CHOREOGRAPHED ARCHITECTURE

Body-Spatial Exploration

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Abstract. This paper presents a design-methodological case study that looks into the practical expansion of conventional conceptual architectural design media by incorporating contemporary technology of motion capture. It discusses challenges of integrating dance movement as a real-time input parameter for architectural design that aims at translating body motion into space. The paper consists of four parts, beginning with a historic background overview of scientists, physiologists, artists, choreographers, and architects who have attempted capturing body motion and turning the motion into space. The second part of the paper discusses the iterative development of the ‘Dance Machine’ as a methodological tool for the integration of motion capture into conceptual architectural design. Thirdly, the paper discusses tested design applications of the ‘Dance Machine’ by looking at two sited applications. Finally, the overall methodology is critically assessed and discussed in the light of continuous development of creative applications of motion capturing technology. The paper concludes by highlighting the architectural potential found in specific qualities of dance and by advocating for a broader palette of tools, techniques, and input methods for the conceptual design of architecture.

Keywords. Choreographed architecture; Motion capture; Conceptual design media; Space design; Human body.

1. Introduction

This design research project introduces “Choreographed Architecture” as a field that emphasises experience in-motion, generated by distinctive design actions from dance routines, as input for architectural spatial design. The design outcome gives specific sensations and impressions to the people moving within. Dance operates as a dynamic catalyst for this sensation and becomes the information source for the communication between designer and user through spatial definition and configuration.

The paper 1) studies whether the typically available architectural design solution space can be practically and productively expanded in ways that incorporate unique qualities proprietary to choreography in space, and 2) critically explores how body movement can define spatial form.
Relatively recent technological advancements have dramatically changed the tools and techniques used during the conceptual design phases of architecture. Appliances such as the computer mouse or drawing tablets have been incorporated to track, register, and store architects’ motion as design input for additional digital processing. Via the gaming industry, further technology democratisation expanded these means to include 3D scanners capable of capturing full body motion. User-friendly data management interfaces allow the harnessing of this data for use in architectural design, opening a fascinating new chapter in a series of historic attempts to capture body motion in visual arts and architecture.

As means of creative expression affected by space, dance has always positioned itself opposite of architecture due to its ephemeral and temporary nature. Yet, overlapping qualities can be found in structural build-up and composition, especially the reciprocal dialogue between the human being and space in time. This case-study paper studies how qualities in dance, such as fluidity, variety, rhythm, transition, and repetition can provide further input to architectural space design.

2. Motion Capture Precedents

Motion research originates with Etienne-Jules Marey (1830-1904), whose chronophotography studies (1882-1883) for the first time considered the body as an animated machine, decomposing and capturing the invisible sequence of motion in space over time. The principle of chronophotography influenced the art world greatly, as found in work by Marcel Duchamp. His abstract painting ‘Nude Descending a Staircase No.2’ (1912), inspired by Marey’s technique, presented a body in motion with a subject from one view at multiple moments. The technique is expanded several decades later by Harold Eugene Edgerton (1954), who investigated alternative techniques for capturing motion using high-speed procedures with less than half a second per photograph. Half a century later, digital technology continued to provide further improvements in revealing the actual state of motion. Its direct impact on architecture can be seen in projects like DECOI’s installation ‘Ether/I’ (1995). This structure presented a frozen trace of a disappearing dance and literally translated motion into space. Further, the ‘Dune Formations’ by Zaha Hadid Design and David Gill Galleries (2007) suggest a multiplicity of use of design in motion, presenting a unique design in organic form for furniture. Today, we start to see the formal complexity of such designs appear in built form at architectural scale. The ‘Heydar Aliyev Centre’ by Zaha Hadid Architects (2013) presents a design with an unconventional structural system that articulates fluid form and space. Also, ‘Arnhem Central Station’ by UNstudio (2015) successfully translates people motion into dynamic space that determines how people move around and use it.

3. Theory of Dance

Rudolf Laban (1879-1958) is one of the pioneers of early twentieth-century movement theory. He developed a system to record the possibilities of human movement and stated that dance and architecture are the two basic arts of man
from which others are derived (Spier, 2011). Laban’s Theory of Space articulates how we inhabit, harmonise, and explode our personal space to expand knowledge of the human body into space. He introduces the concept of the ‘Kinesphere’ and ‘Space Harmony’, and considers the Kinesphere to be an invisible sphere, containing 27 main directions, around the body which periphery can be reached by extended limbs without stepping away from the point of support. The invisible space around our body is changing once we shift our weight (Newlove, 1993). Consequently, the Kinesphere is moving while the human body is moving. It stays invisible until the moment we move within it and make it tangible by leaving the spatial consequences of our movements. Space harmony is the further extension of Kinesphere. It deals with the form of movement based on 12 inclinations in a total of 24 directions (Newlove, 1993). Analysing the harmony in space is essential to generate a choreography with a good spatial quality.

As Laban stated, harmony gives structure and meaning to movement in a choreography. He defined three spatial laws that affect and characterise this harmony: (a) law of equilibrium: how directions within the Kinesphere link to stability (3D in dimensional scale) and lability (diagonal directions, linked to harmony as allowing a flow of movement); (b) law of flowing-from-the-centre: each movement initiated by any part of the body starts from the centre or affects it (responsible for sequentiality and connectivity in the body); (c) law of countermovement: each movement happening in one or more directions contains its stabilizing counterpart (Moore, 2009).

To imagine an alternation in gravity, the human body contains multiple centres instead of single centre point, meaning the rule of verticality in the human body has disappeared. The loss of verticality generates the dynamic effect which enhances the spatial possibility between body and space. This introduces the question what happens if the body is off-balance and the movement no longer contains a boundary of equilibrium.

4. Methodology

Based on the concept of Kinesphere, the ‘Dance Machine’ has been created as a new design tool to expand and incorporate its corporal possibilities into architecture. This tool generates and captures dynamic spaces derived from body movements with a changing point of support. The Dance Machine is iteratively developed as a methodological tool for the integration of motion capture into conceptual architectural design. It follows an Action Research Methodology (Groat and Wang, 2013; Herr, 2015), based on a ‘Plan-Act-Assess-Reflect’ cycle in which problem definition, as well as iterative improvements, allow for a workable solution to emerge.

The Dance Machine is a flexible device that consists of several components. A Microsoft Kinect motion sensing input device is used to capture the architects’ dance performance skeletal data and bring this into a customised Rhinoceros’ Grasshopper interface. Here, procedural modelling is used to extract and manipulate data, and feed it back to the performer in a real-time spatial experience for architectural design (see Fig. 1 & 2). Twenty points of the human body can be
detected by the sensor in three dimensions over time. These positions are translated into dynamic space by using them as control points for curves in-between which surface geometry is lofted. Thus, the Dance Machine translates body part motion by tracking selected points of the human body.

Figure 1. The principle of Dance Machine.

Figure 2. The Dance Machine’s decision-making process.

The methodological approach is used to analyse the viability of translating personal space to permanent space by exploring transitional elements on both dance and architecture. Assuming the machine does not possess control of captured movement, what is the influence of translating the motion into space? This can be seen during early trials of data generation and the consequent production of abstract form with it. Gradual refinement and selection of captured
data are needed to advance the project. Levels of data post-processing are needed to allow the motion data to become a usable element in the design process.

Several approaches exist to create a choreography. All are composed with common basic qualities: unity, continuity, and variety. Early attempts to create an appropriate choreography for the dance machine had as single intention to test machine continuity and variety to ensure the unity of flow. The results indicated that the type and length of choreography required skeletal action amplification to increase the dance movements’ significance in the architectural space generation. Architectural considerations like control over site, program, spatial layering, and circulation must be considered and integrated into the composition of the choreography.

The Dance Machine is a recording machine that turns a subjective dance experience into an objective architectural reality. Its output forms a basis for further design operations at different scales. Focusing on architecture, the construction technical part becomes a major concern in addition to the overall aesthetic appearance. This challenges the use of the Dance Machine as a medium to operate at various scales beyond conceptual stage.

Currently, the design outcome from the machine is limited by the fluid quality of movement, and only dynamic space can be generated. A future improvement possibility is to enable a wider range of spatial typologies generated by a wide range of dance types and choreography.

5. Application of Dance Machine

The Dance Machine application was first tested by abstract form generation and later by looking at two sited applications. For the primary test, the machine is considered as an abstract and scale-less form generator. Without any further manipulation, movement is captured over time and turned into a dynamically designed form. Results revealed that the body movements are easily lacking the careful control needed for spatial design and frequently overlap themselves (see Fig. 3).

Following initial test result evaluations, manipulators of skeletal points are incorporated in a second version of the machine that allows more clear definition of specifically used body segment.

To avoid overlapping of movement, a third machine iteration was designed to include a guide path along which the centre of the Kinesphere is moved (see Fig. 4). A timer is added to control the positioning between the start and the end point, as well as to track the length of the choreography. This iteration tested the theory of the extended Kinesphere by observing the body’s change in weight and position, meaning the centre point of the body is moving through space while the space around it remained in a fixed relation to the body.
To allow for spatial arrangements to be affected by the rhythm in choreography, a scale manipulator is incorporated that allows expanding the created space. Through this function, the machine operator can amplify parts of the choreography. The outcomes of the original studies can thus be refined and enhanced through the input parameter values of the machine. Site, context and program that inform the movement in the final project can be incorporated into the design by linking them to the level of manipulation, or by informing the guided path. These manipulators and guides allow for the transition from the abstract space generator to a concrete design.

The setup was assessed on a site in Wan Chai, Hong Kong, through an iterative process that counted over fifty cycles. This preliminary study involved the design of a conceptual event space and was intended to identify both challenges and opportunities provided the Dance Machine. Each iteration started with a choreographed intention and ended with the observation and evaluation of the
end results which fed back into the further refinement of both choreography and manipulators (see Fig. 5). Following numerous tests to ‘tame’ the machine, the medium became more familiar, manageable, and controllable. Particularly the design sequence was frequently changed, as this component resulted in the various layers of architectural design elements. The overall design sequence started with the choreography of outer surfaces to the main space creation, wall/slab insertions, and structure, and ended with the development of the enclosure.

A second iterative project design cycle involved the conceptual design development of a performance event space in Shek Kip Mei, Hong Kong (see Fig. 6). The site is located at the junction area of Shek Kip Mei Street and Woh Chai Street, adjacent to the Woh Chai Hill in Shek Kip Mei. This district is the first public housing estate in Hong Kong. The site preserved some of its history and sense of community as the area is known today for its arts and crafts. As it is a densely-populated area lacking community services, a cultural centre is proposed to be built. The total building floor area is approximately 3550 sq.m., including the main theatre, small theatre, library, exhibition area, roof garden and lots of open spaces.

Figure 5. A demo of iterative process.

Figure 6. A second iterative cycle: process of outer surface creation.
Following several iterations, eventually two choreographies were captured and recorded by the Dance Machine as the main architectural input. These generated two main layers of the architectural space, the outer surface and the main theatre space. Each choreography contained six steps of modification. These were based on evaluations and observation of the previous iterations that used plans, sections, and perspectives to assess the quality and movement of created space. The final choreography of the outer surface presents eight continuity actions, whereas the main theatre’s presented four since these included a repetition due to the symmetry in spatial arrangement. The continuity actions at the foundation of the space form design are dance movements recorded in real-time, highlighting the close relationship between the performer and the architecture. (see Fig. 7-10)

Figure 7. Space form design based on dance movements recorded in real-time.

Figure 8. Performance event space in Shek Kip Mei, Hong Kong: floorplans.
Figure 9. Performance event space in Shek Kip Mei, Hong Kong: section.

Figure 10. Performance event space in Shek Kip Mei, Hong Kong: physical model.
6. Conclusion

The Dance Machine is a case-study for research that seeks to combine elements of dance and architecture and incorporates these into a common digital design software environment through widely available technology of motion capture. The findings illustrate a practical approach to expanding how architectural design can be done through dance. The Dance Machine becomes a highly personal and autobiographical design tool which enables dancers to capture their individual dance signature and express and translate this into architectural space. The methodology has potential to be employed in design of dynamic form and space at different scales, including sculpture, furniture, and architecture. The design process shows how the machine’s efficiency, speed and power, once familiar and under control, allows designers to generate dynamic, fluid, and continuous space for a specific building program and site in a relatively short time.

References


