt and Casasanto, 2022). These considerations imply that interaction is both a technical challenge along with a perceptual and cognitive one.

This research project operates at the intersection of architecture, technology, and performativity, using iterative prototyping to analyse the possibilities of recognition, quantification, interpretation and expressive transformation of qualitative movement characteristics. It reconsiders architecture not as a fixed, static container but as a dynamic, relational system. The research proposes a conceptual model of interactive architecture organised into sensory, cognitive, and expressive layers. Through them, spatial structures interpret human presence and act in real time using multisensory algorithms. This way, architecture becomes an active co-performer in the complex embodied experience.

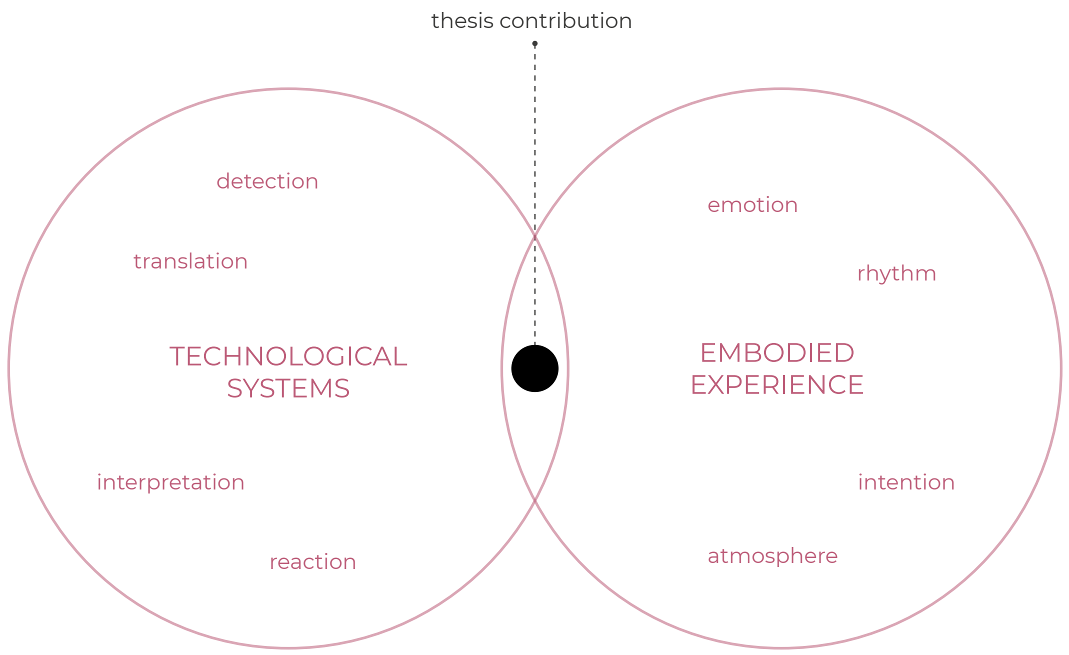
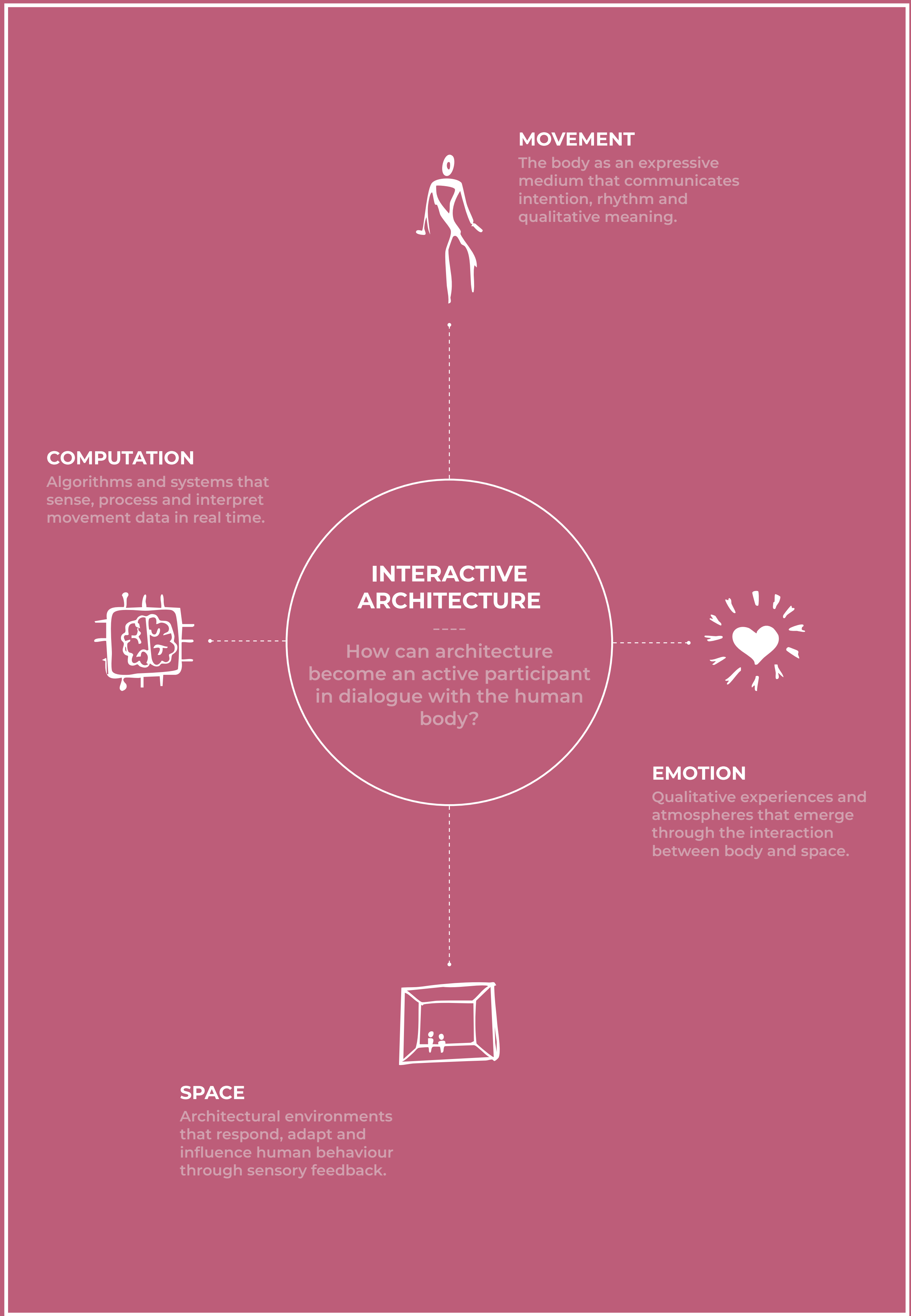


Figure 3.:Thesis Positioning (Author, 2026)



THESIS QUESTION

HOW CAN INTERACTIVE ARCHITECTURE BE DESIGNED AS A CO-PERFORMATIVE SPATIAL SYSTEM THAT INTERPRETS HUMAN MOVEMENT AND RESPONDS THROUGH MULTISENSORY FEEDBACK?

- What distinguishes responsive, kinetic, and interactive architecture, and how can interactivity be understood as a reciprocal relationship between body, computation, and space?
- How can qualitative movement characteristics, such as speed, proximity, posture, rhythm, and direction, be translated into computational parameters?
- How can computationally interpreted movement be expressed through light, sound, projection, and kinetic spatial behaviour?
- How can controlled unpredictability and multisensory feedback support embodied engagement, agency, and atmospheric experience?

Figure 4.:Core Research Framework Diagram
(Author, 2026)

METHODOLOGY

Research Approach

This work employs a research-through-design methodology that combines theoretical inquiry with practical experimentation to explore how architectural space can interact with human movement. Design-based research best serves the exploration of emerging spatial solutions, where, rather than deriving insights solely through analysis, results are also derived through experimentation with design and technological prototyping.

Within this framework, design is not viewed merely as a medium for creating a final artifact, but as a method of inquiry through which theoretical concepts are translated into spatial and computational systems. The interactive prototype developed in this research therefore functions both as a design outcome and as an experimental tool used to test the relationships between motion capture, computational interpretation, and spatial response.

The methodological structure is formulated by a conceptual model proposed within a theoretical framework that conceives of interactive architecture as a system consisting of three interconnected layers. The sensory layer, responsible for detecting human movement and environmental conditions, the cognitive layer, where captured data is interpreted through computational processes, and the expressive layer, through which the system generates spatial responses such as light, sound, or kinetic movement

These layers together shape a cyclical interaction loop between the participant and the architectural environment, enabling the research to explore how architecture might function as an active co-participant in embodied interaction.

Research Process

The research is carried out through an iterative design process, the concentration of which can be framed into three main phases: motion capture, computational interpretation, and the generation of spatial responses. These phases correspond to the sensory, cognitive, and expressive layers of the interactive architectural system.

Rather than following a strictly linear sequence, the process functions as a cyclical workflow in which each phase informs the next and is constantly refined and improved through experimentation.

1, Motion Capture
(Sensory Layer)

The first phase examines how human movement can be tracked and translated into digital data. Motion tracking technologies, including Kinect and MediaPipe, are used to detect body position, gestures, and spatial relationships between body parts in real time.

Through these systems, the body is transformed into a dynamic data source capable of generating information about the qualities of movement, such as:

- **velocity and acceleration**
- **direction of movement**
- **proximity between body parts**
- **spatial position and posture**

Inspired by Laban's analysis of movement, as cited in Fehr and Erkut (2015), these quantifiable parameters are interpreted as indicators for the qualitative characteristics of movement. This phase establishes the perceptual capacity of the architectural system, enabling the environment to register the presence and expressive qualities of human body motions.

2, Computational Interpretation
(Cognitive Layer)

The second phase focuses on the interpretation of captured motion data through computational processes. Data generated and processed by motion tracking systems are analysed in the TouchDesigner interface, where algorithms break down motion parameters and translate them into behavioural logic.

Various mapping strategies are explored to determine how qualitative characteristics of movement can influence spatial behaviour. For example, changes in movement speed can be translated into changes in colour intensity or rhythm, while spatial proximity between body parts can trigger specific visual or acoustic responses.

The phase represents the cognitive layer of the system, where the architectural environment parses sensory inputs and determines appropriate responses. Through iterative testing and refinement, the interaction logic is optimised to ensure that responses remain perceptually coherent and intuitively understandable to participants.

3, Spatial Response Phase
(Expressive Layer)

During the third phase, computational outputs are transformed into multisensory spatial responses. These responses are realised through visual projections, dynamic lighting, sound, and kinetic elements controlled by digital interfaces and microcontrollers.

The purpose of this step is to create a feedback loop in which the installation's spatial actions influence subsequent human movement. Rather than functioning as a simple stimulus-response mechanism, the system seeks to create a reciprocal cycle of interaction, where physical movement generates an environmental transformation, and that alteration subsequently influences the participant's behaviour.

Through this process, the architectural environment functions not merely as a reactive system, but as a performative spatial entity capable of engaging in a dynamic dialogue with the human body.

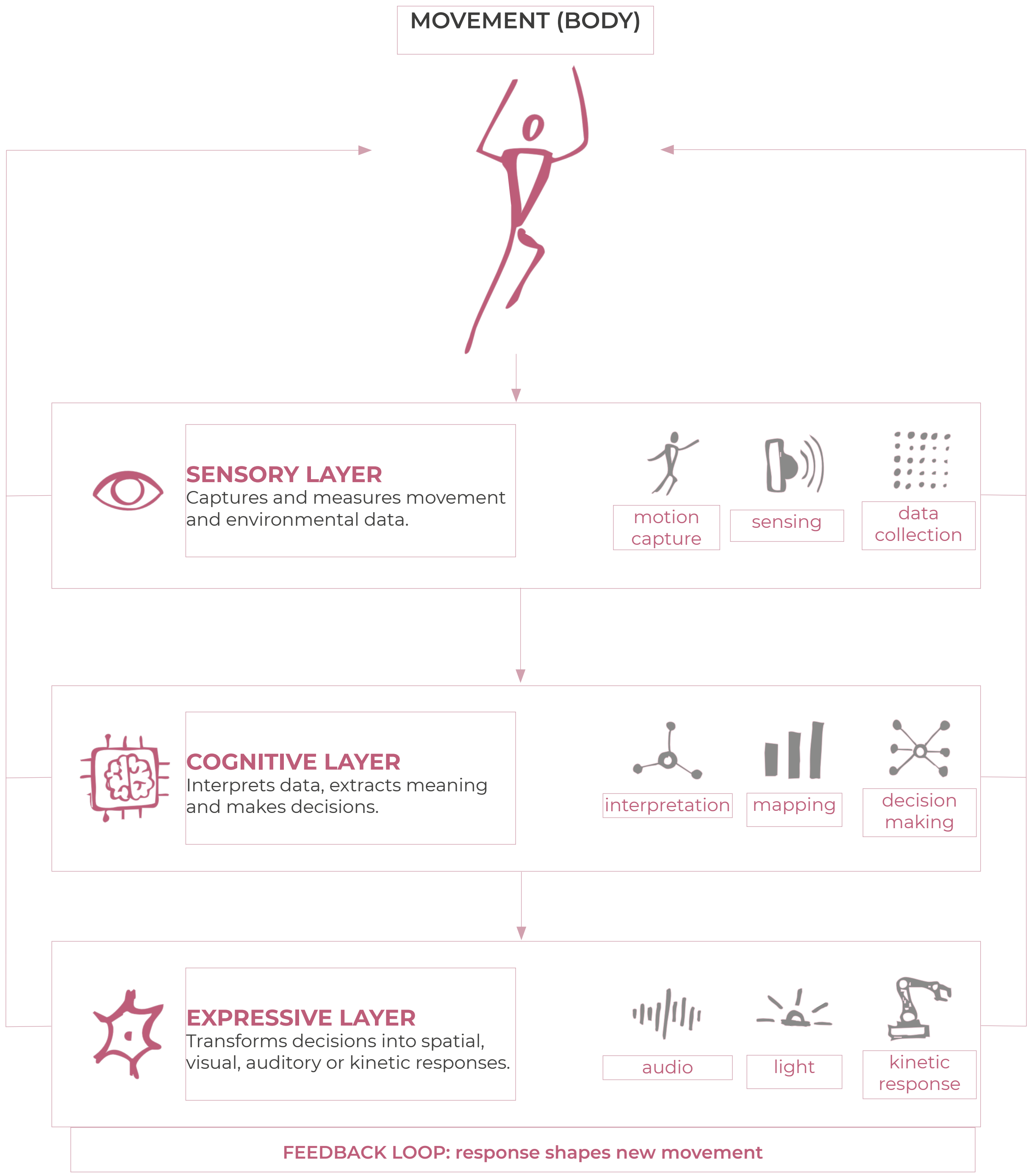


Figure 5.:Sensory, Cognitive, and Expressive Layer Model (Author, 2026)

Experimental Prototyping

The development process builds on the methodology of iterative prototyping, within which it creates a series of targeted experimental probes. These isolated systems serve to verify hypotheses in the field of interactive design and to seek optimal synergy among the three key pillars.

These prototypes function as individual testing environments. Within them, the complex relationships are deconstructed into measurable parameters, allowing for a precise evaluation of the effectiveness of particular solutions, ranging from the sensitivity of triggers based on hand movement dynamics, through algorithms that transform gesture speed into visual aesthetics, to spatial reactivity influenced by the user's distance and presence.

Through repeated cycles of testing and improvement, the experiments gradually evolve into a more integrated interactive environment where physical activity, computational logic, and the atmospheric qualities of the space are interconnected into a single functional system.

Evaluation

The developed prototypes are qualitatively evaluated through observation of the interaction between the participant and the spatial system. The evaluation focuses on the experiential and behavioural aspects of the interaction rather than purely technical performance.

Particular attention is paid to:

- **the clarity and legibility of the interaction between the body and the space**
- **the coherence between movement characteristics and spatial responses**
- **the emergence of exploratory or playful behaviour among participants**
- **the extent to which the system fosters a sense of reciprocity between the participant and the surroundings**

These observations provide insight into how interactive architectural systems can influence bodily behaviour and spatial perception, and inform the further refinement of interactive design

DELIMITATIONS

This research operates within several conceptual, methodological, and technical limitations that define the scope of the investigation.

1. FOCUS ON HUMAN MOVEMENT

First, the study focuses specifically on human movement as the primary interface for spatial interaction, using dance as a representative form of expressive bodily motion. Although other forms of interaction, such as voice or touch, could also be explored, these fall outside the scope of this research.

2. FOCUS ON SPECIFIC SENSORY OUTPUTS

Second, the research focuses on specific sensory outputs, particularly visual, auditory, and kinetic responses, such as light modulation, projection, and mechanical movement. Other sensory modalities, including smell, temperature, or tactile feedback, are recognized as relevant to a multisensory architectural experience but are not implemented at this stage due to technical limitations.

3. PERFORMATIVE INSTALLATION AT SMALL SCALE

Third, the project is developed as a performative installation rather than a full-scale architectural building. Experiments are conducted on a small scale. The findings should therefore be understood as a conceptual exploration of interactive architectural behaviour rather than specific construction solutions.

4. TECHNOLOGICAL IMPLEMENTATION

Fourth, the technological implementation relies on available motion tracking systems, including Kinect, MediaPipe, and TouchDesigner. Although these technologies enable real-time interaction and quick prototyping, they present limitations in terms of tracking accuracy, environmental sensitivity, and computational complexity.

5. NOT A COMPLETE SYSTEM

Ultimately, the research does not aim to create a broadly applicable interactive system. Instead, it proposes a conceptual and experimental framework for understanding how architecture could function as a performative spatial agent capable of sensing, interpreting, and responding to human movement, pushing architectural thinking beyond static forms.

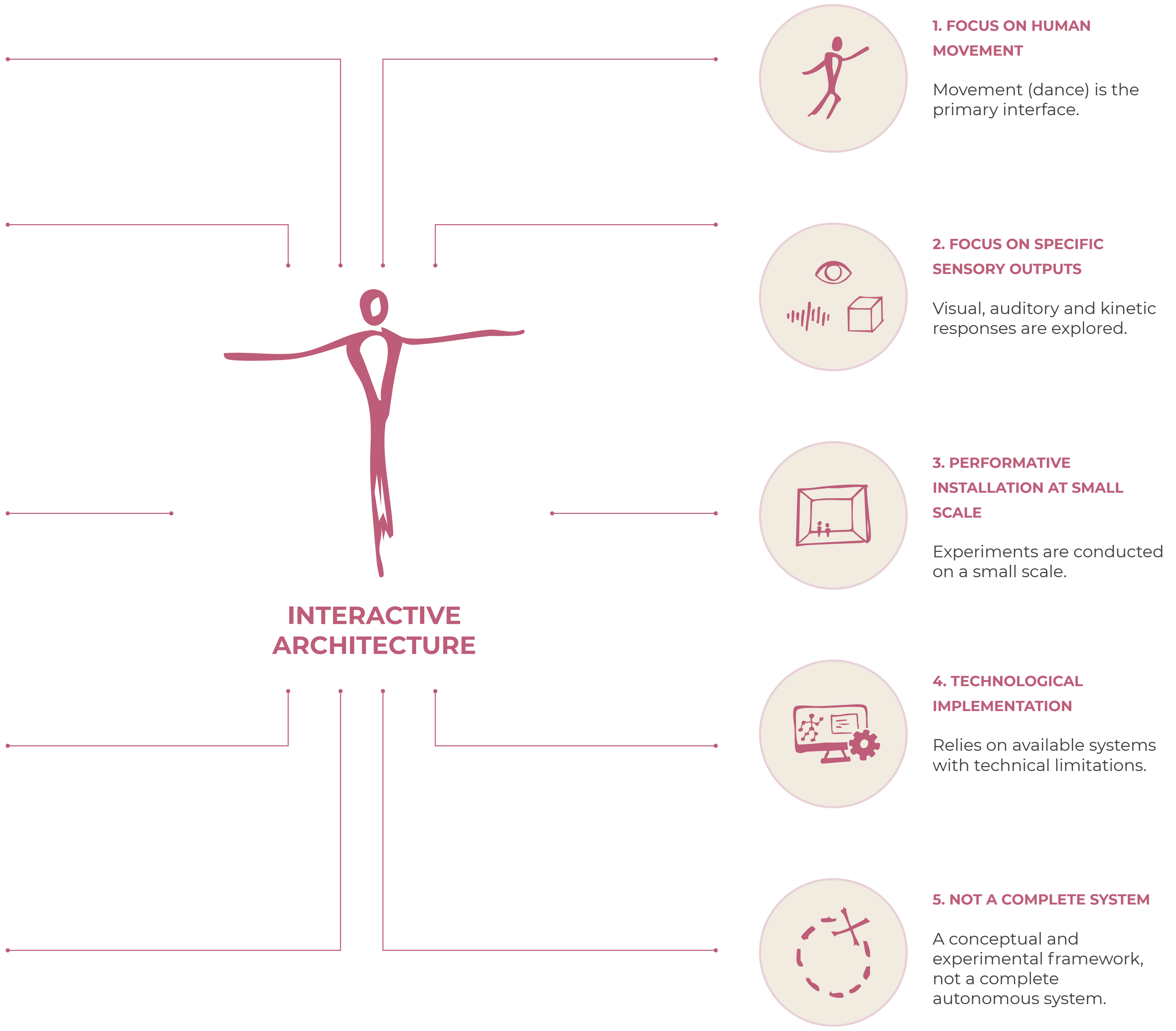
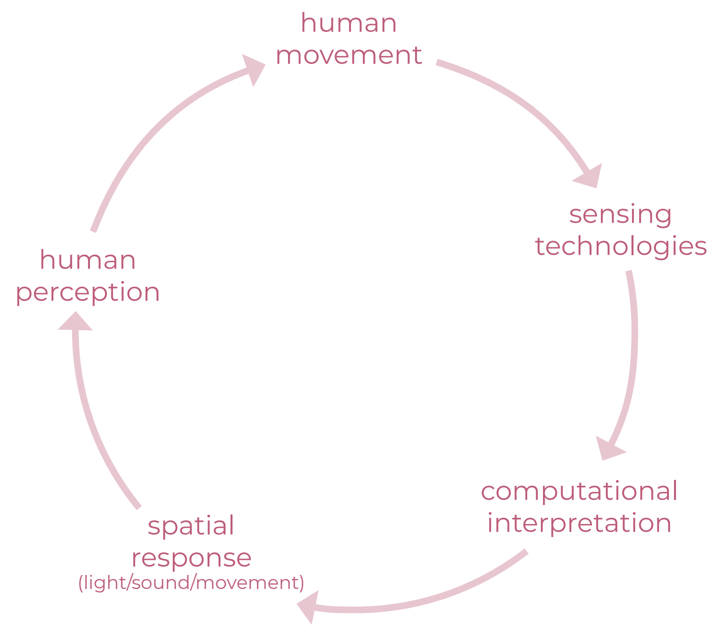


Figure 6.:Research Delimitations Diagram (Author, 2026)

THEORETICAL GROUNDING

Contemporary architecture is experiencing a fundamental transformation that goes beyond the traditional understanding of space as a static object. Continuous development of Information and Communication Technology (ICT) has pushed the boundaries of architectural design towards dynamic systems, which enabled the emergence of intelligent, responsive and interactive environments, where buildings and installations become active participants in communication with humans. This shift represents a deflection from architecture as "hard" construction to architecture as an environment of behaviour, response and information sharing. (Lee et al., 2021) While stability, control and durability are represented in traditional spaces, the contemporary approach is progressively characterised by change, adaptation and reaction, not only within the technological framework, but also in the way of thinking and understanding. Architectural space thus ceases to be a backdrop and becomes an actor/partner in interaction with humans. It is in this context that the question arises of how movement and the body, the fundamental carriers of human presence, can be understood as a language of communication with space. The answer lies in the intersection of architecture, performative art and interactive design. The master's thesis, therefore, aims to research interactive architecture in relation to dance, which becomes a medium through which a new form of relationship among body, technology and space is explored.

The Cybernetic Ontological Shift
The shift from "hard" architecture as a stable structure towards behavioural architecture is theoretically supported by cybernetics, a theory that considers the environment to be a system of communication, regulation, and adaptation rather than the sum of immutable objects. Pask (1969) redefines architecture as a "compilation of active systems" rather than a static object of matter consisting of isolated technical "tools." Architecture and cybernetics both have a common focus on organising relationships between humans and the environment through feedback and adaptation. Architects function in this framework as "systems designers" that orchestrate the invisible properties of development, communication, and control. They create a system that senses, interprets, and responds to changing conditions, including human movement, making the spatial experience constantly negotiated rather than predetermined. As a result, traditional architectural functionalism is refined into "mutualism," which defines the environment not as a tool but rather as a cooperative space where the user can "externalise their mental processes" (Pask, 1969). The integration of second-order cybernetics broadly reinforces the theoretical basis for the position of the designer and participant/observer as part of the process of self-organisation of the system (Fischer and Herr, 2019). Movement and the body become a "language" of communication with space, in which output (architectural response) becomes new input (human perception and behaviour), creating a continuous cycle of exchange (Pask, 1969).



Interactive architecture
According to Lee et al. (2021), interactive architecture can be understood as an extension of an intelligent environment defined by a constant dialogue between Interactive behaviour (IB) and collective behaviour (CB). Interactive Behaviour represents visible changes such as physical transformation of forms or the modification of the environment (changes, movements), while Collective behaviour can be explained as a hidden sensing, thinking and controlling processes that process information and conduct IBs (p.2). Responsive and kinetic architectures function as transitional models in the evolution of interactive environments and represent intermediate steps towards the behavioural and communicative properties of physical systems.

Responsive architecture operates primarily through reflexive mechanisms: it alters its form or atmospheric characteristics based on environmental data and predefined parameters, functioning through an unidirectional stimulus–response logic. Its Interactive Behaviours (IBs) include mechatronic actions such as delta-robot kinematics, material adaptations through Shape Memory Alloys (SMAs) or other smart materials, spatial adjustments in geometry, colour, or light. Meanwhile, its Collective Behaviours (CBs) encompass environmental sensing (temperature, humidity, sun-tracking) and control mechanisms. Internal, when the system self-adjusts based on stimuli like CO_2 or precipitation, and external, when decisions are governed by centralised computation and algorithmic feedback loops. While these systems successfully translate environmental information into physical change, they remain largely reflexive (Lee et al., 2021). The environment reacts to stimuli but does not yet engage with its users.

The distinction between these behaviours can be fundamentally reinforced by shifting the conceptual framework towards second-order cybernetics. While responsive systems typically operate on first-order cybernetic principles, using linear feedback loops to maintain environmental constants, interactive behaviour represents a transition to circular causality, where the environment and user are included in a single, self-organising system. In this regard, true interactivity is characterised by a transition from what Heinz von Foerster defines as a "trivial machine" to a "non-trivial machine." A trivial system is characteristic of simple reactive architecture and performs predictable, one-way responses to specific triggers. In the other case, a non-trivial architectural system has internal conditions or memory that change with each interaction, which means that its subsequent outputs depend not only on the current inputs, but also on the prior record of its interactions with the user.

A mutualistic environment, in which the building is no longer just a tool but a cooperative partner, facilitates a dialogue loop in which the system perceives the affective nuances of human movement, transforms its own internal state, and produces a kinetic response that serves as new input for the user. Mun (2023) points out that this form of interactivity is cyclical, bidirectional, and affective, involving a continuous exchange of energy, information, and meaning. (p. 8-9).

Kinetic architecture further expands responsiveness into a spatial and expressive dimension. Utilising mechanical and movable structures that often metaphorically evoke biological processes, such as folding, breathing, or transforming forms that suggest life and movement. Its IBs involve structural adaptivity through folding mechanisms, kinetic skins, retractable units or smart material deformations. Advanced actuation and sensing networks are included in CBs, which are often scenario-based, integrating physical performance with computational simulation. Even though kinetic architecture extends responsiveness beyond purely environmental adaptation and introduces movement as a communicative and performative act, its motion is typically predefined and functional rather than interpretive. The system, therefore, exhibits motion but not yet intention.

The transition toward true interactivity emerges at the intersection of these two paradigms. From responsive architecture, interactivity has inherited its capacity for sensing, adaptation, and data-driven control. From kinetic architecture, it has adopted embodied motion and spatial expressivity. A key distinction of true interactivity is the autonomy that enables independent actions and adapts when there is no direct interaction input, through its internal logic, embedded algorithms, or randomised processes (Mun, 2023). To achieve the status of a partner, architecture must comply with the principle of necessary diversity to ensure its internal complexity matches the diversity of human behaviours it seeks to engage. The system no longer reacts in isolation but enters into a circular dialogue with the user, perceiving, interpreting, and transforming its responses according to the qualities of human movement. This marks a shift from architecture as an adaptive object to architecture as a performative subject. A space is capable of sensing the affective nuances of motion and expressing its own rhythm in return.

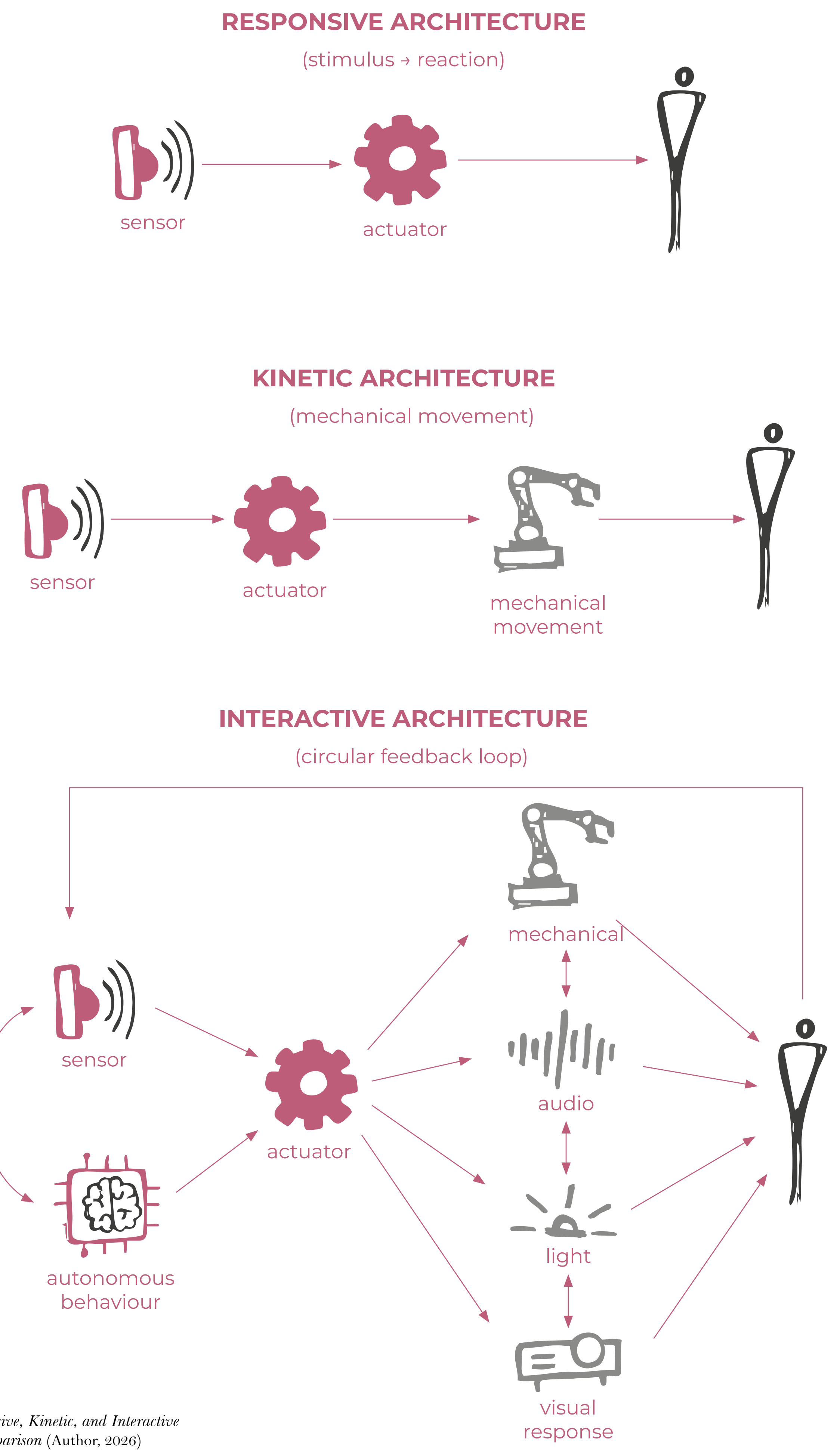


Figure 7.:Responsive, Kinetic, and Interactive Architecture Comparison (Author, 2026)

Embodied interaction and body performativity

The traditional approach to technology was based on the principle of control wherein the user enters the system via an interface, enters commands, and obtains results. This "input–output" model is typical for human-computer interaction (HCI) and treats the environment as a passive recipient of instructions (Mun, 2023). In architectural research, however, this paradigm is increasingly being replaced by the concept of embodied interaction, which refers to how human cognition, perception, and action are realised through the physical body. Unlike the traditional model of computer control based on visual commands, embodied interaction emphasises movement, gestures, rhythm, and physical presence. In this sense, the logocentric Cartesian paradigm of „I think, therefore I am" is shifted by prioritising embodied experience into „I experience, therefore I am" (Simanowski, 2011).

Interactive installations serve as a medium in which "the body becomes an interface." (Fleischmann and Strauss, 1995, as cited in Simanowski (2011). Here, interaction is not merely a cognitive act, but a sensory and affective process. The body is a source of both data and meaning. David Rokeby already applied this principle in his work Very Nervous System (1982–1990), where the body becomes an interface and music a direct response to movement. Rokeby points to the need for intuitive interaction that balances technological rationality with sensuality and physicality. (Simanowski, 2011). In this spirit, the dancer's movement serves as an ideal medium for exploring this relationship. The dancer's movement is not simply functional, physical activity or a technical input, but a form of conscious movement, an alternative language that conveys intention, rhythm, and mood. When architecture becomes a partner in this dialogue, a spatial performance emerges, a space that responds, feels, and communicates alongside the performer.

This transition from command-based interaction to embodiment-based interaction represents a significant change from controlling the environment to connecting with it. In design cybernetics, systems are understood as influencing one another through reciprocal, circular interactions, in which meaning and behaviour arise from the relationships among components rather than from unidirectional manipulation (Fischer and Herr, 2019). As a result, the dancer participates in feedback characterised by looped causality. Mutualism views the artist and the environment as engaging in a cooperative dialogue, where each action is a response to the previous state (Pask, 1969).

In this loop, the dancer's movement becomes immediately perceptible to the body, shaping the quality and intention of the next movement, rather than creating a spatial response that merely serves as an output. It creates a generative process where the body and the environment adapt to each other in real time. True embodied interaction allows it to perceive affective nuances and respond as an autonomous performative subject. This constant process of perception, transformation, and response ensures that interaction is not just a collection of isolated triggers, but a shared act of transformation between the person and the architectural surroundings.

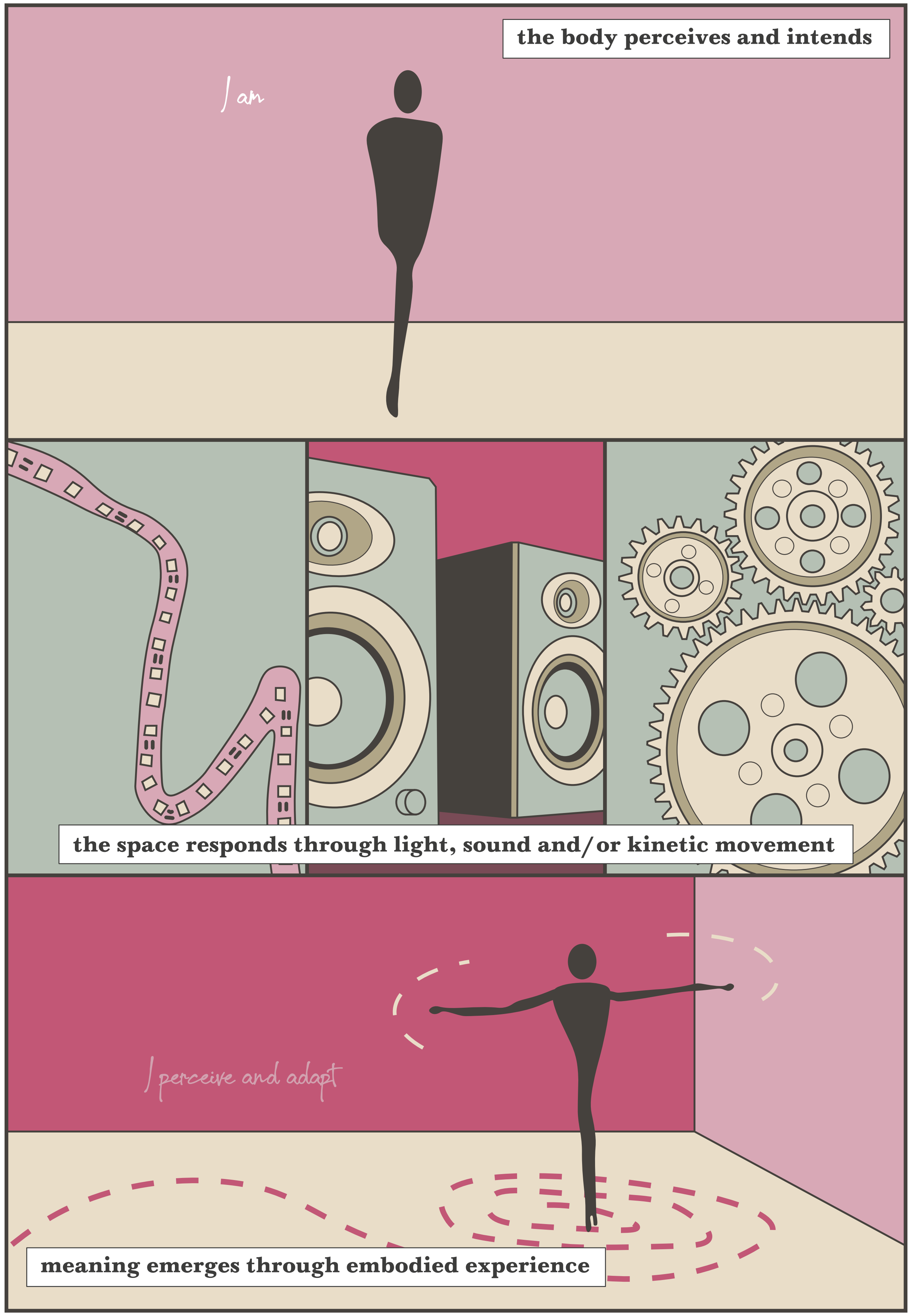
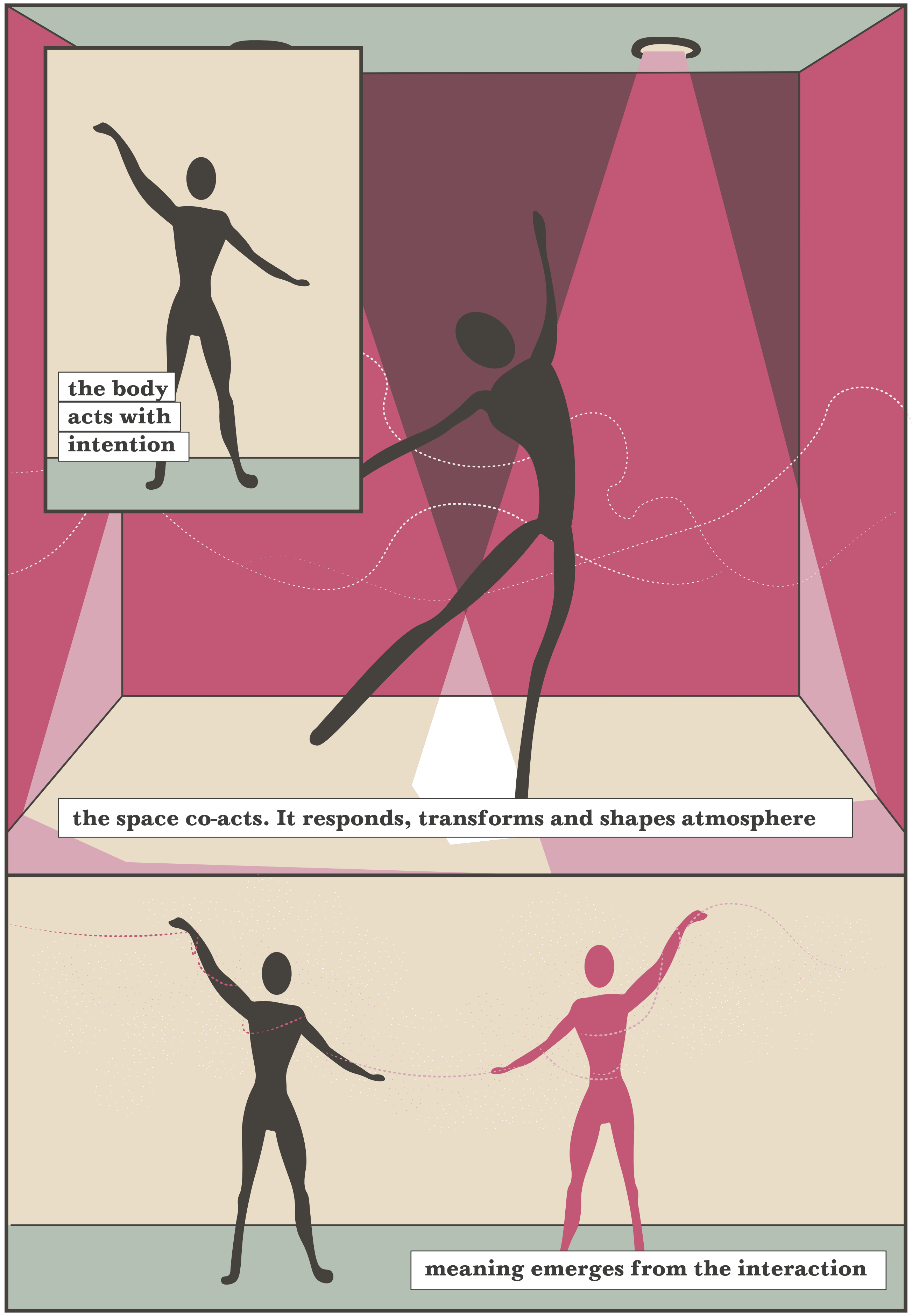


Figure 8.:Embodied Feedback Loop (Author, 2026)

A continuous dialogue where body and space adapt to each other. Meaning emerges through embodied experience



A choreography between body and architecture. The space is not passive, it performs with you.

Figure 9.:Body and Architecture as Co-Performers
(Author, 2026)

Performative Architecture and Poetry of Interaction,

Interactive architecture builds on the concept of performativity, understanding architecture as an action, not as an object. Every change in light, every movement of a wall, or change in tone of sound is an act that has both a visual and a semantic dimension.

This conception of architectural behaviour is in line with Meagher's theories of responsive architecture, where building elements become dynamic interfaces between environmental conditions and human activity, and thus design not only gains meaning through technical performance, but also by detecting patterns of human activity. As Meagher (2015) argues, responsive building elements can act as expressive components that mould changing environmental conditions and reveal the "choreography" of spatial behaviour within the built environment (p. 162). The systems translate environmental or residents' behavioural changes into spatial transformations through mechanisms of sensing, calculation, and activation. In this sense, architecture functions as a feedback-based system that is capable of adapting to external stimuli and internal patterns of use, so that the environment can actively participate in creating the spatial experience, rather than only providing a passive static backdrop for human activity (Meagher, 2015). Such feedback relations between user behaviour and spatial response correspond to the cybernetic models of interaction, in which the surroundings and inhabitants constantly and mutually influence each other.

Simanowski (2011) points out that a performative environment must balance immersion and distance: immersing the participant in the experience, but at the same time allowing them to reflect (p. 9). This balance distinguishes architectural performance from a purely technical attraction. Mun (2023) takes this aspect further, claiming that interaction acquires a cognitive and affective dimension if it allows a person to feel meaning and agency. A space that responds with a certain degree of unpredictability creates a moment of surprise and discovery (p. 11). Mun (2023) talks about the strategy of "imperfection to emergence" that is, the deliberate integration of uncertainty that encourages curiosity and engagement, providing an open-ended approach, personal association, controlled and out-of-control elements generally providing unpredictability (p. 20-22). This principle is evident in many works of interactive art, for instance, in the installation Rain Room (Random International, 2012), where sensors turn off the rain around the visitor. Although the system works precisely, the result is poetic: a person stands in the rain and does not get wet. Technological precision creates an emotional paradox that transforms an ordinary experience into an introspective moment. (p. 49-50)

Multisensory Perception and Spatial Atmosphere,

Spence (2020) points out that 20th-century architecture was long affected by oculocentrism, an emphasis on the visual aspect at the expense of other senses. More than half of the cerebral cortex processes visual stimuli, but sensory experiences are, in fact, complex and interconnected. As a result of the unifocal approach, many spaces have become psychologically unbalanced. Ignoring sound, touch, or smell can lead to Sick Building Syndrome or sensory deprivation (p. 2). On the contrary, multisensory architecture understands space as a synesthetic system. Sensory congruence, harmony between the individual modalities, is crucial (p. 16). Böhme (2016) refers to this combination of sensory and emotional qualities as atmosphere, an invisible field that shapes our relationship to space (p. 14). According to Spence (2020), sensory congruence is key, representing harmony between individual modalities, and is therefore crucial. If the visual, auditory, and haptic levels support each other, a fluid and positive experience is created. If they diverge, cognitive dissonance occurs. Therefore, interactive spaces must consider the choreography of the senses, how light reacts to sound, how sound affects the rhythm of movement, and how warmth and touch modulate mood (p. 16-18). This principle is perfectly illustrated by the Mapped Empathies project (Requena, 2018), where sensors detect visitors' heartbeats and transform them into a symphony of light and sound. The space becomes an emotional organism that responds to the collective rhythm of the bodies present. It is architecture, it is dance, as a rhythmic and physical form of perception, that allows this harmony to be recognised and transmitted. When body movement is projected into a change in light, sound, or material, architecture is created as a synesthetic experience, a bridge between perception and emotion.

This approach can be further understood if we consider sensory congruence to be a design limitation of interactive environments. When we understand interactive space as an environment that communicates through various dynamic outputs, such as light, its intensity, acoustic feedback, or material transformations, then we can see that the semantic coherence of these outputs determines whether the system is perceived as comprehensible or confusing, as a source of cognitive dissonance for the body. This perspective resonates closely with the emphasis in design cybernetics, which considers interaction to be a "negotiated process" of feedback between the system and the user (Fischer and Herr, 2019). Under these conditions, a system that produces unstable or contradictory responses effectively disrupts the bidirectional dialogue or interaction loop, which reduces the clarity of communication and the feeling of residents that they have influence over their environment (Fischer and Herr, 2019). Conversely, when sensory outputs are harmonised with movement characteristics and atmospheric intention, interactivity becomes readable. This intelligibility allows architecture to exceed its role as an unpredictable, machine-like responder and instead function as an expressive partner in a shared spatial performance.

Social Dimension,

Interactivity has not only an individual but also a social dimension. Miccoli, Bakogianni and Fatah gen. Schieck (2015) showed in their study Breathing Display that responsive environments in urban spaces can create new forms of social cohesion. Their installation, which responded to the presence of passers-by with breathing movements was built on the concept of shared encounters, „the interaction between two people or within a group where a sense of performative co-presence is experienced by mutual recognition of spatial or social proximity“ (Wills et al.,2010, as cited in Miccoli et al., 2015), and demonstrated a phenomenon called the honey-pot effect when people joined when they saw others interacting (Brignull and Rogers, 2003, as cited in Miccoli et al., 2015). Architecture understood in this way becomes a social catalyst. It enables spontaneous encounters, a sense of belonging, and shared experiences. In contrast to traditional urban objects that regulate behaviour, interactive installations relax the rules and encourage playfulness. From the perspective of architectural experience research, this means that space can be a mediator between people. It creates situations that are not only aesthetic but also social. The architect thus becomes a curator of relationships, not just shapes.

Beyond the experiential and social dimensions mentioned above, interactive architecture can also be understood and interpreted as a systemic and processual phenomenon that operates within broader urban and technological networks (Romero and Leal, 2022). The social dimension of interactive environments could also be interpreted through a cybernetic lens that perceives architecture as a mediating system within a broader social ecology (Fischer and Herr, 2019). Pask (1969) argues that architects are paying increasing attention to the nature of organisational and behavioural systems, suggesting that architecture cannot exist detached from the dynamics of human communication and collective behaviour (p. 70). In responsive settings, this systemic interaction necessitates the management of complexity, which cybernetic theory describes through Ashby's Law of Requisite Variety (as cited in Fischer and Herr, 2019). Following this principle, a control system, such as an interactive building, remains stable as long as its internal capacity to respond corresponds to the diversity of environmental and social conditions it encounters (Sáez Vacas, 1991). This understanding of systems aligns with Vidler's (1977) "Third Typology," in which architecture is described not as an isolated object but rather as a component defined by its connections to the urban environment (as cited in Romero and Leal, 2022, p. 1). Furthermore, models such as "Shearing Layers of Change" highlight the temporal differences between permanent structural elements and rapidly evolving technological components (Meagher, 2015). By reflecting this dynamic relationship and taking these changes into account, architecture opens up the possibility of using participatory design methods, in which inhabitants become key actors in the process of the constant transformation of their surroundings. (Romero and Leal, 2022). Interactive spaces sensitive to group dynamics serve as tools for social coordination through the generation of collective stimuli and experiences. Through this process, interactivity can foster a sense of belonging and shared presence. From this perspective, architects become less designers of fixed forms and more creators of relational arrangements, where rules of interaction and feedback influence how people encounter each other in space (Pask, 1969).

Gestures, movement qualities and interpretation,

Research by Fehr and Erkut (2015) in the LichtGestalt project provides an important theoretical framework for understanding the relationship between gesture, movement quality, and spatial response. The authors use Laban Movement Analysis (LMA), which allows gestures to be classified according to four parameters: Activity, Energy, Directivity, and Consistency (p.3). These parameters are a tool for translating movement into data that carries information about expression and intention. Laban's model functions here as a "grammar". It allows us to read bodily expression not as a random signal, but as a structured language of interaction, whose syntax can be implemented into an architectural system through light, sound, or kinetics. From this perspective, gesture becomes a way of communicating with space. The quality of movement determines the quality of the system's response. If the movement is fluid and focused, the response may be soft and continuous. If it is jerky and energetic, the space may respond with a faster rhythm or a change in intensity (p. 2). Fehr and Erkut (2015) point out that it is precisely this relationship between physical expression and the modality of response that is the key to the transition from pure technological responsiveness to performative interactivity (p. 1). That builds a situation in which gesture and space become equal partners in dialogue. Empirical support for this principle is provided by the Breathing Display study (Miccoli et al., 2015), which examines how different types of interactive system responses are reflected in people's behaviour and interpretation in space. The installation simulated "breathing" through changing movements and light intensity, with the authors testing three response variants: 1) a smooth change in movement intensity according to the distance of the person, 2) stopping movement when approaching, 3) activation of movement only when presence is detected. The results showed that it was the smooth, gradually changing response that elicited the highest level of engagement and physical interaction. People intuitively reacted, slowed down, stopped, or mimicked the rhythm of "breathing". However, suddenly turning the movement on or off seemed technical and disruptive, losing the sense of continuity between the body and the environment. The authors interpreted this as evidence that the quality of timing and gradation of response fundamentally influences the way a person perceives an interactive space, either as a living organism or as a mechanical object (Miccoli et al., 2015). Combining both studies provides a comprehensive view of interaction. Fehr and Erkut show how gestures can be translated into data and system behaviour, while Miccoli et al. reveal how qualitative characteristics of responses retroactively shape the interpretation of gestures. Together, they suggest that interactive architecture should work with the dynamics of response as an expressive element, that the timing, intensity, and fluidity of the response are as important as the content or technology of the response itself. From this perspective, architecture becomes a choreographer of sensory and motion responses. The environment responds to the dancer's gesture, but at the same time offers a rhythmic and emotional framework that influences their further movement. The gesture is therefore not only an entry into the system, but also a mirror of one's own expression. Its interpretation arises in a constant exchange between the body and space

Cognitive metaphors,

Human understanding of space is deeply rooted in metaphorical thinking. Pitt and Casasanto (2022) explain Lakoff and Johnson´s (1980) theory of conceptual metaphors (CMT), which holds that human thinking is deeply anchored in spatial images: up is good, right is the future, left is the past (p. 2). These so-called CORE principles (Correlation in Experience) are universal frameworks that influence how we intuitively read movement and orientation and shape our emotional response (p. 10). In interactive architecture, this theory has practical implications as it supports the cognitive fluency and comprehensibility of the system. Upward movement is often associated with positive tension, transcendence, or a feeling of euphoria, while horizontal movements express the passage of time, continuity, and permanence (p. 4–6). Architecture that works with dance can consciously use these mental metaphors and transform abstract concepts into physical gestures. This approach allows for the creation of spaces in which movement becomes a visual and acoustic translation of thinking, a space that "thinks" in metaphors, thus stimulating cognitive activity and promoting introspection. Architecture that "dances back" allows the user to perceive their movement as part of a larger mental space

Precedents of an interactive environment

The following precedents are analysed to demonstrate how interactive environments transform human behaviour into responsive spatial phenomena. Rather than serving solely as stylistic references, these projects are examined through the analytical lens of the sensory–cognitive–expressive interaction framework developed in this paper. Chosen projects serve as conceptual references that illustrate how responsive architectural systems mediate relationships among human movement, technological processes, and spatial atmosphere. Responsive spatial systems, including embodied gesture, collective participation, affective sensing, and kinetic spatial expression, are demonstrated by individual installations. Their examination reveals integration of sensing technologies, computational interpretation, and spatial response in interactive environments.

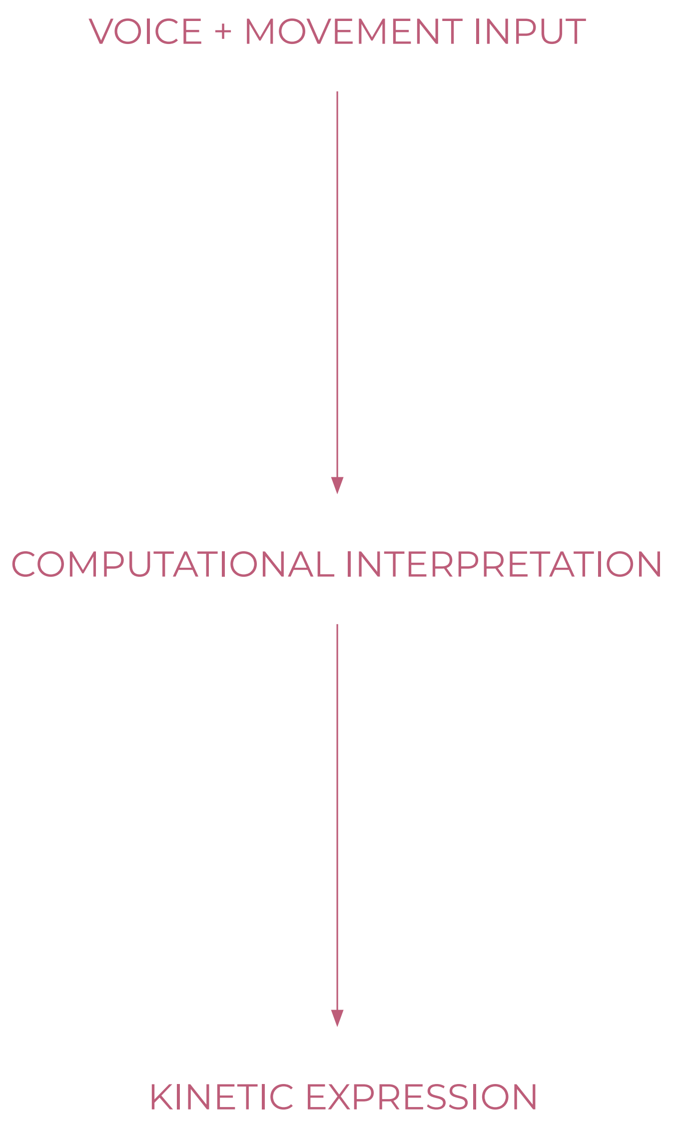


Figure 10.:Precedent Diagram: Voice and Movement Input (Author, 2026)

Embodied interaction and Gesture

Messa di Voce
Golan Levin and Zachary Lieberman (2004)

Messa di Voce is an interactive audiovisual installation that investigates how bodily expression and vocal performance can be translated into responsive visual environments.

The piece Messa di Voce (2003), created by Golan Levin and Zachary Lieberman, sets a precedent in the field of performative interactivity through the conceptual framework of "In-Situ speech visualisation." The project explores the question of what speech might look like if it could be perceived visually and proposes a form where graphic representations of sound emerge directly from the speaker's mouth (Levin and Lieberman, 2004). The installation integrates real-time capture, speech analysis, and generative graphics to create a tight connection between the performer's body, voice, and visualisations such as fluid simulations, elastic meshes, and particle systems. The system tracks head position and body orientation, while simultaneously extracting parameters such as pitch, volume, and spectral content to ensure a spatio-temporal link between the body and its digital extension (Levin and Lieberman, 2004). Instead of functioning as a passive projection surface, the environment becomes an interactive medium through which the performers can influence the visual elements generated by their own sound production.

A characteristic of this work is that the visual elements not only represent sound but also function as interactive interfaces. During certain parts of the performance, graphic objects generated by vocals can be manipulated by the performers' bodies or shadows, creating a feedback loop between voice, movement, and visual response. Through this mutual interaction, Messa di Voce demonstrates how reactive systems can interpret bodily expression and transform it into spatial behaviour.

The project thus highlights the potential of sensing, computational interpretation, and visual expression to form a feedback loop between the human body and its digital environment, forecasting the interactive principles on which interactive design systems are based.

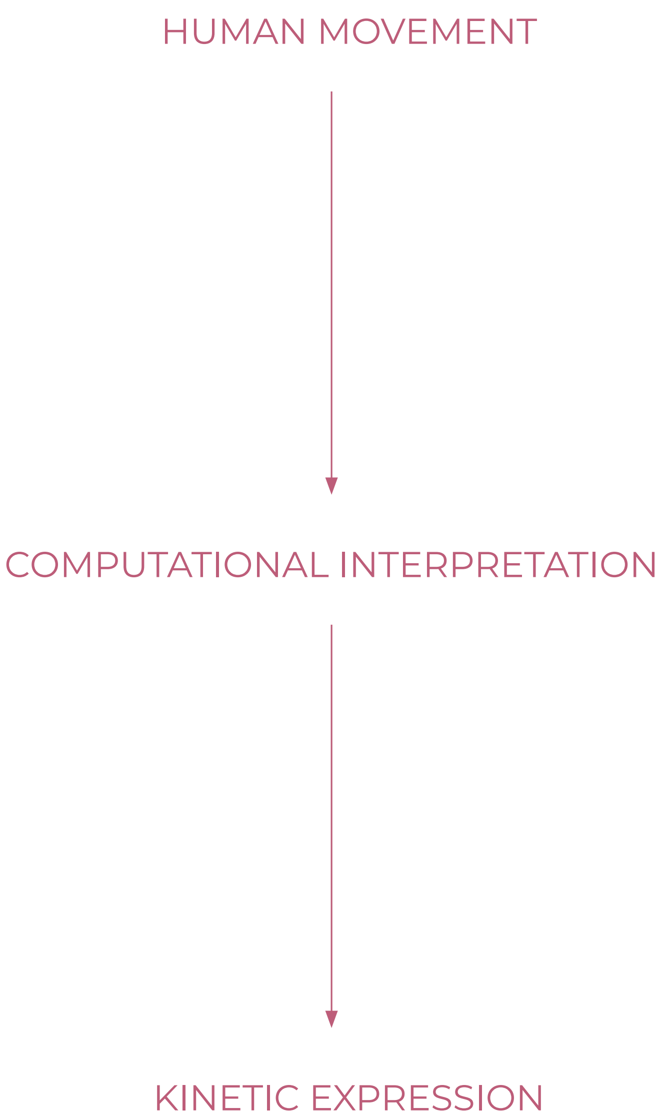


Figure 11.:Precedent Diagram: Human Movement and Kinetic Expression (Author, 2026)

Relational Interaction and Collective Behaviour

No One Is an Island
Random International and Studio Wayne McGregor (2020)

No One Is an Island is a multidisciplinary installation that explores how computational systems can interpret human movement and translate it into kinetic spatial behaviour.

No One is an Island is a multidisciplinary installation produced by Random International in collaboration with Wayne McGregor's studio. First presented in 2020 with the support of BMW i and Superblue. The project blends sculptural installation, choreography, and digital media to explore the relationships between human movement, artificial intelligence, and automated systems (Random International, 2020).

At the centre of the work stands a kinetic sculpture titled Fifteen Points / II, which explores how minimal visual information can evoke the perception of the human body in motion. The installation explores how a small number of moving points can suggest human behaviour and examines the threshold at which viewers recognise an animated form as human (Random International, 2020).

The installation is complemented by choreographed performances by dancers from Studio Wayne McGregor, whose movements conceptually interact with the sculptural system and extend its exploration of the relationship between human and mechanical motion. Through this interaction, the project reflects on the ongoing dialogue between embodied human action and computational interpretation (ArtReview, 2020).

The No One Is an Island project illustrates, within the context of interactive environments, how computational systems can reinterpret human movement and translate it into expressive mechanical behaviour. In this way, the project highlights the role of algorithmic processes as mediators of relationships between human bodies, technological systems, and spatial perception. Using the interactive framework developed in this research, the installation demonstrates how bodily movement can be analysed and transformed through computational interpretation, subsequently expressed through kinetic spatial systems.

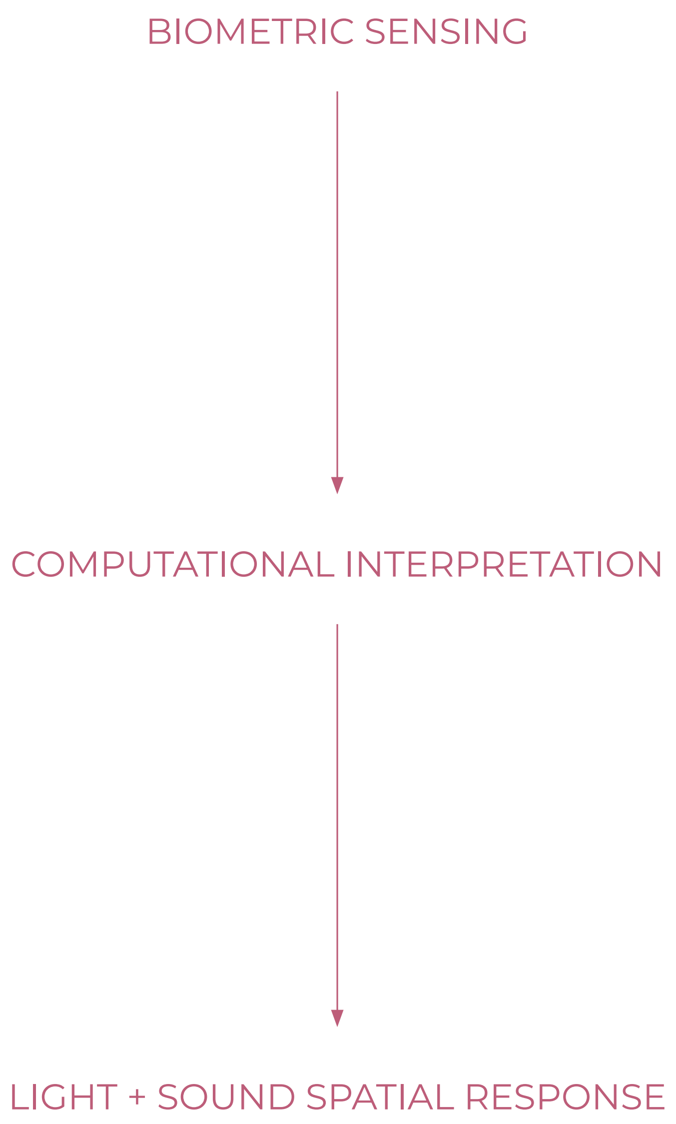


Figure 12.:Precedent Diagram: Biometric Sensing and Spatial Response (Author, 2026)

Mapped Empathies
Estudio Guto Requena (2018)

Mapped Empathies is an interactive installation that explores how biometric data, such as heartbeat, can be translated into audiovisual spatial responses, revealing emotional connections between participants.

The work Mapped Empathies (2018), created by Estudio Guto Requena in São Paulo, represents a precedent in the field of "performative urban furniture" that uses biometric data to foster meaningful shared spatial experiences (Requena, n.d.). Installed as a public bench, the project invites visitors to interact with sensors built into the structure. Participants place their fingers on biometric sensors that record their heart rate, which are then processed through generative music software and translated into a synchronised symphony of light and sound. This technical setup illustrates a sensory-cognitive-expressive loop where the sensory layer registers the heartbeat, the cognitive layer (software) interprets this biological input, and the expressive layer materialises it through multimodal atmospheric transformations.

The installation investigates how digital technologies can expose and strengthen emotional bonds between individuals in public spaces. Each participant's heartbeat is recorded in real time and transformed into audiovisual patterns that other users within the installation can perceive. Through this process, internal physiological signals become part of a collective spatial experience, allowing participants to sense the emotional rhythms of others within a shared setting (Requena, n.d.).

The theoretical significance of the project lies in its ability to transform an architectural intervention into "a large sculpture of emotions," thereby blurring the ontological boundaries between physical infrastructure, digital technology, and human emotion. Through the visualisation and sonification of inner bodily conditions, the installation contributes to a mutualistic principle in which participants are connected through a shared, immersive sensory experience. This aligns with Böhme's (2016) concept of atmosphere as the temple-like form and harmonic feedback create a contemplative environment that modulates the collective mood of the public space.

Mapped Empathies ultimately demonstrates how architecture can exceed its role as a static container and become an "emotional organism" that actively participates, using biometric sensing to generate interactive spatial behaviour. The design illustrates how sensors register subtle physiological signals, which are then translated and interpreted through environmental change. This installation emphasises how reactive environments can transform human emotions into spatial phenomena.

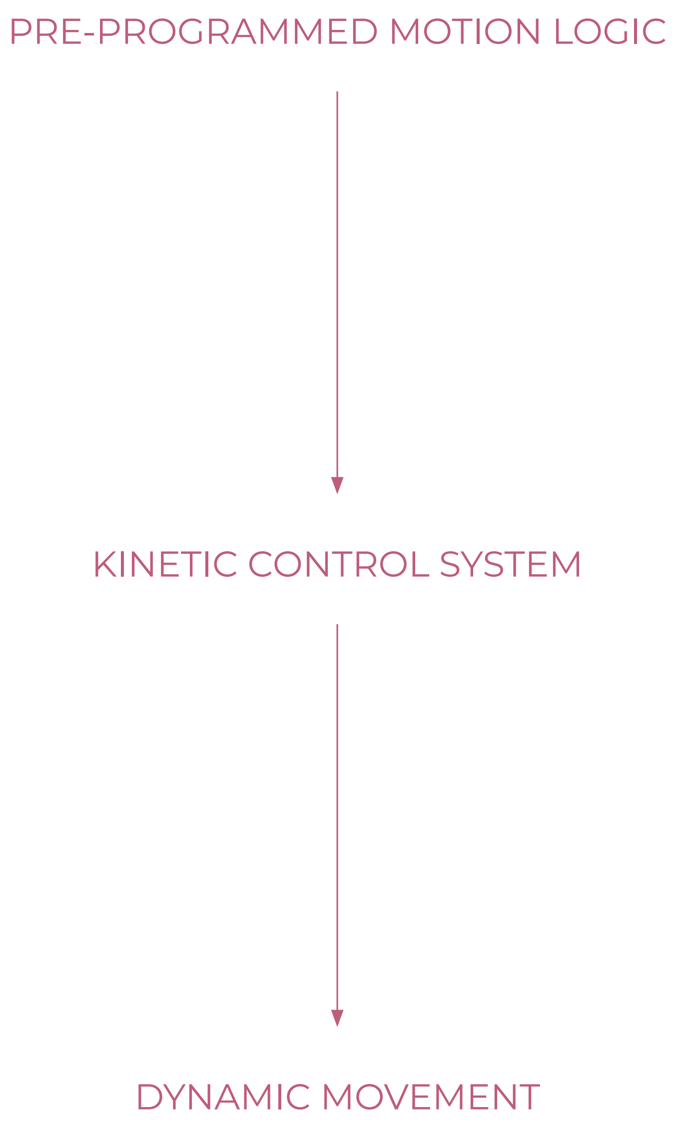


Figure 13.:Precedent Diagram: Pre-Programmed Motion Logic (Author, 2026)

Kinetic, Atmospheric and Expressive Spatial Systems

Shylight
Studio Drift (2014)

Shylight is a kinetic light installation that investigates how choreographed movement and illumination can transform the atmospheric perception of architectural space.

Shylight is a kinetic light installation created by the design studio Studio Drift in Amsterdam. The installation features suspended silk luminaires that move in an architectural space according to pre-programmed, choreographed pattern sequences. Using a system of robotic mechanisms, each light element unfolds, drops down, and closes again, creating a dynamic interplay between light, movement, and the perception of space (Studio Drift, n.d.)

The design concept was inspired by the natural phenomenon of nyctinasty, a biological event in which specific flowers open and close in response to environmental conditions. Turning this natural process into mechanical movement, the artwork experiments with how artificial objects can mimic organic motion and communicate emotional or atmospheric qualities (Studio Drift, n.d.).

Located in the Philips Wing of the Rijksmuseum in Amsterdam, the dynamic sculptures create a constantly changing spatial experience. As the silk structures slide down and unfold, their illuminated surfaces create shifting light patterns that alter the appearance of the architectural space (Yatzer, 2015). Consequently, the installation operates as a performative spatial system in which movement and light collaborate to shape the audience's perception of the surroundings.

Shylight is an example of how a kinetic lighting system can be used as a creative tool for reshaping a spatial atmosphere. It demonstrates that, through choreographed and pre-programmed movement and light, architecture can transform static interiors into dynamic environments where spatial perception and experience evolve over time.

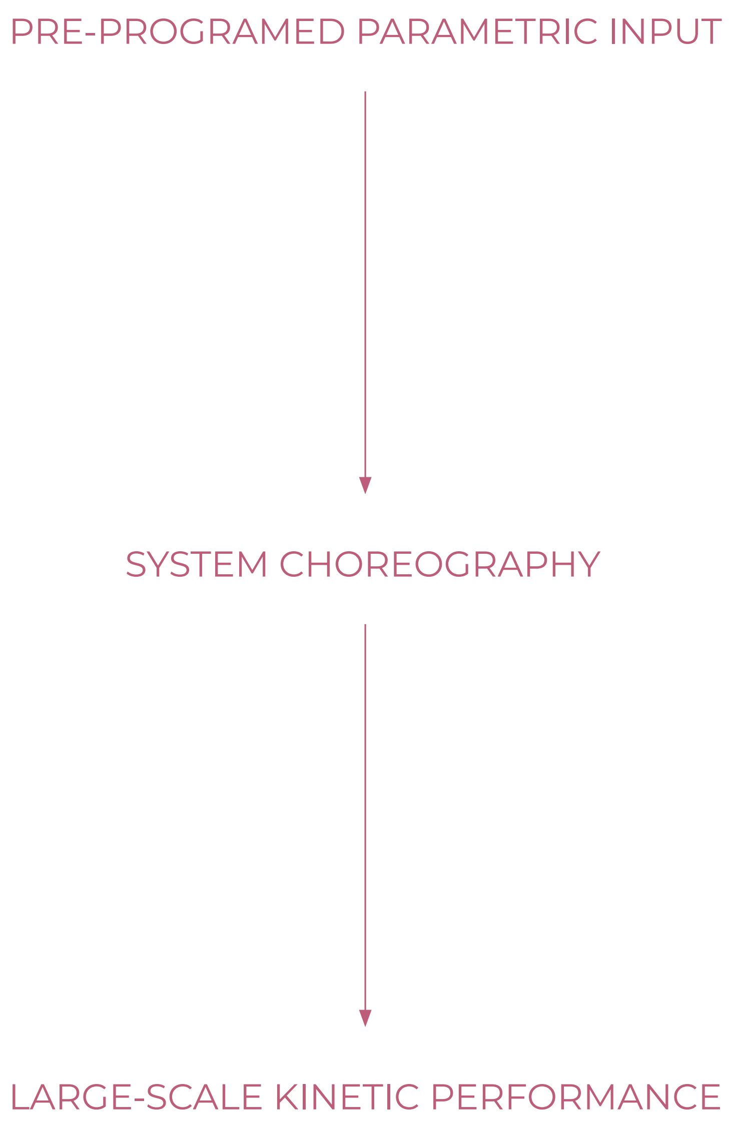


Figure 14.:Precedent Diagram: Large-Scale Kinetic Performance (Author, 2026)

Heavenly Symphony
Skyform Studio (n.d.)

Heavenly Symphony is a large-scale kinetic lighting installation that demonstrates how coordinated motion and programmable illumination can generate dynamic spatial environments.

Developed by Skyform Studio, Heavenly Symphony is a large-scale kinetic installation that explores how coordinated movement and lighting can transform an architectural space. The installation is built of an array of suspended light units controlled by programmable motors, allowing each one to move independently, vertically while creating pre-programmed spatial and visual effects. Using synchronised movement and colour variations, the installation creates gradually varying spatial patterns across the ceiling above the exhibition space (Skyform Studio, n.d.).

It works as a dynamic spatial composition in which light and movement are harmoniously choreographed to create flowing formations, ornamental patterns, and fluid geometries, creating the impression of a constantly changing “living canvas” within the architectural environment.

How interactive technological systems can transform the perceptual experience of space is illustrated by the installation that fuses kinetic movement with programmable LED lighting. The transformation of this complex structure creates a dynamic ambience that adapts to programmed sequences, time, or the context. Heavenly Symphony is an example of a kinetic lighting system that operates as an expressive spatial medium able to transform static architectural interiors into dynamic and engaging environments.

In the selection of projects, we can observe how spatial environments simultaneously interconnect, interpret, and alter information, which consequently affects and transforms human actions into spatial behaviour. Interactive environments do not act as a passive backdrop for activity. Instead, they behave as dynamic systems in which sensory technologies, computer interpretation, and expressive spatial media create a continuous feedback loop between the body and space. Within the examined projects, three frequently recurring operational principles can be identified.

1. Sensory detection of human activity.
The interactivity of the environment relies on sensory mechanisms capable of detecting physical presence and behaviour using parameters such as movement, gestures, voice, or biometric signals. These sensory inputs allow the system to register the human action as dynamic data sources, thus transforming the physical body into an actively participating element of the spatial system.

2. Computational translation and interpretation.
The captured inputs are computationally processed, and subsequently, behavioural patterns are interpreted and eventually translated into structured responses. Through this computational layer, technological systems act as mediators that transform raw sensory data into meaningful spatial actions and generate behaviour that mimics independent thinking or decision-making.

3. Expressive spatial response.
The interpreted data are further expressed through physically perceptible spatial media such as light, sound, movement, or kinetic elements. Such outputs constantly reshape the experiential qualities of the environment, creating a dynamic atmosphere and spatial behaviour that respond in real time to human presence.
Taken together, this set of principles confirms that interactivity in architectural design does not function as a single technological mechanism, but as a layered system in which perception, interpretation, and spatial expression operate as co-dependent processes. This understanding is the conceptual core of the sensory-cognitive-expressive framework of interactive architecture proposed in this thesis.

Layered model appropriation

There is a clear demand for a structured framework when interactive architecture is conceptualised as a complex socio-technical system. Interactive spaces are not perceived as being controlled by a linear cause-and-effect mechanism, but rather as interconnected processes spanning perception, cognitive interpretation, and spatial expression. These layers interact recursively, with stimulations being processed through cognitive layers and translated into behavioural and spatial responses. This approach is consistent with the cybernetic theories of Sáez-Vacas (1991), who argues that technological systems should be understood at several levels of complexity, specifically when human and social factors are involved, because technological innovation does not exist outside these interacting layers (p. 1).

While his research focuses on office automation, the underlying system principle is transferable to interactive spaces. The positioning of architecture as a system integrating technological processes with physical experience forces a shift from simplifying linear interpretations to a comprehensive model that, instead of searching for a single cause, reflects the nonlinear and dynamic layering of mutual influences. This approach inspires the sensory-cognitive-expressive framework outlined below as a practical method for describing how interactive architecture becomes readable and meaningful through the interdependent layers of the system.

Towards a holistic model of interactive architecture,

Interactive architecture can be understood as a complex socio-technical ecosystem of behaviours in which physical, digital, sensory, and affective layers intersect. As discussed earlier in this paper, such spaces operate through feedback between human behaviour and sensitive spatial technologies. An interactive setting is neither static nor unidirectional in its communication. It is a dynamic environment in which perception, interpretation, and spatial expression constantly affect one another. From this standpoint, a holistic framework that describes how interaction takes place within multiple interconnected processes becomes necessary. This research, therefore, introduces a model based on three interconnected layers:

• The sensory layer collects data about the environment and human movement through sensors (movement, distance, speed, sound). This layer represents the perception of space and its ability to register events.

• The cognitive layer processes and interprets this data. It includes computational logics that analyse patterns of movement, rhythm, and intensity and make decisions based on them. This is where learning and behaviour prediction take place, as well as the system's ability to respond in a differentiated, non-repetitive manner.

• The expressive layer is the output of the system. It materialises behaviour through light, sound, movement, shadow, or changes in material. It represents the communication of space towards humans.

These layers do not follow a hierarchical principle but form a continuous feedback loop in which sensory perceptions, cognitive interpretation, and expressive spatial output mutually condition each other. The environment thus becomes an adaptive system that dynamically reacts to human movement and builds an authentic reciprocal relationship between the body and space. This cycle can be compared to a living organism, the architecture "breathes" with the user, creating a reciprocal interaction. The space reacts, the person responds, and the response returns to the system as new input.

This holistic model shifts architecture from an object to a process of constant exchange. Interactivity is no longer a technological add-on, but a fundamental quality of space that can perceive, interpret, and express itself. The key aspect here is the affective dimension, the ability of the system to respond not only to presence, but also to the quality of movement and emotion. Space thus becomes a co-player that adapts its behaviour to the rhythm, energy, and mood of the human being.

This concept gives rise to several principles that can serve as a starting point for the design of an interactive environment based on dance and physicality:

• Reciprocity and mutuality, interaction must be two-way: the space perceives and responds at the same time.

• Fluidity of responses, the system responds in time, not immediately: there may be a delay between stimulus and response, which creates rhythm and tension.

• Sensory congruency, the responses of the space (light, sound, movement) should be congruent, sensorially harmonised, to create a unified atmosphere.

• Affective variability, the space should have a range of "emotional modes" that change according to the quality of movement or collective dynamics.

• Emergent behaviour, the result of interaction, may not be predictable: the possibility of spontaneous emergence of new situations and patterns is important.

These principles form a framework for architecture as a performative environment that thrives on the exchange between movement, senses, and technology. Such a space can be understood as an intelligent body that perceives through sensors, thinks through algorithms, and expresses its affective state through light or movement. The holistic model of interactive architecture is therefore not a definitive typology, but an open framework for designing environments that have their own behaviour, rhythm, and mood. It allows us to create architecture that is not only functional, but also sensually present and empathetic, architecture that communicates with the body, responds to it, and becomes its extension.

The sensory, cognitive, and expressive layers form a cybernetic interaction loop that defines the interactive relationship between human movement and responsive architectural space. Within this framework, the environment perceives the body through sensors, processes and interprets movement using internal computational logic, and responds through expressive spatial transformations such as changes in light, sound, or mechanical movement. These reactions are subsequently perceived by the body, shaping further movement and sustaining a continuous cycle of interaction between human and environment (Pask, 1969). Drawing on this approach, architecture is no longer solely a passive container for human activity but rather an active participant in the composition of spatial experience. Interactive environments serve as adaptive systems that communicate, respond, and evolve through embodied interaction. By conceptualising the proposed model as a continuous feedback loop rather than a simple sequence of actions, the framework accommodates key characteristics of interactive architectural systems, including reciprocity, fluid responsiveness, affective variability, and emergent behaviour. In this way, the sensory–cognitive–expressive model provides a coherent conceptual structure for understanding how spatial interaction acquires meaning through the ongoing, dynamic relationship among body, system, and environment.

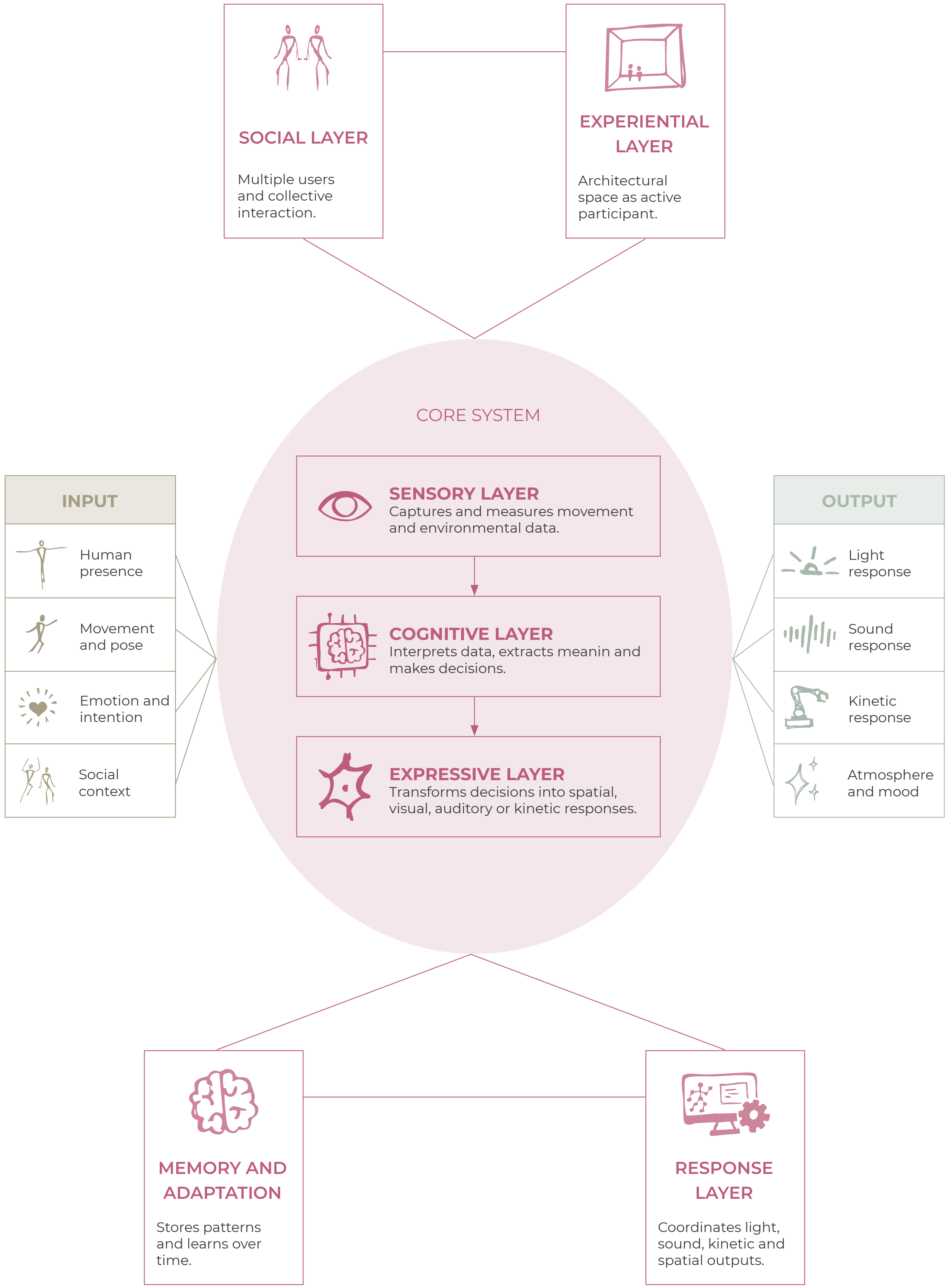


Figure 15.:Expanded Layered Model (Author, 2026)

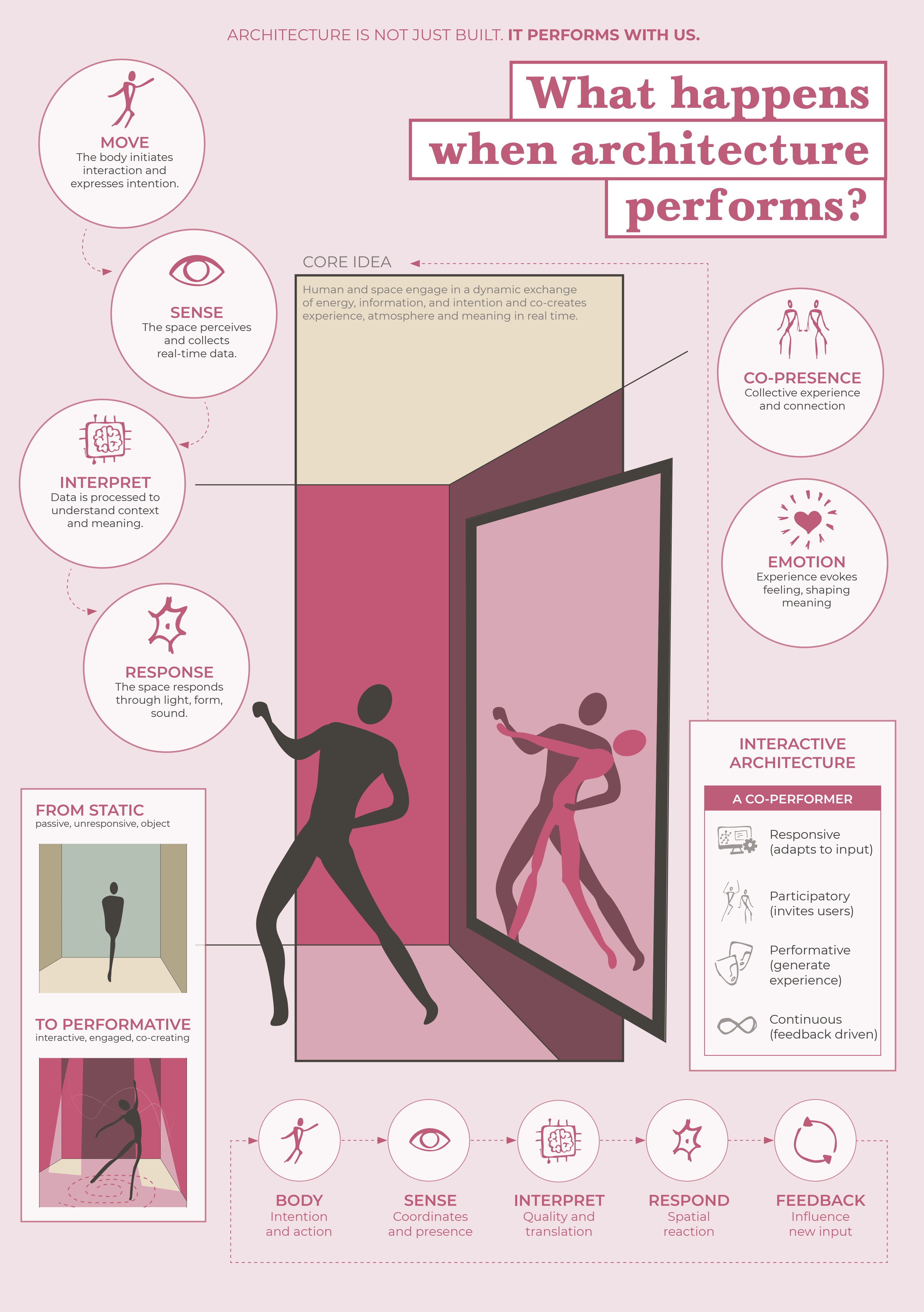


Figure 16.:Performative Architecture Concept
(Author, 2026)

Conclusion,
Interactive architecture is positioned within a broader transformation of architectural thinking. The theoretical discussion reveals a fundamental ontological shift from the conception of space as a static, "hard" spatial object toward its recognition as a dynamic system of relationships between bodies, technologies, and environments. Drawing on cybernetic theory and interactive design, architectural form evolves from first-order reflexive responses to second-order circular causality. The architectural medium leaves behind the predictability and emerges as a non-trivial performative subject. Within this paradigm, architecture appears as a bidirectional, participatory system that shapes spatial experience.

Rather than a technological feature added to architectural form, interactivity becomes a fundamental architectural principle that reshapes the relationship between the body and space, prioritising embodied experience in which the body serves as both a source of data and a linguistic tool for communication. When movement is treated as an alternative language, the interaction loop reaches an affective and semantic depth, thereby enabling the participant to feel a sense of meaning and agency. Concepts such as performative architecture, multisensory perception, and social interaction demonstrate that spatial meaning is not produced solely by material form, but by the dynamic interplay that can be reinforced by the principle of sensory congruence. It acts as a systemic limitation of design to ensure that multimodal outputs of light, sound, and material kinetics are harmonised into a legible and immersive atmosphere.

The model of the interactive architecture design approach, proposed in this thesis, provides a conceptual framework for understanding essential relationships. By conceptualising interaction as a layered process of recognition, interpretation and transformation led by dialogue between the body, the system, and the environment. Architecture thus becomes capable of generating responsive spatial expressions that evolve and encourage architects to move from purely static proposals to curating dynamic relational arrangements.

Consequently, the proposed sensory–cognitive–expressive framework formalises this transition by organising interaction as a continuous interplay of stimuli and mutual dialogue. The model introduces a method for designing adaptive and communicative environments that are sensitive to the rhythms of human presence. Architecture as a "living" medium expands experience boundaries to include the dimensions of empathy, intuition, and unpredictability. Architecture is no longer a silent witness, but a co-creator of atmospheric impact.

EXPERIMENTAL EXPLORATIONS

Explorations were carried out through a series of experiments primarily in the computational realm as part of a research-through-design process. Rather than isolated tests, the experiments were approached as a collection of design probes through which an understanding of how body movement, computational interpretation, and spatial response relate to one another is gradually built. Each investigation tested a specific aspect of the interactive system, moving from basic motion detection and data mapping toward more complex audiovisual, kinetic, and atmospheric feedback, in order to support the thesis's goal of understanding architecture as an active collaborator rather than a passive container. Such testing contributed to the development of the framework essential for translating theoretical concepts, such as embodiment, feedback, spatial atmosphere, and performativity, into operational design strategies. The process is guided by a sensory-cognitive-expressive concept in which movement is first captured, then interpreted computationally, and finally expressed through visual, auditory, or kinetic spatial behaviour, in accordance with the thesis methodology. Each of these experiments serves as a tool for testing the interplay between the body, computation, and space. The set of tests was divided into four phases to illustrate the progression from basic detection to architectural integration.

In every experiment, motion data necessarily requires calibration before it can be transformed into spatial behaviour. Each configuration of the sensor involves defining coordinate ranges, minimum and maximum values, trigger zones, thresholds, smoothing, and value remapping. Any significant change in camera viewpoint or tracking method required recalibration, as the same movement produced different numerical ranges depending on distance, framing, camera position, and capture technology. These values had to be physically tested through movement. For each captured parameter, such as hand speed, body proximity, leg distance, or spatial position, the movement had to be performed repeatedly to determine its effective range. Calibration was thus an integral part of the design process itself, as it determined how the system interprets the body and how the body can influence spatial behaviour.

Initial tests were carried out with a laptop webcam, while later experiments primarily used Kinect. Tools used throughout the process included TouchDesigner, MediaPipe, Kinect, Arduino, Ableton, Stable Diffusion, servomotors, LEDs, and Rhinoceros 3D. The most useful tracking points were the hands, wrists, feet, face, and hips. The most frequently used motion parameters were proximity, position, and velocity.

Throughout the experiments, there was a certain degree of imperfections arising from the limitations of commonly available software in the form of noise, jitter, false triggers, and occasional data loss. Rather than being completely eliminated, these imperfections were mitigated through filtering, smoothing, value clipping, and setting thresholds. It reinforced the understanding that interactive behaviour is not produced solely by the technology itself, but rather together with careful calibration of the relationships between motion, data, and response.

PHASE 1

The first phase focused on developing a basic procedural workflow linking body movement, sensor technology, computational processing, and real-time feedback in order to test whether the body could be adequately detected, whether motion data could be converted into usable values, and whether these values could control visual or physical outputs.

The initial set of experiments established the basic technical foundation of the interactive system. It confirmed that body movement can be detected, processed, and translated into a visual or mechanical response. At the same time, it showed that while the system was able to respond successfully, communication between the participant and the system, using direct mapping, remained at this stage responsive and linear, rather than a meaningful, true interaction.

No.	Exploration	Aim and Method	Outcome
1-2	Hand Detection and Visual Mapping	To investigate whether hand movements could be detected with sufficient accuracy and used to modify visual behaviour in real time, the tests utilised a laptop webcam in combination with MediaPipe and TouchDesigner. XYZ coordinates of both hands were extracted, calibrated, scaled, and linked to simple visual parameters.	The workflow successfully associated hand movement in real time with a visual response. Hand movement was matched to a visual change, although more complex gestures required additional filtering and calibration. This experiment provided the basic capture-and-response logic used in subsequent tests.
3	Arduino Communication and Servo Activation	To test whether motion data could be translated into physical activation, hand position data based on zones from TouchDesigner was sent to the Arduino to activate four servomotors according to the detected hand position.	Basic communication between the software and the physical output, from TouchDesigner, through Arduino to servo motors, was successfully achieved. However, unstable detection, inappropriate trigger logic, and insufficient delay settings caused undesired multiple servo activations. The experiment demonstrated that mechanical output requires clearer thresholds and more robust filtering.
4	Directional Gesture to Servo Choreography	To investigate whether recognised hand movement directions could organise coordinated kinetic behaviour, a 4×4 grid of servomotors was programmed to respond to six movement directions: up, down, left, right, diagonally up, and diagonally down.	Directional gestures generated legible, wave-like mechanical patterns. Scaling the system revealed challenges with energy distribution and connectivity, demonstrating the necessity of powering and wiring considerations throughout the whole design process. The test confirmed that the direction of motion can organise various spatial behaviours.

No.	Exploration	Aim and Method	Outcome
5	Hands-Up Flash Trigger	To test whether a clearly defined body configuration could trigger a discrete visual response, a true or false position detection component was created by comparing the vertical coordinates of both hands with the position of the head. The flash was triggered only when both hands were detected above the head.	The pose was clearly recognised and translated into a simple light response. The experiment confirmed that clear relationships between body coordinates can function as stable trigger conditions, particularly for binary responses.
6	Hand Velocity to Colour Translation	To investigate how movement speed could be transformed into visual or atmospheric qualities. Wrist speed for both hands was calculated from the changing hand coordinates, scaled, and mapped to colour ramps. Colour values from each hand were overlapped to create blended colour responses.	Wrist velocity has proven to be an effective measure because hand movement is expressive, frequent, and visually readable. Tests clarified the requirements for normalising and scaling velocity values before they become usable visual data. This shifted the motion data from positional tracking toward expressive qualities such as speed, intensity, and colour atmosphere.

Figure 17.:Phase 1: Basic Detection and Response Tests (Author, 2026)

PHASE 2

The second phase progressed beyond simple detection and began to explore the characteristics of movement and to seek qualitative interpretations. Besides whether the body could evoke certain reactions, the experiments focused on examining how speed, proximity, direction, posture, and relational movement could be interpreted as expressive parameters. It was an essential step in the evolution of the inquiry, as it began to shift the project from a direct input-output reaction toward a more nuanced computational interpretation.

In this phase, interaction becomes more meaningful as the system interprets the relationships between body parts, movement tendencies, and changing states, rather than merely responding to fixed coordinates. This was particularly evident in the hand proximity experiment, where collapse and reconstruction of point cloud were triggered by the direction of change between the hands. The system no longer reacted merely to where the body happened to be, but also to what the body was doing.

No.	Exploration	Aim and Method	Outcome
7	Hip Movement and Particle Vortex	To explore beyond the limits of obvious hand gestures and to test whether subtler body movements could generate visual behaviour, the average velocity of the hips was calculated and used to control the duration, radius, and intensity of a rotating particle system.	Hip movement successfully prompted a dynamic, vortex-like visual response that required more careful calibration than hand-based interactions. The experiment expanded the vocabulary of interactions by being able to quantify duration and intensity, while showing that less explicit body parts can generate expressive spatial effects as well, when interpreted through the quality of movement.
8	Foot Proximity and Pattern Transformation	The goal was to investigate whether the distance between body parts could be categorised and translated into a simple geometric transformation. The changing distance between both legs was mapped to various ranges of values that control a basic linear pattern. Both real-time tracking and tracking using imported video were explored.	Proximity data could be used to identify different states of movement. The experiment presented proximity as an important parameter of interaction and suggested how bodily openness, posture, and proximity might influence spatial response. The input information was successfully categorised and paired with an appropriate response, featuring smooth transitions.
9	Hand Proximity and Particle Disintegration	Testing gradually more advanced interpretative interaction based on relational movement rather than absolute position. The point cloud was configured to disintegrate when the hands moved apart and to recompose when the hands moved towards each other. A hold feature retained the last detected state until an opposite direction movement occurred.	The system successfully responded to the tendency of movement rather than to a simple position. This represented an important concept transition from a direct reaction to interpretation and introduced memory-like behaviour through the maintenance of the last state.
10	Pose Detection for Mechanical and Light Response	Testing the ability to recognise performative poses and translate them into spatial activation. Teachable Machine was first tested for autonomous pose detection, but the logic was later manually scripted in TouchDesigner using relationships between the hips, nose, shoulders, and wrists to recognise behaviour like bowing down and the raised arm greeting gesture.	Manual scripting offered greater control than AI-based pose recognition. Poses such as bows and waves could be translated into binary information for mechanical response transferred through Arduino and a light reaction. The experiment proved Teachable Machine tool unsuitable for the desired outcomes.

No.	Exploration	Aim and Method	Outcome
11	Pose-Based Music Trigger	With the aim of investigating whether body poses could define audio categories and introduce controlled unpredictability, Teachable Machine was tested as a pose detector to recognise poses from a predefined list and subsequently play a randomly selected track from a library depending on the genre.	The AI-based pose recognition workflow in Teachable Machine interface was found to be unreliable in this context. However, by substituting numerical triggers with manually provided constants, the system was able to trigger the desired song and play it until the end. The experiment introduced the idea of selecting sound based on movement, but it appeared unconvincing and additionally demonstrated that this approach requires more development than the project's timeframe allowed.
12	Depth Tracking and Water Ripple Response	The goal was to create autonomously acting behaviour outside of true interaction, which would primarily function as a vegetative state in the absence of external inputs while simultaneously provoking interest to initiate interaction. The primary focus was on fluid animation of the water surface, which utilised depth tracking to trigger the rippling of the water whenever someone walked past or approached the sensor field.	Depth data enabled a subtle reaction without the need for an explicit signal from users. This individually dynamic expression subtly reacts to the proximity of the communication partner, so it draws their attention, stimulates curiosity, and stimulates a desire to explore this behaviour.

Figure 18.:Phase 2: Movement Qualities and Interpretation (Author, 2026)

PHASE 3

The third phase became most relevant for practical application within the framework of speculative design. In this phase, the investigation transitioned from isolated visual or mechanical responses to multisensory feedback systems for future design and the testing of individual technical solutions. Sound, projection, colour, kinetic response and light were tested as interconnected atmospheric outputs. This phase also developed an understanding of interactivity in the project as a larger complex system of mutually influencing operations.

This phase highlighted that the distinction between responsiveness and interactivity cannot be reduced to the mere existence of sensor technology, but also lies in the complexity of the relationships between inputs, interpretations, and outputs. When movement alters sound, sound changes visual elements, and the resulting atmosphere shapes the dancer's next movement, the system appears to function not as a one-way reaction but as a feedback loop. Interactivity thus manifests itself as a series of interdependent combinatorial operations.

No.	Exploration	Aim and Method	Outcome
13	Motion-Based Audio Control	To develop a foundation of reciprocal feedback between movement, sound, and visual aesthetics. TouchDesigner was interconnected with Ableton Live, enabling hand movement recognition and thus allowing for the modulation of audio clips in real time. Analysis of modified sound was further used to influence abstract generative visuals, particularly through higher frequencies.	The user could hear the altered sound, react with movement, and continue to modify the audio-visual environment. This experiment contributed to progress from simple responsiveness to reciprocal interaction and directly informed the multisensory logic of the final installation.
14	Wave Choreography for Kinetic Ceiling	Translate movement traits into the choreography of a suspended kinetic ceiling. Dance nuances such as hip swaying, standing on one leg, the T-pose, and upward or downward hand movements were translated into radial, circular, vertical, front-to-back, and back-to-front wave patterns. These patterns were pixelated and transformed into numerical values of rotation angles for micro servo motors and converted for streaming outputs to Arduino.	Visual patterns derived from various gradients were properly translated into a numerical grid and converted into mechanical rotation values that defined the height of displacement along the Z-axis. This experiment served as a crucial transition between computational interpretation and kinetic behaviour.
15	Initial Projection Atmosphere	The main goal was to define a motion-responsive visualisation capable of adapting its colour scheme to match the atmosphere. The abstract visual could have been distorted by information from the depth map, while for generating colour palette variations, noise-instancing was used.	The test offered a possible method for creating a mood reflecting projection environment. It shaped the visual atmosphere of the installation and supported an affective spatial layer.
16	Initial Projection Atmosphere	This experiment was performed to test whether AI image generation could be used to introduce unpredictability into the visual atmosphere. A method utilising the Stable Diffusion tool, combined with a simple mock-up switch, was tested to generate atmospheric images.	The method was conceptually promising but technically unsuitable within the project's timeframe, and the selection of prompts and tools would require further development. The experiment remained speculative and was not integrated into the main system, but it clarified the limits of AI-generated responses for real-time interaction.

No.	Exploration	Aim and Method	Outcome
17	Projection Mask Following the Body	To link the independent atmospheric projection with the participant's position in real time. Adding the character of the floor surface, which has the potential to further influence the dancer and their connection to the ground. The visuals of the masking textures were linked to the body's X and Y coordinates and layered over the main projected image. Mask characters included textures such as sand, water ripples, and cracking glass.	The projection was able to follow the participant and create a dynamic relationship between body and floor. This allowed the floor projection to evolve into an interactive condition of surface contact that could influence the dancer's perception of weight, surface, and movement.
18	LED Colour Logic	To translate numerical data into controlled colour schemes for the LED light strip output. Tempo values were converted to colour wheel numbers and then translated into RGB colour codes. The resulting choreography was prepared in a format for serial output from the Arduino.	The numerical values were successfully translated into colour ranges, allowing sound or tempo information to define the LED's appearance. This created a technical groundwork for correlating the sound's tempo, colour, and the light's behaviour in the final installation.

Figure 19.:Phase 3: Audio, Projection, and Kinetic Feedback (Author, 2026)

PHASE 4

The final phase applied the experimental logic to architectural agency. These experiments focused on a kinetic ceiling, spatial organisation, physical prototyping, and advanced sound interaction. In this phase, the system was no longer understood as a collection of isolated effects, but as a three-dimensional environment in which movement, sound, light, projection, and kinetic elements are able to interact.

The final phase integrated technical experiments with architectural design. The ceiling was no longer purely a mechanical structure, but an expressive spatial field. Similarly, sound was no longer considered a triggered background element, but an atmospheric layer that could be modified and shaped by the body. These experiments directly influenced the final design of the speculative installation.

No.	Exploration	Aim and Method	Outcome
19	Motion-Based Audio Control	To develop a foundation of reciprocal feedback between movement, sound, and visual aesthetics. TouchDesigner was interconnected with Ableton Live, enabling hand movement recognition and thus allowing for the modulation of audio clips in real time. Analysis of modified sound was further used to influence abstract generative visuals, particularly through higher frequencies.	The user could hear the altered sound, react with movement, and continue to modify the audio-visual environment. This experiment contributed to progress from simple responsiveness to reciprocal interaction and directly informed the multisensory logic of the final installation.
20	Wave Choreography for Kinetic Ceiling	Translate movement traits into the choreography of a suspended kinetic ceiling. Dance nuances such as hip swaying, standing on one leg, the T-pose, and upward or downward hand movements were translated into radial, circular, vertical, front-to-back, and back-to-front wave patterns. These patterns were pixelated and transformed into numerical values of rotation angles for micro servo motors and converted for streaming outputs to Arduino.	Visual patterns derived from various gradients were properly translated into a numerical grid and converted into mechanical rotation values that defined the height of displacement along the Z-axis. This experiment served as a crucial transition between computational interpretation and kinetic behaviour.
21	Initial Atmospheric Projection	The main goal was to define a motion-responsive visualisation capable of adapting its colour scheme to match the atmosphere. The abstract visual could have been distorted by information from the depth map, while for generating colour palette variations, noise-instancing was used.	The test offered a possible method for creating a mood reflecting projection environment. It shaped the visual atmosphere of the installation and supported an affective spatial layer.

Figure 20.:Phase 4: Integrated Atmospheric Response Tests (Author, 2026)

SYNTHESIS AND DE-SIGN IMPLICATIONS

The collected experiments document a gradual transition from reactive to interactive behaviour. The earliest tests established the system's technical foundation, including motion detection, coordinate calibration, value scaling, threshold definition, and basic response mapping. These explorations revealed how bodily movement can be converted into computational data and how this data can be translated into visual, auditory, or mechanical outputs. However, these trials were limited by a direct input-output logic that was effective for an initial introduction to the basic processes but predictable and primarily reactive at the same time. Later experiments implemented richer relationships between movement and spatial behaviour. Where they had previously assigned a single output to a single input, several parameters were now combined, including proximity, speed, position, posture, and relationships between body parts. This combinatorial logic allowed the system to remain comprehensible while also allowing participants to recognise that their bodies influenced the environment, although the exact response was not always entirely predictable. This balance between understanding and uncertainty became a central element in the project's concept of interaction.

These findings directly influenced the final proposal. Motion tracking experiments clarified how to sense movement through parameters such as position, proximity, velocity, and relationships between body parts. Calibration and mapping experiments defined how these values can be interpreted via thresholds, scaling, smoothing, and combinations of parameters. Experiments involving projection, sound, light, and kinetic motion were then used to test how such interpreted data can be spatially expressed through atmosphere, rhythm, colour, light, and physical movement.

The most significant breakthrough came when the system progressed from detecting isolated gestures to interpreting layered relationships between input stimuli and output responses. This is reflected in the development from simple hand detection and visual mapping toward advanced sound control, projection masking, and combined kinetic ceiling choreography. During the experimental process, the difference between responsiveness and interactivity became clearer. Responsiveness occurred when the system merely reacted to detected input, while interactivity emerged when several operations began to influence one another. Movement modified sound, sound affected visual elements, the projection impacted physical perception, and, together with kinetic movement, spatial behaviour, as a holistic whole, altered atmosphere. When layering individual stimuli and responses, it is essential to pay attention to the balance between unpredictability and predictability, so that behaviour remains readable enough for the participant to feel engaged, yet open enough to stimulate curiosity, surprise, and further exploration.

This experimental process is, in this context, a method directly related to the final design, through which the design was discovered, tested, and refined. The following chapter unfolds the final design proposal as a synthesis of prior experimental findings, while translating the observed behaviour into an architectural system characterised by embodied, multisensory, and performative experience.

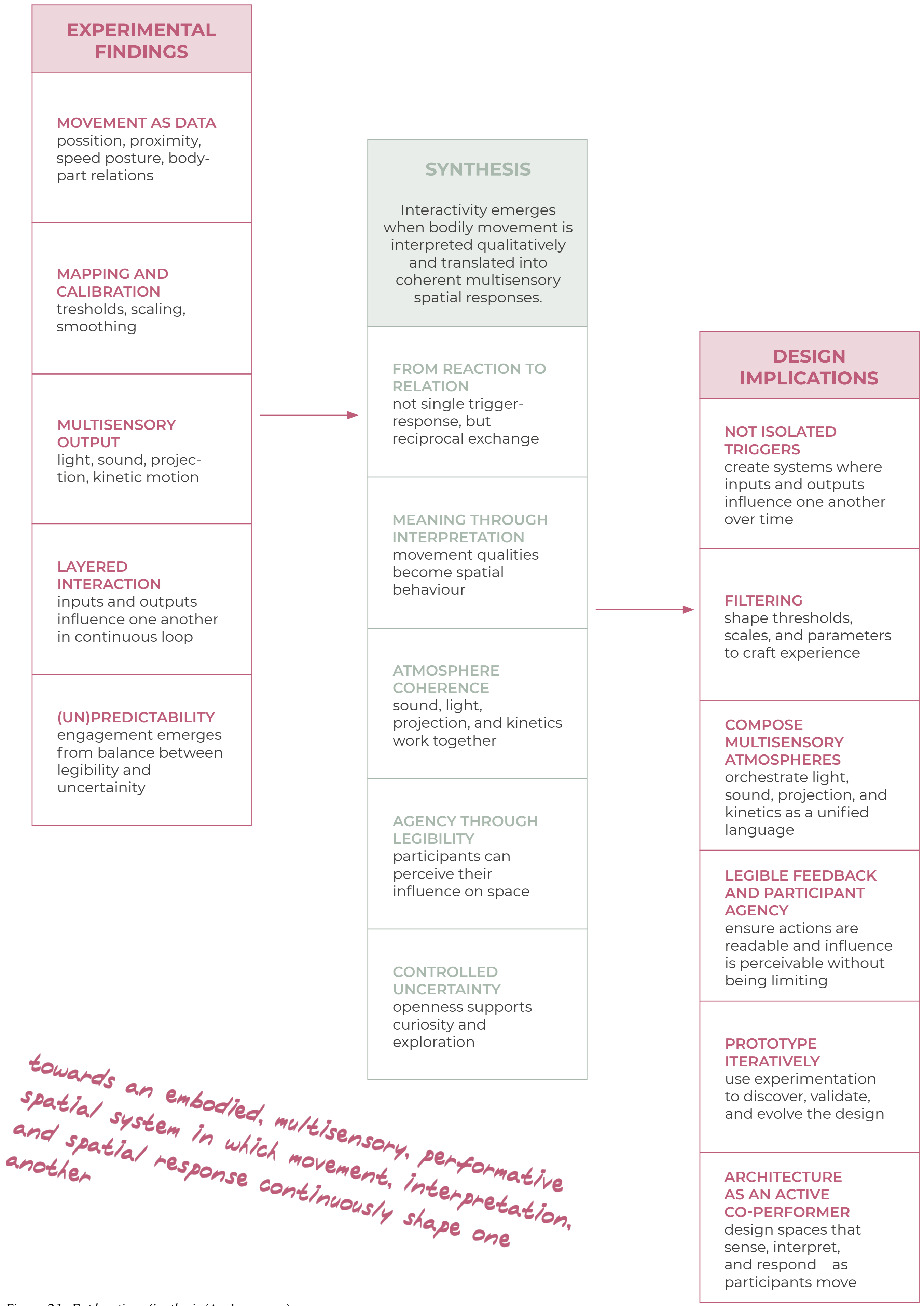


Figure 21.:Explorations Synthesis (Author, 2026)

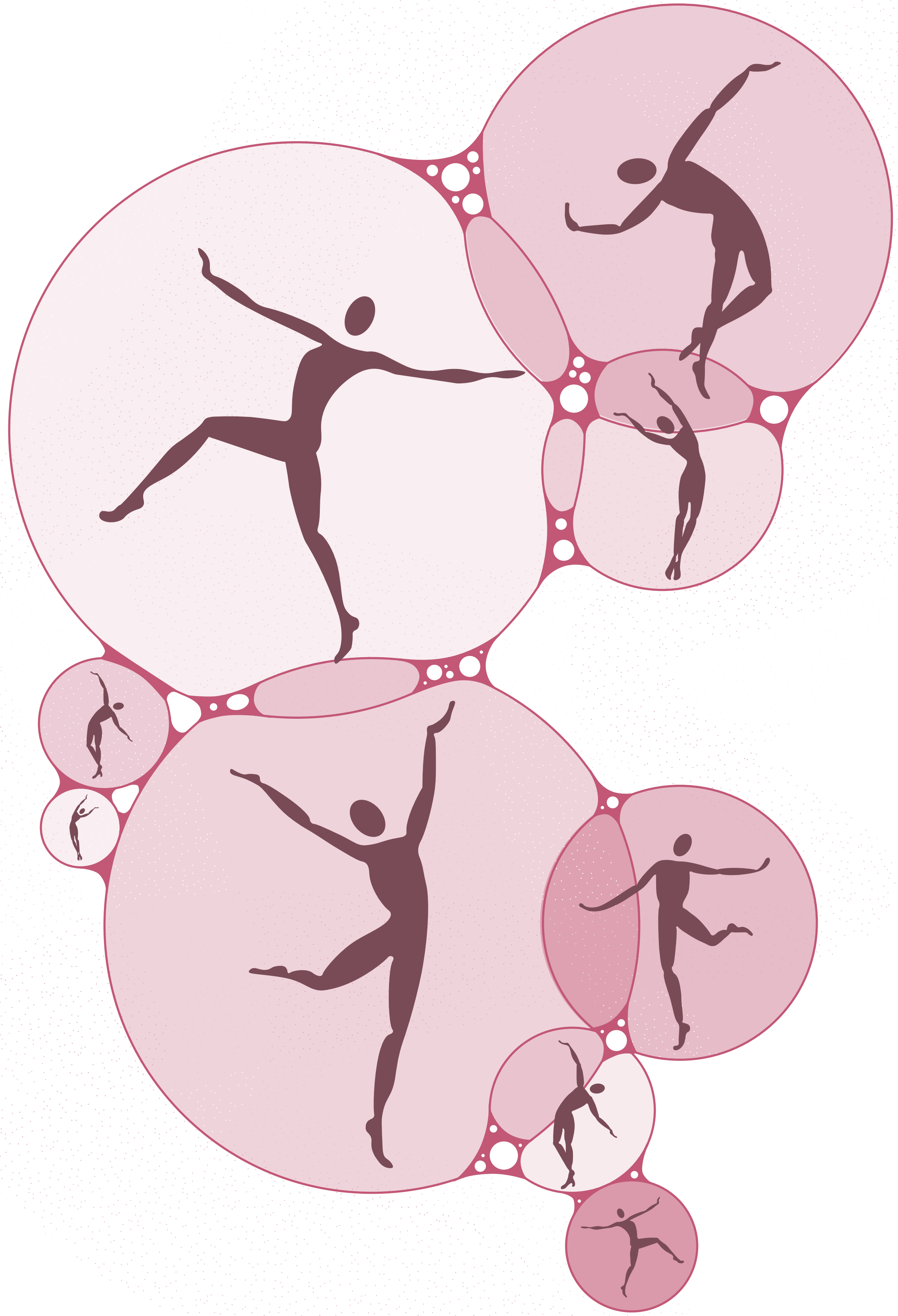


Figure 22.:Our bubbles illustration (Author, 2026)

We live in our bubble

We like to think the world is shared, that the ground beneath us is stable, objective, and waiting for us in the same way it waits for everyone else who enters it.

But that is just a convenient illusion.

The truth is, we do not inhabit the same space. We never have. Each of us carries a personal field of perception. A shifting, restless sphere shaped by what we remember, how we move, and what we choose to notice.

What we call reality is not a gift. It is a craft. It is continuously interpreted, filtered, reconstructed, and lived. We move through the world, but the world also moves through us. Every step or pause changes how the room unfolds around us, not in its physical dimensions, but in how it feels, how we experience.

This is not a limitation. It is just how we are.

Instead of standing on the sidelines watching space happen, we are part of its becoming.

Our "bubbles" are not closed, isolated hideouts. They intersect one another, collide and overlap. Sometimes we align for a moment, and we mistake that brief, unstable spark for "objectivity." Although those moments are not testimony of a shared world, they are merely a temporary settlement of our differences.

Nothing around us is neutral. The space we occupy is always in a quiet dialogue with who we are, how we move and how we behave, interact.

Perception is not a camera frame. It is an act. Experience is not something we receive, but rather something we produce. Once we accept this, a new understanding may occur.

Space is not just a place we enter. It is something that emerges with us.

DESIGN MOTIVATION AND CONCEPT

Contemporary architectural space continues to be perceived largely as a static stage, a backdrop, a space in which activity takes place. It is a stable framework, optimised for performance, efficiency, and utility, within which the human body exists as a temporary occupant. Even within emerging interactive approaches, spatial systems often remain limited to reactive models, where predefined inputs trigger predictable responses. In these cases, the user's role is reduced to activation rather than participation, which limits the potential for meaningful engagement.
This project challenges this status quo by proposing an expansion of architectural space beyond the boundaries of its static and reactive paradigms. It positions architecture not as a backdrop for human activity, but as an active entity capable of entering into a reciprocal relationship with the participant. Within this framework, interaction is understood not as control, but as dialogue.

The conceptual foundation of the project lies in introducing an alternative approach to interactive spatial design. Unlike conventional responsive systems, which operate through linear input-output logic, the proposed system introduces a bidirectional and interpretive flow of communication. Human movement is captured through parameters such as position, speed, rhythm, and proximity, and is subsequently interpreted and translated into a response that informs the next move and creates a communication loop between actors and the system. This interpretation operates through a metaphorical recognition of the affective and expressive qualities of movement, allowing the system to respond in a way that is legible but not entirely predictable.

This shift from reaction to interpretation is a core principle of the project. It introduces a certain degree of autonomy into the system, bringing it closer to a collaborative interface than a controllable one. The interaction between the participant and the space thus resembles a form of improvisational exchange, where the influence is mutual but never entirely predetermined. Unpredictability becomes a key characteristic that enables variability, complexity, and sustained engagement.

The experiential dimension of the project is structured around this relationship. The participant is positioned not as an operator, but as a contributor to an ever-evolving spatial state. Through movement, the user influences visual, auditory, and kinetic outputs while simultaneously responding to the system's feedback. This creates a dynamic feedback loop in which the experience emerges through ongoing negotiation rather than predefined scenarios.

The form of the object strengthens this conceptual approach. The minimalist cubic exterior encloses an inner spherical environment, creating an intentional contrast between external neutrality and internal immersion. This transition introduces a moment of perceptual shift that aligns with the project's fundamental metaphor of an individual "bubble." Rather than being explicitly defined, this state manifests through spatial qualities such as continuity, reflection, and the dissolution of clear boundaries.

The project is conceptualised as an experiential installation that operates at the junction of architectural space and an interactive system. It integrates multisensory outputs, including light, sound, projection, and kinetic elements, to create an immersive experience that responds to the physical presence of human subjects. Although the current design does not implement long-term system memory due to technical limitations, it creates a framework that could be expanded toward more complex data processing and truly autonomous, adaptive behaviour.

Ultimately, the project aims to contribute to a broader discourse on the expansion of architectural space. By introducing interpretive interaction and positioning space as an active participant, it proposes a shift toward a more affective, performative, and engaging environment. In doing so, it opens a discussion on how architecture can move beyond the boundaries of static form and reactive functionality to become a medium for a collectively creative and embodied experience.

SYSTEM LOGICS

The installation operates through an interconnected system consisting of motion tracking, computational processing, audiovisual feedback, and kinetic spatial elements. The system is designed as a multilayered structure in which the participant's movement is translated into atmospheric and spatial transformations. The overall organisational logic of the system is illustrated in the system diagram.

The primary input source of the installation consists of a full-body tracking sensor that continuously records the participant's position, body parts coordinates, movements, proximity relationships, speed, posture, and movement intensity. The system processes both absolute spatial position and relational conditions of motion between body parts, enabling it to distinguish between expansion, contraction, stillness, rhythm, and direction.

Collected data are transmitted to a computational interpretation layer, where individual parameters are analysed, combined, and mapped into behavioural outputs. Unlike isolated trigger-based systems, this system combines multiple simultaneous movement parameters, such as the proximity of the hand affecting sound width and tonal modulation, while the body influences atmospheric lighting gradients and projection behaviour. For example, the proximity of hands influences sound width and tone modulation, while the body influences atmospheric lighting gradients and projection behaviour. Furthermore, velocity and rhythmic properties modify parameters such as tempo, transition speed, and response intensity.

The computational layer translates the processed information to projection, sound, atmospheric lighting, or kinetic output systems that run in parallel and affect each other

The projection system controls visual masking, atmospheric rendering, and visual transformations mapped onto the floor. The behaviour of the projection changes in response to the participant's movements, selected atmospheric states, and internally generated behavioural conditions that influence the dancer's conceptualisation of relationships with the ground.

The sound environment operates through dynamic modulation of rhythm, tempo, tone qualities, and the spatial width of the sound. Rather than functioning as merely a background ambient environment, the sound acts as an active acoustic feedback mechanism that directly responds to the movement conditions detected within the physical space.

The lighting system combines LED lighting and ambient atmospheric lighting. Colour, rhythm, variation, intensity of illumination, and light transitions are continuously adjusted according to the interpretation of dance and inner conditions of the system. HSV colour logic and gradient mapping are used to generate smooth atmospheric transitions instead of binary changes.

The kinetic ceiling system consists of a hexagonal grid organised into a circular shape and of suspended elements capable of gradual, choreographed movement along the Z-axis. The ceiling's spatial transformation is designed to influence the overall atmospheric perception of the environment. Various behavioural modes, including choreographies like circular, radial or linear waves, as well as disintegration mode, alter spatial perception over time.

Apart from actions controlled by participants, the installation also incorporates autonomous behavioural operations. Randomisation of value generation, timers, delayed transitions, and internal atmospheric states allows the system to continue operating independently without direct user involvement. Consequently, the installation behaves more like an active environmental entity than a controllable device.

The entire system thus functions as a constantly evolving atmospheric structure in which sensing, computation, and spatial response are all functioning simultaneously and are interdependent. Movement becomes not only a trigger for interaction but also part of a broader behavioural and spatial choreography.

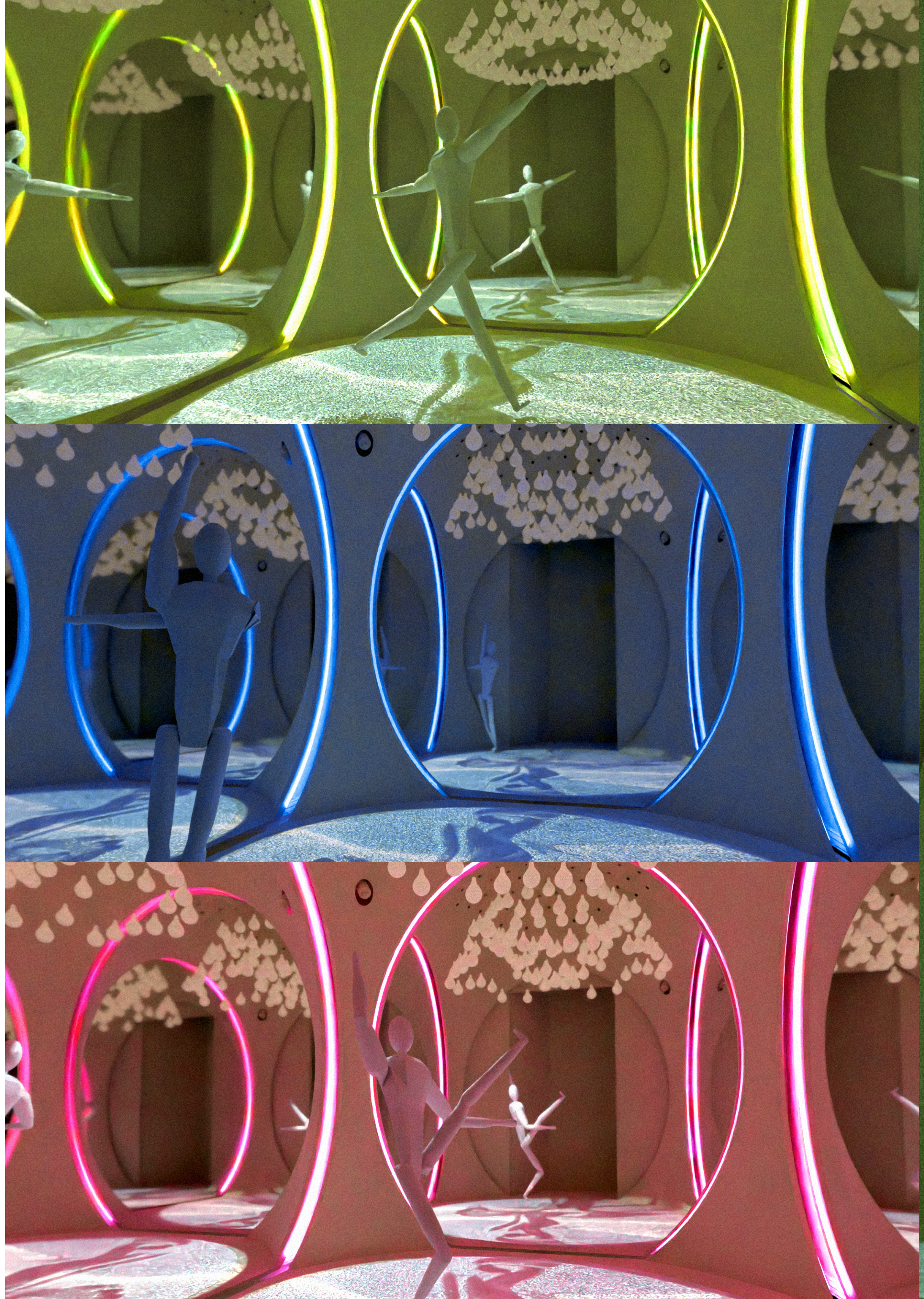


Figure 23.:Main Computational System Diagram
(Author, 2026)


BODY X-coordinate
BODY Y-coordinate
BODY Z-coordinate
PERSON ID
L HAND X-coordinate
L HAND Y-coordinate
L HAND Z-coordinate
R HAND X-coordinate
R HAND Y-coordinate
R HAND Z-coordinate
FACE Z-coordinate
L FOOT X-coordinate
L FOOT Y-coordinate
L FOOT Z-coordinate
R FOOT X-coordinate
R FOOT Y-coordinate
R FOOT Z-coordinate
PERSON DETECTION
ACTIVATION SWITCH
PERSONS COUNT
MASK POSITION DATA
HIGH POSE
LOW POSE
NEUTRAL POSE ZONE
HANDS CLOSER TOGETHER
HANDS FARTHER APART
NEUTRAL POSITION ZONE
MOVING CLOSER
MOVING FURTHER
NEUTRAL POSITION ZONE
QUICK HAND MOVEMENT
LEGS WIDE APART
TONE INCREASE
TONE DECREASE
ORIGINAL TONE
SMALLER HANDS PROXIMITY
BIGGER HANDS PROXIMITY
ORIGINAL SOUND WIDTH
TEMPO INCREASE
TEMPO DECREASE
ORIGINAL TEMPO
HANDS VELOCITY
LEGS PROXIMITY
VISUALS MASK
MASK THEME
ATMOSPHERE IMAGE
PROJECTION
CHANGED TONE
CHANGED SOUND WIDTH
SONG
CHANGED SONG
CHANGED BPM
CEILING EXPLODE MODE ON
SOLO PIANO ON
HSV TONE
HSV TO RGB
SCALING WIDTH
GRADIENT PERIOD
BEAT
SIXTEENTH
RHYTHM
CIRCULAR WAVES MODE ON
RANDOM ELEMENT SELECTION
RANDOMISED ON VALUE
FLORAL ELEMENTS OPEN SWITCH
TIMER ON
LIGHTS BLOOMING
LED LIGHT COLOUR
LED LIGHT PATTERN
ATMOSPHERE LIGHTING
MOVEMENT SPEED
GRADIENT PHASE
INTENSITY
CEILING CIRCULAR WAVING
CEILING CHOREOGRAPHY

PHYSICAL DESIGN AND CONSTRUCTION

Spatial Organisation

The installation is designed as a temporary cubic pavilion with a central spherical interior with a total building footprint of 35m² on a square floor plan with dimensions 5.9m by 5.9m and a maximum height of 6.3 m. The overall layout is built on a regular asymmetrical floor plan with a defined movement route leading from the exterior to the main interactive space. This floor plan separates the entrance corridor from the central chamber, creating a transitional zone between the outside world and the interior experience.

The entrance is oriented as a consiously designed route, instead of a direct opening into the centre of the installation. This creates a controlled access sequence and prevents the immediate visual exposure of the main interior space, facilitating a gradual transition before entering the central zone.

The central spherical room has 17m² with a circular active zone having a radius of 1.65m and operates as the primary interaction area. It is designed to allow for individual movement, dance, and participation in small groups, while users remain within range of the sensor, projection surface, lighting systems, and ceiling kinetic elements. The specific proposed space is designed for one primary tracked participant, with the option for multiple users to participate in a group of up to 8 members.

Figure 24.:Atmospheric Visualisations (Author, 2026)

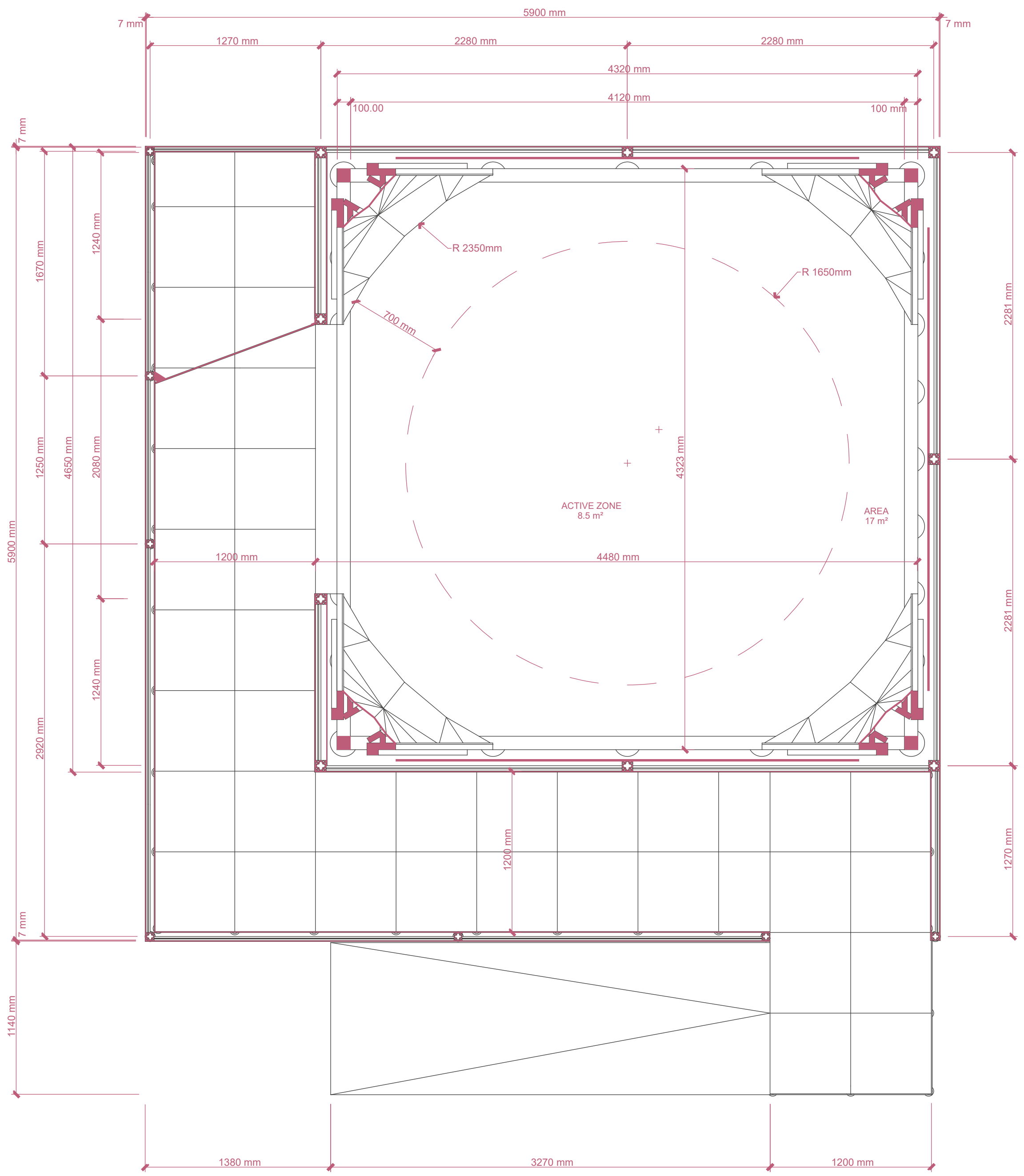


Figure 25.:Pavilion Spatial Organisation (Author, 2026)

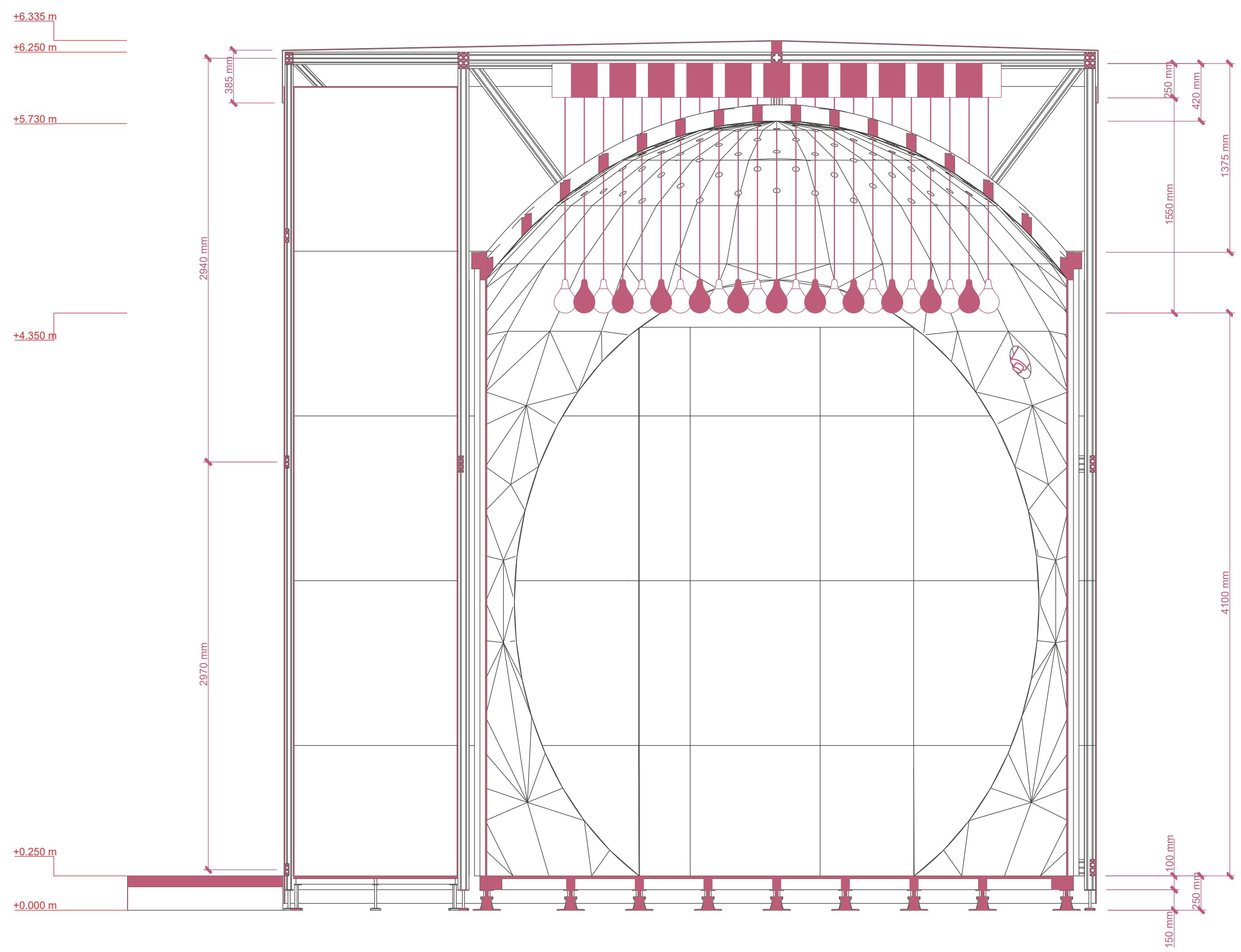


Figure 26.:Pavilion Section and Height Organisation (Author, 2026)

Construction System

The structure consists of two major structural systems, an inner wooden dome and an outer modular aluminium frame. The inner spherical skeleton is formed from arched glued-laminated timber beams, which allow for curved shapes with controlled dimensional accuracy and sufficient load-bearing capacity. The wooden ribs are arranged in three directions and interlock to form a stable dome geometry. Such system provides the required spatial rigidity and base for interior finishes, cladding, and selected technical components.

The outer frame is made of aluminium profiles. This solution provides a systemic, modular, and dismantlable supporting structure for cladding panels, roof components, technical mounting points, and secondary reinforcements. Aluminium profiles, being lightweight, precise, and reusable, are well-suited for temporary structures and allow for simple bolt joints without complicated on-site fabrication.

Lightweight 6mm Parklex facade boards are used as the primary panel material for cladding on flat wall surfaces. They are mounted on an aluminium frame to create a subtle, uniform and consistent wall surface system. Their use allows for quick installation, clean details, and, if necessary, panel replacement. This modular system allows the casing to be split into transportable and manageable components. The cladding of the enclosed space is designed using thin, flexible wall panels, either veneer or paper-based.

The roof is designed as a simple, lightweight PVC tarpaulin cover stretched over the upper support frame and secured through eyelets. This solution was chosen since the installation is temporary and does not require a permanent roof deck. The membrane provides an effective, economical, lightweight, and easily replaceable cover that can be quickly installed and removed when no longer needed.

The structural design also includes an elevated modular floor raised approximately by 150 mm above the existing surface using adjustable legs. This platform provides a consistent base for the pavilion and creates additional service space for cable routing and power distribution, while enabling the structure to compensate for uneven terrain and facilitating installation at various temporary exhibition sites. The floor is organised as a modular grid system, which simplifies maintenance, assembly, and disassembly while keeping the visible interior surfaces clean and uninterrupted.

The whole structure is designed for assembly and disassembly. Where it is possible, components are grouped into repeatable elements such as aluminium profile modules, Parklex panels, floor panels, and linear wooden profiles. Most junctions are designed for reversible connection, primarily using bolts or mechanical fasteners. This reduces construction time and allows for the transport, storage, and reassembly of the pavilion.

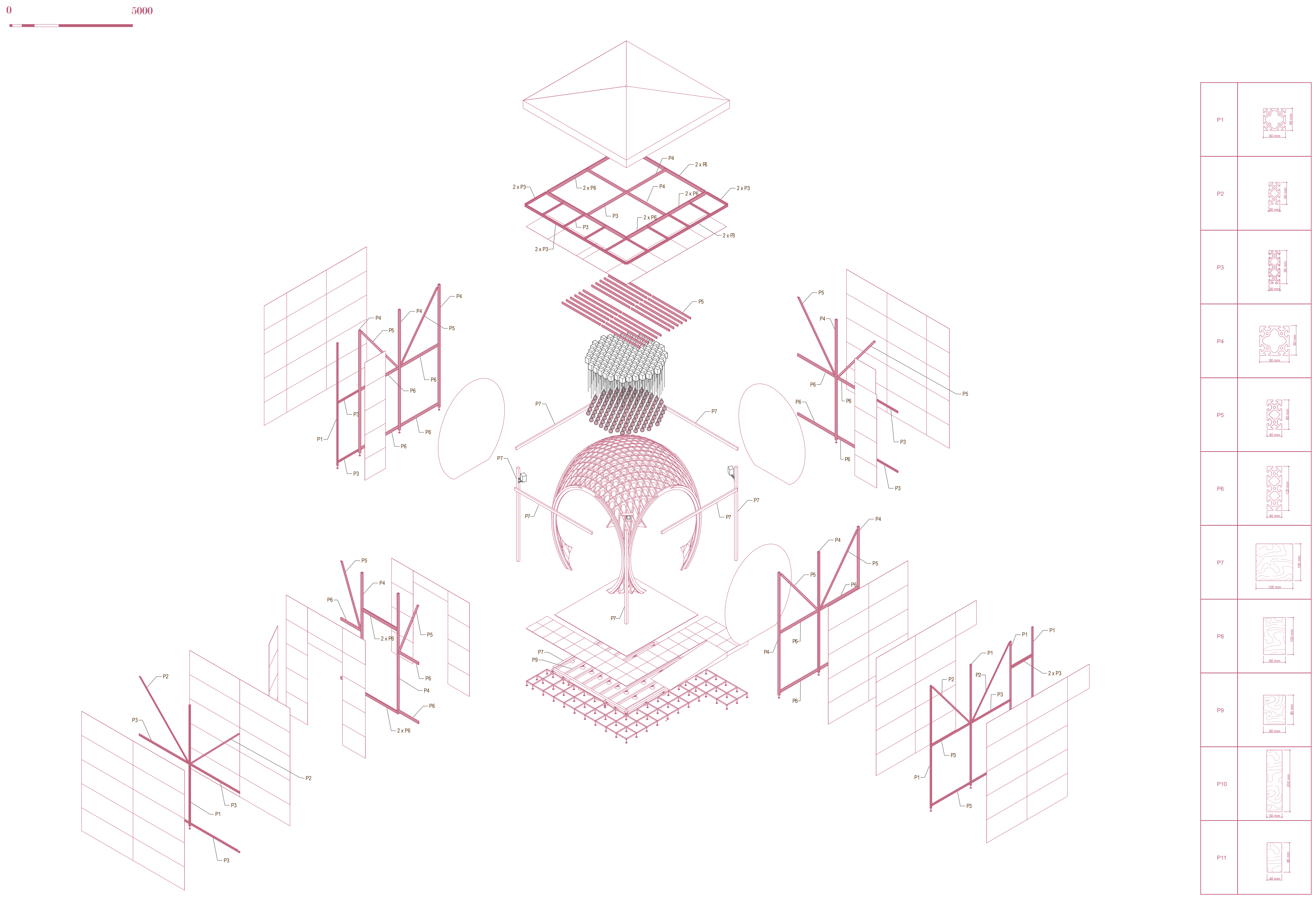


Figure 27.:Assembly System (Author, 2026)

Integrated Technical Infrastructure

The physical structure is designed to support the installation's technical systems, including sensing, projection, lighting, sound, kinetic movement, power supply, and data distribution. Technical components are integrated into the frame, ceiling area and raised floor to keep the system organised and accessible.

The entire installation is designed for a single sensor located in the frontal wall so that it covers the central interaction area without excessive distortion. The placement must provide a clear view of the participant's body, ideally with a horizontal viewing axis. The camera is mounted at fixed structural points in the dome frame, so its position remains stable even after calibration.

Two projectors enable redundant projection, positioned in opposite corners in order to cover the entire active floor area. Dome geometry requires careful calibration of projection direction, masking, and alignment. The projectors are mounted on the designated consoles attached to the structural frame. Their placement is coordinated with the dome's curvature and the participant zone to minimise shadows and maintain consistent image overlap. Due to the focal distance and projection scale, the required lens has a focal length of 0.9–1.2.

Lighting is divided into ambient lighting and responsive LED lighting. Ambient lighting is provided by enclosed suspended floral elements that are part of the kinetic ceiling installation and support the overall spatial atmosphere, while LED elements provide colour variations, transitions, changes in intensity, and programmed patterns.

The audio system is positioned to support three-dimensional sound feedback. The speakers are placed to ensure balanced spatial audio coverage in the interior. Cabling for audio, lighting, projection, sensors, and kinetic mechanisms is channelled through raised flooring and a load-bearing frame.

The ceiling zone contains the most concentrated technical infrastructure. It supports 121 servomotors responsible for kinetic movement of suspended elements, as well as cabling and service access. The ceiling structure, therefore, requires sufficient load-bearing capacity and adequate maintenance spaces. Technical components are grouped wherever possible to simplify wiring, reduce visual clutter, and enable systematic installation.

Control hardware, power supplies, microcontrollers, and data interfaces are located in accessible service zones, preferably outside the main interaction area above the ceiling or under removable floor panels if necessary. This keeps the central interior area clear while allowing for system adjustment, repair, or recalibration during installation.

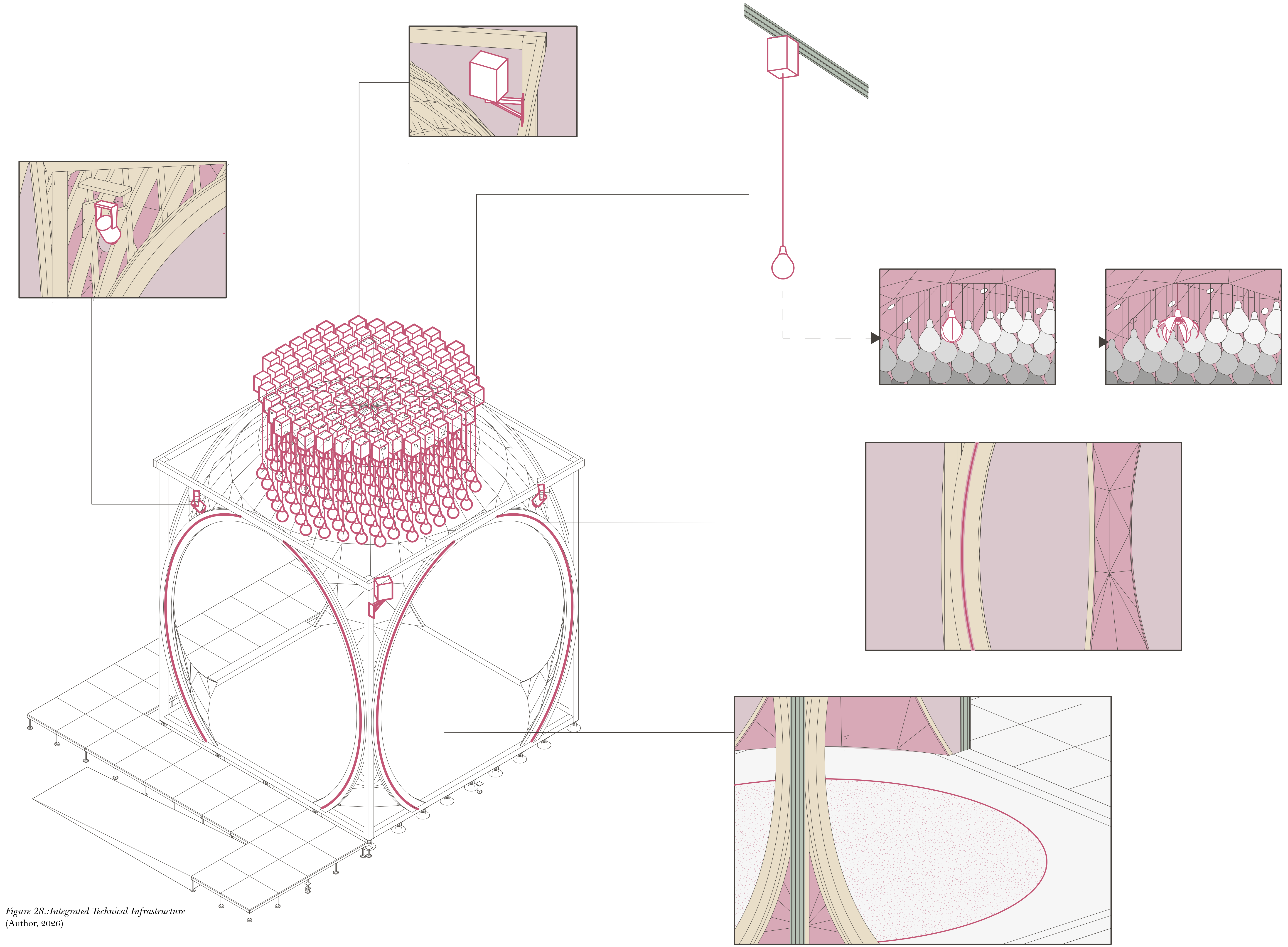


Figure 28.: Integrated Technical Infrastructure
(Author, 2026)

Kinetic Suspended Element Development

The Kinetic suspended Element is developed as a suspended mechanical lighting component consisting of curved radial panels connected to a central operating body. The element is designed to open and close via motorised movement, which gradually changes the appearance of the ceiling in the interaction area.

The floral module consists of six lightweight petals arranged around a central core. Each panel is connected by a pivot mechanism that allows for controlled rotation. The main body includes the key structural connection, the control system, and the suspension point. The principle of action is based on coordinated mechanical opening, where the petals move together as a single kinetic entity.

To test the mechanical principles and assembly logic, a functional 1:1 scale prototype was built. The chosen manufacturing method was 3D printing with PETG filament for core parts and petals out of TPU-82A. The prototype allowed for the evaluation of the panel's geometry, weight, pivot positions, friction, range of motion, motor placement, and assembly details. This testing was necessary to fully evaluate the physical behaviour of the component.

The prototype demonstrated the importance of balancing the panel's weight, stiffness, motor capacity, and joint resistance. The panel material needs to be light enough to be easily controlled, yet strong enough to maintain its rounded shape during movement.

The final element is designed to be suspended from the ceiling structure and connected to the control system. Electrical wiring for the motor and control signal is routed along the suspension to the ceiling service space, and its operation is controlled systematically based on the proposal's computational logic.

This element functions both as a mechanical outcome and as an architectural design detail. Its development physically illustrates one installation part that was developed further in detail, moving from abstract system logic toward a modular component with defined material, structural, and mechanical requirements.

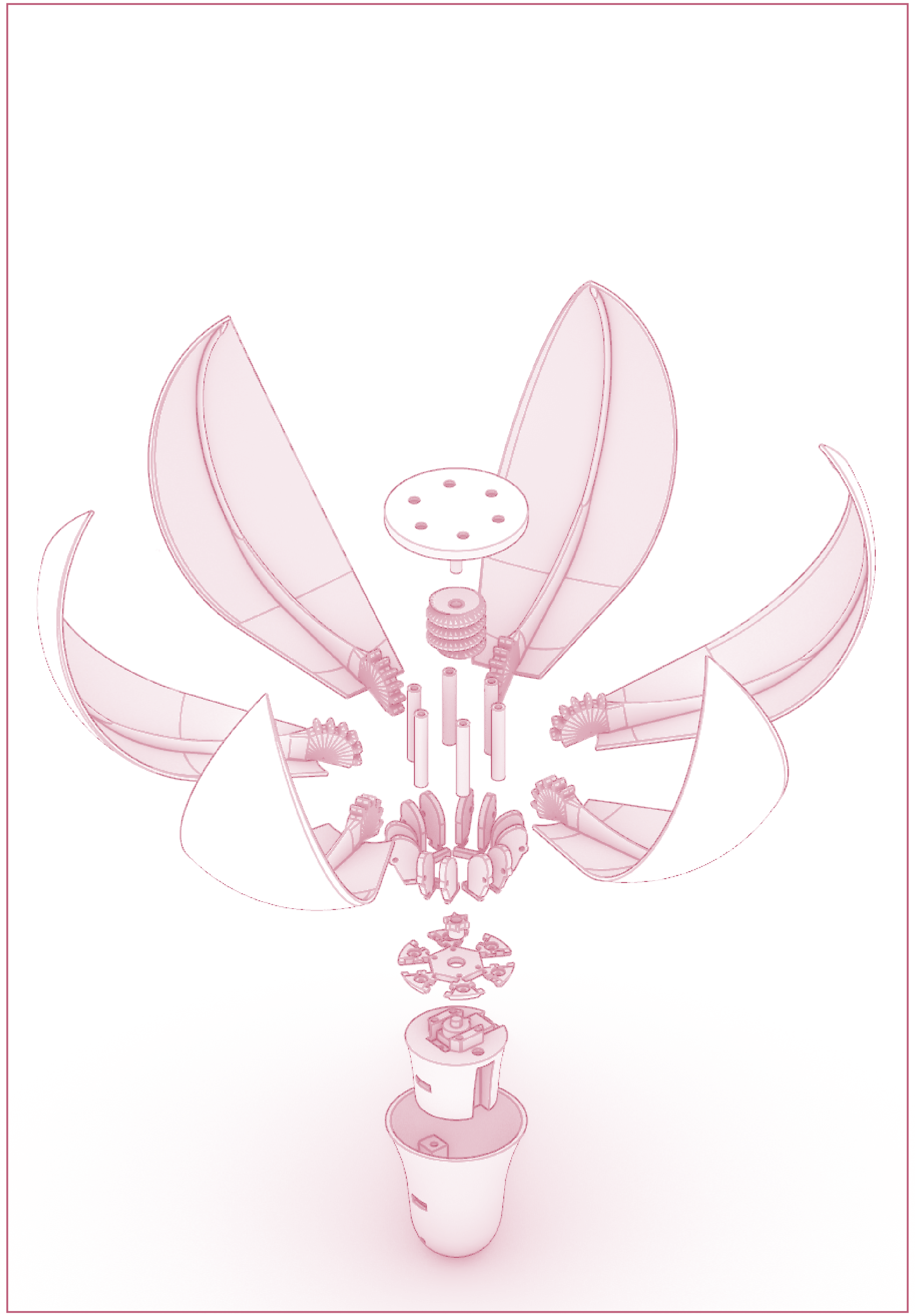


Figure 29.:Kinetic Element Prototype Detail (Author, 2026)

DISCUSSION

Throughout this chapter, we will evaluate how the project addresses the main research question "How can interactive architecture be designed as a co-performative spatial system that interprets human movement and responds through multi-sensory feedback ?" and its subquestions. The discussion is not only about the technological success of the project but also about the quality of the relationship it creates between the body, computation, and space. The pivotal problem thus is not only whether the system responds but simultaneously whether its responses create a meaningful state of reciprocity, agency, and transformation of the atmosphere.

My thesis builds on the premise that architecture should not be understood merely as a static container for human activity. Instead, it explores architecture as a dynamic spatial system capable of sensing bodily presence, interpreting the characteristics of movement, and returning them as visual, auditory, and kinetic feedback. This position was elaborated theoretically through a distinction between responsive, kinetic, and interactive architecture, and practically through a process of research-through-design. Experimental work has gradually evolved from basic motion detection and data mapping toward more complex forms of audiovisual, kinetic, and atmospheric feedback, intending to understand architecture as an active collaborative partner rather than a passively existing surroundings.

From response to interaction

One of the fundamental narratives of this work is that responsiveness and interactivity are not equivalent. During the initial experiments, which involved operations such as hand detection, servo activation, directional gesture mapping, pose triggers, and the conversion of hand velocity colour translation, it was demonstrated that body movement can be captured and converted into visual or physical outputs, and the project's core technical workflow was established. Motion detection, coordinate extraction, value calibration, threshold definition, and linking data to output behaviour thus became essential for creating the system framework of the entire final design. These tests demonstrated that the body successfully functions as a real-time trigger. However, such direct mapping was limited to a unidirectional information flow, which created a system mechanism of reaction rather than interaction.

This distinction supports Lee et al.'s (2021) differentiation between responsive and interactive architectural behaviours, while also aligning with cybernetic understandings of feedback as a reciprocal rather than linear process. It is important since a space that reacts to movement is not automatically interactive in a meaningful architectural sense. If a single movement produces a single predictable output each time, participants may understand the system, but the relationship can only be instrumental. The environment acts more like an interface meant to be controlled than a spatial partner. Initial tests, therefore, confirmed the feasibility of responsiveness but did not yet fulfil the project's ambition of collaborative performance.

The project gradually progressed towards interaction during later experiments, which shifted the focus from isolated positions to relationships and tendencies within movement. The interpretation of bodily action expanded from positional coordinate data to a response to an interpreted intention. In this step, we began to distinguish whether hands were moving apart or towards each other, whether hips generated intensity, whether legs indicated expansion or contraction, whether posture indicated a specific performative state, or whether the speed of movement influenced rhythm and atmosphere. These later experiments developed a richer vocabulary of spatial reactions through the interpretation of proximity, velocity, posture, direction, and relational movement.

The most significant shift, thus, occurred from reaction to interpretation. Reaction describes a direct relationship between input and output. Interpretation describes a more complex state in which movement is filtered, compared, combined, and transformed before it becomes spatial behaviour. This transition is essential to the idea of architecture as a co-acting agent. Such a space then begins to develop behaviour via the movement of the participant, and this behaviour is returned as an altered atmospheric state that prompts a new change in reaction.

However, the project achieves this form of interactivity only partially. The system still relies on predefined mappings, thresholds, and designed relationships. It does not yet feature long-term adaptive memory that would allow it to evolve independently through repeated encounters. For this reason, the project should not be understood as a fully autonomous interactive architecture, but rather as a framework demonstrating architecture's shift toward interpretive spatial exchange rather than direct reaction.

Movement as spatial information

The second key finding was that motion does not automatically become meaningful data. It must be constructed through calibration, scaling, smoothing, filtering, thresholding, value remapping, and repeated testing. Every change in sensor position, camera angle, distance, framing, or tracking method alters the numerical range of the captured data. For this reason, calibration has become an essential part of the design process, as it specifies how the system understands the body movement and how the body can influence spatial behaviour.

Crucial for interactive architecture also became computation, but not as merely a layer of technical support, rather an integral part of the design medium. Threshold, delay, smoothing value, or mapping range directly influence the rhythm, sensitivity, clarity, and emotional quality of the spatial response. If the threshold is too low, the system becomes unstable and produces false triggers. If it is too high, the participant loses the ability to make decisions because their movement is no longer recognised. If the response is too immediate, it can feel mechanical, but if it is too delayed, the relationship between action and consequence becomes unclear. Designing interaction, therefore, means designing the relational sensitivity between movement, data, interpretation, and spatial expression.

Several movement parameters were found to be particularly effective. Velocity allowed intensity to be translated into colour, particle behaviour, and sound modulation. Proximity enabled the system to detect bodily expansion, contraction, and relational movement. Direction allowed for the organisation of wave-like kinetic behaviour. Posture allowed specific bodily states to trigger light, mechanical, or auditory responses. Position allowed projections and atmospheric effects to follow or surround the participant. Together, these parameters demonstrate that the body communicates with space not only through raw coordinates but also through additional changing qualities.

Therefore, the project perceives movement as a spatial language, but not in a literal or universal sense. The system does not understand the human meaning of a gesture. Instead, it analyses specific movement characteristics according to a predefined computational logic so that the sensing is not suggestive but, on the contrary, sufficiently open to the user's own realisation. This puts the designer in a key role. The designer decides which bodily properties are important, how they are measured, how they are combined, and how they are spatially expressed.

This clarification is important for the academic positioning of the master's thesis. The project does not claim to solve the problem of reading bodily expression in general. Rather, it develops a contextual design method for translating movement qualities based on dance into architectural behaviour. More specifically, this paper aims to show how architecture can begin to interact with embodied expression without reducing the body to a mere controller of the system, but instead understanding it as a medium through which perception, action, and meaning are produced (Simanowski, 2011).

Multisensory feedback and atmosphere

The most significant step from an architectural perspective was when the response was no longer limited to individual outputs but was distributed across projection, sound, lighting, and kinetic movement. The final installation functions as a multi-layered system in which full-body tracking captures the position, coordinates of body parts, proximity, velocity, posture, rhythm, and intensity of movement. These values are interpreted computationally, interconnected, and expressed through spatial systems that operate in parallel and influence each other as well.

This is significant because the architectural experience is not created through a single sensory channel. The project's multisensory strategy builds on Spence's argument that spatial experience depends on the congruence of sensory modalities rather than visual perception alone (Spence, 2020). Projection, sound shifts, changes in light, or ceiling movement can each have an effect, but the atmosphere arises through their coordination. In the final design, the projection alters the participant's relationship to the floor. Sound modifies rhythm, tempo, tonal quality, and width. Lighting adjusts colour, intensity, transition, and mood. The kinetic ceiling alters the perceived volume and presence of the space overhead. In combination, these outputs create an environment that responds not as a set of devices, but as an atmospheric field.

The system diagram emphasises this trend from a linear response toward layered behaviour. It does not depict a single input connected to a single output, but rather a network of relationships between body coordinates, the proximity of hands and feet, pose zones, speed of movement, tone, tempo, LED light colours, projection masking, atmospheric images, value randomisation, blooming lights, and ceiling choreography. The diagram is therefore not merely technical documentation but also visualises the central argument of the project, which states that interactivity is created through interdependent operations rather than isolated effects.

The spatial organisation of the installation amplifies this atmospheric logic. The minimalist cubic exterior and spherical interior massing create a transition from external neutrality to internal immersion. The entry route gradually reveals the central chamber to its entirety, as the round room becomes the primary field of interaction. This supports the project's metaphor of an individual perceptual "bubble," where space is not understood as a neutral container, but as something shaped by perception, action, and feedback.

From this point, the project moves beyond technical prototyping and becomes architectural. The aim is not to simply force movement to generate effects. Proposal heads to create a spatial state in which the dance choreography contributes to the evolving environment. The project's architectural quality therefore lies in the coordination of sensing, computation, construction, and multisensory feedback into a coherent experience.

Agency, uncertainty, and co-performance

In interactive architecture, balancing readability and unpredictability is a core challenge. If the system is completely predictable, the participant quickly learns how to control it, and the interaction becomes repetitive. If the system is too random, the participant loses motivation because the response seems disconnected from their movement. The most powerful moments in the project occur between these extremes.

Later experiments showed that controlled unpredictability can foster engagement when the participant understands that their movement has consequences but cannot fully predict the exact outcome. This was particularly evident in advanced auditory and multisensory experiments where a number of parameters were applied simultaneously. The body not only triggered the sound but also modulated the tempo, volume, pitch, and frequency through proximity, position, and the relationships between body parts. Since these parameters interacted, the result became partially unpredictable, yet remained linked to recognisable bodily activity thanks to subconscious cognitive metaphors. In this way, a person can automatically assign properties to certain tendencies based on experience, such as the directions up and down, forward and backwards, right and left, apart or together. The concept became a critical strategy for the final design.

The entire collaboration concept is dependent on this balance. Space as interactive partner is not a passive object, nor is it a fully controllable tool. It has its own timing, tendencies, and behavioural variations. In the final design, this condition is supported by randomisation of generated values, timers, delayed transitions, and internal atmospheric states that allow the installation to continue operating even without direct human input. As a result, the room begins to behave increasingly as an active environmental entity capable of independent existence. Participants' agency is thus not based on complete control. It is based on negotiation. Dancers move, observe the reaction, adjust their movement, and explore new possibilities through feedback. This creates an improvisational relationship in which the experience is created between the body and the space, and not just by one of them alone. The performer is a contributor to the evolving spatial condition.

A space that merely submits becomes an interface. For interactive architecture, the meaning of space is expanded by processes that partially delay, transform, reinterpret, or exceed the participant's movement, as it has the potential to become performative. This aligns with Mun's (2023) concept of "imperfection to emergence," where uncertainty and partial loss of control can encourage curiosity, interpretation, and engagement (Mun, 2023). The role of controlled unpredictability is therefore not merely decorative. It is what allows the environment to feel less like a machine and more like a partner in creating the experience.

Material and technical integration

The final design also demonstrates that the system proposal of interactive architecture cannot be separated from the physical structure. The system depends on the integration of sensors, projectors, lighting, sound, kinetic components, power supply, data distribution, service zones, and access for recalibration. The raised floor, ceiling zone, dome geometry, structural frame, and service spaces are not purely formal or structural decisions, but simultaneously, they support the technical infrastructure necessary for interaction.

This is notably evident when looking at the kinetic ceiling. It contains the most concentrated technical infrastructure, including 121 suspension motors, cabling, control hardware, suspended floral elements, and service access. Its spatial effect depends on the coordination of mechanical performance, structural stability, motor control, maintenance logic, and computational choreography.

Designing a kinetic suspended light module demonstrates this relationship at the detail level. The blooming component required testing of geometry, mass, rotation angles, friction, range of motion, motor placement, material stiffness, and assembly details, which proved that architectural behaviour is not created by software alone. It must be supported by material, structure, mechanism, and maintenance.

Interactive architecture is often discussed through abstract diagrams of sensing and response. The project, on the other hand, demonstrates that the reliability of spatial behaviour depends on construction details. The sensor needs to remain stable after calibration. The projection has to be correctly mapped according to the angles of device placement. Kinetic elements should be light enough to move, yet robust enough to retain their shape. Cables, motors, and access points require careful organisation to keep the central interactive space visually and physically uncluttered. In this sense, the work demonstrates that co-performative architecture is both computational and tectonic.

The project has several limitations that define its scope. The first concerns the scale of the design, which is intended to be more in a performative installation dimension than a full-scale building. This scale is suitable for testing embodied interaction as it allows for relatively controlled conditions for sensing, projection, lighting, sound, and kinetic movement within a short thesis timeframe. However, this means that the findings ought to be understood as a conceptual and experimental framework rather than a directly transferable building system.

A second limitation lies in tracking accuracy and technical reliability, as the experiments depended on available tools such as webcam tracking, Kinect, MediaPipe, TouchDesigner, Arduino, Ableton, LED light strips, low-power microservomotors in experiments, and similar devices. These tools enabled rapid experimentation but also introduced noise, jitter, false triggers, data loss, and sensitivity to the environment. The project addressed these issues through filtering, smoothing, clipping, thresholding, and recalibration, but it was not possible to eliminate them entirely.

A third limitation involves autonomy. Although the final system incorporates randomisation, timers, delayed transitions, and internal states, it does not include long-term adaptive memory. This means that the installation can behave with a certain degree of independence, but it cannot learn deeply from repeated interactions over time. Its autonomy is therefore partial rather than complete.

A further restriction lies in the participation, since the system, as it is now, is primarily designed to follow one person, with the possibility of a small group being present where focus is shared. This promotes clarity in the interaction but limits the exploration of collective behaviour. Future development could explore how multiple bodily inputs influence the same spatial system, how competing inputs are prioritised or blended, and how group movement can generate shared atmospheric states.

A final constraint is the sensory scope, with attention primarily on visual, auditory, and kinetic feedback. These outputs are well-suited to the relationship between dance, movement, and atmosphere, but other sensory modalities, such as touch, temperature, airflow, vibration, or scent, could theoretically further deepen the embodied experience, although the scope of the ongoing project has, since the beginning, narrowed the outputs to visual, auditory, or kinetic.

Rather than weakening the inquiry, these limitations firmly situate the project within a research-through-design framework that aims to understand how interactive spatial systems can be conceptualised, tested, and developed, instead of presenting a finished autonomous architecture.

Contribution to interactive architecture

This work offers a conceptual contribution by defining interactive architecture as a co-performative relationship rather than a reactive mechanism. The project demonstrates that the mere presence of sensors, projections, motors, or responsive effects is not sufficient. What matters is the quality of the feedback between the body, computation, and space. At the same time, the thesis makes a methodological contribution through a sensory-cognitive-expressive framework. This framework clarifies how movement can be captured, interpreted, and spatially expressed. It outlines a strategy for transition between theory, experiment, and design and links technical processes with architectural experience. Theoretical Proposal presents this model as a layered process of recognition, interpretation, and transformation between the body, the system, and the environment. As a further speculative proposal for a pavilion, it offers a design that demonstrates how motion tracking, projection, sound modulation, atmospheric lighting, autonomous behaviour, and kinetic ceiling systems can be integrated into a coherent spatial environment. The final design not only illustrates the theory but also tests how theory can become architecture.

Perhaps one of the strongest contributions of this work is the argument that interactive architecture becomes meaningful when it exceeds the boundaries of direct responsiveness. The project demonstrates how movement can be perceived as a data set, interpreted through selected qualitative parameters, and reflected through the creation of a multisensory atmosphere. In this process, the participant not only occupies the space but also helps to shape it. Architecture is no longer a mere stage for movement but becomes an integral part of its unfolding.

The work, therefore, answers the research question by demonstrating that architecture can become co-performative when designed as a layered feedback system. It must be sensory in how it perceives the body, cognitive in how it interprets dance, and expressive in how it transforms the spatial atmosphere. While this does not create a fully autonomous architectural subject, it opens up a clear framework for future interactive environments that are more embodied, relational, and affective. In this model, one does not simply enter a space. It is continuously negotiated between body and environment.

CONCLUSION

This master's thesis explored how interactive architecture can be designed as a co-performative spatial system that interprets human movement and responds through multisensory feedback. Building on a critique of architecture as a static container for human activity, this project instead proposes that space can be understood as an active participant in embodied experience within a true interaction. Through theoretical research, experimental prototyping, and speculative architectural design, my thesis investigated how the body, computation, and space can enter into a reciprocal relationship.

The central argument of my thesis is that meaningful interactive architecture depends on more than just the ability to react. A reactive system produces an output when it receives an input stimulus. In this way, a co-performative system, on the other hand, creates a feedback loop in which movement influences the environment, and the transformed environment influences further movement, perception, and engagement. The project thus distinguishes between responsiveness as a technical reaction and interactivity as an embodied, relational, and atmospheric exchange.

Researchers have shown that movement can become a form of spatial information when interpreted through specific qualitative parameters. Early experiments confirmed that bodily movement can be captured, calibrated, and linked to visual or mechanical outputs. Later experiments became more significant because they moved beyond direct mapping and began to interpret speed, proximity, posture, direction, rhythm, and relational movement. This shift is key to the thesis because it shows that architecture can start to interact with the body not only as a moving object but also as an expressive medium.

The sensor-cognitive-expressive framework developed in the thesis provides a structure where the sensory layer captures bodily movement, the cognitive layer interprets movement through computational logic, and the expressive layer translates this interpretation into spatial feedback. This context connects theoretical questions of embodiment, feedback, performativity, and atmosphere with the practical development of interactive systems. It also clarifies that computations are not just a technical tool but a full-fledged part of the architectural design environment. Thresholds, mappings, delays, smoothing values, and calibration decisions shape how the participant experiences agency, sensitivity, and spatial presence.

The final installation design synthesises all these findings into a speculative architectural environment. Its cubic exterior and round interior create a transition from external minimalistic neutrality to internal immersion, thereby supporting the concept of a personal perceptual "bubble." In this environment, movement influences projection, sound, lighting, and kinetic behaviour. These responses are not intended as isolated effects, but as part of a multisensory atmospheric field. The project, therefore, demonstrates how interactive architecture can function less as a controllable device and more as an environment that listens, transforms, and participates.

Another significant finding of the research is that controlled unpredictability is essential for collaborative performance. If an interactive system is entirely predictable, it risks becoming a device. If it is entirely random, the participant loses their agency. The project seeks and explores a middle ground in which the participant realises that their actions are important but cannot fully control the outcome. This encourages the interaction to become exploratory, improvisational, and reciprocal. The participant not only controls the system but also negotiates with it.

It is clear from the proposal that interactive architecture is as much computational as it is material. Spatial behaviour depends not only on software, data monitoring, and processing, but also on structure, weight, friction, motor capacity, access, wiring, projection alignment, and maintenance. The kinetic ceiling and suspended elements demonstrate this particularly clearly. Architectural behaviour must be designed with an emphasis on material and tectonic decisions as well as through digital logic.

Through its content, this master's thesis contributes to interactive architecture in three interconnected ways. Conceptually, it rethinks interactivity as a shared performance rather than a reaction. Methodologically, it proposes a sensory-cognitive-expressive framework as a means of linking motion capture, computational interpretation, and spatial expression and finally, architecturally, it demonstrates how these ideas can be translated into a speculative installation where movement, atmosphere, and spatial behaviour are generated collectively.

The project's limitations also define its informative value. The proposal remains more of a small design-research installation than a complete building system. Its autonomy is only partial, and its interaction model depends on available tracking, calibration, and output technologies. These limitations make the work most useful as a framework for future development, rather than as a finished solution.

Future research could extend this work through more robust tracking systems, adaptive calibration, machine learning-based motion recognition, long-term behavioural memory, and multi-user interaction. As well as expand the sensory field through touch, temperature, airflow, vibration, or scent and test the framework at larger architectural scales. Such developments would bring the project's ideas closer to truly adaptive and socially responsive architecture.

In conclusion, this work argues that architecture can become co-performative when designed as a layered feedback system. As a sensory layer, it perceives the body, as a cognitive layer, it interprets movement, and as an expressive layer, it transforms the atmosphere. Interactive architecture becomes meaningful not when space simply reacts to the body, but when the body and space begin to influence each other through constant interpretation, feedback, and adaptation. In this model, space is not merely entered. It is constantly negotiated, enacted, and produced through embodied experience.

LIST OF REFERENCES

- ArtReview. (2020). 'No One is an Island' presented by Random International and Studio Wayne McGregor. https://artreview.com/superblue-bmw-i-no-one-is-an-island-random-international-wayne-mcgregor/

- Böhme, G. (2016). Part III Architecture and Part IV Light and sound. In The aesthetics of atmospheres. https://doi.org/10.4324/9781315538181

- Fehr, J., & Erkut, C. (2015). Indirection between movement and sound in an interactive sound installation. MOCO '15: Proceedings of the 2nd International Workshop on Movement and Computing, 160–163. https://doi.org/10.1145/2790994.2791016

- Fischer, T., & Herr, C. M. (2019). Design Cybernetics. In Design research foundations. https://doi.org/10.1007/978-3-030-18557-2

- Lee, J. H., Ostwald, M. J., & Kim, M. J. (2021). Characterizing Smart Environments as Interactive and Collective Platforms: A Review of the Key Behaviours of Responsive Architecture. Sensors, 21(10), 3417. https://doi.org/10.3390/s21103417

- Levin, G., & Lieberman, Z. (2004). In-situ speech visualization in real-time interactive installation and performance. Proceedings of the 3rd International Symposium on Non-Photorealistic Animation and Rendering, Annecy, France. https://doi.org/10.1145/987657.987659

- Meagher, M. (2015). Designing for change: The poetic potential of responsive architecture. Frontiers of Architectural Research, 4(2), 159–165. https://doi.org/10.1016/j.foar.2015.03.002

- Merleau-Ponty, M. (2002). Phenomenology of perception (C. Smith, Trans.). Routledge. (Original work published 1945). http://voidnetwork.gr/wp-content/uploads/2016/09/Phenomenology-of-Perception-by-Maurice-Merleau-Ponty.pdf

- Miccoli, G., Bakogianni, A., Fatah gen. Schieck, A. (2015). Breathing Display: Exploring the Effects of a Responsive Installation on People's Behaviour in Public Space. Proceedings of the 4th International Symposium on Pervasive Displays, 273–274. Presented at the Saarbruecken, Germany. doi:10.1145/2757710.2776821

- Mun, R. S. (2023). Strategies for Influential Interactivity in the Physical Domain [Thesis, Massachusetts Institute of Technology]. https://hdl.handle.net/1721.1/151328

- Pask, G. (1969). The architectural relevance of cybernetics. Architectural Design, 39(6), 494–496. https://arl.human.cornell.edu/879Readings/GordonPask_Architectural%20Relevance%20of%20Cybernetics.pdf

- Pitt, B., & Casasanto, D. (2022). Spatial metaphors and the design of everyday things. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.1019957

- Random International. (2020). No One is an Island. https://www.random-international.com/no-one-is-an-island-2020/

- Estudio Guto Requena. (n.d.). Mapped Empathies. https://en.gutorequena.com/mappedempathies/

- Romero, A. C. G., & Leal, J. A. F. (2022). Responsive Architecture: New paradigms of urban relations. SHS Web of Conferences, 139, Article 01005. https://doi.org/10.1051/shsconf/202213901005

- Sáez Vacas, F. (1991). A cybernetic theory about computer interfaces and human factors within a framework of technological innovation. Paper presented at the Conference on Human Jobs and Computer Interfaces, Tampere, Finland. https://oa.upm.es/22705/

- Simanowski, R. (2011). Interactive Installations. In Digital Art and Meaning: Reading Kinetic Poetry, Text Machines, Mapping Art, and Interactive Installations. Minneapolis: University of Minnesota Press. https://muse.jhu.edu/book/24671.

- Skyform Studio. (n.d.). Heavenly Symphony: Kinetic light installation. https://skyformstudio.com/sky-symphony-kinetic-art/

- Spence, C. (2020). Senses of place: architectural design for the multisensory mind. Cognitive research: principles and implications, 5(1), 46. https://doi.org/10.1186/s41235-020-00243-4

- Studio Drift. (n.d.). Shylight. https://studiodrift.com/work/shylight/

- Yatzer. (2015). A choreography of lights by Studio Drift in Amsterdam's Rijksmuseum. https://www.yatzer.com/choreography-lights-studio-drift-amsterdams-rijksmuseum

Statement on the Use of Generative AI

In preparing this thesis, I used Grammarly for grammar and style correction, DeepL for translation, ChatGPT (OpenAI) for phrasing, structure revision, improving textual coherence, and for assistance in writing and debugging scripts in TouchDesigner and Arduino IDE. I also used NotebookLM (Google) to organise and narrow the list of relevant references. All AI-assisted outputs were critically reviewed, verified, and edited by me, and no AI system was used to generate original ideas, data, or analytical results.

Tereza Táborská

taborskatereza@gmail.com
taborska@chalmers.se
+421915255646

- **Architecture and Urban Design** I **Master's Degree**
  ARCHITECTURE AND CIVIL ENGINEERING, CHALMERS UNIVERSITY OF TECHNOLOGY
  GOTHENBURG, SWEDEN
  2024 - 2026
  Architecture in the anthropocene - ACE400
  Sustainable development and the design professions - ACE380
  Material and technique - ACE475
  Urban inequalities - ACE390
  Media and representations - ACE415
  Social-ecological urbanism - ACE535
  Master's thesis preparation: Design approaches and narratives - ACE425
  Master's thesis preparation: Academic approaches and general structure - ACE370
  Mediated material interfaces - ACE510
  Master's thesis in Architecture - ACEX35

- **Architecture and Urbanism** I **Bachelor's degree**
  FACULTY OF ARCHITECTURE, CZECH TECHNICAL UNIVERSITY IN PRAGUE,
  PRAGUE, CZECH REPUBLIC
  2021- 2024

- **Teaching Assistant**
  CHALMERS UNIVERSITY OF TECHNOLOGY
  GOTHENBURG, SWEDEN
  2025 - 2026
  in courses: Architecture in the Anthropocene, Digital Design, Rum och Geometri

- **Architectural intern**
  N/A ARCHITEKTI
  BRATISLAVA, SLOVAKIA
  2025

- **Student competition finals in London**
  ULI HINES STUDENT COMPETITION,
  LONDON, UNITED KINGDOM
  2025

- **Award for affordable housing design from the Ministry of Regional Development of the Czech Republic (as part of the team from the Faculty of Civil Engineering, CTU)**
  CONSTRUCTION HACKATHON, FESTIVAL OF ARCHITECTURE,
  BRNO, CZECH REPUBLIC
  2024

CHALMERS
UNIVERSITY OF TECHNOLOGY

THANK YOU

I would like to sincerely thank my supervisor, Kengo Skoric, for his guidance, critical feedback, and continuous support throughout the development of this thesis. His warm and encouraging approach helped me stay motivated and confident during the process.

I would also like to thank my examiner, Jonas Lundberg, for his role in the evaluation of this thesis and for contributing to the academic framework of the final presentation.

I am deeply grateful to my family for their constant support and patience throughout my studies.

Finally, I want to thank everyone who supported me through discussions, encouragement, testing, and patience. I am especially grateful to Kostas and Niki for their support, honest feedback, and for being there throughout this process. This thesis has been a long process of exploration, and your support helped me bring it from an abstract idea into a structured architectural proposal.