Part II: Research for Design
necessary to acknowledge this complexity and to identify the challenges it presents for
the documentation and interpretation of movement (Hutchinson Guest, 1984). Badler
and Smoliar (1979) tell us that there have been many approaches for representing
human motion within a digital context. A lack of consensus regarding the manner in
which movement should be described creates distinct challenges to researchers in
identifying a framework for its consideration (N. I. Badler and Smoliar, 1979). Taking
this view into account, it is necessary to acknowledge these difficulties, and to supply a
basis upon which movement is perceived, described, and understood throughout this
thesis.

Movement is a result of internal or external muscular responses that motivate the
the explicit and implicit characteristics of human movement, and the challenges
involved in reiterating its description by way of the written word or speech, because of
its inherent ambiguity. The intricacies involved in providing a sufficient reference to a
continuous flow of movement and rhythm in a three-dimensional space become
challenging when the numerous movements the body can perform simultaneously are
considered (Barbacci, 2002). While the muscular impetus of the body is not vital to the
documentation of movement, the result of its force allows for a visual form that may be
recorded successfully (Hutchinson Guest, 1977). Typically, a record of movement
involves the translation of space, time, energy, and body into a symbolic structure that
can be interpreted and converted to a physical form (Hutchinson Guest, 1977). This
method of translation requires an explicit description of movement that can
appropriately convey the nuances of movement in a tangible record that is universally
understood.

**Perceiving and Interpreting Movement**

Tangible records of movement provide an historic account of human motion that
enables the interpretation, analysis, and reconstruction of movement for its
performance. As dance creation and composition finds greater application in a digital
environment, the perception of the body and its disembodiment with a physical
presence has become an emergent topic (Behm, 2004; Bench, 2004; Fernandes, 2002;
Kroker, 1995; Neville, 2003; Sharir, 2007; Stelarc, 2005). Foster (1986) investigates the
Hutchinson Guest, 1977, 1984; Sheets, 1966). While this approach does not attempt to link the fields of dance and science, it serves to juxtapose elements of their use in the exploration and analysis of movement to establish a basis upon which I consider movement throughout this thesis.

Hutchinson Guest (1984) argues that dance is primarily a scientific endeavour that can only be described, interpreted, documented, and developed through symbolic languages. Her view is premised on an understanding that elements of artistic qualities attributed to the art of dance are perceived as creative human developments that contribute to a fundamentally scientific discipline (Hutchinson Guest, 1984). For Hutchinson Guest (1977), symbolic languages provide an objective record of movement that enable methods of innovative research to be performed through the comparative analysis and identification of movement structures and patterns. This is significant to this research because it enables me to attach structures to movement. Chatfield (in Fraleigh and Hanstein, 1999) argues that there is a necessity for a scientific framework in which the collection of data applicable to dance research can be objectively observed and analysed. He (Chatfield in Fraleigh and Hanstein, 1999) challenges the notion that scientific practise is fundamentally formulaic, and maintains that creative aspects of scientific experimentation comparable to the choreographic process can be used to augment discovery and innovation. While there is a perception that creative methods of exploration result in the exclusion of effective forms of analysis or logic (Laurel, 1993), creative experimentation can be leveraged for methods of investigation and innovation. Sheets (1966), however, takes into account the perspective of the performance and the experience of movement, in relation to its actuality and observation, as significant to the uniqueness and quality of dance. This suggests that the phenomenology of dance is one that places value on the meaning found in the immediate experience of dance, rather than on the result of objective reflection (Sheets, 1966). A canvassing of the varying contexts in which movement is perceived provides insights that are significant to the description and context of the analysis of dance.

**Describing Movement**

If we accept the notion put forward by Hutchinson Guest (1984) that dance is primarily a scientific activity that makes use of symbolic writing systems, it is necessary to
consider symbolic languages that have the capacity to describe movement for its documentation, analysis, and reconstruction. One symbolic language in particular that is readily available and broad in its field of communication is natural language. It is generally accepted that the use of words, or natural language, can be utilised to facilitate a description of movement that is commonly understood (N. I. Badler and Smoliar, 1979; Hall and Herbison-Evans, 1990; Hutchinson Guest, 1984, 1989). However, difficulties associated with the complex nature of movement and the capacity to provide an adequate portrayal of its occurrence (Sheets-Johnstone, Hutchinson Guest, 1984, 1989; Jensen, 2005) generally result in convoluted descriptions of movement that offer little assistance in the clarification or concept of motion. In support of this argument Badler and Smoliar (1979), tell us that natural language descriptions are more susceptible to imprecision and ambiguity when attempting to specify complex aspects of movement such as dynamics and style. Nevertheless, occasions in which natural language are employed as a method to describe movement can be found in “Danscore” – *The Easy Way to Write a Dance* (in Hutchinson Guest, 1984) and the proposed application “Ballet Animation Language Linked over Nudes Ellipsoid System” or “BALLONES” (Hall-Marriott and Herbison-Evans, 2007).

Danscore offers its users predefined word descriptions. These descriptions are designed to facilitate the documentation of movement by encompassing a range of actions achievable within a particular dance genre (Hutchinson Guest, 1984). Elaborate combinations of word descriptions form the foundation of movements available for selection. This requires a user to circle key words from each group of text descriptions to indicate a record of the desired movement that aligns itself with accompanying musical scores and stage plans.

The computer application BALLONES eliminates the use of dance notation systems, and interprets natural language in the context of classical ballet terminology to facilitate a representation of movement (Hall-Marriott and Herbison-Evans, 2007). This is achieved by documenting a concise description of movement using classical ballet terminology that BALLONES then translates to an animated form (Hall-Marriott and Herbison-Evans, 2007). Communicating a description of dance through written words appears to be ideally suited to members of the dance community, because classically trained dancers are customarily educated in the terminology of classical ballet.
Within the context of specific dance genres, however, there exist distinct techniques and styles of dance that require subtle variations in their description of movement, to differentiate one style from another. For example, the Russian Vaganova method of classical ballet and the English style of the Royal Academy of Dance are examples in which the variations between these two techniques could not be easily identified using a generic form of ballet terminology. A consequence of the inability to accurately describe these differences could produce undesirable results in their interpretation. This is because classical ballet terminology does not consider those movements outside the context of the language to which it subscribes. As Hutchinson Guest (1984) tells us, dance terminology is not universal in its application or interpretation. Systems that employ words to document movement limit the extent to which they find application in a wide range of fields (Hutchinson Guest, 1984). This suggests that the use of natural language in the context of a specific dance genre is limited in its capacity to account for the explicit representation of a complex range of movements.

To overcome such a limitation, Laurel (1993) argues that the requirements of objectivity and accuracy eliminate the role of natural language in favour of unambiguous numerical forms of symbolic representation. In contrast to this Badler and Smoliar (1979) recognise the advantages of symbolic languages in the expressive facility they offer in computer animation over the use of artificial or man-made languages such as computer programming languages. This becomes significant for the use of language and its potential for computation into movement descriptions and animated forms, because the practicalities of symbolic languages provide a concise and objective description of movement in a visual system that can be easily identified and referenced (Hutchinson Guest, 1984).

The literature (Mlakar in Buck, 2003; Hutchinson Guest, 1984; Knust, 1979; Wang, 2004) emphasises the use of movement notation systems as a symbolic form of communication. The above-mentioned authors provide methods of analysis to further enhance dance literacy, and warrant the preservation of movement to cultivate a richer dance heritage. Singh et al. (1983) call attention to the use of notation systems as a means for encapsulating and translating a choreographer’s abstract movement concepts to those who execute their performance. It is the ability for notated choreography to be communicated and danced. The communication of movement, therefore, becomes
significant in this research; not only in its representation, but also by what it is, that is communicated, and how the exchange of ideas is made possible.

**Authenticity of Movement**

Techniques utilised to document and interpret movement serve to inform the authenticity and aesthetic qualities of movement reconstructed for performance. The term “reconstructor” in this instance refers to an individual; other than the original choreographer of a specific work; who utilises notation scores to reconstruct a dance work as closely as possible to its original state (Thomas in Carter, 2004). The analysis and interpretation of dance notation scores enable a choreologist to recreate dance works in their entirety.

The authenticity of movement provided by notation scores is a highly contentious area among academics (Hutchinson Guest, 1984; Jeschke, 1999; Thomas, 2003; Van Zile, 1985). A parallel can be drawn between the fields of dance and music that have endured similar theoretical and practical debates concerning the authenticity, recreation, and preservation of music (Hutchinson Guest, 1984; Thomas, 2003). However, a key distinction must be made between the preservation of dance and music. While musicians have the training and capacity to document and preserve the original intent of their work in established conventions and protocols for writing music; choreographers must rely on a notator’s ability to communicate this appropriately in a dance notation score. Concerns surrounding the information notation scores embody perpetuate speculation as to whether these scores illustrate a choreographer’s intent; a notator’s interpretation of a choreographer’s intent; or captures a performer’s interpretation of movement (Thomas, 2003). Discussions concerning these topics are by no means an attempt to resolve these issues. Rather, they offer an overview of the complexities associated with the authenticity of movement to determine the way in which movement can be considered in the process of its translation and visualisation.

The authenticity of movement can be evaluated, to a certain extent, for its faithfulness to the original intent of the choreographer; the degree of autonomy permitted to its performers; or the level of precision in its documentation and interpretation. Dance notation languages provide choreologists with the tools to encapsulate the impetus and
concepts behind a broad range of movements (Hutchinson Guest, 1984). Significant to
the art of dance is not only the physical knowledge of its performance, but the
expression of its aesthetic (Fraleigh in Neville, 2003). Trained choreologists learn to
observe and notate various aspects of movement that are central to the objective of its
documentation. However, these descriptions can vary considerably with respect to the
manner in which movement is understood and subsequently documented (Hutchinson
Guest, 1984). Variances in the description and documentation of movement challenge
the authenticity of these scores. Choreologists act as translators in communicating the
structure and meaning of a choreographer’s work in a symbolic form (Hutchinson
Guest, 1984). It is through an indirect interpretation of movement that the authenticity
of notation scores are queried (Thomas, 2003). Main (in Thomas, 2003) argues that
notation scores documented by dancers of a specific work adequately encapsulate the
sense and meaning of the choreography. As a result, interpretations of movement by
those with direct experience of its performance provide these scores with a greater sense
of aesthetics and authenticity (Main in Thomas, 2003). This notion is reflected to a
degree within the practise of professional dance companies. The role of a
choreographer, ballet master, rehearsal director, and dancer become vital resources in
supplying firsthand knowledge of a specific dance work. Through the experiential
knowledge of movement, they enable the exchange of detailed information to be
communicated in the reconstruction of dance works.

Descriptions of movement are central to shaping the type and style of information a
choreographer or choreologist wishes to capture (Hutchinson Guest, 1977, 1984). The
nature of these descriptions supplies choreologists with descriptive and prescriptive
representations of movement. A descriptive representation of movement illustrates
movement in the style it was originally performed, while a prescriptive representation
refers to the manner in which it should be performed (Hutchinson Guest, 1984). These
descriptions propound choreologists with distinct knowledge of the information they
elucidate for the reconstruction of movement.

During the process of reconstructing movement, notation systems make visible
performative knowledge, that is, the symbolic communication of physical experiences
(Jeschke, 1999). This knowledge is representative of an implicit description of
movement that negotiates the ideal skills and capabilities of the body and movement
From this perspective, performative knowledge enables the individual interpretation of movement, and provides a framework for its application to dance (Jeschke, 1999). Implicit or general descriptions of movement enable performers greater autonomy in the expression and interpretation of movement (Hutchinson Guest, 1977). Their reconstruction and resulting performances generate new perspectives of dance knowledge (Jeschke, 1999). The notation of an explicit description of movement, however, will impart a distinct record of movement, regardless of a performer’s individual capability, interpretation, or talent. Explicit descriptions of movement enable the intent of a choreographer’s style and context of movement to be effectively preserved (Hutchinson Guest, 1984; Wang, 2004). For that reason, implicit and explicit descriptions of movement are fundamental to the record and interpretation of movement.

The interrelationship of the comprehension, description, and interpretation of movement are complex. An appropriate record of movement is not the only characteristic required for the dedicated reconstruction of movement to effectively communicate the style, context, and motivation of a dance work. Choreologists interpret notation scores based on individual understanding, experience, dance training, technique, and artistic judgement (Harrington, Delaney and Fox, 2001; Hutchinson Guest, 1984; R. J. Neagle, 2003). In this research, I focus on developing an appreciation and understanding of the diversity in which movement can be described, documented, and interpreted; rather than on the nature of its authenticity.

Understanding Movement

In view of the arguments outlined above, the debate continues in relation to whether notated movement should depict the practicalities of movement or encompass the concept and motivation underpinning it (Hutchinson Guest, 1984). Similar difficulties surrounding the representation of movement and its intention of providing a reference to the manner in which movement is, or should be, performed have yet to be determined (Hutchinson Guest, 1984). Divergent perceptions and analyses of movement provide a foundation upon which distinct aspects of motion can be scrutinised for their authenticity and aesthetic value.
This research sits within distinct parameters. It does not attempt to provide a solution to the authenticity of documenting movement. Rather, it takes into consideration that no two individuals will interpret, describe, or record movement in the same way. In assisting the precise grammatical record of movement, it is not the intent of this research to modify the symbolic language of dance notation. As an alternative, technology will be used to facilitate the accurate placement and construction of notation symbols on a score, so that movement may be preserved, documented, and interpreted with greater syntactic and grammatical precision. In allowing for greater precision in the authorship and interpretation of dance notation systems, in this sense, there is the potential to enhance dance literacy in the dance community, and safeguard the accurate preservation of valuable cultural archives. For the purpose of this research, the method of scientific movement observation and analysis provided by Hutchinson Guest (1984) is adopted as a framework in which the documentation and interpretation of movement is understood. This involves the use of movement notation systems to facilitate a symbolic description of movement.

**Movement Notation Systems**

Hutchinson Guest (1984) tells us that dance notation systems enable a symbolic representation of movement to be documented. This is achieved by providing recognisable signs on paper for individual analysis and interpretation. The signs are comparable to the use of music notation for musicians and the written word for drama (Hutchinson Guest, 1984). If we accept Hutchinson Guest’s (1984) definition of notation systems, then we can acknowledge the range of benefits in writing, recording, and viewing movement; particularly in the description and preservation of dance. An in-depth study of these languages is provided by Hutchinson Guest (1984, p. 203).

Notation systems permit varying degrees of detail to be captured in the documentation of movement (Hutchinson Guest, 1984). This is achieved by recognising the vital aspects of motion, and evaluating their role in the preservation of movement to facilitate its reconstruction (Hutchinson Guest, 1984). It relies upon elements of body part, location, direction, weight transference, style, duration, and dynamics to be recorded accurately (Hutchinson Guest, 1977, 1984; Knust, 1979). A comparison can be drawn between the technique notators use to identify and record key elements of action, and
the key poses of action traditional animators record as “key-frames” to generate animated movement (Calvert et al., 2002; Hutchinson Guest, 1984; Lasseter, 1994). A general description of implicit movement allows for the reconstruction of dance works from notation scores, giving a performer greater autonomy in the interpretation and expression of their performance (Hutchinson Guest, 1977). For a choreographer’s intent to be explicitly represented and communicated, a precise record of movement is required for the study of movement analysis (Hutchinson Guest, 1984).

Difficulties associated with the complexity of movement and the practical use of notation systems are further complicated by these systems’ capacity to accommodate a comprehensive range of human movement that extends from simple to complex symbolic representations of movement (Calvert and Chapman, 1978; Calvert et al., 1980; Lansdown, 1995; Singh et al., 1983). Generally, each system consists of a rigorous lexicon of symbols. These lexicons require a thorough understanding of each system’s detailed orthography to ensure that a precise account of movement is documented correctly (Herbison-Evans, 2003). Similarities can be drawn between the correct use of grammar and linguistics in verbal communication, and the arrangement of symbolic movement (Brown & Smoliar, 1976; Calvert et al., 2002; Hutchinson Guest, 1977, 1984). Hutchinson Guest (1977, p. 19) illustrates the correspondence of movement to a linguistic form in a Movement Family Tree (see also Chapter Seven, “Mapping Interface Objects and Actions”). The structure and visual representation of notation systems becomes significant in maintaining a logical discourse in the comprehension and composition of movement. Hutchinson Guest (1984) claims that an effective use of semiotic and linguistic communication simplifies the interpretation of notation. This means that the proficiency of a system to symbolically represent a structured account of movement contributes to the capacity in which it successfully communicates and translates knowledge or meaning. Whether this can be attributed to the semiotic value of a system is considered further in Chapter One, “Symbolic Communication” and Chapter Two, “Visual Representation.” A method of description comparable to the grammatical structure of words and sentences allows for a sufficient level of expression with regard to the characteristics of movement description. Such a method allows for an association between the object of movement and its action to form a logical relationship with each other, and in the context of a complete sequence of movements (Hutchinson Guest, 1977, 1984). A solution to this based on the linguistic
structure of notation systems may also be used within dance notation applications to support efficient methods of assistance in the documentation of movement.

A broad range of symbolic notation systems has been developed for the analysis of, or description of, movement in a number of disciplines such as personal assessment, interpersonal communication, dance, clinical medicine, animation, anthropology, physiotherapy, psychotherapy, athletics, movement-centred interactivity, and industrial time and motion study (N. Badler, Chi, Costa, and Zhao, 2000; The Benesh Institute, 2007; Bishko, 2005; Calvert and Chapman, 1978; Calvert et al., 1980; The Dance Notation Bureau, 2008; Jensen, 2005; The Labanotation Institute, 2007; Loke, Larssen, and Robertson, 2005). An overview of various notation systems and their association to specific areas of application are illustrated in Figure 4. Notation Systems in Fields of Application.

A Comprehensive System

Notation systems are designed in relation to the needs and requirements of a particular field. These target a distinct function, as defined by the designers of such systems, that interpret and understand movement in a specific context (Hutchinson Guest, 1984, 1989). This is exemplified by the characteristics of the “Beauchamps-Feuillet” notation system that was designed specifically to record the ornate style of baroque dancing (Barbacci, 2002; Pierce, 1998; Wilson, 2003). With such a definite purpose for its creation, the exclusive nature of this highly stylised form of notation renders itself useful only to its own precise context.

Notation systems have now developed beyond the original intent of their design functions (Hutchinson Guest, 1989). This is because of an increasing awareness surrounding the need for alternative descriptions of movement (Hutchinson Guest, 1989). Research that investigates a range of movement notation languages is illustrated in Figure 4. Notation Systems in Fields of Application. This data demonstrates that each language is beneficial to an extensive range of disciplines. The ability of notation languages to be used either generally or specifically further highlights the capacity of a language to encompass a comprehensive description of movement or remain specific to
### Notation Systems

<table>
<thead>
<tr>
<th>Notation Systems</th>
<th>- Fields of Application</th>
<th>Relevant Disciplines</th>
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<tbody>
<tr>
<td><strong>Benesh Notation</strong></td>
<td>- Tennis</td>
<td>- Theory</td>
</tr>
<tr>
<td><strong>FASR-System</strong></td>
<td>- Karate</td>
<td>- Aesthetics</td>
</tr>
<tr>
<td><strong>The Absolute Kinegraphic Notation System (AKNS)</strong></td>
<td>- Ice Skating</td>
<td>- Early Dance</td>
</tr>
<tr>
<td><strong>Laban Notation</strong></td>
<td>- Football</td>
<td>- Critique of Dance</td>
</tr>
<tr>
<td><strong>Morris Dance Notation</strong></td>
<td>- Basketball</td>
<td>- Dance Research</td>
</tr>
<tr>
<td><strong>Sutton Dance Writing</strong></td>
<td>- Baseball</td>
<td>- Record &amp; View Choreography</td>
</tr>
<tr>
<td><strong>Sutton Sign Writing</strong></td>
<td>- Gymnastics</td>
<td>- Computer Assisted Instruction</td>
</tr>
<tr>
<td><strong>Eshkol - Wachman Movement Notation</strong></td>
<td>- Players &amp; Coaches</td>
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<td><strong>LOD</strong></td>
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<tr>
<td><strong>Kestenberg Movement Profile</strong></td>
<td>- Tennis</td>
<td>- Dance Technology</td>
</tr>
<tr>
<td><strong>HamNoSys</strong></td>
<td>- Karate</td>
<td>- Record &amp; View Choreography</td>
</tr>
</tbody>
</table>

### Key

- **Animation**
  - Expressive Character Acting
- **Computation**
  - Robotics
  - CAD/CAM
  - Virtual Reality
- **Human Modeling & Simulation**
  - Training
  - Engineering Evaluations
  - Ergonomic Evaluations
  - Performance Analysis
  - Human Factors
- **Linguistic Analysis**
  - Sign Language Machine Gesture
  - Sign Language Dictionaries
  - Sign Writing
  - Sign Synthesis/Animation
  - Sign Language Recognition
- **Psychobiology**
  - Animal Behavior
  - Animal Movement
  - Brain Research
  - Animal Morphology
- **Psychology**
  - Animal Behavior
  - Animal Movement
  - Brain Research
  - Animal Morphology

### Figure 4

*Notation Systems in Fields of Application*
a single purpose. This is an example of the restrictions on the use and actual capacity of notation languages, especially when compared to the ability of the Beauchamps-Feuillet notation system to effectively describe a range of movement beyond the capacity of its original intent. Laurel (1993, pp. 156–157) informs us that:

The nature of the task and the form of the representation presented to people can serve to constrain the intentionality and physical characteristics of the gestures that they are likely to employ.

The range of movement possible within a particular dance form, then, becomes stereotypical to its context. This is because of a rigid offering of symbolic description. While systems of this nature appear beneficial for maintaining high levels of accuracy, they neglect the capacity to foster the development of contemporary movement appropriately. Once we begin to consider the function of notation languages outside of the context of the specific field they were designed to facilitate; as a foreign instrument, their ability to communicate to a wider audience is challenged (Buxton in Laurel, 1993). This demonstrates a necessity for notation systems to encompass a broad perspective of movement in their symbolic description. For that reason, notation systems need to be far-reaching in their capacity to communicate.

The design of a universal vocabulary to record implicit and explicit movement is necessitated by the potential benefits in which a system of communication may facilitate a direct representation of the form and quality of movement outside the confines of context-specific motion (Laurel, 1993). Similarities can be made between the development of sign notation systems and movement notation systems. Miller (2002b) tells us that derivatives of various sign notation languages have resulted in the prevalent use of the “HamNoSys” (Bentele, 2007) and “Stokoe Notation” (J. Martin, 2007) systems. Lack of a universal language, which would be necessary to assist the explicit representation of gestural movement, predicates the call for a standardised sign notation system (Miller, 2002b). An attempt to provide the deaf community with a universal form of notation was made by Delsarte (Laurel, 1993) in the nineteenth century, which also was the original intent behind the design of the HamNoSys (Miller, 2002a) system. Analogous with the design of dance notation, sign languages are
developed exclusively for specific use within communities, and are not universal in their application (Nakamura, 1995).

Dance is inherently stylised and requires a system of documentation that allows for the analysis of movement within a specific field. The absence of a universally applied system to document movement necessitates the investigation of symbolic languages that cater to a comprehensive representation of movement (Hutchinson Guest, 1977; Singh et al., 1983; Thomas, 2003; Wang, 2004). The derivation of sign notation systems, as stated above, illustrates the consequential use of two central notation systems within the deaf community. Uncertainty remains as to the success that a synthesis of existing dance notation languages may have to be utilised to create a universal dance notation system. Hutchinson Guest (1984) maintains that through the practical application of notation systems the capacity for use will be revealed. Practicalities surrounding the exclusive use of notation systems to a specific need or group of individuals may perpetuate a situation in which a universal language is less desirable (Hutchinson Guest, 1984). The purpose of this investigation does not attempt to lay claim to a notation system for universal application. Rather, the evaluation of existing notation systems works to identify the most appropriate system to meet the purposes of this research. The evaluation of existing notation systems is the basis for identifying a system capable of encompassing a broad range of movement disciplines that enables a level of precision in its vocabulary; equivalent to a system designed for explicit use. This provides the potential for notation applications to employ the use of a comprehensive notation system that facilitates a wide application of movement analysis. It also offers an opportunity in which the findings of this research may be applied beyond that of the dance community. In order to achieve this, it is necessary to investigate a comprehensive range of movement notation languages that extend beyond the confines of dance (Hutchinson Guest, 1984). For the purposes of this research, the capacity in which notation systems enable a critical analysis of movement concepts becomes significant in supplying the dance community with a means to develop dance literacy.

The characteristics of a comprehensive notation language can be recognised in the dominant practise of the Labanotation and “Eshkol-Wachman Movement Notation” (EW) systems, as illustrated earlier in Figure 4. Notation Systems in Fields of Application. These notation languages highlight a generalised structure of their design,
which allows them to sustain various needs across a wide range of disciplines (Calvert and Chapman, 1978; Calvert et al., 1980). Three dance notation systems noted for their ability to encapsulate various styles of dance movement are Benesh, Labanotation, and EW (Lansdown, 1995). Each was created for the notation of dance. Benesh and Labanotation currently enjoy wide use; however, the EW system finds greater application in scientific research (Faulkes, 1998). This is because of its mathematical structure, which offers the user a choice in its unit of measurement. An analysis of these notation systems illustrates their diversity for a distinct use or broad application. Moreover, these languages are the three most commonly used and widely established dance notation systems (Herbison-Evans, 2003; Hutchinson Guest, 1984; Lansdown, 1995; R. J. Neagle and Ng, 2003; R. J. Neagle et al., 2004; Singh et al., 1983).

**Visual Representation**

Notation languages are symbolic languages. The method in which these symbols represent information visually is relevant to the success in which they communicate. The visual and descriptive capacity of notation systems to provide an unambiguous association to a detailed description of movement that is both visually aesthetic and easily interpreted is difficult. This is because symbols do not explicitly represent the objects they depict. In relation to their semiotic value, Krippendorff (2006b) tells us that signs or symbols are established by the conditions or conventions of their use; rather than a consideration for their ability to be meaningful or useful to users of such systems. I argue that this determines the capacity for which notation systems can provide an understanding of the movement they represent. Dictated by the rules and conventions of a specific language or notation system, the aesthetic value of abstract languages such as Labanotation are regarded as secondary to the concern for their functionality and kinetic content (Barbacci, 2002). This, in turn, affects the accessibility and subsequent usability of such systems by an unassuming community of participants. This is important because it represents a fundamental issue of design which concerns the transfer of semantics to imagery (Barthes, 1977).

The identification and interpretation of symbolic writing systems by a community of participants that engage in the practise of disseminating knowledge via such systems, is central to their use and practical application. This is because without an understanding
of the information various signs and symbols of a system communicate, there is less potential for their use. While technology has removed the necessity to write notation scores (Hutchinson Guest, 1984; Venable, 2005), visual aspects concerning the representation and interpretation of dimension and perspective remain vital to the symbolic efficiency of notation systems (Hutchinson Guest, 1989). Barbacci (2002) tells us that fundamental characteristics of notation systems are designed to provide varying methods of movement analysis, symbolic representation, or levels of description. Depicting movement by distinct forms of visual representation achieves this variance in the function of notation systems. Specific types of notation systems are identified by the manner in which they describe movement. Stick figure (Hutchinson Guest, 1989, p. 35), music note (Hutchinson Guest, 1989, p. 79), or abstract symbols (Hutchinson Guest, 1989, p. 119) are the means through which movement is described and symbolically represented (Hutchinson Guest, 1989). Each type of notation system is acknowledged for its benefits to a specific purpose.

Stick figure systems indicate movement by way of pictorial figure drawings (Hutchinson Guest, 1989). They provide an impression of motion that is immediately understood for their aesthetic resemblance to the human form (Hutchinson Guest, 1989). Through the symbolic use of abstract signs; elements of body, direction, time, and force are arranged to describe and represent movement (Hutchinson Guest, 1989). Generally, systems that make use of abstract symbols allow for a rigorous description of movement (Hutchinson Guest, 1989). However, the ability to discern the movement they represent is a highly ambiguous activity. This is due to their level of abstraction and, because of this, the capacity to describe a comprehensive range of movements at a conceptual level. The apparent contradiction in terms gives emphasis to the difficulties concerning the description and interpretation of movement in a consistent and reproducible form. This is with particular reference to the rigour in which movement is documented and the potential for difference in the individual interpretation of its symbolic representation. By comparison, music notation has been adapted by music note systems to signify the timing and position of movement as opposed to pitch (Hutchinson Guest, 1989; Singh et al., 1983). Because of this, the ability to capture complex variations in time and space means that music note systems are too rigid for the notation of movement (Hutchinson Guest, 2005a).
It is useful to consider the visual characteristics of these languages in relation to their ability to convey movement aesthetically; particularly in practical use situations where it may be possible to gain a basic understanding of the movement a system signifies, without knowledge of its conventions or performing an exhaustive analysis of the language. A specific style of symbolic representation could work as a constructive element that assists the formation of meaningful associations to the movement it represents for users of its language. Hutchinson Guest (1984) tells us that the visual appeal of a system contributes significantly to its ability to communicate with its intended audience. In light of this, it is possible to appreciate the propensity to supply dancers with immediate modes of visual representation through stick figure systems. Examining the propensity in which symbolic notation systems have the capacity to communicate various aspects of dance knowledge becomes significant in this research when facilitating the use of a system that has the potential to offer the dance community an accessible means of reading, writing, and interpreting movement.

**Evaluative Method of Notation Systems**

In order to conduct a proficient, comparative analysis of notation systems, the degree to which notation systems function to provide an efficient and logical framework to establish an appropriate discourse in the composition of movement needs to be defined. Hutchinson Guest (1984) provides us with an extensive model for the evaluation of notation systems. This establishes a basis upon which each criterion was adapted to stipulate a distinct condition.

Fundamental to the method used in this evaluation is the design of a systematic approach for identifying a notation system that enables an appropriate description and representation of movement suitable for computation. To date, an in-depth comparative analysis of the existing eighty-five or more movement notation systems has not been formally undertaken (Hutchinson Guest, 1984). The nature of this research and its specific focus on notation systems that may be used by the dance community for the purposes of education, scholarship, and research does not attempt to provide a rigorous evaluation of a broad range of systems. As Hutchinson Guest (1984) suggests, the following method of evaluation that I designed offers a comparative evaluation with
other systems that focuses on the strengths and weaknesses found in Benesh, Labanotation, and EW.

In this evaluation, I consider key aspects of the structure, representation, and measure (timing) of movement as fundamental elements in the identification of a comprehensive movement notation system. My definition of these criteria offers a framework for the comparative analysis of each system to be documented. This allows the extent of their value, use, and possible outcomes to be exhibited.

The following criteria illustrate the degree to which each notation system is required to operate to demonstrate capabilities for its use. They are required to:

1. Encompass a comprehensive range of human movement that is both flexible in its application and detailed in its description;
2. Embody a structure suitable for computation;
3. Allow for the analysis of movement concepts to a degree suitable for the education, research, and theory of movement;
4. Provide timely visual communication of movement through symbolic representation;
5. Effectively represent three-dimensional direction within a spatial context; and,
6. Provide a reference for complex rhythm.

Movement notation systems that facilitate a record of movement play a significant role in determining the extent and ease in which an extensive range of movement can be accurately documented. Each system under review provides various strengths and weaknesses in its ability to capture and represent movement concepts. As a result, it is necessary to examine the unique aspects each system offers in the documentation and representation of movement to reach a suitable outcome. The above criteria characterise the visual, symbolic, spatial, and structural aspects of notation systems needed to facilitate the analysis of movement. When these criteria are applied, they provide evidence of a notation system’s capacity to meet them.

These criteria are applied to the examination of the following movement notation systems:
- Benesh
- Labanotation
- EW.

Mapping notation systems that are extensive when applied in the description of movement against the above criteria establishes a method of analysis that I address in the examination of each notation system.

**Benesh Movement Notation**

Benesh, devised by Joan and Rudolf Benesh, takes the visual representation of movement as its primary concern (Damle, 2002). (See Figure 5. Benesh Movement Notation Score for a visual representation of Benesh.) A five-line musical staff provides a two-dimensional reference of movement that distinguishes elements of the body through the positioning of pictorial symbols. Three-dimensional spatial coordinates are indicated with the addition of symbolic modifiers (Hutchinson Guest, 1989; Singh et al., 1983). A Benesh score describes movement as it is observed when standing behind a performer. This enables movement to be easily interpreted from the perspective of the reader, and provides a viewer with an immediate representation of movement and time (Hutchinson Guest, 1989). Benesh was specifically designed to indicate rhythm for dancers who react to the pulse of music rather than notes (Damle, 2002). A time signature and tempo are indicated at the beginning of the staff, with additional rhythmic symbols positioned above for the identification of beats (Hutchinson Guest, 1989; R. J. Neagle, Ng, and Ruddle, 2002).

![Benesh Movement Notation Score](http://web.archive.org/web/20070311051028/http://www.benesh.org/frames.html)

**Figure 5.** Benesh Movement Notation Score
Benesh was originally devised to record all forms of movement (Hutchinson Guest, 1984). However, it has identified a greater application in assisting with the description of movement within the rules and structure of classical ballet (Calvert and Chapman, 1978; Calvert et al., 1980; Hutchinson Guest, 1989; R. J. Neagle and Ng, 2003; Wang, 2004). These rules refer to the stylised nuances of movement and precise positioning of limbs necessary to achieve the visual aesthetic classical ballet demands. More recently, Benesh has evolved to accommodate a description of movement outside the stylistic confines of classical ballet (Wang, 2004). Hutchinson Guest (1989) notes the difficulties associated with the use of visual notation systems by telling us that documenting a dancer’s key visual positions does not effectively capture a description of movement. Abstract movements then become problematic for a notator to capture in a pictorial form. In so doing, it distorts the original intent of movement (Hutchinson Guest, 1989). This suggests that Benesh remains restrictive in its ability to provide a comprehensive range of movement (Hutchinson Guest, 1989; Lansdown, 1995; Wang, 2004).

The design of Benesh allows for a concise description of movement that works on a principle of redundancy avoidance. This involves the elimination of excess symbolic descriptions beneficial to the timely composition and visual interpretation of Benesh scores. However, the omission of a detailed and precise description of movement opens itself up to ambiguity and becomes a problem in the analysis of movement (Hutchinson Guest, 1989). With an emphasis placed on the simplification of movement descriptions, visual notation systems fail to provide necessary movement concepts such as motivation or dynamics to be successfully recorded for movement analysis (Hutchinson Guest, 1989). Given these shortcomings, current dance notation editors MacBenesh (R. Ryman, 1999) and “Benesh Movement Notation Editor” (R. Ryman, Singh, Beatty, and Booth, 1984; Singh et al., 1983) are still able to demonstrate the successful application of Benesh within a digital environment. Furthermore, Lansdown (1995) and Singh et al. (1983) make reference to collaborative and individual developments made by Politis and Herbison-Evans that endeavour to simplify the translation of computer models for animation through the use of Benesh.
**Labanotation**

Created by Rudolf Laban in 1928, Labanotation is documented on a vertical staff, and is read from bottom to top (Hutchinson Guest, 1984). In a similar style to that of Benesh, a Labanotation score presents a description of movement from the rear view of a performer. (See Figure 6. Labanotation Score for a visual representation of Labanotation.) A Labanotation staff is made up of three lines that are divided by a centre line to indicate the left and right side of the body (Hutchinson Guest, 1984). This provides a symmetrical representation of the body in which each column of the staff is reserved for a specific body part (Hutchinson Guest, 1984). Information pertaining to time, direction, level, and body part are contained within a single Labanotation symbol (Barbacci, 2002). This is illustrated by the particular shape, shading, and size of each symbol. Hutchinson Guest (1989) tells us that such an economy of information cannot be found in other notation systems. Labanotation represents the duration of movement through the length of its symbols that is proportional to the time it takes to perform (Hutchinson Guest, 1989). The design of a system that embodies elements of time in this manner eliminates the need for a visual reference to a musical score alongside the movement notation (Hutchinson Guest, 1989).

![Figure 6. Labanotation Score](image-url)
Labanotation caters to a broad range of research and analysis across movement-based disciplines (Hutchinson Guest, 1989). It enables a degree of flexibility that accommodates varying levels of description because of the underlying structure, movement principles, and attributes of the system. These attributes provide researchers with the vocabulary and the analytical framework necessary to describe movement (Badler, Chi, Costa, and Zhao, 2000). Dance educationalists (Blum, 1999; Curran, 2001, 2005; Hackeny, 2005; Harrington Delaney, 1999; Hutchinson Guest, 1977, 2005b; Fox in Wang, 2004) tell us that commonalities between Labanotation, “Laban Movement Analysis” (LMA), and Motif Description provide significant benefits for the education and development of dance literacy. I will draw upon these suggested benefits because of the association between the three languages. Literature from the above-mentioned dance educationalists tell us that an understanding of Motif Description provides a foundation for learning Labanotation; while an understanding of LMA principles can enhance the use and application of both systems.

Research that I have undertaken to examine existing notation applications (see Figure 7. Notation Applications) illustrates various types of notation languages that form a direct relationship to the development of computer software and notation applications. It highlights Labanotation as a language that is frequently used to develop existing notation applications. Similarity, Singh et al. (1983) have found that Labanotation has repeatedly been used as a means to interpret movement. However, this comprehensive facility of Labanotation poses distinct challenges in the learning of its extensive range of symbols, when compared to other systems (Yasuda, 2001). This is because of the broad vocabulary and number of symbols that Labanotation uses to define motion (Sternberg and Essa, 2002). Hutchinson Guest (1977) tells us that information portrayed by notation symbols that allow for the research and analysis of movement require abstraction. This means that abstract notation systems, such as Labanotation, are criticised for their ability to perform as a visual language in the immediate documentation and interpretation of movement (Hutchinson Guest, 1984, 1989; Yasuda, 2001).
### Figure 7. Notation Applications

<table>
<thead>
<tr>
<th>Year</th>
<th>Notation</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>Benesh Notation</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
<tr>
<td>1980</td>
<td>Eshkol - Wachman Movement Notation</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
<tr>
<td>1928</td>
<td>Laban Notation</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
<tr>
<td>1997</td>
<td>Morris Dance Notation</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
<tr>
<td>1980’s</td>
<td>FASR-System</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
<tr>
<td>1979</td>
<td>Kestenberg Movement Profile</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
<tr>
<td>1973</td>
<td>Sutton Sign Writing</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
<tr>
<td>1993</td>
<td>EW Notator</td>
<td>Windows, Macintosh, and Platform Unknown</td>
</tr>
</tbody>
</table>

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**Notation Languages**

- Laban Notation
- Benesh Notation
- Sutton Sign Writing
- Kestenberg Movement Profile
- Eshkol - Wachman Movement Notation
- FASR-System
- HamNoSys
- Morris Dance Notation

**Notation Applications**

- LabanWriter
- LabanDancer
- LabanReader
- LabanEditor
- MacBenesh
- Benesh Notation Editor
- SignWriter & SignWriter Tiger
- EW Notator
- DANCER
- STRIKMAN
- HamNoSys
- KeStenberg Movement Profile Analysis Program
- Dance Pattern Database
- Morris Dance

**Multimedia Applications**

- Labanary
- Limeight
- LED & Linter
- Calaban
- Macintosh
- LabanWriter
- LabanDancer
- LabanReader
- LabanEditor
- MacBenesh
- SignWriter & SignWriter Tiger
- EW Notator
- DANCER
- STRIKMAN
- HamNoSys
- KeStenberg Movement Profile Analysis Program
- Dance Pattern Database
- Morris Dance

- Limelight
- LED & Linter
- Calaban
- Macintosh
- LabanWriter
- LabanDancer
- LabanReader
- LabanEditor
- MacBenesh
- SignWriter & SignWriter Tiger
- EW Notator
- DANCER
- STRIKMAN
- HamNoSys
- KeStenberg Movement Profile Analysis Program
- Dance Pattern Database
- Morris Dance

**Notation Based Applications**

- Labanary
- Limeight
- LED & Linter
- Calaban
- Macintosh
- LabanWriter
- LabanDancer
- LabanReader
- LabanEditor
- MacBenesh
- SignWriter & SignWriter Tiger
- EW Notator
- DANCER
- STRIKMAN
- HamNoSys
- KeStenberg Movement Profile Analysis Program
- Dance Pattern Database
- Morris Dance

**Dance Technology**

- Emote
- Web 3D Dance
- danceCODES 1.2
- The Artificial Suite
- SpacePlaceGuide 3.0
- Interactive Design Project
- LabanLab
- Alliance of Dance Notation Educators

**Multimedia Applications**

- The Artificial Suite
- SpacePlaceGuide 3.0
- Interactive Design Project
- LabanLab
- Alliance of Dance Notation Educators

**Notation Based Applications**

- Labanary
- Limeight
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**Dance Technology**

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Eshkol-Wachman Movement Notation

The EW system developed by Noa Eshkol and Abraham Wachmann is based on mathematical logic that brings a scientific approach to the documentation of movement (Hutchinson Guest, 1984). (See Figure 8. Eshkol-Wachman Movement Notation Score for a visual representation of EW.) Designed to encapsulate all forms of movement, it describes movement in anatomical terms (Faulkes, 1998; Hutchinson Guest, 1984, 1989). It takes the circular movement of the joints of the body as fundamental to the description of motion. This allows for movement to be defined by spatial coordinates (see Hutchinson Guest, 1989, p. 189). Movement is then interpreted by reading an initial starting pose, its time structure, the direction and degree of motion, and the final position (Faulkes, 1998). Two numerical coordinates represent the position and destination of movement (Faulkes, 1998; Hutchinson Guest, 1984).

\[
\begin{array}{c|c|c}
\text{Hand} & (0,0) & \text{ } \\
\text{Lower Arm} & (0,0) & \text{ } \\
\text{Right Arm} & (0,0) & 1 \downarrow \leftarrow (2,2) \\
\end{array}
\]


Figure 8. Eshkol-Wachman Movement Notation Score

Movements are represented on horizontal staffs that are read from left to right. These staffs are divided into clearly defined segments positioned from the top to the bottom of a score. A written indication of a particular body part provides a context for the description of movement. However, the use of numbers to signify these elements does not allow for a symmetrical representation of the body in its division among the staffs (Hutchinson Guest, 1984). As in music, units of time in EW are indicated by the placement of double vertical lines at set intervals along a score (Faulkes, 1998; Hutchinson Guest, 1984).
EW enables a flexible description of movement. It has the capacity to amend the standard measure of time and movement displacement (Hutchinson Guest, 1984, 1989), which allows it to capture complex variations in space and time. The system offers an extensive range of specialisation and generalisation in its facility to describe all forms of movement (Faulkes, 1998; Hutchinson Guest, 1989). Its primary concern is the shape of movements that illustrate an objective account of motion and its destination from a mathematical perspective (Hutchinson Guest, 1984, 1989). In its description of movement, however, it does not consider the stylistic nuances or dynamics of human movement (Faulkes, 1998; Hutchinson Guest, 1984).

The conceptual shift required to interpret numbers to physical motion is challenging in comparison with visual notation systems. Sternberg and Essa (2002) argue that a minimum of training is required to assist the accurate definition of movement because of its visual simplicity. The contrast between these arguments suggests that, while EW does not provide a qualitative description of movement, it demonstrates a high level of compatibility with the scientific description of movement. In providing a description of movement that defines movement by limb angles and spatial coordinates, it shares commonalities relevant to the method in which computer representations decode spatial coordinates. This highlights the suitability of EW as a language for computation. This is further evidenced by the existing notation application “EW Notator” (Drewes, 2007). Furthermore, EW has been used as a basis to facilitate the control of movement in computer animation because of its high level of representation and compatibility with computation (Sternberg and Essa, 2002).

**Research Findings**

Researchers with expert knowledge of specific notation systems are equipped to conduct a comparative analysis of these systems (Hutchinson Guest, 1984). Literature (Hutchinson Guest, 1977, 1984, 1989) that provides information specific to the systems under review has made the comparative analysis of Benesh, Labanotation, and EW possible. A comparative analysis of the systems mapped against the criteria I specified in the “Evaluative Method of Notation Systems” above demonstrates that Labanotation is most successful in meeting three of the six criteria (see Table 1. Movement Notation Evaluation). This is further confirmed by its capacity to provide a comprehensive
Table 1. Movement Notation Evaluation

account of movement required for analysis, and the ability to reference complex time structures (Hutchinson Guest, 2005a).

One of the evaluation criteria’s key objectives listed above in the “Evaluative Method of Notation Systems” was to establish the accuracy in which the systems provide a description of movement, and its suitability for computation. In conjunction with these criteria, the ability of a system to communicate easily through its symbolic representation was essential to the elucidation of information. The extensive application of Benesh to classical ballet means that the dance community has a language in which the visual representation of movement is easily communicated and understood. However, this is achieved at the cost of a detailed record of movement (Barbacci, 2002). Visual notation systems based on an impression of movement do not allow for the analysis of that movement (Hutchinson Guest, 1989). While visual systems appear advantageous to the immediate clarification of movement, knowledge of these systems
and their style of representation remain crucial to their interpretation (Hutchinson Guest, 1984). Abstract notation systems such as EW offer a precise record of movement at the cost of immediate forms of visual interpretation (Barbacci, 2002). The issues concerning the documentation of abstract movement are indeed contentious. This is because notation systems represent movement differently and are bound by the particular rules and conventions of a language. It should therefore be noted that with each notation system there exists a number of trade-offs in which the capacity of a system can capture a comprehensive range of movement in a visually illustrative manner. In light of this, my research proceeds on the basis of a balance needing to be found between the visual representation of movement and the scientific approach to its description; to enable efficient methods of movement analysis.

Goodman (in Damle, 2002) tells us that the challenges associated with a symbolic representation of movement are exemplified in the differences between predominantly descriptive and pictorial notation systems. Interpreting the meaning of symbolic notation systems is fundamental to the outcome. Goodman (in Damle, 2002) argues that the significance of a system lies in the context in which a symbolic account of information is interpreted. This is in relation to the contextual positioning and interpretation of a system’s symbolic vocabulary; rather than assessing it at face value (Goodman in Damle, 2002). The relevance of this underpins the notion that a system which embodies higher levels of description within its symbolic structure is necessary for the analysis of movement. Research by Lansdown (1995) has found Benesh limiting in its vocabulary and its ability to successfully capture an expressive range of movement required for choreography, while the anatomical description of movement provided by EW is more suited to the specific focus of scientific analysis and computation (Hutchinson Guest, 1977; Sternberg and Essa, 2002). Comparative analysis of the Benesh, Labanotation, and EW systems by Reynolds (in Hutchinson Guest, 1984) has found that Labanotation provides greater accuracy than Benesh, and is more practical than EW. This provides us with a result that places greater emphasis on the practicable application of Labanotation.

This method of comparative analysis establishes Labanotation as a system that meets the requirements of the criteria stated in the “Evaluative Method of Notation Systems” above as being necessary within a digital environment. I argue that the meeting of these
criteria facilitates modes of assistance in the documentation, interpretation, and understanding of movement. It supplies the dance community with a language that offers a logical discourse in the description of movement, and allows for the analysis of movement across a broad range of disciplines.

Labanotation’s symbolic language illustrates the abstract representation of movement and the challenges it presents. Because of this, the identification of movement remains a concern (Hutchinson Guest, 1989; Yasuda, 2001). This creates considerable difficulties for beginners learning this system (Hutchinson Guest 1989; Yasuda 2001) because the notation itself it is not visually suggestive of the movement it describes. Research that has endeavoured to assist novice users in the comprehension of notation symbols has seen the development of ballet illustrations and ciphers as a means to complement the visual communication of this notation (Wilmer and Resende, 1998). As a response to the visual complexity of notation systems, Damle (2002) argues that enhancing the graphic design of these symbolic languages may not improve their ability to communicate visually. Hutchinson Guest (1984) and Damle (2002) advocate the training and education of users of these systems as a means to assist in their interpretation. This is because notation systems that provide a greater abstraction in their symbolic description require a greater depth of study than visual systems (Hutchinson Guest 1989). Therefore, it is necessary to recognise that abstract symbols must be learned in order to associate meaning with their symbolic representation and facilitate their use.

**Summary**

This research describes the intricacies involved in perceiving, interpreting, and describing movement. It discusses the issues surrounding the capacity in which notation systems can represent an unambiguous description of movement that are easily interpreted and suitable for movement analysis. The underlying structures of notation systems are also considered for their ability to supply a logical discourse in the comprehension and composition of movement. Accordingly, I have adopted a scientific framework for movement observation and analysis for the purposes of this research.
Through an explicit comparative analysis of three notation systems, I have shown that Labanotation enables the preservation of a comprehensive range of movement, and has the capacity to foster the development of contemporary dance. The outcome of the comparative analysis suggests that the structural makeup of Labanotation supports a logical discourse in the composition of movement that can be efficiently and effectively utilised for the computational documentation of movement. However, to extend the use of Labanotation to the wider dance community, concerns surrounding its usability need to be addressed. This indicates a need to facilitate the learning of Labanotation, and to devise an approach that renders the language more accessible to members of the dance community. It is therefore necessary to examine current technologies that enable a suitable level of accuracy in the description and visualisation of movement to assist this development. I turn my attention to this in Chapter Four.
The Application of Technology to Movement

The notation (Labanotation) is based on an agreed-upon form of moving, which I believe is misleading, Mark Morris said after his All Fours was staged from a score at Ohio State University last year: “It’s nearly impossible to accurately communicate dynamics and phrasing, although I grudgingly admit that it was a far better tool than I had anticipated.” (Sulcas, 2007)

Introduction

Significant work regarding the development of notation-based, computer-generated animation (N. I. Badler and Smoliar, 1979; Calvert et al., 1980; Lansdown, 1995) and movement notation systems (Hutchinson Guest, 1984, 1989) provide a number of references to literature that is still cited today. An examination of this early work allows an understanding of the fundamental issues emerging from these fields to be developed, and suggests their continued influence on the technical development of notation applications.

Throughout this chapter I draw on work by developed by Calvert (Calvert, Bruderlin, Mah, Schiphorst, & Welman, 1993; Calvert & Chapman, 1978; Calvert, Chapman, & Patla, 1980; Calvert, Coyle, & Maranan, 2002; Calvert, Fox, & Ryman, 2001; Calvert, Fox, Ryman, & Wilke, 2005; Calvert, Fox, Ryman, & Wilke, 2005a) and his various collaborators, to illustrate how the theoretical basis of existing knowledge supports the further development of dance notation applications. Again, my purpose in this chapter is not to provide a critical assessment of literature in the field or develop a novel evaluative methodology suited to the technology of dance notation applications. I undertake this research in order to develop a rationale that supports the development of the prototype application LabanAssist.

Existing computer applications rely heavily on the successful implementation of practical uses for technology. The level of ease in which technology records movement
to allow choreographers, choreologists, and dancers to capture and preserve the creative process is discussed. In this chapter, my main concern is with the function of technology used to develop dance notation applications. The choice and application of technology for the development of appropriate deliverables is essential. Notation applications must remain accessible to the dance community, while providing a comprehensive description and record of movement. The focus of this chapter is to ascertain if the use of notation-based animation derived from Labanotation is a suitable use of technology to record, edit, translate, and visualise movement in a digital environment.

I begin by investigating current technologies employed to describe and record movement. The functionality they provide in offering a suitable level of accuracy in the description of movement, and their accessibility to the dance community, are also evaluated. This involves the selection and definition of specific criteria to construct a means of evaluation to demonstrate the potential success in which each technology under review has when fulfilling its purpose. I argue that Labanotation is the most effective technology for providing a comprehensive description and record of movement.

This chapter also looks at technology that interprets and visualises movement. I examine methods involving the translation of movement from tangible and virtual records of movement. Records that emulate a representation of movement, and those that encapsulate the fundamental nature of motion, are also examined for their ability to supply a detailed representation of movement for its reconstruction. I design explicit evaluative criteria to provide a framework for this examination, and to demonstrate the capacity of each technology to provide evidence of its use.

In this evaluation, I argue that notation-based animation that utilises a description of movement provided by Labanotation has the potential to successfully facilitate the interpretation for the visualisation of movement. I discuss underlying concerns and the possible benefits associated with the accessibility and current practise of applications that make use of Labanotation.
The Application of Technology to the Documentation of Movement

The effective preservation of dance ensures the safeguarding and development of a culture’s heritage and identity. Modern technologies concerned with the computational processing of digital data, from one format to another, provide a means by which the documentation of movement can be captured, translated, and visualised in a digital form. Specifically designed computer systems follow a systematic process in the acceptance, analysis, and demonstration of motion data. This data is supplied by technology used to describe and capture movement. Fundamental to this process is an appropriate description of movement for computation. This is referred to as input data that is directly accepted by a system (Calvert in R. Ryman, 2001). Input data forms the basis upon which movement is then interpreted and translated by a system model to a usable form (Calvert in R. Ryman, 2001). Programmers create this system model or framework to efficiently interpret the input of data for its conversion (Calvert, Fox, and Ryman, 2001). The resulting data represents the initial description of movement once it has been translated. For prototype applications such as LabanDancer (Tom Calvert et al., 2005b) and computer applications such as DanceForms (Credo Interactive Inc, 2005a), the representation of translated data is demonstrated by means of a visual interface in the form of an animated figure. In this way, the description of movement becomes significant to its interpretation and visualisation in a digital environment.

Drawing on Dewey’s (1938) notion of technology as an art of production or the practical application of a technique for the purposes of problem-solving and inquiry, it is possible to view symbolic writing systems as a technology. Adopting a scientific method of movement observation and analysis in this research (see Chapter Two, “Understanding Movement”) means that the practical application of Labanotation as a technique to document and interpret dance knowledge can be considered a technology. Curran (2001) argues that the function dance notation serves in providing a practical means to an end can be understood as a technology.

Labanotation, motion capture, key-frame animation, and digital video are used within existing notation applications to describe and record motion data. The use of these technologies is identified in the variety of applications presented in Figure 9. Technologies in Application. Each of these categories consists of varying computer
**Figure 9. Technologies in Application**
applications (identified in Chapter Seven, “Notation Applications”) that make use of a particular technology or a combination of technologies designed to fulfil a specific function. While each application has a defined use, it is important to consider how effective the technologies they employ are in successfully achieving their objectives. It is necessary to examine and assess technologies that provide these functions when offering a comprehensive description and record of movement for the analysis or preservation of movement. In this examination, I consider the limitations of existing technologies in their ability to effectively describe and record movement within a specific context.

**Evaluative Method of Technology That Preserves Movement**

Before it is possible to identify a suitable use of technology, it is necessary to define an appropriate set of criteria to evaluate technologies that record and edit movement. It is central to this evaluation to construct a systematic approach to establish the extent in which an appropriate use of technology accurately records and edits movement. Using the literature available, (N. I. Badler and Smoliar, 1979; Calvert et al., 2002; T. Calvert et al., 2005; Furniss, 1999; M. Gleicher, 1999; K. Hachimura, Matsumoto, and Nakamura, 2005; R. Ryman, 2001; Venable, 2001b; Wang, 2004) I identify key aspects concerning the functionality, usability, and expediency of dance notation applications; and tailor these aspects to allow each criterion to specify a distinct condition. These criteria provide a sufficient framework to document the use and value of each technology. This has permitted a comparative analysis to determine a reasonable outcome.

The following criteria highlight the degree of functionality each of the investigated technologies is required to exhibit to demonstrate capabilities for its use. These uses include:

1. The ability to record the entire range of human movement at an appropriate level of accuracy allowing for the description of detailed nuances and stylistic movement;
2. A reasonably high level of flexibility and control during the editing process;
3. An appropriate ease of use in which nonexperts may operate the technology in question;
4. A relatively immediate approach to recording and editing movement;
5. Equipment that is easily used in a space where movement is usually performed and recorded;
6. Minimal storage space that allows for immediate transfers to remote locations; and,
7. Cost-effective provision to the dance community.

Technologies employed to record and edit movement play a fundamental role in determining the treatment and extent to which movement sequences are translated into digital form. Each technology under examination exhibits varying strengths and weaknesses in the method it employs to record and document movement. It is, therefore, necessary to closely examine the overall effects a technology may present in any given situation. The criteria as stated above highlight the efficiency and immediacy of a technology that acknowledges a need to remain user-friendly and economically viable to provide evidence of its overall suitability.

These criteria are applied to the examination of the following:

- Labanotation as it finds use in existing notation editors such as LabanWriter;
- Key-frame animation as it currently exists within the application DanceForms;
- Motion capture with an emphasis on the capturing of data; and,
- Digital video.

Mapping the technologies found in existing dance notation applications against the above criteria has established a method of analysis that I address throughout each technology under examination. I take a use of functionality that alleviates complex processes to facilitate the needs of the user as the measure of appropriateness for evaluation.
Labanotation

Before the advent of computer technology, dance notation systems were used to represent movement as signs on paper (Hutchinson Guest, 1984). Today, these notation systems operate within a digital environment in computer applications that facilitate the process of recording movement (Birmingham, 2001; Dance, 2008; K. Hachimura, Matsuoka, and Yoshida, 2002; Labanatory, 2007; LED and Linter, 2007; MacBenesh, 2003; R. Ryman et al., 1984). In this examination, Labanotation is evaluated within the context of a digital environment that finds use within the dance notation application LabanWriter.

Labanotation provides a technology that allows for a precise method for recording a wide range of human movements. Badler and Smoliar (1979) tell us that the semantic structure of Labanotation provides an explicit description of most human movement, and possesses the necessary capacity to facilitate more subtle variations of movement descriptions.

The comprehensive range of movement Labanotation offers in the description of dance underpins its function and proficiency as a technology to record movement. To utilise a technology with an expressive capacity of this measure requires a thorough understanding of movement analysis and an expert knowledge of its symbolic vocabulary (Hutchinson Guest, 1984).

Traditionally, the role of a choreologist trained in the use of dance notation systems is to translate symbolic representations of movement for dancers to interpret and perform (Hutchinson Guest, 1984). A choreologist is employed to observe and notate a number of dancer’s movements for the period of time allocated for the creation and/or rehearsals of a new work. A reliable source of reference material such as a rehearsal involving live performers is essential to facilitating a record of movement in Labanotation (Hutchinson Guest, 1984). Should a rehearsal schedule be shortened, or a reliable source of reference material no longer is available, the ability of a choreologist to record movement using Labanotation would no longer be viable.
The nature of composing a score in Labanotation is a timely process that is relative to the complexity of the range of movement being described (Hutchinson Guest, 1984). Despite dance notation applications such as LabanWriter that no longer make it necessary to write its symbolic language, a solid knowledge of the practise of Labanotation still is needed to maximise its potential. The complexity of notating dance in Labanotation can be attributed to its nonintuitive symbolic representation of movement (Kahol, Tripathi, and Panchanathan, 2005). This suggests that a level more advanced than that defined by the evaluation criteria is required to facilitate the composition of Labanotation. This a fundamental concern regarding the accessibility and current practise of Labanotation.

The function of Labanotation, as found in existing dance notation applications, allows for an efficient means to record and edit notation. This permits the production of relatively small data files that may be easily accessed and digitally transferred to a location accessible via the Internet. The ability to archive files in a digital format ensures the preservation of data that may be printed and produced in a tangible form. Currently, the dance notation editor LabanWriter is available to users as a free application. This means that this particular notation editor is a cost-effective solution for members of the dance community who have access to personal computers.

**Motion Capture**

With an emphasis on capturing data, motion capture systems provide an accurate account of realistic human movement (Bregler, Loeb, Chuang, and Deshpande, 2002; Michael Gleicher and Ferrier, 2002; K. Hachimura et al., 2005). This involves the recording of a sensor or marker’s point of reference during a sequence of movement. These sensors are usually attached to the human body where the recorded information, garnered as a result of this process, is translated to a computer-usable data format. Four methods exist in the motion capture process: (1) mechanical, (2) electromagnetic, (3) optical, and (4) video-based. Each of these processes provides varying degrees and amounts of accuracy in their ability to efficiently and accurately capture motion.

Mechanical motion capture uses an exoskeleton suit made up of metallic pieces to track and measure information from joint angles, and locates the position of limbs as a
performer moves. A disadvantage of this technique is its inability to supply ground plane calculations or to calculate movements that disconnect from it should a performer become airborne through a sequence of jumps (Furniss, 1999). Without the assistance of additional sensors, an exact directional position of the performer is unattainable (Furniss, 1999). Limits to the range of measurement devices; restrictions in the range of movement achievable by a performer; and the instability of an exoskeleton suit contribute to data errors and the loss of expressive movement (de Aguiar, 2003).

Electromagnetic techniques offer the absolute positioning of motion data in a near real-time environment, making this option an immediate and accurate solution for capturing movement (de Aguiar, 2003). This is made possible by the use of a fixed transmitter that tracks the movement of magnetic sensors covering the body of a mobile performer. The quality of resulting motion data may become distorted and unclear if the distance from the magnetic transmitter is too great. While this is the preferred technique for performance animation (M. Gleicher, 1999), it is highly susceptible to interference from surrounding magnetic fields, and may require the use of a specially built stage (de Aguiar, 2003; Furniss, 1999).

Optical motion capture employs the use of multiple cameras to record points and varying perspectives of motion garnered from reflective markers worn by a performer. Captured information from each camera undergoes a cleaning process to render the files usable for computation, and requires further processing time to provide the resulting data in a 3D format. This a lengthy process, and can result in the production of an inaccurate record of motion data from occlusion or the overlapping of markers during the capturing process (de Aguiar, 2003; Furniss, 1999; M. Gleicher, 1999).

Video-based motion capture offers the potential to capture movement data from digital video material without the expense and intrusion experienced by the above techniques (Michael Gleicher and Ferrier, 2002). While initial research in this area has progressed, the development of video-based motion capture and its performance in animation applications has yet to reach a satisfactory standard (Michael Gleicher and Ferrier, 2002; Zillner, Gelautz, and Kallinger, 2002).
To provide a definitive record of movement for preservation, motion-capture data requires further adjustment by a choreographer or notator (Calvert et al., 2002; R. Ryman, 2001; Wang, 2004). The editing of captured data presents a number of difficulties when reading, identifying, and implementing changes to complex information (Michael Gleicher and Ferrier, 2002). The volume of acquired motion data is relevant in file size to the amount of detailed motion that is recorded. Large data files become a problem in relation to the efficient transfer of information. Concerns about accessibility, usability, cost, and the expediency of motion capture as a technique to record movement at present outweigh the significant benefits it holds for capturing detailed human movement.

**Digital Video**

Digital video offers an immediate and viable solution for the recording and archiving of dance works (Windreich, 2002). The technology and equipment is cost-effective, convenient, and accessible to the dance community (R. J. Neagle and Ng, 2003). Typically, the recording of dance works using digital video technology involves recording movement in a rehearsal studio during the choreographic process, or videoing the completed work under performance conditions.

Research into the methods of dance preservation techniques within professional dance companies in Australia indicates the extensive use of digital video as an accessible technology for the documentation of dance (Anderson, 2005; Brady, 2005; Card, 2005; Fee, 2005; Greig, 2005; Gulash, 2005; Hughes, 2005; Lee, 2005; R. Martin, 2005; Saunders, 2005; Tyndall, 2005). Digital video technology provides choreographers with a means to enhance the creative process of choreography. An iterative process of development in which previously recorded rehearsal periods are reviewed brings new insight into the dancers’ skills and abilities (Calvert et al., 1993; Kucks-Cho, 2005; Wang, 2004). This enables a choreographer to rework a sequence until it is perfected (Calvert et al., 1993; Kucks-Cho, 2005; Wang, 2004). The efficiency and ease of use made available by digital video means that dance companies and choreographers in Australia and Asia commonly use this technology for recording and developing dance (Kucks-Cho, 2005). While the visual distortion of video data can be an inspiration to the creative process, such data if taken as a precise record for the reconstruction of
movement poses serious implications for the safeguarding of choreographic works (Hutchinson Guest, 1984). This is because of the lack of visual clarity that digital video offers in the representation and communication of movement. If taken as an adequate reference for the preservation, dissemination, and interpretation of dance knowledge; it could bring about the gradual reinterpretation of dance works. This in turn presents distinct challenges for the integrity of a choreographer’s work to be sufficiently preserved and communicated in its original form over an extended period of time.

The ability of digital video to accurately record a range of movement is highly dependant on the techniques employed to record a performance. To capture a complete record of movement, it is necessary to ensure that all dancers remain visible and within frame of at least one of the cameras. This could involve the use of a single camera placed at the rear of a dance studio to capture both the back and front perspectives of a performance through the reflection of a mirror positioned at the front of a dance studio. Alternatively, recording a live performance may require three or more cameras to capture multiple angles of performed movement. The methods of recording movement, either in a dance studio or from a live stage performance, are susceptible to ambiguity; particularly upon their reexamination. In spite of this, an advantage in recording live performances with digital video allows for the inclusion of the stage, music, costume, and lighting effects that other technologies do not incorporate.

Editing digitally captured material is difficult. In order to edit digital video data, it is necessary to have access to a computer-based editing suite. This is required to make composite, multiple takes of recorded data; and remove unwanted performance material. Otherwise, the original material could be rerecorded. This is a time-consuming process that demands the repetition of a performance until the required changes have been captured. As a format to record detailed accounts of rehearsal periods or live performances, digital video can generate considerable quantities of data (Windreich, 2002). It may prove costly and timely to transport this data to remote locations. Converting data to a compressed format suitable for transfer via high-bandwidth cables would require the use of additional software, and compromise the resulting quality of the material.
As a means to archive dance material, videotapes have a limited life span, and therefore are unsuitable for the long-term preservation of dance works. Added to this constraint, storage of this archived material would require specially constructed areas; able to maintain the capacity of the data collected, and to preserve the quality of the material for an indefinite period of time. Current developments in digital technology would allow the digital data to be archived in a DVD format. However, this adds another element to a process that would require further investment in digital technologies.

Key-frame Animation

It is possible through the development of the 3D animation package DanceForms for dancers, choreographers, and dance educators to record movement sequences in a 3D environment. As a tool to notate movement, DanceForms presents the dance community with an application more familiar to professional animators working with character animation development for motion picture or computer game industries (T. Calvert et al., 2005). This is an application that is customised specifically for use by dancers that know little of animation techniques, yet rely on a process of key-frame animation to record dance sequences.

The function and technology of dance notation applications is significant to the success in which complex processes may be facilitated more easily to allow for the accurate documentation of movement. The ability to achieve this using DanceForms is tied to a user’s ability to set key-frames of dance poses to effectively document a precise record of movement. The capability of an animator is indicative of this level of artistry that requires talent and training (M. Gleicher, 1999; R. J. Neagle, 2003). Neagle (2003) tells us that a highly developed awareness of dance movement is necessary to achieve aesthetically pleasing animations.

This view espouses the skill set deemed necessary by professional animators to provide an aesthetically pleasing and accurate record of movement. However, I argue that an in-depth understanding of dance contributes to the potential dancers, choreographers, and educators have to animate a comprehensive range of movement. Key-frame animation is an arduous and time-consuming process (Bregler et al., 2002; de Aguiar, 2003; Pullen and Bregler, 2002; Sternberg and Essa, 2002). The time required learning the skills
necessary to use DanceForms as an application, and to generate key-frame animation, is considerable. The ability to achieve aesthetically pleasing animation would be relative to a user’s knowledge of animation techniques, or an aptitude to develop these skills. Feedback concerning the usability of DanceForms is reflected in comments made by dance educators from the *Summary of Labanotation Survey by the Dance Notation Bureau in 2000-2001* (Venable, 2001b):

We found DanceForms quite unsatisfactory. It wasn’t interesting. It took way too long to get anything to happen. We’ve let that go (Venable, 2001b, p. 16).

I used DanceForms with a student we had who was wheelchair bound. He was somebody with a very strong movement sense. He would create movement sequences and show the screen to dancers who could begin to try them out (Venable, 2001b, p. 16).

This represents two different interpretations of the application that offer a balance in users’ perspectives on the usability of DanceForms. The contrast in opinions suggests that, while animation techniques may be difficult to master, a nonexpert knowledge of key-frame animation may allow a user to take advantage of the method in which this technology offers a record of movement. The provision of animated dance libraries within “Life Forms Dance Studio,” a special version of the DanceForms program, would accommodate novice users in the process of recording and editing movement (R. Ryman, 2001). However, I argue that, from a creative aspect, the use of predetermined movement sequences poses limitations to the generation of movement for variations of the options available within these libraries.

Currently, DanceForms is a tool accessible to the dance community. This is indicated by the number of participants accessing their current user database (Credo Interactive Inc, 2005b). DanceForms also presents a relatively expedient method to edit and record movement. The application itself produces moderately small data files that remain accessible by digital transfer, and are easily archived.
Research Findings

An examination of Labanotation, motion capture, digital video, and key-frame animation, as discussed above, illustrates various strengths and weaknesses associated with each technology and its ability to provide a suitable method to record and edit movement. I designed a number of criteria also stated above in “Evaluative Method of Technology That Preserves Movement” to demonstrate their capacity to meet their objectives. The findings of the evaluation are documented in Table 2. Technology That Record and Edit Movement Evaluation.

<table>
<thead>
<tr>
<th>Key</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Labanotation" /></td>
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</tbody>
</table>

### Evaluation of Technology that Record and Edit Movement

<table>
<thead>
<tr>
<th>Level of Capability</th>
<th>Functionality</th>
<th>Usability</th>
<th>Expediency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Successful</td>
<td><img src="image5.png" alt="Range of Movement" /></td>
<td><img src="image6.png" alt="Editing Capabilities" /></td>
<td><img src="image7.png" alt="Physical Attributes" /></td>
</tr>
<tr>
<td>Moderately Successful</td>
<td><img src="image8.png" alt="Ease of Use" /></td>
<td><img src="image9.png" alt="Immediacy of Task" /></td>
<td><img src="image10.png" alt="Storage &amp; Transfer" /></td>
</tr>
<tr>
<td>Less Successful</td>
<td><img src="image11.png" alt="Functionality" /></td>
<td><img src="image12.png" alt="Usability" /></td>
<td><img src="image13.png" alt="Expediency" /></td>
</tr>
<tr>
<td>Least Successful</td>
<td><img src="image14.png" alt="Functionality" /></td>
<td><img src="image15.png" alt="Usability" /></td>
<td><img src="image16.png" alt="Expediency" /></td>
</tr>
</tbody>
</table>

**Table 2. Technology That Record and Edit Movement Evaluation**

An evaluation of available technologies showed that they all were most successful in their ability to meet the parameters defined by the criteria. Therefore, it was necessary to reduce these findings to a single, appropriate use of technology. The evaluation
criteria were essential for the comparative analysis of each technology within a set framework. Further evaluation involved nominating a key criterion. Technologies found to provide a higher degree of accuracy in their description of movement had the advantage in circumstances where two technologies were found to be of equal value using the subsequent criteria. This distinguished the first criterion, “range of movement,” as the basis upon which the following evaluation criteria were considered.

Motion capture provides an accurate and detailed account of human movement to a greater degree than Labanotation (K. Hachimura et al., 2005). Of all the technologies examined, the advanced technology motion capture systems are the most costly, labour intensive, timely, and the least attainable by the dance community. This suggests that motion capture is unsuitable as an accessible technology at this time. Research by Wang (2004); which illustrates and evaluates the strengths and weaknesses of notation-based, audiovisual, and motion capture technology; found that Labanotation provides the most rigorous and accurate description of movement. However, usability and immediacy play a fundamental role in determining the success of a technology to facilitate complex processes for greater user interaction. Given these determinates, motion capture becomes a less viable option.

The analyses of the various technologies indicate that the success and functionality of a technology generally is consistent with not only the level of complexity it encompasses, but also that required for operation. Thus, it was necessary to determine an appropriate solution that allowed for ease-of-use; a sufficient level of complexity in the description of movement; and a relatively simplified manner of recording and editing movement. Overall, through a method of comparative analysis, Labanotation provides a technology that best serves these purposes. My argument is reinforced by Wang (2004), who tells us that the development of existing and emerging technologies cannot supersede the significance of notation systems in the function they serve to record movement.

The evaluation of technologies that record and edit movement is limited by its specific focus. I designed criteria to specify conditions of functionality, usability, and immediacy in which Labanotation, motion capture, digital video, and key-frame animation were assessed. Limitations of current technologies found in available
literature offered a theoretical method of analysis to determine a suitable use of technology.

I identified fundamental issues concerning the accessibility and practise of Labanotation between the development of an ideal and an appropriate use of technology. The outcome of this examination necessitated further research into methods that enable greater accessibility of tangible dance records to the dance community in order to ascertain if Labanotation can provide a suitable use of technology to translate and visualise movement in a digital environment. I achieved this through an investigation of various uses of technology that facilitate the translation and visualisation of movement.

The Application of Technology to Virtual Movement

There are various benefits deriving from the visualisation of movement. They include the potential for the representation of movement to communicate the aesthetic and technical performance of dance for analysis and reconstruction. The virtual representation of movement becomes a powerful tool in the education of dance (Calvert et al., 2002; I. Fox, 1999; Herbison-Evans, 2003; Kalajdziski, Trajkoviae, and Davèev, 2002; R. Ryman, 2001). A virtual environment presents a situation in which the technical execution of complex movements may be demonstrated and analysed (Herbison-Evans, 2003; Kalajdziski et al., 2002). Furthermore, it enables greater accessibility to emerging technologies utilised for their accuracy in the documentation of movement that facilitates the process of reconstructing that movement.

To enable the reconstruction of movement, a record of movement undergoes a process of interpretation and translation to realise its performance. Documentation that provides an understanding of the technical and qualitative attributes of movement serves as the foundation upon which movement is reconstructed. Approaches to the virtual representation of movement include the development of key-frame animation (R. Ryman, 2001); notation-based animation (Griesbeck, 1996; Hattori and Takamori, 2002; Herbison-Evans, Hunt, and Politis, 1989; R. J. Neagle et al., 2004; Singh et al., 1983); and motion-capture-based animation (K. Hachimura and M. Nakamura, 2001; Laban Capture, 2002; Web 3D Dance, 2003) that all require further interpretation by
specifically designed system models programmed to translate movement into an animated form.

The objective in which movement is visualised serves to provide an interpretation of movement that is used to specify distinct aspects of motion. These vary between levels of realistic and stylised motion. Technologies utilised in the visualisation of movement provide either an objective and precise account of movement devoid of expressivity, or a subjective representation of movement that is less precise but encompasses qualitative aspects of motion (Calvert et al., 1980). The distinctions between these types of visual information provide substantially different sources of information for their interpretation and, subsequently, produce diverse reconstructions of movement.

Lansdown (1995) maintains that the interpretation of symbolic data is beyond the means of computational interpretation. He argues that assumptions based on the information notation symbols contain can only be effectively interpreted by humans (Lansdown, 1995). While this claim was made more than ten years ago, it represents an area of contention surrounding the perception and interpretation of movement as outlined in Chapter Three, “Perceiving and Interpreting Movement.” Furthermore, it points out the limitations of existing technology to translate movement descriptions that follow rule-based writing techniques and conventions of specific notation languages. This becomes an issue in a digital environment when assumptions that humans naturally make about the representation of symbolic information cannot be adequately communicated as data in a digital environment. In light of Lansdown’s (1995) views, it is reasonable to suggest that varying levels of human intervention and the implementation of enhanced technical functions are required to assist the translation of animated movement from diverse forms of motion data (Calvert et al., 2002; T. Calvert et al., 2005; Michael Gleicher and Ferrier, 2002; R. Ryman, 2001; Wang, 2004). The relevance of this supplies us with an understanding of the extent to which technology is capable of interpreting movement. It highlights the necessity for the development of customised tools and expert systems to assist in the translation of, not only symbolic descriptions of movement, but also those offered by alternate uses of technology.

The interpretation and visualisation of movement illustrates the effectiveness of current technology to achieve its objective. Therefore, it is necessary to assess the manner in
which various technologies function to interpret and appropriately represent movement. The following examination considers the extent in which existing technologies have the capacity to effectively facilitate and interpret a reliable representation of movement.

**Evaluative Method of Technology That Visualises Movement**

To enable an efficient process of comparative analysis between technologies that interpret and visualise movement, the extent to which they function to substantiate their use needs to be established. Literature (Calvert et al., 2002, 2001; Kalajdziski et al., 2002; R. J. Neagle et al., 2002; R. J. Neagle and Ng, 2003; R. J. Neagle, Ng, and Ruddle, 2003; R. J. Neagle et al., 2004; R. Ryman, 2001) provided the basis upon which the evaluation criteria are established. The literature specifies distinct conditions necessary for each technology to meet; to provide evidence of its ability; and to represent a suitable account of movement in its reconstruction.

Evaluative criteria are designed to provide a framework for the examination of varying degrees of accuracy, aesthetics, spatial representation, immediacy, and accessibility of existing technologies to meet these requirements. Critical to this analysis is the manner in which these records disseminate evidence of a movement’s technical execution and artistic quality for their reconstruction.

The following criteria are used to emphasise levels of performance each technology under examination is required to maintain in order to demonstrate capabilities for its use. The criteria specify that each technology will:

1. Provide an appropriate level of accuracy in the representation of movement for reconstruction and technical analysis;
2. Portray a reasonable level of movement aesthetic for qualitative analysis;
3. Demonstrate an ability to display multiple perspectives of movement;
4. Offer an immediate solution to visualise movement; and,
5. Provide an accessible solution to dance institutes, universities, and schools.

Difficulties surrounding an accurate record of movement identified above in “Evaluation of Technology that Preserves Movement” are further emphasised in their
interpretation and visualisation. When assisted by specifically designed system models to facilitate the interpretation of movement, varying technical approaches utilised to realise their visual result further impact their effectiveness to do so. It is, therefore, necessary to examine the benefits and limitations of Labanotation and digital video as reconstructive tools that facilitate the interpretation of movement without additional computational assistance. 3D animation derived from key-frame animation, notation systems, and motion capture data are examined for their capacity to successfully interpret and visualise movement in a virtual environment.

These criteria were applied to the examination of the following:

- Labanotation, as it is used by choreologists;
- Digital video, as it is used by ballet masters, choreographers, and dancers;
- Key-frame animation, as it currently exists within the application DanceForms (Credo Interactive Inc, 2005a);
- Notation-based animation, as it is used within prototype applications such as LabanDancer (Tom Calvert et al., 2005b) that used Labanotation as its data source; and,
- Motion-capture-based animation, as it is used within applications such as Web 3D Dance (Web 3D Dance, 2003) and LabanEditor (K. Hachimura et al., 2002; K. Hachimura and M. Nakamura, 2001).

Following a consistent framework of analysis addressed throughout this examination, the design of criteria established a method of evaluation that was implemented in the examination of the subsequent technologies. Mapping these technologies against the above criteria served to establish a suitable level of assessment to determine an appropriate outcome for the interpretation and visualisation of a correct account of movement.

**Labanotation**

Labanotation is a technology that provides an accurate and comprehensive vocabulary to describe human movement. The use of Labanotation as a technology necessarily includes the abilities of a choreologist or notator to effectively capture movement. This
is because scores of Labanotation are interpreted by choreologists to assist the visualisation of movement. Choreologists are employed to read, write, and interpret notation. The technique practised by choreologists to interpret and translate movement from a written score is referred to as “directing from the score.” Through the demonstration of verbal explanations and physical movements, choreologists utilise the information contained within dance notation systems to reconstruct movement. The level of accuracy achieved through the method of visualising movement in the practise of directing from the score is contentious. It is largely dependent on a choreologist’s individual experience and interpretation of notated movement. Difficulties associated with the perception and interpretations of movement were discussed in Chapter Three, “Authenticity of Movement” and “Perceiving and Interpreting Movement.” Previous knowledge of a specific choreographic style, dance training, technique, experience, and personal judgement contribute to the manner in which notation scores are interpreted and translated (T. Calvert et al., 2005; Harrington Delaney and Fox, 2001; Hutchinson Guest, 1984; R. J. Neagle, 2003).

The advantage of experiencing a choreologist’s interpretation of movement directly from a score provides dancers with a practise of reconstructing movement that is interactive and engaging. The combination of verbal descriptions and demonstrations of movement supplies dancers with a clearer explanation and understanding of movement. This facilitates a process of direct communication between choreologists and dancers in which movement concepts are interpreted and performed. The period of time required to reproduce a dance work from Labanotation is relative to the ability of a choreologist to interpret a score, and the amount of detailed movement requiring translation. Since formal qualifications are required to practise choreology, this level of professional practise should impact positively on their means of interpreting movement. Readers of notation scores benefit from the ease and efficiency in which specific sequences or phrases of movement can be located (Hutchinson Guest, 1984). A parallel can be drawn between the use of music and notation scores that underline the convenience and mobility they offer their readers as sources of reference material.

However, unlike musical scores, which enjoy widespread use among musicians and to a certain extent the general public, members of the dance community are unable to comprehend or utilise the facility of dance notation systems. The number of certified
professional Labanotators (choreologists that use Labanotation) is relatively small. In 2007, only thirty-eight (Mockabee, 2007) practising Labanotators were identified at the Dance Notation Bureau. This is a scarce resource, and there exist few other alternatives to assist the translation of Labanotation scores to performed movement. The accessibility and usability of the information contained within Labanotation scores then becomes a significant factor in the preservation and dissemination of dance knowledge. Wilmer and Resende (1998) tell us that Labanotation scores are difficult to read and interpret because of their level of abstraction. This means that the visual representation of Labanotation’s symbolic language prevents the straightforward recognition of the movement it describes. At present, it is difficult to interpret the information Labanotation scores contain without the assistance of a professional choreologist (R. J. Neagle, 2003) or a thorough knowledge of the language.

**Digital Video**

The quality of the performance, the environment, and the visual perspective in which movement is recorded contribute to the level of accuracy that digital video technology permits. This accuracy then impacts the level of analysis and reconstruction possible. As a means of facilitating the process of reconstructing movement, digital video offers a description of movement that is ambiguous and circumstantial. Andrews (in Hutchinson Guest, 1984) informs us that digital video represents an impression of movement. In support of this, Parker and Macmillan (in Damle, 2002) tell us that digital video cannot supply sufficient information regarding the technique or concept of movement for its performance.

As a reference to facilitate the reconstruction of movement as closely to the original as possible, digital video is representative of the dancers and the dance; not the intent of the choreographer (Hutchinson Guest, 1984; R. Ryman, 2001; Wang, 2004). The vocabulary of a choreographic work is established in the actuality of its performance. Practical experience in the creation of new dance works sees the development of movement take shape during a lengthy rehearsal period. Typically, the resulting movement sequences are influenced and transformed by a performer’s artistic capability. This is exemplified by a dancer’s personal idiosyncrasies, individual interpretation, and physical capability to perform movements as intended by the
choreographer. This means that a flawless performance of the exact choreography is required to enable an accurate record of movement to be captured. Furthermore, reference to alternative casts of dancers introduces further variations to the performance and analysis of movement for its reconstruction. In light of this, performed movement is no longer ideal in its representation (R. Ryman, 2001; Wang, 2004).

The visual perspective used to record movement is vital in supplying an overall view of a performance, and ensuring that specific aspects of detailed motion are discernible. The visibility of group formations can be severely distorted if a full range of movement is not successfully captured. This medium is reliant on the viewpoint of the camera (R. J. Neagle and Ng, 2003). This is particularly apparent when an individual’s view is either blocked or lost from the camera’s range of vision. Lack of a third dimension in its visual representation renders this medium insufficient to explore the full range of movements (Naugle in Furniss, 1999). Archives of stage performances are further obscured with the addition of stage scenery, costumes, and lights (Wang, 2004). While this provides a comprehensive record for the technical restaging of the production, these elements can obscure the visibility of a dancer’s movement and result in the adaptation of the intended choreography, provided the movement being recorded is accurate in the first place.

Digital video archives provide an instant visual reference of dance material that is readily accessible to dancers, ballet masters, rehearsal directors, and choreographers during the rehearsing and recreation of a dance performance. However, difficulties locating and referencing specific segments of recorded material (Andrews in Hutchinson Guest, 1984; Kalajdziski et al., 2002) do not attest to the efficiency or immediacy of this format.

**Key-frame Animation**

Key-frame animation enables the computer generation of movement in a 3D form. This is achieved by specifying key frames of motion that represent the fundamental poses of action for animation. These key frames constitute an animated sequence of movement, which undergoes a process of calculation and interpolation in order to generate animated movement. It is a technology that enables greater precision in the definition of
movement, and enhanced control over the resulting animation (Pullen and Bregler, 2002).

The degree of accuracy key-frame animation offers in the description and interpretation of movement is comparable to the role of notation systems (R. Ryman, 2001). It provides a record of movement that is free from performance error (Calvert et al., 2001), and appropriately conveys the original intent of a choreographer (R. Ryman, 2001). Unlike notation systems, key-frame animation is limited in its ability to communicate the concept and motivation of movement. However, Yasuda (2001) maintains that the application DanceForms augments a user’s ability to visually perceive movement. DanceForms facilitates the visualisation of movement from key-frame animation. The significance of this highlights the potential benefit this method of animation has in the education and examination of movement.

Sophisticated movement models are developed for the interpolation of key-frame animation to generate an appropriate representation of movement. Inverse kinematics assist the designation of movement by constraining the degree of motion an animated figure is permitted to perform (T. Calvert et al., 2005; de Aguiar, 2003). The generation of animated movement depends on the extent to which these models perform, and the capacity of an animator to compose a comprehensive representation of movement (N. Badler et al., 2000; de Aguiar, 2003; M. Gleicher, 1999). De Aguiar (2003) tells us that procedurally generated movement typically involves the interpolation of smooth splines that limit the degree of realism in the representation of human movement. A lack of detail and quality in generated movement also can be the result of an insufficient number of key frames used to define a movement sequence (de Aguiar, 2003).

Badler et al. (2000) argue that the facility of an animation system does not exclusively determine the quality of animation it produces. Highly skilled animators and the specific application of classical animation principles contribute to the construction of expressive movement (N. Badler et al., 2000). Research by Neagle et al. (2003) demonstrates the capacity in which varying subtleties of human emotion are discernible from computer-generated movement. It suggests that significantly low levels in the fidelity of movement do not inhibit a user’s ability to identify expressive motion (R. J.
Neagle et al., 2003), and that this medium presents a suitably accurate and qualitative representation of movement fidelity for its reconstruction.

Key-frame animation offers members of the dance community an accessible solution for a 3D visualisation of movement that is central to facilitating interactive methods of movement observation. It enables a three-hundred-and-sixty-degree perspective of motion to be obtained, which presents significant benefits for the technical understanding and education of complex movement. Real-time rendering caters to the immediacy of this medium, which allows for the visual manipulation of data to be easily selected and controlled.

**Notation-based Animation**

Advances in technology have seen the development of dance notation applications that interpret and translate notation scores into an animated form (T. Calvert et al., 2005). This method of translation can be broadly defined as notation-based animation. It is a method of creating motion for computer animation that utilises the symbolic vocabulary of notation systems as a data source. Strengths and weaknesses found in the translation of Labanotation provide a specific focus for this research. This is done to better understand how different technologies modify the structural makeup of Labanotation as a data source, to enable the efficient and effective composition of movement in a digital environment.

Neagle (2002) maintains that the mathematical structures of dance notation systems appropriately facilitate the virtual representation of movement. However, there is no direct method of translating Labanotation into a digital form (Kalajdziski et al., 2002). It requires the manual programming and development of tools to assist in its translation to a machine-readable format (T. Calvert et al., 2005). A programmer creates a translation model capable of interpreting the symbolic vocabulary of Labanotation (Calvert et al., 2001). These models are developed to maintain the correct interpolation of computer-generated animation. This in turn constrains the possible movements of an animated figure to ensure that it animates or performs within a realistic range of motion.
The accuracy and detail Labanotation provides as a tool to describe and convey the concepts of movement underpin the benefits it provides in translating notation to digital representations of movement (N. I. Badler and Smoliar, 1979; Calvert et al., 1980; Calvert et al., 2002). Variations in the symbolic description of movement provide comparable movement representations and, when used effectively, work to simplify the structure of a score and the interpretation process (Calvert et al., 2002; Hutchinson Guest, 1984). However, the implicit description of movement supplied by notation systems is a problem in relation to: (1) the development of exceptions in the interpretation process; (2) animated transitions; (3) the application of anatomical constraints; and (4) stylistic conventions of specific dance genres (Calvert et al., 2002; T. Calvert et al., 2005; R. J. Neagle et al., 2004; R. Ryman, 2001).

Sternberg and Essa (2002) tell us that the generation of a symbolic description of movement has yet to produce animation of a highly expressive quality. Neagle et al. (2004) theorise that a realistic virtual demonstration of movement is possible from a machine-readable format of notation. They use a component of LMA (Davies, 2006) to control the process of interpolation, and to produce aesthetically pleasing animation (R. J. Neagle et al., 2004). Loke et al. (2005) and Badler et al. (2000) refer to existing work that utilises Labanotation and the principles of LMA to enhance the qualitative aspects of computer-generated movement. This provides an insight into the facility of Labanotation and the implementation of Laban’s movement principles to effectively generate the aesthetics of movement in a virtual environment.

Notation-based animation utilises the technology of 3D animation to generate a virtual representation of movement. It offers levels of accessibility and immediacy in its visualisation that are comparable to those found in 3D computer-generated animation. This extends to the capacity in which a virtual 3D environment allows the control of various viewpoints and perspectives of the movement to be examined.

Motion Capture-based Animation

Motion capture-based animation broadly defines the technique of generating animated movement from motion-capture data. Limitations identified earlier in the above evaluation of Motion Capture as a tool to record movement are exemplified as a product
of its virtual representation. These limitations refer to the visual quality and accuracy of the animation generated.

The level of precision in the virtual representation of dance is fundamental to facilitating a reconstruction of movement that sufficiently conveys the technique and aesthetics of movement for analysis. Gleicher and Ferrier (2002) argue that residual artefacts in motion-capture data, such as high-frequency noise, contribute to common visual errors in its animated representation, and disrupts the illusion of realistic movement. These residual artefacts can be recognised in the slipping or floating of a models feet, jitters in usually smooth actions, and extreme pops where the positioning of an object from one instance to another appears to be the least feasible (Michael Gleicher and Ferrier, 2002). Data processes for the removal of excess noise and artefacts from motion-capture data usually require additional manual editing for the effective translation of motion-capture data to animation (Michael Gleicher and Ferrier, 2002). Over-filtering techniques used to refine motion-capture data can produce adverse effects that result in the loss of key actions, such as gesture and the unnatural spatial orientation of an animated figure and its environment (Michael Gleicher and Ferrier, 2002).

The visualisation of motion-capture-based animation is a complex data source to draw on for the reconstruction of movement. Ryman (2001) and Wang (2004) claim that motion-capture-based animation is representative of performed movement. Similar to that of digital video, it embodies a record of movement that is subject to the limitations of the technology used to capture this information, and the inherent capabilities of its performers (R. Ryman, 2001; Wang, 2004). As a result, animation derived from motion-capture data no longer represents an ideal account of movement.

Computer-generated animation that uses motion-capture data as its source is limited in capturing a realistic representation of movement (Bregler et al., 2002; Wang, 2004). Important lifelike qualities and expressive characteristics of motion remain elusive in motion-capture systems because of the results of data processing and various computational techniques used to adapt and model human motion (Laban Capture, 2002). However, research examining various techniques to produce stylised computer animation from motion-capture data sees the implementation of traditional animation
techniques and the principles of LMA as an attempt to combat these shortcomings (Bregler et al., 2002; Laban Capture, 2002).

Motion-capture-based animation is visualised in a virtual 3D environment. This presents an environment that caters to greater immediacy and flexibility in the manipulation and demonstration of movement. In spite of this, access to motion-capture data that facilitates this representation of animated movement remains inaccessible to members of the dance community.

**Research Findings**

The investigation of Labanotation, digital video, key-frame animation, notation-based animation, and motion-capture-based animation has demonstrated various benefits and limitations each technology offers in the interpretation and visualisation of movement. A set of explicit criteria provided a specific focus for this investigation, and was used to determine the extent to which each technology under review met these objectives. These findings are illustrated in Table 3. Technology That Interprets and Visualises Movement Evaluation.

Having mapped the above-mentioned technologies against the criteria, the outcome suggests that Labanotation, as used by choreologists, provides the most accurate use of technology to interpret and visualise movement when compared with the other technologies described above. It also demonstrates digital video as an immediate and accessible technology to assist in the reconstruction of movement. Experimental research by Fügedi (2001) involving the comparative analysis of dance reconstruction from digital video and Labanotation tells us that Labanotation enables a higher level of precision and movement fidelity in the reconstruction of movement than digital video. Parker and Macmillan (in Damle, 2002) confirm that references supplied by notation systems are superior to video recordings in their ability to facilitate an understanding of movement concepts. The imprecision offered by digital video, and limitations to the accessibility of choreologists to interpret Labanotation, has meant that it has become necessary to look to the next suitable technology to provide an appropriate outcome.
Table 3. Technology That Interprets and Visualises Movement Evaluation

The research literature identifies notation-based animation as the most appropriate technology to interpret and visualise movement. Neagle et al. (2004) and Wang (2004) tell us that real-time computer graphics are well-suited for facilitating the process of visualising movement from notation scores by demonstration of an animated figure. Badler and Smoliar (1979) and Calvert et al. (2002) confirm this by acknowledging the sound framework Labanotation provides in the definition and mapping of limb positions to an animated figure at distinct moments in time.

Calvert et al. (2005) discuss the necessity for an unambiguous, machine-readable representation of human movement to assist in the interpretation and visualisation of notation systems. While the development of intelligent system models to facilitate this process is outside the scope of this research, Calvert et al. (2002) tell us that a well-
structured Labanotation score provides a more efficient means of translation to animation. If we accept the notions put forward by Calvert et al. (2002), then we can recognise that a significant element to the process of interpreting notation to animation is found in the structure and composition of Labanotation scores.

The absence of a system that detects structural and syntax errors made during the composition of notation scores is not only a problem for the preservation of cultural archives, but for the translation of notation-based data to animation. I argue that methods of score composition that facilitate the correct grammatical structure of notation scores should be developed. If this potential could be realised, greater modes of assistance in the formation of Labanotation scores would result in higher levels of proficiency in the documentation of notation scores and their efficient translation to animated movement.

Summary
This research examines the capacity of existing technologies to provide an appropriate level of functionality, usability, and expediency in the documentation and subsequent modification of movement. The difficulties associated with translating a description of movement to an animated form are also discussed in relation to the types of motion data that provide a basis for its interpretation.

Two methods of evaluation were designed to examine the efficacy with which specific technologies could facilitate various needs of the dance community in an easy-to-use, immediate, and accessible manner. The results of the comparative analysis of technologies utilised in both the documentation of movement and those in its representation suggest that notation-based animation derived from Labanotation is a suitable use of technology to record, edit, translate, and visualise movement in a digital environment.

Computers are facilitating the composition, editing, and interpretation of dance notation systems. The careful composition and visual interpretation of Labanotation is fundamental to maintaining a precise syntactical and grammatical record of movement. This research proceeds on the basis that further research and development towards
supporting the processes of documenting and editing of notation scores is required (Singh et al., 1983; Wang, 2004) to assist in the composition and interpretation of movement. In order to achieve this, I begin Chapter Five by gaining an understanding of a design approach that could be used to enhance the conceptual development of novel design outcomes, and accommodate diverse use situations.