Multimodal Sports Interaction: Wearables and HCI in Motion*

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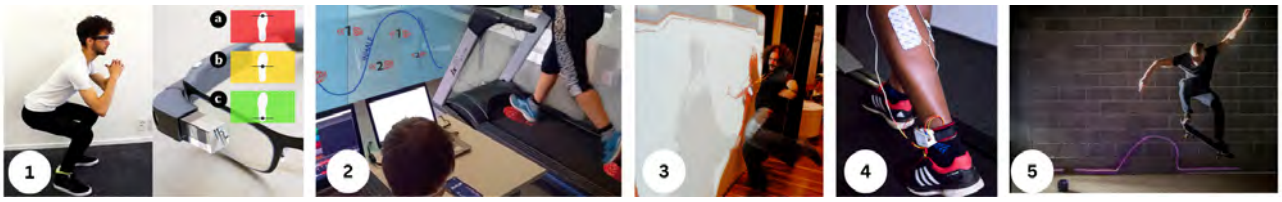

Figure 1: Modalities in SportsHCI concepts and designs. 1: Google Glass to provide feedback to improve body posture when performing squats [7], 2: using sound to connect breath and running movement into a rhythm [10, 33], 3: visual modality to allow for shadowboxing over a distance [20], 4: Haptic feedback for running technique with electro-muscular stimulation [11], 5: visual and sound feedback in skateboarding [22]

ABSTRACT

Wearable and mobile technologies hold the promise to be used 'on the move' as they are portable. It is common to listen to music during a run, track steps during the day, and have phone calls on the go. More advanced systems support, for example, athletes in increasing their performance, enhance their technique, and discuss sports data with a coach. To facilitate these experiences, providing such often multimodal feedback that is understandable, timely, and does not interfere with the sports activity is key. In this workshop, we will discuss multimodal feedback for sports so that more people can profit from wearable technologies. We will use prior work on truly mobile interaction as a framework analyze existing works and will hands-on explore various modalities to experience the pros and cons of modalities in motion.

KEYWORDS

Multimodal interaction, Wearables, Feedback systems, Sports

*1-day workshop

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1 INTRODUCTION

Wearable technology has attracted the interest of many sports enthusiasts, such as athletes, coaches and researchers, due to a wide range of uses, such as improving sports performance [29], and sports technique [10, 11], facilitating coaching tasks [27], reducing the risk of injuries [23], and supporting the experiential aspects of sports activities [12]. Particularly, researchers pointed out that the multimodal interactions wearables afford could be one of the success factors for sports [18]. Furthermore, the portability of mobile systems, such as smartphones and smartwatches, does not directly imply that the interactions with these systems can be used during movement in highly dynamic activities such as skateboarding [22], swimming [1] or rowing [25]. However, there is not much knowledge about how to design multimodal interactions for sports wearables. This workshop aims to develop an understanding of multimodal interaction of these complex contexts of use.

Researchers have utilized a variety of modalities in sports contexts for in-motion feedback [6, 18]. Visual feedback is predominantly provided through screens (e.g. through a Head-up Display [7] or in smartwatches [26, 29]) or through LEDs [1]. While vision is the preferred modality for swimming [1], many researchers argue that the visual modality is less applicable for sports as it obscures the

vision that is needed for the sports activity itself (e.g. [13, 25, 34]). Haptics is mainly explored through vibro-tactile feedback (e.g. [14] and through electro-muscular stimulation [11]. Sound has been commonly explored within the realm of sports, as shown by a variety of literature reviews on sonification [25, 30], and exemplified by [22, 33]. Next to sonification also verbal cues are used to provide feedback, e.g. in common sports applications such as Strava [1]. Only limited amount of studies aimed to compare modalities in sports contexts, such as [1, 8, 14].

The physical context of certain sports affords opportunities and restrictions to how wearables can be designed [6, 15]. For example, a snowboard provides a ready surface for visual feedback [4] and cycles offer a sturdy frame to mount equipment [5]. While fast and rapid changes in movement are a key consideration for feedback design, sports activities require mental load from the athlete, and external factors such as temperature, wind, rain may obscure the athletes' ability to perceive feedback. An understanding of the sports context — activities, materials, and outdoor environment — are key for designing effective multimodal feedback.

Although HCI researchers face challenges in developing mobile devices for sports, Marshall et al. [15] provided a taxonomy of mobile interaction to begin closing this gap. This taxonomy divides movement interaction into two dimensions. First, to what extent is the interaction task related to the locomotion task. Second, to what extent does the locomotion activity inhibit the ability of the user to interact with a system? Additionally, they provide four strategies for designing mobile interactions. We will take this work as a starting point to analyse and discuss feedback modalities in sports contexts.

In this workshop, we aim to establish a multidisciplinary platform where researchers, practitioners, and designers to explore multimodal feedback for sports wearables. Other workshops have explored the context of SportsHCI[16, 17, 21, 28, 31**?**], showcasing a wide interest in the field. In contrast, to these workshops, we explore how multimodal feedback can support different sports by discussing existing interaction frameworks from (mobile) computing such as glanceable interactions [9], peripheral interactions [2]. Additionally, we will hands-on explore multimodal feedback in sports through "quick and dirty" prototyping, delving into under-explored modalities such as temperature change and smell, and look into technologies such as shape-changing inflatables [24].

2 GOALS OF THE WORKSHOP

The workshop goals are as follows:

- Providing an interdisciplinary forum for researchers, practitioners and designers to discuss multimodal feedback modalities for sports wearables
- Discussing state-of-the-art research on mobile systems for sports, as well as practices and experiences from using wearables to sports applications
- Getting hands-on experience with various feedback modality prototypes (haptic, sound, visual, etc)
- Building an overview of feedback modalities for sports and
- Contributing a special issue on feedback modalities in sports wearables (e.g., in Interactions)

[1] https://www.strava.com/

3 TOPICS OF INTEREST

The topics of interest for the workshop include theories, technologies, and applications related to the use of mobile sports wearables. Relevant topics include, but are not limited to:

- Multimodal feedback modalities for sports, going beyond visual, auditory and haptic feedback
- Mobile technology, including portable hardware, and software such as AI
- Wearable devices, from existing off-the-shelf devices to research prototypes utilising sensors and actuators
- Applications in indoor/outdoor sports
- Truly mobile interaction design approach [15] for wearable systems in sport
- Accessibility and inclusivity through interaction design
- Methods for longitudinal studies with mobile and wearable systems for sports.

4 PRE-WORKSHOP PLANS

We aim for 15-25 participants to participate in the workshop. To achieve this, we will announce the call for participation (CFP, see App. A) on the workshop's website and share it extensively with potential interested individuals and communities. Participation is welcome from (academic) researchers, and industry professionals. The CFP will additionally be distributed through HCI-related mailing lists (e.g. CHI Announcements) and social media. Those interested will be required to submit a position paper providing the following information:

- Background: Describing the participant's experience using wearable, mobile or interactive systems in sports, as well as their previous research practice in the area.
- Sport systems and experiences: Two good and two bad examples of modality usage in sports, arguing the choice of the examples and, if possible, adding a representative image. The participants can present systems they made themselves. The examples will be used in the proposed activities, which will be explained in the next section.
- Short description of the quick and dirty prototyping materials that the authors aim to bring to explore and conceptualize novel feedback modalities (e.g. actuators, wearables, mobile systems that can be repurposed)

Additionally, we will provide a basis for the quick and dirty prototyping exercise (as described below). This will consist of actuators to prototype and experience a variety of feedback modalities (e.g. shape-changing haptics, sound, lights), and accessories to prototype wearability (e.g. elastic bands and t-shirts with Velcro to attach actuators). Furthermore, we will reach out to participants to ensure an inclusive and accessible workshop (see App. B).

5 WORKSHOP STRUCTURE

The workshop will be 6 hours in duration. Activities include a presentation by an invited speaker, brief participants' presentations, content discussion and quick and dirty prototyping to explore novel multimodal wearable and mobile systems for sports. In detail, the activities will be conducted in the following order:

- Activity one: Workshop introduction and keynote speaker.

- Activity two: Participants will present/demonstrate their examples of good and bad systems, and are encouraged to cluster them to the truly mobile interaction framework [15].
- Activity three: Participants will be divided into groups and engage in quick and dirty prototyping to conceptualize novel multimodal feedback for a specific sport activity.
- Activity four: Participants present/demonstrate the concepts. These will be clustered again according to the truly mobile interaction framework. The workshop is closed by identifying the next steps for mobile wearable systems for sports.

6 TIMELINE

Table 1 shows the proposed timeline for the workshop. We will adapt the timeline depending on the number of participants to allow for a well-balanced and energetic workshop.

Table 1: Tentative Workshop Timeline

Time	Activity
10 minutes	Opening
20 minutes	Keynote
55 minutes	Participants' presentations + clustering of examples
15 minutes	Break
55 minutes	Participants' presentations
30 minutes	Break
55 minutes	Hands-on quick and dirty prototyping activity
15 minutes	Break
60 minutes	Group presentations + clustering of concepts
15 minutes	Break
30 Minutes	Next steps
10 minutes	Closing

7 POST-WORKSHOP PLANS & OUTCOMES

The workshop results will be communicated to a larger audience through the workshop website. A selection of academic publications will be considered based on the outputs of the workshop sessions(e.g. an ACM Interactions report, an IMWUT paper based on the discussions).

Through the workshop activities, and building on the expertise of facilitators and participants, the anticipated workshops outcomes are as follows:

- Overview of pros and cons of feedback modalities for sports
- Novel modality design concepts for feedback systems in sports
- Articulation of next steps for feedback modalities in SportsHCI
- Collaboration towards a joint journal contribution

8 ORGANIZERS

The organizing team includes scholars of different backgrounds with extensive experience in hosting workshops at major HCI venues, with a focus on embodied interaction, SportsHCI, and mobility. Four of the organisers participated in the SportsHCI Dagstuhl seminar in 2023 and co-authored the Grand Challenges in SportsHCI paper [6].

Vincent van Rheden is a research fellow at the Human-Computer Interaction division of the University of Salzburg, Austria. His PhD focuses on supporting runners with breathing techniques through interactive sonification systems [32, 34]. Additional interests are in embodied interaction and SportsHCI [30] in general. He has co-organized the CHI'21 workshop "Out of Your Mind!? Embodied Interaction in Sports"[31].

Maria 'Mafe' Montoya Vega is a PhD candidate at Exertion Games Lab, Department of Human-Centred Computing of Monash University, Melbourne, Australia. Her research project focused on designing novel experiences for water activities using interactive Technologies [19]. She co-organized the WaterHCI CHI'22 workshop "Splash! Identifying the Grand Challenges for WaterHCI" [3]. Moreover, her prior experience is focused on developing virtual reality environments for rehabilitation and physical activity using physiological sensors.

Don Samitha Elvitigala is an assistant professor in the Exertion Games Lab, Department of Human-Centred Computing of Monash University, Melbourne Australia. His research investigates novel human augmentations that can enhance human capabilities using closed-loop sensing and actuation. In particular, he explores how we can develop closed-loop bodily integrations utilising everyday clothes and clothing accessories. He has co-organized the TEI'24 studio "Foot Augmentation 101: Design your own Augmented Experiences"[35] and he is the co-program chair for AHs'24.

Prof. Alexander Meschtscherjakov is a full professor at the HCI division of Salzburg University. His research focus on new forms of user interface design, user experience with mobility systems, and persuasion to foster new forms of behaviour. He co-organized conferences such as AutomotiveUI'11 or Persuasive'15 and was co-organizer of more than 25 workshops (e.g., AutomotiveUI'13-16, CHI'15-'21).

Prof. Florian 'Floyd' Mueller is Professor of Future Interfaces at Monash University in Melbourne, Australia, directing the Exertion Games Lab. His research spans interaction design, human-computer interaction, game design, computer science, information science, sports science, philosophy, mechanical and electrical engineering. Floyd was general co-chair for CHI PLAY'18 and was selected to co-chair CHI'20 and CHI'24. Floyd has co-organized over 6 workshops and Dagstuhl seminars around SportsHCI.

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A CALL FOR PARTICIPATION

Feedback modalities are and essential aspect of the success and effectiveness of wearable systems that are used during mobile activities. In the past decades researchers have explored a variety of feedback and feed-forward modalities systems aimed at mobile interactions. Dynamic activities such as sports inhibit interactions, but also offer opportunities for novel interaction designs and technologies. The choice of modalities is essential to provide feedback that is understandable, timely, and does not interfere with the sports activity. This well-balanced hands-on workshop aims to bring together practitioners and researchers working on and interested in mobile and wearable systems. Workshop participants will be offered a platform to collectively discuss and explore current approaches, methods, and tools related to feedback modalities for mobile interactions. To apply, submit a 2-4-page paper (single-column ACM template) position paper consisting of:

- Background: Describing the participant's experience using wearable, mobile or interactive systems in sports, as well as their previous research practice in the area.
- Sport systems and experiences: Two good and two bad examples of modality usage in sports, arguing the choice of the examples. For each example describe how the feedback modality was utilized and the type of feedback that was given and argue why this was a good or bad approach and consider alternative modalities and provide key insights and challenges. and, if possible, adding a representative image. The participants can present systems they made themselves.
- Authors are encouraged to bring material for quick and dirty prototyping to explore conceptualize novel feedback modalities (e.g. actuators, wearables, mobile systems that can be repurposed). Provide a short (visual) description of these materials and how they can be used in the appendix.

- **Submission deadline: 07.06.2024**
- **Notification to authors: 28.06.2024**

Submissions will be reviewed by the organizers and selected according to their relevance to the workshop and the likelihood of sparking discussions and inspire novel feedback approaches and modalities. Accepted workshop papers will be included in the ACM DL. Please note that at least one author of each accepted submission must attend the workshop, and UbiComp/ISWC 2024 is in-person only. For more information, visit: exertiongameslab.org

B INCLUSION AND ACCESSIBILITY

As workshop organizers, we are dedicated to create an inclusive and easily accessible experience for all participants. With the emphasis on sports we recognize the need to ensure that every individual attending the workshop can fully participate, irrespective of their individual requirements. Recognizing the diverse abilities of our participants, we take proactive steps to reach out beforehand to understand any specific needs or accommodations necessary. From addressing sensitivity to touch to managing sensory overload, we customize workshop activities to accommodate a variety of needs. Our approach is mindful of the broad spectrum of participants, aiming to cultivate an environment that respects individual differences and encourages full participation from everyone. Our goal is to ensure that the workshop is a truly enriching and accessible experience for each attendee. Furthermore, our workshop's website, and online materials will adhere to web accessibility standards (such as WCAG) to guarantee accessibility for all.