Gaze typed Rotating Flower Text entry In AR

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As Augmented Reality (AR) devices become more popular and integrated into everyday life, it is important to explore new interfaces and interaction techniques that offer greater efficiency and advantages over traditional methods. This paper introduces the Rotating Flower Text Entry technique for gaze-based typing and explores its effectiveness in comparison to traditional controller-based inputs and other popular text entry layouts used in AR devices. The goal is to improve the text entry interface for AR applications, increasing typing speed, reducing error rates, and improving overall usability. Results of the study show that the Rotating Flower Text Entry technique offers greater efficiency and ease of use compared to traditional gaze-based layouts in AR devices. Advanced users could achieve a typing speed of 10 to 11 words per minute at a dwell time of 0.5 seconds.

CCS Concepts: • **Human-centered computing** → **Text input**.

Additional Key Words and Phrases: augmented reality, eye-tracking, gaze interaction, multimodal UI, text entry, virtual keyboard

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1 INTRODUCTION

Numerous studies have investigated the effectiveness, user-friendliness, and ease of learning of gaze typing through various interfaces. Various layouts have been proposed by researchers for gaze typing, including those that utilize gestures [15, 17, 18] and others that aim to simplify the keyboard by reducing the number of buttons[3, 6, 8, 14]. However, these alternative layouts may have a steeper learning curve for users. Therefore, a more feasible approach is to modify the QWERTY keyboard that users are already accustomed to for gaze typing purposes.

Our project aims to introduce a new and enhanced version of the Flower Text Entry keyboard layout, initially proposed by JIaye Leng et al.[9], for use in gaze typing applications. The rotating Flower text entry layout key is designed to rotate by 360 degrees after a letter is selected, before returning to its original position, enabling the user to input the next letter. This feature helps to improve the efficiency of text entry when multiple instances of a single letter are required. Additionally, the rotating feature provides an opportunity to explore dwell time reduction options that are crucial for gaze-based text entry.

To assess the effectiveness of our proposed rotating Flower text entry keyboard layout, we conduct an evaluation and compare it with other standard eye typing keyboards. We used phrase sets introduced by I. Scott MacKenzie et al.[11] for evaluating text entry speed and accuracy. In addition, we compare our gaze-typed keyboard design with the air typing keyboard commonly used in many current augmented reality devices. This evaluation process helps to determine the efficiency, usability, and practicality of our keyboard design in comparison with other commonly used eye typing interfaces.

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In summary, our paper presents a novel rotating flower-based gaze-typed text entry keyboard layout. We evaluate its effectiveness by comparing it with standard gaze typing keyboard layouts using phrase sets introduced by I. Scott MacKenzie et al.[11]. We also compare our design with the air typing keyboard commonly used in current augmented reality devices.

2 BACKGROUND

Gaze typing, also known as eye typing or eye gaze communication, is a method of communication that allows individuals with limited or no physical mobility to interact with computers and other devices by tracking their eye movements. This technology has been widely used for individuals with disabilities [13], such as Amyotrophic Lateral Sclerosis (ALS), cerebral palsy, and spinal cord injuries, as well as for those who have suffered a stroke or traumatic brain injury [7].

One of the earliest examples of gaze typing dates back to the 1800s, when a French ophthalmologist, Louis Émile Javal, observed that individuals with ocular motor deficits could still communicate by tracking their eye movements. However, it wasn't until the advent of computer technology that gaze typing became a feasible and practical means of communication.

The first gaze tracking systems were developed in the 1980s, using video cameras to track the position of the pupil and cornea [13]. Over time, these systems became more sophisticated, with the development of infrared-based systems that could track the movement of the eye even in low light conditions [5, 16].

Today, there are a variety of gaze tracking systems available, ranging from high-end research systems to low-cost consumer devices. These systems use a variety of technologies, including infrared cameras, video cameras, and sensors, to track the movement of the eye [5, 13] .

3 USER STUDY

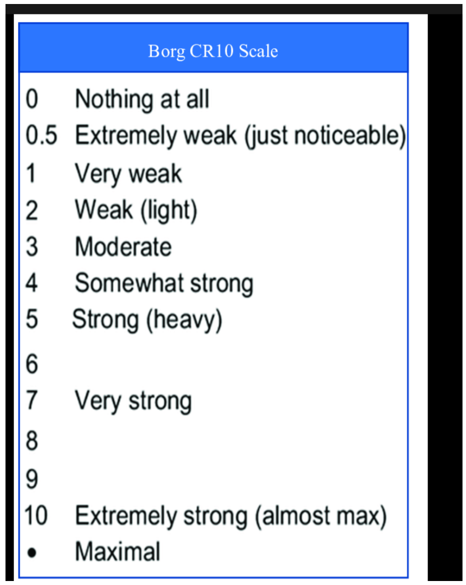
The aim of this research is to enhance our comprehension of how users perform while typing in augmented reality (AR) using the Rotating Flower text entry method for gaze-typing alignment. Additionally, we aim to compare our technique to state-of-the-art gaze-based text entry methods for head-mounted displays (HMDs). To achieve this, we compare different input variations against two baseline interaction techniques that are utilized for typing in a standard text entry task.

3.1 Apparatus

The design and study are implemented with Unity with the Microsoft Mixed Reality Toolkit (MRTK) on the Microsoft HoloLens 2. This Head-mounted Display has a resolution of 2048 * 1080 pixels per eye, 8MP camera, and 2 IR cameras for eye tracking. The Integrated eye tracker features a sampling rate of 30 Hz and a nominal Spatial Accuracy of 1.5 - 3 degrees[1, 2].

3.2 Task

A total of 5 participants were recruited for the study. In this study, the participants transcribe phrases using each of the text entry techniques. They are instructed to complete the task as quickly and accurately as possible. If any mistakes are made, the user can restart the task via clear button. The phrases used in the task will be selected randomly from a subset of MacKenzie's[11] phrase set.



Borg CR10 Scale	
0	Nothing at all
0.5	Extremely weak (just noticeable)
1	Very weak
2	Weak (light)
3	Moderate
4	Somewhat strong
5	Strong (heavy)
6	
7	Very strong
8	
9	
10	Extremely strong (almost max)
•	Maximal

Fig. 1. Borg of CR-10 scale

3.3 Study Design

The variables that is measured in this study include Words Per Minute (WPM), Total Error Rate, and an adapted Borg CR10[4] scale for eye fatigue. These measures will allow us to evaluate the performance of each text entry technique in terms of typing speed, accuracy, and the level of eye fatigue experienced by the users. The adapted Borg CR10[4] scale is a subjective measure that allows users to rate their level of eye fatigue on a scale of 0 to 10, with 0 being no fatigue and 10 being extreme fatigue. This measure will provide us with insights into the level of discomfort experienced by users while using each text entry technique.

3.4 Procedure

At the beginning of the study, participants were asked to provide their consent and complete a demographics questionnaire. They also receive a briefing about the study. Participants wear a Head Mounted Display (HMD) and calibrate the eye tracker before starting the study. Prior to each condition, participants watch a short video demonstrating the typing technique and then type two phrases for training purposes. The experimenter provided assistance during the training session and explain how the technique works.

After completing the training session, participants proceed with the study session using the designated technique to type phrases while their performance is being recorded. They also fill out questionnaires after each condition. Towards the end of the study, participants complete a ranking questionnaire and participate in an interview.

Images

4 RESULTS

The study demonstrated that the dwell time significantly impacted the typing speed of participants. The most comfortable dwell time was found to be 1 second, with advanced users achieving a reasonably good typing speed at 0.5 seconds.

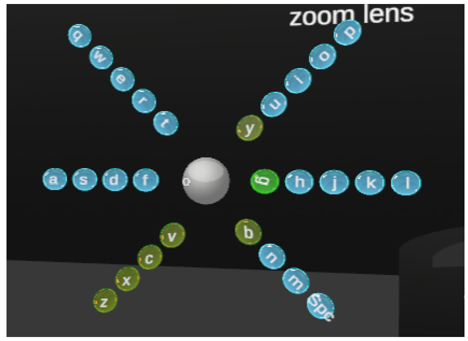


Fig. 2. Rotating Flower layout text entry interface

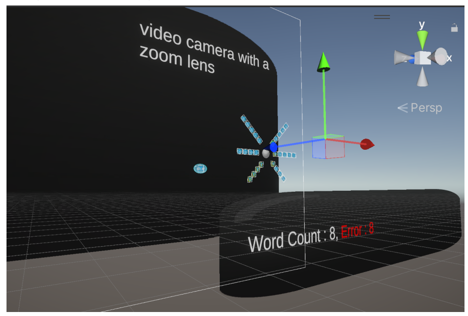


Fig. 3. The reference phrase set and the words typed and error rate input area

Participants were initially exposed to a dwell time of 4 seconds, which aided in their training and familiarity with the keyboard layout. The participants achieved a mean typing speed of 3 wpm with a low to no error rate of 2-3%.

Furthermore, the study found that the group using a dwell time of 1 second had a mean typing speed of 9.3 wpm but with significantly higher error rates of 12-15%. The group using a dwell time of 0.5 seconds had a mean typing speed of 10.4 wpm, with a high error rate of 35-40%. Participants required multiple trials to achieve higher speeds. It is important to note that the higher typing speed was associated with a higher error rate.

The questionnaire and interview data revealed that participants experienced more eye fatigue when using gaze typing on the HMD. Due to the larger keyboard layout, users had to move their heads, and the limited spatial accuracy of the HMD (about 2-3 degrees) caused higher error rates for closely spaced keys. Additionally, keys located closer to the center and requiring less travel were easier and more accurately typed than those requiring more travel.

Moreover, the results showed that the flower text entry method had significantly higher typing speed than the standard gaze typed keyboard, which achieved a typing speed of only 5-6 wpm. However, the flower text entry method was slower and more error-prone than the standard air typing interface available in the Hololens 2, which enabled users to achieve typing speeds of 12.24 wpm.

Overall, the study's findings highlight the challenges of gaze typing on an HMD and the potential benefits and drawbacks of different text entry methods. The study also emphasizes the critical role of dwell time in affecting typing speed. These results can inform the design of more efficient and user-friendly text entry interfaces for HMDs.

5 DISCUSSION

The study investigated the effectiveness of the rotating flower text entry in augmented reality and its impact on typing speed and error rates. The results indicate that shorter dwell times can increase typing speed but lead to higher error rates. The reason for this could be that shorter dwell times allow for more efficient use of time between keystrokes, while longer dwell times may cause delays between key selection and character appearance on the screen. However, shorter dwell times also mean lesser time for fixations, leading to more saccades being registered as fixations, which increased error rates.

The study was conducted using the Microsoft Hololens 2, which had a spatial accuracy of 2-3 degrees, which was not sufficient for the gaze typing interface. This resulted in registering of neighbouring keys, and the larger key sizes meant more travelling, leading to higher error rates. Finding the optimal layout with respect to spatial accuracy was a trade-off, and the study provides insight into these limitations.

The study's findings have practical implications for individuals who type slowly, as adjusting the dwell time on their keyboard may improve their typing speed, productivity, and efficiency. Future research could explore other key layouts and feedback mechanisms to optimize typing performance and investigate the impact of dwell time on typing speed in individuals with different levels of typing proficiency and disabilities.

6 CONCLUSION

In this paper, we presented a new interface for gaze typing called the Rotating Flower text entry keyboard. Our results show that this interface can improve typing speed compared to traditional gaze typing interfaces, particularly when multiple occurrences of the same letters are present. This makes it particularly useful in natural interaction scenarios such as password or data lookups in augmented reality.

As part of our future work, we plan to further improve the design of the keyboard and explore the potential of adjustable dwell typing as demonstrated by P. Majaranta et al.[12]. Additionally, we will compare the effectiveness of a keyboard fixed with the head versus one that is located in space. We also plan to investigate a more multimodal approach to Rotating Flower text entry and compare it to other newer techniques, such as Gaze Assisted Freehand Selection-based Text Entry in AR, which was presented by Mathias N. Lystbæk et al [10].

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