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OTHER PERSPECTIVES: EXTENDING THE ARCHITECTURAL REPRESENTATION

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ABSTRACT

This paper discusses how the tension between arts and science inherent in the discipline of architecture, can be traced in architectural representations, which are not neutral but actively contribute to the design process, ranging from highly poetic, subjective, and artistic to more exact and objective. Within this paper, we reflect on how to overcome this restrictive perspective implicit in conventional design media by comparing two elective courses that aim to broaden the traditional architectural perspective. In doing so, we take a position in the broader debate on the role of artistic practices within an academic learning environment.

KEYWORDS

architectural representation, digital design media, design process, design tools, embodied experience, artistic practices, education, sensuous body

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INTRODUCTION

Architecture is pre-eminently a discipline in which science and art come together and are strongly intertwined. It is a generalist field dealing with wicked problems and challenges involving many parameters that do not have an optimal or singular solution. Architectural practice builds on knowledge and practices from diverse disciplines, synthesizing them into specific and often unique design solutions. Architectural research analyses partial aspects of architectural production and constructs theoretical insights, which are disseminated through a range of academic and professional publications. The connection between and interdependence of architectural practice and architectural research is often debated and further highlighted through the relatively recent academization of architectural education.[1] The tensions between art and science, synthesis and analysis, practice and theory are permeating architectural practice, education, and research.

Architectural practice is an increasingly differentiated field with diverse approaches and positions (Hyde, 2012). Architects respond to spatial questions, self-initiated or for clients, by designing architectural propositions. Research is often part of architectural design processes, while this label covers acts of inquiry that diverge from scientific rigor and methodology (Hensel & Nilsson, 2016). Architectural production ranges from speculative to concrete, and takes the form of various media, from publications over installations to buildings. Architects play a central role in designing and orchestrating the execution of projects, relying on knowledge from other experts and practitioners to realize projects.

In architectural education, the interdependence of art and science is made explicit in the structure of curricula, in particular in the first years of architectural bachelor's programs. Across different institutes and universities these programs can differ substantially in learning environments and pedagogical approaches (Spiller & Clear, 2014), they combine theoretical courses with practical design studios and generally contain the following elements. Architectural history and theory build mainly on fields of humanities such as history, philosophy, sociology, anthropology… Building technologies, construction, structure, climate and physics are based on engineering and exact sciences. Practical education in drawing, composition, architectural representation, making, and craftsmanship, builds on various artistic and crafts practices and techniques. The design studio is conceived as the learning environment where these various forms of knowledge and practices are integrated into an iterative architectural design process, often mimicking the orchestrating role architects have in practice.

Research in architecture institutions can be roughly broken down into the same fields as architectural education outlined above.[2] Architectural history and theory and building technologies are well-established self-sufficient fields of research, that mainly use research methodologies from humanities and engineering sciences respectively. Only more recently has research been developed into the practice of architecture, where architectural design processes are the main driver for knowledge production, in parallel with the emergence of design research (Fraser, 2014) and artistic research (Hougaard et al., 2016). The debate on what constitutes valid and rigorous research into the artistic dimension and design practice in architecture are far from settled, distinctions being made between practice-based, design-led research and research into, by, and for design and the modes of knowledge production.

The interdependence of art and science permeates all aspects of architectural practice, education, research, and is particularly present in the different media architects use to develop and communicate knowledge. In this paper, we look at visual representations in architectural design processes, and how they afford scientific and artistic practices and knowledge production. Hereby we only take into account visualizations in their role as a design tool and not as instructional technical communication documents. After discussing the foundational importance of visual representation and perception in architecture, and outlining artistic and scientific tendencies in visual representation, we propose alternative perspectives or plot different trajectories in the overlap between arts and sciences. The research is based on comparing two elective courses that address visual representation and experience from different perspectives.

SHIFTING ROLE OF VISUAL REPRESENTATION IN ARCHITECTURE

Visual representations, most notably the architectural drawing, have been the principal medium within architectural design. But also, various other forms of representations are used to analyze and map sites, explore design variation, develop architectural propositions, and communicate and disseminate design ideas. Given that design proposals originate as an idea in the architect's mind, it is particularly the architectural drawing that allows imagined spatial ideas to become explicit and be further developed. Therefore, the architectural drawing serves a highly important role in architectural design processes. Despite these representations being predominantly visual, architects also use tactile media such as physical models, prototypes, material samples, and even hand drawings involving a degree of tactile engagement. According to English architect and historian Robin Evans (1997), the emergence of drawing as a means of claiming authorship in architectural design coincided with the formation of the profession of architecture (p. 160). Furthermore, he argues that the development of visual representation techniques such as orthographic projection and linear perspective works as distancing devices enabling architects to design in the studio rather than on the construction side. As such, the drawing separates the act of designing from the act of constructing and emancipating architecture to become liberal art. In contrast to many other design disciplines, architects generally do not work directly on the object they are designing but always use an intervening medium, i.e., architects do not work on-site or make buildings they make representations of buildings. Also, as Evans (1997) states, the distance, the translation between drawing and building, is not neutral but may generate novel design ideas.

All phases of the architectural design process are affected by the widespread adoption of digital technologies in architectural practice, from design to construction and use. The most direct impact of computation can be found in the tools, media, and procedures architects use for architectural design. Initially, digital design tools were developed as digital versions of familiar analog techniques of drafting and modelling, as can be seen in the early adoption of computer-aided design (CAD), drawing remained the principal means of developing and communicating. Later, cinematic visualizations followed to simulate moving around in a design. Recently we have seen a shift from this analog drawing-based approach to a digital model-based one (Marcus & Kudless, 2018, p. 47), enabled by developments in parametric modeling, computational design, and building information modelling (BIM), where digital models become the main medium for developing and communicating architectural design (Scheer, 2014). In this digital model-based approach, 2D drawings are still produced. They are seen as views on or sections through the model that exactly represents the design.

These shifts deeply affect the central role of architectural drawing. Some have argued that architectural drawings are anachronistic and should be dismissed for architecture to fully engage with the innovative potential of digital technologies. At the same time, the adoption of a digital model-based approach has freed architectural drawing from its instrumental function, which resulted in a renewed interest in drawing both in academia and practice, which is attested in the extensive number of conferences, exhibitions, and publications. The renewed interest in architectural drawing can be seen as a revaluation of the role of craft in architectural design (Riedijk, 2010), resisting the deterministic nature of a model-based approach, or even digitization itself. More interestingly, we see an evolution toward post-digital drawing approaches (Leach, 2018), combining or switching between analog and digital media. These practitioners embrace digital technologies not as means of closing the gap between design and making, but for opening up novel ways of designing.

SPATIAL PERCEPTION AND THE SENSUOUS BODY IN ARCHITECTURE

Given the afore-described nature of the architectural design process, which is primarily based on representations of not yet materialized spatial designs instead of on "the making" of the designed artifact itself, architects are constantly confronted by the impossibility of representing the architectural design, including its technical preconditions and at the same time experience it as an entity (Evans, 2000). The latter concerns a tension that is inherent in the architectural design process and can be linked to the limitations of architectural representations. Conventional architectural representation methods such as plans, sections, and elevations represent a given space or spatial artifact mainly in terms of its functional and quantitative aspects. In contrast, perspective drawings (including 3D renderings) are commonly used to understand and communicate the experiential and qualitative aspects of a particular design. In this respect, architectural representations have a double function: on the one hand, they are used as a tool for designing and, on the other hand, as a tool to communicate. During the process of creation, the imagination and the understanding concerning spatial qualities of a design occur. But likewise, the architectural representation serves as a tool for communicating what has been designed to external viewers. For both functions, the conventional architectural representation is at stake.

However, in both of its functions, whether as a design tool or a tool for communication, conventional architectural representations cannot deal with bodily experiences that go beyond the visual. As such, how a spatial design is ultimately experienced is left to the imagination and empathy of its creator as well as its reader and can only be evaluated based on visual aspects of the representations. While spatial experiences at the time designs are realized concerns a 3D given involving all bodily senses. Therefore, throughout architectural history, several academics argue that conventional architectural representation tools are not sufficient to design, nor to communicate about bodily experience of a design (Halprin, 1965; Tschumi, 1990; Virilio, 1994; Pallasmaa, 1996).

The architectural representation can be considered a form of language translating the spatial perceptions of designers. It is not the intention to elaborate on philosophical, cognitive, and psychological definitions, theories, and insights regarding the concept of perception. However, it is found to be relevant to frame the notion and some of its characteristics concerning space to establish its translation within architectural representations. British geographer Paul Rodaway (2005) identifies a certain duality residing in the concept of perception, which he describes as two dimensions. The first dimension originates from the sensation of environmental stimuli, involving both kinetic and biochemical interactions between individuals and their environment. In comparison, the second dimension involves a cognitive process that arises from recognition, memory, associations, and so on. He ultimately considers the interaction between both dimensions to be individual perception, which enables humans to understand the world around them, and hence acquire an understanding of space. However, in addition to his definition, he also emphasizes three characteristics of the concept. First, he states that perception is multisensory. As such, it always involves an interaction between different senses, the brain, and environmental stimuli. Secondly, he argues that it concerns "a learned behaviour" through which "any definition of perception will be culturally specific" (Rodaway, 2005, p. 12). Finally, he adds that "perception is corporeal; it is mediated by our bodies and the technological extensions employed by the body" (Rodaway, 2005, p. 12). With this definition and clarifications, Rodaway (2005) stresses the complexity of the concept, which can be understood as an individual and culturally bound process. Concerning architectural representations, the perception of the designer is decisive in its role as a design tool and, on the other hand, the perception of the recipient is important for the interpretation and reading of the created representation in its function as a communication tool.

Following Rodaway's (2005) definition of perception, it can be stated that the sensuous body fulfills a major role in the acquisition of spatial perception. From a traditional approach to the sensuous body, five senses can be distinguished—sight, hearing, taste, smell, and touch—at the basis of human sensory experience. Within this traditional view, kinaesthesia is often neglected or underestimated as a sensorial experience (Berthoz, 2002; Moore & Yamamoto, 2012; Noë, 2010, Sheet-Johnstone, 2011). Kinaesthesia according to Rodaway (2005) concerns "an active sense which is integrally involved with the locomotive ability of the body and specifically focuses upon the role of touch in the perception of space and relationships to place". Touch involves the skin and all underlying muscles and can be considered a foundation for all body senses (Montagu, 1971). Moreover, the skin is one of the first senses to be fully developed, as humans are born with impaired vision, and it is also the largest sense in terms of size as it encompasses the whole body.

Apart from the visual dominance in the architectural design process, conventional architectural representations generally tend to exclude the sensorial human body (Spurr, 2009). When a human figure is depicted, it acts almost exclusively as a scale reference[3] rather than communicating sensory aspects related to space. British professor Adam Sharr argues that: "Drawings may be instruments of control, but slippages in translation between author and reader—multiple readings, partial readings, and different understandings—mean that they are not always as directly controlling as is frequently assumed... Although their representations operate within many of the conventions of architectural drafting, they are admirably self-reflexive" (Sharr, 2009, pp. 318-319).

To summarize, conventional architectural design tools do not allow questioning or communicating about the spatial experience. Although architects might intend both, the imagined spatial experience is primarily apparent in their minds and bodies during the process of designing and, to a limited extent, translated by the tools deployed in communicating them. As such, regarding the spatial experience, the architectural design tools burden the creation process with a twofold problem: firstly, the main focus on the visual experience and secondly the limitations of the conventions as a way of communicating and revealing insights on sensorial experiences beyond the visual.

ENCODING OTHER PERSPECTIVES

The shift from an analog drawing to a digital model-based design process seems to imply a shift from intuitive and open to an exact and controlled design process, from more artistic to scientific representation. This is confirmed by architect William Mitchell (1990), who describes design media as opening up "design worlds", which allow for certain representational tokens and processes. Analog design worlds are inherently open in tokens and processes and behave analogously to the design they represent. Digital design tools on the other hand are inherently closed, design ideas are represented as numeric and geometric elements, stored as discrete data, and there is a finite number of operations. Moreover, the perception of digital design worlds is explicitly encoded into the software and reaffirms orthographic projections and linear perspective, but also introduces novel modes of interacting with design models, such as zooming, panning, scrolling, and orbiting. As processes are often irreversible exploring design variations in analog design worlds requires backtracking and starting over again, digital design tokens are more malleable, allowing for variations to be explored rapidly. Technologies today allow for translating between or combining analog and digital, which allows for combining strengths of both analog and digital design media.

The description of digital design media as leaning towards the exact and control might be read as a rejection of digital design tools as an explorative design medium, this is partly due to the black-boxed nature of design software, which does not allow for the designer to manipulate the tokens and procedures. The elective *Computation & Materiality* introduces students to computational design through using parametric modelling, scripting, and programming, giving them access to the underlying algorithms of digital design worlds. Computation is approached as more than a tool for expressing already known design ideas, but a design medium that generates new design insights. Instead of using pre-programmed design tools, it looks into making bespoke design tools to develop a speculative design project. In contrast to top-down design approaches where making tends to be the final phase of a design process, the elective starts from hands-on experimentation with code and gradually builds them into computational design tools.

Coding in Processing[4] is introduced as the main design tool, demonstrating how it can be integrated into architectural design processes and work together with other modelling and scripting tools. Processing is a programming language, integrated development environment, and online community aimed at opening up computer programming to artists, designers, architects, and students, promoting "software literacy within the visual arts and visual literacy within technology".[5] It was initiated by Casey Reas and Ben Fry when they were studying at the Aesthetics and Computation Group at MIT led by John Maeda. It is an open-source project, which has a large community of users, and its core functionality can be extended with third-party libraries developed by the community. Processing embraces the idea of coding to explore ideas that are not fully formed. The practice of sketching with code is central to Processing, programs are called sketches, and the collection of works is called a sketchbook. While in other development environments it takes a considerable amount of time to start a new project, import relevant libraries and start coding, Processing reduces the amount of time spent between writing code and having visual feedback on the screen.

The elective consists of three parts, providing a framework and agenda through reading key texts on computation as a design medium, a hands-on introduction to Processing through tutorials, and developing a speculative design project. The tutorials are conceived as a crash course, i.e., providing enough knowledge into coding to be able to read it, and know where to find answers when errors are encountered. The project starts from given example codes that introduce more complex techniques and produces visual outcomes of a certain complexity, these codes are then altered, combined, and remixed to produce the final project. The course is aimed at Master's students with a well-developed design skillset and emphasizes how coding in processing can be integrated into existing design workflows, operating in-between different software. The result of the elective is a research catalog demonstrating the design process, a working version of the main code, and the final project produced in a medium relevant to the project, often a set of drawings, a video or animation or an interactive application. Below we discuss a selection of outcomes from the elective grouped according to the other perspective they explore.

HYPERASSEMBLAGE

This project course looked into axonometric projection as means of producing collages and assemblages that combine 2D and 3D fragments. Axonometric projection is a form of parallel projection where multiple sites of an object are revealed by rotating an object around one or more axes. Unlike linear perspective in axonometric projection there is no vanishing point or foreshortening, i.e., objects farther away appear smaller on the picture plane. The origins of axonometric drawing can be found in Chinese art, painted, or drawn on scrolls. The absence of foreshortening meant that objects could be drawn in 3D, and still be measured in the picture plane, in particular in isometric projection, which made it suitable for exact technical drawings and scientific diagrams, axonometric projection was theorized in the middle of the 19th century and became an essential part of engineering and architectural education. In the historical avant-garde of 1910 and 1920 axonometric projection was used alongside fragmentation and collage to challenge traditional painting, this had a substantial impact on early modernist architecture.[6] The disruptive potential was taken up in post-war radical architecture from the 1960s and 1970s, often as a basis to produce visionary and radical spatial propositions.[7]

The project started from a selection of historic architectural drawings that explicitly used axonometric projection as a medium for representing the qualities and processes of the architecture.[8] Students were given a series of processing sketches that allowed them to sample these existing axonometric drawings, bring in 2D and 3D fragments and control their behavior within the picture plane. Through a series of smaller exercises, called remix, rework, reimagine, and repeat students gradually went from analyzing and remixing the existing drawings into reworking the inherent properties of axonometric projection, to appropriating them to produce their architectural drawings. Because this was programmed in processing, the procedure of composition was partly automated, allowing for multiple variations to be explored but also for using several fragments that would be time-consuming in a manual collage. The results are a series of HyperAssemblages (Fig. 1) that raise questions on where agency and authorship can be located in work mediated through computation: partly in the original drawings that started the process, partly in the algorithms (both the code by the author as the algorithms present in libraries and platforms this builds upon), and partly with the students that made the final works.

SPHERICAL INVERSION

Digital design processes operate always through interfaces that translate between the physical world and the digital design world, whether it is digitizing information through scanners, or cameras, interacting with information through a mouse, keyboard or rendering information visible on-screen or through print. Architecture mainly uses generally available interfaces that often flatten data to 2D representations. Recently there have been developments in 3D scanning, and photogrammetry that allow for spaces to be scanned and digitized as 3D point clouds or meshes. While the democratization of digital and robotic fabrication, in particular 3D printing and additive manufacturing, allow for 3D digital files to be fabricated as material artifacts. These technical innovations generally are seen as part of the shift from analog drawing based to digital model-based design processes, eliminating the

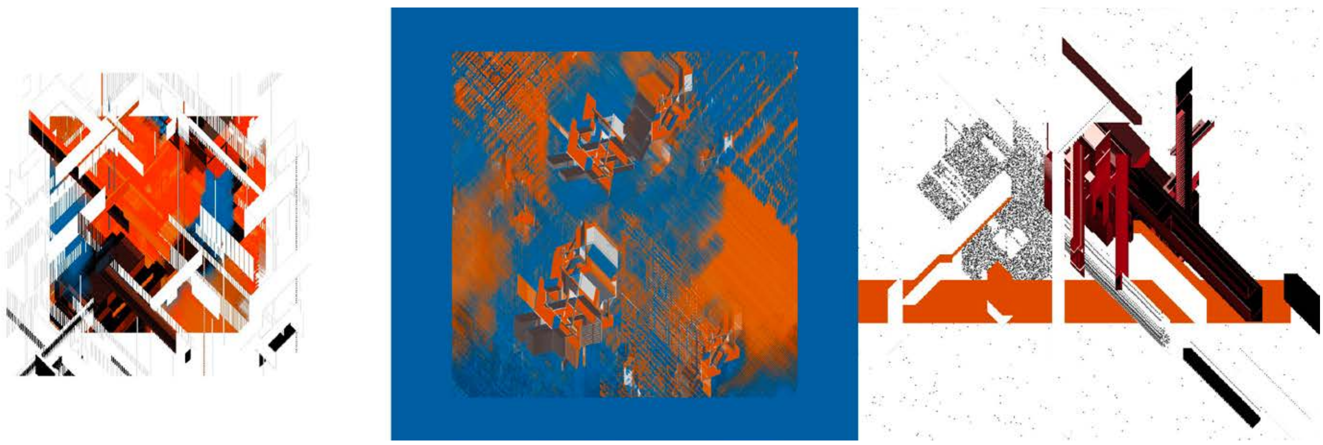

Figure 1: HyperAssemblages

need for drawing, and thus substantially altering perspective in architectural representations.

The spherical inversion project (Fig. 2) looked into making site-specific representations of a surrounding environment through modeling, 3D scanning, and photogrammetry. These were then 3D printed and presented on-site. A spherical inversion is a mathematical transformation of spatial coordinates, where all points outside of the sphere are translated into the sphere, with infinity collapsed at its center. This is analogous to how a lidar scanner "sees" the world: casting rays from a point in space, capturing close-by objects in high resolution, and reducing fidelity with increasing distance. In contrast to how architects draw and model spaces, structuring spaces in their constituent parts, and selecting important elements while excluding superfluous information, the machinic view of the world captures everything through the same lens.

ALGORITHMIC VISION

Digital photography seemingly operates similarly to its analog predecessor; however, it introduces properties that work very differently. Light is sampled at a discrete resolution as pixels, short for picture elements. This digitalization of images into computable elements allows for algorithmic processing of the images. While these can be relatively simple processes such as filtering, sorting, and blurring, the fields of computer vision and machine learning try to build a high-level understanding of what is depicted in the image. The impact of algorithmic vision is substantial, from cameras tracking our movement in urban environments, facial recognition in cameras and social media, and object detection. The *Chrono Drawings* (Fig. 3) use computer vision, not so much from a regime of control, but as means of capturing temporal, behavioral and ephemeral qualities of spaces. Processing video

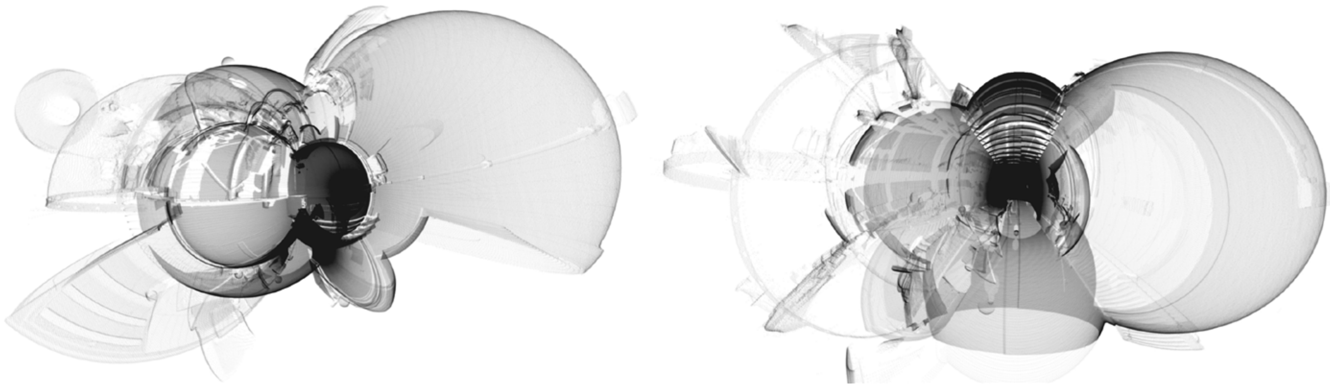

Figure 2: Spherical Inversion

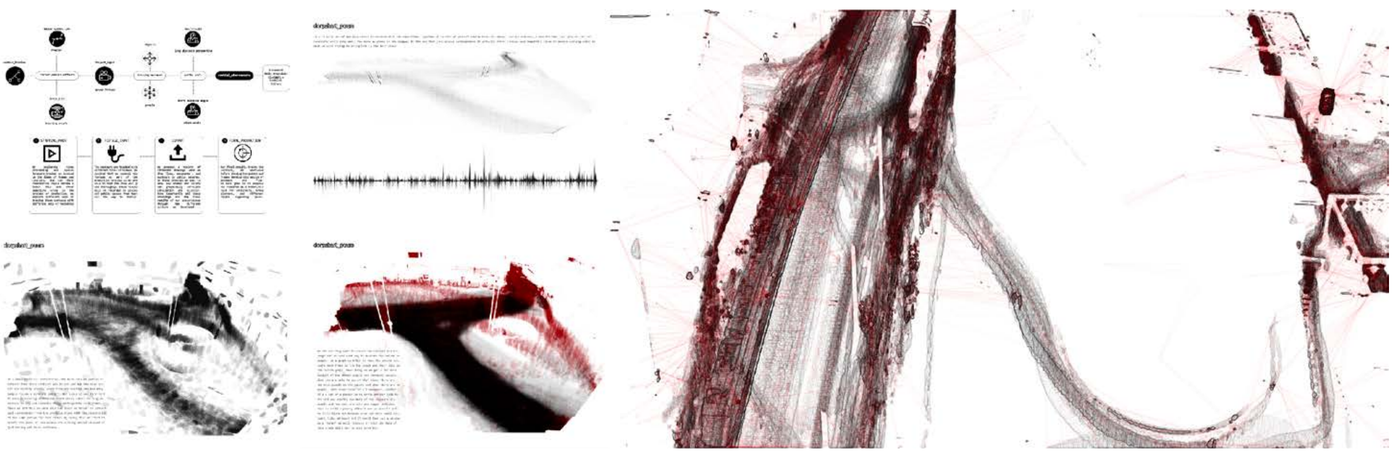

Figure 3: Chrono Drawings

footage through computer vision algorithms such as contour tracking and background subtraction, it compresses multiple frames in a single drawing, capturing flows and occupancy of urban environments. The video *Artificial Landscapes: Machine Point of View* (Fig. 4) uses similar algorithms to process drone footage over landscapes, creating abstract representations of landscapes that express how machines look at environments.

MAPPING EMBODIED EXPERIENCES

In contrast to the previous section, which addressed the use of digital techniques to broaden architectural thinking and, thereby design processes, this section looks at analog techniques aiming to enhance students' understanding of bodily experiences. The elective course "Mapping, Drawing, Visualising the Experienced"[9] is set up as a response to the conflict described above concerning the limitations of computational architectural representation relating to spatial experiences. It was set up from the premise that kinesthesia encompasses all other sensory experiences hence indispensable to the design process. Yet in common architectural design process movement is usually neither explicitly considered nor represented, except for functional purposes such as circulation flows in the function of safety exits. Besides, a paradox rests in the representation of movement, because from the moment it is put on paper, it becomes static (Doane, 2006). In the 1960s, American landscape architect Lawrence Halprin (1965) was one of the first to identify the problem. He stated that "Any good designer or planner will think, while . . . designing, of the activity that eventually will occur within this space. But [they] cannot design the movement, for [they have] no tools to do so. Even highway engineers who deal with movement have no method of describing it" (Halprin, 1965, p. 208). However, since then, there have been major developments through the digitalization of design tools. Cinematic visualizations for example provide a partial answer to this problem statement. Also, numerous plug-ins have been developed, such as MassMotion and uCrowds, to simulate the movement flows of people in a design using agents, enabling the identification of possible problems concerning accessibility, passage or escape capacity. However, this evolution enabling to visualize human movement in space, and these representations remain disassociated from the living sensorial body and experience (Sharr, 2009).

As such, two main objectives underlie the elective course. Firstly, we are looking for ways to perceive and represent movement beyond architectural representations and secondly, the intention is to increase the student's body awareness and hence expand spatial perception. Therefore, Master's students are asked to seek ways to represent movement in its relation to space, based on introduced references on the one hand and intuitively on the other hand. In doing so, they are invited to think beyond the preconceptions they acquired when entering architectural education and to adopt an alternative position in the production of visual representations. Subsequently, the students are forced to move away from the visual focus of experience inherent in traditional architectural representations and processes. Architects are generally taught to approach the subject of their process from the outside, as an observer. Whereas architectural designs are primarily experienced from the inside through active interaction, and thus as a performer rather than an observer. Therefore, within the framework of this elective course, students are encouraged

Figure 4: Artificial Landscapes: Machine Point of View

to actively take up their role as performers in the process instead of exclusively being an observer. Consequently, the course acts as a testing ground for concepts, ideas, and reflections on the practice of architectural design and, more particularly, on the role of the sensuous body.

The essence of the practice of architects can be compared to that of choreographers. Whereas choreographers "design" the movement of bodies based on instructions, architects instruct bodies based on spatial elements (position of walls, columns, stairs, slopes, etc.). The creation tools used for choreography are, first and foremost, the body, but there are also other tools involved, such as "movement notations". In that regard, movement notations can be compared to the set of conventional architectural design tools as it concerns a way of recording an artistic creation on paper. Hence, movement notations communicate what architectural instruments are incapable of.

Halprin (1965) perceived these choreographic movement notations as a source of inspiration for developing his notation system for the discipline of architecture. Also, French urbanist and philosopher Paul Virilio (1994) considers movement notation as a possible enrichment for the "discipline of architecture. In an interview with dance historian Laurence Louppe, he argued: "Space is movement, it is the quality of a volume, and is therefore very difficult to note down"(p. 35). He also believes that dance notations could enable architects to qualify space and, in a way, "complement the architect's plans and cross-sections . . . because [these] don't measure time" (p. 35) and from a pedagogical point of view envisaged these as a possible added value "to complete [architecture's] traditional approach to space" (p. 36).

MOVEMENT NOTATIONS

Students were introduced to movement notations in the first part of this 10-week elective. In contrast to architectural representations, no universal conventions are established within the discipline of dance and, consequently, a heterogeneous quantity of movement notations exist. In addition, they serve different objectives in the creative process compared to representations in architectural practices. Where the architectural drawing is both a design tool and a tool for communicating, movement notations are in most cases meant to communicate: to instruct, to memorize or even to archive. Despite these differences, we looked into what kind of insights these particular representations may bring to the discipline of architecture and in what way they can enrich or supplement architectural representations.

At the start of the course, students were introduced through a condensed presentation to a limited number of exemplary practices of movement notations, ranging from Labanotation[10] to Anna Teresa De Keersmaeker's scores.[11] Movement notations are coded systems that communicate aspects of movement according to a certain logic. Some of these systems strive for universality, while others are only meant for a select group of individuals. Since movement cannot exist without space and time, each of these types of notations is always implicitly representing space as well. Subsequently, the assignment consisted of actively experimenting with these introduced notations of movement, extended by own searched references using them for observing people's movement in a semi-public space (Fig. 5) and recording their movements over a limited trajectory (Fig. 6).

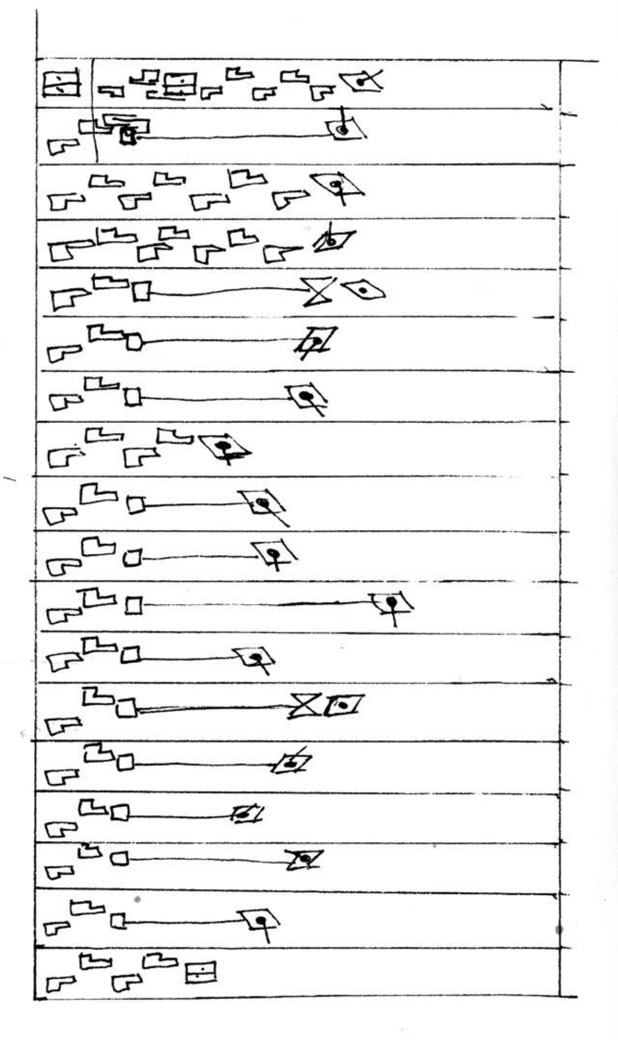

Figure 5: Recorded people's movements

Figure 6: Recorded personal movements

This part of the elective was developed in response to the difficulties students encountered in performing the first part of the elective by recording instantaneous movements simultaneously with the moment they occurred using a different set of representation tools they are used to. Through performative drawings, students were liberated to draw movements of a particular body part instantaneously when they occurred. In doing so, the drawing produced by the performance became a residue of a particular gesture rather than a way of communicating. Again, employing various assignments in which they had to observe the movement of passers-by on the one hand (Fig. 7) and record their movements on the other (Fig. 8), within this part the students were implicitly forced into the role of performer.

To conclude, exploring movement through actively engaging with different modes of operation regarding the representation of movement, forced students to open up the conventional architectural perspective learned throughout architecture education. It resulted in a wide range of different kinds of drawings, which each could be perceived as visual testimonials harboring a force of expression,

PERFORMATIVE DRAWINGS

The second part of the elective focused mainly on performative drawings. What divides performative drawings from movement notations is somewhat ambiguous. For example, hieroglyphs produced by the American choreographer and dancer Nancy Starck (Albright, 1989) look more like a language of signs, a movement notation, which she also used to note from left to right. However, she explains in an interview that these glyphs arise in response to sensory stimuli. Starck describes the creation and writing of these glyphs as an "embodied activity", translating dance to the sheet "writing from the body" (Batson, 2013).[12] As such, "performative drawing" concerns a concept that borders between performance art and visual art. The notion was introduced by Catherine de Zegher in the mid-20th century (Foá et al., 2020). Different to movement notations, these kinds of drawings do not pursue any communication purposes as such but arise from the movement itself.

Figure 7: Recorded people's movements

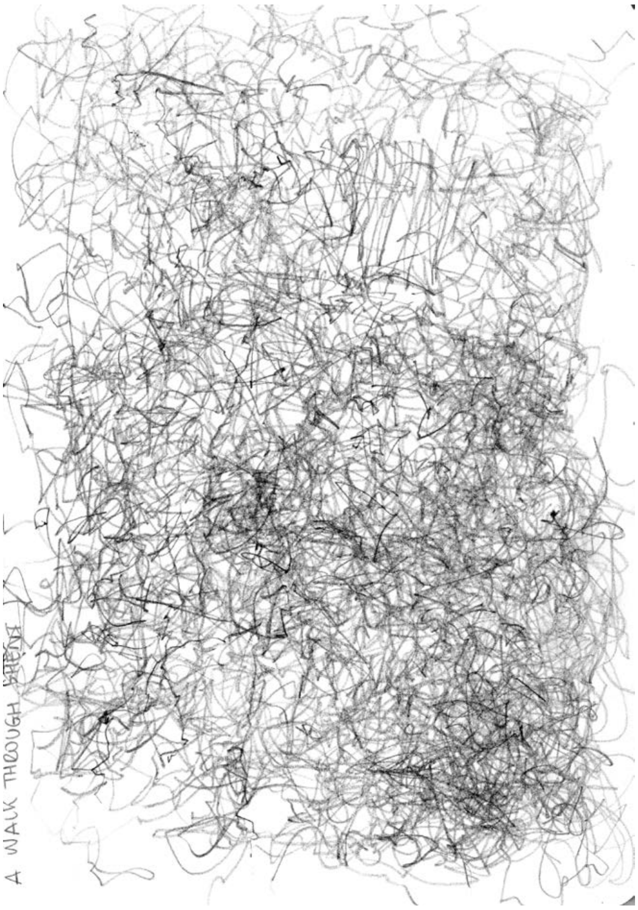

Figure 8: Recorded personal movements

related to the body and the movement that gave them birth. However, as dance historian Guest (1970) explains, there were many "unsuccessful" attempts within the discipline of dance to arrive at a universal language because of the space factor and the number of possible actions that the body can perform simultaneously. The elective has therefore not led to an addition to the conventional sets of architectural tools for representing body movement. However, introducing these "new" ways of operating made students look more consciously at the interaction between body and space.

EXTENDING ARCHITECTURAL REPRESENTATIONS

When comparing both electives, "Computation & Materiality" on the one hand and "Mapping, Drawing, Visualising the Experienced" on the other, a common theme can be recognized, despite their different approach and focus. Each contributes to a different set of problems concerning the limitations of representations in architecture. "Computation & Materiality" focuses on actively engaging the mediation resulting from digital technologies, through exploring the underlying algorithms, and repurposing scientific, computational processes and forms of representation to produce designerly and artistic results. In the three discussed outcomes, implicit perspectives present within digital media are made explicit and opened up for design exploration: the resolution and position of the lens through which environments are observed and turned into discrete data, the algorithms and operations used in design processes, as the perspectives implicit in how the outcomes are rendered as projections or drawings.

In "Mapping, Drawing, Visualising the Experienced", conventional architectural representations are questioned on their ability to convey information and understand the embodied experience. By linking the moving body to representation techniques physical thinking is introduced. Although representations are at the origin of the elective, the outcome primarily engages the impact on the spatial perception of the learners involved. However, this impact is not directly observable, as "the human body is a unique object of perception, unique because we can use both inner and outer sources of information to refine what we perceive" (Moore & Yamamoto, 2012, p. 9). A large part of that process, therefore, takes place in the bodies and minds of these involved learners.

Both electives result in drawings, mappings, videos, models, or other forms of visual representation, to make students more aware of the underlying processes and invite them to explore different aspects of architecture by offering these other perspectives. The proposed processes question the impact of sensorial input, whether it is experienced through bodily motion or through technological lenses, the difficulties of capturing or recording these experiences, and the potential new insights that emerge through these representations. In either case, this questioning moves away from an exclusively scientific approach and introduces a rather artistic approach to the subject matter. To conclude, the two electives discussed are grounded in theoretical reflections, which are responded to with practical artistic explorations and demonstrate how the practice of architecture cannot be separated from art and science.

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ENDNOTES

1 The Bologna Declaration (19 June 1999) brought about a profound change in European Architectural Education.

2 For a comprehensive overview of research methodologies in architecture see, Wang, D., & Groat, L. N. (2013). Architectural research methods (Second Edition). Wiley.

3 Although these reduced human bodies do not communicate about sensory aspects, they often tell us something about cultural background, see "An Unfinished Encyclopedia of Scale Figures without Architecture" (Meredith et al., 2019).

4 See https://processing.org/, consulted on 20/02/2022.

5 Quoted from their mission statement on https://processing.org/, consulted on 20/02/2022.

6 The use of axonometric projection was most explicitly theorised in El Lissitzky K. und de Pangeometrie and formed the basis of his PROUN paintings and architectural projects.

7 Spiller, N. (2006). Visionary architecture: Blueprints of the modern imagination. Thames & Hudson.

8 Axonometric drawing of the Schröder House by Gerrit Rietveld (1924), Kabinett der Abstrakten by El Lissitzky (1927), Design for a Modern Living Room/Bedroom with Built-in Bed and Cabinets by Margarethe Fröhlich (1933), The City of the Captive Globe Project by Rem Koolhaas and Madelon Vriesendorp (1972) and Drawing for House VI by Peter Eisenman (1972–1975).

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10 Labanotation concerns a movement notations system developed by Hungarian dance theorist Rudolph von Laban at the beginning of the 19th century. The system is based on music notations with the attempt to be universal. It was the first system that could be read from the performer's perspective (first-person perspective) and allowed any form of movement to be noted thus it went beyond the boundaries of its discipline.

11 Belgian dancer and choreographer Anna Teresa De Keersmaeker developed her personal movement notation which is variable depending on piece she is working on. see for examples De Keersmaeker, A. T., & Cvejic, B. (2012). A Choreographer's Score: Fase, Rosas danst Rosas, Elena's Aria, Bartók (Collector's edition). Mercatorfonds.

12 Batson, G. (2013). CORE: Embodied investigation with Nancy Stark Smith. Hieroglyphs: Embodied activity #1, Meta-academy at Bates 2013.

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