Simulating Idiosyncratic Movement Qualities

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Abstract. Qualitative aspects of body movement play an important role in contemporary dance. These aspects are equally important when creating synthetic movements for artificial dancers. This article describes the approach chosen by the two authors, one a software developer and the other a choreographer, to translate idiosyncratic movement qualities into simulation-based behaviours for non-anthropomorphic artificial dancers. The work culminated in the creation of two scenes for a new dance piece in which the simulated dancers control the movements of robotic lights on stage. The chosen approach is meant to illustrate how the adoption of idiosyncratic movement qualities renders non-anthropomorphic entities, despite their non-human appearance, readable and relatable to as dancers that are interesting for choreographers to work and for human dancers to engage with.

Keywords: Dance and Technology · Movement Qualities · Computer Simulation · Generative Art

1 Introduction

In contemporary dance, qualitative aspects of body movement play an important role. These aspects foreground the communicative, stylistic and expressive potential of movement. When designing computer generated characters as artificial dancers, it is desirable to endow them with similarly evocative movements.

A common approach involves the transfer of recorded motions from a human dancer to an artificial dancer. While this method faithfully replicates the quantitative and qualitative aspects of the recorded motions, it suffers from several drawbacks that limit the creative possibilities of working with artificial dancers. These limitations include a lack of flexibility in creating additional motions beyond those recorded, and the necessity to match the skeleton topology of the computer generated character to that of the recorded subject. This makes

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it difficult to experiment with artificial dancers that possess morphologies and movement capabilities that differ significantly from those of a human dancer.

This article describes the authors' attempt to employ a computer simulation for transferring movement qualities to non-anthropomorphic morphologies. The selected movement qualities form part of a vocabulary of choreographic building blocks that are employed by the second author who is a professional dancer and choreographer. The development of simulation-based representations of movement qualities was embedded into a process that started with an investigation into the second author's choreographic creation techniques through interviews and that ended with the production of a new dance piece. Based on the insights gained from the interviews, several movement qualities were selected for further analysis through video and motion capture recordings. These recordings informed the design of simulation-based non-anthropomorphic morphologies and behaviours. Subsequently, the simulated morphologies were given a physical presence on stage by mapping their movements onto robotic lights. The robotic lights play their role as artificial dancers in two different scenes, one in which the lights take turns in interacting with a human dancer, and one in which the lights perform autonomously.

2 Background

The background section provides some examples of prior research that are relevant as context for the authors' work. These examples are split into two groups. The first group comprises research that focuses on the characterisation of movement qualities. The second group includes research that deals with the translation of movement qualities into digital form.

2.1 Characterising Movement Qualities

Up to now, there exists no commonly accepted taxonomy for characterising and classifying movement qualities in dance.

Nevertheless, the structural notation *Laban Movement Analysis* (LMA) introduced by Rudolf Laban [16] has gained prominence. Central to LMA are four categories that formalise different aspects of the human body [12]: *Body*, *Space*, *Shape*, and *Effort*. Of particular interest with regards to movement qualities is the *Effort* category. This category describes aspects that relate to the dynamics, energy, and inner intention of movement, all of which contribute to the expressivity of movement [4]. LMA is widely adopted by dance scholars and has also informed technical fields such as robotics and human computer interaction.

Several researchers and dance practitioners characterise movement qualities in terms of relationships between forces and dynamics. According to this principle, the dynamics of movement results from the interaction between force and time [5]. Related to this principle is the concept of flowing energies whose initiation, sustenance, and termination gives rise to the articulated attributes of movement [3,15]. Movement qualities relating to dynamics are frequently employed by dance practitioners and in dance education.

Many choreographers in contemporary dance develop their own movement qualities alongside terminology to characterise them. Some choreographers have taken the initiative to disseminate their use of movement qualities to a wider audience.

Since 2005, choreographer Emio Greco and director Pieter C. Scholten have participated in several interdisciplinary research projects that document the communicative processes employed in their dance company *EC | PC* [14]. A particular focus was placed on the oral instructions given to the dancers. These instructions emphasise the conceptual aspects of movement and avoid prescriptive proposals to not limit the dancers' own inspiration. There are three different types of movement qualities that the instructions relate to: instructions to invoke imagery relating to the sensation of movement, instructions that deal with the intentional aspect of movement, and instructions that convey the meaning of the action that is involved in the movement.

A specific emphasis on the relationship between mental imagery and movement qualities has emerged from a collaboration between choreographer Wayne McGregor and cognitive scientist Philip Barnard [13]. McGregor involves his dancers in the creation of new movement material by giving them *tasks* in the form of verbal or written instructions. This approach was refined by relating the tasks to mental imagery which dancers can explore through mental manipulation techniques. Following this approach, dancers draw from their mental landscape and ideate movements that are guided by their perceived and imagined surroundings. The movement qualities that result from this approach are related to mental attributes rather than properties of the movements themselves.

2.2 Translating Movement Qualities

Several researchers and artists have experimented with the adoption of movement qualities for artificial entities that exist in the digital domain. In the context of this article, the research that is most relevant deals with artificial entities that possess a non-human-like appearance. The choice of working with non-anthropomorphic entities is informed by both scientific and artistic considerations. The observations of and interactions with non-anthropomorphic entities are less biased by preconceptions and anthropomorphic projections [7]. Accordingly, the movement quality of a non-anthropomorphic entity is more likely to be judged based on movement alone rather than bodily appearance. Furthermore, designing bodies and behaviours for non-anthropomorphic entities exploits the versatility of digital media and complements rather than replicates the appearance and capabilities of human dancers.

Several researchers adopt movement qualities based on LMA for creating synthetic movements. Larboulette and Gibet assessed whether the behaviour of a non-anthropomorphic entity in the shape of a tree can express the emotional content of an originally human motion [10]. For this purpose, basic movement descriptors and *Laban Effort Factors* were extracted from recordings of theatrical movements executed with different emotional states. These movement properties were subsequently mapped on the parameters of a mass-spring system and a particle simulation that control the morphology and appearance of the artificial tree.

Fehr and Erkut realised an installation in which a single visitor interacts through hand movements with a flocking simulation which in turn controls the creation of synthetic audio and video [8]. The visitor's hand movements are analysed with regards to four movement qualities that are derived from *Laban Effort Factors*: *Activity*, *Energy*, *Directivity*, and *Consistency*. These movement qualities are translated into three different behavioural states according to which the flocking agents are either attracted towards, repelled away from, or unaffected by the visitor's hands.

Lockyer and colleagues conducted a user experience design study to evaluate how concepts from LMA can inform the creation of expressive motions for abstract objects [11]. The authors deconstruct the LMA concepts of *Shape*, *Space*, and *Effort* into parameters that can be expressed through established motion algorithms such as motion trajectories and flocking simulations.

Hsie and Luciani developed a creativity support tool for choreographers that is inspired by energy-based notions of movement qualities [9]. The authors use the Cordis-Anima simulation system [6] within which they deconstruct a dancing body into a minimal set of essential interactions between masses that are necessary for modelling a specific type of dance movement. For each movement, the distribution of energy across the masses is modelled from its starting location, subsequent propagation, and eventual dissipation. Four dance movements named *Rebound*, *Jump*, *Flip*, and *Wave* are modelled in this manner.

Alaoui and colleagues have adopted several movement qualities unique to the dance company *EG | PC*. In a proof of concept installation entitled *A light touch*, the motion and brightness of a light spot evokes the same movement qualities that a visitor exhibits in his or her hand movements [1]. The qualities *Breathing*, *Expanding*, *Reducing* are extracted by analysing the oscillatory dynamics and energy of the visitor's hand movements. These properties are mapped on the position and brightness of the light spot.

Alaoui and colleagues have also realised an educational installation entitled *Double Skin/Double Mind* which is meant to familiarize dancers with several movement qualities [2]. The installation attempts to recognise in the movement of the visitor the qualities *Breathing*, *Jumping*, *Expanding*, and *Reducing*. If it succeeds to do so, it mirrors the recognised quality through the behaviour of a simulated mass-spring system.

3 Realisation

The following section describes the main stages of a research and development process that dealt with the transfer of idiosyncratic movement qualities to synthetic non-anthropomorphic morphologies. These stages include the definition of a vocabulary of movement qualities, the selection of movement qualities for further analysis, the design of articulated non-anthropomorphic morphologies, the implementation of simulation-based behaviours, the configuration of simulation parameters and behaviours to match the selected movement qualities, and the mapping of movements from simulation to robotic lights.

3.1 Movement Vocabulary

Over the course of her career as professional dancer and choreographer, the second author has developed a creative process that heavily relies on employing movement qualities as choreographic building blocks. The first author interviewed the second author to gain the insights into her creative process. These insights informed the selection of movement qualities and the choice of simulation-based modelling techniques. Based on these interviews, it became evident that the movement qualities are organised hierarchically. At the lowest level, movements qualities are elementary in the sense that they expose their expressive characteristics within a single domain. At higher levels, more complicated movement qualities can be constructed by combining or juxtaposing lower level movement qualities. The domains of elementary movement qualities are: *Dynamics*, *Time*, *Space*, and *Shape*. *Dynamics* deals with the temporal evolution of movement, focusing on changes in velocity and directionality. *Time* deals with the long term temporal structure of movement or the absence of movement. *Space* deals with how movement traverses space or places movements or poses within space. *Shape* deals with the transformation of movements or poses while preserving some of their recognisability. For the purpose of this project, it was decided to focus on elementary movement qualities that lend themselves to modelling by a conventional physics simulation. These movement qualities were analysed through video and motion capture recordings. For this purpose, a marker-based optical motion capture system was employed that was provided by the dance company *Cie Gilles Jobin*[1]. This analysis led to a selection of five movement qualities as candidates for implementation in a computer simulation. Four of these movement qualities are from the domain of *Dynamics* and one from the domain of *Space*. The five movement qualities can be described as follows:

– *Space* - *Levitation*: Body parts are pulled towards a target position within the dancer's reach space.
– *Dynamics* - *Fluidity*: Body parts move smoothly without taking sharp turns or suddenly changing velocity.
– *Dynamics* - *Particles*: Body parts float weightlessly while frequently and erratically changing direction.
– *Dynamics* - *Staccato*: Body parts move along straight lines and quickly speed up and slow down at the beginning and ending of a line.
– *Dynamics* - *Thrusting*: Body parts propel themselves outwards and rebound afterwards.

Still images of the motion capture animation of each movement quality are shown in Fig. 1). Video recordings[2] and skeleton animations[3] of motion capture record-

[1] Cie Gilles Jobin: www.gillesjobin.com.
[2] Video recordings: *Levitation*, *Fluidity*, *Particles*, *Staccato*, *Thrusting*.
[3] Skeleton animations: *Levitation*, *Fluidity*, *Particles*, *Staccato*, *Thrusting*.

ings are available online for each of these movement qualities. Videos, motion capture data, and descriptions of all recorded movement qualities are available as dataset[4].

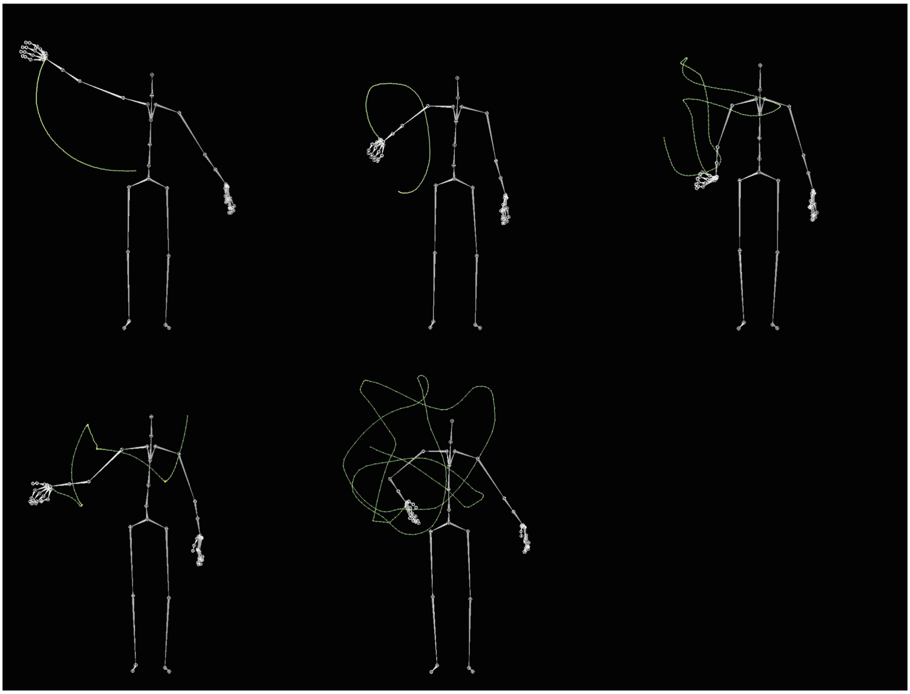

Fig. 1. Still images of skeleton animations of five different movement qualities. The trajectory of the right hand is drawn to highlight the movement. The movement qualities depicted are (from left to right and top to bottom): *Space - Levitation*, *Dynamics - Fluidity*, *Dynamics - Particles*, *Dynamics - Staccato*, *Dynamics - Thrusting*.

3.2 Simulation

As first step towards translating movement qualities into a computer simulation, two non-anthropomorphic morphologies were designed using the *OnShape*[5] online CAD software. The two morphologies are depicted in Fig. 2.

Both morphologies are fairly minimalistic and possess the same type of body architecture and joint articulation. This architecture has a non-branching structure and the joints that connect successive body segments possess one rotational degree of freedom. The smaller of the two morphologies consists of 6 joints and

[4] Movement Qualities Dataset: *zenodo.org*.
[5] OnShape: www.onshape.com.

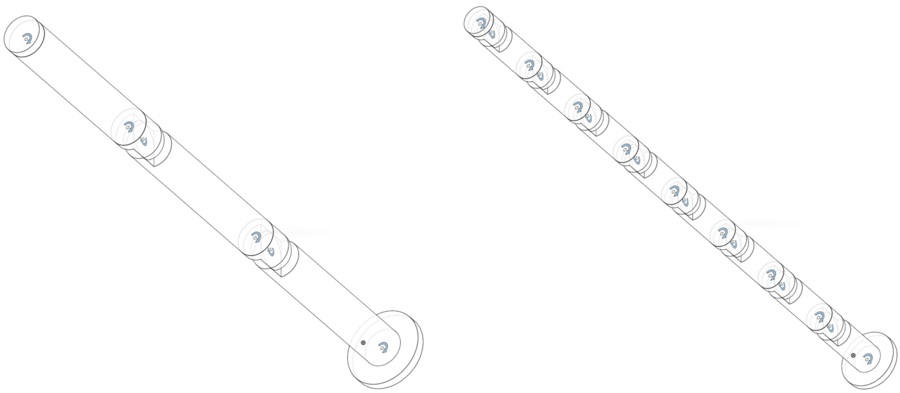

Fig. 2. Non-Anthropomorphic Morphologies. Two morphologies have been designed for simulating different movement qualities. In this rendering, solid body segment are depicted as outlined shapes and rotational joints as curved arrows. The image on the left shows a morphology that consists of 6 joints and 7 body segments. The image on the right shows a morphology that consists of 17 joints and 18 body segments.

7 body segments, the larger morphology consists of 17 joints and 18 body segments. Henceforth, these two morphologies are referred to as *Arm6* and *Arm17*. In both morphologies, the first body segment acts as base and fixes the morphology in space.

These two morphologies have been designed with the following considerations in mind. They are extremely simple in shape and type of articulation which makes them appear and move in a manner that bears little similarity to a human body. Fixing the base part in space permits to focus solely on movement qualities without having to deal with issues of body balance and locomotion. The two morphologies are sufficiently similar to each other to facilitate the design of behaviours that are suitable for both of them. At the same time, the morphologies are different from each other with regards to their postural flexibility and the diversity of movements they can exhibit.

The articulated movements of the two morphologies are simulated using the rigid body dynamics functionality of the *Bullet* physics engine[6]. This engine permits to freely configure among others the mass and inertia of body parts, their linear and angular damping, and the characteristics of joints. Joints can either be passively or actively actuated. Actively actuated joints can operate as spinning motors, as servo motors with position control, or as damped springs that possess a linear and/or angular rest length. To trigger body articulations, a combination of physical parameter settings and custom designed behaviours was employed. The custom designed behaviours are not directly part of the simulation. Instead, they operate as external routines that cause an articulated morphology to exhibit autonomous movements. They do so either by altering

[6] Bullet pybullet.org.

some of the parameters of the body parts or joints that are assigned to them or by exerting physical forces. Two different behaviours have currently been implemented. A behaviour named *ForceBehaviour* generates forces that impact externally on body parts. A behaviour named *RotationBehaviour* specifies target angles towards which joints rotate to. Both behaviours exert their effects either deterministically or randomly. In the latter case, the range of the randomised values and the frequency of their randomisation can be configured. In the experiments conducted so far, the behaviours were configured to operate in a randomised manner in order to obtain body movements that are recognisable in terms of movement quality but not in terms of movement trajectory. To obtain articulations that exhibit a desired movement quality, different parameter settings for simulation and behaviours and different body part/joint assignments to behaviours have been explored and evaluated. These evaluations were based on a subjective comparison between visualisations of the simulated morphologies and motion capture recordings. Figure 3 shows the current choice of the most relevant behaviours and parameter settings for each of the movement qualities. Figures 4 and 5 show still images from visualisations of the *Arm6* and *Arm17* morphologies exhibiting different movement qualities, respectively. Animated versions of these visualisations are available online[7,8].

		Settings							
		Behavior Type	Assigned Body Parts	Assigned Body Joints	Joint Type	Joint Strength	Body Mass	Damping	Change Interval
Qualities	Levitation	Force	Single Most Distal	None	Passive	n/a	Medium	High	Long
	Particles	Force	Single Most Distal	None	Passive	n/a	High	High	Short
	Fluidity	Rotation	None	All	Spring	Medium	Medium	High	Medium
	Staccato	Rotation	None	All	Servo	Medium	Low or Very Low	Very High	Medium
	Thrusting	Rotation	None	Two Most Proximal	Servo	High and Low	High or Low	High or Medium	Medium

Fig. 3. Parameter Settings for Physical Simulation and Behaviours. This figure shows the chosen behaviour, joint and part assignments, joint types, and the most relevant parameter settings for each of the movement qualities. The terms distal and proximal refer to the part or joint position relative to a morphology's fixed base.

3.3 Robotic Lights

The simulated morphologies were integrated into two scenes of a dance performance. In these scenes, the morphologies play the role of artificial dancers that follow their own improvised or choreographed movement principles. The artificial dancers are present on stage in the form of robotic lights. The decision to

[7] *Arm6* visualisations: *Levitation*, *Fluidity*, *Particles*, *Staccato*, *Thrusting*.
[8] *Arm17* visualisations: *Levitation*, *Fluidity*, *Particles*, *Staccato*, *Thrusting*.

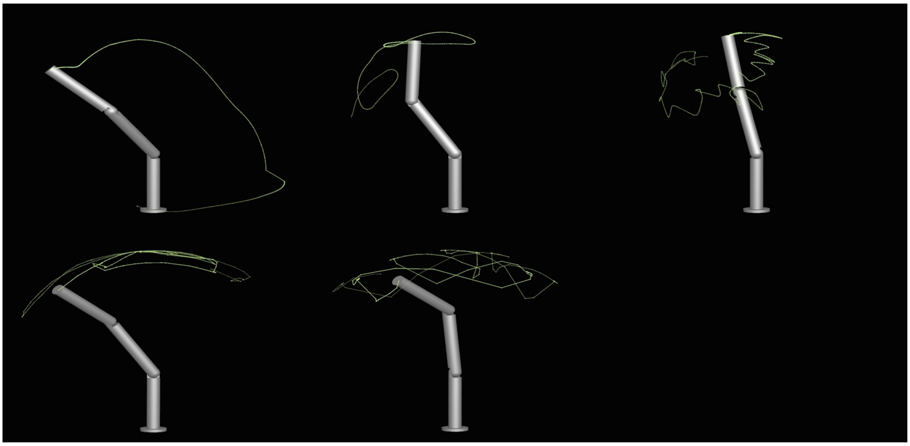

Fig. 4. Visualisations of Different Movement Qualities Exhibited by *Arm6*. The movement qualities depicted are (from left to right and top to bottom): *Space - Levitation*, *Dynamics - Fluidity*, *Dynamics - Particles*, *Dynamics - Staccato*, *Dynamics - Thrusting*.

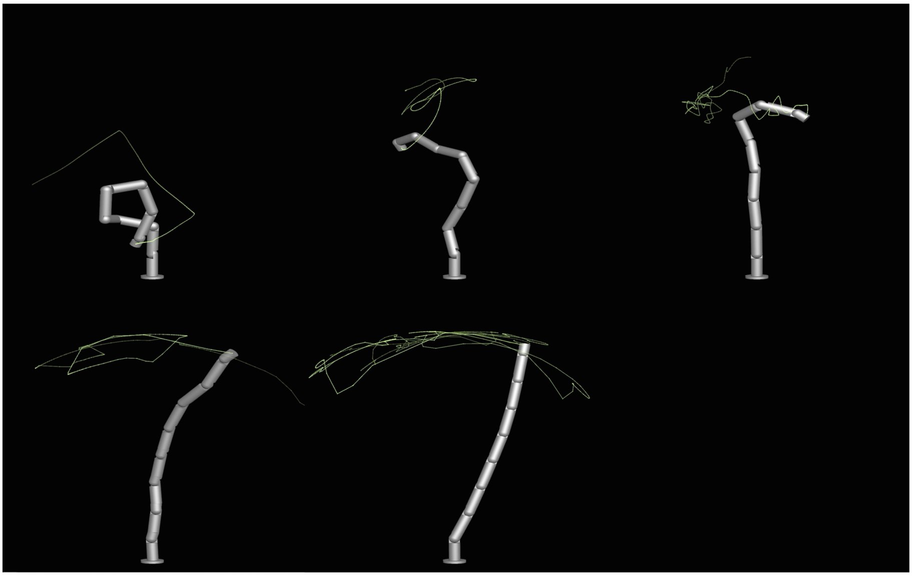

Fig. 5. Visualisations of Different Movement Qualities Exhibited by *Arm17*. The movement qualities depicted are (from left to right and top to bottom): *Space - Levitation*, *Dynamics - Fluidity*, *Dynamics - Particles*, *Dynamics - Staccato*, *Dynamics - Thrusting*.

present the artificial dancers as robotic lights rather than video projected visualisations of the simulation was made for two reasons. Firstly, as tangible bodies and lights the artificial dancers are more easily integrated into a choreographic creation process that is engaged with physical bodies and light scenography. Secondly, as real objects, the artificial dancers share the same space as a human dancer. This establishes a more equivalent form of presence for the artificial and human dancers and renders their space and movement relationships more evident.

After several trials with different robotic lights, a model was selected whose head is very lightweight and has a centred mass[9] (Fig. 6). These properties turned out to be essential to preserve most of the characteristics of the movement qualities when mapping them from simulation to robotic lights. Since the robotic lights possess only two rotational degrees of freedom, only a subset of the joints of a simulated morphology could be assigned to a robotic light. Two different mapping strategies were employed for the two different morphologies (Fig. 6). In the case of *Arm6*, the first joint with it's rotation axis aligned with the main body direction and the last joint with its rotation axis perpendicular to the main body direction were assigned to the pan and tilt axes of a robotic light, respectively. In this assignment, the number of simulated morphologies matches the number of robotic lights. In the case of *Arm17*, each pair of successive joints with their alternating rotation axis directions is mapped to the pan and tilt axis of a robotic light. In this assignment, the number of robotic lights corresponds to the number of joint pairs of a single simulated morphology. In both mapping strategies, the intensity and colour of the emitted light was unaffected by the simulation and was kept constant. After several experiments, it was concluded that the movement qualities were more readily recognisable in the robotic lights when employing a mapping from *Arm6* than from *Arm17*. For this reason, the dance scenes were created by choreographing several *Arm6* morphologies.

4 Dance Performance

The two scenes form part of a dance piece entitled *Embodied Machine* which was premiered at *Mercat de les Flors*[10] on July 11 2022. In this performance, 16 robotic lights were part of the stage setup, with 8 lights placed in a circle on the ground with a diameter of 5 m, and 8 lights hanged at a height of 7 m from a circular truss with a diameter of 3 m. Photographs of the two scenes are shown in Fig. 7. Excerpts of video recordings of the scenes are available online[11].

4.1 Scene 1 - *Approximation*

In the scene entitled *Approximation*, 8 *Arm6* morphologies control the movement qualities exhibited by 8 robotic lights placed on stage. The spatial arrangement of

[9] ACL 360I - Elation Lighting.
[10] Mercat de les Flors: mercatflors.cat.
[11] Embodied Machine: Scene *Approxmation*, Scene *Progression*.

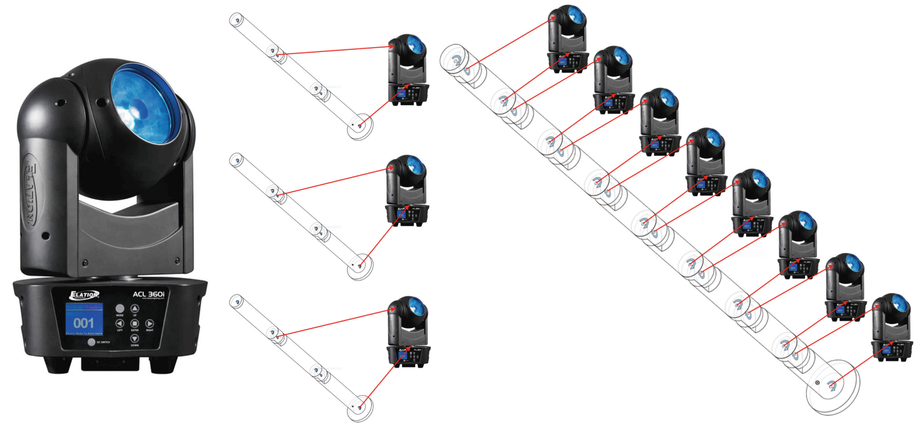

Fig. 6. Robotic Moving Lights and Joint Mappings. Depicted from left to right are: an Elation Lighting ACL 360I robotic light, the mapping of rotation angles from multiple *Arm6* morphologies to multiple robotic lights, the mapping of rotation angles from a single *Arm17* morphology to multiple robotic lights.

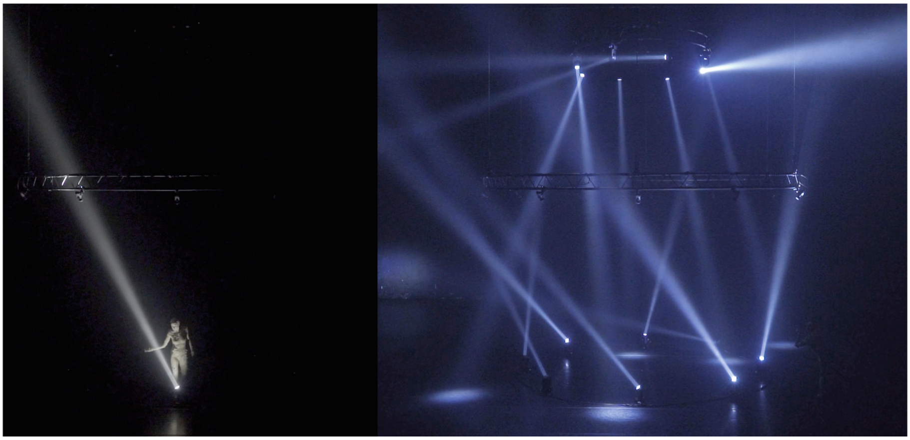

Fig. 7. Two Scenes in the Dance Piece Embodied Machine. The image on the left depicts a moment in the scene *Approximation* during which a dancer performs a duet with a single robotic light. The image on the right depicts a moment in the scene *Progression* during which the robotic lights follow their own choreography.

the *Arm6* morphologies in the simulation matches those of the robotic lights on stage. The dancer's position is tracked using an optical motion capture system. The position is mapped into simulation and used for a proximity-based trigger mechanism that activates and deactivates the robotic lights The scene plays out as a series of duets between a human dancer and each robotic light in turn (Fig. 7, left image). The dancer walks along a circle approaching one robotic light after the other. Once the dancer is sufficiently close to a robotic light, the light becomes active. An active robotic light emits light and chooses a random movement quality according to which it behaves. The dancer freely improvises alongside the robotic light without otherwise affecting its behaviour. When the dancer walks away, the robotic light stops moving and ceases to emit light.

4.2 Scene 2 - *Progression*

In the scene entitled *Progression*, 16 *Arm6* morphologies control the movement qualities exhibited by all robotic lights. Again, the spatial arrangement of the *Arm6* morphologies in the simulation matches those of the robotic lights. Here, the robotic lights follow their own choreography independently of the activities of the human dancer (Fig. 7, right image). The choreography progresses through several stages. Initually, one robotic light after the other performs the same movement quality (*Levitation*), then all lights perform the movement quality (*Fluidity*) in unison. After that, the lights on stage and those hanging perform movement qualities that are in contrast to each other such as *Fluidity* and *Particles* or *Thrusting* and *Staccato*. Finally, all the lights individually and repeatedly chose a random movement quality. During this last stage, the rotation limits of the *Arm6* morphologies are gradually reduced until they are so small that the lights cease moving.

5 Discussion

The process of translating idiosyncratic movement qualities into behaviours for non-anthropomorphic morphologies has proven to be both insightful and challenging. Evaluating movement qualities with regards to their suitability for creating synthetic movements requires an understanding of the characteristics of the chosen movement qualities, the capabilities of the generative system employed for creating the synthetic movements, and the properties of the artificial morphologies by with the movements are expressed. While the second two aspects where predominantly within the responsibility of the first author, the second author has played a key role with regards to the first aspect. Experiencing the movement qualities in four different forms, through the choreographer's own body, as video recordings, as motion captured skeleton animations, and as visualisations of simulated morphologies, enabled her to reflect about what constitutes the essential elements of a movement quality independently of its actual manifestation in a human body. This reflection informed the design of the morphologies for the artificial entities and their simulation-based behaviours. Working with highly simplified body architectures and actuation principles facilitated the gaining of an understanding for how physical parameters and behavioural properties exert their effects on the resulting movement qualities. For example, it became clear that forces which are initiated by a few active joints only travel very differently across the morphologies of *Arm6* and *Arm17*. This is due to the arms' differences with regards to their number of joints, weight distribution, and inertia. Furthermore, the two morphologies differ with respect to the frequency of self-collisions which hinder or disrupt the execution of movement qualities. Self-collisions occurred much more frequently in *Arm17* than in *Arm6*. For these reasons, it proved challenging to design and configure simulation-based behaviours that evoke the same movement qualities in both morphologies. This challenge was further exacerbated when mapping the movements from simulation to robotic lights. Despite the fact that the robotic lights are both light and fast, their physical properties and control mechanisms tended to smoothen out small variations in velocities and limit spikes in acceleration. The first effect had a significant impact on the recognisability of the movement quality *Particles* and the latter on the movement quality *Thrusting*.

6 Conclusion and Outlook

The current approach offers room for further experimentation and research. As a next step, the authors plan to work with additional movements qualities, focusing particularly on qualities whose core properties might not be so obviously related to physical and dynamical principles that can easily be modelled by a physics simulation. This includes movement qualities in which experiential or emotional aspects play a dominant role. In those cases that involve robots as dancing entities, more attention has to be paid to the transition from simulation to robotic object. It is likely necessary to model the robots' morphologies and actuation more accurately in simulation to avoid loosing important nuances in movement qualities. Alternatively, it might be possible to skip the simulation step altogether and instead work directly with the morphology and actuation controls of the robots.

The authors believe that the approach chosen for translating idiosyncratic movement qualities for non-anthropomorphic morphologies is promising. Experimenting with such morphologies opens up new artistic possibilities and expands choreographic decision making beyond what is possible with human bodies. The adoption of movement qualities with which choreographer and dancers have become accustomed to supports the creative process of working with non-anthropomorphic morphologies. It is through such movement qualities that non-anthropomorphic morphologies become readable as expressive entities to which choreographers and dancers can relate to.

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References

1. Alaoui, S.F., Caramiaux, B., Serrano, M., Bevilacqua, F.: Movement qualities as interaction modality. In: Proceedings of the Designing Interactive Systems Conference, pp. 761–769 (2012)

2. Alaoui, S.F., Henry, C., Jacquemin, C.: Physical modelling for interactive installations and the performing arts. Int. J. Perform. Arts Digit. Media **10**(2), 159–178 (2014)
3. Arnold, P.J.: Aspects of the dancer's role in the art of dance. J. Aesthetic Educ. **34**(1), 87–95 (2000)
4. Bartenieff, I., Lewis, D.: Body Movement: Coping with the Environment, 1st edn. Routledge, London (2013)
5. Blom, L.A., Chaplin, L.T.: The Intimate act of Choreography. University of Pittsburgh Pre (1982)
6. Cadoz, C., Luciani, A., Florens, J.L.: CORDIS-ANIMA: a modeling and simulation system for sound and image synthesis - the general formalism. Comput. Music. J. **17**(1), 19–29 (1993)
7. Dautenhahn, K.: Human-Robot Interaction. The Encyclopedia of Human-Computer Interaction, 2nd edn. (2013)
8. Fehr, J., Erkut, C.: Indirection between movement and sound in an interactive sound installation. In: Proceedings of the 2nd International Workshop on Movement and Computing, pp. 160–163 (2015)
9. Hsieh, C.M., Luciani, A.: Generating dance verbs and assisting computer choreography. In: Proceedings of the 13th Annual ACM international Conference on Multimedia, pp. 774–782 (2005)
10. Larboulette, C., Gibet, S.: I am a tree: embodiment using physically based animation driven by expressive descriptors of motion. In: Proceedings of the 3rd International Symposium on Movement and Computing, pp. 1–8 (2016)
11. Lockyer, M., Bartram, L., Schiphorst, T., Studd, K.: Extending computational models of abstract motion with movement qualities. In: Proceedings of the 2nd International Workshop on Movement and Computing, pp. 92–99 (2015)
12. Maletic, V.: Body, Space, Expression: The Development of Rudolf Laban's Movement and Dance Concepts. Approaches to Semiotics; 75, Mouton de Gruyter, Berlin, New York (1987)
13. May, J., et al.: Points in mental space: an interdisciplinary study of imagery in movement creation. Dance Res. **29**(supplement), 404–432 (2011)
14. Pascual, B.B.: What is involved in the process of naming movement? An insight into a research project on pre-choreographic elements based on the work of Emio Greco and Pieter C. Scholten. Multimodality and Performance, pp. 132–143 (2016)
15. Preston, S.: "Giving dance room to breathe" dance-music relationships in Siobhan Davies' choreography, 1972–1979. Dance Chronicle **22**(3), 321–357 (1999)
16. Von Laban, R.: Modern Educational Dance, 3rd edn. McDonald & Evans, London (1975)