Designing Personalized Movement-based Representations to Support Yoga

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Abstract
An inherent consequence of the turn to a third-wave HCI is the need to design for diversity in interaction and therefore a need for personalization of movement-based interactions, based on each's skills and characteristics. However, one of the major challenges is the question how designers can represent movement. Personalization is an essential issue in Yoga practice because there are no standard movements. The specific actions and poses depend on the individual body conditions of each practitioner. Three movement-based representations for personalized feedback during Yoga were developed (visual, auditory and haptic). Different participants offered different explanations about the feedback they received during the exercises. This leads us to believe that there is indeed a need for personalization of movement-based representations.

Author Keywords
Interaction design; personalization; movement-based design; Yoga; haptic feedback.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Figure 1: First-person perspective methodology, Yoga sessions with the design team.

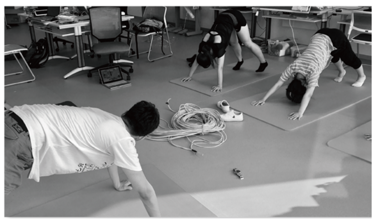

Figure 2: Downward Facing Dog pose.

Figure 3: Collaborative affinity diagramming session with design team.

Introduction

Third-wave Human-Computer Interaction emphasizes the embodied and situated nature of interaction, and the construction of meaning through interaction [1], [2]. An important challenge within this paradigm is the need to enable all of a person's senses to be leveraged in an emergent design space [3]. Various approaches have gained interest within the HCI community, such as somaesthetics [4], movement-based interaction [5]-[7], and the design of aesthetic experiences [8]. Wilde et al. addressed this issue by analyzing and combining several methods into a framework which aims to make it easier to discriminate between different methods, share them, adopt and adapt them [3]. Most of these methods are drawing mainly from phenomenology and have in common the appreciation for lived experience and the lived body, in accordance to the unique action possibilities of each person [9], [10]. As Hummels et al. put it "Because we all have our own physical, emotional and rational characteristics, our own history in life and our own needs, our preferred movements will differ, and consequently we prefer different possibilities for action" [5]. Therefore, as our starting point for this provocation, we argue that an inherent consequence of the turn to a third-wave HCI is the need to design for diversity in interaction and therefore a need for personalization of movement-based interactions, based on each individual's skills and characteristics.

The emerging area of movement-based interaction design is increasingly popular, with application domains ranging from dance, sport, gaming to physical rehabilitation [11]. However, one of the major challenges for the design of movement enabled interaction is the question how designers can represent movement, as well as which aspects of movement can be used as input for sensing technology [12]. As a particular movement-based practice for this design inquiry, we have taken Yoga as a focus point to explore representation modalities of movement. Personalization is an essential issue in Yoga practice because there are no standard movements. The specific actions and poses depend on the individual body conditions of each practitioner. In addition, people with different health conditions are in need of different types of feedback. Therefore, personalized training can benefit people with different needs and conditions to finish the Yoga poses efficiently and without harm to their health. Moreover, by practicing Yoga ourselves, we were able to consider movement-based interactions through the lens of a first-person perspective, enabling the design team to communication and collaboration regarding the designed subjective aesthetic experiences [13].

Yoga has been used as a practice related to developments in HCI in other related work. For example, Fels et al. developed a system that could recognize gestures and enhance the Yoga experience through visual, auditory and olfactory feedback [14]. "Sonic Cradle" aimed to offer mindfulness training by creating an auditory soundscape [15]. In the case of "Social Yoga Mats" the aim was to share physical exercise activity with others [16]. Through more technical perspective several studies investigated how to recognize Yoga poses to offer better training feedback. For example by using Computer Vision to detected specific poses [17]. In the case of "Cloud Mat" specific poses could be detected by the Mat itself and could be used to visualize training progress [18]. Other research focused on using wearable sensors to translate and synchronize the Yoga poses to an accurate avatar in a virtual environment [19].

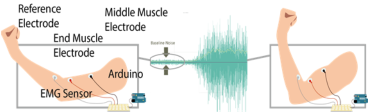

Figure 4: EMG sensor with three surface electrodes placed on the skin; it uses an amplifier and microcontroller to visualize the voltage difference between two electrodes.

Figure 5: Real-time visual feedback. Wrong muscles indicated with red color, correct muscles indicated with green color.

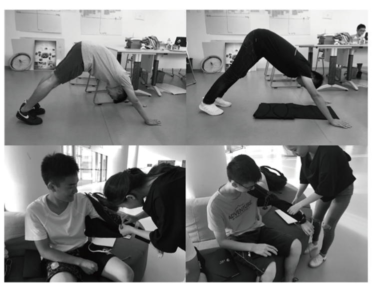

Figure 6: Testing the prototype (a sleeve with sensors and vibration motors) with participants.

Designing Feedback

Interviews were conducted among 20 Yoga practitioners and Yoga teachers in a Yoga school in Suzhou (China) and analyzed by the team during a collaborative affinity diagramming session (Figure 3). Many beginners choose to take classes because they are afraid to hurt themselves. Some experienced Yoga practitioners mentioned that using the wrong muscles, could result in immediate or long-term physical damage. Furthermore, the team organized weekly Yoga sessions to understand the Yoga learning process from a first-person perspective (Figure 1).

A valuable insight was that a fundamental Yoga pose such as the "Downward Facing Dog" consists of many intricate movements, which are easily mistakenly performed (Figure 2). The team used video as an instruction method but noticed that it is difficult to follow visual representations of the Yoga movements because of the disconnect between the body movement and the video. Based on this initial research the team decided to focus on exploring how personalized movement feedback could be provided during Yoga. Because of the focus on personalized movement feedback rather than technical recognition of Yoga poses we focused only on the Downward Facing Dog pose; a versatile pose that incorporates elements of standing poses, arm balancing, forward bends and backbends. We used an electromyography (EMG) sensor to detect the tension of a muscle, or, in other words, whether a muscle is working or not (Figure 4). The triceps muscle was selected because of the importance during the pose, its convenient location and the signal quality. The sensor was integrated in a sleeve which could be strapped around the upper-arm of the Yoga practitioner (the sleeve is shown in Figure 7).

- *Visual Feedback:* Animations were designed using Principle and connected wirelessly to the EMG sensor using MaxMSP. Based on the time-real data from the EMG sensor, the animations showed different colors representing the status of the various muscles. If the user uses wrong muscles, the visual feedback will point it out with red colors, and if it is correct, the visual feedback will be identified with a green color (Figure 5).
- *Auditory Feedback:* The audio feedback provides real-time feedback as training advice. When the correct muscle is working, and the wrong muscle is relaxing, the software will provide positive audio feedback such as "Correct posture. Well done!". Vice versa, if the user is using the wrong muscle, which means the user's posture is wrong, there will be negative audio feedback as a warning and reminder, such as "Please bend your elbow slightly and push the ground by your hands, feeling the triceps muscles of your arms tensed."
- *Haptic Feedback:* Temperature (hard to feel during the exercise) and electrical muscle stimulation (lead to uncontrollable muscle contraction) were considered as haptic feedback mechanisms. Finally, vibration feedback was further developed by adding vibration motors to the prototype on the muscle groups around the triceps area. If the muscle was required to be used (but not activated by the user) the motors located on that muscle would start to vibrate. Three different patterns of vibration for the elbow and triceps muscle were designed. Pattern 1 (Figure 7) aimed to inform the user to correct their arm from straight to slightly bent. Pattern 2 (Figure 8) aimed to inform users to turn their elbow slightly outward. Pattern 3 (Figure 9) aimed to help users to recognize the location of the muscle required to be used.

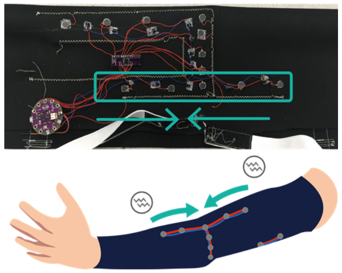

Figure 7: Vibration Pattern 1. Varied vibration intensity: the outside two motors' intensity is strong, inside two is medium, and the central motor is weak.

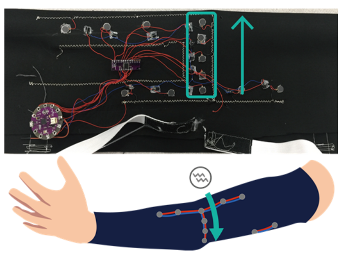

Figure 8: Vibration Pattern 2. Motors vibrate one by one from inside of the elbow to outside of the elbow.

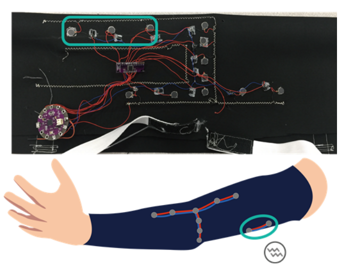

Figure 9: Vibration Pattern 3. Three single motors vibrate synchronously on the triceps muscles, with the same intensity.

Reflection on Personalized Feedback

We invited five participants to test the different feedback mechanisms in combination with the measurements of the EMG sensor (Figure 6). Each participant was asked to practice the Downward Facing Dog pose; first instructed by a pre-recorded video, and the second time provided with real-time visual, auditory, and haptic feedback.

Visual feedback: Some participants felt confused about the real-time feedback because they didn't understand what the colorful lines and blocks meant without extra explanation. The combination of the visuals with the physical location of the sensor offered hints, as one participant mentioned: "Maybe according to the visual feedback and the position where you put the sensor to my skin I could get an idea that if I want to do the right pose my elbow may need to be bent to an angle."
Auditory feedback: The auditory feedback was helpful to make people aware when they were in the right position. However, based on the observations, the auditory feedback is not precise enough to help participants make adjustments during their movements.
Haptic feedback: Two participants mentioned that Pattern 1 suggested them to use more strength. All the three participants mentioned that they could feel the intensity change of motors in Pattern 2, and believed that this meant something. During Pattern 2, one participant mentioned that when it vibrates inside of his elbow, he would bend his elbow while when it vibrates on the outside, he would stretch his elbow. The other participants noticed that motors were vibrating on their arms but couldn't determine the specific location. Pattern 3 worked best because it offered the clearest feedback about where the triceps muscle was located.

Insights and reaction to provocation

Based on the explorations and tests with participants we believe the issue of movement based feedback offers many more dimensions than we have currently explored. For example, one participant mentioned the difficulty of positioning their body in space: "I can't imagine the position and situation of my waist in space. Should I do like this, or lower, or slightly backward, or something else?". The indication that feedback could be combined with spatial information is an exciting future direction. Moreover, several participants offered different explanations about the movement representations they received during the exercises, for example in the case of the visual feedback and the haptic feedback in Vibration Pattern 2. This leads us to believe that our earlier provocation holds some merit; there could be a need for personalization of movement-based interactions, based on each individual's skills and characteristics. Further developments of the representations, and more extensive comparative testing could offer more insights. Although this exploration is limited by the short timeframe of the project, there is a potential of further pursuing the exploration of personalized movement-based feedback in the context of Yoga, but also for the broader design area of interactive systems.

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