Enabling Input on Tiny/Headless Systems Using Morse Code

Anna-Maria Gueorguieva  
Human-Computer Interaction Group  
University of California, Merced  
California, Merced, USA  
agueorguieva501267@muhsdstudents.org

Gulnar Rakhmetulla  
Human-Computer Interaction Group  
University of California, Merced  
California, Merced, USA  
grakhmetulla@ucmerced.edu

Ahmed Sabbir Arif  
Human-Computer Interaction Group  
University of California, Merced  
California, Merced, USA  
asarif@ucmerced.edu

ABSTRACT

This paper presents results of a pilot study that explored the potential of Morse code as a method for text entry on mobile devices. In the study, participants without prior experience with Morse code reached 6.7 wpm with a Morse code keyboard in three short sessions. Learning was observed both in terms of text entry speed and accuracy, which suggests that the overall performance of the keyboard is likely to improve with practice.

KEYWORDS

Morse code, accessibility, text entry, smartphone, virtual keyboard.

1 INTRODUCTION

Entering text on devices with tiny or no displays (referred to as headless devices) remains a challenge. Conventional virtual keyboards are ineffective on devices with tiny displays, like smartwatches or smart thermostats, since the keys of these keyboards are too small for precise selection [1]. Entering text on a headless devices, such as a digital tangible in a tangible-tabletop system, is even more challenging due to the difficulties in verifying or correcting an input without visual feedback on a display. This work investigates the potential of Morse code as a method for text entry on these devices. Morse code encodes characters as standardized sequences of dots (.) and dashes (−) (Fig. 1). Since it was originally designed for telegraphs, a device without a display [16], we hypothesize that it can enable users to enter text on both tiny and headless devices. In this work, however, we focus only on the learning of the code.

2 RELATED WORK

Not much work has investigated the potential of Morse code as an input method on computer systems. The earliest work in this area studied the effectiveness of Morse code as an input method with a Z-80 based microcomputer [9]. In the study, six participants yielded a 7.9 wpm entry speed after two months of training (2–3 sessions per week). A different work investigated if Morse code can be learned through passive haptic learning (PHL) using the bone conduction transducer on a Google Glass [14]. In their study, participants reached an 8 wpm entry speed after four hours of exposure to passive stimuli. A follow up study demonstrated PHL of Morse code on a smartwatch [13]. Table 1 summarizes the findings of these studies.

| Reference   | N  | Session | Support | Speed |
|-------------|----|---------|---------|-------|
| Levine et al. [9] | 6  | 26−40   | Cheat Sheet | 7.9   |
| Seim et al. [14] | 12 | 4       | PHL     | 8.0   |

3 MORSE CODE KEYBOARD

We developed a simple virtual keyboard based on Morse code. It enables users to enter characters using sequences of dots (.) and dashes (−). The keyboard has dedicated keys for dot, dash, backspace, and space (Fig. 2). To enter the letter “R”, represented by “−.−” in Morse code, the user presses the respective keys in that exact sequence, followed by the SEND key, which terminates the input sequence. The user presses the NEXT key to terminate the current phrase and progress to the next one. The keyboard does not use a predictive system, thus does not auto-complete words, auto-correct incorrect words, or suggest the next probable words.
Figure 2: The device and keyboard used in the pilot study.

4 PILOT STUDY
We conducted a pilot study to investigate the learning of Morse code and the potential of Morse code as a method for text entry.

4.1 Apparatus
We used a Motorola Moto G5 Plus smartphone (150.2×74×7.7 mm, 155 g) at 1080×1920 pixels (Fig. 2). The Morse code keyboard was developed with the Android Studio 3.1, SDK 27. It automatically calculated all performance metrics and recorded all interactions with timestamps.

4.2 Participants
Two participants took part in the pilot study. Both of them were 25 years old. One of them was female and the other was male. They used both hands to hold the device and the thumbs to type (Fig. 3). They were proficient in the English language. Both were experienced smartphone users (9 years’ of experience) but had no prior experience with Morse code.

4.3 Design
We used a within-subjects design, where the independent variable was session and the dependent variables were the commonly used words per minute (wpm) and error rate (ER) performance metrics [3]. In summary, the design was as follows:

- 2 participants ×
- 3 sessions (different days) ×
- 10 pangram entries = 60 entries, in total.

Figure 3: A volunteer transcribing text with the Morse code keyboard with the aid of a cheat sheet.

4.4 Procedure
The study was conducted in a quiet room. On the first day, we explained the research to the participants, demonstrated Morse code and the custom keyboard, then enabled them to practice with the keyboard by entering free-form text for about five minutes. The first session started after that, where participants were instructed to enter the pangram “the quick brown fox jumps over the lazy dog” as fast and accurate as possible, then tap the NEXT key to submit the phrase. This was repeated for ten times. Participants could use a cheat sheet to look up the code for a character (Fig. 3). Error correction was disabled during the study. We instructed the participants to ignore all errors. Logging started from the first tap on the display and ended when participants pressed NEXT. The following sessions followed the same procedure, except for the demonstration and practice. The sessions were scheduled on consecutive days.

5 RESULTS
We only report descriptive statistics due to the small sample size ($N = 2$) of the study.

5.1 Entry Speed
Participants yielded an average of 5.9 wpm (SD = 1.1). The average entry speed in the three sessions were 5.0 wpm (SD = 0.6), 5.9 wpm (SD = 1.2), and 6.7 wpm (SD = 0.4), respectively (Fig. 4).

Figure 4: Average entry speed (wpm) in the three sessions fitted to a power trendline.

5.2 Error Rate
The average error rate in the study was 1.7% (SD = 2.6). The average error rate in the three sessions were 3.4% (SD = 3.0), 0.8% (SD = 1.2), and 1.0% (SD = 2.5), respectively (Fig. 5).

6 DISCUSSION
Participants yielded a competitive entry speed with the Morse code keyboard (Table 1), reaching an average of 6.7 wpm by the final session. It is inspiring that learning occurred even in such brief sessions of the study. Entry speed improved by 16% in the second session and by 12% in the third session compared to the preceding sessions. The average entry speed over session correlated well ($R^2 = 0.9965$) with the power law of practice [15]. This suggests that users are likely to get much faster with the method with practice. Participants made more errors in the first session (3.4%), which
We conducted a pilot study to investigate the potential of Morse code as a method for text entry on mobile devices. For this, we developed a simple Morse code keyboard. In the study, participants without prior experience with Morse code reached 6.7 wpm with the keyboard in three short sessions. Learning was observed both in terms of entry speed and accuracy, suggesting that the performance of the keyboard is likely to improve with practice.

7 LIMITATIONS AND FUTURE WORK

There are several limitations of the work, which we will address in future studies. First, we evaluated the method on a smartphone where users could see their input. This visual feedback most likely reduced by 76% in the second session. The error rate in the second and the final sessions were comparable (about 1%). Innately, the average error rate over session moderately correlated ($R^2 = 0.7158$) with the power law of practice [15]. This suggests, unlike entry speed, error rate is unlikely to reduce substantially with practice. These findings indicate towards the possibility that Morse code could enable text entry on devices where using conventional input methods is impractical. Although it was not the focus of this work, Morse code could also enable people with various motor disabilities to enter text on computer systems.

REFERENCES

[1] Ahmed Sabbir Arif and Ali Mazeale. 2016. A Survey of Text Entry Techniques for Smartwatches. In Human-Computer Interaction. Interaction Platforms and Techniques ( Lecture Notes in Computer Science), Masaaki Karousa (Ed.). Springer International Publishing, Cham, 255–267. https://doi.org/10.1007/978-3-319-39516-6_24
[2] Ahmed Sabbir Arif, Ali Mazeale, and Wolfgang Stuerzlinger. 2014. The Use of Pseudo Pressure in Authenticating Smartphone Users. In Proceedings of the 11th International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services (MobiQuitous ’14). ICST, Brussels, Belgium, 151–160. https://doi.org/10.4108/icst.mobiquitous.2014.257919
[3] Ahmed Sabbir Arif and Wolfgang Stuerzlinger. 2009. Analysis of Text Entry Performance Metrics. In 2009 IEEE Toronto International Conference Science and Technology for Humanity (TIC-STH). 100–105. https://doi.org/10.1109/TIC-STH.2009.5444533
[4] Ahmed Sabbir Arif and Wolfgang Stuerzlinger. 2010. Predicting the Cost of Error Correction in Character-Based Text Entry Technologies. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI ’10). ACM, New York, NY, USA, 5–14. https://doi.org/10.1145/1753326.1753329
[5] Mathias Baglioni, Sylvain Malacia, Eric Lecolinet, and Yves Guiard. 2011. Flick-and-Brake: Finger Control Over Inertial/Sustained Scroll Motion. In CHI ’11 Extended Abstracts on Human Factors in Computing Systems (CHI EA ’11). ACM, New York, NY, USA, 2281–2286. https://doi.org/10.1145/1979742.1979853
[6] Staas de Jong, Dinyka Kirkali, Hanna Schraffenberger, Jeroen Jijlissen, Alwin de Rooij, and Arnout Terpstra. 2010. One-Preset Control: A Tactile Input Method for Pressure-Sensitive Computer Keyboards. In CHI ’10 Extended Abstracts on Human Factors in Computing Systems (CHI EA ’10). ACM, New York, NY, USA, 4261–4266. https://doi.org/10.1145/1753986.1754138
[7] Seongkook Heo and Guee Hyuk Lee. 2011. Forcetap: Extending the Input Vocabulary of Mobile Touch Screens by Adding Tap Gestures. In Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services (MobiHIC ’11). ACM, New York, NY, USA, 113–122. https://doi.org/10.1145/2037373.2037939
[8] Heidi Horstmann Koester and Sajay Arthanat. 2018. Text Entry Rate of Access Interfaces Used by People with Physical Disabilities: A Systematic Review. Assistive Technology 30, 3 (May 2018), 151–163. https://doi.org/10.1080/0400435.2017.1291544
[9] Simon Levine, John Gauger, Lisa Bowers, and Karen Khan. 1986. A comparison of Mouthstick and Morse code text inputs. Augmentative and Alternative Communication 2, 2 (Jan. 1986), 51–55. https://doi.org/10.1080/07434618612331273890
[10] K. Mukherjee and D. Chatterjee. 2015. Augmentative and Alternative Communication Device Based on Eye-Blink Detection and Conversion to Morse Code to Aid Paralyzed Individuals. In 2015 International Conference on Communication, Information Computing Technology (ICICTCT) 1–5. https://doi.org/10.1109/ICICTCT.2015.7045754
[11] Diego Pedrossa and Maria da Graça C. Pimentel. 2014. Text Entry Using a Foot for Severely Motor- Impaired Individuals. In Proceedings of the 29th Annual ACM Symposium on Applied Computing ( SAC ’14). Association for Computing Machinery, New York, NY, USA, 957–963. https://doi.org/10.1145/2554850.2554948
[12] L. R. Sapaco and M. Sato. 2011. Analysis of Vision-Based Text Entry Using Morse Code Generated by Tongue Gestures. In 2011 4th International Conference on Human System Interactions, HSI 2011. 158–164. https://doi.org/10.1109/HSI.2011.5937359
[13] Caitlyn Seim, Rodrigo Pontes, Sanjana Kadiveti, Zaeem Adamjee, Annette Cochran, Timothy Aveni, Peter Preist, and Thad Starner. 2018. Towards Haptic Learning on a Smartwatch. In Proceedings of the 2018 ACM International Symposium on Wearable Computers - ISWC ’18. ACM, New York, NY, USA, 228–229. https://doi.org/10.1145/3267422.3267269
[14] Caitlyn Seim, Saul Reynolds-Haertle, Sathark Srivinas, and Thad Starner. 2016. Tactile Taps Teach Rhythmic Text Entry: Passive Haptic Learning of Morse Code. In Proceedings of the 2016 ACM International Symposium on Wearable Computers - ISWC ’16. ACM Press, Heidelberg, Germany, 164–171. https://doi.org/10.1145/2971763.2971768
[15] G. S. Snoddy. 1926. Learning and Stability: A Psychophysiological Analysis of a Case of Motor Learning with Clinical Applications. Journal of Applied Psychology 10, 1 (1926), 1–36. https://doi.org/10.1037/h0078141
[16] Rhey T. Snodgrass and Victor F. Camp. 1922. Radio Receiving for Beginners. New York: MacMillan.
[17] Kumiko Tanaka-Ishii and Ian Frank. 2005. Dit4dah: Predictive Pruning for Morse Code. Text Entry. In Natural Language Processing — IJCNLP 2004. Reh-Yih Su, Jun-ichi Tsujii, Jong-Hyeok Lee, and Oi Yee Kwong (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 765–775.
[18] Robert Zelerik, Timothy Miller, and Andrew Forssberg. 2001. Pop Through Mouse Button Interactions. In Proceedings of the 14th Annual ACM Symposium on User Interface Software and Technology (UIST ’01). ACM, New York, NY, USA, 195–196. https://doi.org/10.1145/502348.502384