Text entry for Smart Watches

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ABSTRACT

Smart Watches are computerised wristwatches that were developed from the miniaturization of computing devices. Due to the screen size restrictions, Smart Watches require specially designed input and output techniques to allow efficient interaction with the watch. While certain output and input techniques are specific to the type of application, entering text is often needed for all kinds of applications but due to the Smart Watches' ultra-small screen size, usual text entering techniques become impractical.

Therefore, various research has been done to propose unique text entry techniques for ultra-small devices that claim to improve the performance and user experience while entering text. This paper reviews some of these text entry methods that either propose a new keyboard layout, use external hardware or employ completely new unique techniques. The literature review aims at comparing and evaluating the usability of these methods using the evaluation results of each method and a specified keyboard evaluation criteria.

Author Keywords

Smart Watch; text entry; input devices; touch screens; small devices.

INTRODUCTION

The wristwatch has been a popular wearable device, since its first release in the late 1900s. Many researchers have viewed this as motivation to start computing and have attempted to improve its capabilities to the next level. Due to the emerging interest in miniaturising computing devices, IBM introduced first watch with a full, running operating system in 2000. However, initial smartwatch faced many issues of practicality as its screen size could not be increased like a smart phone to carry many computerised functions.

Recent improvements in the electronics, making devices faster and smarter have given researchers the opportunity to improve the way smartwatches work. This has given rise to many capable and practical smartwatches and its applications such as the Pebble watch that has gained a lot of appreciation in the media. Large organisations such as Sony and Samsung have also started producing smart watches with various features such as reading emails and instant messaging.

Due to the restricted screen size of a smart watch, it has been a constant challenge to develop its user interface in a way that can be usable and practical. It has caused many researchers to explore the different input and output techniques that can be usable on such small devices. In specific, the increased range of application on a smartwatch, has increased the need to enter text effectively and efficiently through a small touch screen.

This literature review focuses on exploring and evaluating few of the many research works that has taken place to enable a user to enter text on small devices. The report explores different designs of a keyboard layout that could fit on a small screen, external hardware used to enter text and other unique approaches to text entry. The report evaluated the different various methods of text input using four main criteria:

Screen Space: Allowing maximum screen space to view and interact with the text is essential to any text entry process.

Learning Curve: User familiarity to interactions is essential for a quick and feasible text entry process.

Typing Speed: Faster text entry allows users to complete more tasks on their smartwatch.

Accurate Text Entry: It is necessary to enter precise text for password or website URL.

KEYBOARD LAYOUT

Existing smart watches' include speech to text to easily allow user to enter text. This approach has obvious issues such as privacy. Therefore, Dunlop et al. [1], Li et al. [4] and MacKenzie et al. [5] attempted to design new keyboard layouts that is feasible to use on a small screen. These new keyboard designs aim at using the existing tap interaction, to reduce the learning curve as the users are already expected to learn about the new keyboard layout.

High Quality Text Entry

Dunlop et al. [1] describes and attempts to create a new keyboard layout for small screen sizes. The team constrained their design specifically for small screen sizes (eg. 25x25 mm), where entry must be through a finger and support wide range of input (such as numbers and punctuation). The report describes team's initial design, implementation and user testing results.

The team analysed various arrangements of alphabets using normalised ambiguity score based on bigrams frequencies for English and distance based on bigram data. The analysis
showed that keyboard with most of last half of alphabet on the last key delivered the least ambiguous keyboard. Whereas all of the first half of the alphabets placed on the first key required the least movement of the finger. Due to the small screen size of a smart watch, the movement is already limited therefore, the final design equally split the alphabets on six keys. Three buttons placed at the top of the screen, three buttons placed at the bottom and middle space is used to view the entered text. Furthermore, few more gestures such as left wipe for backspace, upwards swipe to achieve capitalisation and downward swipe to get numbers and punctuation.

User evaluations showed that the watch was not responsive to fast multiple taps and many quick finger movements were registered as swipes. Therefore, the team decided to improve the sensitivity of the watch before conducting further studies and improve the layout of the text entry for more clear indication of each key role.

**H4 Writer**

H4-writer [5] is a text entry method that aims at using one thumb and four buttons to enter text. It utilises huffman's algorithm to generate "minimum redundancy code" in a way that the average number of keys or key strokes are minimised. The algorithm looks at the probability and frequency of certain characters within a language and assigns shorter codes for the high frequency characters and longer codes for lower frequency characters.

The report focuses on evaluating base-4 (4 keys) layout as other methods such as EdgeWrite and LURD-Writer also use 4 keys, it can be a good basis for comparison against existing systems. Initial H4 codes proved to have the lowest KSPC (Key stroke per character) of 2.074, but it only contained 26 alphabets and a space, which is not enough for a comprehensive text input. Therefore, it was later improved to include extra characters such as punctuation, digits, caps lock, etc., which increased the KSPC to 2.321 but still lower than the existing systems.

Furthermore, the user evaluations proved the performance of this method to be 20 wpm on average, at the last trial. This shows that H4-writer can be a good method to be used on small devices such as smart watches as it only contains 4 buttons for accurate and detailed text input.

**1Line Keyboard**

1Line keyboard [4] is a QWERTY layout keyboard condensed on one line. This layout of the keyboard was motivated by the fact that devices are becoming smaller in size which require smaller keyboards and users rarely want to spend time learning new keyboard layouts. The basic concept of the design is to combine the letters of each column of QWERTY keyboard onto one key. The design resulted in 8 keys on one line, with each key containing few alphabetical letters on one key. The team extends the design by incorporating flick gestures for backspaces, enter and choose list of disambiguated words produced as user starts to type. Furthermore, the design includes taping on the bezel to enter space.

The user evaluation results outlined in the report suggest that the overall performance of 1Line keyboard was very similar to the performance achieved from QWERTY layout keyboard. Due to both the base of both keyboards are same, the learning curve for participants was very low, however, t-paired tests showed a lower speed while using 1Line keyboard. The drop in performance mainly came from the inaccurate bezel spacebar that incurred various false positives and negatives. Disambiguation word algorithm suggested completely wrong words, if there was a typo in the beginning of the word.

In spite of the known issues (which can be fixed) of 1Line keyboard, decreasing the size of the keyboard to 60% of original keyboard size, provides a lot of extra screen space to interact with. This increases text visibility and allows further functions to be carried out such as text editing.

**EXTERNAL HARDWARE**

As the last section showed, modifying the layout of a keyboard increases the learning curve significantly for a user. Therefore, few researchers such as Touch sensitive wristband [2] and clip-on gadgets [7] introduced external hardware to enter text. Use of external hardware expands the surface area to provide fat finger touch interactions.

**Touch sensitive Wristband**

Touch sensitive wristband [2] introduces a new approach for text entry into smart watches, by using touch sensitive wristband. A team of developers produced a prototype that uses inexpensive material such as steel inclusive with Spectrasymbol SoftPot potentiometer (linear touch sensor). The paper discusses about the two different designs of the keyboard implemented and evaluated by the team. 1) The keyboard design incorporated mutitap system on both sides of the wristband, where the user is required to press a certain button multiple times until they get their desired output. 2) The second keyboard layout consisted of characters placed in a linear fashion. The user must scroll to their desired character and whichever character they lift their finger off, will be used as their chosen character.

User evaluations performed by the team on these two different layouts showed that participants were able to achieve higher speed(wpm) and made less correction to errors for mutitap system. 3.45 WPM, show that the touch sensitive wristband is a good effort from the team to bring an unique technique into the field, but due to its low performance, this solution does not seem very practical.

While this technology uses cheap materials to implement a touch wristband, which does not require extra hardware to be carried by the user, this method requires the implementation of a complete new watch. Also, the use of wristband to incorporate a fixed keyboard creates issues for
user with very small wrists. These users would have to twist their entire wrist to enter all the required text and would disable them from seeing the screen at that point.

None the less, this technology would enable the entire screen size to available for other text editing interactions. It would also provide somewhat accurate text input as the buttons on the wristband are considerably larger than the buttons on screen.

Clip-on Gadgets
Clip-on gadgets [7] use conductive materials to expand users' touches on physical controllers to touch points along the edges of multi touch screens. The gadgets intend to expand the interaction area, with battery free, easily detachable devices.

The gadgets detect a touch point by sensing the change in capacitance as user's finger touches a contact point through a conductive rubber. The registered touch event is decoded to find the exact button pressed by the user. The team has developed toolkit for IOS 4 devices and the software architecture is responsible for converting dispatched touch events into tactile events, to call back functions that perform application specific logic.

While the clip-on gadgets have not produced clip-on for keyboard, it is clear that this unique technology can be used to produce keyboards that can be attached to smart watches. The clip-on keyboards would help extend the smart watch area temporarily for text entry.

OTHER
Changing the keyboard layout contributes significantly to the learning curve of user and use of external hardware require production of specialised hardware. Other researchers such as Zoomboard [6] have introduced solutions that intend to use existing keyboard layout. And TouchSense [3] attempts to use the readily available input techniques such as different areas of the finger pad.

Zoomboard
ZoomBoard [6] is a QWERTY soft keyboard for ultra-small devices, it uses iterative zooming to allow accurate text input by users. The design of the keyboard is based on three main objectives: 1) To develop a method that enables text entry on ultra-small devices, 2) the mechanism must be familiar to the user and 3) make use of the existing training users have with keyboards. Due to these three objectives, Zoomboard incorporated QWERTY layout for their keyboard design as it is the most popular method of text input. Zoomboard mechanism zooms into the area clicked by the user, up to three levels to allow accurate text input. It also allows specific swipe gestures, such left swipe to erase and right swipe to enter space.

As the evaluation results in the report outlines, the participants of Zoomboard user evaluation achieved 7.6 wpm, on average and 9.3 wpm by the final trial. While these results are low compared to other systems such as Multitap, Graffiti and H4-Writer, it is believed that these systems contain larger keys for their keyboard. Therefore, those techniques do not require zooming into the keyboard, which decreases the time taken to enter a word. However, the zooming of keyboard achieved higher accuracy compared to non-zooming keyboards which suggests that Zoomboard is a reasonably efficient method of text entry.

Users will be expected to get used to a different keyboard style that zooms in, but this idea is replicated from a smart phone function of zooming into very small areas. Therefore, it is safe to assume that a zoom able QWERTY layout keyboard is mostly familiar to users. Also, the miniaturisation of the keyboard allows extra screen space to view more text.

Touch Sense
Touch Sense [3] explores single-tap switching using different areas of the finger pad. The method explores how an user can tap a single key with different areas of their finger pads, which would allow integration of extra interactions. The study discusses how precisely can a user tap specific area on a finger pad and how many areas of a finger pad could be used to increase interaction.

The conducted user studies showed that areas on the finger tip (upper region) can be mapped precisely, whereas lower regions of the finger pad suffer from larger offsets. Furthermore, another user study showed that most users use upper central area to perform a normal tap on a touch screen. Therefore, this area must be reserved for a normal touch interaction.

The team developed a prototype that would scan users fingerprints to recognise which area of the finger pad is being used for the interaction. However, the implemented technology is not available on a smart watch at the moment and is uncertain, if it can be scaled down to such small device.

OVERALL COMPARISON
Table 1. shows the results of some of the user evaluations taken in place to evaluate the usability and efficiency of the new technology. Since these results are measured with the same units, but from different usability studies, with different participants and reasonably different procedures, it would be incorrect to make direct comparisons. It is also useful to note the device a certain methodology was tested upon as it affects the button sizes and in return affects the results gained. None the less, the below figures provide a good indication of the efficiency of certain systems.
The proposed solution, mainly because of the use of touch buttons on the wrist, has taken place to control the required actions to take place to incorporate the wristwatch. While small, the pressure and touch interactions are very limited on small screen devices as users would not have to write full words. Also, it is worth noting that a clip-on for a keyboard has not been implemented yet.

### SUMMARY

Above research findings show that a large amount of work has taken place to improve the way users interact with small devices such as smart watches.

Research work to modify the layout of a keyboard that could fit on a small screen size and yet feasible enough for a user to interact with, requires users to learn a new keyboard layout. However, these approaches only introduce new software, which can be easily integrated into existing hardware.

Whereas, ideas introduced by touch sensitive wristband and clip-on gadgets, requires users to either carry the external hardware with them (clip-on). Otherwise, require a specific size for the hardware (wristband), which makes it inefficient to be used by users with small wrist as they must turn their wrist to correctly enter text.

The other ideas such as zoomboard seemed to be the best fit out of all the proposed solution, mainly because of the use of QWERTY layout keyboard. The layout familiarity highly contributes to the efficiency and speed. While tapping three times to enter a character can be frustrating, it ensures accuracy and proves to be more error prone system.

### FUTURE WORK

Further research needs to take place to incorporate error correction and word suggestion to quicken process of entering text. While most of the approaches to improve text entry were reasonable, very few approaches included word suggestions. It may be useful to incorporate the existing smart text entry such as the ability to learn about user’s choices over time and decrease its size for a small screen device. The ability to automatically write or suggest text highly contributes to the ease of entering text in such small devices as users would not have to write full words.

Other areas of research is to make use of all the possible touch interaction of a touch screen such its sides. Many wristwatch user are familiar with pressing buttons on the sides of a watch to carry out functions. This familiarity and extra input area can be used to implement text entry through touch interaction on the sides of the watch.

Making use of existing devices a user may have on them such as smart phone. Research has taken place to control a smart phone using smart watch, but for more complicated input interactions such as text entry, further research can be done to explore how a user can use the existing smart phone to enter text in smart watch.

### REFERENCES


2. Funk, M., Sahami, A., Henze, N. and Schmidt, A. Using a touch-sensitive wristband for text entry on smart devices.

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### Table 1. Different input method efficiency.

<table>
<thead>
<tr>
<th>Method</th>
<th>WPM</th>
<th>KSPC</th>
<th>MSD</th>
<th>Keyboard Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoomboard</td>
<td>9.30</td>
<td>2.15</td>
<td>0.20</td>
<td>Small</td>
</tr>
<tr>
<td>H4-Writer</td>
<td>20.40</td>
<td>2.32</td>
<td>0.69</td>
<td>Large</td>
</tr>
<tr>
<td>1Line Keyboard</td>
<td>30.7</td>
<td>1.31</td>
<td>-</td>
<td>Large</td>
</tr>
<tr>
<td>Touch Sensitive - Linear</td>
<td>2.91</td>
<td>1.83</td>
<td>3.17</td>
<td>Small</td>
</tr>
<tr>
<td>Touch Sensitive - Multitap</td>
<td>3.45</td>
<td>1.54</td>
<td>2.58</td>
<td>Small</td>
</tr>
</tbody>
</table>

1 WPM: Words Per Minute
2 KSPC: Key Strokes Per Character
3 MSD: Mean string Distance
4 Keyboard size used while conducting usability study, where small is smartwatch size, medium is smartPhone size and large is iPad size.


