Sensing and Recreating Mobile Device Manipulations for Remote Usability Studies

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Abstract
Our hands and fingers tell stories of ongoing emotions. A sweating hand can indicate frustration and strong grips can reflect anger. Sensing finger-level data lets us peek into the emotional world of mobile device users. This is especially important for remote usability studies where important context data like emotions are often left out due to lack of adequate collection methods. We propose a mobile device case that non-intrusively captures hand and device state. The case can also be used to reenact data via LED arrays. This hardware will help researchers better understand the ergonomics and usability of mobile devices.

Author Keywords
mobile device behavior; pressure sensing; motion visualization; fabrication; remote studies; mobile sensing.

CCS Concepts
•**Human-centered computing** → **Gestural input;** *Usability testing;*

Introduction
Remote usability studies on mobile devices benefit from understanding how users physically interact with them. For example, users' grips or holding gestures have shown value in understanding their underlying emotions. Existing approaches use mobile devices' on-board gyroscope and ac-

Sensors to be Used

Mobile Device Case

- Pressure Sensitive Conductive Grid

  Finger and palm positions and pressure on back and side of case

- 9DOF IMU

  Secondary source of orientation of mobile device

Robotic Mounted Display

- Display Mobile Device + Servo Motors + Cardboard

  Physically replicate orientation of mobile device

- RGB LED Grid

  Shows pressure of all grips and touches

- Coral Dev Board

  Analysis of user behavior

celerometer sensors to estimate users' grips[1], or replay remote users' movement to infer users' grips [2]. However, factors such as the exact gripping gesture, the force of the grip, and skin conductivity are not captured in current methods, and these factors are useful to estimate users' stress and emotional changes during a task.

Video recording can provide cues for users' emotional changes. However, in remote usability studies, locations such as bedrooms can be extremely sensitive to privacy. A sensor based method would non-intrusively help later review of users' emotional changes during a task without extra privacy risks.

Proposal

We propose a novel sensor filled cardboard case that can be slipped onto users' smartphone to increase the data modalities. This case will contain a grid of pressure sensors made from conductive fabric that will surround the case's back and edges to capture exact finger placement. The case will also record absolute orientation. Together, this allows for more detailed tracking of fingers, the strength of the grip, and the change in skin conductivity during task performance. This will provide insight into how different levels of task complexity impacts users' performance, gripping position, and finger placement, generating practical usability and ergonomic lessons.

Multiple studies have found that physical representations of the data are a helpful cognitive aid. With that in mind, we also propose representing the data with a mobile device mounted to a 6 degrees of freedom (DOF) cardboard robotic arm. This arm will hold a mobile device and replicate the remote device's orientation and rotational movement. Meanwhile, we also improve on prior work by representing users' grip strength with a number of color changing LEDs located in a grid outside of the mobile device.

In addition to the physical replication of users' manipulations, we will provide machine learning based predictions about the current user finger and grip positions as well as emotional state on a nearby display. The predictions can generate insights for userâĂŹs finger positions and the relationship between different emotions and the grip. This will be accomplished with the help of the Coral Dev Board and a TensorFlow model trained on gathered user data. While a researcher would likely want to make their own conclusions about user behaviors, the automated insight can serve as a jumping off point.

We hope that the increased level of behavioral capture and replication presented by these devices will provide unparalleled insight into user behavior for mobile devices. In particular, we believe that adding grip and holding gestures sensing and machine learning predictions will result in new discoveries about usability and ergonomics.

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