An Arabic Eye Controlled Onscreen Keyboard for People with Disabilities

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***Abstract*—This paper presents an innovative onscreen eye-controlled virtual keyboard designed to facilitate typing for disabled users by using eye movements and blinking as inputs. The proposed system supports both Arabic and English languages, addressing the need for multilingual accessibility. The core of the design integrates a "divide and conquer" methodology to speed up the typing process. By analyzing user gaze patterns and blink duration, the system ensures accurate character selection and reduces eye strain. The study highlights the potential of combining eye tracking technology with adaptive algorithms to create inclusive digital communication tools that cater to a diverse range of physical needs.**

Keywords—virtual keyboard, eye gaze, disabilities, Arabic

I. Introduction

In 1938, the first computer was introduced to the world, primarily designed for arithmetic operations and word processing. Over time, computers evolved significantly, becoming essential components of our personal and professional lives, with functions like internet browsing and connecting people globally through social media. However, this rapid technological advancement has created barriers for some people with disabilities who struggle to adapt, particularly those with hand movement impairments. Use the enter key to start a new paragraph. The appropriate spacing and indent are automatically applied.

This gap underscores the need for digital assistive technologies. Our research focuses on addressing challenges faced by individuals with disabilities affecting hand movement, including those with rehabilitative disabilities (e.g., spinal cord injuries, repetitive strain injuries) and motor disabilities (e.g., autism, cerebral palsy, ALS). Our goal is to empower them with the ability to write text on computers.

The global market for assistive devices for the elderly and disabled is experiencing significant growth, driven by the increasing number of people who require these technologies. Over 2.5 billion individuals currently rely on assistive aids for daily living, and this figure is expected to reach 3.5 billion by 2050 due to rising life expectancy and the growing prevalence of non-communicable diseases. The market, valued at $27 billion in 2022, is projected to reach $46.78 billion by 2032, with a compound annual growth rate of 5.70% during this period.[1].

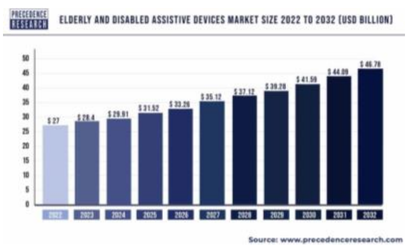

Fig. 1. Disabled Assistive Devices Market Size

II. Literature Review

In Robiul Islam et al. [2] and Partha Chakraborty et al. [3], a similar approach was used. Both applications relied on the user blinking to type. They started with face detection followed by eye detection. The user looks at either the left or right part of the keyboard. In [2], both the left and right parts of the keyboard light up in the same direction. In [1], the left part of the keyboard lights up in the backward direction while the right part lights up in the forward direction. This principle makes the keyboard in [2] faster. This method of lighting up the letters sequentially and typing by blinking is more time consuming than tracking exactly where the user is looking to type a certain letter, but it also more cost-efficient, has higher accuracy, and can be applied using the device's built-in webcam. Robiul Islam et al. used Histogram of Oriented Gradient (HOG) and Support Vector Machine (SVM) for face detection, while Partha Chakraborty et al. used HOG and Dlib. For eye detection, 68 facial landmarks detector was used to detect the 12 points that represent both eyes. Two lines are drawn on the eye, one horizontal and the other vertical. The vertical line is the indicator for eye blinking. Its length decreases while the eye is closing. Eye gaze detection is used to distinguish the iris from the white part of the eye to determine whether the person is looking at the left or right part of the keyboard. When blinking is detected, it indicates the user wants to type the letter that's currently lit up. Results in [1] revealed higher accuracy than existing models. The evaluation was done by considering the following parameters.

- Character Per Minute (CPM)
- Word Per Minute (WPM)
- Total Error

In [2], they found that eyeglasses do not affect the detection of blinking but give false results when detecting eye gaze due to reflection. Gaze direction detection was generally inaccurate due to the use of a webcam. Another limitation was that the size of their writing board only allowed for a hundred letters. Our goal is to integrate the keyboard to be used with any app on the laptop such as MS Word rather than rely on a small writing board.

In Chern-Sheng Lin et al. [4], the authors developed a virtual keyboard that can detect both the user's fingers as well as track their eye movement. Eye movement was tracked using an infrared CCD camera. They worked on correcting the detection of eye movement in a horizontal line using a three-section correction method. The curve that describes the movement of the eyes was divided into three sections and coordinate transformation was used for the points responsible for the curve to approximate it to a horizontal line.

In K. Dobosz et al. [5], authors integrated between EEG signals and eye blinking detection to include predictive text. They utilized a divide and conquer method. The keyboard was divided into 5 rows lit up sequentially. If the user chooses a row by double blinking, the keys of that row light up in two groups. Once a group is chosen, individual keys are lit up for the user to choose from. Typing a letter requires double blinking three times, which, while efficient, puts a strain on the user’s eyes with time. The EEG signals main role was the switching between typing and choosing from predictive test based on whether the user was in a relaxed or active state of mind, which relies on the frequency of the signal. Since the user was focused when typing, the active state of mind indicated the choice of typing, while the relaxed state indicated the desire to choose from the available predictive words. The relaxed state of mind can easily be achieved by closing one’s eyes for a moment, which enables easy switching between both modes.

Below is the comparison of the achieved Words Per Minute (WPM) for the discussed methods.

TABLE I. WORDS PER MINUTE ACHIEVED BY DIFFERENT METHODOLOGIES

EEG signals and blinking	Backward and Forward Keyboard with Eye Blinking
1.27	2.09

III. CONTRIBUTION OF OUR WORK

Our goal is to create a virtual keyboard app with both Arabic and English letters that can be integrated seamlessly with the user’s laptop or personal computer. We hope to provide disabled users with a method for them to express themselves freely, as well as some independence. This desktop app will be useful to people with multiple different disabilities such as quadriplegia, where the patient is in complete loss of control over their body except for their eyes. Amputees will also benefit from this project, as well as people suffering from amyotrophic lateral sclerosis (ALS), multiple sclerosis (MS), severe arthritis, carpal tunnel syndrome, or cerebral palsy. We also aim to improve the WPM that the user can type using prediction text, as well as ease the process of deleting mistakes by allowing the delete button to be specially selected and not sequentially. Additionally, more studies are needed to decide on an optimal placement for both English and Arabic lettering for faster typing. While the keyboard will not provide complete access to all device functions, it will be a step in the right direction.

IV. METHODOLOGY

Fig. 2. Steps of Eye Detection

Developing the onscreen eye-controlled virtual keyboard is divided into two main components: eye tracking and keyboard mechanism. For eye tracking, we employ computer vision techniques to detect and interpret eye movements and blinking, thereby eliminating the need for EEG or IMU sensors. The system utilizes face detection to locate the user's face within the camera frame, followed by eye gaze detection to determine which side of the keyboard the user is looking at. Blinking is detected through analysis of 12 key landmarks around the eye using the Dlib library, which allows for accurate and responsive input based on eye blinks. The model needs to be trained on middle eastern features.

V. KEYBOARD DESIGN

In Fig.2 and Fig.3, we can see a preliminary design for the virtual keyboard. It is divided into two sides. The left side includes all letters and numbers, and the most common punctuation marks. The right side has all the control keys. The user can use the arrows to navigate between the text. They can also clear their entire text, press tab to confirm the predicted text, and change the language. One limitation for the Arabic keyboard (Fig. 2) is the absence of certain characters such as “أ”, “آ”. Despite limiting the variability of words, the omission of these characters allows us to keep the design simple. This way the keyboard remains functional while maintaining ease of use. However, this could be an area of improvement in the future.

Fig. 3. Arabic Mode

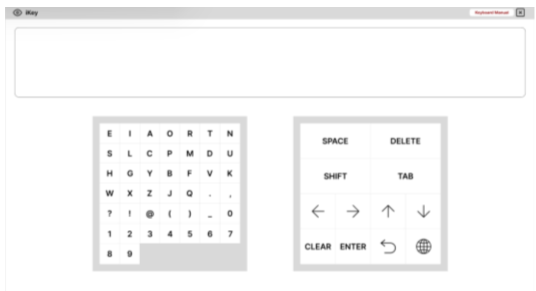

Fig. 4. English Mode

Choosing a letter requires the user to blink 3 times. One for the row, another for the group, and the last for the letter. The model is trained to recognize the difference between autonomous and intentional blinking. This reduces eye strain due to double blinking while maintaining the efficiency of the divide and conquer method.

After the user is done typing, they can choose “enter” key to place their text in the desired app. Since there’s not yet a way to switch between programs using the user’s eyes, this feature is not completely independent and requires human assistance. In the future, we aim to develop a companion cursor that can provide full independence for disabled users.

VI. SWOT ANALYSIS

A. *Strengths*

1) Arabic Letters

2) Text Prediction: AI assistance for both Arabic and English.

3) No Special Gear: No EEG or eye-tracking device needed.

4) Seamless Integration: The keyboard is intended to work in place of a physical keyboard.

5) Easy Access: Letters that are more frequent in the language are faster to access.

6) Less Eye Strain: Separating autonomous from intentional blinks avoids the need for double blinking.

B. Weaknesses

1) Learning Curve: The order of the letters is unfamiliar and requires practice but will increase the WPM with use.

2) Missing Punctuation & Functionalities: The keyboard won't provide full functionality but it's a step in the right direction.

3) No Backtracking: If a user misses the row or letter they want, they have to wait out the sequence. This can be solved by double-blinking to restart the process.

4) Taking Up Space: As with all virtual keyboards, iKey takes up a portion of the screen and may block the view.

5) Semi-Independence: Using the keyboard to type in any program requires assistance in switching between programs.

C. Opportunities

1) Language Customization

2) Companion Cursor App: to provide full independence.

D. Threats

1) Advances Eye-Tracking: Can detect exactly where the eye is looking so it eliminates the need for an algorithm for choosing the letters.

2) BCI: Some studies are exploring the possibility of using BCI to type letters based on signal pattern recognition.

VII. Business Model

A. Key Partners

1) Healthcare & Accessibility Organizations: to promote and test our product.

2) AI and Computer Vision Experts

B. Key Activities

1) Development & Training: develop the AI model and CV algorithms.

2) Software Integration: with laptop functionalities.

3) Testing & Iteration: to improve user experience.

4) User training: provide support to effectively assess the virtual keyboard.

C. Key Resources

1) Data & Technology: access to facial recognition and eye-blinking detection & datasets for model training.

2) Software Integration: with laptop functionalities.

3) Testing & Iteration: to improve user experience.

4) User training: provide support to effectively assess the virtual keyboard.

D. Value Proposition

1) Accessibility: Hands-free typing solution to ease communication and improve independence.

2) Language Support: supporting both Arabic and English.

3) Ease of Use: straightforward interface with a small learning curve.

4) Integration: seamless use in place of a physical keyboard.

5) No additional gear required: no eye-tracking device or EEG.

E. Customer Relationship

1) Feedback Mechanism: users provide suggestions for continuous improvement.

F. Channels

1) Website: a simple static website for downloading the app and customer support.

G. Customer Segments

1) People with Disabilities: users who need AT for typing such as amputees and people with quadriplegia.

2) Tech Enthusiasts

3) Healthcare Professionals: who can recommend AT

4) to patients.

H. Cost Structure

1) Development Costs: related to AI, CV, and software testing and engineering.

2) Operational Costs: maintaining and updating the website and software.

3) Marketing & Distribution: costs for promotional activities.

I. Revenue Stream

1) Sales: accessing the virtual keyboard software requires a one-time purchase and provides lifetime support.

2) Partnerships & Sponsorships: potential revenue from partnering with interested organizations.

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References

[1] M. R. R. Bharath, D. Kumar .L, Jayasuriya .C, and M. Sundaram .T, "Controlling Mouse and Virtual Keyboard using Eye-Tracking by Computer Vision," *JOURNAL OF ALGEBRAIC STATISTICS*, vol. 13, no. 3, Art. no. 3, Jul. 2022.

[2] M. R. Islam, M. S. Rahman, and A. Sarkar, "Computer Vision Based Eye Gaze Controlled Virtual Keyboard for People with Quadriplegia," in *2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI)*, Rajshahi, Bangladesh, 2021, pp. 1-6. doi: 10.1109/ACMI53878.2021.9528213

[3] P. Chakraborty, D. Roy, Z. R. Zahid, and S. Rahman, "Eye Gaze Controlled Virtual Keyboard," International Journal of Recent Technology and Engineering (IJRTE), vol. 8, no. 4, pp. 3264-3269, Nov. 2019.

[4] C.-S. Lin, C.-H. Lin, Y.-L. Lay, M.-S. Yeh, and H.-C. Chang, "Eye-controlled virtual keyboard using a new coordinate transformation of long and narrow region," *Optica Applicata*, vol. 38, no. 2, pp. 481-490, 2008

[5] K. Dobosz and K. Stawski, "Touchless Virtual Keyboard Controlled by Eye Blinking and EEG Signals," in *Proc. Int. Conf. Man-Machine Interactions*, 2017, pp. 67-76, doi: 10.1007/978-3-319-67792-7_6.