Phones on Wheels: Exploring Interaction for Smartphones with Kinetic Capabilities

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Figure 1. a: The overview of our hardware prototype. Our mobile accessory includes two robot wheels, offering kinetic capabilities to smartphones. b: Motor actuation allows a phone enough power to push small loads. c: With sensors, smartphones can kinetically react to the user. d: Thanks to rotary encoders, wheels can be used as an input channel, such as measuring the length of objects.

ABSTRACT
This paper introduces novel interaction and applications using smartphones with kinetic capabilities. We develop an accessory module with robot wheels for a smartphone. With this module, the smartphone can move in a linear direction or rotate with sufficient power. The module also includes rotary encoders, allowing us to use the wheels as an input modality. We demonstrate a series of novel mobile interaction for mobile devices with kinetic capabilities through three applications.

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces

Author Keywords
Mobile interfaces; kinetic interaction.

INTRODUCTION
Recent studies have made efforts on enriching and reshaping mobile interaction through additional output capabilities. Examples include haptic enhancements [1], shape-changing displays [2], and deformable surfaces [3]. This work attempts to extend the design space of mobile interaction by adding kinetic capabilities. We achieve this through attaching robot wheels to smartphones.

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Yamanaka *et al.* [4] demonstrated kinetic behavior in smartphones using multiple vibration motors connected to a case. Their system can offer the user notifications through motions. For example, the device can move towards the user's hand to make a contact for providing haptic notifications. The device can leave a message by rotation and change of its orientation for visual information even after the battery runs out. However, their approach can achieve a very limited set of movements, and thus interaction design in mobile devices with kinetic capabilities remains under-explored.

We demonstrate a series of interaction that smartphones with kinetic capabilities enable. We create an accessory with robot wheels for a smartphone (Figure 1a). This accessory can control the linear and rotational movements of the phone with enough power to push small loads (Figure 1b). Sensors in the smartphone allow interactions such as moving towards / away from human (Figure 1c). As robot wheels can serve as an input modality, users can interact with the phone through directly rotating the wheels (Figure 1d). In this paper, we describe our implementation, the interaction set our device offers, and applications demonstrating new forms of mobile interfaces. We conclude the paper with some future work.

IMPLEMENTATION
Our prototype device comprises of a smartphone (Google Nexus5), a custom-made accessory with wheels, and plastic cases. We manufactured the wheels and cases by 3D printing. The circuit board in the attachment component includes a micro-controller, USB-serial converter, motors, motor drivers, and rotary encoders. It is directly connected to the smartphone,

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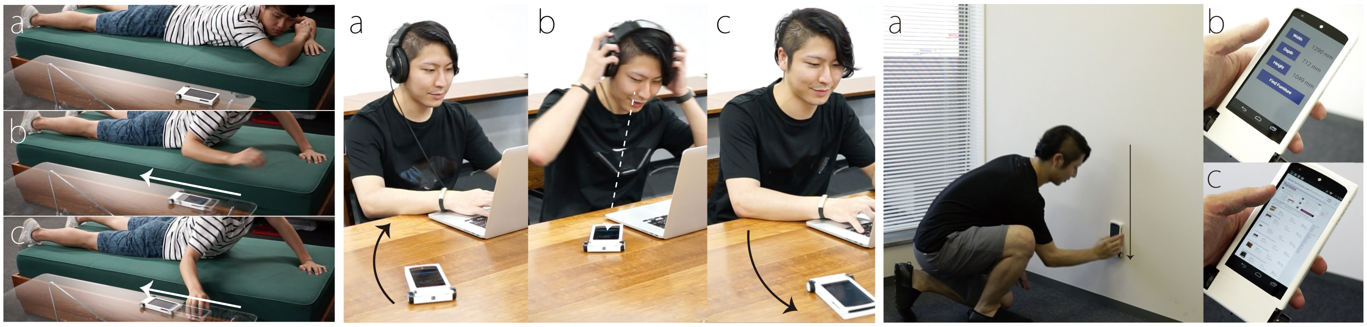
(A) Runaway Snooze (B) Hard Push (C) Scale Trace

Figure 2. Three applications illustrate unique characteristics of our device. A: *Runaway Snooze* **is an alarm application enhanced by motion. By sensing the user with proximity and light sensors, it escapes from him/her and interferes snooze. B:** *Hard Push* **visually emphasizes important notifications by moving towards the user. C:** *Scale Trace* **demonstrates the feasibility of our prototype as an input modality. By measuring width, depth, and height using rotary encoders, it recommends the user the list of furniture that fits to the space.**

controlling and sensing the wheels. We chose a wired USB connection as a communication bus instead of wireless methods, achieving robust and responsive controls of the wheels. This design also allows the power supply of up to 500 mA to the smartphone thanks to the correct USB connection with negotiation (if there is no negotiation, supply is limited to 100 mA; this value is not enough for driving motors). Although robot wheels offer direct controls of kinetic behavior, future work should consider other approaches, such as vibration, soft robotic actuation, and electrostatic force.

APPLICATIONS

We present three demonstrations that illustrate the unique capabilities of our device.

Runaway Snooze

Runaway Snooze is an alarm application enhanced by motion as shown Figure 2A. When the user is trying to hold the phone to stop an alarm, the device senses the user's hand by the light and proximity sensors and escapes from it. In this manner, the phone can force the user to wake up and get off from the bed.

We may apply a similar concept to decrease user's distractions by mobile phones. When the user is engaged in work on a laptop, the device gradually moves away from her and automatically stops notifications about unimportant messages. When the user is free, the phone moves closer to him/her so that it can be available to him/her needs.

Hard Push

Hard Push is a new way to inform the user of incoming critical notifications shown in Figure 2B. For instance, when the phone receives uncritical emails or messages, it simply notifies the user in a silent way (e.g., blinking a LED light). But when an important notification comes, the phone moves towards the user to encourage him/her to check. Our system can offer a unique form of ambient displays as illustrated in this application.

Scale Trace

Scale Trace is an example of demonstrations where robot wheels serve as an input modality. Existing applications mostly employ vision-based methods to measure the length of physical objects. But they are susceptible to ambient lighting conditions and physical shapes. The wheels in our device are sensitive and can achieve accurate measurements.

Figure 2C shows an example use scenario of *Scale Trace*. The user can quickly measure the width, depth, height of a sideboard to make sure whether it fits into his/her room. The user can measure lengths on non-flat surfaces as well.

CONCLUSION AND FUTURE WORK

In this paper, we demonstrate smartphones with kinetic capabilities. We report the implementation of our prototype and describe three enabled applications. In future work, we will deeply examine the design space of smartphones with kinetic capabilities. We will also explore other possible approaches to producing kinetic behavior embeddable to devices in a mobile form-factor.

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REFERENCES

1. Olivier Bau, Ivan Poupyrev, Ali Israr, and Chris Harrison. 2010. TeslaTouch: electrovibration for touch surfaces. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology*. 283–292.
2. Sungjune Jang, Lawrence H Kim, Kesler Tanner, Hiroshi Ishii, and Sean Follmer. 2016. Haptic Edge Display for Mobile Tactile Interaction. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. 3706–3716.
3. Viktor Miruchna, Robert Walter, David Lindlbauer, Maren Lehmann, Regine Von Klitzing, and Jörg Müller. 2015. GelTouch: Localized Tactile Feedback Through Thin, Programmable Gel. In *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology*. 3–10.
4. Shota Yamanaka and Homei Miyashita. 2014. Vibkinesis: notification by direct tap and'dying message'using vibronic movement controllable smartphones. In *Proceedings of the 27th annual ACM symposium on User interface software and technology*. 535–540.