Demo: *FingerT9*: Leveraging thumb-to-finger interaction for one-handed text entry on smartwatches

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ABSTRACT

We introduce *FingerT9*, leveraging the action of thumb-to-finger touching and the surface of the finger segments, to support one-handed text entry on smartwatches. This is achieved by mapping a T9 keyboard layout on the surface of finger segments, combined with a predictive input method. Our solution avoids the problems of fat finger and screen occlusion, and enables text entry using a single hand. Eyes-free text entry is made possible once users are familiar with the keyboard layout. In other words, users can focus on the screen output during typing without looking at the keyboard layout mapped on the surface of finger segments.

CCS CONCEPTS

• **Human-centered computing** → *Ubiquitous and mobile computing design and evaluation methods*;

KEYWORDS

mobile interaction, thumb-to-finger interaction, one-handed, smartwatch, text entry

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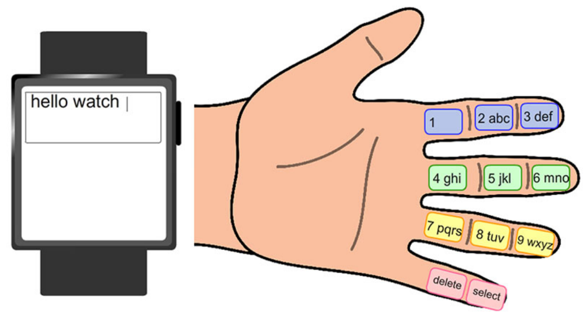

Figure 1: *FingerT9* overview

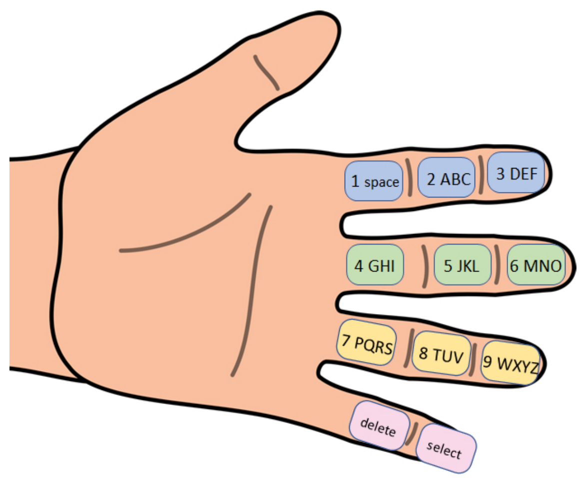

Figure 2: *FingerT9* key arrangement

1 INTRODUCTION

The smartwatch is emerging as another major category of personal computing devices after the desktop PCs, laptops, smart phones, and tablets. There are various smartwatch applications, such as checking emails, calling, messaging, and social networking. Among these applications, typing/text entry is an essential activity. Traditionally, text entry techniques for small displays employ QWERTY-like soft keyboards [Leiva et al. 2015], and several methods, such as multiple tap selection [Oney et al. 2013] and memorization of individual gestures [Gong et al. 2016], have been proposed to facilitate smartwatch text entry. Voice input is an alternative input method. However, it becomes awkward in a broad range of situations, e.g., due to privacy or noisy environment. Furthermore, touching on smartwatch usually requires the input from the non-wearing hand, being difficult to perform one-handed interaction with smartwatches, as it is almost impossible for the wearing hand to reach the touch screen of the watch. Users often adopt one-handed strategies to interact with mobile devices when the users' hands are occupied while holding objects. There is lack of one-handed technique that particularly aims to address the problem of text entry on smartwatches.

Research showed that people can accurately touch the surface of their finger segments with their thumbs and thumb-to-finger interfaces support effective eyes-free interaction [Huang et al. 2016].

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Figure 3: Experimental prototype, typing in hand up (left) and hand down (right) condition

In this paper, we introduce *FingerT9*, leveraging the action of thumb-to-finger touching and the surface of the finger segments, to support one-handed text entry on smartwatches (Fig. 1). In *FingerT9*, a T9 keyboard layout is mapped to the finger segments (Fig. 2). The T9 layout was chosen due to its common usage especially among feature phone users and the straightforward mapping between the T9 keys and the finger segments. We developed an experimental prototype of *FingerT9* using force sensors attached to the finger segments (Fig. 3). We implemented *FingerT9* that mimics the T9 input and predicts userâĂŹs input based on the combination of single thumb-to-finger taps.

Our contributions:

1) Integration of thumb-to-finger interaction with smartwatches

2) *FingerT9* design and implementation

2 DESIGN

FingerT9 mimics a T9 keyboard on finger segments (Fig. 2). Eleven keys are mapped on finger segments of index, middle, ring and pinky fingers. Eight keys are responsible for typing letter and three function keys are used for adding space, deleting, and triggering candidate selection. Eight segments on index, middle, and ring finger correspond to eight keys in which several letters are associated with each key. Three segments, one on index finger and two on pinky finger, are the functional keys.

Designing the arrangement to map the T9 keyboard on finger segments, a questionnaire was conducted with 22 participants (7 females, aged 20 to 28) to investigate the suitable arrangement for mapping the T9 keyboard. We proposed three layouts (Fig. 5) with different key arrangements. Layout 1 directly maps the T9 keyboard on finger segments, while Layout 2 vertically flips the letter keys (for the use when the hand faces down) and the space key, and Layout 3 rotates the keyboard in Layout 1 by 90Âřorientation. We then asked the participants to rate the ease of use and ease of memorizing each layout. Finally, we adopted Layout 1, since the participants found the chosen arrangement is the most natural and is easier to remember.

We built an experimental prototype with 11 pressure sensors to detect thumb-to-finger touching on the surface of finger segments. Network communication is used to connect the smartwatch and the sensors via an Arduino board. The current prototype does not require calibration and uses a pre-specified pressure threshold to detect tapping action: touch with pressure over the threshold is regarded as a tap.

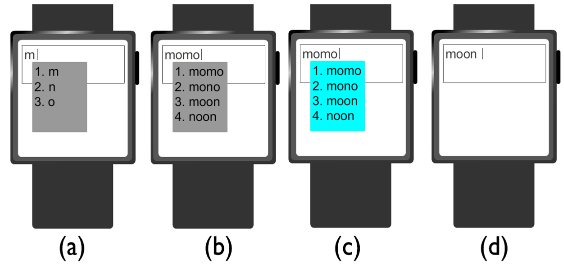

Figure 4: A storyboard illustrating a user entering âĂIJ-moonâĂİ with FingerT9. (a) Type by tapping a key on finger segment. (b) Type the word letter by letter. Candidate list is displayed. (c) The user taps the âĂIJselectâĂİ key. Candidate list turns to cyan to indicate selection is triggered. (d) The user taps "3" to confirm selection of third candidate.

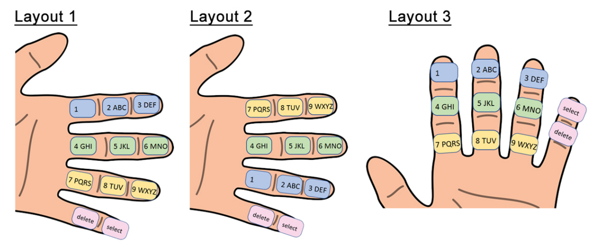

Figure 5: Three layouts with different key arrangements

3 *FINGERT9* INTERACTION

The interaction of *FingerT9* consists of two parts: 1) word typing (Fig 4ab) and 2) candidate selection (Fig. 4cd).

In the word typing part, users perform a single thumb touch on a particular finger segment to type a letter. Once users type the word letter by letter, a candidate list of possible words will be shown. After typing, users can perform a single thumb touch on the finger segment at the tip of pinky finger to trigger candidate selection.

In candidate selection, all words in the candidate list are numbered and each finger segment represents a particular number. Users can perform a thumb touch on respective finger segment to confirm the selected candidate. In some cases, if the desired candidate is the first one, users can simply perform a touch on the space key, and the first candidate will be selected as default without triggering candidate selection.

4 FUTURE WORK

We have introduced *FingerT9*, a novel text entry approach combining traditional T9 keyboard and thumb-to-finger interaction to support one-handed eyes-free text entry on smartwatches.

In the future, we would like to improve the prototype thumb-to-finger touch sensing ability by calibrating usersâĂŹ touch force on their finger segments. People usually apply different touch forces on different finger segments. Once the pressure threshold of one finger segment is calibrated, the threshold of all finger segments can be defined according to the finger segment positions. Besides, we plan to conduct evaluations on the proposed text entry method *FingerT9*.

The evaluations will include three aspects: 1) the performance of using in hand up and hand down conditions, 2) the comparison between the proposed technique and existing text-entry techniques such as tilt-based round keyboard, and direct touch on soft keyboard, and 3) the learning effect of *FingerT9* and its feasibility of eyes-free usage.

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