Synergetic Collaboration between Intimate Touch and Soft Robotics: Opportunities and Challenges

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In this position paper, I discuss possibilities of synergetic collaboration between intimate touch research and Soft Robotics. I introduce my research interest by describing the concept of intimate touch and exemplifying potential research themes within the context of women's wellbeing and health that are open for applications of actuated materials. Then I outline prospective opportunities and challenges that could arise from the crossover of the two fields aforementioned. Using FlowIO as an example, I delineate how intimate touch research and Soft Robotics can leverage each other, what kind of epistemological contributions could emerge, and possible challenges with regards to this collaboration.

CCS Concepts: • **Human-centered computing** → *Interaction design process and methods*; **Interaction design process and methods**.

Additional Key Words and Phrases: intimate touch, soft robotics, feminist HCI, wearable, actuated material

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1 EXPLORING NOVEL DIGITAL TOUCH INTERACTION THROUGH INTIMACY

Intimate touch is a concept proposed by Balaam et al. which places emphasis upon intimacy in designing digital touch interaction and technologies [3]. It has its conceptual underpinning on Baradian notion of *intra-action* acknowledging the dynamic formation of agency through inseparable relationships between subjects and objects of touching [4]. Intimate touch attends to the generation of bodily knowledge inspired by soma design [16]. Intimate touch distinguishes itself from disruptive touch technologies in the sense that it does not seek to discipline the body based on certain judgment, but rather focuses on elevating understanding between oneself and the body [3]. It enacts a critical feminist understanding of bodies by paying attention to different possible forms and temporalities of bodies.

The concept of intimate touch is inspired by recent works by a number of HCI and interaction design researchers addressing the agendas of women's wellbeing and health [3]. New ways of reciprocal touching between women and their menstruating bodies were explored in a format of cultural probes [6], shape-changing embodied prototyping toolkit [24], and co-design workshops [8]. The Pelvic Chair [23] reflects consideration of intimate touch to cultivate bodily awareness around the inner yet critical body parts of the pelvic floor. Albeit outside the realm of women's wellbeing, body parts that have been neglected [25] or difficult to be acknowledged without professional skills [9] were engaged as well through intimate technologies of touch.

I draw on the concept of intimate touch as a guidance to develop novel touch interaction for underexplored contexts of women's wellbeing and health. First of all, it directs HCI researchers and practitioners to question experiential

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qualities of touch [3, 8, 17, 23–25]. This reroutes the questions of 'what to solve and optimize' towards 'how should we touch our bodies'. Intimate touch opens up a space to speculate on manners of touch - the pragmatics of touch language. This is a critical and timely question to ask considering the momentum of digital technologies approaching closer to our bodies. Notably, the context of women's wellbeing is closely entangled with diverse psychosocial, cultural, and political factors like taboos, cultural norms, and sexualities. [1, 2, 6, 8, 23, 24, 26]. Explicating how they are interwoven and dynamically influence each other would be a challenging yet rewarding journey, crystallizing touch modalities of care.

Furthermore, intimate touch reclaims the importance of our felt experience and stresses our bodies' capability of generating self-knowledge. Historically bodies have been disregarded as a source of knowledge, especially those in a feminine shape being treated as minor or odd [20]. This tendency seems to be here to stay, accompanied by the proliferation of self-tracking healthcare services and FemTech (Female Technology) products abstracting and datafying bodies [11, 19, 26]. Using intimate touch as guidance, I want to resist this trend of separating bodies from the context by grounding design on situated bodily knowledge and aiming to cultivate people's body literacy. This goes hand in hand with the feminist perspective of acknowledging the materialities of bodies.

2 A RECIPROCAL COLLABORATION OF INTIMATE TOUCH AND SOFT ROBOTICS RESEARCH: EMERGENT OPPORTUNITIES

Abundance of epistemological, empirical, and methodological contributions will be made through the collaboration of intimate technology and Soft Robotics research. I anticipate this relationship to be synergetic and reciprocal, each discipline offering an intellectual springboard to each other, conjointly investigating more philosophical questions about human body and its boundaries. Together, they will respond to the call for interdisciplinary feminist HCI movements [5] and replenish the research gap in advanced technologies for women's wellbeing [1].

In this section, I conjecture how two field of studies can mutually support each other. I occasionally draw on FlowIO [22] as an example to provide more concrete pictures of what this collaboration would look like.

2.1 For Soft Robotics research, what can Intimate Touch bring?

Probing intimate touch interaction will provide a fruitful design space for soft robotic research to expand repertoires of digital touch. Designing for women's wellbeing and health concerns being in touch with private and sensitive body parts that are closely tied to the historical and sociocultural association of sexuality or taboos [1–3, 8]. Figuring out relevant experiential qualities of touch situated in these compound settings, researchers can better articulate the linkages between experiential qualities and material characteristics of soft robotics materials. For example, pneumatic garment wearable powered by 1 psi pressure could elicit a caring experience in some countries but in other cultural regions, it might be felt like an intimidating or overwhelming experience in others. Exploring diverse qualities of touch and creating vocabularies of touch will bridge the gap between HCI and material science fields [21].

Researching the multiplicity of contexts through the lens of soma design will broaden the horizon of multi-modal touch interaction. How touch is received is contingent upon many factors like body parts, age, culture, gender, or disability, and combinations of these factors. One setting might require more nuanced and indirect modalities of touch which does not involve physical contact. In other settings, it might be more suitable to integrate other sensory modalities (e.g., sound, smell, taste) with tactile interaction to achieve a more immersive multi-sensory experience. Insights generated from sensory experiments of touch could potentially be fed into the future works of FlowIO, SoftRobotics.IO development [22], diversifying the spectrum of programmable actuation modules.

Intimate touch research will provide Soft Robotics and material science field with numerous contexts open for empirical case studies. Intimate care, women's wellbeing, and health have been under-researched areas in both HCI and material science fields - and even in medical studies [1] - with a big research gap in the intersection of emergent technologies and women's health [1]. Thus, this collaboration will offer an abundance of space to explore different user experience scenarios of intelligent wearable technology and investigate sociotechnical implications of actuated materials.

Most notably, Soft Robotics research could contribute to the value of inclusion and diversity both methodologically and epistemologically. Empathizing with the feminist value of empowering research subjects through their involvement in the research, intimate touch research actively adopts a participatory design approach [5]. Through devising low-complexity shape-changing material toolkits, soft robotics research can gain methodological knowledge of designing more accessible soft robotics strategies. Furthermore, soft robotics research can expand its scope of knowledge in wearable technology by engaging with hitherto marginalized users such as non-heterosexual populations, people going through menopause, transgender people and etc.

2.2 How can Soft Robotics add value to the Intimate Touch research?

Production and realistic demonstration of autonomous touch interaction will be the most conspicuous contribution of soft robotics strategies. Speculative futures of intimate touch can be manifested into material embodiments which can be worn, touched, and felt by participants and researchers. Working together with material scientists and microsystems engineers, intimate touch research can iteratively explore different forms and qualities of touch through heterogeneous combinations of materials and properties. This would be helpful not only in terms of touch research but also other HCI fields of research since it can create a thorough inventories of material technologies, mechanisms, and fabrication methods to manufacture particular experiential qualities. And perhaps, this could help researchers to acknowledge qualities of touch that are irreplaceable by technologies - which is also greatly valuable.

Increased capabilities of manufacturing more visceral and elaborate touch interaction can drastically contribute to the research on cultivation of body literacy. Almeida et al. and Ståhl et al.'s research demonstrated the importance of 'touch by others' and transferring of somaesthetic expert knowledge as a starting point of developing bodily awareness [2, 23]. It is especially apparent in intimate care because pertinent body parts are internally located, difficult to strengthen, or have little visibility (e.g., pelvic floor muscle, hip joints, or cervix area) [2]. Being touched these body parts can evoke feelings of humiliation, discomfort, or frustration due to their sensitive and covert nature. For this reason, soft robotics strategies can be implemented to invent more sophisticated and effectual ways of touching. For instance, self-actuated materials, activity-aware e-textiles, or unobtrusive interaction can be researched to aid wearer's confident reconnection and refocusing to their own bodies, while minimizing other sensory distractions. In this respect, intimate touch research can support more sustainable practices of personal wellbeing.

Lastly, a whole new world of possibilities of longitudinal intimate touch studies would arise as autonomous interactive technologies become available. With the help of soft robotics and material science expertise, we can develop robust wearable designs powered by more compact actuation components and better calibrated touch interactions. Designs can be deployed in the actual context and embodied "*in and through*" [7] users' bodies over a long period of time. In so doing, researchers will be able to examine how these interactive intimate technologies influence and transform people's lives.

2.3 Jointly posing critical questions over our bodies, cyborgs, and robotic skins

The overarching contribution of this collaborative study would be about eliciting critical yet controversial discussions about human bodies, cyborgs, and material-semiotic embodiments of robotic skins [7, 14]. Continuous works will take place exploring different material structures of intimate touch and identifying objects that need to be sensed and measured. By bringing the intimate touch closer to the skin, we could contemplate on reciprocal implications of body's materialities and meanings [17]. What does it mean for a robotic wearable 'to touch a human body'? Where is the boundary and limit for a human body? Where is the touch experience located? Do we live inside our skin or can our being transcend beyond the skins? What makes certain technology natural, organic, and intimate? And what does it even mean to be natural?

These philosophical conversations will greatly inspire the feminist technoscientific discourses on bodies. The forms and qualities of actuated intimate touch might disclose embodied inequalities and normative predispositions. Or they could facilitate us to conjecture re-materialization of our bodies and alternative relationships of bodily encounters that *does not fetishize, consume, or eat the other* [15].

3 CHALLENGES

While we have a wide varieties of opportunities to unfold, there are practical concerns and challenges present in this partnership. I would like to wrap up this position paper by outlining four aspects of expected challenges.

(1) Fabricating Delicate and Nuanced Touch More research should be taken place to help designers create more delicate and nuanced touch interaction. From HCI's side, GUI interfaces can be developed, through which designers can modify and iteratively refine nuances of touch interaction. From material science, mechanics, and physics studies, ways to translate huge force of power into sinuous, disseminated, and minimized force should be more researched. Taking FlowIO as an example, researchers could explore other inflatable shapes suitable to touch intimate body parts and address noise generated from the activated pump [18].

(2) Easy and Stable Soft Robotics The implementation of actuated materials in participatory design sessions and longitudinal user studies will require researchers to come up with more easy-to-use and stable robotic structures. Programmable materials are still quite complex ingredients of matter to be explored with participants - and even researchers - without sufficient technical knowledge. More accessible and comprehensible kinds of actuated materials should be invented to utilize them as design materials in participatory design workshops. Furthermore, soft robotic materials' robustness, stable network server connection, and easy initial server setup should also be taken into account to allow longitudinal user studies. Researchers should be able to easily set up a cloud server of the design, make adjustments, and fix quickly in case of malfunction.

(3) Bodily Data Justice The development of autonomous intimate technologies entails ethical issues regarding measurement, collection, usage, and storage of private and sensitive personal data, ranging from behavioral patterns, sexualities, menstruation cycle, bodily fluids to microbiomes [10]. Ethical handling of these bodily data should be taken seriously and protocols for ethical development of intimate technologies should be established first before their deployment. How should bodily data be handled and taken care of? How can designers ensure that their technology is justice-oriented? And how can we prevent it from giving a rise to another form of participatory physiological surveillance [12]?

(4) Discovering Sustainable and Body-Safe Materials Last but not least, we need to work towards more sustainable and safety-proof alternative materials. As wearable electronics emerged as a main contributor of e-waste problem [13],

environmental aspects of body-worn materials and electronic components should be taken into account. A conscious transformation towards decomposable or recyclable materials is necessary. Furthermore, since these technologies would be touching the intimate parts of our bodies, it is important to discover and create materials that are harmless and safe in a long run.

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