AI for Haptics and Haptics for AI: Challenges and Opportunities

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Abstract

AI has transformed methods and knowledge across many domains. However, the intersection of AI and haptics remains underexplored. While modern AI techniques – fueled by machine learning and using powerful techniques such as generative modeling and reinforcement learning – offer powerful opportunities for advancing haptic design, insights from haptics research, such as perception modeling and adaptive interaction - grounded in human touch, embodiment, and multisensory integration — can also play a critical role in shaping more human-centered AI systems. This workshop will bring together an interdisciplinary community of researchers from HCI, haptics, AI, robotics, and design to (1) identify pressing questions in haptics that could benefit from AI approaches and (2) highlight ways in which haptic knowledge can support the development of embodied and context-aware AI. Through position papers and paper presentations, we will map key challenges, exchange methods, and explore new research directions that connect the two fields. By framing haptics and AI as mutually reinforcing, the workshop aims to build a shared research agenda and foster collaborations that advance both the science of touch and the design of intelligent interactive systems.

CCS Concepts

• **Human-centered computing → Interaction techniques**; *Interaction design theory, concepts and paradigms.*

Keywords

haptics, tactile, machine learning, artificial intelligence, generative AI

ACM Reference Format:
Easa AliAbbasi, Dennis Wittchen, Yinan Li, Shihan Lu, Thomas Müller, Donald Degraen, Thomas Leimkühler, Sang Ho Yoon, Hasti Seifi, Oliver Schneider, Heather Culbertson, Jürgen Steimle, and Paul Strohmeier. 2026.

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CHI EA '26, Barcelona, Spain

ACM ISBN 979-8-4007-2281-3/2026/04
https://doi.org/10.1145/3772363.3778763

AI for Haptics and Haptics for AI: Challenges and Opportunities. In *Extended Abstracts of the 2026 CHI Conference on Human Factors in Computing Systems (CHI EA '26), April 13–17, 2026, Barcelona, Spain.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3772363.3778763

1 Introduction

The rapid rise of artificial intelligence (AI) and multimodal interaction is gradually reshaping human–computer interaction (HCI) [25, 37]. AI-powered systems are no longer limited to single modalities such as text, image, or audio. Instead, they are integrated with multiple input and output modalities, including visuals, speech, and gesture, to create richer and more intuitive user experiences [9, 11, 31]. This shift creates opportunities for designing interfaces that allow users to interact with machines in ways that feel natural, context-aware, and adaptive [11, 28, 47]. As these multimodal systems continue to mature, they offer new pathways for more immersive, seamless, and personalized interactions in various domains such as education, healthcare, and entertainment.

In parallel to this growth, haptic technology has advanced significantly, expanding from simple vibration alerts in mobile phones to sophisticated feedback in wearable devices [38, 58], augmented and virtual reality systems (AR/VR) [18, 51, 52], and next-generation mobile platforms [4, 10]. Despite these advances, haptics remains an "underexplored sensory channel" in AI-driven interfaces, often overshadowed by visual and auditory modalities. For vision and audio, AI systems have achieved remarkable progress in tasks such as recognition, generation, and context-aware adaptation, enabling applications like image captioning [24], speech synthesis [60], and multimodal assistants [30]. However, haptics have not yet reached comparable levels of sophistication with AI systems. On the other hand, the potential impact of haptics on AI systems is profound. For example, for robots to interact intelligently and safely in the physical world, they must be able to sense and interpret touch [61]. In other words, robots should be able to distinguish between textures, forces, and the difference between holding an egg and lifting a heavy object [12, 32, 59]. Similarly, embodied AI agents in AR/VR or assistive technologies require tactile feedback to achieve levels of precision, adaptability, and trustworthiness that vision and audio alone cannot provide [23]. In this sense, haptics is not only an additional channel for user interactions but a critical enabler of AI systems that aspire to act with human-like competence in complex environments. Having said that, the challenge of haptics lies in its multidimensional and context-dependent nature and being tied to the physical world. From this complexity, two questions can arise: (1) What unique challenges of haptics can be addressed by AI and (2) how the distinctive capabilities of haptics might inform or enhance future AI approaches.

A major limitation of haptics is in *the way tactile experiences have been studied*. Much of the literature is based on small-scale, qualitative investigations, often focused on specific devices or narrowly defined use cases (e.g., [5–8, 15–17, 19, 20, 22, 26, 27, 33–35, 40, 45, 49]). While such studies provide valuable insights, they do not scale to the large and diverse datasets that AI methods typically require. Before AI can be effectively used for haptics technologies, we need *large-scale and diverse datasets* that capture the variability of touch across contexts, devices, and users. However, generating such datasets is particularly difficult since haptic interaction requires physical contact, controlled sensing environments, and often specialized measurement hardware [49]. Unlike vision or audio, where data can be harvested at a massive scale from digital media, haptic data cannot be easily captured "in the wild". Even when data is available, there are open questions about *how to best represent and model haptics*. Touch involves multiple dimensions – e.g., roughness, stickiness, compliance, and temperature – on different layers – physical, device, and user layers – that are not easily reduced to a single unified format. Developing representations that are both perceptually and computationally valid remains a major challenge. Moreover, for AI-driven systems to be impactful, these models must be *scalable to new contexts*, while covering the diversity of human tactile experiences across cultures, abilities, and individual sensitivities. Current progress, however, often focuses on *specific modalities* (such as vibrotactile feedback, e.g. [26, 28, 33, 35, 49]) or *narrow application domains* (e.g., VR gloves [39, 53]), limiting the generalization and transferability of haptics. From a technical perspective, haptic devices can present the same tactile stimulus differently depending on whether it is delivered via a smartwatch, smartphone, or VR controller, creating challenges for cross-device generalization. Once we overcome the above-mentioned challenges, the *lack of perceptually valid evaluation metrics* makes it difficult to measure whether the developed haptic models actually can capture human experience. Finally, at the design level, *creating compelling haptic experiences is resource-intensive*, often requiring specialized expertise and trained designers, which restricts experimentation and scalability. Another related challenge is the absence of a common language or representation for haptic experiences, making it difficult to communicate design intent to AI models (e.g., via text prompts) or to systematically leverage AI in haptic design.

Current AI systems – especially robots and embodied agents – are heavily reliant on vision and audio, but these modalities alone are insufficient for navigating the physical world with human-like competence. Haptics introduces an *"additional layer of intelligence"* by grounding AI in materiality. For example, it can enable robots to infer physical properties such as slipperiness and softness that cameras cannot capture. In interactive contexts, haptics allows AI to *express intention* through touch, opening new pathways for social communication and trust-building with humans. Moreover, integrating haptics into AI could inspire *new forms of representation and reasoning* [13, 14] – embodied knowledge that extends beyond pattern recognition toward physical intuition. In this way, haptics does not merely complement existing modalities but can act as a catalyst for the next generation of AI systems that are grounded and aligned with the richness of human experience.

However, exploring the feasibility of translating AI approaches to enhance haptics and haptic technology to enhance AI requires critical discussion among experts who understand the unique characteristics of touch and AI. For example, there are opportunities to overcome some of the challenges in haptics by drawing inspiration from the progress made by AI in vision and audio domains. In terms of applications, there are opportunities to build robots that can better navigate human environments, develop systems that can provide better diagnostic feedback, and achieve better AI through material context. Addressing these challenges requires not only technical innovation but also interdisciplinary dialogue that bridges perspectives across HCI, haptics, and AI. Each field brings complementary strengths: HCI contributes a deep understanding of user needs and interaction design, haptics provides expertise in hardware, perception, and experience design, and AI offers methods for modeling, representation, and large-scale data-driven reasoning. By convening researchers, practitioners, and designers across these domains, we can create a shared space to accelerate progress that no single community could achieve in isolation.

The goal of this workshop is to *identify shared challenges* that cut across disciplines, such as the need for standardized data representations, large-scale datasets, equipping robots with human-like experience, and the problem of cross-device generalization, while also surfacing new perspectives that each field can contribute. This can lead to a community or forum for the researchers of both fields.

Through discussion and collaborative agenda-setting, we aim to *build roadmaps* for advancing AI-driven haptic interactions [28, 29, 48, 49] and haptic-driven AIs [44]. Such roadmaps should not only outline technical directions but also consider ethical, cultural, and accessibility dimensions (we will specifically try to recruit some thinkers about haptics & ethics and AI & ethics), ensuring that future developments are inclusive and socially responsible. The workshop aspires to catalyze a research agenda that elevates both fields from an underexplored channel to a core dimension of multimodal human–AI interaction, which can result in a “grand challenges paper”.

2 Organizers

Easa AliAbbasi is a postdoctoral researcher in the Sensorimotor Interaction Group at Max Planck Institute for Informatics, where his research focuses on understanding human sense of touch, developing AI models to enhance haptics, and developing tactile displays to convey sensory information. During his PhD studies, he published several articles on electroadhesive tactile displays and understanding human touch [1, 3]. He (co-)organized several internal workshops and one successful workshop at CHI25 [46].

Dennis Wittchen is a PhD student at Max Planck Institute for Informatics (MPI-INF) associated with University of Saarland and research associate at Dresden University of Applied Sciences. His research explores tools and methods for augmenting human experiences and behaviors through vibrotactile stimuli. He is further interested in the design processes and strategies employed by designers when creating such interactions and augmentations. Building on these insights, he develops Creativity Support Tools (CSTs) in the context of haptic experience design (HaXD). He has co-organized several workshops and studios in the past (e.g., [42, 43, 54, 56]), demonstrating experience in facilitating discussions and managing academic events.

Yinan Li is a PhD student at Arizona State University, specializing in human–computer interaction. Her research focuses on multimodal haptic experiences and computational approaches to user haptic perception and interaction.

Shihan Lu is a postdoctoral researcher at Northwestern University. His PhD research was centered around two bidirectional questions: (1) how can we recreate the touch sensations in virtual environments? (2) how can we equip the robots with humanlike or even superhuman touch capabilities? Among these questions, he focused on modeling and rendering of haptic and auditory feedback generated when scratching across textured surfaces, and active tactile sensing and perception for contact-rich robotic manipulation scenarios. The efforts aim to bridge the gap between human touch and its technology counterparts, advancing both haptic interfaces and robotic dexterity.

Thomas Müller is a haptic UX designer and co-founder of the Hapticlabs.io platform. His work focuses on building accessible tools and frameworks to democratize the haptic design and development process.

Donald Degraen is a Lecturer (Assistant Professor) at the HIT Lab NZ, a research centre at the University of Canterbury, New Zealand. His research explores the intersection of haptics, fabrication and virtual reality to democratize the design of touch experiences, e.g., by developing methods to create physical tactile experiences [19, 21], leveraging cross-sensory correspondences [18, 41, 50], or enabling collaboration in the design process [55, 57]. Donald completed his PhD at the Saarland University funded by an ESR Marie Skłodowska-Curie fellowship. Previously, he was a postdoctoral researcher at the University of Duisburg-Essen and the Saarland University, and a research fellow at the Intel Visual Computing Institute and the Expertise Centre for Digital Media.

Thomas Leimkühler is a senior researcher and research group leader at Max Planck Institute for Informatics (MPI-INF), Germany. His research lies at the intersection of visual computing and machine learning, with special interests in neural signal representations, generative models, rendering of all flavors, and efficient parallel algorithms. Prior to his current position, Thomas was a postdoctoral researcher at Inria Sophia-Antipolis, France, following the completion of his PhD at MPI-INF. Thomas is a recipient of a Eurographics PhD Award, the Otto Hahn Medal of the Max Planck Society, a Eurographics Junior Fellowship, and several best-paper awards.

Sang Ho Yoon is an Associate Professor in the Graduate School of Culture Technology at KAIST. His research has focused on promoting natural interactions with novel sensing and haptic methodologies with the aid of AI for future interfaces. His recent research focuses on embedding physicality for adaptive interaction to advance spatial-physical computing. Sang Ho has also organized several international HCI workshops at CHI, WHC, and ISMAR.

Hasti Seifi is an assistant professor in the School of Computing and Augmented Intelligence at Arizona State University. Her research focuses on haptic design, robotics, and the accessibility of visual media. She has developed open-source datasets, generative AI models, and interactive tools for haptics and XR, and has co-organized workshops at ACM CHI, IEEE VR, and IEEE World Haptics.

Oliver Schneider leads the Haptic Experience Lab (HX Lab) as an Associate Professor at the University of Waterloo, Department of

Management Science and Engineering. His research focus is understanding haptic experience design and evaluation, and enabling anyone, anywhere to be able to work with haptic technology to achieve meaningful impact, with application areas including health, accessibility, sustainability, and social justice.

Heather Culbertson is an Associate Professor of Computer Science and Biomedical Engineering at the University of Southern California. Her research focuses on the design and control of haptic devices and rendering systems, human-robot interaction, and virtual reality. Particularly she is interested in creating haptic interactions that are natural and realistically mimic the touch sensations experienced during interactions with the physical world. Previously, she was a research scientist in the Department of Mechanical Engineering at Stanford University where she worked in the Collaborative Haptics and Robotics in Medicine (CHARM) Lab.

Jürgen Steimle is a Professor at Saarland University where he leads the Human-Computer Interaction Lab. Previously he was Senior Researcher at the MPI-INF and Visiting Assistant Professor at the MIT Media Lab. He holds a PhD in Computer Science from TU Darmstadt. Jürgen specializes in body-based interfaces that are soft and deformable, to offer novel opportunities for rich and expressive multi-sensory interaction. He is recipient of an ERC Starting Grant and his work on body-based interfaces has received Best Paper Awards at CHI and UIST.

Paul Strohmeier is a Senior Researcher at the Max Planck Institute for Informatics (MPI-INF) where he leads the Sensorimotor Interaction group and an Associate Fellow of Saarland University. His PhD work was honored with the SIGCHI Outstanding Dissertation Award. He has received an ERC Starting Grant for conducting research on kinesthetic perception, sensory augmentation, and on-body systems. Paul has co-hosted 9 events at ACM conferences (Workshops, Studios and SIGs) many of which are directly related to this proposal. Paul has also been instrumental in ensuring that such events have tangible outcomes, for example in the form of follow up workshops [43, 54] and academic papers [36, 57].

3 Pre-Workshop Plans

The Call for Participation will be distributed through the related mailing lists (e.g., ACM SIGCHI, UIST, EuroHaptics Society, Technical Committee on Haptics, Augmented Humans, ACM SIGGRAPH) and through the organizers' professional networks. This will ensure that researchers in HCI, haptics, and AI are aware of the workshop. All information will be available on the workshop website[1], which will include the full program and accepted papers.

We invite contributions from people with different backgrounds (e.g., HCI, psychology, engineering, haptics, AI, design) to encourage conversations across disciplines. Potential participants are asked to submit a 2—4 pages position paper. In this paper, they can articulate their perspectives on current challenges and opportunities in AI-driven haptic interactions or haptic-driven AI systems, propose research questions or directions, describe their prior work, and highlight potential interdisciplinary collaborations or methods at the intersection of haptics and AI. The organizing committee will review all submissions and invite 15—20 participants to attend the workshop. Authors of accepted submissions will be given the opportunity to present their position papers during the workshop.

Prior to the workshop, the organizers will upload the accepted submissions to a Miro board, which will be accessible to all participants in advance. The same board will also serve as a space for documenting discussions during the workshop.

4 Workshop

The in-person workshop consists of two sessions. The first session is dedicated to *"AI for Haptics"* and the second session to *"Haptics for AI"*. In total, the workshop lasts 180 minutes; 10 minutes for the opening, 80 minutes for each session, and 10 minutes for the closing. The workshop centers on participant-led lightning talks and group discussions designed to surface key challenges, insights, and future directions in haptics and AI, framed around the themes of the two sessions. A detailed schedule is provided in Table 1.

Introduction of the Workshop: We begin with a brief and general introduction to the workshop, its organizers, and the agenda for both sessions. This will be followed by a lightning talk from an organizer to reiterate the goals of the workshop and the research questions to be addressed.

Lightning Talks: The core of the workshop consists of lightning talks delivered by participants and group discussions. We will allocate 20 slots for lightning talks (10 slots per session, see Table 1), each lasting two minutes–to pitch the core ideas or highlight takeaways from their position papers– followed by one minute for questions. This format is designed to maximize exposure to diverse ideas and research perspectives and encourage interaction in the follow-up group discussion. In case fewer slots are filled, additional time will be allocated either for an extended discussion of individual talks or for a broader group discussion.

Discussion Sessions: We will allocate 40 minutes to discuss *"AI for Haptics"* in session #1 and *"Haptics for AI"* in session #2 in more detail. Participants will be divided into two groups of approximately ten people to facilitate more focused, inclusive, and interactive discussions, allowing all participants to contribute meaningfully. To support the conversation, the organizing committee will provide a set of guiding questions, and one organizer per group will moderate the discussion. During this session, participants and organizers will collaboratively identify and discuss common challenges, open questions, and potential research directions. Each table will be equipped with sticky notes and a poster where participants can add ideas, comments, and insights throughout the session. Two additional organizers per group will collect and digitize these materials in real time, organizing them on a shared Miro board. After the discussion, one organizer will lead a brief summary of the session (about 10 minutes) using the Miro board, which will be projected for everyone to see. Participants will be encouraged to share their key takeaways from each session during the summary.

Synthesize and Conclude: The workshop will conclude with a short session (about 10 minutes) led by one of the organizers aimed

[1] https://derikon.github.io/HapticsAI_Workshop/

Table 1: Schedule of the two-session workshop.

Open	**10 minutes**	**Introducing the Workshop**
Session #1	**80 minutes**	**Talks & Discussions**
	30 minutes	Lightning Talks
	40 minutes	Discussion: AI for Haptics
	10 minutes	Summary of Session #1
Break	*20 minutes*	*Coffee and Informal Networking*
Session #2	**80 minutes**	**Talks & Discussions**
	30 minutes	Lightning Talks
	40 minutes	Discussion: Haptics for AI
	10 minutes	Summary of Session #2
Close	**10 minutes**	**Synthesize & Conclude**

at *'connecting the dots'* across the presented work, i.e., to synthesize insights from individual talks and group discussions, and to foster a cohesive agenda for future research. This will also focus on planning next steps for the community, including opportunities for collaboration, shared resources, and pathways toward developing haptics and AI.

Capturing Ideas and Fostering Engagement: To support collaboration during and after the workshop, organizers and participants will have access to a shared Miro board that will serve as a central information hub. The board will be used to document discussions, capture key ideas, and collect additional resources in real time. Participants will be encouraged to add content both during and after the sessions, ensuring that diverse perspectives are represented. Beyond the event itself, the Miro board will remain available as a living record of the workshop, providing a valuable resource for later engagement, reflection, and planning of follow-up activities.

5 Post-Workshop

Our post-workshop activities will focus on three complementary aspects. First, all submitted position papers will be made publicly available to ensure lasting impact and accessibility. Participants will be asked to self-archive their individual papers on arXiv. Following this, the organizers will compile and publish an index on arXiv of all papers, including links to the arXiv entries.

Second, following the workshop, we plan to consolidate and disseminate the insights and outcomes generated during the sessions. This includes summarizing key discussion points, challenges and opportunities, and potential research directions identified during the lightning talks and group discussions. The summary will be shared with all participants and made publicly available, serving as a reference for the broader research community interested in haptic and AI. For the latter, we plan to share the outcome of the workshop either in the form of a blog post (e.g., at ACM Interactions) or an academic publication to reach researchers and practitioners beyond the CHI community. The purpose of this publication will be to define the field in a way that helps junior researchers identify relevant research problems, and more senior researchers contextualize and position their work for grant writing or similar activities, for example, by articulating *grand challenges* [2] and *opportunities* [36] for haptics and AI.

Third, with this workshop, we also intend to support creating a community of researchers interested in the intersection of haptics and AI that can extend beyond the workshop. Therefore, we will submit a proposal for a meet-up to CHI 2027. We will also create an online space (e.g., Discord community or Slack group) to foster community beyond the conference, with the aim of having a shared space where discussions and collaborations can continue beyond the workshop. Finally, we intend to follow up with a dedicated Dagstuhl Seminar[2] if we find interest from the broader community.

6 Call for Participation

We invite researchers and practitioners to join the workshop "AI for Haptics and Haptics for AI: Challenges and Opportunities" at CHI'26. This workshop explores the intersection of haptics research and artificial intelligence, focusing on challenges, opportunities, and future directions for haptics and AI.

The workshop will be organized in two 80-minute sessions and feature: lightning talks and group discussions to synthesize insights, identify challenges, and plan next steps for the community. We welcome participation from researchers in HCI, AI, haptics, and related fields, as well as designers and practitioners of haptic and multimodal interactions and AI-driven haptic technologies. Potential participants need to submit a position paper (2–4 pages, excluding references) using the CHI Extended Abstracts format and submit it as a non-anonymized PDF.

Submissions should be sent via this online form https://forms.gle/MK2GhNu13qTFkRGL7 by February 12, 2026 (midnight AoE). We will notify applicants by March 10, 2026. At least one author per accepted submission should attend the workshop and will be given the opportunity to present the paper in a lightning talk (2 minutes + 1 minute Q&A). Accepted submissions and discussion summaries will be made available on arXiv and on the workshop website, respectively. Post-workshop, we will compile a summary report highlighting key challenges, insights, and potential collaborations.

We anticipate 15 to 20 participants. Join us to help shape the future of AI-driven haptics and haptic-driven AIs, and foster a collaborative research community. For more information, please visit our website: https://derikon.github.io/HapticsAI_Workshop/.

7 Website

Information about the workshop will be available online at https://derikon.github.io/HapticsAI_Workshop/, before, during, and after the workshop. This information includes an introduction to the workshop topics, detailed schedule, and a call for participation. The website also links to an online form, where interested people can apply to participate by uploading a position paper. Participants can have their position papers published on the website (i.e., link to arXiv submission), and reports on results from the workshop will also be made available through the website.

Acknowledgments

Paul Strohmeier acknowledges funding from the European Research Council (ERC) for the project entitled Kinesthetic Displays (Grant No.: 101165100). Sang Ho Yoon acknowledges the support by the Institute of Information & Communications Technology Planning

[2]https://www.dagstuhl.de/de/seminars/dagstuhl-seminars

& Evaluation(IITP) grant funded by the Korea government (MSIT) (IITP-RS-2025-02214780, Generative Haptics and Fine Response Inference for Flexible Tactile Interfaces). Hasti Seifi acknowledges that this work was partially supported by research grants from VILLUM FONDEN (VIL50296) and the National Science Foundation (#2339707).

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