# Challenges Identified During Early Prototyping of a Ubiquitous Text-Entry System

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## Abstract
Ubiquitous text-entry, i.e. where text-entry can take place anywhere, during different contexts, requires a novel paradigm than what has been previously proposed for designing text-entry systems. In this paper, we report on our experience designing and implementing a ubiquitous text-entry system, aimed at facilitating text-input with any wearable device, including a smart-watch or a head-worn display. We report on the major issues encountered, including our approach for solving these. We present these concerns to raise the discussion level of ubiquitous text-entry systems from the lab to practice.

## Author Keywords
Ubiquitous text-entry, eyes-free text-entry, ubiquitous analytics.

## ACM Classification Keywords
H.5.2 User Interfaces; Input devices and strategies (e.g., mouse, touchscreen); Prototyping;

## Introduction
Recent advances in wearable technologies, such as head mounted displays (HMDs) have led researchers to take significant interest in novel approaches for data

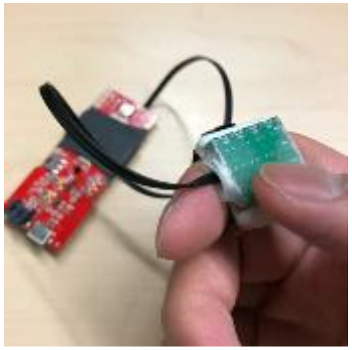

Figure 1. User wearing our ring-shaped prototype.

Figure 2. Early design of our techniques shown on multiple devices. Left: smartglasses. Right: smartwatch.

analytics. In particular, the ability to now explore, analyze and make decisions based on big data, or Ubiquitous Analytics [3], is upon reach. However, to allow such actions to take place anywhere, novel systems are needed to allow for ubiquitous text-entry.

In this position paper, we share our experience and present four challenges we encountered during the early phases of prototyping a ubiquitous text-entry system. We identified these challenges as we proceeded onto a step-by-step approach to create a ubiquitous text-entry device with a corresponding set of input techniques (Figure 2). We find that these challenges can be critical and can be generalized for similar projects and systems.

We propose a ring-shaped prototype, then summarize four challenges researchers must deal with during the design process. Designing a text-entry system relies on numerous design considerations, such as the device form factor, the shape of the learning curve, feedback mechanism(s), and techniques evaluation.

### Hardware Prototype

To advance our exploration of ubiquitous text-entry, we developed a ring-shaped prototype. The device (Figure 1) can be worn on the index finger phalanges and is embedded with a touchpad. We chose a ring-shaped device as (i) it can be paired with other wearable devices for text-entry, thus satisfying the constraint of input ‘anywhere’ and ‘anytime’; (ii) has a small footprint, thus limiting interference with other activities, such as holding objects necessary for a given task; and (iii) affords good ergonomics.

### Form Factor

To be used as a ubiquitous input device, it is critical that the hardware should be small enough or embedded [6]. It implies mobility. Recent technology allows wearable devices to be as small as needed. For instance, our ring prototype embeds various sensors, such as a gyroscope, an accelerometer, and a touchpad.

Since our prototype has a new form factor that has not been explored in this area, we followed a step-by-step design process to assess several research questions. For instance, what is the human motor precision with this new form factor? However, these research questions have already been answered on other devices such as smartphones and smartwatches. We argue that researchers will have to answers these questions again for each new ubiquitous input devices. Even if this can allow for results replications or new design guidelines, this redundancy of experiment also slows down the creation of novel input techniques. In addition, this step-by-step approach mainly aims to cover novices’ performances since the technique is not designed yet. We next describe a challenge related to the learning curve when using such new devices.

### Learning Curves

As explained above, we followed a step-by-step approach to assess human motor performances with a small touchpad attached to a ring device. This design leads to a relatively simple input technique using a $2 \times 3$ discretized input space containing groups of letters (Figure 3). This configuration allows for a good tradeoff between input time and accuracy. However, a final evaluation of novices’ performances revealed entry rates of 5 Word-Per-Minute (WPM). Although this is in range with other text-entry input techniques on small

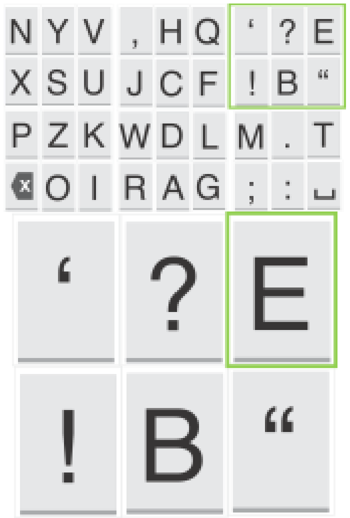


Figure 3. Sample layout of our early design. Users can select a character(‘E’) by (1, top) selecting the corresponding group of characters (green circled), and (2, bottom) perform a second selection among previously selected characters only.

touch surfaces [7], we argue that such relatively low entry rates might not be good enough for actual everyday usage. We are currently setting up another experimental evaluation to assess expert performances. One potential result is a substantial increase of text-entry performances. However, we also consider the second option: a minor increase. Indeed, we can do the parallel with the commonly used physical keyboard. Such device requires training to reach sufficient text-entry rates. Thus, we argue that the shape of the learning curves is another important aspect to consider during the design process. This adds extra-steps to the ones previously reported during the explorations of design properties related to the form factor.

## Feedback Mechanism

Any interactive system can fit into one of the three categorizations, namely eyes-off, eyes-on, and eyes-free, depending on the input and output spatial relationship.

- Eyes-On: Feedback is displayed directly where the interaction takes place (i.e. direct input). This is the case for most soft-keyboard used with smartphones for instance. The keyboard and the text are spatially collocated.
- Eyes-Off: Input and output spaces are separated (i.e. indirect input). This is the case for physical keyboards for instance. Users type on the keyboard, but focus on the screen. Our prototype falls into this category.
- Eyes-Free: No visual output is provided. Users can input text while visually focusing on other tasks (e.g., walking in the street and paying attention to traffic)

Our approach consists in going toward eyes-free techniques. Direct input (eyes-on) would be inefficient for ubiquitous environment, as user would need to learn several input techniques, i.e. one per device. Our prototype avoids this issue by adopting an eyes-off design. This allows users to input text on any output devices from only one input device – the ring, without requiring any skill transfer between devices. Our next step aims for an eyes-free input technique, hence, tackle new problems such as personal safety while on the go. We will consider how other modalities such as audio and haptic can play a role and be integrated into the networks of sensors/actuators offered by new wearable devices.

## Techniques Evaluation

Most previous works used in-lab evaluations [1][4][7]. This allows researchers to fully control the experimental factors, thus getting a deeper understanding of the mechanics happening during the use of a system. However, the end-goal of our research is to provide a ubiquitous text-entry device, hence requiring a use in everyday situations and contexts. We then enter an area in which research prototyping reaches its limits. We report our concerns regarding three limitations.

First, there is the actual look-and-feel aspect. Although participants are fully aware that a prototype does not have its final look-and-feel design, they still have to potentially use it in public spaces (e.g., in a bus). Gathering data about social acceptability might be compromised.

Second, there is the bulkiness aspect. If we take the example of our ring prototype, although every sensors fit on the ring, the processing board and the battery are still external pieces of hardware attached to a wrist band. Being able to miniaturize all components like a commercial manufactured product is not possible at this stage. Thus, gathering data about the ease of use and comfort might be compromised.

Third, there is the integration aspect. In-lab evaluations provide fully controlled development- and usage-platforms. Into the wild evaluations are subjects to technical problems (e.g., integration with participants' other items such as smartphones and smartwatches, connectivity issues, etc.). Participants might not have the knowledge to notice and/or fix these issues. Thus, gathering data about actual usage might be compromised.

We acknowledge that these issues can arise in every field studies – not necessarily linked to ubiquitous text-entry tasks. However, our concern is motivated by the nature of ubiquitous text-entry devices itself: by definition, field studies are necessary in this context.

## Conclusion

In this position paper, we shared our issues encountered during our prototyping in both exploration and evaluation stages. We believe that discussions and brainstorming at the workshop can (1) reveal other issues not covered in this position paper, and (2) cover a broad exploration of potential solutions.

## Workshop demo

We plan to bring our early prototype along with a smartwatch and smartglasses for participants at the workshop to try our text-entry technique.

## Author biographies

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*Tony Havelka* is President of Tek Gear, Inc. He specializes in body worn hardware for VR, AR and Wearable applications. His work focuses on creating I/O devices – such as the Twiddler – that make the human-computer interface more intuitive, interactive and immersive.

*Pourang Irani* is Professor in Computer Science and Canada Research Chair in Ubiquitous Analytics. His work on ubiquitous text-entry has explored using tilt and pressure sensors for input.

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