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# Bodytraces: Embodied Movement Exploration via Feedforward Visualizations

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## ABSTRACT

A phenomenological approach to interaction design puts the body at the center of inquiry. When designing body-centric interfaces, reflective awareness of how the body moves is an important aspect for consideration. This paper presents a full-body interactive system that allows end users to explore movements using dynamic feedforward visualizations of movement pathways. We propose a demonstration of the system as an interactive installation through which participants are encouraged to move in order to interact with visual representations of their movement characteristics. The system captures each participant's movement in terms of spatial trajectories and dynamic qualities. It then encourages the participants to improvise using existing movement ideas by embodying, appropriating, and varying them. The global visual canvas makes visible the movement traces of the participants over a specified period of time as feedback and the future possibilities and movement potential as feedforward.

## ACM Classification Keywords

### Author Keywords

Kinaesthetic awareness; Movement visualization; Full-body interaction

## INTRODUCTION

Recent advances in motion detection and recognition technologies have facilitated studies of human movement as an interface to dynamic interactive systems. These studies address particularly the notion of an “enactive approach to perception” [8], where meaning is constructed through active bodily interaction. This is distinctively different from the Cartesian approach where meaning construction is cognitive and abstract.

This body-centric view places experience as its central focus. “Experience” here refers to “continuous engagement with the world through acts of sense-making at many levels” [10]. A

system whose design follows the philosophical concept of embodiment seeks to engage the body-mind directly by promoting kinaesthetic awareness during interaction.

Kinaesthetic awareness refers to the “conscious perception” of the body's movement in space [6]. When applied to interactive systems, it serves as a catalyst for experimentation and encourages exploration of movement outside of “socially acquired bodily practices” [9]. Instead of relying on designers to provide full expression, systems that prioritize kinaesthetic awareness heighten user's physical engagement and thus enhance individual expressivity by shifting the emphasis from information processing to movement awareness.

This paper proposes a practice-based articulation of the phenomenological perspective on interface design where the concept of kinaesthetic awareness is explored in a full-body interactive installation. Specifically, the system we propose enhances kinaesthetic awareness by allowing participants to explore their movements using dynamic feedforward visualizations of movement pathways and continuous feedback of movement qualities.

## RELATED WORK

Phenomenologically-inspired design considers the experiential aspects of interaction such as user experience, meaning construction, and expression. Extensive research has gone into exploring movement as the entry point to investigating these notions.

The dynamics of movement such as speed and energy contain expressive information and are often used to interact with dynamic systems. Alaoui et al. investigated movement qualities as means to control lighting behaviors [1]. Caramiaux et al. studied the potential of using gestural variations in movement dynamics as expressive instruments for interaction [4]. While these systems are a step toward understanding movement expressivity, they do not investigate directly how dynamics contribute to creating kinaesthetic awareness during interaction.

To facilitate continuous expressive interaction, researchers have proposed different methods to track, in real-time, the temporal evolution of movement characteristics. Bevilacqua et al. [2] developed a method based on hidden Markov model that synchronizes gestures to music. Caramiaux et al. [5] extends this method to allow tracking of variations between performed

and trained gestures. Rather than full-body movements, these techniques have mostly been tested with 2D gestures or single-hand 3D gestures.

Our system exploits the power of continuous recognition system to track and predict temporal motion parameters. We apply it to a full-body context in order to create kinaesthetic awareness via dynamic visualizations.

## SYSTEM DESIGN

In keeping with the phenomenological principles of bodily thinking through unmediated perception rather than through analytical reasoning, the goal of the system is to allow users to explore whole body movements by providing visual feedback to support awareness of their movement qualities and to encourage improvisation. Real-time visual feedforward on the user's movements are provided to guide exploration of different movement possibilities.

### Motion capture

Kinect is used to capture user movements. The application is developed in openFrameworks, building on RAM Dance Toolkit [7] by creating scenes and adding functionalities in the environment that track the skeletal data and feed the joint positions as inputs to the gesture recognition system. Gesture Variation Follower (GVF) [3] is used to compare the performed movement against a movement set for recognition. We crowdsource movement sequences by collecting recordings made by people of different movement expertise. We pre-select from the recordings to assemble the movement set used by the system. The users also have the option of adding their own movement sequences to the movement set during interaction.

### Interaction

The installation is intended for single user at a time. The graphical interface consists of two parts: real-time progressive feedforward on future movement possibilities and feedback on current movement qualities.

The feedforward mechanism predicts future movement trajectories given the user's current movement execution. It shows the remaining subset of movement possibilities (Figure 2). This allows the user to select the movements they want to explore.

While the user selects the movements for exploration, the system also outputs continuous feedback (Figure 1) on the progression of the currently executed movement against the recognized movement sequence in the movement set. The feedback is represented as line or bounding box traces. For this iteration of the system, we focus on tracking hands and feet so as to not induce cognitive overload by visualizing too many joints.

In addition to visualizing the temporal evolution of the movement as feedback, the system also visualizes the variations in movement qualities. The user improvises on the selected movement by exploring variations between the current movement and the recorded movement. GVF computes incremental estimates of the variations that occur during execution.

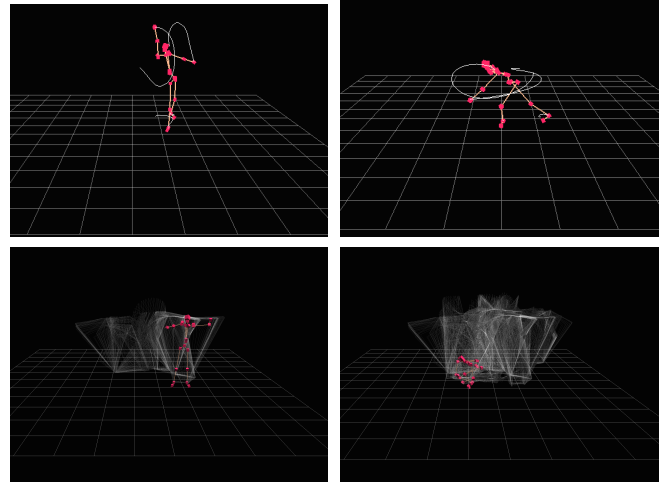


Figure 1. Traces of the user's currently executed movements as real-time feedback

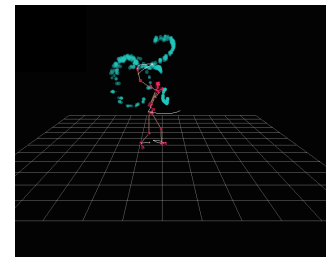


Figure 2. Feedforward visualization of possible future pathways

### Variation and mapping

We examine both spatial and temporal variations of each performed movement and use them to control the visual effects applied to the trace forms during movement exploration. Each variation parameter is mapped to a customized visual output:

- **Scale variation** is mapped to the width of the trace form. If the scale is bigger than the recorded movement, the line increases in width and vice versa.
- **Speed variation** is mapped to the color of the trace form. The faster the current movement is compared to the original recorded movement, the closer the color grows toward the shade of red. Similarly, when the movement is slower than the original, the color retreats toward the shade of orange.

## CONCLUSION

Kinaesthetic awareness is the sense of the nuances in movement during execution. Its importance is manifold – it can improve movement ability, increase enjoyment, as well as foster creativity. In our system, kinaesthetic awareness is achieved by guiding users through movement exploration via feedforward visualizations and by providing continuous visual feedback on variations in movement qualities. By harnessing the ability to track gestural variations provided by GVF and applying it to a whole-body context, we empower users to exercise agency in interaction – embodying, varying, and appropriating previously recorded movements.

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