SIG: Towards More Personal Health Sensing

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ABSTRACT

With the development of low-cost electronics, rapid prototyping techniques, as well as widely available mobile devices (e.g. mobile phones, smart watches), projects related to the design and fabrication of personal health sensing applications, either on top of existing device platforms (e.g. mHealth), or as stand-alone devices, have emerged in the last decade. In addition, recent advances in novel sensing and interface technologies, accessibility studies and system design open up new possibilities and can bring in different perspectives for personal health sensing. We believe that joining the forces in such interdisciplinary work is a key to moving the field of personal health sensing forward. This Special Interest Group aims to bring in researchers from different fields, identify the significance and challenges of the personal health sensing domain, discuss potential solutions and future research directions, and promote collaborative research opportunities.

CCS CONCEPTS

• **Human-centered computing → Interactive systems and tools**; **Ubiquitous and mobile devices**; **Accessibility systems and tools**.

KEYWORDS

health sensing, personal fabrication, sensing interface, accessibility, design

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1 BACKGROUND

With the development of low-cost electronics, rapid prototyping techniques, as well as widely available mobile devices (e.g. mobile phones, smart watches), projects related to the design and fabrication of personal health sensing devices and applications have emerged in the last decade. These projects are usually either built on top of existing device platforms, such as mobile phones (e.g. *HemaApp* [20], *Seismo* [21]) and smart watches (e.g. Ravichandran et al. [17],), or as stand-alone devices (e.g. *Glabella* [7], *DoppleSleep* [16], *EIT-kit* [23]). Recently, with the assistance of interactive device prototyping tools, such as *CurveBoards* [22], *SqueezaPulse* [6] and *MorphSensor* [24], as well as widely available personal fabrication machines [1], users with limited electronics knowledge can also design and fabricate customized health sensing devices, which opens up opportunities for the field of personal health sensing.

However, there are more interdisciplinary research topics that can be applied to personal health sensing. For example, works about novel sensing and interface technologies increase the design space and provide novel sensing techniques that can be integrated into personal health sensing devices, such as kinesthetic sensing (*bioSync* [14], Kasahara et al. [12]), smell sensing (Brooks et al. [3]) skin interfaces (*SkinMorph* [9], *SkinWire* [10]), and even some unconventional on-body interfaces like fingernail interfaces (*NailO* [11]). In addition, well-evaluated accessibility studies, like accessibility for blind and low vision people [13, 15], as well as for d/Deaf and hard of hearing (DHH) people [5, 8], can be considered as design guidelines for future personal health sensing devices.

Another perspective that is often overlooked is the design of personal health sensing devices. Apart from the "functional" aspect of the device design, such as customizing the shape for ensuring constant contact to the measured area [2], and altering measuring locations for capturing better biomedical signals [19], the form factors and appearance of the device also have impacts over user's self-esteem and even mental health [18]. Like other everyday personal belongings, personal health sensing devices design should consider user's artistic needs and the effects on the user's mental state. Instead of being rigid and box-like, they can also be unobtrusive, or be part of the user's personal decoration and social expression.

In this SIG, we will be discovering these potential research spaces, and building an interdisciplinary network of researchers to bring solutions and new perspectives into the personal health sensing domain. We will use this SIG as a platform to learn about each other's work — the challenges, tools and techniques being used, and discuss if and how they can be applied to personal health sensing. We believe that joining the forces in such interdisciplinary work is a key to moving the field of personal health sensing forward.

2 AIMS AND GOALS

In this SIG about personal health sensing, we aim to:

- define the term personal health sensing and discuss how it relates to (and differentiates from) traditional health sensing and other research disciplines in HCI;
- identify the core aspects of personal health sensing and define the open challenges / opportunities, such as the device form factors, personalized sensing interfaces, acquisition of ground truth data, clinical trials, device feedback that respects a user's intention / voluntary, user privacy, applicable novel sensing and fabrication technologies etc.;
- vote for the top identified opening challenges with participants and collaboratively brainstorm solutions;
- summarize potential future research directions in personal health sensing and promote collaborative research opportunities.

This process will involve open discussions with attendees. During the session, we will ask attendees to share their own diverse backgrounds, experiences, and opinions to get a broad picture of what personal health sensing means to the community. We will then hold small group discussions to identify the core challenges of personal heath sensing and brainstorm solutions, which will then be shared with the entire audience. We will vote on the most important challenges identified in the small group discussions through online voting platforms (e.g. Slido [4]), so that attendees can participate both physically and virtually with their preferred devices. We hope to compose a summary of this SIG and submit it to a future CHI conference as a workshop or a journal position paper to reach the broader community and create further engagement. We are welcoming both experienced health sensing related researchers and new-comers to participant this SIG.

3 ORGANIZING TEAM AND ATTENDEES

This SIG is targeted at researchers that work in fields related to personal health sensing, and those who have general interests in the topics. To align the composition of the organizing team with the goals of the SIG and attract researchers from related fields, the main organizers Junyi Zhu and Stefanie Mueller have already reached out to researchers of related disciplines and invited them to join the SIG organization, such as Edward Wang from the health sensing domain, Liang He from personal fabrication, Hamid Ghaednia from the medical field, Jun Nishida from sensing and interface technologies, Hsin-Liu (Cindy) Kao with design expertise, as well as Jon Froehlich who focuses on accessibility studies. The organizers will act as "hosts" for their respective fields, i.e. they will provide an overview of research from their discipline and how it relates to personal health sensing. In addition, they will help to distribute this SIG among their disciplines to attract participants, as well as connect HCI researchers with potential collaborators in their field.

The SIG will be held under the hybrid format to enable both physical and virtual attendees to join. However, all participants are encouraged to attend physically when possible for the most interactive experience. Our SIG welcomes both experienced health sensing researchers who wish to develop the field further, and new-comers looking to get a taste for the field.

4 SIG MEETING AGENDA

The SIG will be held under the hybrid format in which attendees can participate both physically and remotely. For remotely-attending participants, we will have a Zoom link that streams the SIG in real time. Remote participants will also be assigned to breakout rooms for small group discussion sessions. For selecting the core aspects and most significant challenges, remote participants can use the online voting system in the same way as the physical attendees on their own devices.

We propose the following 75-minute agenda:

- **Introduction:** We will begin with an overview of personal health sensing, rapid 1-minute introductions of the co-organizers and their work related to personal health sensing, and an ice-breaker activity. (15 minutes)
- **Small Group Brainstorm (core aspects & challenges):** We will then break into small groups to brainstorm and discuss the core aspects and challenges in the area of personal health sensing. Each group will be seeded with a separate list of initial ideas (i.e. the ones mentioned in Section 2) to ensure topic coverage. (15 minutes)
- **Present & Discuss:** Each group will present its results to the entire SIG and lead a small discussion. We will take notes of the identified challenges, and set up an online voting system for all participants to select the most significant ones. (15 minutes)
- **Small Group Brainstorm (solutions & opportunities):** Once all groups have presented and voting has closed, attendees will focus on the top ~5 key challenges and again split into small groups (same groups as previous brainstorm session) to discuss solutions and potential opportunities. We will provide a Google Docs / Slides for each group to document the discussion. (15 minutes)
- **Closing Discussion:** We will reconvene as the entire SIG and review potential solutions and key future research topics in the field of personal health sensing as identified in the small group discussions. Organizers will provide access to a Slack group for further discussion. (15 minutes)

5 EXPECTED OUTCOMES AND NEXT STEPS

We expect this SIG to influence and establish future research directions in the area of personal health sensing. We hope to bring in researchers from different fields, form connections across disciplines, explore new perspectives of each other's field, and promote collaborative research opportunities. We will compose a summary of this SIG and submit it to a future CHI conference as a workshop or a journal position paper to reach the broader community and further engagement.

REFERENCES

[1] Patrick Baudisch and Stefanie Mueller. 2017. Personal Fabrication. *Foundations and Trends® in Human–Computer Interaction* 10, 3–4 (2017), 165–293. https://doi.org/10.1561/1100000055

[2] Alistair Boyle and Andy Adler. 2011. The impact of electrode area, contact impedance and boundary shape on EIT images. *Physiological Measurement* 32, 7 (jun 2011), 745–754. https://doi.org/10.1088/0967-3334/32/7/s02

[3] Jas Brooks, Shan-Yuan Teng, Jingxuan Wen, Romain Nith, Jun Nishida, and Pedro Lopes. 2021. *Stereo-Smell via Electrical Trigeminal Stimulation.* Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3411764.3445300

[4] Inc. Cisco Systems. [n. d.]. *Slido.* https://www.sli.do

[5] Steven M. Goodman, Ping Liu, Dhruv Jain, Emma J. McDonnell, Jon E. Froehlich, and Leah Findlater. 2021. Toward User-Driven Sound Recognizer Personalization with People Who Are d/Deaf or Hard of Hearing. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 5, 2, Article 63 (2021), 23 pages. https://doi.org/10.1145/3463501

[6] Liang He, Gierad Laput, Eric Brockmeyer, and Jon E. Froehlich. 2017. SqueezaPulse: Adding Interactive Input to Fabricated Objects Using Corrugated Tubes and Air Pulses. In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction* (Yokohama, Japan) *(TEI '17)*. Association for Computing Machinery, New York, NY, USA, 341–350. https://doi.org/10.1145/3024969.3024976

[7] Christian Holz and Edward J. Wang. 2017. Glabella: Continuously Sensing Blood Pressure Behavior Using an Unobtrusive Wearable Device. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 1, 3 (2017), 23. https://doi.org/10.1145/3132024

[8] Dhruv Jain, Kelly Mack, Akli Amrous, Matt Wright, Steven Goodman, Leah Findlater, and Jon E. Froehlich. 2020. HomeSound: An Iterative Field Deployment of an In-Home Sound Awareness System for Deaf or Hard of Hearing Users. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3313831.3376758

[9] Hsin-Liu (Cindy) Kao, Miren Bamforth, David Kim, and Chris Schmandt. 2018. Skinmorph: Texture-Tunable on-Skin Interface through Thin, Programmable Gel. In *Proceedings of the 2018 ACM International Symposium on Wearable Computers* (Singapore, Singapore) *(ISWC '18)*. Association for Computing Machinery, New York, NY, USA, 196–203. https://doi.org/10.1145/3267242.3267262

[10] Hsin-Liu Cindy Kao, Abdelkareem Bedri, and Kent Lyons. 2018. SkinWire: Fabricating a Self-Contained On-Skin PCB for the Hand. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 2, 3, Article 116 (Sept. 2018), 23 pages. https://doi.org/10.1145/3264926

[11] Hsin-Liu (Cindy) Kao, Artem Dementyev, Joseph A. Paradiso, and Chris Schmandt. 2015. NailO: Fingernails as an Input Surface. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI '15)*. Association for Computing Machinery, New York, NY, USA, 3015–3018. https://doi.org/10.1145/2702123.2702572

[12] Shunichi Kasahara, Kazuma Takada, Jun Nishida, Kazuhisa Shibata, Shinsuke Shimojo, and Pedro Lopes. 2021. *Preserving Agency During Electrical Muscle Stimulation Training Speeds up Reaction Time Directly After Removing EMS.* Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3411764.3445147

[13] Kelly Mack, Emma McDonnell, Dhruv Jain, Lucy Lu Wang, Jon E. Froehlich, and Leah Findlater. 2021. *What Do We Mean by "Accessibility Research"? A Literature Survey of Accessibility Papers in CHI and ASSETS from 1994 to 2019.* Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3411764.3445412

[14] Jun Nishida and Kenji Suzuki. 2017. BioSync: A Paired Wearable Device for Blending Kinesthetic Experience. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 3316–3327. https://doi.org/10.1145/3025453.3025829

[15] Venkatesh Potluri, Tad Grindeland, Jon E. Froehlich, and Jennifer Mankoff. 2021. Examining Visual Semantic Understanding in Blind and Low-Vision Technology Users.

[16] Tauhidur Rahman, Alexander T. Adams, Ruth Vinisha Ravichandran, Mi Zhang, Shwetak N. Patel, Julie A. Kientz, and Tanzeem Choudhury. 2015. DoppleSleep: A Contactless Unobtrusive Sleep Sensing System Using Short-range Doppler Radar. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Osaka, Japan) *(UbiComp '15)*. ACM, New York, NY, USA, 39–50. https://doi.org/10.1145/2750858.2804280

[17] Ruth Ravichandran, Sang-Wha Sien, Shwetak N. Patel, Julie A. Kientz, and Laura R. Pina. 2017. Making Sense of Sleep Sensors: How Sleep Sensing Technologies Support and Undermine Sleep Health. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. ACM, New York, NY, USA, 6864–6875. https://doi.org/10.1145/3025453.3025557

[18] M. Schukat, D. McCaldin, K. Wang, G. Schreier, N. H. Lovell, M. Marschollek, and S. J. Redmond. 2016. Unintended Consequences of Wearable Sensor Use in Healthcare. Contribution of the IMIA Wearable Sensors in Healthcare WG. *Yearbook of medical informatics* 1 (10 Nov 2016), 73–86. https://pubmed.ncbi.nlm.nih.gov/27830234 27830234[pmid].

[19] Akifumi Takahashi, Jas Brooks, Hiroyuki Kajimoto, and Pedro Lopes. 2021. *Increasing Electrical Muscle Stimulation's Dexterity by Means of Back of the Hand Actuation.* Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3411764.3445761

[20] Edward Jay Wang, William Li, Doug Hawkins, Terry Gernsheimer, Colette Norby-Slycord, and Shwetak N. Patel. 2016. HemaApp: Noninvasive Blood Screening of Hemoglobin Using Smartphone Cameras. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Heidelberg, Germany) *(UbiComp '16)*. Association for Computing Machinery, New York, NY, USA, 593–604. https://doi.org/10.1145/2971648.2971653

[21] Edward Jay Wang, Junyi Zhu, Mohit Jain, Tien-Jui Lee, Elliot Saba, Lama Nachman, and Shwetak N. Patel. 2018. Seismo: Blood Pressure Monitoring Using Built-in Smartphone Accelerometer and Camera. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–9. https://doi.org/10.1145/3173574.3173999

[22] Junyi Zhu, Lotta-Gili Blumberg, Yunyi Zhu, Martin Nisser, Ethan Levi Carlson, Xin Wen, Kevin Shum, Jessica Ayeley Quaye, and Stefanie Mueller. 2020. CurveBoards: Integrating Breadboards into Physical Objects to Prototype Function in the Context of Form. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.

[23] Junyi Zhu, Jackson Snowden, Joshua Verdejo, Emily Chen, Paul Zhang, Hamid Ghaednia, Joseph H. Schwab, and Stefanie Mueller. 2021. EIT-kit: An Electrical Impedance Tomography Toolkit for Health and Motion Sensing. In *Proceedings of the 34th Annual ACM Symposium on User Interface Software and Technology*. https://doi.org/10.1145/3472749.3474758

[24] Junyi Zhu, Yunyi Zhu, Jiaming Cui, Leon Cheng, Jackson Snowden, Mark Chounlakone, Michael Wessely, and Stefanie Mueller. 2020. MorphSensor: A 3D Electronic Design Tool for Reforming Sensor Modules. In *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology*.