A Wearable Input Mechanism for Blind users of Computers based on Mental Mapping of Thumb-To-Phalanx Distances

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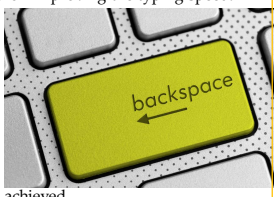
Introduction

- Errors produced during typing affect the **quality** of work.
- Prior work on accessible mechanisms for input has focused on improving the typing speed.
- We aim to maximize the **accuracy of typing**.
- The human hand has 14 digital bones called **phalanges**.
- We propose an **affordable** input mechanism which maps individual keys to the phalanges of each finger.
- We have achieved an average Character.
- Error Rate of 3.58% with up to 100 minutes of practice.
- Entry Rates of up to 6.0 Words Per Minute (WPM) are also achieved.

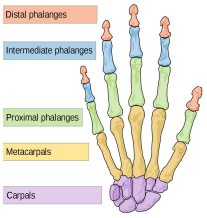


Methodology

- In the human hand, the **thumb** offers the **smoothest motion** [1].
- It gives **larger reach** for interaction across the hand[1].
- It enables the user to **reach each phalanx bone** on the person's hand.
- Starting at the ages of 8-12 months human babies start to perform fine muscle operations such as grasping.[2]
- These **fine motor movements are perfected** over years of daily use.
- Our design aims to take advantage of the precision of such muscle operations.

Mechanism Specifications

- **32 push-buttons** with tactile responses.
- **26 alphabet + 6 modifiers**
- Alphabet arranged in order from index to little finger.
- **6 modifiers**: POWER, NUM/Alphabet, Spacebar, Enter, CAPS LOCK and CTRL keys.
- **2 extra buttons** on metacarpals of **index finger (chosen by suggestions of participants).**



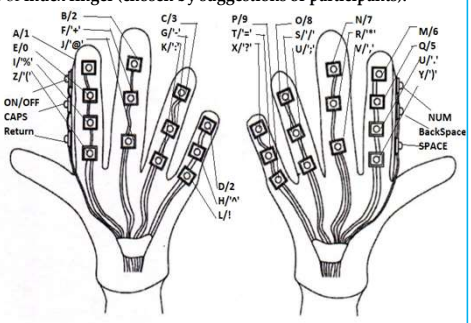
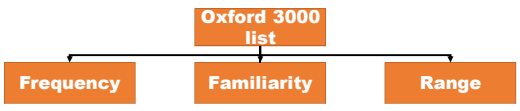


Figure 1: Phalanx bones (Phalanges) of the right hand (with palms upward)
Figure 2: Glove mechanism layout, with key values displayed.

Study

5 blind participants x 5 sessions/participant x 20 minutes each.



What We Measured:

$$Entry\ Rate\ (wpm) = \frac{Number\ of\ characters\ typed\ /\ 5}{Time\ in\ minutes}$$ **(Typing Speed)**

$$Backspaces\ Per\ Tap = \frac{Total\ number\ of\ Backspace\ Taps}{Total\ Number\ of\ Taps}$$ **(Known errors while typing)**

$$Character\ Error\ Rate = \frac{Number\ of\ changes\ to\ get\ reference\ text}{Total\ number\ of\ characters\ in\ reference\ text} \times 100$$ **(All errors occurring while typing)**

Acknowledgments

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- Prashant Naik, my father who has supported me throughout.

Session Number	Reference Text	Explanation
1	abcdefghijklmnop qrstuvwxyz	Alphabet
2	my as it is	2 letter words
3	Cat dog try all	3 letter words
4	Baby quit hole zone	4 letter words
5	That is a brown fox	Sentence with at most 25 characters and with one 5 letter word

Table 1: Details about each session and corresponding text samples used with participants
Figure 3: Images of mechanism with blind participants of different age groups.

Results

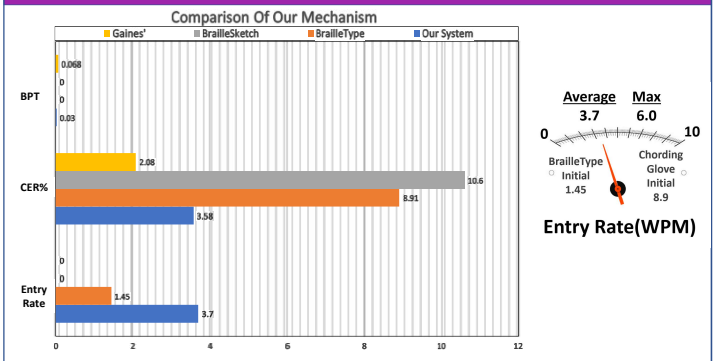

Figure 4: Comparison of our mechanism's parameters with those of other systems' initial round values in literature review. (0 means data was unavailable for this parameter).
Figure 5: Entry Rate Comparison.

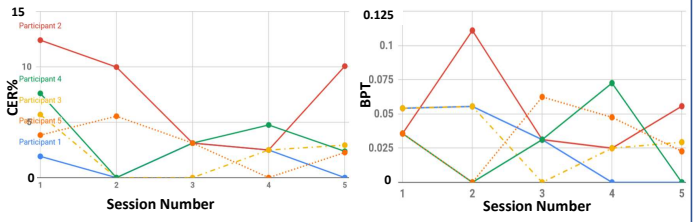

Figure 6: Line Graph showing session values of CER% of each participant.
Figure 7: Line Graph showing session values of BPT of each participant.

- The average CER% was 3.58% and the average BPT was 0.03, both of which are very competitive with Gaines' (2.08% and 0.068), BrailleType's (8.91%) and BrailleSketch's (10.6%).

Conclusions and Future Studies

- The **average BPT and CER% decreased after each session** except one.
- Further studies will analyse the upper limit of accuracy and typing efficiency.
- Typing accuracy is competitive with existing mechanisms.
- We are looking at **alternate circuit designs** as well to make the system easy to setup.
- **Security:** Ways to prevent attackers from reading sensitive information the user may be typing.
- **Autism:** Our mechanism requires 2 Gestures Per Character (GPC) which may benefit users with autism.

References

[1] Rachaveti, Dhanush et al. "Thumbs up: movements made by the thumb are smoother and larger than fingers in finger-thumb opposition tasks" doi:10.7717/peerj.5763

[2] Choc Children's: Development Milestones: Fine Motor Skills And Visual Skills

[3] Oxford Learners Dictionary: Oxford 3000 List

[4] Dylan Gaines. 2018. Exploring an Ambiguous Technique For Eyes-Free Mobile Text Entry.

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