Social Physiological Data Awareness in Collocated Mixed Reality Movement

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Abstract

We are a research team embarking on a project to explore how physiological data could augment the sociality of collocated movement. We briefly discuss how related HCI research in social wearables and embodiment can inform how physiological signals can augment collocated experiences in mixed reality. Then, we present three types of social awareness of physiological data overlays in mixed reality. To illustrate use cases, we present depictions of mixed reality with physiological data overlays for individual training, group exercise, and the mutual movements of acroyoga and capoeira. Finally, we raise topics for discussion during the workshop related to this project.

Keywords

Mixed Reality, Collocated Movement, Physiological Signals, Social Sensemaking

1. Introduction

Mixed Reality (XR) accessed through head mounted displays (HMDs) provide an opportunity for users to juxtapose digital interfaces with realtime views of the real world environment. In the context of remote work, McVeigh-Schultz et al. discuss that XR affordances may even offer ways to transcend the benefits offered by in-person presence by showing digital visualizations and providing computational tools that augment social interaction [1]. Such benefits may be possible during collocated movements for exercise and play; if people engaged in collocated movement wore HMDs, perhaps XR interfaces could provide opportunities for enhancement. For example, Walmink et al. demonstrate how displaying a heart rate on a bicycle helmet could offer useful technology interactions in social movement [2]. While this HMD does not show a biosignal in an immersive environment such as XR, it is an example of how HMDs could be worn during sport while displaying biosignals over multiple moving sources. We are a research team embarking on a project to explore how physiological data interfaces in XR augment sociality during different types of collocated movement activities. To approach researching designs of such interfaces, we are currently examining related work in immersive exergaming, collocated embodiment, and integration of physiological signals. In this workshop paper we present three types of social awareness of physiological signals and discuss speculative circumstances, opportunities, and challenges.

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2. Related Work

Turmo Vidal et al. present the strong concept of Intercorporeal Biofeedback, where information from physiological data sources guide movement and serve as an interactional resource for people in social movement practices [3]. The presentation of this concept emphasizes an idea that the role of technology should not replace human expertise, but provide augmentations that can be selectively used. This is especially important for partnered activities discussed later in this paper, such as acroyoga (Fig. 3) and capoeira (Fig. 4), where practitioners rely on instincts and proprioception built through experience. Márquez Segura et al. give design criteria through an analysis of social fitness games and describe how these criteria can transfer to immersive experiences [4]. Within immersive games, wearable technology can be used in a system to record physiological signals for adaptive interfaces in games [5], and alter body perception [6]. In the context of enhancement, such biodata can be collected to expand physiological state awareness [7], modulate exertion or to enhance synchrony [8] or cohesion [9] among users.

Physiological signals can be used to represent myriad internal states. In the overlays depicted in this paper (Fig. 1,2,3), we show heart rate and heart rate zones which can be represented with numbers and colors. Physiological signals can also provide information about affective state [10], however, the complexity of data sources and processing may increase the cognitive load of real-time sensemaking. Daudén Roquet et al. explore the use of color palettes for depicting emotional states from brain computer interfaces [11], an example of using an abstract representation of physiological signals.

Once the physiological data is processed for representation, HCI research in social wearables and collocation can inform XR design. For example, in True Colors, a wearable device which can signal vulnerability during a live action role playing game, players can see the internal state of other players by interpreting the lights on a wearable device [12]. In a similar way, overlays in mixed reality can help reveal internal state.

3. Types of Social Physiological Signal Overlays

To explore challenges and opportunities that physiological data visualizations could afford collocated mixed reality applications, we present three types of social awareness of this data. Such types have differing symmetry of access [13] which could inform interface design.

- **One to one** - One person wears an HMD to view detailed physiological data and related visualizations on an individual.
- **One to many** - One person wears an HMD to viewands physiological data and aggregate information of several individuals.
- **Mutual** - Each person participating in the collocated activity wears an HMD and can view each other's physiological data visualizations in mixed reality.

In Table 1 we show each of these types with the use cases. In the following sections, we elaborate on opportunities and challenges.

Table 1
Types of Social Physiological Awareness with example circumstances

Type	Circumstances
One to one	Partner drills, individual training
One to many	Coaching a team, teaching a group exercise class
Mutual	Cooperative play

Figure 1: *Left:* A training partner who would be wearing a mixed reality device indicates a location on the ground using a stick. *Right:* A trainee performs a one-handed push-up exercise on that location. Augmented overlays indicate heart rate, heart rate zone, and a history of exercise locations color coded by effort calculated from physiological signals.

4. One to one

Fig. 1 depicts a partnered training drill where the trainer indicates a location on the ground and the trainee attempts to do a one-handed push-up at that location. The trainer is responsible for selecting a variety of locations while modulating the difficulty during each session. In the figure, the overlay on top of the trainee shows the trainee's heart rate and heart zone, indications of effort. On the floor, an overlay depicts the history of previous movements, color-coded by the difficulty calculated from the heart rate.

While the trainee is fully focused on performing a complex movement, one to one physiological data overlays provide an opportunity for the trainer to make informed decisions to guide the training. However, there is a design challenge in the integration of the history of physiological signals with representations of prior movements in the data visualization on the floor.

5. One to many

In a one to many circumstances, a coach or a group exercise trainer may be monitoring the efforts of several trainees simultaneously. Fig. 2 depicts the view of a coach supervising two people who are performing weight training exercises at the gym. In this way, a coach can quickly see the heart rate zones as an indicator of effort, and advise a trainee if the heart zones

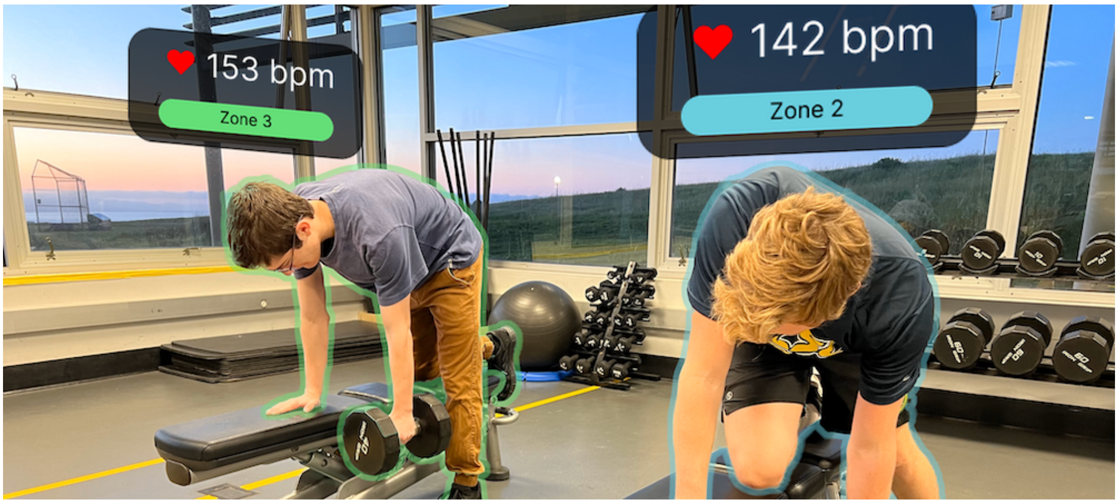

Figure 2: In this speculative view from a mixed reality device, two people perform a weight training exercises with an overlay containing their heart rates above.

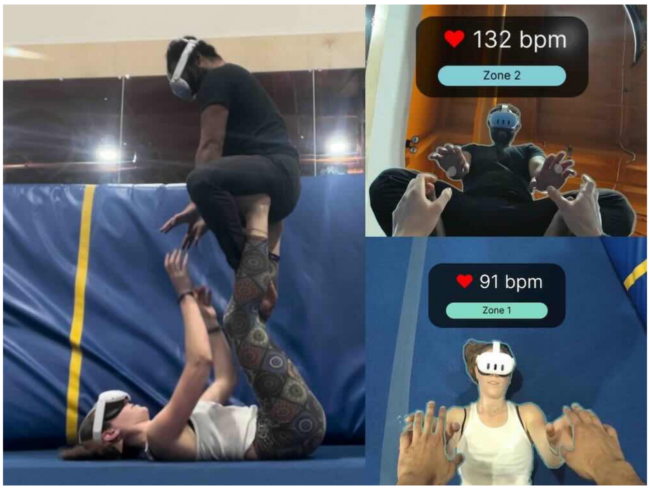

Figure 3: *Left:* The authors demonstrate an acroyoga pose called throne. The person on the bottom is called a *base*, and the person on the top is a *flyer*. *Top Right:* View captured from the base's Meta Quest 3 with a speculative heart rate overlay. *Bottom Right:* View captured from the flyer's Meta Quest 3 with a speculative overlay.

are at an concerning level. As the quantity of trainees increases, or if trainees are moving around, there is a challenge in designing an interface that can selectively call attention to important information.

Figure 4: The authors play capoeira while wearing mixed reality headsets.

6. Mutual

In mutual collocated movement, participants cooperatively move while constantly perceiving each other's physiological state to avoid taking actions that could cause harm. For example, during acroyoga, participants work together for partner acrobatics, communicating through speech and touch in order to achieve poses. In the interface depicted in Fig. 3, participants can see each other's heart rate as a representation of effort. However, during poses, participants may not always be able to see other, so overlays that are positioned over a partner's head may not be helpful.

This is especially difficult during capoiera, a playful martial art where players may attempt to push each other, but not past a threshold where there is risk of injury. Such complexity, in the context of HCI, has been researched [14] and could inform the design of interface for combative movement. While physiological signal overlays could enhance the perception of a partner's internal state, players may not have their partner in their field of view while performing an acrobatic movement, such as the player on the left in Fig. 4. There is a need for interface designs that promote the view of this information during atypical movement. Since both acroyoga and capoiera are ways of playing, there is an opportunity to apply a body-centric framework for play to the design of such applications [15], as well as explore complex intimacy [16] and the emotion of a face to face computer-mediated social interaction [17].

7. Topics for the Workshop

We are in the process of creating prototypes for these circumstances and designing participatory design and validation methods for these interface designs. By attending this workshop, we hope to meet potential collaborators for this project and foster discussion on the following topics:

- Which physiological signals should be tested in mixed reality visualizations? (i.e. galvanic skin response, stretch and strain)

- What are ways that physiological signals could augment sociality in collocated movement?
- How should the sensor system be implemented for the movement and realtime needs of collocated movement? (i.e. deformable sensors, electroencephalography)
- How should the display of these signals be visualized in virtual reality?
- How do we navigate the ethical and privacy concerns of social physiological data?
- How should sensors and wearable devices be designed for safety during collocated movement?

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