Choreographic Interfaces: Wearable Approaches to Movement Learning in Creative Processes

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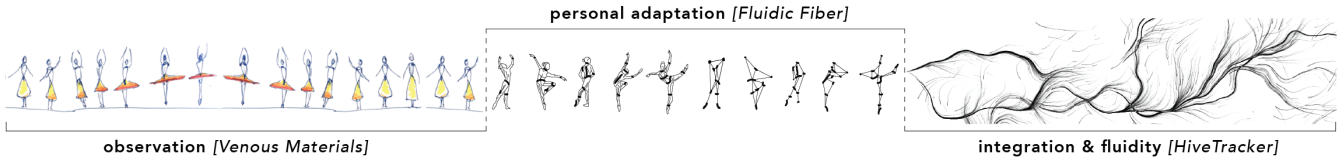

Figure 1: Vision sketch, three layers of Choreographic Interfaces

ABSTRACT

In this position paper, we present a set of tangible and wearable computing approaches to creative movement learning and expertise. We aim to rethink and articulate how we can build a combination of tangible and computational tools that yield a novel and expressive somatic vocabulary for human bodies through a model concept that we call *Choreographic Interfaces*.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Haptic devices.*

KEYWORDS

Wearable Motion Sensing, eTextiles, Fluidic Interfaces, Haptics.

1 INTRODUCTION

To convey the concept of *Choreographic Interfaces* we first define choreography as the practice of designing a sequential movement which requires the perception of multiple bodily factors. The source of choreographic thinking can reside in multi-modalities: visual, auditory, tactile, muscular, verbal, and is later expressed through movement. [12]

Movement is an essential feature of how we interact with the tangible world: from the most basic daily operations, to body language and personal communications and expressions. Maurice Merleau-Ponty's philosophical milestone in the explanation of skill acquisition and movement expertise [11] prompted researchers to focus on the encoding of embodied experience in various types of movement cultures; from sports, tool use to performative arts. For example, in HCI field, intelligent tools are being introduced to support creative processes such as dance [3, 4], music [8, 14] and craftsmanship [10, 17] where the tacit somatic knowledge of the individual can be better grasped when supported by computational processes such as [16]. The cognition of movement-based processes can also be further deepened and retained with the support of technologies that augment different experiential qualities of movement, which we pose in this paper as *three tangible layers* that are essential to form a choreographic interface.

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2 THREE LAYERS OF CHOREOGRAPHIC INTERFACES

In this section, we present three technologies, each serving as a wearable support layer for creative movement learning and transfer.

2.1 Visualizing hidden bodily forces and movements: Venous Materials

The soft, conformable, and analog characteristics of Venous Materials (Fig. 2) allows to dynamically visualize information of bodily actions and applied forces for use in the analysis of various isolated elements that contribute to the whole of the movement. Venous

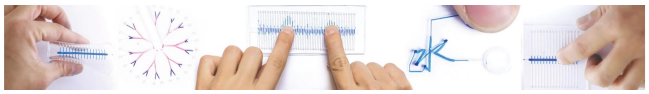

Figure 2: Venous Materials: (from left to right) Bending visualization. Capturing memory of applied pressure. Slider. Visualizing Character for learning to write in Chinese.

Materials [9] is both a concept and a set of materials together enabling a novel approach of designing interactive materials using fluid mechanisms. These materials act as embedded analog sensors and display responses to the physical deformation input from the user by displaying the flow and color change of the embedded fluidic channels. While common robotics require batteries and rigid components, Venous Materials is a self contained, entirely soft and deformable material. With this approach, we consider the fluid as the medium that drives and displays the tangible information.

Worn on the body or attached to objects/ tools (Fig.3), Venous Materials allows for display of hidden forces and movement information. Applicability of such material can serve as an informative tool for performers / audience, it can also be useful as a real-time expressive tool for learning creative activities such as playing the piano and painting.

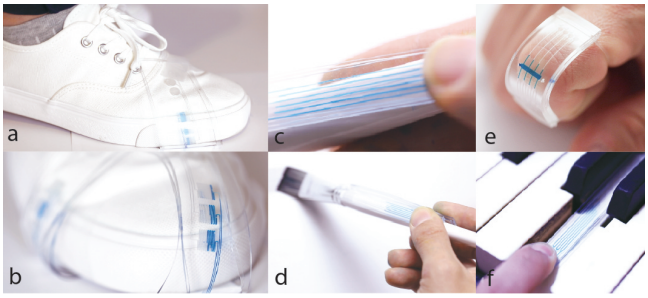

Figure 3: Venous Materials applications: (a-b) Attached on shoes to visualize pressure and balance difference for gait training. (c-d) Attached to paintbrush. (e) Joint bending sensor. (f) Visualize applied pressure on piano key.

2.2 Haptic I/O for bilateral transfer of somatic knowledge: Fluidic Fiber

When learning a movement the dancer is required to directly engage with, and perhaps take on aspects of another dancer's embodiment. [11] Fluidic Fiber leverages the haptic channel for capturing and direct transmission of otherwise unfelt, embedded movement qualities like "viscosity" [1] performed by another person's body, for responsive shape-change and haptic feedback in a bidirectional manner.

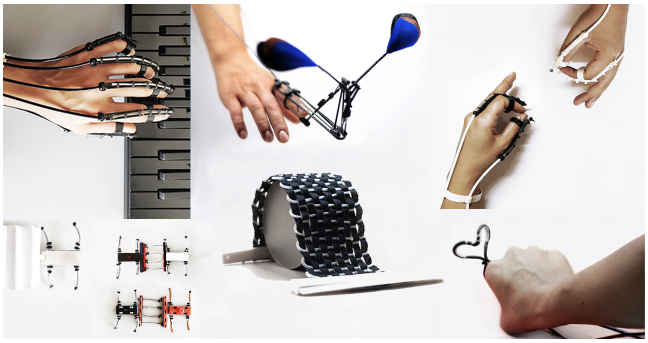

Figure 4: Fluidic Fiber: Bidirectional interactions using fluidic fiber-integrated devices for remote skill transfer for musical instruments, sign language, expressive tangible communication and robotic crafting.

Thin linear forms are ubiquitous geometric building blocks found throughout nature and the human body. In Fluidic Fiber, we utilize this thin and flexible fiber form factor as a building-block to choreograph closed loop movement-based HHI (Human-Human Interaction). Our interface toolkit constitutes a modular design system based on strain-programmable multimodal fluidic muscle fibers. (Fig.4) While the design system is based on existing thin McKibben muscles similar to [7], we augmented their functionality by (1) integrating heterogeneous sensing, (2) modularity to augment the expressive bandwidth of movement interaction techniques, (3) omni-directionality, shape-change and shape-locking for motion dexterity, (4) miniaturization (650μm) for machine knittability of programmable full-body garments.

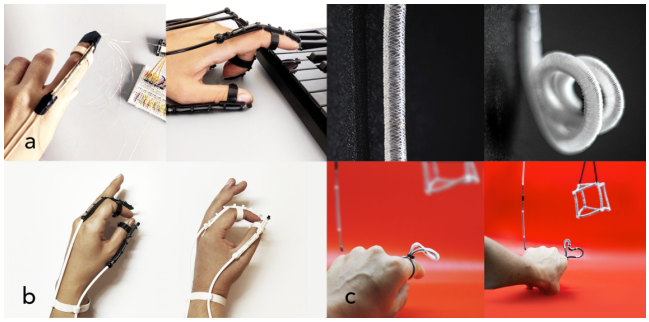

Figure 5: Fluidic Fiber: (a) bidirectional interaction wearing fluidic fiber-integrated assistive devices for remote piano learning. (b) sign language enhanced by haptic feedback in co-located scenario. (c) expressive line-form wearables.

Patterning high strain (>140%) sensing components on the fiber allows feedback loops for body-device and body-body interactions in co-located and remote scenarios for:

- Tangible record (movement memory) & replay of motion sequences for the novice to observe and segment movements at her desired pace
- Direct mapping of kinaesthetic feedback from expert's body to novice & vice versa in remote learning scenario (Fig. 5a)

We advanced the motion range of a single muscle fiber with the addition of selective strain limitation, resulting in multi-bend & coiling, going beyond simple axial deformations. This allows the user to utilize the fibers as:

- Visual guide in observing precise finger motions as in sign language, calligraphy or instrument playing. (Fig.5b)
- Dynamic expressive layer on the dancer's garment (Fig.5c)

Our vision is leveraging computing fibers and fabric with functions as sensing, actuation, information storage and processing embedded in a single conformable substrate accounting for subjective variations and changes in the body for learning contexts.

2.3 Capturing the moving body in relation to 3D space: HiveTracker & PolySense

Movement is situated in and accessed through the individual's body, thus cannot be described as abstracted from the position and integration of that particular body in space. As a result of our collaboration with neuroscientists and roboticists, we found that many movement-focused applications require an affordable tool for accurate positioning in 3D space. HiveTracker [5] is a miniaturized system for scalable and accurate 3D positioning (see Fig. 6a). It allows sub-millimetric 3D positioning, and embeds a 9DoF IMU with sensor fusion for 3D orientation. As a result of collaboration with neuroscientists and roboticists, we found that many movement-focused applications require this kind of tool:

- Dance performances can already be improved with machine learning (e.g. PoseNet) but not easily in real-time.
- Robotic surgery controllers can be improved by size & weight.
- Rats "hive" position versus brain activity tracking is the most direct application.

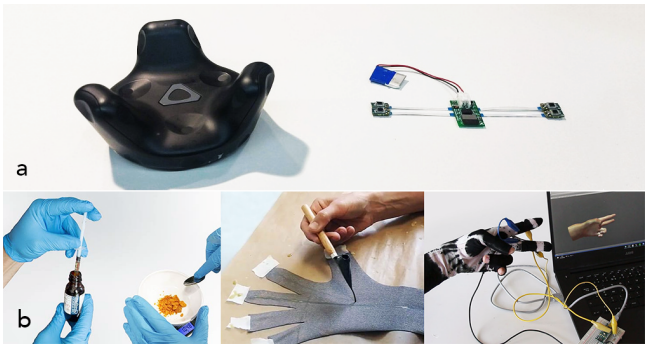

Figure 6: (a) HiveTracker: miniaturized 3D position sensing. (b) PolySense: From chemistry to eTextile for VR

Optical 3D positioning is robust to occlusion, but there are other wearable approaches, such as eTextile sensors for motion capture and augmentation.

PolySense [6] is an accessible process to augment materials with electrical properties. The cotton glove in Fig. 6b is connected with clips to a microcontroller, and a VR model simulates the measured movements. Further on-skin approaches were explored with [13] by resistive (pressure, strain) or capacitive sensing (touch localization). These wearable components can be patched onto different body parts to document the movement or augment e.g. the dance by sonification or visualization of it.

3 DISCUSSION

The integration of such multimodal approaches to wearables provokes new challenges and opportunities we are interested in exploring further in the HCI community: What new human skills could evolve with novel tangible tools? [15] How would it affect processes of skill-acquisition, transfer? What new movement and gestures space [2] could then develop? What new methodologies should we use to evaluate the short and long-term influences of *Choreographic Interfaces* on our bodies and behaviour? Above all, how can we establish platforms and toolkits for future research that account for the subjective aspects and variations of human experience, allowing the invention of new skills and expressions?

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