Designing and measuring gesture using Laban Movement Analysis and Electromyogram.

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Abstract
Movement design are typically based on evoking shapes in space. In interactive systems, user movement is often dictated by the systems sensing capabilities. In neither of these cases are the differences across individual users or expressive variations they make accommodated. We present an exploratory study that uses Laban Movement Analysis as a framework for designing gesture, and electromyogram (EMG) signals for measuring gestural output. We were interested to see if these approaches for specifying and measuring gesture could produce and capture a "sameness" in gesture that in gross spatial movement, be quite different.

Author Keywords
EMG; Gestural Control; LMA.

ACM Classification Keywords
H.1.2. [Models and Principles]: User/Machine Systems

Introduction
How do we design movement? Technologies of whole body interaction allow limb movement to be captured, but they require strategies for authoring gestures. Moreover, there is a normative pressure for different users to perform gestures similarly to make these systems function in a reproducible manner.

The specification of gesture typically takes place by indicating trajectories based on limb position, often leading to the specification of posture. Trajectories can be described as elemental shapes to be executed by ”drawing” in space[3][4][16].

The design of movement by specifying shapes do not account for nuance and complex combinations of natural gesture. We propose a method, based on Laban Movement Analysis (LMA)[9] to author gesture sequences in a way that allows us to break sequences into their component parts. We capture the gesture using physiological signals of the muscle, the electromyogram (EMG) to detect nuances of speed and scale. By using gesture design measurement approaches independent of the Cartesian space in which movement took place, we were interested to see if these qualities with individual variants, could be considered the ”same” gesture by a computational system.

Background and related work

Analyzing, Learning, and Interacting with Movement
LMA is a method and lexicon for describing and categorising body movement. It has been used in interaction design[11][17]. Here, we wanted to see if LMA terms could be used not in the analysis of gesture, but in its design and specification.

Anderson and Bischof[2] discuss the learnability of a gesture set as a key problem for gesture based interfaces. Rokeby discusses the use of a metaphor to encourage users of the early Very Nervous System (VNS)[15] to move in a manner the system responds to.

Dance has been used to design movement based interaction[8]. Moen [13] explores movement awareness and “kinaesthetic sense” in a dance course. Loke and Robertson[12] examined transfer of choreographic methods to technology design. Hashim et al use effort theory as the basis for their framework for graceful movement in interaction[5]. Alaoui[1] describes a framework that uses movement quality as interaction modality, integrating feedback and display.

Space and Effort in LMA
LMA presents a comprehensive lexicon for the description of movement. The *kinesphere* is the space around the body whose periphery can be reached. Three sizes of kinesphere use are defined, small, medium and large, referring to close to the body, at about elbow distance away, and as far as the mover can reach respectively.

There are three *approaches* to the kinesphere: *central*, where the kinesphere is revealed with movement radiating out from and coming back to the centre of the body; *peripheral*, where the kinesphere is revealed by movement along the edge of the kinesphere which maintains a distance from the centre and; and *transverse*, where the kinesphere use is revealed by movement which cuts or sweeps through the space revealing the space between the centre and the edge.

Movement is considered in terms of how it unfolds with relation to the *vertical*, *sagittal* and *horizontal* dimensions with each dimension having a “spatial pull. Motion in two of the dimensions constitute movement in a plane. Movement in each of the cardinal planes (vertical, horizontal, sagittal) is movement which invests in two spatial pulls at the same time. In the study described below, we used this subset of the LMA lexicon to design and specify gesture.

Multimodal Sensing of Gesture
We have previously demonstrated multimodal analysis of arm gesture execution using inertial and physiological sensors, identifying modes of synchroniticity, coupling, and cor-

releation as salient. Non-specialist users were able to reproduce sonic examples differentiating two different modes of muscle sensing, the mechanomygram (MMG) and electromyogram (EMG) [3]. Subjects were able to expressively vary gesture "power," which was measured by the instantaneous amplitude of the EMG. In recent unpublished work, we found that there is a high variability of gesture execution across users and even within trials by a single user, if a gesture is described by endpoint posture. This points to the problem of specification of gesture and the elaboration of what it means to perform (or not) the "same gesture".

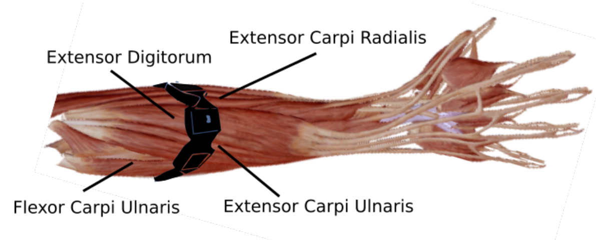

Figure 1: Position of the device on the forearm.

Study

We conducted an autoethnographic gesture-design workshop [10]. Based on Jensen et al.'s "action before product" approach[7], we wanted to place an emphasis on designing the actions that an interactive system (such as a digital musical instrument) might exploit, before designing the interaction mapping. By using LMA to focus on movement qualities rather than absolute trajectories, we were interested to specify and measure "how" the gesture was executed.

There were three workshop participants, all researchers with specific interest in interactive musicperformance. The workshop leader had theoretical knowledge of LMA, was not Laban certified. One of the participants had extensive experience in musical applications of EMG, while the third had experience in motion-capture for multimedia performance.

We acquired 8 channels of EMG data in a circular formation around the dominant forearm of each participant and IMU data consisting of 3-axis accelerometer, 3-axis gyroscope, using the commercial Myo device. (Fig. 1). Raw data from the device was captured using custom software written in Max/Msp and recorded for offline analysis.

The workshop began with a discussion of the main categories of LMA and their subcategories [6]. The four main categories of the Effort system, Space, Weight, Time and Flow were described. Having explored the 4 effort qualities and after attempting to devise movement that epitomised each Effort quality polarity we decided to focus on Time Effort and Flow Effort.

Following the initial discussion, participants were asked to devise a simple one-arm movement phrase that explored specific polarities of two or three qualities. Each participant demonstrated the movement phrase they had devised whilst describing its progression using the LMA terms they had focused on during its definition. (Fig. 2, 3). Each phrase was executed with variation of "flow", first free flow and then bound flow.

Similarity between *free* and *bound* versions of the gestures was measured by taking the Euclidean distance between each channel of EMG (Figure4).

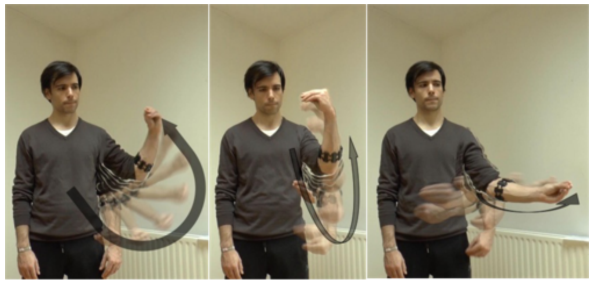

Figure 2: Horizontal, Vertical, and Sagittal planes

Figure 3: Central to Peripheral approaches to the Kinesphere.

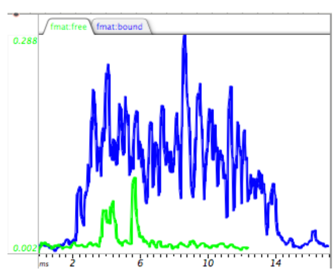

Figure 4: EMG amplitude for *free* (green) vs. *bound* (blue).

Discussion

Auto Ethnographic Analysis

Each participant provided a report of their experience during the workshop. We focused on two main questions: 1) to assess the usefulness of LMA to conceptualise and design a sequence of distinct gesture, and 2) how LMA helped in communicating amongst one another to teach and learn the different gesture sequences.

We found that the LMA vocabulary was useful in allowing for a systematic exploration of movement. It supported discussion and communication amongst the workshop group and allowed us to make suggestions for new movements based on what one participant was doing. Furthermore, it helped to identify the specific qualities that we were most interested in with the movement. Participants stated that they worries less about the specific trajectory of the hand as long as it was in the correct "plane", or showed the correct approach to the kinesphere. The abstraction that LMA provides allowed us to focus on movement phrases, not sequences of individual gestures. This permitted us to access the sensation when changing an LMA qualities within the Laban-defined continuum.

Data Analysis

Our data analysis methodology provides a good measure of similarity between pairs of signals, this means that if the number of trials is increased it will be necessary to calculate all possible pair combinations. Due to the fact that all trials would represent a free interpretation of the gesture guides by each participant, there is no ideal template or model for each gesture within the context of the study (no ground truth). Methodologies for data reduction of all pairwise comparison need to be explored.

The study and subsequent analysis showed a potential for this approach, but pointed out specific challenges that need to be addressed. For a quantitative analysis, we would need to establish a pre-processing methodology to be able to compare similarity between signals of different temporal ranges. The signals need to be normalised to the same scale while the ratios between them need to be kept consistent. An option for accomplishing this would be to find the local Maxima for each gesture pair, scale it to a consistent range (0.0 - 1.0) and apply the same scaling coefficients for each signal pair.

Conclusions

The study as presented here demonstrates the perceived usefulness of LMA in gesture authoring, with potential to be validated in further work, and applied to application cases such as the design of Digital Musical Instruments (DMI). LMA-based gesture design, and subsequent physiological sensing and data analysis provide an interesting specification and measure of gesture that are independent of a Cartesian coordinate basis for representing gross movement. This points out the possibility of these techniques to be pertinent in the study of subtle, expressive gesture that may result from the same intention by users but vary in their actual execution.

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