Sparkle: A Detachable and Versatile Wearable Sensing Platform in a Sustainable Casing

Adarsh Ravi
School of Electrical and Computer Engineering, Cornell University, Ithaca, NY, USA
ar2256@cornell.edu

Hsin-Liu (Cindy) Kao
Hybrid Body Lab, Cornell University, Ithaca, NY, USA
cindykao@cornell.edu

ABSTRACT

An easy to wear versatile and a compact sensing platform, Sparkle, which consists of a customizable array of sensors: 3-axis accelerometer, temperature sensor, capacitive touch sensor, RFID chip, and light emitting diodes (LED) is presented. The sensing system is cased inside naturally occurring materials such as a seashell and a seed of an oak tree; thereby showing a possibility of usage of ecofriendly materials in smart wearable gadgets. Sparkle uses a Velcro patch that enables easy attachment and removal from any already worn ornament or a gadget. Prototypes of Sparkle attached to a silicone ring, a beaded necklace and to a watch were evaluated for their functionality. The results from an exploratory user study are presented.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interaction devices, HCI design and evaluation methods.

KEYWORDS

Wearable Computing, Compact sensing system, Sustainable design, Easy attachment, Ecofriendly wearables

ACM Reference Format:
Adarsh Ravi and Hsin-Liu (Cindy) Kao. 2021. Sparkle: A Detachable and Versatile Wearable Sensing Platform in a Sustainable Casing. In *Augmented Humans Conference 2021 (AHs'21), February 22–24, 2021, Rovaniemi, Finland.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3458709.3459004

1 INTRODUCTION

The advancement in the microelectronics technology has enabled the development of compact smart wearable gadgets. Additionally, awareness about the importance of continuous monitoring of one's health and wellbeing has resulted in the inclusion of several sensors in these wearables [1, 2], thereby contributing to a high growth rate of consumer wearable market.

The wearable market mainly comprises of smart-watches, wristbands, and earphones [3]. These "pod"-like devices house the electronics which are then strapped or worn on the body. Most of these gadgets are easy to wear, monitor vital health parameters such as temperature and heartbeat, include display screens and track location and movements [4]. However, these wearables are restricted to a fixed body location.

Sparkle, on the other hand, is a sensing platform that can be easily attached to or removed from any worn ornament or a gadget, affording a greater range of customizability in body location. Sparkle consists of a customizable array of sensors and is encapsulated in a naturally available material such as a seashell or a seed of an oak tree. Hence, offering an underexplored aesthetic for "pod"-like devices. The features of Sparkle make it a versatile and a compact sensing system for on-body wearables that shows a possibility of usage of sustainable materials in smart wearable gadgets.

AHs'21, February 22–24, 2021, Rovaniemi, Finland

ACM ISBN 978-1-4503-8428-5/21/02.
https://doi.org/10.1145/3458709.3459004

2 RELATED WORK

The growing wearable technology market necessitates development of more sustainable wearables that positively impact the quality of life and the society [4]. To reduce the compounded increase in the wastage production from wearables, the need for usage of recyclable materials arises [5].

Most of the reported and commercially available wearable technologies require a middleware technology, that is usually cased inside a plastic or a metallic package. Furthermore, it is often restricted to a position or part of a body – wrist, ear, eye, etc., making it application specific. Khurana et al. [6] report a detachable smartwatch that enables it to morph into different forms for better user interaction and enhanced functionality.

The advancement in the wearable technology has also resulted in the miniaturization of wearables with wireless communication capability in addition to the housing of various sensing, actuation, and display elements [4, 7].

Sparkle is a sustainable wearable technology, in the sense that it uses ecofriendly material, is not restricted to a single middleware technology or an ornament.

3 DEVICE DESIGN AND PROTOTYPES

3.1 Device Design and Fabrication

With a motivation to eventually support applications including motion and health sensing, identification, and smart displays, devices such as accelerometers, touch and temperature sensors, RFID and display by means of LEDs were included in Sparkle.

Figures 1A and 1.B show Sparkle encapsulated in sustainable materials (e.g., seashell and oak-tree seed). A 3-axis accelerometer board consisting of a BMA- 250 accelerometer and a temperature

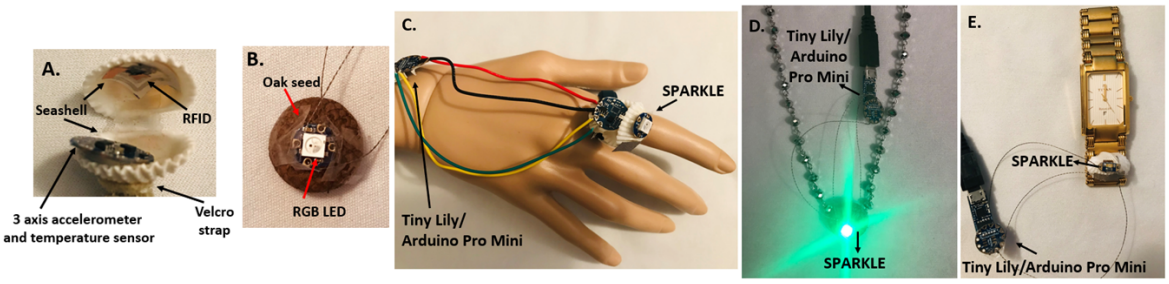

Figure 1: Images of Sparkle showing the placement of sensors and LEDs: A. inside a seashell B. inside an oak seed; Prototypes of Sparkle applied to various body locations: C. Sparkle attached to silicone ring, both placed on a finger of a mannequin arm; D. Sparkle in an oak seed attached to a beaded necklace; E. Sparkle in a seashell attached to a watch.

sensor was used. The board uses I2C communication protocol for communicating with an external microcontroller.

A piece of conductive fabric was applied onto the top surface of the natural case, to sense the touch. The fabric tape was connected to the external circuitry by means of conductive threads. Sparkle also has a programmable RGB LED and a non-programmable LED to show its capability for smart displays. An RFID chip attached to an inductor made from a thin copper sheet was also included.

The sensors are all placed inside a natural encapsulation material – seashell or seed of an oak tree. The LEDs were bonded to the top side of the encapsulation material by means of a lamination adhesive tape. A Velcro strap is attached onto the bottom surface of Sparkle to enable easy attachment and removal from any already worn ornament or a gadget.

The operation of sensors in Sparkle requires a 3.3V supply. The low voltage operation and the CMOS compatibility of these sensors [8] could enable further miniaturization of Sparkle.

3.2 Prototype and Exploratory Study

Three different prototypes were used for evaluation. First prototype consists of Sparkle inside a seashell attached to a silicone ring. The system was then placed on the pointing finger of a mannequin arm (Fig.1C).

The second prototype (Fig. 1.D) consists of Sparkle in an oak seed case attached to a beaded necklace. The third prototype (Fig.1.E) consists of Sparkle in a seashell attached to the metallic strap of a watch. The leads from Sparkle in all the three prototypes were connected to a TinyLily/ Arduino Pro mini microcontroller by means of a conductive thread or flexible hook-up wires.

The 3.3V supply came from wiring the Arduino Pro mini to a laptop computer. The first prototype was used to detect the hand movement and sense the temperature of the ambient. Sparkle attached to a necklace was used to evaluate the programmable RGB LED (Fig. 1.D) to emit different color light. Lastly, Sparkle attached to a watch was evaluated for touch sensing and display LED light.

4 PRELIMINARY USER SURVEY

As a part of an exploratory user survey, the first prototype was showed. This was followed by playing a minute-long video showing other sensor and display evaluation tests. 15 participants participated in the study and filled in a six-question survey. Participants included male (7), female (7) and a person of the non-binary gender. Of the 15, 9 participants said that they wore at least one wearable device. Participants were then asked to rate the Sparkle technology on a scale of 1 (not good) to 5 (it is great), The results showed an average rating of 4.2 out of 5.

When asked about their willingness to wear such a versatile wearable sensing system, 5 participants answered, "Definitely Yes", and the rest of them answered "Probably Yes".

The last question was about the feature they liked the most about Sparkle. 33.3% of the participants liked the natural casing, 26.67% liked the easy attachment feature. However, none ranked LEDs as the best feature in Sparkle.

5 SUMMARY AND FUTURE WORK

Sparkle is a versatile and a compact sensing system that is encapsulated in naturally occurring aesthetic and ecofriendly materials. Furthermore, it is easily detachable from an already worn ornament or a wearable gadget. By making the system wireless with a rechargeable battery, integrating all the sensors and displays, and enabling interactions among them, the wearable could find multitude of applications in motion and health sensing.

ACKNOWLEDGMENTS

The authors would like to thank all the volunteers for participating in the survey and the students and TAs from DEA 6040 Future Body Craft. A.R. thanks National Science Foundation - EFRI program for the funding.

REFERENCES

[1] D.R. Seshadri, J. R. Rowbottom, C. Drummond, J. E. Voos and J. Craker, "A review of wearable technology: Moving beyond the hype: From need through sensor implementation," 2016 8th Cairo International Biomedical Engineering Conference (CIBEC), Cairo, 2016, pp. 52-55, doi: 10.1109/CIBEC.2016.7836118.

[2] D. Blaauw *et al.*, "IoT design space challenges: Circuits and systems," 2014 Symposium on VLSI Technology (VLSI-Technology): Digest of Technical Papers, Honolulu, HI, 2014, pp. 1-2, doi: 10.1109/VLSIT.2014.6894411.

[3] IDC. Worldwide Wearables Market Forecast to Maintain Double-Digit Growth in 2020 and Through 2024. (25 Sep 2020). Retrieved 11 Dec 2020 from https://www.idc.com/getdoc.jsp?containerId=prUS46885820.

[4] Jaewoon Lee, Dongho Kim, Han-Young Ryoo and Byeong-Seok Shin, "Sustainable Wearables: Wearable Technology for Enhancing the Quality of Human Life," Sustainability 2016, 8(5), 466; https://doi.org/10.3390/su8050466

[5] A. Habibipour, A. M. Padyab, and A. Stahlbrost, "Social, Ethical and Ecological Issues in Wearable Technologies," in AMCIS 2019 Proceedings, 2019.

[6] Rushil Khurana, Mayank Goel, and Kent Lyons. 2019. Detachable Smartwatch: More Than A Wearable. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 3, 2, Article 50 (June 2019), 14 pages. DOI:https://doi.org/10.1145/3328921

[7] Kent Lyons, *et al.*, 2013. BitWear: a platform for small, connected, interactive devices. In Proceedings of the adjunct publication of the 26th annual ACM symposium on User interface software and technology (UIST '13 Adjunct). Association for Computing Machinery, New York, NY, USA, 73–74. DOI:https://doi.org/10.1145/2508468.2514716

[8] G. K. Fedder, R. T. Howe, T. K. Liu and E. P. Quevy, "Technologies for Cofabricating MEMS and Electronics," in Proceedings of the IEEE, vol. 96, no. 2, pp. 306-322, Feb. 2008, doi: 10.1109/JPROC.2007.911064.

[9] Cindy Hsin-Liu Kao, Christian Holz, Asta Roseway, Andres Calvo, and Chris Schmandt. "DuoSkin: rapidly prototyping on-skin user interfaces using skin-friendly materials." In Proceedings of the 2016 ACM International Symposium on Wearable Computers, pp. 16-23. 2016.