First steps in body-machine choreography

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ABSTRACT

Kinetic, autonomous and interactive behaviours can be embedded in material objects and the built environment, blending the digital with the physical. This emergent trend towards animate behaviours in our everyday environment, already signalled by the ubiquitous computing paradigm, poses new challenges and issues for cross-disciplinary design in interaction design and experimental architecture. The design of such environments and behaviours can be viewed as a form of choreography across bodies and machines. We present *Black Spring*, a first prototype of such an environment. The development of the prototype and companion performance is discussed in terms of the interaction design, using a tool that enables a systematic analysis of the interaction between the performer and the machine in the language of choreography.

Author Keywords
Architecture, body, choreography, kinetic environment, movement-based interaction

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Kinetic, autonomous and interactive behaviours can be embedded in material objects and the built environment, blending the digital with the physical and overturning our understandings and expectations of the world in which we live. This emergent trend towards animate behaviours in our everyday environment, already signalled by the ubiquitous computing paradigm, poses new challenges and issues for cross-disciplinary design in interaction design and experimental architecture.

Since the 1990's, architects and artists have been creating responsive environments and installations for aesthetic purposes (Beesley et al., 2006). These installations have been predominantly screen-based or sonic immersive environments, using various sensors to detect and respond to the presence and activity of visitors or performers. The recent shift to digital fabrication and material environments replaces two-dimensional visuals/screens with three-dimensional forms that exhibit dynamic behaviours in physical (c.f. virtual) space and time (e.g., Philip Beesley's Hylozoic Ground, 2010; Reinhardt and Jakovich, 2009)

Much of the research in ubiquitous computing and responsive architecture is driven by innovation in material properties, the fusing of the digital and the physical in 'transitive materials' (Coelho et al., 2007) and the application of generative or genetic algorithms (e.g., Diniz, 2007) for programming dynamic responsive behaviours. These new computational materials integrating form, function and computation afford new forms of interaction and necessitate a re-examination of human-computer interaction (HCI) design principles and methods. In contrast to materially-driven design, our work drives the behavioural design through choreography and a poetics of interaction, giving prominence to the human experience over the material properties.

Forsythe's notion of the 'choreographic object' (2009) contends that choreographic principles can transition across media other than the body, the traditional site of enactment. "A choreographic object is not a substitute for the body, but rather an alternative site for the understanding of potential instigation and organization of action to reside." Continuing with the idea that alternative sites for expression of choreographic principles can include computational materials and installations, then our approach of choreographing across bodies and machines extends the application of choreographic principles to machine behaviour. For the purposes of this paper, we often refer to the entire installation as 'the machine' to indicate there is a logic of processing and behaviour tied to a mechanical apparatus.

Our research is motivated by two broad research aims: 1) understanding the human experience of interactive, kinetic environments in artistic contexts and 2) how to design interactive behaviours and experiences. In this paper our focus is on investigating new languages and tools for describing and representing movement in the design process – the movement of human actors and the movement of artificial (fabricated), programmable materials.

We present *Black Spring*, a first prototype of our explorations into the design of environments with kinetic, autonomous and interactive behaviours. The development of the prototype and companion performance is discussed in terms of the interaction design, using a tool that enables a systematic analysis of the interaction between

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the performer and the machine in the language of choreography.

BLACK SPRING

Black Spring is an installation composed of a digitally fabricated landscape made out of timber and perspex, connected to an array of suspended polypropylene 'flowers' whose movements can be controlled through programmable electronics. It functions as an interactive environment responsive to audience presence and has a separate mode for choreographed performance. It was exhibited in the *Digital Interdisciplinations* exhibition, Tin Sheds Gallery in August 2012.

We chose to use the Microsoft Kinect motion sensor as the input device for its capacity to provide skeleton tracking functionality. The input data from the Kinect sensor is used to vary the kinetic behaviour of the 'flowers'. The flowers are dubbed the 'swarm' with the intent of programming them with swarm-like behaviours. A solitary flower presides over a segment of the landscape, apart from the swarm, and is known as the Black Queen. The flowers can move up and down on pulleys controlled by servo motor actuators.

The space was divided into four distinct spatial zones used to trigger different machine responses based on how we programmed the use of the Kinect input data. The sensing zones could be resized and were used in conjunction with the choreographic tool discussed in the next section.

Figure 1. Performer in landscape and swarm of flowers

The performance was conceptualised in response to the fundamental question of, How to inhabit this new landscape? The choreography then explored the human figure taking up varying relationships to the environment in which it finds itself, from one of shelter to merging into the landscape to moving in a mechanical way dictated by the segmented landscape (see Figure 1). The performer wears a piece of the landscape to symbolise the interdependency between the two.

Choreographing the interaction

The interaction between the performer and the 'machine' can be considered a form of choreography. Traditionally choreography is the art of creating a dance with the moving body in space and time. Here we extend choreographic principles to the kinetic behaviour of the machine. Our approach to choreographing the interaction was a dialogue between performer, choreographer, interaction designer and programmer. The choreography of the performer within the installation was tentatively sketched out in tandem with the choreography of the swarm. The swarm behaviour was then programmed, followed by testing with the performer. This cycle was iterated until a coherent and robust interaction was reached.

To aid this process, we devised a choreographic tool that enabled the mapping between the performer's actions and the machine's response. It is a derivation and extension of a design tool constructed by Robertson and Loke (2009), adapted from Suchman's (1987) analytic framework (see Figure 2).

The User		**The Machine**	
Actions not available to the machine	Actions available to the machine	Effects available to the user	Design rationale

Figure 2 Suchman's analytic framework

Suchman's framework analyses the interaction between humans and machines in terms of the resources available to each for mutual intelligibility and on-going interaction. The important insight offered by Suchman is that the machine too has a situation and as designers, we can design the resources available to the machine. That is, the choice of input devices and the interpretations of the input data determine what is available to the machine for sensing its world. The grey columns in Figure 2 represent the interface between the user and the machine.

In previous work by Loke and Robertson (2009), the framework was adapted as a flexible, generative design tool in the development of *Bystander*, a multi-user, audiovisual, immersive environment built on motion-sensing technologies (see Figure 3). This new tool is another adaptation of the framework, oriented towards choreography.

The tool breaks down the performer's actions and motivations into a set of parameters forming a movement score (see Table 1). These parameters can be specified over time to form a series of distinct sections in the score. The movement parameters describe the performance of the moving body in spatial, temporal, gestural and expressive dimensions. *Location/Path* describes where the performer is located in space and on what path they are moving. *Orientation/Focus* describes the direction of facing of the body or where the eye gaze is directed. *Body Configuration* describes the spatial shaping of the body. *Speed* is the degree/rate of movement. *Active Part* highlights which part(s) of the body are actively initiating movement. *Image Loading/Quality* describes the aesthetic, poetic and imagistic qualities informing the movement. Each section of the score can then be mapped to a specific machine state or response (see Table 2). The two tables are linked by the 'Section Name' column.

The four parameters (Location/Path, Orientation/Focus, Body Configuration and Speed) in Table 1 and the column 'Machine Sensing (Kinect)' in Table 2 are equivalent to Suchman's 'Actions available to the machine'. The Kinect sensor and available software

libraries provide skeleton tracking functions that enable the detection of the user's position in 3-dimensional space as a set of joint coordinates.

The User			The Machine		
Actions not available to the machine		Actions available to the machine	Effects available to the user	Internal machine behaviour not available to user	
Scenario + Key events	User perception	User activity: Movement/Stillness	Machine effects (audiovisual)	Machine state	Machine perception

Figure 3. Adaptation of Suchman's analytic framework as a design tool

Table 1. Performer choreography

Section Name	Location/Path	Orientation/ Focus	Body Configuration	Speed	Active Part	Image Loading/ Quality
Wall travel	On wall RHS, Moving along wall towards landscape	Soft-focus gaze	Upright, with head constant point of contact with wall	Very slow, 1cm/sec total body speed	Suspension in body	Armoured body subservient to rotating head
Dilating in swarm	Inside swarm	Facing out towards audience	Upright	Still	Sense of expansion/ presence	Absorbing the frenetic energy of the swarm
Embedded	Close, next to landscape	Facing landscape	Crouching, wing as shield	Slow	Whole body seeking fit with landscape	Hard, fragmented, merging
Machinic re-forming	Moving away from landscape and Black Queen (flower)	Side-on to landscape. Focus on landscape / Black Queen (flower)	Morphing articulated configurations	Quick 1-2-3-stop	Articulated body	Mechanical, non-human kinetic form-making dictated by articulated landscape

Table 2. Machine choreography

Section Name	Machine Sensing (Kinect)	State Behaviour	
		Black Queen (Cluster 1)	**Swarm (Cluster 2-10)**
Wall travel	No detection	Still	Intermittent quiver
Dilating in swarm	User tracking, Zone 2	Hovering	Go crazy
Embedded	Head tracking, Zone 3	Still	Following
Machinic re-forming	User tracking, Zone 4	Go crazy	Still

The column 'State behaviour' is equivalent to Suchman's 'Effects available to the user'. It describes the animated behaviour of the swarm, which is composed of 10 separately controlled components. Each component is a cluster of flowers, attached to a string on a rotating servo motor. The software program controls the movement and position of the flower clusters in response to where the performer is located, by sending commands to the servo motors.

For the performer, the movement score provides a structure within which to generate movement. The movement can be tightly scripted or more fluidly improvised in the moment, as is the case here. For example, the *Embedded* section of the score is about the human becoming part of, or merging with, the landscape (see shaded row in Table 1 and Table 2, and Figure 4).

Figure 4. The Embedded section of the performance

The performer moves slowly from standing in the swarm to crouching near the landscape, holding the armoured wing as a shield. The shield is angled to blend with the landscape. The performer's movement is activated by the idea of the whole body seeking to fit

with the landscape. The image loading of hard, fragmented and merging is the quality of the landscape that is taken on in the body by the performer – this is expressed in the movement quality discernable to others watching.

The machine is programmed to track the position of the user's head. The swarm follows the vertical position of the head, lowering as the user's head moves closer to the ground. The Black Queen remains still, reinforcing the concept of merging between human and landscape.

The state behaviour of the machine is described in the table with evocative, qualitative terms. It is also defined in terms of movement parameters/properties characteristic to the specific actuators: speed, distance and direction. These values were not recorded in the choreographic design tool; instead they were entered directly into the code and tweaked there.

The language used to describe and capture the state behaviour of the machine is currently quite crude and colloquial. It relied on a roughly negotiated understanding between the choreographer, the interaction designer and the programmer. For example, the term 'Go crazy' translated to an agreement that each cluster would move to a distance and at a speed randomly generated. The actual values for distance and speed were worked out through a process of trial and error, observing and judging the resultant behaviour in relation to the desired aesthetic. This is an area for further exploration, as we develop more complex and sophisticated programs for machine behaviour.

CONCLUSIONS

A first prototype of an interactive, kinetic environment was presented to begin to understand the possible interactions that can be designed following a choreographic approach. A choreographic tool was devised for this purpose, enabling a systematic mapping between the performer actions and the machine behaviour. This tool is an extension of a design tool that forms part of a holistic design methodology for movement-based interaction (Loke and Robertson, 2012). An important feature of the methodology is the attention given to the multiple perspectives of the first-person mover, the observer and the machine. The choreographic tool facilitates representation of the performer and machine perspectives and uses the language of choreography to specify the performance of the human and the behavioural qualities of the machine.

The use of choreographic language for machine behaviour is an emergent area in HCI and potentially contributes to design approaches interested in a poetics or aesthetics of interaction. Thinking in terms of choreography provides resources for considering the spatial and temporal aspects of interaction, as well as the poetic and imagistic. Choreography offers a language for articulating the entire body in movement, from the finest nuance of an individual to mass movements of large groups of people. The same principles can be applied to the design of the movements of kinetic elements of machines.

With Black Spring, the performance drove the design of the interactive behaviour of the installation. We are interested in designing for two modes: performer and audience. In audience mode, we envisage the installation having a life of its own, which the audience then enters. The next step in the project is to explore and develop more complex machine behaviours that are embedded in kinetic materials. This is part of an ongoing investigation into interactive kinetic environments that looks at biomimetic principles as a source of inspiration for programming animate behaviours. One of the issues for HCI then becomes about how people experience these new animate, kinetic environments and the implications for corporeal sustainability and well-being.

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