Exploring Wearable Output Modalities - Screens & Beyond

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For decades, wearable research has explored different output modalities (e.g. screens, lights, scents, thermal, vibrotactile, shape change) implemented in wearable form factors. With these output modalities, prior research addresses a wide range of issues from information representation to self-expression and social cohesion. However, the close proximity of wearables to our bodies makes their design a complex task that requires attention to functional, social, and cultural aspects. Wearables are not just practical artifacts (e.g. conveying concise information for the user or the observer) but have a potential effect on our appearance and social interactions. In this workshop, we look into informative aspects and social challenges around designing different output modalities on bodies. By bringing together researchers and practitioners, we see particular potential in providing a broader perspective on the practical and social aspects of designing wearable output modalities.

CCS Concepts: • **Human-centered computing** → *Ubiquitous and mobile computing*.

Additional Key Words and Phrases: wearable technology, output modalities, ambient displays, social wearables.

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1 BACKGROUND & MOTIVATIONS

Wearable computing devices are a growing form of interactive technologies, which have emerged from research to an ever-widening set of products, including form factors such as watches, bracelets, rings, and garments. Whereas wrists are today a typical body location for a commercial wearables product, and much of their use cases address wellbeing and health [13], wearables are expanding towards a wider set of functions and designs. Technology miniaturization has allowed aesthetics and sophisticated design to play an increasingly important role, as for instance with smart jewelry [22]. As wearable technologies are becoming an increasingly popular tool for data collection, smart clothing and accessories have also started to be adorned with different output modalities, e.g. screens, lights, scents, thermal, vibrotactile and shape changing. With these output features, wearable technologies are capable of conveying information or meaning and reacting to various data from sensors placed on the body, or the surrounding environment [21]. However, designing wearable displays is still a complex task since wearable technologies, in contrast to other interactive objects,

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share the same design space with traditional clothes and accessories. Their design should also consider wearables' social and cultural roles, e.g., in expressing style and/or appropriateness for a context [1, 7, 9].

A common approach in research concepts has been to use visual display elements as an output modality in wearables. Examples range from displaying explicit textual or numerical information related to wellness [18, 21] or the wearer's personal and social character [14], images on a handbag display [4], to a single ambient display light elements on a bracelet [8, 19] or a non-emissive dynamic graphics on a shoe [15]. The output and input modalities on wearables affect the different social interaction levels (tight or relaxed) they will afford [3]. Similarly, the body location of the display influences e.g. the wearer's reaction time to the visual stimulus [10], and how public or private the device is perceived [11]. Research is also exploring the modalities beyond the visual. Shape-changing interfaces have been demonstrated, e.g., with an actuated scarf [23], inflatable extensions in a garment [16], or a bracelet that can crawl up and down the user's arm [6]. The sense of smell has also been utilised, e.g in an olfactory wearable UI with a scent-based notifications [5]. Examples for haptic modalities range from vibrotactile motors embedded in a whole suit [2] to arm-worn wearables creating compression feelings [20] on the arm, or a shawl conveying notifications with heat [24].

Apart from specific applications, a number of workshops have been organized in the past concerning wearables (e.g. [12], [17]). While prior works provide implications for various on-body output techniques, we believe a systematic reflection on the social and practical aspects of wearable output modalities might be valuable contribution to the HCI.

2 WORKSHOP AIM AND THEMES

The workshop aims to provide a venue to discuss specific challenges, opportunities, and lessons learned around designing different on-body output modalities in various contexts of use. For this purpose, the workshop gathers together researchers, designers, and practitioners that are working with wearable design. We encourage multi-disciplinary participation with a background in, but not limited to, HCI, design, arts, fashion, and social sciences. The workshop invites submission of novel implementations, case studies, methodological notes, and position papers.

During the workshop, discussions will be structure into three main themes:

- *Design decisions and criteria.* We will identify the aims of different output modalities on wearable technologies. Why do participants choose to include a particular modality in their wearable design? What are the motivations behind certain form factors, body placements, materials, or information representation styles in their design?
- *Conveying intended meaning/information.* We will discuss the positive and negative aspects of certain output modalities in terms of their capability to convey intended meaning and/or information. What types of information/meanings do participants try to convey with different modalities? Which properties of a certain modality make it suitable to convey the intended information/meaning?
- *Social and cultural acceptability.* We will discuss the characteristics of output modalities that are challenging and/or advantageous for social and cultural acceptability. How do participants consider the social and cultural challenges in terms of appearance and interaction while designing wearables with a particular output modality? What is the influence of the targeted user and context of use on the design of the modality?

3 PRE-WORKSHOP PLANS

Prior to the workshop, we will publish a workshop website including detailed information about the workshop call, the organizers, and the submission process. We will also advertise the call through relevant HCI mailing lists, social media,

and direct invitations. Submissions will be in the format of pictorials [1] The submissions will be peer-reviewed by at least two reviewers. Prior to the workshop date, the accepted pictorials will be made available through the website.

4 WORKSHOP STRUCTURE & OUTCOME

The workshop is structured in two sessions (morning and afternoon):

- **Show and Tell.** Participants will present their accepted pictorial and reflect on their own designs through the lens of three workshop themes. Presenters are encouraged to bring demos to support their presentation. After and during each presentation, discussions will be encouraged.
- **Group Work - Output Modality Redesign.** Small groups will be formed based on participants' experiences in designing different wearable output modalities. Groups will discuss the functional advantages/disadvantages of the modalities, terms of conveying meaning or information, and potential social challenges/opportunities. One of each participant's existing designs will be selected and, as a group exercise, re-designed to utilise an alternative output modality. For example, an existing design using light output will be redesigned to utilise shape changing output modality. The resulting designs will be further discussed with the workshop attendees as a whole.

As an outcome, the accepted pictorial submissions will be distributed through the workshop website and a mailing list of the participants will be established to foster further collaborations. We also will prepare a visual poster that summarizes the outcomes of the workshop and disseminate it through social media channels to reach a more general audience. Also, we will summarize the specific challenges and opportunities of different wearable output modalities for a publication in a journal, e.g. the Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies.

5 ORGANIZERS

Caglar Genc (main contact) is a post-doctoral researcher at the University of Lapland, the faculty of Art and Design. During his Ph.D., he researched the relationship between fashion and computation to design wearable displays.

Ashley Colley is a post-doctoral researcher in the UX team at the University of Lapland. He has an extensive background as a creative technologist, e.g. wellness tracking and interactive prototypes.

Oguz 'Oz' Buruk is a Marie Curie Fellow in the Gamification Group at Tampere University, Tampere, Finland. He holds a PhD in Interaction Design (2017) from Koç University-Arçelik Research Center for Creative Industries (KUAR). His work focuses on designing playful wearables and he leads two research projects focusing on integrating wearables to mainstream gaming and extended reality environments.

Minna Pakanen is an assistant professor in the Socio-technical Design group at the Department of Engineering at Aarhus University. She holds a PhD in Information Processing Science at the University of Oulu, Finland. Her research focuses on co-design, interaction design, and crafting of on-body technology and tangible everyday objects for the healthcare domain, as well as developing methods for anticipated UX evaluations with visual/tangible materials.

Jan Gugenheimer (www.gugenheimer.com) is an assistant professor at Telecom-Paris/Institute Polytechnique des Paris. His research explores mixed reality technology and focuses around upcoming social challenges for mixed reality and how to embed this technology into the fabric of our daily lives.

[1] https://dis.acm.org/2020/pictorials.html

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