SIG PhysioCHI: Human-Centered Physiological Computing in Practice

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Abstract

In recent years, integrating physiological signals in Human-Computer Interaction research has significantly advanced our understanding of user experiences and interactions. However, the interdisciplinary nature of this research presents numerous challenges, including the need for standardized protocols and reporting guidelines. By fostering cross-disciplinary collaboration, we seek to enhance the reproducibility, transparency, and ethical considerations of physiological data in HCI. The purpose of this SIG is to offer a lightweight opportunity for CHI attendees to connect with the community around the center point of physiological computing. This SIG will address key topics such as technical challenges, ethical implications, reproducibility, and open science. We aim to meet as a community and connect with HCI researchers and practitioners to network and exchange bi-directional ideas. Ultimately, our goal is to create a foundation for future research and to establish a community around physiological computing.

CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**.

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Keywords

Physiological Computing, Open Science, EEG, fNIRS, Brain-Computer Interface, Eye Tracking, Electrodermal Activity, ECG, EMG

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1 Motivation

In Human-Computer Interaction (HCI), the integration of physiological data into interactive systems represents a key research focus aimed at enabling more intuitive, adaptable, and responsive user experiences. Physiological sensors, such as those measuring heart rate, respiration, electrodermal activity, muscle tension, and electrophysiological and metabolic brain activity, provide valuable insights into users' physical and affective states [33]. These signals are particularly important as they offer objective measures of users' internal states, central to designing intelligent systems that are aware of and adapt to user needs. Beyond adaptation, these signals also inform the ergonomics and usability of systems, offering precise and objective insights into how users physically and cognitively engage with technology. By utilizing these objective indicators, physiologically adaptive systems can tailor interactions based on user states, enhancing usability and overall user experience [8, 12, 13]. As sensor technology becomes more practical and reliable, the field is expanding rapidly, with more applications appearing in real-world settings [3, 6].

Although researchers have explored innovative methods for integrating neurological and physiological data into HCI for decades, the field still lacks shared theoretical and methodological standards [10, 34]. Recently, a new move in the HCI research field has focused on the scientific rigor our community has shown and has identified significant methodological and theoretical issues [2, 22]. However, these are critical to better interpret physiological signals during user interactions and to inform the design of more explainable intelligent adaptive systems that prioritize user privacy and align with ethical standards [32]. Being at the forefront of the field, this SIG aims to bridge these gaps by fostering collaboration to develop unified frameworks that advance the use of physiological data in adaptive and ethical HCI systems. There, the following four key challenges are core to the SIG, which we want to address with the wider HCI community:

- Technical challenges in developing and recording physiological data
- Ethical implications when recording personal physiological data
- Challenges and requirements around reproducibility and open science
- Applications of human-centered physiological computing for implicit and explicit interaction

Putze et al. [30] argue that expertise across various domains is essential, including neuroscience, signal acquisition, signal processing, machine learning, and software engineering, along with traditional HCI and design. The complexity and specialization within these areas create a steep learning curve for those looking to operate in this interdisciplinary space [28, 30, 40].

This interdisciplinary reliance often hinders innovation, leading researchers to develop their methodologies, analysis pipelines, and datasets in isolation. This fragmentation of resources and lack of shared standards further complicates efforts to build upon previous work, making it difficult to reproduce and reuse research outputs [2, 30, 37]. For this reason, a Special Interest Group (SIG) is essential to unite diverse HCI perspectives, fostering collaboration and creating a focused, interactive space to address the challenges of designing and implementing physiologically adaptive systems, including ethical considerations, technical barriers, and reproducibility, while exploring their potential to advance user-centered and responsive interactions.

2 SIG Topics

We will structure the discussion around four well-known topics and challenges in the field of physiological signals. This will allow the attendees to share their individual experiences and challenges they have run into by working with a particular signal or group of signals.

2.1 Topic 1: Technical Challenges

Integrating physiological signals in systems comes with many technical challenges, such as scalability, robustness in continuous sensing, and adaptability to different systems [21, 31, 41]. Although the development of sensors has advanced and made sensing in a controlled environment more reliable, the challenges of reliable sensing in the wild persist [27]. This poses further difficulties when interactions with systems depend on the physiological data from the user to convey states or execute functions.

For example, for many physiological data processing steps (e.g., EDA, heart rate, respiration), one needs to consider not only the device characteristics but also how (sensor) noise can impact the signal analysis, making it difficult to interpret the data correctly. This furthermore includes the art and science of electrode placement, sensor interruptions, sampling rates, and artifact removal, all of which are essential for interpreting and reporting signal analysis meaningfully (cf., heartbeat analysis [16]). Such pre-processing is, in turn, crucial for prediction tasks that rely on physiological signals, for example, emotion self-report state prediction [39].

2.2 Topic 2: Ethical Implications

Working with physiological signals raises significant ethical and privacy concerns. These signals reveal sensitive internal states, requiring careful handling to ensure user agency and informed consent. Ethical frameworks, such as those in affective computing, emphasize transparency and guidance for developers, operators, and regulators to prevent misuse and unintended applications [4, 17].

Inconsistent privacy standards across academia, healthcare, and industry amplify these concerns [15]. Privacy-by-design approaches can integrate privacy considerations into every stage of system development, while techniques like federated learning offer alternatives by enabling model training without centralizing sensitive data [7].

A key challenge lies in ensuring meaningful consent, as physiological signals can reveal states beyond user awareness. Systems must clearly communicate data use implications and provide users with control over their data, including options for revocation. In addition, questions of long-term storage, data ownership, and equitable access to technology require further exploration to establish universal standards for the ethical and secure use of physiological data [23].

2.3 Topic 3: Reproducibility and Open Science

Along various disciplines, reproducibility and replicability of output are crucial for ensuring research continuity and trustworthiness [14]. These principles are tightly connected to having open access to data, code, and protocols, which play a crucial role in reproducibility. Open data-sharing enables result validation, encourages creative re-analysis, and adapts to evolving scientific methodologies. However, access to the data itself is insufficient, especially in fields practicing resource-intense methodologies and where the lack of standardization is present [1]. To make this data usable by the wider community, there is a need for standardized documentation detailing the protocol and how the data should be shared and interpreted.

While more researchers in the fields of physiological signals are taking a step towards open access and reproducibility, the complexity and diversity of signals slow down the adoption of the practice

[18]. Therefore, the initial challenges persist, leaving a limited availability of shared datasets and poor labeling that pose difficulties in extending the research efforts.

2.4 Topic 4: Applications of Human-Centered Physiological Computing for Implicit and Explicit Interaction

Evaluating interactions and using physiological signals as inputs are closely linked processes in physiological computing. Interaction evaluation helps us understand user behavior and state by integrating physiological data such as EEG, EDA, or heart rate [11, 19, 29]. This understanding informs how systems can dynamically adapt to users while shaping how experiments and tasks are designed to include these signals effectively [13]. Input, in this context, refers to using physiological signals not just for analysis but also as active input and control in interactive systems [25, 35, 36].

Designing evaluation tasks requires careful consideration of signal relevance, participant comfort, and context to ensure meaningful and interpretable data [5, 20, 26]. This data is then mapped into the system's behavior, allowing the systems to adapt in real-time based on the user's state, such as cognitive load or stress. Moving to online processing introduces additional challenges, including ensuring signal quality, managing latency, and contextualizing inputs within the broader interaction.

Using physiological signals as active inputs requires systematic methods for processing and interpreting data[9, 24, 38]. Pipelines must be robust and scalable for real-time environments, with clear strategies to integrate physiological data alongside traditional inputs such as touch or speech. By combining interaction evaluation with thoughtful signal design, researchers can develop systems that respond more effectively to users in dynamic and personalized ways.

3 Aims of the SIG

This SIG aims to create a meeting point and open forum for researchers from various disciplines who already work or are interested in working with physiological signals. As stated before, HCI topics are often widespread through various disciplines, and multi-disciplinary collaborations are needed to ensure continuity and prosperity in research. By welcoming a diverse group of participants, we aim to create discussion groups that will address the participants' specific points of interest. We will encourage them to share their challenges and work together on ways to combat them. By doing so, we hope the attendees can identify future collaborators or consult with each other. We hope that the variety of topics will attract a diverse group of attendees to combat the challenges in such way, where expertise from multiple fields will be present. Further on, we would like to identify the size of this community to determine future steps and agenda for further initiatives. The session will explore how these solutions, if implemented, could advance HCI as a field.

Based on the discussions with participants, we will disseminate the results in blog posts and ACM Interaction magazine publications. Moreover, we invite all to join our Slack Workspace [1], forming a community around human-centered physiological computing.

4 SIG Structure

Within the given time frame, the SIG will be structured in four parts, including an introduction, a group discussion, synthesis, and a conclusion determining the next steps.

4.1 Introduction and Context Setting (10 minutes)

The session begins with a brief introduction of the organizers and the topics to be discussed. To engage participants, we use Mentimeter to pose provocative questions related to ethical and practical challenges in physiological computing, such as, "What is your biggest concern about using physiological signals in HCI systems?" Participants' responses will guide the formation of discussion groups around specific topics. Attendees will be directed to tables corresponding to their preferred topic based on the poll results.

4.2 Breakout Discussion in Small Groups (30 minutes)

Participants will join their chosen tables to engage in focused discussions on challenges within their topic of interest. Each table will address specific aspects, such as ethical concerns, real-time processing, or designing adaptive systems, see Section 2. Table facilitators will guide the conversations, ensuring key points are documented. The challenges discussed will be shared digitally via QR codes linked to Google Forms, where participants can input their insights and visions in real-time.

4.3 Group Synthesis and Roadmap Creation (20 minutes)

After the small group discussions, each table will summarize their key challenges and insights. Using interactive polling tools like Mentimeter, the session will prioritize challenges to address. Based on these priorities, participants will collaboratively propose a roadmap outlining actionable steps to tackle the identified issues. To support collaborative note-taking, we invite the participants to use a Miro board, where they can revisit and expand on their ideas later.

4.4 Next Steps (15 minutes)

The session concludes with a discussion of potential solutions to the challenges identified. Participants will brainstorm the impact these solutions could have on HCI, such as improved user agency, ethical standards, and technological innovation. The session will explore how these solutions, if implemented, could advance HCI as a field. Participants will also be invited to contribute to follow-up initiatives, such as a mailing list or collaborative workshops, to continue the dialogue beyond the SIG.

[1] Slack Workspace Invitation Link: https://join.slack.com/t/physio-interaction/shared_invite/zt-28pn4un4j-wfbPw0eTuTrl89BdDLSx2Q

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A Appendix

B Description of the Community

This SIG aims to discuss the cross-disciplinary challenges of working with physiological signals and outline actionable steps. The integration of physiological signals in HCI requires a very wide range of expertise, spanning different areas such as signal processing, data analysis, machine learning etc. This calls for multidisciplinary collaborations to ensure continuous research output and assure good practices. With the aim to create a meeting point for researchers with diverse backgrounds from all around the world, we welcome experts from various disciplines such as HCI researchers, neuroscientists, machine learning engineers, system designers, psychologists, data scientists, and other relevant fields. By bringing together researchers with diverse backgrounds, we hope to create a community that will dispose with relevant expertise to discuss challenges and solutions that address the interdisciplinary nature of integrating physiological signals in interactive systems.

C Assumed attendee background

We consider the program of the session to be relevant for academics as well as for industry specialists which are engaging human-centered physiological computing.

D Schedule

This SIG will follow an in-person program. The session will be dissected in four parts: **Introduction and Context Settings**, **Breakout Discussion in Small Groups**, **Group Synthesis and Roadmap Creation**, and **Next Steps**, as described in Table 1. This approach will allow easy communication between the participants and will ensure the fluidity of the session.

After the introduction, participants will be divided into small groups, each focusing on one of the SIG's topics. Within these groups, the participants will collaboratively discuss challenges they have encountered, synthesise their ideas and share expertise. During the third part, the participants will prioritize the challenges they would like to address and will collaboratively outline actionable steps to tackle the identified issues.

Table 1: The schedule of the SIG.

Duration	Activity
10 mins	**Introduction and Context Setting** The organizers will begin by outlining the structure of the SIG, introducing the discussion topics, and providing a brief background on the organizing team.
30 mins	**Breakout Discussion in Small Groups** Participants will join their chosen groups to engage in focused discussions on challenges within their topic of interest. Within the groups, they will address their points of interest through discussion. The facilitators of the workshops will supervise the discussion and document key points to retain the knowledge.
20 mins	**Group Synthesis and Roadmap Creation** Groups will consolidate their discussions into a concise presentation. They will summarize their ideas to share with the entire SIG. This phase allows participants to refine their insights and create a cohesive narrative for their approach.
15 mins	**Next Steps** In this part, the groups get a chance to present their insights and proposed solutions in front of the broader SIG audience. To deepen the discussion, participants will discuss on how their proposed solutions will shape the future of HCI.

The last part of the session will serve to discuss and present the proposed solutions by the working groups. To widen the discussion, the participants will also discuss the impact that these solutions would have on HCI. We will create a dedicated Slack channel for further discussions and keeping in touch with the created community. Last but not least, we will encourage participants to contribute to follow up initiatives of a similar nature and extend the dialogue beyond the SIG.

E Plan on Attracting Attendees

We will promote the SIG on existing Slack servers on which we started to from a community around the topic. To engage the wider HCI community, we will promote the in research groups, at upcoming HCI conferences, the SIG webpage, ACM SIGCHI-related forums, institutional outreach channels, social media, personal contacts, as well as professional networks to attract participants whose interests align with the field of physiological computing. We intent that our advertisement will increase the reach, diversity, and inclusion of the event.

F Primary Contact

Teodora Mitrevska is the main contact for this SIG (https://www.medien.ifi.lmu.de/team/teodora.mitrevska/). She is a PhD researcher at the LMU Munich in Human-Computer Interaction. Her research interests lie in wearable EEG devices and the usage of physiological signals as a form of implicit feedback in the context of Human-AI interaction.