AnyButton: Unpowered, Modeless and Highly Available Mobile Input Using Unmodified Clothing Buttons

Liwei Chan* **Chien-Ting Weng** † **Rong-Hao Liang** ‡ **Bing-Yu Chen***
*†‡National Taiwan University ‡Academia Sinica
*{liweichan,robin}@ntu.edu.tw †‡{howieliang,ctweng}@cmlab.csie.ntu.edu.tw

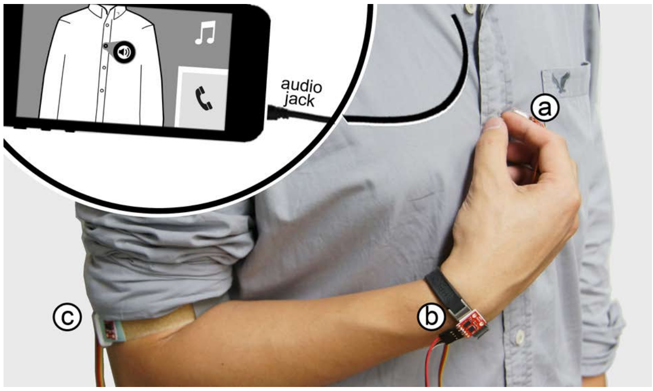

Figure 1. AnyButton turns unmodified buttons on the clothing into opportunistic mobile controls, by adding three motion sensors on the index fingernail, on the wrist and elbow. The user tunes up the music volume by pinching up and spinning the second button.

ABSTRACT

This paper presents wearable opportunistic controls using unmodified clothing buttons. Buttons are commonly sewn on formal clothing and often came with multiple duplicates. In this paper, we turn passive buttons into dial widgets. Each button provides simple input modalities (e.g., tap and spin inputs). Multiple buttons allow for modeless and rich interactions. We present AnyButton, a wearable motion-sensor set, allowing for transferring buttons on clothing into mobile input on the move. Our prototype consists of three motion sensors attached on the index fingernail, the wrist, and the elbow. We interpret which button is under user interaction according to the wrist and elbow orientations, and how the button in the user's finger pinches being operated according to the motions on the fingertips. Each button allows for partial tap, discrete spin and dwell spin inputs. By distributing interface to the buttons, applications such as music players and call centers can use opportunistic clothing buttons as wearable controls.

INTRODUCTION

Recent research proposes transferring affordances in the surrounding into use for computer tasks [2][1]. Opportunistic controls [2], for example, utilize unused affordances in the environment, allowing opportunistic haptics for augmented reality applications. iCon [1] utilizes, e.g., cups on the desk, as controls for peripheral interaction. The affordance, according to the tangible form allows, facilitates direct manipulation and reduces operational errors. This paper extends the concept of *transferring affordance* from tangibles in surrounding environment to tangibles that are very small and are commonly worn by the users. We focus on clothing buttons.

The main idea of the paper is to enable *wearable opportunistic controls* using unmodified clothing buttons. We present AnyButton, a wearable motion sensor set, allowing for transferring passive buttons on clothing into mobile tangible inputs. As shown in Figure 1, the prototype consists of three motion sensors, each placing on the index fingernail, the wrist, and the elbow. Our approach interprets which button is under user interaction according to wrist orientation, and how the button pinched by the user being operated according to the motions on the fingertips. By placing the sensors on nails, we are able to preserve user fingers for naive functions of human hands (e.g., pinch a small clothing button).

PROTOTYPE

Our prototype includes three 6-degrees-of-freedom inertial measurement unit (IMU) sensors (Figure 3): one glued on index fingernails and the other two attached to the wrist and elbow with wristbands. We determine to use three sensors and their positions to attach through exploring the following two questions: (1) which button is under user interaction and (2) what interactions are applied to the button.

POSTURE ENCODE BUTTON LOCATIONS

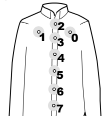

Figure 2. The mapping of the button IDs and locations on the study cloth.

We conducted a user evaluation to determine where to place the IMU sensors on the user's hand. Participants put on the buttoned-shirt we prepared for the study, and four IMU sensors on the index and thumb fingernails, the wrist, and the upper arm. Note that the forth IMU sensor adding to a thumbnail is purportedly included to understand how detection performance is accordingly affected. Participants were instructed to pinch the buttons indicated by the study host (Figure 2). We recorded the sensor data from all IMUs and the corresponding button locations for a post-hoc evaluation. 15 participants (7 female), between 21 and 34, were recruited. The data is used to detect the buttons location using SVM. According to the results

AH'14, March 07 - 09 2014, Kobe, Japan

http://dx.doi.org/10.1145/2582051.2582075

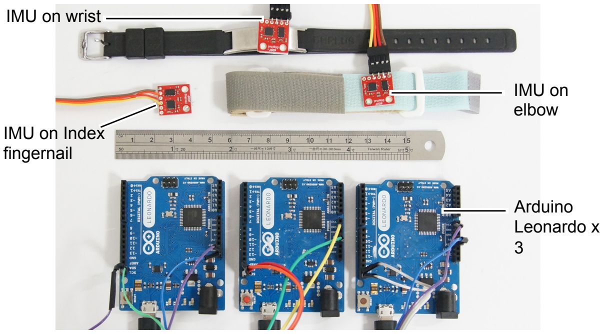

Figure 3. Our prototype consists of three 6DOF IMU, each connecting to an Arduino Leonardo microprocessors. All IMU data is aggregated on the computer for processing.

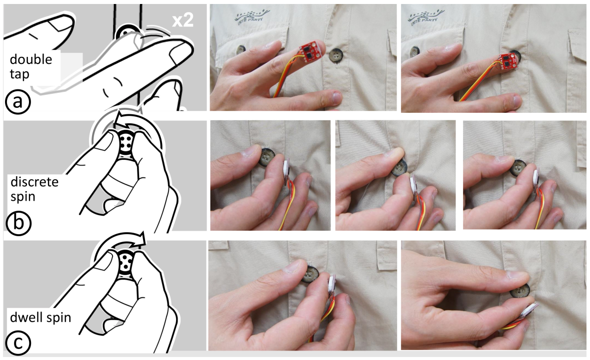

Figure 4. Three input methods are implemented: (a) tap input, (b) discrete spin, and (c) dwell spin

in Table 1, we include both the wrist and elbow IMUs in the prototype for locating the operation button.

IMU In Use	Button In Use	Recognition Rate
Thumb, Index-finger	0,1,2,3,4,5,6,7	38%
wrist, upper-arm	0,1,2,3,4,5,6,7	86.25%
wrist, upper-arm	2,3,4,5,6,7	86.67%
wrist, upper-arm	2,4,6/3,5,7	100%/100%
wrist	0,1,2,3,4,5,6,7	62.50%
wrist	2,3,4,5,6,7	65%
wrist	2,4,6/3,5,7	97%/100%

Table 1. The recognition rate of button localization in different sensor combinations.

TAP &SPIN INPUT

Tap input (Figure 4a) dose not be affected by the posture problems, because it comes with clear and sharp motion patterns. We compute the derivative in the yaw, pitch, and roll axes, respectively, using a sliding window, for the index-IMU, and iterate over this sliding window, looking for consecutive positive and negative derivative. We report tapping when the index-IMU observed a candidate at one of the three axes.

Spin input (Figure 4bc) can be affected by pinch postures (e.g., the spin level and whether users spin clockwise or counterclockwise). In a prior test, we found that index fingers move more prominently than thumbs while users performing spin input on buttons. Hence, we did not include a thumbnail motion sensor in the final prototype, and only report values on index fingernail sensor in the below.

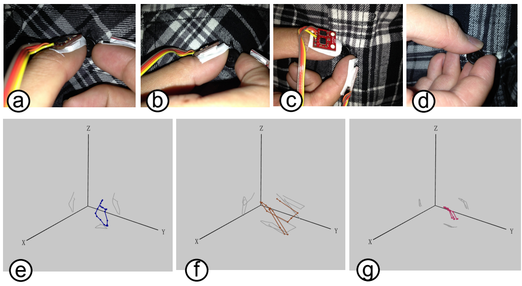

Figure 5. Three input methods are implemented: (a) tap input, (b) discrete spin, and (c) dwell spin

Figure 5e-g present the orientation values (yaw, pitch roll) on the index finger IMU while the participants spin a button clockwise and back to the original angle, using different pinch postures (Figure 5a-c). The trace, according to the posture applied, represents a curve in the 3D coordinate system. Even though the curves have different shape, they basically move toward a certain direction, forth and back. We perform the principal component analysis (PCA) on the trace, to extract the the principal moving direction. By projecting the trace on its principal axis, the movement on the represents a good indicator to the spin input. However, the principal axis might be different each time users pinch a button. This may be worse, as the same user might pinch the same button with different pinch posture. Hence, there is a need to capture the principal axis for each use. We therefore propose triple-spin gesture. To perform spin input, the user first spins twice as the initial input for computing the principal axis, followed up by the third spin as the intended spin input to indicate the spin direction. The trace in third spin is projected to the axis determined on the first two spin traces, and used to compute the spin levels.

CONCLUSION

We presented AnyButton as a proof of concept for wearable opportunistic controls using unmodified clothing buttons. To enable the concept, our approach targets two questions: (1) detecting which button is under user interaction and (2) detecting what motions are applied to the button. For further works, we would like to include other wearable passive accessories such as neckless and as mobile input using the proposed techniques.

ACKNOWLEDGMENTS

This paper was partially supported by National Science Council of Taiwan under NSC101-2622-E-002-006-CC2.

REFERENCES

1. Cheng, K.-Y., Liang, R.-H., Chen, B.-Y., Laing, R.-H., and Kuo, S.-Y. iCon: utilizing everyday objects as additional, auxiliary and instant tabletop controllers. In *Proc. ACM CHI ’10* (2010), 1155–1164.
2. Henderson, S. J., and Feiner, S. Opportunistic controls: leveraging natural affordances as tangible user interfaces for augmented reality. In *Proc. ACM VRST ’08* (2008), 211–218.