Chapter 3

The Moving Body

> To separate myself into a mind and a body would be to perform a radical surgery upon myself such that a vibrant kinetic reality is reduced to faint and impotent pulp, or excised altogether. (Sheets-Johnstone, 1999a, p.487)

The moving body is essential to how we experience the world. It, along with our primary senses of sight, sound and touch, constitute our perception of external things and ourselves. The moving body is simultaneously involved in acting and perceiving. The central role of movement in perception and cognition[1], as argued by phenomenologists, Maurice-Merleau Ponty and Maxine Sheets-Johnstone among others, is presented as a theoretical foundation for this thesis. A range of different understandings of the moving body, gleaned from various disciplines including anthropology, dance, physiotherapy and somatics, is presented in order to contribute to a greater understanding of movement in the discourse and practice of interaction design. Ways of analysing and describing movement are discussed, including systems of movement analysis where movement is viewed in the frames of social and spatial interaction, movement notations and algorithmic analysis of motion by computers.

[1]In this thesis, perception is regarded as active perception and as a cognitive activity. I use the terms, perception and cognition, as separate terms when I need to highlight/emphasise perception particularly amongst the full range of human cognitive activities.

3.1 The central role of movement

> Movement is, on the contrary, first and foremost the natural mode of being a body—a ready and perpetual kinetic susceptibility and effusion, as it were, of animate life. (Sheets-Johnstone, 1999a, p.494)

The central role of movement in perception and cognition is outlined, from the perspectives of two philosophers working in the phenomenological tradition, Maurice Merleau-Ponty and Maxine Sheets-Johnstone, as a foundation for my theoretical approach to this research. Their work supports the primary thrust of my thesis, that of designing for, and from, the experiential, moving body, beginning with an experience of movement.

Merleau-Ponty (1962) is important for his insights into the phenomenology of perception, in particular the central role that *movement* plays in perception. The body is conceptualised as an integrating function, the site of perception, a dynamic field of potentials for action. For Merleau-Ponty, perception is always active, embodied and generative of meaning (Robertson, 1997b). The philosophical notion of intentionality underlies Merleau-Ponty's analysis of perception. Perception is always directed 'towards something'. His assertion that "to move one's body is to aim at things through it" (Merleau-Ponty, 1962, p.160–161) suggests the *instrumentality* of the moving body in acts of perception, particularly perception of the external world, as suggested in this quote:

> Our bodily experience of movement is not a particular case of knowledge; it provides us with a way of access to the world and the object, with a 'praktognosia', which has to be recognized as original and perhaps as primary. (Merleau-Ponty, 1962, p.162)

He talks of a *body-image*, a total sense of one's posture in the intersensory world, defined in relation to the *value* of existing or possible tasks. Lingis (1994) interprets the work of Merleau-Ponty in his book, *Foreign Bodies*, as being primarily concerned with the exposition of a *competent* body, destined for the world. He explains the workings of the body-image, or postural schema, in this quote:

> The perception of intersensorial things is done by the postural schema which integrates the body's powers and converges its sensory surfaces. It is the postural schema that makes the body's mass into force and power. The postural schema that advances unto things and takes hold of them is not a momentary invention, but a dynamic diagram for operations which maintains itself and varies itself. The postural schema is the locus of perceptual competence. A movement perceives an object, aims at an objective. Perceptual competence is motor competence. (Lingis, 1994, p.20)

Lingis chides Merleau-Ponty for not giving sufficient weight to the other spaces we inhabit, the "unpracticable spaces", the world of the imagination, dreams and death, "the private theatres of delirious apparitions" (Lingis, 1994, p.21). Our immersion in these other spaces also shapes our experiences of our own bodies and provides imperatives for creativity and action.

What is missing from Merleau-Ponty's *Phenomenology of Perception* is the notion of *kinesthesis* as the organ of perception of *self*-movement. Kinesthesis, kinaesthesia or the kinaesthetic sense[2], comes from the Greek, kines=to move + theses=feeling. It enables us to know and be aware of internal sensations of body movement. It provides the felt, qualitative dynamic of our own body in movement. Sheets-Johnstone's phenomenological accounts of the moving body emphasise and explicate the kinaesthetic sense as vital to our perception of self-movement. Sheets-Johnstone draws heavily on the work of Husserl with regard to animate forms, movement and kinaethesia and extends his work to consider more rigorously the phenomenon of *thinking in movement*. Where Husserl considered movement only with respect to external perception, Sheets-Johnstone extends the analysis to include the actual perceptual experience of self-movement in the phenomenon of kinaesthesia. She brings together contemporary findings from studies of infancy, impro-

[2]Note that the kinaesthetic sense is often used interchangeably with proprioception in the fields of dance and somatics. This is in contrast to the usage of the terms in other fields, where a narrower definition of kinaesthesia refers to the sense of muscular effort and proprioception to our sense of balance. Gendlin (1992), a philosopher and psychotherapist, notable for his work on the 'felt sense', defines kinaesthesia as a sense of movement and proprioception as a sense of muscular effort. In this thesis, I adopt the definition of kinaesthesia as the felt sense of motion and tension, after Sheets-Johnstone.

vised dance, paleoanthropology and evolutionary biology to form a case for moving as a way of knowing and how thinking in movement is foundational to the lives of animate forms.

Sheets-Johnstone points out our common apprenticeship in learning to move our own bodies as infants, this being the basis for our fundamental knowledge of the world. We learn to move ourselves,

> not by *looking* and *seeing* what we're moving; we do so by attending to our bodily feelings of movement, which include a bodily felt sense of the direction of our movement, its speed, its range, its tension, and so on. Our bodily feelings of movement have a certain dynamic. We feel, for example, the swiftness or slowness of our movement, its constrictedness or openness, its tensional tightness or looseness, and more. In short, we perceive the *qualia* of our own movement; our bodily feelings of movement have a certain *qualitative character*. (Sheets-Johnstone, 1999a, p.56, original emphasis)

Accessing this original experience of learning to move is difficult for an adult body. However, she proposes the practical phenomenological method of 'free variation' for 'making the familiar strange', as a means of bringing to awareness the felt, qualitative character of one's movement. This notion of making the familiar strange, directly informed my design methodology of Moving and Making Strange, the primary contribution of the thesis, and will be discussed in Chapter 9.

3.2 Understandings of the moving body

This section provides a range of different understandings of movement, drawn from other disciplines such as anthropology, dance, somatics and physiotherapy, that contribute to a greater understanding of movement in the discourse and practice of interaction design. It proffers a set of five conceptions of movement that may be useful for thinking through the possible functions, meanings and interpretations of the moving body in the design of movement-based interaction. These various conceptions of movement are not mutually

exclusive categories, rather they offer different perspectives and approaches to understanding the moving body and for rethinking assumptions about movement that may be built into interactive technologies. The five conceptions of movement I present here provide an emphasis on the experiential, expressive, perceptual and social character of movement, to support the shift in design perspective inherent in my proposed design methodology. The literature is organised and presented according to the five conceptions of movement given below.

- Movement as anatomical, mechanical function
- Movement as expression and transformation
- Movement as perception
- Movement as felt, kinaesthetic experience
- Movement as a communicative act

3.2.1 Movement as anatomical, mechanical function

A starting point for understanding human movement is the physical structure, functioning and movement potential of the human body. The movement potentials of individual people vary according to their particular anatomy, physiology, training and bodily skills. We can focus on the anatomical, physiological and biomechanical characteristics and constraints of the moving body and treat the body as a musculoskeletal system composed of bones, joints, muscles, tendons and ligaments that can be subjected to measurement (Gray, 1995; Alcamo, 1997; Trew and Everett, 2001) and analysed as a biomechanical system of structures and forces (Hall, 1999; Trew and Everett, 2001). This view is useful for interaction design as the human body provides both constraints and resources in the determination of possible movement profiles for physical interaction with technology.

3.2.2 Movement as expression and transformation

The realm of dance goes beyond a functional, instrumental view of movement and sees the body as an expressive force that can move through space and time (Sheets-Johnstone, 1966; Laban, 1971; Bartenieff and Lewis, 1980; Fraleigh, 1987, 1999; Blom and Chaplin, 1988). In dance the focus is on the aesthetic, expressive and transformative qualities of movement. Sondra Horton Fraleigh (1987, p.49) provides a definition of dance as "human movement created and expressed for an aesthetic purpose", where aesthetic means 'affectively vital' and implies receptivity by an audience.

> When dance is valued as art, it engages us in the vital qualities of its medium—the vital qualities of the lived body. On a primal level, dance expresses and is experienced through the vital body—through movement, not words. Thus it does not necessarily express (or represent) literal emotions or feelings, although it can. It is, however, necessarily rooted in human feeling and founded in kinesthetic sensitivity and intelligence. (Fraleigh, 1987, p.47)

Exploring the moving body in dance is a deeper inquiry into the possibilities of expressive movement that is of a heightened form compared to the everyday. In dance the expressive element is not necessarily self-expression, but a more universal "extension of the expressive condition of the human body" (Fraleigh, 1987, p.28). The consciousness and imagination that one brings to the moving body yields possibilities of transformative experience.

> But a dance does not necessarily call for interpretation in words; it exists as a site for a wordless (yet poetic) communion. The power for communion resides in the human body, which exhibits an expressive condition in its motion and in its stillness. We are drawn to dance because it transports us beyond the literal word and into the body's poetry. (Fraleigh, 1987, p.74)

The dancer and ethnographer, Sally Ann Ness (1992) describes the transformative nature of learning and acquiring a new dance, a new choreography.

The mastery of a choreographed movement involves a neuromuscular repatterning that fundamentally reconstitutes our sense of self and brings new insights into who we are.

Dance works with the moving body as a creative medium, shifting between the literal and the abstract. Blom and Chaplin (1988, p.25) define *abstracting* as eliminating the particulars "that tie us to everyday behaviors and responses" and that "makes the resultant movement closer to the universal experience that claims us all." Examples of abstracting include translating concrete images to movement, creating movement metaphors for symbols and verbal instructions and manipulating a motif designed from a gesture. "At higher levels of abstraction, the medium itself becomes more pronounced and active, creating its own sense and syntax, its own magic." (Blom and Chaplin, 1988, p.27).

Butoh, a Japanese dance form, also known as "dance of darkness", works with the primal, organic body, exploring states of being through transformative imagery in the body and through a meditative, disruptive relation to time. It also unmasks the culturally mannered body.

> Butoh is most of all a process of finding expression, a primal body utterance. Its cathartic field is composed of gestural images rising to form out of the subconscious in whatever sublime or awkward manner they take. (Fraleigh, 1999, p.34)

Understanding the moving body as a creative and expressive medium can provide designers with new insights into the potential uses and experience of human movement with interactive technologies. In order to design for new kinds of movement-based interactions, designers can also draw on the creative potential of the moving body within their own design practices.

3.2.3 Movement as perception

A detailed account of the role of movement in perception, as argued by Merleau-Ponty and Sheets-Johnstone, was given previously in section 3.1. Gibson (1986) proposes a complementary view in his ecological approach to visual perception. He radically re-conceptualises vision as a *perceptual*

system composed of a *moveable* eye-head-brain-body complex, in contrast to the then orthodox theory of the retinal image. He describes the centrality of movement in the act of visual perception, where locomotion, head-turning, eyeball movements and tiny, continuous adjustments to the lens, retina and related optical anatomy work in the service of perceiving and exploring the environment. Perception of self and of environment go hand-in-hand.

In the field of somatics[3], an integrative approach to the moving body known as Body-Mind Centering (BMC), developed by Bonnie Bainbridge Cohen (1993), views movement as instrumental to how we perceive the world. It is through the sensing and feeling aspects of movement that we develop through life and participate in life with others. BMC works with direct experience of evolutionary movement patterns that form the basis of growth and perception (Cohen, 1993; Hartley, 1995). Moshe Feldenkrais (1972) and Thomas Hanna (1988) promote the cultivation of sensory awareness through movement for integrating physical and mental development.

Keleman (1985), in *Emotional Anatomy*, views the body as a fluid expression of our emotional state and history. He describes anatomy as "a kinetic morphology, the shapes of human process extended over time. It is a pattern of feeling, a state of tissue." (Keleman, 1985, p.58). He conceives of the patterns of expansion and contraction at all levels of the human organism from cell outwards as organising basic perception and cognition.

In relation to interaction design, an awareness of the interplay and intertwining between body and mind, action and perception broadens the significance of movements selected for interaction and the forms of bodily engagement enabled by particular technology design decisions. The types of movement and the forms of bodily engagement that are encouraged or allowed for interaction have a corresponding impact on the kinds of experiences we might have in computer-mediated environments.

[3]soma: the study of the experienced body as opposed to the objectified body, coined by Thomas Hanna (1988)

3.2.4 Movement as felt, kinaesthetic experience

The kinasthetic sense is recognised as crucial to the experience, performance and training of the body in dance and movement improvisation. As discussed in section 3.1, Sheets-Johnstone (1999a) explicates the primary role of the kinaesthetic sense in our perception of self-movement. Kinaesthetic awareness is defined by Blom and Chaplin (1988) as contributing to the experiential body of knowledge in the practice of dance or movement improvisation. They describe kinaesthetic awareness as a primary perception and self-awareness of the body in motion. The body's proprioceptive system judges "spatial parameters, distances, sizes; monitors the positions of the parts of the body; and stores information about laterality, gravity, verticality, balance, tensions, movement dynamics" (Blom and Chaplin, 1988, p.18). The awareness of the experience of movement grows through repetition and experience. Paying attention to and experimenting with different combinations of movement parameters through movement improvisation, leads to increased sensitivity to felt sensations and to increased ability to produce and direct movement with greater subtlety and range.

Sheets-Johnstone describes four primary qualitative structures that are present in all movement and define a spatio-temporal-energic dynamic. These are identified as tensional, linear, amplitudinal (areal) and projectional qualities. In *The Primacy of Movement*, she states, "These qualitative aspects of movement are of course separable only reflectively, that is, analytically, after the fact; experientially, they are all of a piece in the global qualitatively felt dynamic phenomenon of self-movement." (Sheets-Johnstone, 1999a, p.143).

She defines each qualitative structure as follows:

- tensional quality—our felt effort in moving
- linear quality—felt linear contour of our moving body and the linear paths we describe in the process of moving
- amplitudinal quality—felt expansiveness or contractiveness of our moving body and the spatial extensiveness or constrictedness of our movement

- projectional quality—the manner in which we release force or energy, e.g., in a sustained, explosive or punctuated manner

In another work, she proposes that the intimate relation between emotion and movement is grounded in the congruency of their qualitative dynamics, where affective feelings and tactile-kinaesthetic feelings are experientially intertwined (Sheets-Johnstone, 1999b). Her example of the emotion, *fear* illustrates the resonance between the dynamics of fear and the associated kinetic dynamic: "its felt urgency, clutchedness, stops and starts, desire for escape" (Sheets-Johnstone, 1999b, p.270).

Sheets-Johnstone's four qualitative structures of movement are reminiscent of the Effort-Shape description in the Laban system of movement analysis, although a direct mapping is not easily made or necessarily warranted between the two systems. Laban (1971) also speaks of psychosomatic experience in his description of movement sensations as significant in expressive movement. The Laban system is described in detail in section 3.4.

In movement-based interaction design, designers need ways of developing understandings of the moving body based on an attendance to the felt experience of movement. As outlined above, there are a range of ways of attending to and describing the felt experience of movement that can provide designers with a language and skill in articulating the felt, kinaesthetic aspects of movement.

3.2.5 Movement as a communicative act

The discipline of anthropology treats the moving body as invested with communicative significance. Farnell (1999) presents a contemporary overview of anthropology's current inquiry into human movement that now conceptualises body movement as dynamically embodied action in semantically rich spaces. The production and negotiation of meaning between people occurs through bodily movements that have specific meaning arising from the local context and situation. Reed (1998) provides a review of dance and studies of human movement, focusing on the relations between body, movement and culture and the meanings in patterned and structured movement systems.

Adrienne Kaeppler and Drid Williams both drew inspiration from various schools of linguistic analysis to develop their respective systems of understanding and analysing human movement. Kaeppler (1978) applied the concepts of kinemes[4] and their combinations into morphokines (analogous to phonemes and morphemes in linguistics) to the analysis of dance structure. Williams (1991, 1995) created a human semiotics of action called *semasiology*, in which human movement is considered as *action signs* rather than behaviour. "The action is thus described as a socially and semantically-laden action that is part of a prescribed social set of actions that are rule-governed and language-based." (Williams, 1991, p.182). Movements become action signs when they are employed as signs and symbols to some person(s).

Goodwin (2000) proposes a view of action that is built through the visible, public deployment of multiple semiotic fields that mutually elaborate each other. *Semiotic field* refers to the way signs are deployed within an encompassing medium. He focuses on semiotic fields for spoken language, gesture, posture and bodily orientation. He describes a *participation framework* which is built and sustained through the visible embodied actions of the participants.

Ness (1992) introduces a category of *choreographic phenomena* for identifying and describing patterned body movements from an anthropological perspective. Dance and other structured movement systems often involve conventionalised patterns of movement with particular relationships to space and time. Williams (1991) speaks of the syntax and grammar of dance idioms. These movement idioms usually take place in a structured space that has semantic significance. Williams (1991, p.280, original emphasis) states that "the space *internal to* a rite of a Mass can be shown to be different from the space *internal to* a football game." The priest performs a pattern of codified movement that has specific meaning for the ritual of the mass. Ritual movements tend to emphasise the rhythmic and symbolic aspects of movement. In comparison, the football player tends to perform a series of set moves but in a much more improvised fashion according to the contingent

[4]Kaeppler's usage of the term *kineme* is different from that of Birdwhistell—see section 3.3.1.

action of the game.

In relation to my research, interactive, immersive environments delineate spaces for the development and practice of structured movement systems. The meaning arising from these systems needs to be considered in the design of these environments. Do movement idioms emerge out of these environments or do they need to be explicitly designed?

Gesture

The complex relationship between gesture and spoken language is dissected in a range of ways by McNeill (1992), Kendon (1997) and Roth (2002). McNeill (1992) presents a taxonomy of gestures, where gestures are conceived as spontaneous creations of individual speakers and reveal the imagery of language. Categories of gesture include imagistic—iconic and metaphoric—and non-imagistic—deictic and beats.

Kendon (1997), in his review of gesture, focuses on the communicative and semiotic aspects of gesture, ignoring what he sees as less communicatively intentional forms of body movement such as posture shifts, self-touchings and incidental object manipulations. He examines how gesture and speech are inextricably linked as part of a single process, where gesture is often used to reinforce or specify linguistic expression. Kendon (1997, p.118) describes gesture as "useful both for conspicuous display and for inconspicuous communication, for communicating at a distance and when noise levels are high." His observations of work-setting gesture systems suggested that they exhibit a limited character—the form of the gestures and their meaning have emerged out of the particularities of the work setting and are generally not used outside that setting.

Roth (2002) has explored the relationship between gesture and spoken language, positing that the emergence of discourse is supported and preceded by gesture. His studies on the development of scientific language by school children indicate that their initial explorations through object manipulation (ergotic movements) and sensing of materials (epistemic movements) evolve into iconic gestures (symbolic movements) that then support the emergence

of discourse where abstract concepts can be discussed.

Gestures also play a larger role in human activity than just one of communication. An alternative view of gesture as a form of embodied knowing in the hand is offered by Goodwin (1997). He describes this in his study of chemists learning to discriminate the colours of black in the preparation of a fibre.

> The gestures performed here reveal a way of knowing that flows in the opposite direction, from the hand as a sensory actor alive to the ad hoc sensations it encounters as it works with external materials, to theories about how those sensations are relevant to the accomplishment of the activities in progress. The gesture points not to some hidden image lodged within the speaker's brain, but instead to the hand as an agent of experience in its own right encountering specific phenomena in the world it is working within." (Goodwin, 1997, p.18)

Brereton et al. (2003) also view gesture as having a broader definition than purely communicative. They generated a set of Gesture Themes from an analysis of a range of work practices. The purpose of the Gesture Themes is to identify typical roles that gestures play in activity, prior to designing new gesture-based tools. The five Gesture Themes are (1) Commanding Gestures, (2) Preparatory Gestures, (3) Gestures as Placeholders, (4) Shared Tools, Shared Workspace and (5) Mirroring Gestures.

An understanding of movement as gesture in the broadest sense reveals the multiple roles of gesture in human activity. Movements of the body can play a gestural role in interaction with machines, as well as other people. The discrimination of movements for use in gestural input to interactive systems continues to challenge designers, particularly for interactive, immersive spaces involving multiple users. Wei (2002) addresses this issue by proposing gesture as embodied, a-linguistic experience in his work with responsive media spaces, for example *TGarden*. Here gesture is seen as a subjectifying act of creation, rather than intersubjective signification. The *TGarden* provides a space for the performance of gesture by multiple participants "that can be improvised continuously relative to an open, dense topology of gesture." (Wei, 2002, p.471)

3.2.6 Summary—Understandings of the moving body

The conceptions of movement presented above illustrate the many and varied understandings and conceptualisations of the moving body that I consider most pertinent to the field of movement-based interaction design. When human movement is the direct input to interactive systems and spaces, the moving body must be considered from a manifold of perspectives—the potential for movement as dictated by the anatomy of the body, the felt experience of movement, the sensing and feeling aspects of movement in perception and cognition, the expressive and choreographic aspects of movement, the temporal and spatial patterning and the meaning, intent and communicative power in movement. In this way, designers can assess the implications of their design choices for the quality of the lived experience of active, moving users.

3.3 Analysing and describing movement

This section discusses the literature on describing and analysing movement in space and time, from the social sciences, dance and the computer vision community. Each different system of analysis is founded on its own conceptualisation of the body in motion. These differing conceptualisations give rise to different forms of representing movement. Existing forms of representing human movement are examined, particularly the use of movement/dance notations. One particular system of movement analysis and notation used extensively in this thesis, Laban movement analysis and Labanotation, is described in detail in section 3.4.

3.3.1 People analysing and describing movement

Several systems have been developed for analysing and describing human movement. They each exhibit different foci on the body in motion, from a focus on the changing patterns of motion in the body to a focus on the moving body embedded in social and spatial interaction. A questioning of

the relationship between movement and meaning underlies the different ways of analysing and describing movement.

Analysing movement as social interaction

Anthropologists such as Birdwhistell, Hall and Goffman are renowned for their work on analysing human movement as non-verbal communication. Birdwhistell (1970) developed his theory of human movement known as kinesics. Inspired by structural linguistics and its units of phonemes and morphemes[5] of spoken language, kinesics is an attempt to analyse visible bodily motion into movement units known as *kinemes* that represent the smallest communicative element. The types of body motion found to be used for non-verbal communication include hand, leg and torso movements, posture and weight shifts, gaze shifts, head nods and facial expressions. Daly (1988, p.45), however, suggests that kinesics is not useful for analysing the through-time phenomenon of movement, as "Its roots in the unit-and-structure technique of structural linguistics tends to impose on movement an inappropriately static framework."

Hall's proxemics is a theory of spatial interaction that recognises how culture influences our perception and use of space for communication. Hall (1968) contends that people experience space differently according to the culturally influenced patterning of the senses and selective attention and inattention to specific aspects of the environment. He also includes in his analysis the influences of the various senses, emotions and relationships between people. He distinguishes four categories of intimate, personal, social-consultive and public space.

Goffman (1959) proposed an elaborate theory of social interaction using a theatrical and dramaturgical metaphor, where each interactor performs a role in a routine that is contingently fostered by those involved. To quote Goffman (1959, p.30),

[5]Phoneme—A phonological unit of language that cannot be analysed into smaller linear units and that in any particular language is realized in non-contrastive variants; phonetic elements of a given word. Morpheme—significant elements of a word, be they root, suffix, prefix, inflection or aught else; A minimal and indivisible morphological unit that cannot be analysed into smaller units. Oxford English Dictionary http://dictionary.oed.com

> While in the presence of others, the individual typically infuses his activity with signs which dramatically highlight and portray confirmatory facts that might otherwise remain unapparent or obscure. For if the individual's activity is to become significant to others, he must mobilize his activity so that it will express *during the interaction* what he wishes to convey.

The views of spatial and social interaction, by Hall and Goffman respectively, are potentially useful for observing and describing people moving and interacting in immersive environments, as they provide frames for analysing the movements of people in relation to each other and their environment. More recently researchers in interaction and conversation analysis (Lehn et al., 2001; Heath et al., 2002; Hindmarsh et al., 2005) and museum visitor studies (Fernández and Benlloch, 2000) have contributed to theories of social and spatial interaction concerned with the perception and experience of interactive artworks or museum exhibits. They have shown that people's experience and perception of an exhibit is fundamentally shaped by and through social interaction with others in the same space. The aspects of social interaction included how visitors collaborate and coordinate activity, have sensitivity to others' presence and orientation, encourage or discourage participation, continually monitor the environment and maintain peripheral awareness of and align their activities to the conduct and performance of others, be they companions or strangers. These aspects of social interaction were relevant to the second project, Bystander, as it involved multiple visitors inhabiting the immersive environment of an interactive artwork.

The psychotherapist, Scheflen (1974) contributed significant insights into understanding nonverbal communication and the relationship between movement and meaning. He asserted that behaviour can have many simultaneously different and sometimes contradictory kinds of meanings. He outlined four types of meaning: (1) denotative references, (2) the meaning derived from the immediate context of the interaction or transaction, (3) the cultural origins and personality of the speaker and (4) meta-acts that comment on and qualify one's own behaviour. Daly (1988), in her review of movement analysis, outlines three principles for understanding the relation between

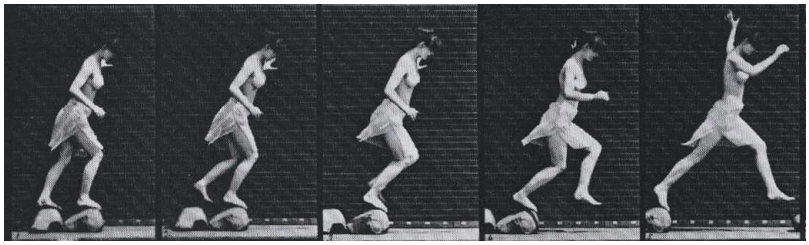

Figure 3.1 Frame by frame motion analysis by Muybridge, first published in 1887

meaning and movement: (1) behaviour is a patterned system, (2) all behaviour in an interaction is seen as functioning in its structure and therefore as contributing to meaning as well and (3) meaning is created by the relationships between behaviour and its many layers of context. She points out that the question of the meaning in movement "involves not just the phenomenon itself but also the observer as active meaning-maker." (Daly, 1988, p.45).

Analysing movement using images and video

An early form of movement analysis developed by Muybridge in 1887 involved the use of sequences of photographic stills. He created a large archive of photographic documentation of what he called human locomotion—sequences of split-second images of people performing actions ranging from stooping for a cup to dancing and dressing (Muybridge, 1984). Figure 3.1 depicts a woman jumping over stepping stones. His work was the forerunner for contemporary methods of movement analysis dominated by use of the video camera (Farnell, 1999).

Jacob Buur and fellow researchers have developed a range of techniques for working with video as a design material in participatory design (Buur and Soendergaard, 2000; Buur, Binder, and Brandt, 2000; Brereton et al., 2003; Buur et al., 2004; Jensen et al., 2005). Not all the techniques focus explicitly on movement, but they all provide means of retaining links to the dynamic, temporal nature of human action and movement. The *Video Card Game* technique involves turning video into tangible arguments, by representing significant sequences of video data (from field studies, situated interviews,

user workshops, usability evaluations) with keyframes on a physical card (Buur and Soendergaard, 2000). The technique aims to encourage designers and developers to make the use of video data an integral part of design work, by appropriating the artefacts and finding relevance in and ownership of them. It is a form of collaborative video editing suitable for novice video analysers.

In Buur et al. (2000), they construct a series of video artefacts from the raw video footage of work practice: video portraits, small thematic videos and type scenarios. The *video portraits* are an attempt to capture the "landscape, the places and the kind of awareness that seemed to be associated with being there." (Buur et al., 2000). The raw footage is analysed for themes and short fragments of interesting footage are assembled into *small thematic videos*. The final kind of video artefact is the *type scenario*. It is a small episodic video that provides a story of practice, encapsulating the issues pertinent to the design work. The scenarios provide "a recognisable and negotiable ground for explorations" of how things might be different (Buur et al., 2000).

The *Video Action Wall* technique involves construction of a mosaic of looped video clips of user actions (Buur et al., 2004). The idea is then to group actions according to perceived qualities of action, by moving the video clips around and positioning like clips closer together. It enables comparison of and conveys temporal, dynamic aspects of physical actions—that is, qualities of movement. Buur et al. (2004) point out the difficulties design students encountered with identifying and naming the *qualities* of the actions, rather than the actions themselves. In the work of Jensen et al. (2005), they found that the use of metaphoric and poetic expressions for describing the movement aspects of physical actions enabled designers to grasp more readily the distinctive character and quality of the movements and physical actions.

Jordan and Henderson (1995, p.39) define the practice of Interaction Analysis in their survey of the field as,

> an interdisciplinary method for the empirical investigation of the interaction of human beings with each other and with objects in their environment. It investigates human activities, such as talk, nonverbal interaction, and the use of artifacts and technologies, identifying

> routine practices and problems and the resources for their solution. Its roots lie in ethnography (especially participant observation), sociolinguistics, ethnomethodology, conversation analysis, kinesics, proxemics, and ethology.

The viewing, editing and transcribing of video data is crucial to the practice of Interaction Analysis. Video recordings enable the close examination of "the temporal organization of moment-to-moment, real-time interaction." (Jordan and Henderson, 1995, p.23). They identify a set of ways of looking at video data defined as *analytic foci*—these include the structure of events (beginnings and endings, segmentation), the temporal organisation of activity (the macro level, rhythm and periodicity), turn-taking, participation structures, trouble and repair, the spatial organisation of human activity and artefacts and documents. Depending on the analytic foci of interest, more or less description of the bodily movements of people will be made in relation to temporal, spatial, social and artefactual characteristics of the interactions.

Kirk, Crabtree, and Rodden (2005) conducted an analysis of the nature and role of gestural action in the performance of a remote collaborative physical task. Their focus is on the bodily practices that participants engage in to mediate interaction and highlight objects for perception, as part of cooperative activity. They approach the analysis of the video data with a concern to understand the 'stroke of gestural phrases'. That is, to describe "particular patterns of gestural phrase and the business or work that they do" (Kirk et al., 2005). They identified a corpus of *gestural phrases* that promote awareness in a mixed reality ecology, where virtual and physical objects are integrated into the same shared workspace.

The analysis of human movement can be undertaken from many different perspectives. The approaches surveyed above focus on movement in its social and cultural contexts, the meanings in patterns of movement and the temporal and spatial qualities of active, moving bodies. The movements of the body can be understood in relation to the body itself as well as in relation to the wider social and cultural contexts. Designers of movement-based interaction need to be able to understand and analyse the moving body from these multiple perspectives, in order to appreciate the implications of de-

sign choices made in relation to the movements of people as direct input to interactive systems.

3.3.2 Movement notations

Movement notation is the translation of four-dimensional (three dimensions of space plus time) movements into signs written on two-dimensional paper. Each system of movement notation assumes an underlying system of analysing movement, a way of conceptualising the body-in-motion. Anne Hutchinson Guest is one of the leading scholars on the history and contemporary practice of dance notation. She provides an in-depth discussion of the historical development of notation styles from the eighteenth century onwards, covering twenty-two different styles of notation (Guest, 1984, 1989). Feuillet is credited with publishing the first dance notation system in 1700. An illustration of a score by Feuillet is presented in Figure 3.2. Contemporary notation systems for documenting dance choreography include Labanotation, Benesh and Eshkol-Wachmann. Labanotation and its system of movement analysis are presented in detail in section 3.4.

Benesh was devised for recording ballet scores and uses a visual representation of the body derived from a stick figure. What is innovative about the Benesh system is the drawing not of the stick figure itself, but the plotting of the position and movements of key points in the body (the extremities and centre joints of the limbs). A matrix of five horizontal lines is used to represent the human figure, with the top line representing the head and the bottom line representing the foot. The symbols are drawn on a music-like staff. A picture of the Benesh staff is given in Figure 3.3. The principle of notating in the Benesh system is one of simplicity; it relies on the comprehension of the language of a particular dance style. A step-hop-hop pattern of movement is illustrated in Figure 3.4 using the Benesh system.

The Eshkol-Wachmann system is based on a mathematical and logical approach to movement. The movements of the body are taken to be circular in nature, as dictated by the structure of the joints of the body. This is illustrated for the conical movements of the limb in Figure 3.5. Movement is

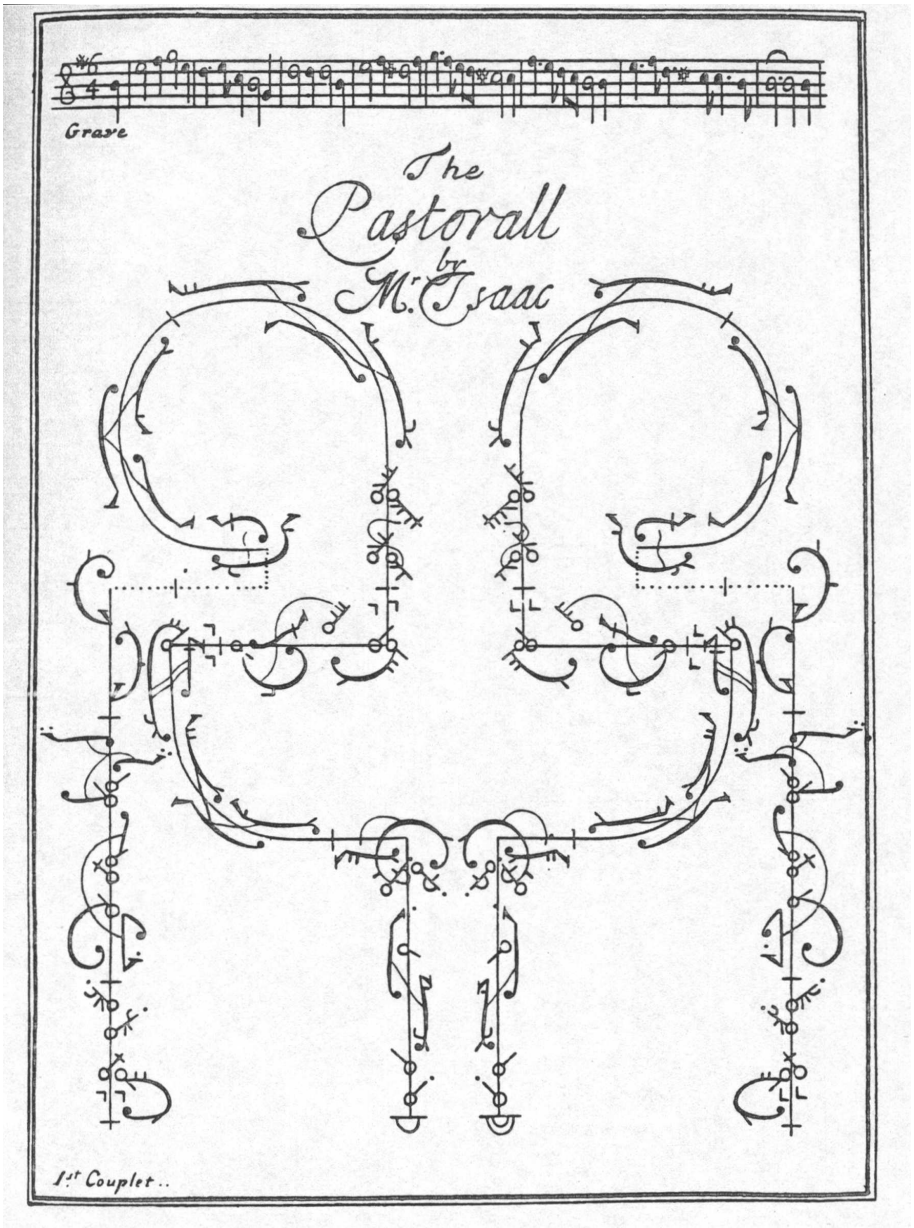

Figure 3.2 An example of a dance notated in the Feuillet system of movement notation, 1700. The spatial arrangements or floor plans are overlaid with notational symbols for moving bodies. Reproduced from the original publication by Guest, 1984.

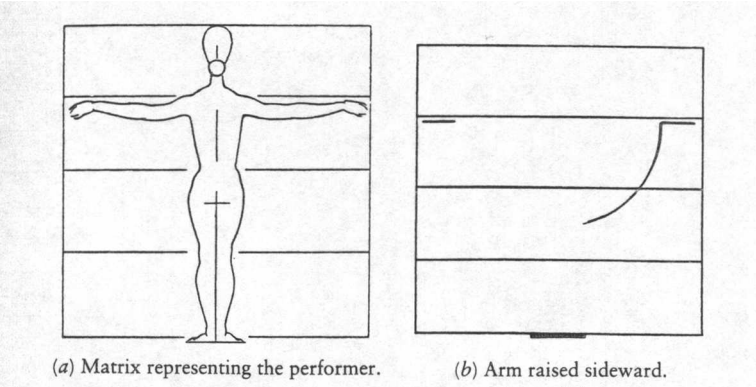

Figure 3.4 The Benesh staff. Reproduced from the original publication by Guest, 1984.

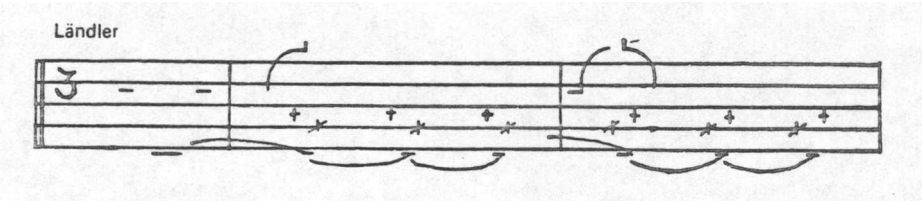

Figure 3.4 A step-hop-hop pattern of movement notated using the Benesh system. Reproduced from the original publication by Guest, 1984.

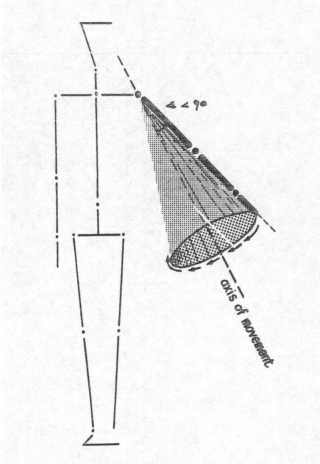

Figure 3.5 A depiction of the axis of conical movement in the Eshkol-Wachmann system. Reproduced from the original publication by Guest, 1984.

described using a system of coordinates to indicate the transition from one point to another, to indicate the character of the path, the sense and amount of movement and the statement of the position of the axis of the limb and axis of the movement. The Eshkol-Wachmann system is concerned only with the changes which take place in the body's configuration. Human expression or motivation is absent from the notation. It has also been applied to the analysis of animal movements. A score for the dance piece, *Diminishing Series* is presented in Figure 3.6.

Guest outlines a comprehensive set of requirements and criteria desirable in a system of movement notation (Guest, 1984, p.189–197). The criteria include universality, comprehensiveness, movement analysis, versatility in movement description, flexibility in application, logicality, visuality, legibility and practicality. The system of movement notation must be able to describe characteristics and components of movement such as the body, space, basic actions, weight, design, degree, relationship to the environment, timing, initiation of movement, dynamics, stage location, group indications, interpretation specified and technical indications.

The process of notating movement is contingent upon the needs of the analysis or documentation of movement—what is to be made visible and what is tacit or left out—and the skills of the notator. "Two notators often describe

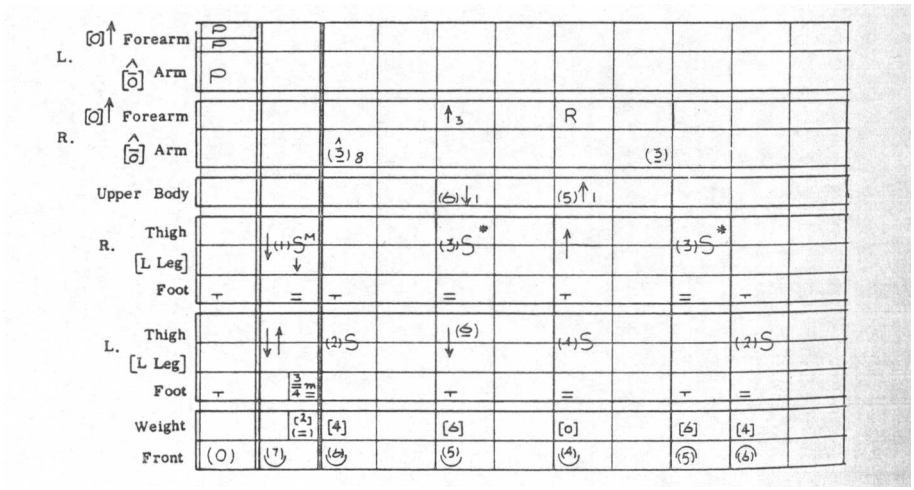

Figure 3.6 A score for the dance piece, *Diminishing Series*, notated using the Eshkol-Wachmann system. The score is read from left to right. Reproduced from the original publication by Guest, 1984.

the same movement differently. What they 'see' in the movement and how they choose to describe it is a direct result of their movement education." (Guest, 1984, p.3).

Bartenieff, Hackney, Jones, van Zile, and Wolz (1984) present their experiences of using Laban movement analysis and notation as a research tool in studying dance. They describe their methodological approach as well as the results of their analysis and notation work. They developed and worked with a range of different representations during their analysis of a particular dance form. These representations included a choreographic outline, summary images, notated scores (for example, Labanotation, Effort-Shape notation, Space Harmony notation) and integrated scores. The *choreographic outline* represents delineations of the major phrases and the outstanding features of each phrase. It is presented as a table composed of distinct sections of the dance. Each section of movement is described firstly as a subjective description of what is happening and secondly as a summary image. A *summary image* expresses the overall feeling or most striking feature of the movement section. *Integrated scores* combine the choreographic outline with the various types of notated scores. An example of an integrated score is given in Figure 3.7. They found that a tension exists between the descriptive

and interpretative styles of individual researchers and the need for a common vocabulary and language for describing observations of movement.

The choice of movement notation for use in movement-based interaction design will reflect the particular needs of the design situation and the aspects of the moving body considered relevant to the design. An overview of Labanotation is given in section 3.4.2, prior to the exploration of the suitability of Labanotation as a design tool in this thesis.

3.3.3 Algorithmic analysis of movement

Research endeavours and design approaches and solutions directed to the use of human movement with technology over the past thirty years have grappled with the technical challenges posed by treating the moving body as input, especially in the area of visual analysis and digital representation of the moving body (Badler and Smoliar, 1979; Gavrila, 1997; Pavlovic, Sharma, and Huang, 1997; Aggarwal and Cai, 1999; Pinhanez, 1999; Camurri, Hashimoto, Ricchetti, Ricci, Suzuki, Trocca, and Volpe, 2000; Camurri, Lagerlof, and Volpe, 2003a; Camurri, Mazzarino, and Volpe, 2003b; Davis and Horaud, 2003; Wang, Hu, and Tan, 2003; Hachimura, Takashina, and Yoshimura, 2005; Sminchisescu, Kanaujia, and Metaxas, 2006). There is a substantial body of work in the area of computer recognition and characterisation of human movement, which relies largely on biometric data and mathematical, statistical models of human movement. *Computer vision* uses video data as input and is concerned with the visual analysis of human movement. It is rooted in algorithmic and computational approaches to the visual analysis of human movement. It aims to recognise human motion at three distinct levels—body parts or gestures, tracking of the whole body and human activities. Recent work has shifted from recognition of low-level motion data to recognition of action, with a focus on the context of human actions (Pinhanez, 1999; Sminchisescu et al., 2006), and recognition of the expressive character of movement (Camurri et al., 2000, 2003a,b; Hachimura et al., 2005).

A host of sensing technologies, besides video-based computer vision, are now available for sensing and recognising human movement, such as data

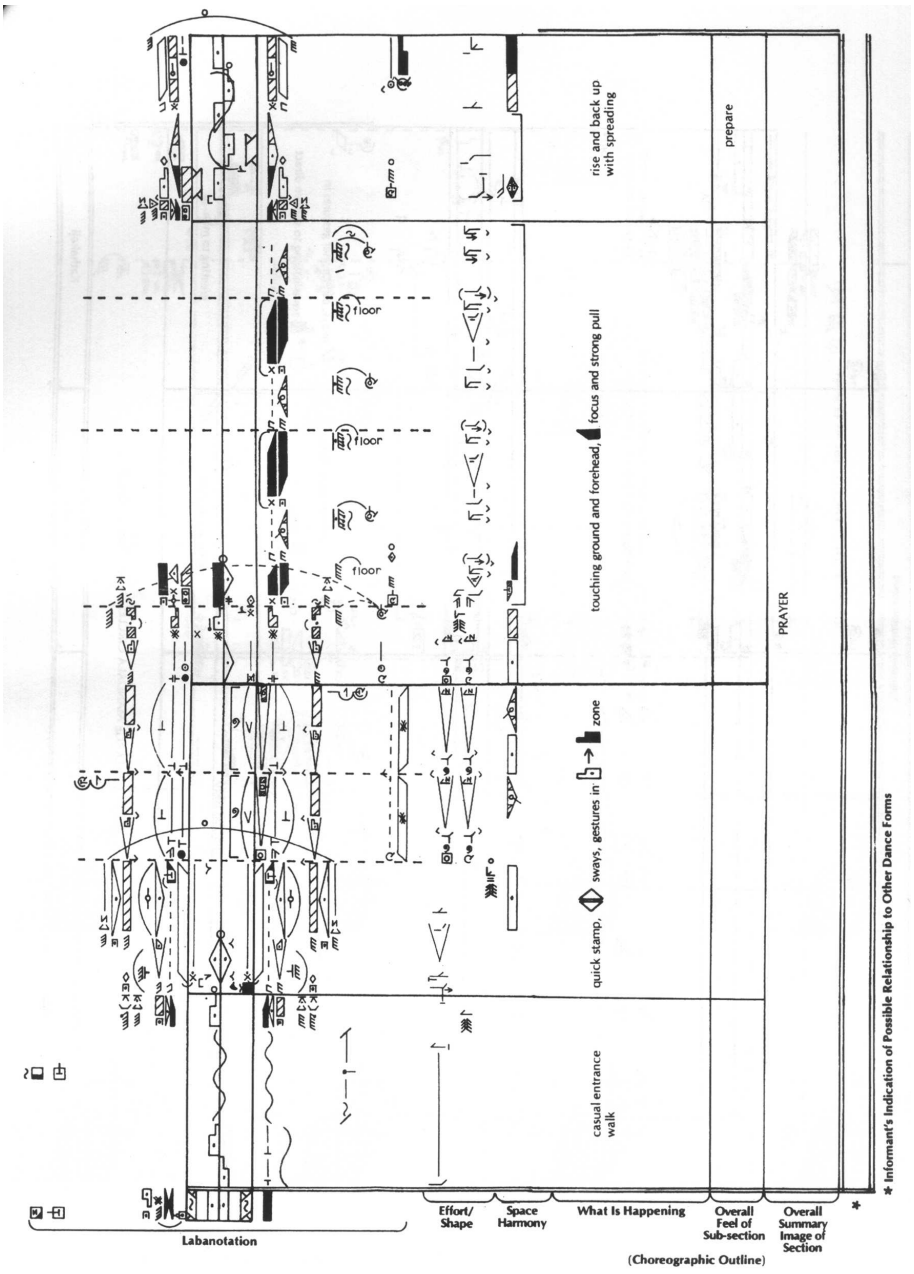

Figure 3.7 An example of an integrated score documenting the movement analysis of a dance from South West India called Cholkettu. Reproduced from the original publication by Bartenieff et al., 1984.

gloves, infra-red sensing, touch or pressure sensitive devices and more recently in the area of ubiquitous computing, the use of mobile phones or radio frequency identification (RFID) tags for detecting movement (Bellotti et al., 2002; Michahelles and Schiele, 2003; Rogers and Muller, 2003). The choice of sensor technologies provides constraints on the characteristics of movement that can be sensed and used for interaction.

The research surveyed here has a strong technical focus on devising computational models and algorithmic solutions for recognising, tracking and interpreting human motion. What it lacks though is connection to the lived experience of movement—the prime focus of my thesis. I propose ways of working directly with the experiential, moving body and design methods and tools for linking the human perspective and the machine perspective of the moving body.

3.3.4 Summary—Analysing and describing movement

Approaches to analysing human movement as non-verbal communication, drawn from the social sciences, include Birdwhistell's kinesics, Hall's proxemics, Goffman's theory of social interaction based on a theatrical metaphor and Scheflen's identification of four types of meaning related to behaviour. With these systems of analysis, the moving body is embedded in social and spatial interaction. Dance and movement notations focus on the changing patterns of motion in the body and between bodies, in relation to parameters of space and time. Different systems of movement notations have their own ways of conceptualising the body-in-motion. The same holds for computerised motion analysis and tracking systems—each has different ways of conceptualising and digitally representing the moving body.

A range of techniques for analysing video data, drawn from the practices of participatory design and interaction analysis, enables a close focus on the moving body. My research draws inspiration and guidance from the work of these researchers and seeks to contribute to ways of working with movement analysis and video data.

3.4 Laban movement analysis and Labanotation

> [Movement] has to be experienced and comprehended as an entirety. The urgent advice is given:- *invent short movement sequences, or mime scenes, in which the movements described can be recognised.* This is a means of training not only observation but also movement imagination, and of finding the immediate connection with the practical application of bodily exertion in terms of artistic expression. (Laban, 1971, p.27, original emphasis)

One of the strands of investigation in this research has been the suitability of Laban's system of movement analysis and notation to this area of movement-based interaction design. Traditionally Laban movement analysis (LMA) and Labanotation have been used in dance and movement observation for observing and recording both natural and choreographed movement and for exploring movement. They continue to be used in fields traditionally associated with the physical body, such as dance choreography (Guest, 1984), physical therapy (Bartenieff and Lewis, 1980) and drama (Newlove, 1993), and have also been applied in anthropology (Lewis, 1995; Farnell, 1999). Since the late 1970's, Laban movement theory has been applied to various fields of computing, such as human-computer interaction, computer animation and artificial intelligence (see section 3.4.3).

LMA is a system and language for observing, describing and analysing all forms of human movement. It was originally developed by Rudolf Laban (1971) in the 1920's and extended primarily by Knust (see Guest, 1984), Hutchinson (1977), Lamb and Watson (1979) and Bartenieff and Lewis (1980). It offers a vocabulary for describing the structural and physical characteristics of the moving body, the use of space and the dynamic, qualitative and expressive aspects of movement. Labanotation is the companion system of recording movement using symbolic notation, originally developed as kinetography by Laban (1971) and further developed by Hutchinson (1977) and others at the Dance Notation Bureau, New York. Unlike most other notation systems, Labanotation (and LMA) includes a thorough analysis of the

dynamics of movement (Guest, 1984).

3.4.1 Laban movement analysis

There are three essential forms of analysis and description—*Motif*, *Effort-Shape* and *Structural*—which focus on the movement characteristics of an individual body.

Motif is the simplest form of description and describes the salient feature of a movement or its motivation. It is a shorthand way of depicting just the essential aspects of the movement within a specific context. For example, it might describe just the steps taken in ballroom dancing or walking without representing any other aspects of the movement.

Effort-Shape describes the more qualitative and expressive aspects of movement and the inner attitude of the mover. It is concerned with "the changing patterns which occur in the ebb and flow of energy within the body" (Hutchinson, 1977, p.12). For example, in dance choreography this form of description conveys the aesthetic, emotional and expressive qualities of the dance. *Effort* (or the energy content) of a movement is described in motion factors of Weight, Space, Time and Flow; together with how a person engages with or resists each factor. Each factor is represented by two polarities: Weight (Light/Strong), Space (Direct/Indirect), Time (Sudden/Sustained) and Flow (Bound/Free). There are eight basic Effort actions derived from the motion factors of Weight, Space and Time. A diagram of the basic Effort actions is illustrated as an Effort cube, otherwise known as The Dynamosphere (Newlove, 1993), in Figure 3.8. For example, a *Glide* is Light in Weight, Direct in Space and Sustained (i.e., slow) in Time (see top, back, left corner of cube in Figure 3.8). A specific example of a movement with an Effort of *Glide* is ironing a delicate fabric. This type of Effort exhibits a delicacy in relation to Weight. In contrast, ironing out the creases with a firm pressure has an Effort of *Press*, which is strong in relation to the dimension of Weight (see bottom, back, left corner of cube in Figure 3.8).

Laban (1971) defines an Effort element in terms of two components: measurable, objective aspects of Resistance, Speed, Direction and Control; and

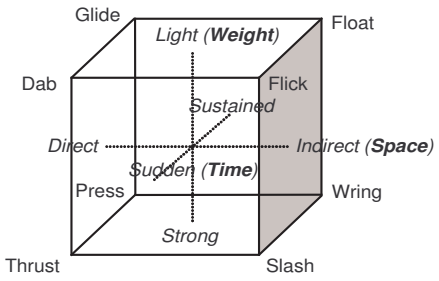

Figure 3.8 Effort Cube

personal and classifiable aspects of Levity, Duration, Expansion and Fluency. The second component relates to the *movement sensation*, that is, qualities of psychosomatic experience. Laban (1971, p.81) describes the significance of movement sensations as,

> While in functional actions the movement sensation is an accompanying factor only, this becomes more prominent in expressive situations where psychosomatic experience is of utmost importance.

A table relating the Measurable and Classifiable Aspects of Effort elements for motion factors of Weight, Time, Space and Flow, is reproduced from his book, *The Mastery of Movement*, in Figure 3.9.

For example, for a Floating effort action, the movement sensation is 'suspended'. In such a movement, the psychosomatic experience of Levity is *light*, as if buoyed aloft, of Duration is *long*, as if existing in everlasting time, and of Expansion is *pliant*, as if crumpled in space.

Shape describes the spatial shaping of form—growing, shrinking or carving patterns in space. It describes the expressiveness inherent in the form of a movement in terms of Shape Flow, Directional Movement and Shaping. The spatial intent of a movement determines the particular spatial shape that is produced as the movement unfolds. For example, the action of pulling a fishing net out of the water has a spatial intent that is directed along a radial line from the centre of the body to the periphery where the hands hold the net. The related spatial shape of the body is one that expands and contracts

Motion factors	**Effort element**: *fighting*	**Effort element**: *yielding*	**Measurable Aspects** (objective function)	**Classifiable Aspects** (movement sensation)
Weight	firm	gentle	Resistance: strong (or lesser degrees to weak)	Levity: light (or lesser degrees to heavy)
Time	sudden	sustained	Speed: quick (or lesser degrees to slow)	Duration: long (or lesser degrees to short)
Space	direct	flexible	Direction: straight (or lesser degrees to wavy)	Expansion: pliant (or lesser degrees to threadlike)
Flow	bound	free	Control: stopping (or lesser degrees to releasing)	Fluency: fluid (or lesser degrees to pausing)

Figure 3.9 Measurable and Classifiable Aspects of Effort elements. Reproduced from *The Mastery of Movement*, Laban (1971)

along the path dictated by the spatial intent as the person repeatedly pulls the net in towards the body (Bartenieff and Lewis, 1980).

The spatial shaping of the body can be analysed in terms of what forms the body makes and the relation of the body to itself and its environment. Shape analysis provides a set of descriptors for dynamic, fluctuating shape characteristics, classified into categories of Shape Form and Shape Quality (other categories exist but have not been used in this research). Shape Form describes the static shapes that the body takes, for example, pin-like, wall-like, ball-like or screw-like. Laban (1971, p.70) defines these four terms in relation to the organisation of parts of the body as (a) spine and its pin-like extension, (b) right-left symmetry of body and its wall-like surface, (c) limbs, together with their respective trunk regions curling and circling in ball-like shapes and (d) shoulder-girdle and pelvis twisted against one another in screw-like fashion.

Shape Quality describes the way the body is changing toward some point in space, for example, opening or closing, indicating the degree of extension or contraction in the body. More specific terms include Rising and Sinking (along the vertical axis of the body), Spreading and Enclosing (along the horizontal axis), and Advancing and Retreating (along the sagittal axis).

Shape analysis was developed primarily by Lamb and Watson (1979). They describe the shaping process as,

> The actual process of variation, which results in a succession of differently sculpted positions, can be described as a sculpturing, or shaping process. If we wish to become more aware of the shape of a person's posture pattern, as he dresses himself, or greets friends at a party, or elbows his way around a store, for example, it helps to imagine that all his joints are emitting vapour trails as though they contained jet engines. (Lamb and Watson, 1979, p.49–50)

They suggest that "effort and shape are the two processes from which movement is created." (Lamb and Watson, 1979, p.81).

Structural provides the fullest and most specific description of movement in clearly defined and measurable terms: the body and its parts, space (direction, level, distance, degree of motion), time (metre and duration) and dynamics (quality or texture, e.g. strong, heavy, elastic, accented, emphasised). The *motivation* for the movement can come from various sources: directional destination, motion, anatomical change, visual design, relationship, centre of weight and balance, dynamics and rhythmic pattern. The *Structural* description is mostly concerned with directional destination as the motivation for movement; that is, where is the body going, where is the movement aimed in space. It forms the basis of the Labanotation.

3.4.2 Labanotation

Labanotation is a movement notation based on LMA, designed for notating movements of an individual body and for group choreography. The notation of movements of an individual body is recorded on a vertical *body staff*. The notation symbols represent change; that is, movement. Labanotation is the only movement notation system that combines the four dimensions of movement (three dimensions of space plus time) into a single symbol. The staff is divided into columns for different body parts—support (typically the legs and the feet), leg gestures, body, arms and head. Movements are understood as either steps or gestures. A step is a movement that involves

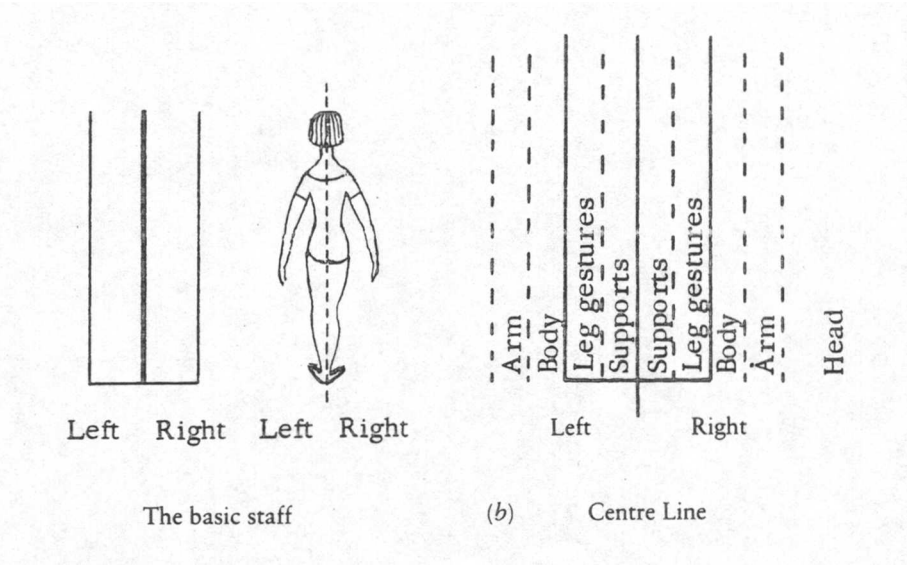

Figure 3.10 The Laban staff. Reproduced from the original publication by Guest, 1984.

a transfer of weight. A gesture is a movement of a part of the body that does not involve a transfer of weight. A diagram of the Laban staff is given in Figure 3.10. An understanding of the model of the body and principles of movement used in Labanotation is required. This model is based on the mechanics of the skeleton and the different degrees of freedom of the various joints and limbs. For example, the arm is connected to the body at the shoulder with a ball and socket joint. This type of joint dictates the available paths of movement of the arm. For arm gestures, the spatial directions and levels originate at the base of the limb, namely the shoulder. The free end, the hand, is at the extremity of the limb. For the arms, a spatial level of High is above the shoulder, Middle is at shoulder height and Low is below the shoulder. The symbols on the body staff below the double line represent the starting position of the body. Any movement is then described as a change from this starting position. Symbols for direction and level of movement in relation to the body are illustrated in Figure 3.11.

The Structural form of Labanotation is read from the bottom to top, with time in the vertical axis. Time can be split into measures (rows in the

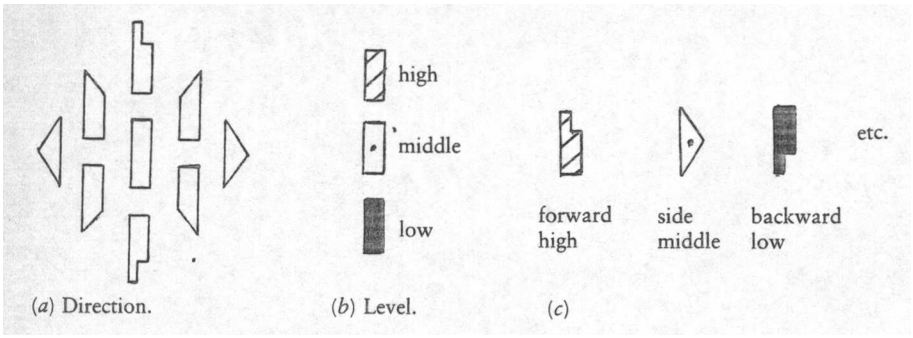

Figure 3.11 Symbols for direction and level of movement in the Laban system. Reproduced from the original publication by Guest, 1984.

diagram), just as in musical scores. The vertical staff represents the body, the centreline being the centreline of the body; the right hand columns represent the right side of the body and likewise for the left. The columns are used for the main parts of the body, such as S—Support, and A—Arm; for example, movements of the arms are written in the 'A' column. Symbols for indicating direction and level of movement in space can be combined and placed in the columns associated with the major body parts. Timing and duration of movement are indicated by the position and length of the symbol. No symbol in a column implies no movement. A wide range of symbols is available to give more detailed information; for example, the degree of contraction of the hand. An example of a notated score for a dance, Balanchine's *Serenade* is given in Figure 3.12.

For group choreography, *floor plans* are used to represent the overall arrangement of moving bodies in space and time. The spatial layout, configuration and trajectories of individual and multiple people can be shown. An example of a floor plan is given in Figure 3.13. This part of the notation is often used in conjunction with the body staff to document both the macro and micro levels of detail of moving bodies in space and time. It was particularly useful in this thesis as it can so easily be extended to represent the social aspects of human activity.

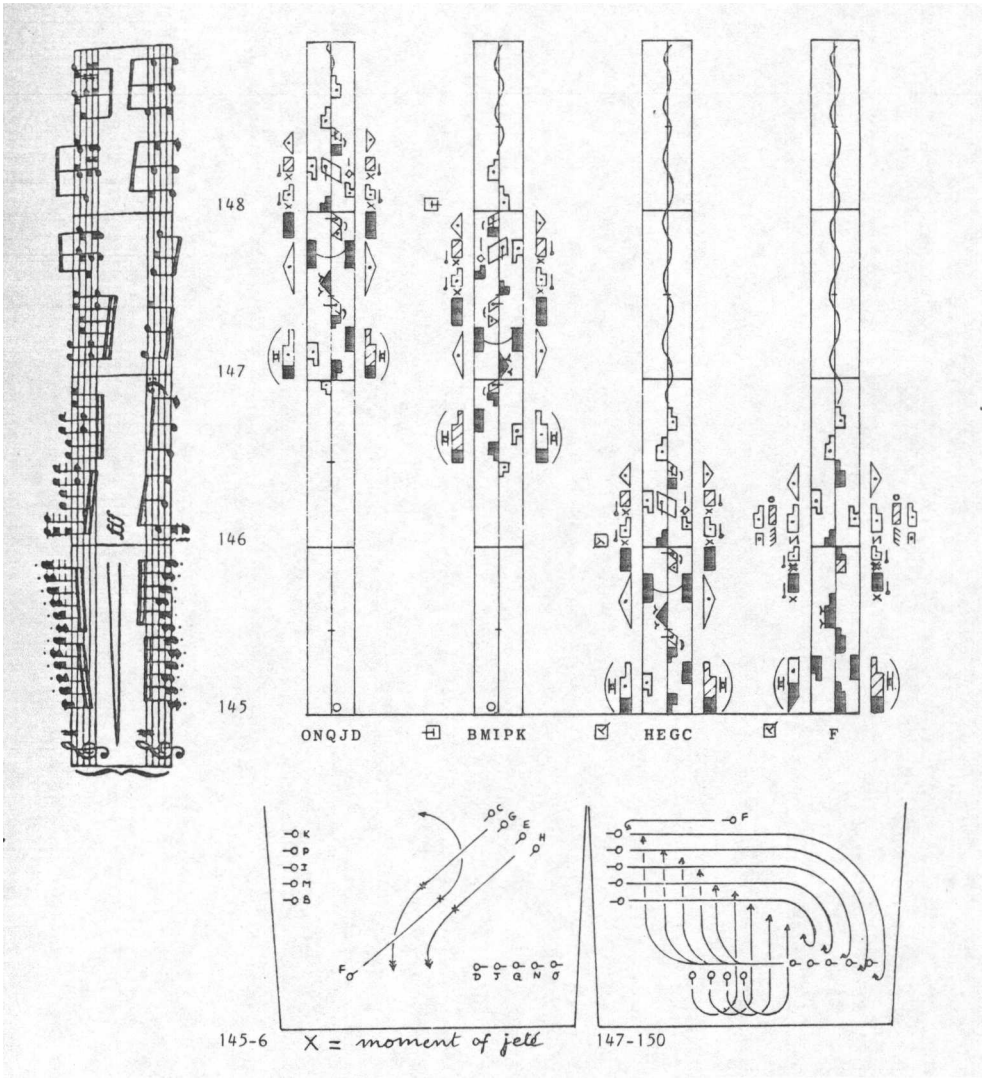

Figure 3.12 An example of a Laban-notated score for a dance, Balanchine's *Serenade*. It includes the Structural description and floor plans and an indication of the timing of the movements with the music. Reproduced from the original publication by Guest, 1984.

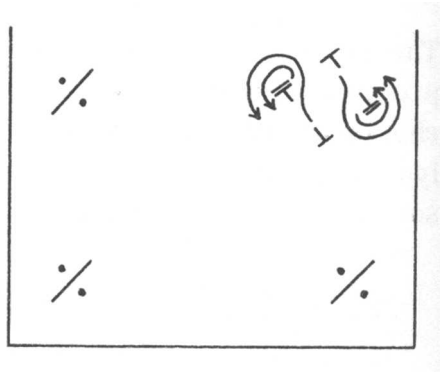

Figure 3.13 An example of a floor plan illustrating the paths of movement for a group of four people in the upper right hand quadrant. Repeat signs indicate that all four groups do the same thing. Reproduced from the original publication by Hutchinson, 1977.

3.4.3 Applications in computing fields

Other researchers in human-computer interaction, computer animation and artificial intelligence have used Labanotation and Laban's theory of movement for *simulation* and *recognition* of movement. Some of the most extensive and early work on simulating movement as part of computer animation, using Labanotation, was done by Badler and Smoliar (1979). They derived a set of "primitive movement concepts" from the model of the body used in Labanotation, to create a realistic computer animation of a human body in movement. This early work has been continued with the development of the EMOTE model—a 3D character animation system that incorporates other elements of Laban's theory such as Effort-Shape parameters in order to produce simulated movement that is more natural and expressive (Badler, Costa, Zhao, and Chi, 2000; Chi, Costa, Zhao, and Badler, 2000). Further examples include animation systems for visualising dance choreography from written notation scores, such as LabanDancer (Calvert, Wilke, Ryman, and Fox, 2005), and for creating virtual avatars (Deray, 2001).

Aspects of Laban's theory are also being used in attempts to extract expressive and emotive qualities from human movement, as part of computerised motion recognition systems. One prime example is *EyesWeb*, a

system that recognises gesture and affect from dance movement (Camurri et al., 2000, 2003a). EyesWeb processes the in-coming video stream using algorithms based on Effort-Shape parameters (Camurri et al., 2000). The EyesWeb expressive gesture processing library offers modules for motion, space and trajectory analysis (Camurri et al., 2003b). Researchers in robot-human communication are also investigating the quantification of LMA in order to extract characteristic features of human movement (Hachimura et al., 2005). The use of LMA and Labanotation in this thesis to describe and represent the spatial shaping of the body and spatial trajectories fits well with motion recognition systems like EyesWeb. Schiphorst, Lovell, and Jaffe (2002) have developed a gestural semantics of caress in which qualitative attributes of gesture are expressed as a function of tactility. The implementation of qualitative semantics is based upon Laban's Effort-Shape analysis.

LMA is being used in the conceptual phases of the design of interactive products. Fagerberg, Stahl, and Hook (2003) applied Effort-Shape analysis to the design of gestures for affective input to mobile phones. Jensen (2007) explored using Laban movement qualities first experienced in the body to then inspire the design of objects exhibiting the same qualities. Jensen et al. (2005) and Buur et al. (2004) describe qualities of human actions in terminology from Laban's Effort description. Similar to the approach of these researchers, my thesis investigates the usefulness of LMA and Labanotation as a system and language for describing, representing and reasoning about movement for the design of movement-based interaction. I am also interested in the potential for representations of movement based on LMA to bridge the two perspectives of the moving body, from the lived experience of the human and from the machine.

3.5 Summary—The Moving Body

Understandings of the moving body drawn from other disciplines such as anthropology, dance, phenomenology, physiotherapy and somatics provide designers of movement-based interaction with resources for conceptualising and articulating different aspects of the moving body for potential interaction

with technology. Attendance to the felt experience of movement as well as the functional aspects of movement opens up spaces for design of new realms of experience enabled by movement-based interactive technologies and is the motivation for the research into design methods and tools presented in this thesis.

Designers working in this emerging area of movement-based interaction design need ways of analysing, describing and representing human movement. There are many existing systems of movement analysis and notation, drawn from the social sciences, interaction analysis and dance, which can be employed by designers for this purpose. The various systems enable interpretations of movement as functional, expressive and qualitative through to the semantic. Dance and movement notations focus on the changing patterns of motion in the body and between bodies, in relation to parameters of space and time. Movement can be interpreted in the sociocultural frame of patterns of social and spatial interaction between people and the patterns of meaning in structured movement systems. These multiple and different frames of analysis and interpretation enable designers to make deeply informed choices about the kinds of movement performed for interaction and the interactive treatment of those movements.

This thesis examines in detail one specific movement notation, Labanotation as a potential design tool for representing movement and acting as a bridging representation between the movements of people and the interpretation by the machine of those movements as input. It is the only notation system that deals with the dynamic, qualitative aspects of movement, as well as the structural and functional. The Laban system of movement analysis is also explored as a tool for designers to develop bodily understandings of movement based in the terminology of the system and to observe the moving bodies of potential users of interactive technologies.