Lecture Notes in Electrical Engineering 1273

Amit Kumar
Vinit Kumar Gunjan
Sabrina Senatore
Yu-Chen Hu *Editors*

Proceedings of the 5th International Conference on Data Science, Machine Learning and Applications; Volume 1

ICDSMLA 2023, 15–16 December, Hyderabad, India

Springer

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ISSN 1876-1100 ISSN 1876-1119 (electronic)
Lecture Notes in Electrical Engineering
ISBN 978-981-97-8030-3 ISBN 978-981-97-8031-0 (eBook)
https://doi.org/10.1007/978-981-97-8031-0

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Contents

Morse Code Encryption: Securing Visual Information with Morse Transform

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Abstract. Leveraging cutting-edge eye-tracking technology and machine learning algorithms, a real-time, non-invasive solution that empowers individuals with motor disabilities, allowing them to communicate seamlessly through natural eye movements. The project encompasses a comprehensive pipeline, starting with the collection of precise eye movement data using state-of-the-art eye-tracking hardware. It employs sophisticated image processing techniques to preprocess the acquired data, filtering out noise and detecting blink patterns accurately. This computer vision project not only showcases the potential of eye blink detection for text-based communication but also highlights the importance of innovative solutions that empower individuals with physical limitations to interact with technology effortlessly. Our recommended approach is continually used to test the effects of light and the distance between a user's eyes and a mobile device to assess the exact position, according to test results, offers 90% general exactness and 100% recognition accuracy for a distance of 15 cm with a false light.

Keywords: Blink Detection · Morse Code · Eye movement Tracking · openCV

1 Introduction

In an increasingly digital world, the ability to communicate effectively is paramount. For individuals living with severe motor disabilities [10], conventional means of communication, such as speech or manual text input, may pose significant challenges. As technology continues to advance, there is a growing need for innovative and inclusive solutions that empower individuals with limited motor function to interact with computers and digital devices effortlessly.

Eyeblink movements, a fundamental and involuntary aspect of human physiology, represent an intriguing avenue for communication. They offer a potential means of bridging the communication gap for those who may have lost their ability to speak or use traditional input devices. Blinking, an instinctive and universally understood action, can serve as a non-invasive and intuitive input method. Harnessing the power of

A. Kumar et al. (Eds.): ICDSMLA 2023, LNEE 1273, pp. 801–810, 2025.
https://doi.org/10.1007/978-981-97-8031-0_85

computer vision and machine learning, this project aims to explore the development of a system that converts eye blink movements into plain text—a transformative concept with far-reaching implications for assistive technology [13] and human-computer interaction.

The advent of eye-tracking technology has paved the way for precise and unobtrusive monitoring of eye movements. This technology allows for the capture of subtle blink patterns, which, when properly analyzed [1], can be translated into meaningful commands or text. By recognizing the unique signatures of blinks, such as their duration, frequency, and intensity, we can create a system that not only interprets these patterns but also enables users to communicate fluently through their natural eye movements. This project seeks to address a critical need within the field of assistive technology. We will outline the comprehensive pipeline of our computer vision project, encompassing data acquisition through state-of-the-art eye-tracking hardware, preprocessing of eye movement data [4], machine learning model development, blink pattern recognition, and the mapping of these patterns to plain text. Furthermore, we will emphasize the importance of user-friendliness, adaptability, and the practicality of our system, ensuring that it can cater to the unique needs and preferences of its users.

2 Literature Survey

Eye blink detection and its application in human-computer interaction have garnered significant interest in recent years. Researchers and engineers have explored various techniques and methodologies to harness the potential of eye blink movements for communication and control. In this section, we review key studies and advancements in the field, providing insights into the evolution of eye blink-based systems.

Lou Gehrig's disease, commonly known as amyotrophic lateral sclerosis (ALS) [10], is a fatal condition in which motor neurons are selectively damaged. As organ malfunction develops, patients eventually lose their movement. Patients eventually experience difficulty performing even tiny movements and making simple sounds. Researchers have concentrated on eye movements to interact with quadriplegic individuals because the eye is the sole moving organ for ALS patients [10]. They have looked on ways to detect eyeblinks using either cameras or brainwaves, as well as various techniques for choosing letters on a screen based on eye movements tracked by eye-tracking cameras. The identification of intent is frequently erroneous when using brainwave-based approaches, which look at electrical signals from eye movements to infer a patient's intent. It's also possible to employ a camera-based technique that integrates letter selection to find moving eye feature points; this technique makes it straightforward to ascertain a patient's [10] intentions using a predetermined decision-making process. However, it takes a while to process and is prone to errors in either the sequential selection processes or the implementation of Morse code that is distributed across all alphabets. We developed iMouse-sMc, a streamlined Morse code-based user interface [15] paradigm using an eye mouse, to allow communication with these individuals quicker and easier. Additionally, we enhanced the eye mouse's detecting capabilities by utilizing image contrast methods, allowing us to communicate with patients even at night. [16] This thesis demonstrates that eye flashes are among the most reliable forms of communication in contemporary human PC involvement systems. This research proposes a novel method for recognizing

eye flashes, based on format planning and close measurements. Before the extraction of the eye format, face disclosure is employed to prevent the fake acknowledgment that would otherwise result from the shifting configuration in the video plot. Because the connection score typically alters whenever a glimmer occurs, Eye Blink acknowledgment is conducted by that score. The method offers a general accuracy of 92 percent and, taking into account, a precision of 99 percentile with a 1 percent false positive rate in a variety of early conditions. In recent years, human PC cooperation has seen a significant increase in the usage of eye Blink localization methods.

For people with motor neuron diseases, eye-based communication languages like Blink-To-Speak [11] are essential for conveying their needs and feelings. The majority of developed eye-based monitoring technologies are expensive and complicated for low-income nations. For patients with speech problems, Blink-To-Live is an eye-tracking device based on a modified Blink-To-Speak language and computer vision. Real-time video frames from a mobile phone camera are sent to computer vision modules for eye recognition and tracking, as well as for detecting face landmarks [5]. The Blink-To-Live eye-based communication language has four distinct key alphabets: Left, Right, Up, and Blink. These eye motions represent more than 60 common orders by alternating between three different eye movement states. The translation module will show the phrases in the patient's native speech on the phone screen when the eye motions encoded sentences are formed, and the synthesized voice may be heard. The Blink-To-Live system's prototype [14] is put to the test utilizing typical instances with various demographics. Blink-To-Live is simpler, more adaptable, and less expensive than previous sensor-based eye-tracking systems, and it is not dependent on any particular software or hardware.

70% of human lives can be saved via appropriate acknowledgment and ongoing well-being monitoring [11]. The tool was created with the express purpose of reducing the evident losses' prosperity features throughout the approved time. The usage of GSM and IoT to track the patient's condition or health [11] has grown more and more practical. This recommended approach comprises several great sensors, such as temperature, heartbeat, eye sparkle, and SPO2 sensors, for evaluating the patient's internal body temperature, coronary pulse, eye advancement, and oxygen saturation level. The microcontroller for this system, which also uses cloud enrollment, is the Arduino Uno board.

The video-based interfaces [11] discussed in this study set up optional special procedures that, in applications that just need decision orders, can replace the mouse. Results demonstrate BlinkLink's ability to clearly discern brash and required glints. EyebrowClicker tests demonstrate that eyes and eyebrows may be identified and tracked, making it possible to identify eyebrow rises with great accuracy. Both prior knowledge of the facial zone or skin tone and unusual illumination are not necessary. The two structures operate reliably and continuously, which is a great concept for systems that must respond to facial cues or prompts [11]. The two interfaces can be used simultaneously with different application applications on modern PCs due to the low computing resource required. Both EyebrowClicker and BlinkLink can evolve to integrate with other assistive advancements to enhance the spot movement of communication for individuals with disabilities. They might also be utilized to provide interfaces for plain-language viewing of both checked and imparted language. One important semantic tool in American Sign Language (ASL) for expressing a request is an eyebrow lift.

To establish a two-way switch and request a decision, two video-based human-PC cooperation devices are introduced. The essential component, known as "BlinkLink," typically detects client eye glints and precisely gauges their lengths. The structure aims to provide a different informational method to enable even the most profoundly incompetent individuals to access a PC. While required short gleams are ignored, headstrong long blinks cause mouse clicks. The system uses "Blink models" for correspondence, which are collections of long and short glimmers that are converted into semiotic messages [12]. Recently, there has been a drive to replace traditional human-computer interfaces like the keyboard and mouse with clever interfaces that allow users to assist the PC even more frequently and appropriately.

The study introduces a dream-based human-PC interaction. Persistent eyeblinks are recognized by the interface as control orders [12]. The used image preparation technologies will include Haar-like features for improved face disclosure and configuration arranging based on eye following and eye-blink confirmation. 49 customers (of whom 12 had a definite blockage) attempted interface performance. The results of the tests demonstrate the utility of the interface in use as a PC communication method of choice. The customers had the option of researching the Internet and were given access to English and Polish content. The interface relies on a notepad equipped with a standard web camera and does not require any additional lighting. It is possible to view the interface application online as open-source code. According to results that have been collected, the suggested computation rewards for cautious confirmation of purposeful eye-Blinks [12] with a movement of around 99%. Test results demonstrate how effective the designed eye-glitter-controlled user interface is for interacting with the machine. Clients who were working less had positive sentiments. Under the moniker "blink," Polish Telecom and the Orange Group provided the foundation for the demonstration of open-source programming as a user interface for people with disabilities.

In summary, the literature reveals a compelling evolution in the field of eye blink detection for communication. From simple binary actions to complex machine learning-based recognition systems, researchers have made substantial strides in harnessing the potential of eye blinks for plain text communication. This project contributes to this evolving landscape by further exploring the capabilities and practicality of blink-based communication systems, aiming to provide users with an intuitive and efficient means of interaction in the digital age.

3 Research Gaps

Morse code transformation using eye blinks is an intriguing and potentially useful area of research, especially for individuals with disabilities or in situations where voice communication is not possible or practical. While there has been some work in this field, there are still several research gaps that need to be addressed. Some of these research gaps include:

The accuracy and speed of Morse code generation and decoding using eye blinks can be improved. Research should focus on developing more efficient algorithms and machine learning models for recognizing and interpreting eye blinks accurately. Designing user-friendly interfaces for Morse code communication with eye blinks is crucial.

Research should explore the development of user-friendly hardware and software interfaces, including eye-tracking devices, headsets, and applications that can be easily used by individuals with different levels of motor control. These systems should be able to adapt to changes in blinking speed and accuracy over time and accommodate users with various eye conditions or impairments. Research should address the issue of noise and interference in eye blink-based Morse code communication. Addressing privacy and security concerns is crucial, especially if this technology is used for sensitive or confidential communication. It's crucial to make sure that the gear and software utilized for eye blink-based Morse code communication are long-term reliable and durable. Investigate how these systems may be updated and maintained throughout time.

4 Methodology

In this approach, [2] the eye blink durations are represented by widely recognized Morse codes demonstrated in Fig. 1, which may be used to map the eye blinks to strings [3], which is useful for communication. The table of Morse codes is seen below.

A ·−	J ·−−−	S ···	1 ·−−−−
B −···	K −·−	T −	2 ··−−−
C −·−·	L ·−··	U ··−	3 ···−−
D −··	M −−	V ···−	4 ····−
E ·	N −·	W ·−−	5 ·····
F ··−·	O −−−	X −··−	6 −····
G −−·	P ·−−·	Y −·−−	7 −−···
H ····	Q −−·−	Z −−··	8 −−−··
I ··	R ·−·	0 −−−−−	9 −−−−·

Fig. 1. Morse-Code table

Face detection and facial landmarks prediction are the first two sub-modules of the facial landmarks detection module. The objective of this module is to identify the patient's face and extract the positions of 68 facial coordinates that correspond to various facial features, including the eyes, mouth, nose, and other features. The words are shown in the patient's original tongue, such as Arabic, German, etc., thanks to a translation module.

Important facial landmarks including the nose, eyes, brows, lips, and others are found on the face. The patient's eyes are the most crucial face feature in our system. In our proposed framework, the facial landmarks module consists of two fundamental steps: identifying the face from the pictures captured from video frames and then accurately localizing the significant facial features on the region of interest on the face. However, before an eye can be identified, a face must first be recognized. The facial landmark

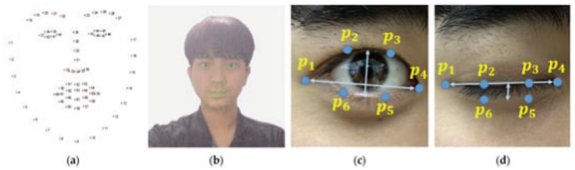

Fig. 2. Positions of the 68 facial landmarks, facial landmark detection, open eyes with landmarks, and closed eyes with landmarks are shown in (a), (b), (c), and (d) of the figure, respectively.

detector then extracts the face's feature points, connects the outline feature points of the eye, and calculates the eye position to complete eye identification. The iBUG 300-W dataset was used to train the model, which is used to estimate the x and y coordinates of 68 face landmarks. The model is implemented in the dlib package. In order to identify face landmarks on real-time pictures retrieved from video frames, our suggested solution uses the dlib pre-trained model. The second phase involves determining whether the eye has blinked for a brief or prolonged amount of time utilizing the size and location of the pupil, the position and angle of the eyelids, etc., within the detected eye area. Then, by comparing the length of the eyeblinks to a predetermined, streamlined Morse code combination, the appropriate letter is deduced. The typo-correcting SymSpell algorithm effectively suggests alternatives when a phrase is inadvertently misspelled.

Using a trained facial landmark detector from the dlib package, we first computed the coordinates of 68 feature points on the face to detect eyes. By computing the gradient in the direction of the histogram at each pixel position in the picture, the landmark detector creates feature vectors based on histograms of directed gradients. A support vector machine classifier is used to identify 68 facial landmarks in the resulting vector, which may be used to define the contour of the face as well as the eyes, nose, ears, and mouth. As a consequence, it numbers each facial feature point as shown in Fig. 2a, and applies it to the face picture to identify landmarks that surround feature portions of the face, such as the eyes and nose, as illustrated in Fig. 2b. The right eye in the illustration corresponds to feature points 43–48, whereas the left eye is represented by feature points 37–42. The appropriate feature points [8] are extracted to identify blinking, but they are extracted with a size big enough to encompass the region around the landmark—roughly 1.2 times the area of the landmark—to reduce detection error. The results of extracting eyes while the eyes are open and closed, respectively, are shown in Fig. 2c,d. Each eye is identified by six feature points (p1…p6).

With the use of the facial landmarks module, each eye is located using six coordinates, and the relationship between eye height and width can be represented by the EAR [6], which is calculated using the formula:

$$\mathbf{EAR} = \frac{\|\boldsymbol{p}2 - \boldsymbol{p}6\| + \|\boldsymbol{p}3 - \boldsymbol{p}5\|}{2\|\boldsymbol{p}1 - \boldsymbol{p}4\|} \tag{1}$$

where p_1, p_2, p_3, etc., are the coordinates of the eye's landmarks

When it blinks, it's roughly equal to zero. Therefore, the ratio can tell if the patient is blinking. It computes t, a predetermined threshold value (0.2 in our application). A single blink is recognized and can be counted as many times as blinks have happened if

the EAR value is dropped by less than 0.2 and then increased by more than 0.2. Based on comparing EAR with the t threshold value, the following equation shows how the eye's opening and shutting states are identified. When compared to the planned blink, which lasts 800 ms, the normal blink, which lasts between 100 and 400 ms, is extremely brief. To differentiate between a typical blink and a patient's blink, which serves as an alphabet in the Blink-To-Live [7] eye-based language, we employed the methodology described. The remedy calls for checking the EAR value throughout the course of 13 video frames; if the EAR is still less than 0.2, the problem is the desired language blink. The blink is very quick and might be normal given that the camera takes 25 frames per second if the number of inspecting frames is less than 13 frames.

$$\begin{cases} Eye_{closed} & EAR \leq t \\ Eye_{open} & EAR > t \end{cases} \tag{2}$$

The red mouse pointer with a circle around it started at the top left corner of a quadrant display like the one in Fig. 3 with quadrant navigation, and it automatically traveled clockwise to the next quadrant every second. Seven alphabetic or control letters—A to G, H to N, O to U, V to Z, Space, and Delete—were allocated to each quadrant, and they remained in place until the patient chose the proper quadrant with two brief blinks. The user had to memorize fewer Morse codes as a result, which made learning easier and allowed for improved accuracy and quicker processing. The user inputs four brief blinks to return to the beginning screen and chooses the alphabet present in the other quadrants once the desired letter is output. After fully keying in the chosen letter, the user moved to the typo correction process with one long blink and two short blinks [9].

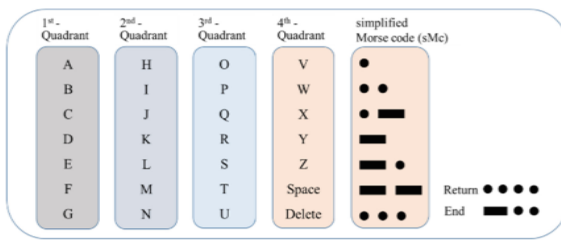

Fig. 3. On-screen keyboard arrangement.

The SymSpell algorithm was used to check for mistakes and, if required, repair them after all the desired alphabets had been output on the screen. It is an effective open-source library that is frequently used for natural language processing tasks like text completion and spell checking. It performs best when using the Damerau-Levenshtein distance metric and N-gram, and because of its quick search times, it may be used for real-time searches. It is very good at processing enormous volumes of data. It begins by compiling a lookup table, or lexicon, from a sizable collection of datasets so that it can identify the correct term if a mistake occurs in an input word. Additionally, it keeps track of the word's frequency for use in mistake correction. The input words are then divided into N-grams using the generated dictionary, and a Trie data structure that identifies the

word to which each N-gram belongs is produced. Based on this, it corrects the input word's typos by first looking for words that contain all of the word's N-grams to create a list of candidate words, scoring those words using frequency and Damerau-Levenshtein distance, and then returning the word with the highest score as the corrected word (Figs. 4 and 5).

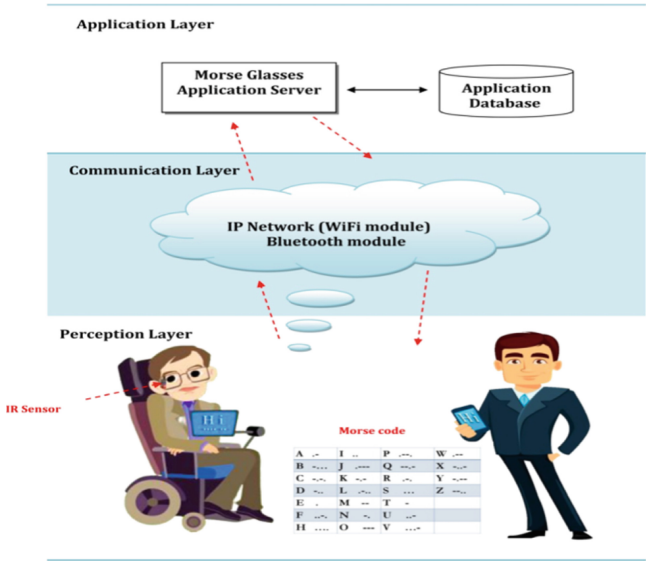

Fig.4. IoT communication system

Fig.5. IoT Smart Glasses for Muscles impaired patients

5 Conclusions

Different eye movements are translated into a set of everyday instructions that patients use to convey their feelings and wants using a collection of computer vision modules and a modified version of the Blink-To-Speak language. Only the phones with compatible

cameras will be used by patients and carers to monitor various patients' eye movements. We have demonstrated that the Eye Aspect Ratio is a very efficient tool for identifying blinks in addition to the traditional method. For spies or military people who need to deliver a coded message without the adversary knowing, this gadget may be useful. Currently, the following assumptions are made about how impaired people communicate. This device can be used for military personnel to communicate in a war zone in a discreet manner with the necessary hardware and software upgrades. Additionally, with a slight modification to the design, it can be applied to smart home apps that allow us to interact with household equipment with simple eye blinks.

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