Shake-It-All: A Toolkit for Sensing Tangible Interactions on Everyday Objects

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As computation is becoming increasingly ubiquitous, researchers and makers have shown a strong interest in similarly adapting the way we interact with technology. To this end novel user interaction devices are being developed. However, prototyping such devices usually requires profound expertise in soft- and hardware development. To empower people without this expertise, we envision a future where plug & play toolkits allow everyday objects to be augmented easily, rapidly, and in an inexpensive manner. We present the concept for the Shake-It-All toolkit, enabling plug & play sensing of a large variety of tangible interactions on everyday objects (e.g., touching, tilting, squeezing, shaking, or moving). We plan to implement Shake-It-All in the future to investigate use cases such as controlling IoT devices, embedded authentication, or physiological sensing.

CCS CONCEPTS • Human-centered computing~Human computer interaction (HCI)~Interactive systems and tools~User interface toolkits

Additional Keywords and Phrases: tangible interaction, augmenting objects, prototyping toolkit

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1 INTRODUCTION

In the era of ubiquitous computing we are currently experiencing, we no longer interact with single centralized machines, but mostly use multiple, networked smart devices. Such devices are spatially distributed in our surroundings and increasingly embedded in our daily routines and everyday objects (e.g., smart toothbrushes or door locks) [17]. As the nature of computation becomes more and more diverse, there is a strong interest in also adapting the way we interact with such technology in research and maker communities (e.g., [1], [3], [16] or [2]). However, the rapid prototyping and refinement of novel input devices (e.g., controllers) requires expertise and involves a substantial amount of effort. Hence, we believe that building on knowledge of how people' *interact with everyday objects* to generate user input is a promising solution to this challenge. With *everyday objects*, we specifically mean objects we frequently interact with but that do not have any computation or sensing capabilities. Such objects are already integrated into our daily routines and environments, allowing for unobtrusive and embedded interactions [8, 9, 17]. *Tangible interactions* (e.g., touching, shaking, tilting) are particularly suitable for this purpose, as they correspond to the way we naturally interact with our environment. Moreover, established input devices have traditionally made use of tangible interactions – think of joysticks, keyboards, or mice.

We envision *Shake-It-All*, a *plug & play* toolkit that enables easy, rapid, and inexpensive augmentation of everyday objects for sensing tangible interactions. Users of the toolkit would not need to implement any soft- or hardware since they can simply attach the *wireless hardware unit* to any existing object and sensed tangible interactions will get directly published to a web server (e.g., "the teddy bear is being touched"). While tangible interactions can also be relational (e.g., putting an object inside another [14]), our toolkit focuses on *on-object tangible interactions* with one single object (e.g., object-in-hand gestures like touching or shaking [15]). The Shake-It-All toolkit especially empowers people *with little DIY expertise* to create novel user input devices since (a) the *objects themselves do not need to be fabricated* and (b) it allows for *plug & play sensing of tangible interaction*, meaning that the user does not need to implement soft- or hardware.

2 THE SHAKE-IT-ALL TOOLKIT: A VISION

In this paper, we present our vision for the Shake-It-All toolkit. We plan to implement the toolkit in the future.

2.1 Measuring Tangible Interactions

Related work presents prototyping toolkits for sensing tangible interactions on specifically created objects [1, 5, 7, 8, 12] or augmented everyday objects [3, 9, 11, 16]. Yet, existing toolkits enabling sensing tangible interactions on everyday objects usually focus on sensing one type of tangible interaction only (e.g., touch [3, 9, 8, 18] or movement [16]). In contrast, we envision our toolkit to be capable of measuring a wide range of tangible interactions. Based on related work we envision this to include e.g., squeezing, tilting, holding, touching, shaking, stroking, and movement (see Table 1). Moreover, the Shake-It-All hardware is stand-alone and, thus, does not require additional external tracking hardware.

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[2] Zack Freedman. Somatic - Wearable Control Anywhere. Hand signs and gestures become keystrokes and mouse clicks. https://hackaday.io/project/169297-somatic-wearable-control-anywhere, last visited in February 2023

Table 1: List of on-object tangible interactions and how they could be measured with the Shake-It-All toolkit.

Interaction	Measuring	Sensor
squeeze, push [6, 13]	touch, force	capacitive touch [3, 8], force-sensitive resistor [4]
tilt [6]	3D rotation	inertial measurement unit [7]
hold, touch, tap, grab, release [2, 6, 9]	touch	capacitive touch [3, 8]
shake, swing, thrust [2]	acceleration	inertial measurement unit [7]
stroke [13]	touches	multiple capacitive touch points [3, 8]
movement [14]	3D acceleration and rotation	inertial measurement unit [7]

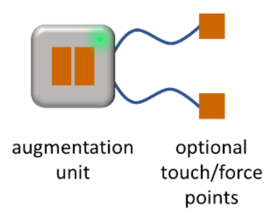

Figure 1.1.: Each augmentation unit can be extended with further touch/force sensing points.

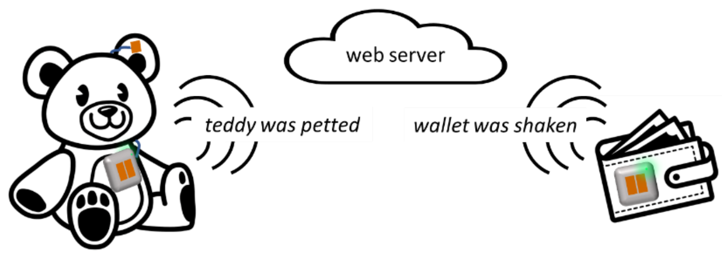

Figure 1.2.: Each augmentation unit notifies a webserver if a tangible interaction is sensed. Figure based on illustrations from [3].

Figure 1: The envisioned implementation of the Shake-It-All toolkit. Users have to attach (e.g., with glue) an augmentation unit to an everyday object. This unit incorporates all necessary hardware components to enable the sensing of tangible interactions.

2.2 Augmenting Everyday Objects

To sense tangible interactions with an everyday object, the user would have to attach the Shake-It-All augmentation unit to the object (see Figure 1). To make this unit easily attachable and lightweight, its size is constrained. The unit also provides means to be attached to an object such as magnets or adhesives. As the unit is stand-alone, it includes a battery and WiFi for communication with a web server. Moreover, the unit incorporates the sensors mentioned in Table 1. These include capacitive touch sensors, an inertial measurement unit, and force sensors. Two electrodes for the capacitive touch sensing and a force-sensitive resistor should be situated on top of the case to allow for direct user interaction with them. Besides the built-in sensors, the unit provides connectors to attach further touch and force sensors. This allows the user to extend the interaction space with the object. Additionally, the unit communicates its current state through a built-in LED.

3 USE CASES

We envision the Shake-It-All toolkit to enable the sensing of a large variety of tangible interactions in a plug & play manner. It empowers people with limited prototyping expertise to create novel and custom user input devices. As we plan to implement the toolkit in the future, we provide an overview of the corresponding use cases we want to investigate.

Controlling Internet of Things (IoT) Devices: Many IoT devices lack intuitive and embedded input functionalities and instead require a smartphone application. However, using a smartphone app e.g., to preheat your coffee machine alters established routines and creates an additional workload. Wouldn't it make much more sense to preheat the coffee machine when we pick up our favorite coffee cup [3]?

[3] goff.brian on vecteezy.com. https://www.vecteezy.com/members/goff-brian, last visited in February 2023.

Embedded Authentication: In our previous research, we conceptualized the usage of touch interactions with everyday objects for authentication purposes [3, 4]. Hence, a user could (a) explicitly touch different objects in a secret sequence (i.e., replacing a pin or password entry) to authenticate, or (b) the user's unique behavior pattern (i.e., routines) while interacting with different objects could be leveraged for identification purposes and thus for implicit authentication.

Implicit Automation or Personalization: The ability to measure implicitly generated tangible interactions would allow, e.g., our smart home to react to our behavior in an automated way. Furthermore, leveraging interaction patterns for identification purposes can be used for personalization e.g., by playing your favorite song once you start cooking.

Gamifying of Our Lives: We are also interested in investigating how the Shake-It-All Toolkit can be used to gamify daily routines and therefore serve as an extrinsic motivator for "boring" tasks. For example, one could augment a toothbrush and reward a child for brushing their teeth regularly.

Physiological Sensing: Equipping everyday objects such as pens, cups, or coffee machines with physiological sensing capabilities has the potential to be used for health and stress monitoring. By embedding sensors in these items, they can measure vital signs in a non-invasive and continuous manner. As an example, by comparing interactions with items over a longer period of time, first signs of diseases like Parkinson could be detected through increased trembling [10].

4 CONCLUSION & OUTLOOK

We believe the future of prototyping lies in providing means for plug & play augmentations of everyday objects. Corresponding toolkits would especially empower people with little expertise in soft- and hardware development. With *Shake-It-All*, we present our vision for a plug & play toolkit that measures tangible interactions on everyday objects. Sensing tangible interactions is particularly useful, as they reflect the way we interact with objects in our environment anyway. Our toolkit enables the easy and rapid development of novel user input prototypes which can be used, e.g., as controllers for IoT devices, to embed authentication processes in surrounding objects, to sense our implicit interactions with our environment, or to gamify our daily routines. Since we plan to build the here presented Shake-It-All toolkit in the future, we hope to get diverse feedback on our vision, the possible implementation, and further use cases through our participation in this CHI'23 workshop.

5 THE USABLE SECURITY AND PRIVACY GROUP AT UNIVERSITY OF THE BUNDESWEHR MUNICH

The Usable Security and Privacy Group explores the design of secure and privacy-preserving systems that blend with how users naturally interact in the physical and digital world. Our research focuses on understanding users' behavior in security-critical contexts, developing novel (tangible) security and privacy mechanisms based on users' behavior and physiology, as well as investigating and mitigating threats that emerge from novel ubiquitous technologies.

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