Choreographic Interfaces: Wearable Approaches to Movement Learning in Creative Processes

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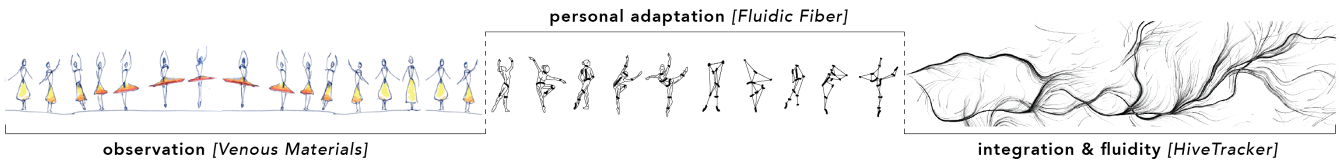

Figure 1: Vision sketch, three layers of Choreographic Interfaces

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 [14]. Movement is an essential feature of how we interact with the tangible world: from the most basic daily operations, to body language and unique 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, 13], music [8, 13, 16] and craftsmanship [10, 19] where the researchers build technologies to support the articulation of tacit knowledge using computational processes such as [18]. We explore if movement-based processes can be further deepened and retained with the support of tangible technologies that augment covert 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 technologies that serve as a wearable support layer for creative movement skill acquisition and transfer.

2.1 Visualizing hidden bodily forces and movements: Venous Materials

The soft, conformable, and analog characteristics of Venous Materials (Fig. 2a) 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.

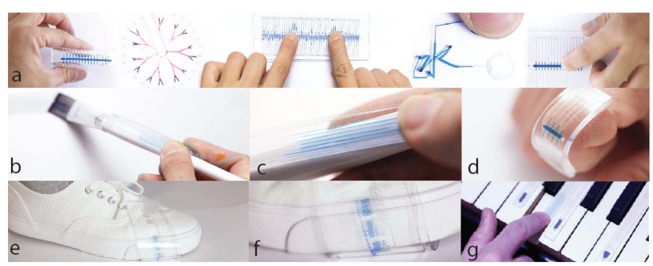

Figure 2: Venous Materials: (a) bending, pressure memory, slider, calligraphy, (b-c) attached to paint brush, (d) joint bending sensor, (e-f) attached on shoe for gait training, (g) applied pressure on a piano key.

Venous Materials [9] is a novel approach to 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.2), Venous Materials allows for display of hidden forces and movement information. Such material can serve as an informative tool for performers / audience. It can also be used as a real-time display for learning creative activities such as playing the piano and painting.

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 provides a haptic channel for capturing and transmission of otherwise unfelt, tacit movement qualities, such as "viscosity" [1], mediating bilateral haptic interactions among multiple bodies. Thin linear forms are ubiquitous geometric building blocks found throughout nature. In Fluidic Fiber, we leverage the thin and flexible fiber form factor as a building-block to choreograph closed loop movement-based interactions. Our toolkit constitutes a modular design system based on strain-programmable fluidic muscle fibers with multimodal haptic feedback capability. (Fig.3a) While our design system is based on existing thin McKibben muscles similar to [7], we augment 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 ($620\mu m$) for machine knittability of programmable full-body garments.

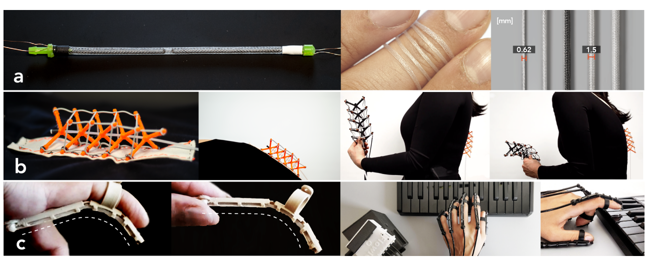

Figure 3: Fluidic Fiber: (a) Strain-programmable fluidic fiber assembly at scales, (b) Garment-attachable spine tensegrity for movement reflection in dance learning processes, (c) Visual and haptic movement guidance in instrument learning.

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 & replay of motion sequences to observe and segment movements at a desired pace (Fig.3b)
- Direct mapping of kinaesthetic feedback from expert's body to the novice & vice versa in a remote learning scenarios

Advancing the motion range of a single muscle fiber by inserting mechanical constraints allows the user to utilize them as a visual guide in observing precise finger motions as in sign language or instrument playing. (Fig.3c)

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, 12] is a miniaturized system for scalable and accurate 3D positioning (see Fig. 4a). 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.
- Rodents position VS brain activity correlation analysis.

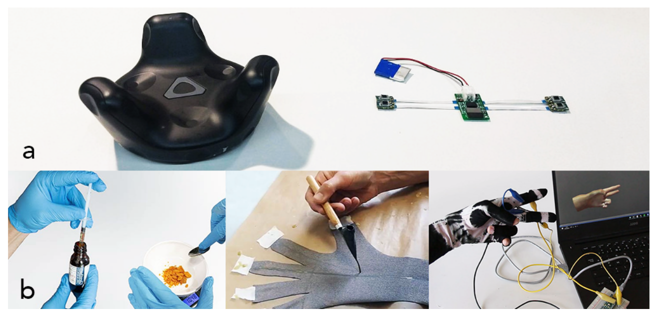

Figure 4: (a) HiveTracker: miniaturized 3D position sensing. (b) PolySense: From chemistry to eTextile for VR

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. 4b is connected with clips to a microcontroller, and a VR model simulates the measured movements. Further on-skin approaches were explored with [15] 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

We proposed a multilayered integration of Choreographic Interfaces to envision how such a system could enable new capabilities for enriching the body's somatic and creative capacities. Such multimodal approach provokes new challenges and opportunities we are interested in exploring further with the HCI community: What new movement and gesture space could develop with the support of tangible tools? [2, 17] What new methodologies should we use to evaluate the short and long-term influences of *Choreographic Interfaces* on our bodies and behaviour? Lastly, how may the integration of such technologies alter the movement practice itself?

REFERENCES

[1] Sarah Fdili Alaoui, Baptiste Caramiaux, Marcos Serrano, and Frédéric Bevilacqua. 2012. Movement Qualities as Interaction Modality. In *Proceedings of the Designing Interactive Systems Conference* (Newcastle Upon Tyne, United Kingdom) *(DIS '12)*. Association for Computing Machinery, New York, NY, USA, 761–769. https://doi.org/10.1145/2317956.2318071

[2] Jessalyn Alvina, Joseph Malloch, and Wendy E. Mackay. 2016. Expressive Keyboards: Enriching Gesture-Typing on Mobile Devices. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology* (Tokyo, Japan) *(UIST '16)*. Association for Computing Machinery, New York, NY, USA, 583–593. https://doi.org/10.1145/2984511.2984560

[3] Marianela Ciolfi Felice, Sarah Fdili Alaoui, and Wendy E. Mackay. 2018. Knotation: Exploring and Documenting Choreographic Processes. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3173574.3174022

[4] Sara Eriksson, Åsa Unander-Scharin, Vincent Trichon, Carl Unander-Scharin, Hedvig Kjellström, and Kristina Höök. 2019. Dancing With Drones: Crafting Novel Artistic Expressions Through Intercorporeality. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3290605.3300847

[5] Cédric Honnet and Gonçalo Lopes. 2019. HiveTracker: 3D Positioning for Ubiquitous Embedded Systems. In *Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers* (London, United Kingdom) *(UbiComp/ISWC '19 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 288–291. https://doi.org/10.1145/3341162.3349295

[6] Cedric Honnet, Hannah Perner-Wilson, Marc Teyssier, Bruno Fruchard, Jürgen Steimle, Ana C. Baptista, and Paul Strohmeier. 2020. *PolySense: Augmenting Textiles with Electrical Functionality Using In-Situ Polymerization*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3313831.3376841

[7] Shunichi Kurumaya, Hiroyuki Nabae, G. Endo, and Koichi Suzumori. 2017. Design of Thin McKibben Muscle and Multifilament Structure. *Sensors and Actuators A: Physical* 261 (05 2017). https://doi.org/10.1016/j.sna.2017.04.047

[8] S. Leigh and P. Maes. 2018. Guitar Machine: Robotic Fretting Augmentation for Hybrid Human-Machine Guitar Play. In *NIME*.

[9] Hila Mor, Tianyu Yu, Ken Nakagaki, Benjamin Harvey Miller, Yichen Jia, and Hiroshi Ishii. 2020. *Venous Materials: Towards Interactive Fluidic Mechanisms*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3313831.3376129

[10] Stefanie Mueller, Anna Seufert, Huaishu Peng, Robert Kovacs, Kevin Reuss, Francois Guimbretiere, and Patrick Baudisch. 2019. FormFab: Continuous Interactive Fabrication. 315–323. https://doi.org/10.1145/3294109.3295620

[11] Aimie Purser. 2017. 'Getting it into the body': understanding skill acquisition through Merleau-Ponty and the embodied practice of dance. *Qualitative Research in Sport, Exercise and Health* 10 (09 2017), 1–15. https://doi.org/10.1080/2159676X.2017.1377756

[12] Darío R. Quiñones, Gonçalo Lopes, Danbee Kim, Cédric Honnet, David Moratal, and Adam Kampff. 2018. HIVE Tracker: A Tiny, Low-Cost, and Scalable Device for Sub-Millimetric 3D Positioning. In *Proceedings of the 9th Augmented Human International Conference* (Seoul, Republic of Korea) *(AH '18)*. Association for Computing Machinery, New York, NY, USA, Article 9, 8 pages. https://doi.org/10.1145/3174910.3174935

[13] Andreas Schlegel and Cedric Honnet. 2017. Digital Oxymorons: From Ordinary to Expressive Objects Using Tiny Wireless IMUs. In *Proceedings of the 4th International Conference on Movement Computing* (London, United Kingdom) *(MOCO '17)*. Association for Computing Machinery, New York, NY, USA, Article 4, 8 pages. https://doi.org/10.1145/3077981.3078040

[14] Catherine Stevens. 2021. Trans-disciplinary approaches to research into creation, performance and appreciation of contemporary dance. 154 (01 2021).

[15] Paul Strohmeier, Narjes Pourjafarian, Marion Koelle, Cedric Honnet, Bruno Fruchard, and Jürgen Steimle. 2020. Sketching On-Body Interactions Using Piezo-Resistive Kinesiology Tape. In *Proceedings of the Augmented Humans International Conference* (Kaiserslautern, Germany) *(AHs '20)*. Association for Computing Machinery, New York, NY, USA, Article 29, 7 pages. https://doi.org/10.1145/3384657.3384774

[16] Xiao Xiao and Hiroshi Ishii. 2010. MirrorFugue: Communicating Hand Gesture in Remote Piano Collaboration. In *Proceedings of the Fifth International Conference on Tangible, Embedded, and Embodied Interaction* (Funchal, Portugal) *(TEI '11)*. Association for Computing Machinery, New York, NY, USA, 13–20. https://doi.org/10.1145/1935701.1935705

[17] Lining Yao, Jifei Ou, Chin-Yi Cheng, Helene Steiner, Wen Wang, Guanyun Wang, and Hiroshi Ishii. 2015. *BioLogic: Natto Cells as Nanoactuators for Shape Changing Interfaces*. Association for Computing Machinery, New York, NY, USA, 1–10. https://doi.org/10.1145/2702123.2702611

[18] Matteo Zago, Ana Francisca Rozin Kleiner, and Peter Andreas Federolf. 2021. Editorial: Machine Learning Approaches to Human Movement Analysis. *Frontiers in Bioengineering and Biotechnology* 8 (2021), 1573. https://doi.org/10.3389/fbioe.2020.638793

[19] Amit Zoran, Roy Shilkrot, Suranga Nanyakkara, and Joseph Paradiso. 2014. The Hybrid Artisans: A Case Study in Smart Tools. *ACM Trans. Comput.-Hum. Interact.* 21, 3, Article 15 (June 2014), 29 pages. https://doi.org/10.1145/2617570