High5: Promoting Interpersonal Hand-to-Hand Touch for Vibrant Workplace with Electrodermal Sensor Watches

Yuhwan Kim[1], Seungchul Lee[1], Inseok Hwang[2*], Hyunho Ro[3], Youngki Lee[4], Miri Moon[3], Junehwa Song[1]

[1]Department of Computer Science
KAIST
Daejeon, 305-701, Republic of Korea

[2]IBM Research – Austin
Austin, TX 78758, USA

[3]Division of Web Science and Technology
KAIST
Daejeon, 305-701, Republic of Korea

[4]School of Information Systems
Singapore Management University
Singapore, 188065, Singapore

[1,3]{yuhwan, seungchul, hyunho, miri.moon, junesong}@nclab.kaist.ac.kr
[4]youngkilee@smu.edu.sg

ABSTRACT
Interpersonal touch is our most primitive social language strongly governing our emotional well-being. Despite the positive implications of touch in many facets of our daily social interactions, we find wide-spread caution and taboo limiting touch-based interactions in workplace relationships that constitute a significant part of our daily social life. In this paper, we explore new opportunities for ubicomp technology to promote a new meme of casual and cheerful interpersonal touch such as high-fives towards facilitating vibrant workplace culture. Specifically, we propose High5, a mobile service with a smartwatch-style system to promote high-fives in everyday workplace interactions. We first present initial user motivation from semi-structured interviews regarding the potentially controversial idea of High5. We then present our smartwatch-style prototype to detect high-fives based on sensing electric skin potential levels. We demonstrate its key technical observation and performance evaluation.

Author Keywords
Interpersonal touch; smartwatch; electrodermal sensing; social interaction; high-five; workplace; organization meme

ACM Classification Keywords
C.3 Special Purpose and Application-based Systems: Real-time and embedded systems; H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; K.4.3 Organizational Impacts

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Figure 1. Doing a high-five with High5 prototypes and an application mockup

INTRODUCTION
Interpersonal touch is a fundamental, yet often overlooked channel of social interaction strongly governing our emotional well-being [8]. Touch interaction plays a critical role in developing mother-infant bond, often surpassing that of nourishment [9]. In non-family/non-romantic contexts, a strong handshake, an encouraging pat on the back, or a gentle brush of the shoulder convey vitality and immediacy at times more powerful than verbal language [15].

Despite the positive implications of interpersonal touch in diverse social interactions, we may find limited touch-based interactions in workplace relationships which constitute a significant part of our daily social life. Yet there are various social or cultural thresholds [8, 25], it could be quite context-sensitive, cautious, or even socially risky to touch other teammates, colleagues, or managers [14, 18]. Field refers to such conservatism against interpersonal touch as 'touch hunger', implying that we may be overlooking many beneficial effects of touch-based social interaction [5].

We believe in the potential that promoting a new meme of casual and cheerful interpersonal touch, such as *high-fives*,

[*] This work was done while this author was at KAIST.

may contribute to propagating vibrant workplace culture. Boosting socially interactive and enjoyable employee culture is a key interest of organizations; common strategies are encouraging open communication or social gatherings [3, 4]. Workplace-situated ambient interfaces have been proposed [17, 22]. Yet, promoting touch in daily workplace interaction has been little adopted, often considered opposed to conventional norms depending on local culture.

In this light, we propose *High5*, a mobile service with a smartwatch-style device to catalyze the adaptation of high-fives as a natural organizational meme, enriching daily workplace interactions to be more friendly and cheerful, e.g., greetings, encouragement, agreement, or cheers.

We focus on the two aspects of High5. First, we explore the controversial idea of High5 through semi-structured preliminary interviews with a video of High5 scenarios; we report multi-lateral positive potentials which High5 might bring to workplace interactions. Second, we then prototype a smartwatch-style wearable sensing system to detect high-fives based on electric skin potential levels and linear acceleration (Figure 1 shows two people doing high-five, wearing our prototype).

The key contributions are twofold. First, we discuss radical ubicomp designs to promote cheerful interpersonal touch in workplace interactions. Second, we propose a wearable sensor prototype to detect high-fives which can leverage upcoming smartwatch platforms, and show its potential in terms of accurate and reliable detection.

HIGH5 SCENARIOS

High5 can enable various applications depending on workplaces or organizations. A few initial examples are as below. We expect many organizations design specific applications for their workplace characteristics.

Checking-in the office in the morning: Jamie, a developer staff working for a software company, has come to his office in the morning. For each teammate he meets, he says "*Good morning!*" to her/him, and does a high-five together. Here, the first high-five functions as an alternative way to make a 'punch-in' record, which so far has been done by tagging his ID card. It redesigns everyday punching-in behavior to be a social and cheerful experience.

Earning high-five points: Jamie can earn high-five points upon doing a high-five with another. Different points are earned for different people, e.g., +1 point for teammates, +3 for a newcomer, +5 for his director, encouraging high-fives with new people and across the hierarchy. Jamie can enjoy small in-company games with his points such as unlocking today's hidden lunch menu or earning a free coffee.

SCENARIO-DRIVEN USER STUDY

Participants and Method

We studied the potential of High5 for workplace settings with consistent peer interactions and relationships. We recruited 19 company employees (6 females, 13 males) from online communities with the following major criteria: (1) those working in an office, (2) closely interacting with 4+ team members, (3) 20+ collocated employees in the workplace. Table 1 summarizes the demographics. We recruited one participant per company to consider diverse workplaces. We recruited employees with less than 5 years of career to primarily focus on individual perspectives; supervisors or executives tend to have organizational perspectives as they have the authority to enforce others to follow. Later we conducted a supplementary interview with a 58-year-old chief executive officer to see any difference.

	Mean	Std. dev.	Min.	Max.
Age (year)	29.3	2.42	27	34
Career (month)	30.2	19.5	3	60

Table 1. Participants' demographics summary

For each participant, we conducted an hour-long semi-structured interview which consisted of two phases. Phase 1 asked about their experiences regarding interpersonal touch in workplaces, and the attempts in their workplaces to promote friendly employee culture. In Phase 2, we showed them our video[1] of High5 scenarios and collected High5-specific responses, e.g., positive or negative expectations and suggestions. Three researchers transcribed and coded the interview logs [27]. Each participant was compensated by an amount equivalent to USD 20.

Findings and Implications

We report our major findings under thematic categories[2]. Some findings (e.g., about social verticality and acceptable touch types) can be culturally specific to Korea or East Asia.

Potential misunderstanding of other colleagues: In Phase 1, we found factors why the participants feel touch is unusual in their workplaces. Interestingly, we found that the potential misunderstanding of other colleagues is a major reason why they refrain from touching others. P3 said: "*I don't want I look too much friendly with our boss*" as others may take it unprofessional or unfair. P13 was afraid that others might wrongly assume his sexual orientation; "*[a male colleague] and I are close enough just like friends, but I don't touch him like I do to my close friends.*" We were told an episode of a male-dominant company with its own norm taking most kinds of male-female touch inappropriate; "(P18) *They'll say I am crazy if I touch [the only female member in the team] even a bit.*" As such, inter-personal touch is not trivial to introduce in workplaces. We anticipate, as more people do high-fives in the workplace, it may alleviate people's concern about misunderstanding.

Intangible incentives motivating people to use High5: Our application scenario offers trivial incentives in doing high-fives, such as a free coffee. While many participants liked it, we found that many 'intangible' incentives would

[1] Jointly archived with this paper in ACM digital library.
[2] All quotes herein are directly translated from Korean.

be true motivating forces. P10 said: "*If my boss praises me with a high-five, I will feel a lot happier than simply saying 'Good job'.*" P11 expected that High5 would help starting a day with a bright mood; "*You know, coming to work in the morning is not quite a happy moment. (...) It will be a fun starting a day with a high-five, laughter, and cheers.*" It was noteworthy that many participants pointed out that high-fives should not be promoted as unidirectional company-driven campaigns or slogans.

Creating chances to strengthen passing-by interactions: Doing high-fives for greetings would create chances of explicit interactions, which are otherwise likely passing-by or inattentive ones. P9 pointed out: "*I walk in my office and simply say 'Good morning' even without looking at anyone. (...) I think it's great and a right thing to say hello to someone and make eye-contact right to him.*" For colleagues in other teams, many participants expected that High5 may initiate personal chats that are unlikely otherwise, helping them better know each other. P8 said: "*I meet [a colleague in the neighboring team] in hallways every day, but I feel it's a bit weird to talk to him. I just nod and walk by.*" P9 expected that High5 would be particularly helpful for newcomers; "*When I joined [my company], I had really hard time because I didn't have many chances to talk to someone first. (...) High5 will make it much easier.*"

Implications of alternative types of interpersonal touch: While handshakes are the most common type of touch in workplace interactions, P6 and P9 consider a handshake somewhat formal, mostly for meeting someone for the first time. P6 said, "*It's weird to handshake with my teammates every day.*" P9 and P10 told that a pat on the back or on the shoulder conveys strong feelings like: "*I sympathize with you*" or "*Good job.*" However, they pointed out that such a pat could not be reciprocal, mostly done in a top-down way.

Supplementary Study with an Executive

We recruited one chief executive officer to seek for a company-wide view. He expected that High5 would be able to restore the family-like culture which his company lost after its recent rapid growth; "*We used to have family gatherings and talked to each other a lot. (...) Now, one employee recently quit but even his team members don't know exactly why. (...) I'll definitely try it in my company.*"

HIGH5 SENSOR AND SYSTEM PROTOTYPING

To support aforementioned applications, we built a new sensor system that detects high-fives in a non-obtrusive and power-efficient way. The core technique has been inspired by previous works on mobile hand gesture sensing [7, 23] and capacitive sensing for human-to-object touch interaction [26]. Figure 2 shows our watch-style prototype that consists of an electrode to capture *Skin Potential Level* (SPL) attached to a custom-designed smartwatch based on Arduino Uno fit to a 3D-printed case. Having its electrode contact with the user's outer wrist, it unobtrusively captures naturally occurring SPL. SPL represents endosomatic voltage levels, which change upon touching conductive

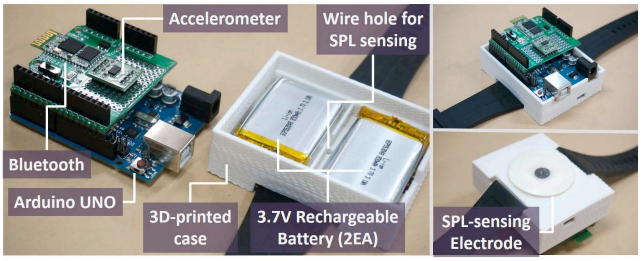

Figure 2. Prototype sensor device for high-five detection

materials, muscular motions, perspiration, and so on [21]. One might have a vague concern about contacting with an electrode on skin continuously. However, sensing SPL is a passive measurement without external current applied on skin, unlike Skin Conductance Level. It thereby resolves such concern even on wet or perspiring skin. We expect this prototype will lead to a practical solution as smartwatches are becoming increasingly popular and the system requires only a small electrode at the bottom where it naturally contacts with the skin.

Our key observation behind the sensor design is that interpersonal touch incurs unique peaks in SPL readings. Figure 3(a) shows SPL readings supporting the observation; it shows a sharp peak at the moment of hand-to-hand contact in a high-five. This unique peak is computationally distinguishable from readings during other non-touch daily activities; Figure 3 (c) and (d) show clearly different SPL readings for walking and keyboard typing, respectively.

A main technical hurdle lies in separating out other touch behaviors such as handshaking, which may show similar patterns in SPL readings, as shown in Figure 3 (b). To address this challenge, we devise a two-stage serial sensing method with accelerometer and SPL, respectively.

Stage 1. Pre-motion filter: The goal of this stage is to filter out other touch behaviors that may show similar peak patterns in SLP sensor reading, generating false positive outputs. We focus on the *pre-motion* of high-fives, i.e., quickly raising the forearm prior to clapping hands to do a high-five. This pre-motion is quite unique from those of other touch behaviors, e.g., handshaking. Also, this step needs to be highly efficient as it runs as an always-running front-end service. To achieve the goals, we devise a simple but effective accelerometer-only heuristics. It windows two seconds of accelerometer data sampled at 120 Hz and evaluate if the y-axis, which is parallel to the forearm, quickly rises towards the gravity.

Stage 2. SPL-based identification: On detecting a positive pre-motion of high-fives, Stage 1 triggers Stage 2, which initiates SPL sensing to find if a touch event indeed follows the pre-motion. Then standard classification techniques are applied on the SPL readings to identify unique peaks from high-five. It windows 2-second SPL data collected at 2 kHz, and extracts features to identify peaks such as 1st-, 2nd-order derivatives, their mean and standard deviations. Such features are classified using J.48 decision tree.

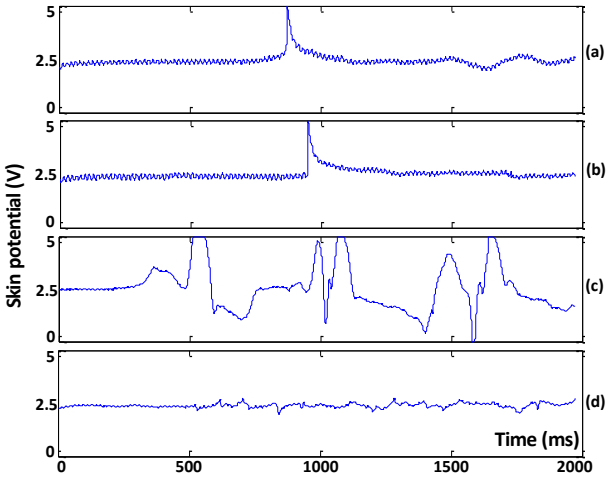

Figure 3. SPL readings during: (a) high-five, (b) handshaking, (c) walking, (d) keyboard typing

Once a high-five is detected, identification information is exchanged across the devices and High5 applications are notified of for further organization-specific processing.

Conversely, one might suggest an alternative high-five detection solely based on accelerometer like Bump [2]. Still, sensing SPL greatly increases the decisive power of High5 to capture true high-fives out of similar gestures without interpersonal touch, e.g., smashing a bug on the wall.

Evaluation settings: To evaluate the detection accuracy of our method, we collected high-fives and nine common office activities (handshaking, typing keyboard, grabbing phone, using phone, using spoon, arm stretching, walking, hand writing). We recruited three office workers and asked them perform each activity type 50 times in natural settings. We trained our algorithm using 60% of the data collected, and tested it with the remaining 40%.

Performance break-down: We first investigate the accuracy of the pre-motion filter. Table 2 shows the confusion matrix. The pre-motion filter could detect 100% of true high-five pre-motions, but not filter out 27.4% of other activities (e.g., phone grabbing, phone using, arm stretching). Note that we loosely tuned the parameters in Stage 1 not to miss a high-five. Importantly, the activities passed Stage 1 include no other human-touch activities that might introduce false positives in the following Stage 2.

We then investigate the accuracy of Stage 2 for the activities which passed Stage 1 (60 high-fives and 148 other activities). Table 3 shows its confusion matrix. The decision tree filters out non high-five activities very effectively; we found that 2nd-order derivative is the feature of the highest information gain to discriminate high-fives. As a result, our prototype achieves end-to-end high-five detection performance at 87.3% precision and 91.7% recall.

DISCUSSION

The qualitative findings from this study are limited in scale and may vary across different culture or generations. A few

Confusion matrix		Predicted	
		Pre-highfive	Non pre-highfive
Actual	Pre-highfive	60 (100%)	0 (0%)
	Non pre-highfive	148 (27.4%)	392 (72.6%)

Table 2. Confusion matrix for Stage 1

Confusion matrix		Predicted	
		High-five	Non high-five
Actual	High-five	55 (91.7%)	5 (8.3%)
	Non high-five	8 (5.4%)	140 (94.6%)

Table 3. Confusion matrix for Stage 2

participants responded that they would hesitate to touch for contextual or personal reason, although they admitted the positive function of touch. Regarding the check-in scenario, P3 commented: "*When I am late in the morning, I'd like to get to my desk covertly.*"

We plan to deploy High5 on real office environments to conduct empirical studies on its impact on the participants' mood and impression. To craft the prototype more usable, we will explore the energy issues under typical day-long usage patterns and evaluate the system more rigorously under more realistic experimental settings.

We expect further implications of High5 in synergy with recently proposed mobile interpersonal or group sensing systems. Interpersonal touch-based interactions may inspire designing next-generation social intervention systems beyond verbal interaction [13, 16], as well as extend the sensing modalities of collocated interpersonal platforms [10, 19, 20]. As touch-based interactions are particularly important in childhood, High5 may serve as a key element in upcoming applications to support parent-to-child interaction [28, 30] or inter-child interaction [11, 12, 29]. Physical social gaming systems may benefit from touch-based interaction as well [1, 6, 24].

CONCLUSION

We proposed High5, a mobile service enabled by skin potential level sensing to promote high-fives as a natural organizational meme. We aim at mitigating wide-spread taboos of touching in workplaces and regaining its positive potential to promote vibrant daily workplace interactions. We found positive implications of High5 scenarios such as mitigating touch-related misunderstanding, strengthening daily fun and morale, etc. We then developed a smartwatch-style prototype naturally sensing SPL to capture high-fives in daily life, and reported initial end-to-end performance. As a whole, High5 envisions that employees would get used to do high-fives in between as a part of everyday greetings and cheers in their workplace.

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REFERENCES

1. Bekker, T., Sturm, J., Eggen, B. Designing playful interactions for social interaction and physical play. *J. Personal Ubiquitous Computing. 2010*, 14, 5 (2010), 385-396.
2. Bump. https://bu.mp/.
3. Carmeli, A. The relationship between emotional intelligence and work attitudes, behavior and outcomes: An examination among senior managers. *J. Managerial Psychology* 18, 8 (2003), 788-813.
4. Cohen, D., Prusak, L. *In Good Company: How Social Capital Makes Organizations Work*. Harvard Business School, 2001.
5. Field, T. *Touch*. MIT (2001).
6. Fingle. http://fingleforipad.com/.
7. Fukui, R., Watanabe, M., Gyota, T., Shimosaka, M., Sato, T. Hand shape classification with a wrist contour sensor: development of a prototype device. *In Proc. UbiComp 2011*, ACM (2011), 311-314.
8. Gallace, A., Spence, C. The Science of Interpersonal Touch: An Overview. *Neuroscience and Biobehavioral Reviews 34*, 2 (2010), 246-259.
9. Harlow, H.F., Harlow, M. Learning to Love. *American Scientist 54*, 3 (1966), 244-272.
10. Hung, H., Englebienne, G., Kools, J. Classifying social actions with a single accelerometer. In *Proc. UbiComp 2013*, ACM (2013), 207-210.
11. Hwang, I., Jang, H., Nachman, L., Song, J. Exploring Inter-child Behavioral Relativity in a Shared Social Environment: A Field Study in a Kindergarten. In *Proc. UbiComp 2010*, ACM (2010), 271-280.
12. Hwang, I., Jang, H., Park, T., Choi, A., Lee, Y., Hwang, C., Choi, Y., Nachman, L., Song, J. Leveraging Children's Behavioral Distribution and Singularities in New Interactive Environments: Study in Kindergarten Field Trips. In *Proc. Pervasive 2012*.
13. Hwang, I., Yoo, C., Hwang, C., Yim, D., Lee, Y., Min, C., Kim, J., Song, J. TalkBetter: family-driven mobile intervention care for children with language delay. In *Proc. CSCW 2014*, ACM (2014), 1283-1296.
14. Jones, S.E. *The Right Touch: Understanding and Using the Language of Physical Contact*. Hampton (1994).
15. Jones, S.E., Yarbrough, A.E. A Naturalistic Study of the Meaning of Touch. *Communication Monographs 52*, 1 (1985), 19-56.
16. Kim, T., Chang, A., Holland, L., Pentland, A. S. Meeting mediator: enhancing group collaborationusing sociometric feedback. In *Proc. CSCW 2008*.
17. Kirkham, R., Mellor, S., Green, D., Lin, J.-S., Ladha, K., Ladha, C., Jackson, D., Olivier, P., Wright, P., Ploetz, T. The Break-time Barometer: An Exploratory System for Workplace Break-Time Social Awareness. In *Proc. UbiComp 2013*, ACM (2013), 73-82.
18. Lee, J. W., Guerrero, L. K. Types of touch in cross-sex relationships between coworkers: Perceptions of relational and emotional messages, inappropriateness, and sexual harassment. *J. Applied Communication Research*, 29, 3 (2001), 197-220.
19. Lee, Y., Ju, Y., Min, C., Kang, S., Hwang, I., Song, J. CoMon: cooperative ambience monitoring platform with continuously and benefit awareness. In *Proc. MobiSys 2012*, ACM (2012), 43-56.
20. Lee, Y., Min, C., Hwang, C., Lee, J., Hwang, I., Ju, Y., Yoo, C., Moon, M., Lee, U., Song, J. Sociophone: Everyday face-to-face interaction monitoring platform using multi-phone sensor fusion. In *Proc. MobiSys 2013*, ACM (2013), 375-388.
21. Malmivuo, J., Plonsey, R. *Bioelectromagnetism: Principles and Applications of Bioelectric and Biomagnetic Fields*. Oxford University, 1995.
22. McCarthy, J.F., Congleton, B., Harper, F.M. The Context, Content & Community Collage: Sharing Personal Digital Media in the Physical Workplace. In *Proc. CSCW 2008*, ACM (2008), 97-106.
23. Park, T., Lee, J., Hwang, I., Yoo, C., Nachman, L., Song, J. E-Gesture: A Collaborative Architecture for Energy-efficient Gesture Recognition with Hand-worn Sensor and Mobile Devices. In *Proc. SenSys 2011*.
24. Park, T., Hwang, I., Lee, U., Lee, S. I., Yoo, C., Lee, Y., Jang, H., Choe, S. P., Park, S., Song, J. ExerLink: enabling pervasive social exergames with heterogeneous exercise devices. In *Proc. MobiSys 2012*.
25. Rabinowitz, F. E. The Male-to-Male Embrace: Breaking the Touch Taboo in a Men's Therapy Group. *J. Counseling & Development*, 69, 6 (1991), 574-576.
26. Sato, M., Poupyrev, I., Harrison, C. Touché: Enhancing Touch Interaction on Humans, Screens, Liquids, and Everyday Objects. In *Proc. CHI 2012*.
27. Strauss, A., Corbin, J. *Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory*. Sage Publications (2007).
28. Teh, J. K. S., Cheok, A. D., Peiris, R. L., Choi, Y., Thuong, V., Lai, S. Huggy Pajama: a mobile parent and child hugging communication system. In *Proc. IDC 2008*, ACM (2008), 250-257.
29. Watanabe, J. I., Yano, K., Matsuda, S. Relationship between Physical Behaviors of Students and Their Scholastic Performance. In *Proc. UIC-ATC 2013*.
30. Yarosh, S., Tang, A., Mokashi, S., Abowd, G. D. "Almost touching": parent-child remote communication using the sharetable system. In *Proc. CSCW 2013*.