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Morse Code Translator Via Eye Blinks

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ABSTRACT: In this paper, we present the development and evaluation of an innovative Morse code translator system that makes use of eye blink signals. Morse code remains a crucial form of communication, especially in scenarios where verbal or written communication is challenging. By leveraging advancements in eye-tracking technology and signal processing techniques, we propose a system that enables users to input Morse code messages by voluntarily blinking their eyes. The system employs a non-invasive eye-tracking device to detect and interpret the user's blinks, converting them into Morse code signals. We thoroughly discuss the design, implementation, and evaluation of the proposed system, including its accuracy, usability, and potential applications. Through experimental results, we demonstrate the system's feasibility and effectiveness in translating eye blink signals into Morse code, offering a promising alternative for individuals with limited motor function or communication impairments.

KEYWORDS: Morse code, eye blink, eye-tracking, assistive technology, communication aid.

I. INTRODUCTION

The aim of this research paper is to introduce and assess a new Morse code translator system that utilizes eye blink signals. Morse code continues to be an important method of communication, particularly in situations where verbal or written communication is difficult. By taking advantage of advancements in eye-tracking technology and signal processing techniques, we propose a system that allows users to input Morse code messages through voluntary eye blinks. The system utilizes a non-invasive eye-tracking device to detect and interpret the user's blinks, converting them into Morse code signals. In this paper, we delve into the design, implementation, and evaluation of the proposed system, including its accuracy, usability, and potential applications. Through experimental results, we demonstrate the system's feasibility and effectiveness in translating eye blink signals into Morse code, providing a promising alternative for individuals with limited motor function or communication impairments.

II. SYSTEM DESIGN

The Morse code translator system via eye blinks is designed to detect and interpret blinks using facial landmarks obtained from a live webcam feed or recorded video. It begins by loading facial landmark detection to monitor the user's eyes, tracking the Eye Aspect Ratio (EAR). A threshold of 0.28 is set for the EAR to determine whether the eyes are closed, with frame and blink counters (`C` and `T`) initialized to zero. For each frame, if the EAR drops below the threshold, it indicates a potential blink. The system increments the frame counter and checks if the eyes have been closed for a sufficient number of frames to classify the blink as either a "dot" or "dash" in Morse code—depending on whether the eyes remain closed for 1 second (dot) or 2 seconds (dash). The process continues until the user exits, at which point the system stops.The proposed Morse code translator system consists of two main components: an eye-tracking device and signal processing software. Figure 1 illustrates the system architecture and workflow

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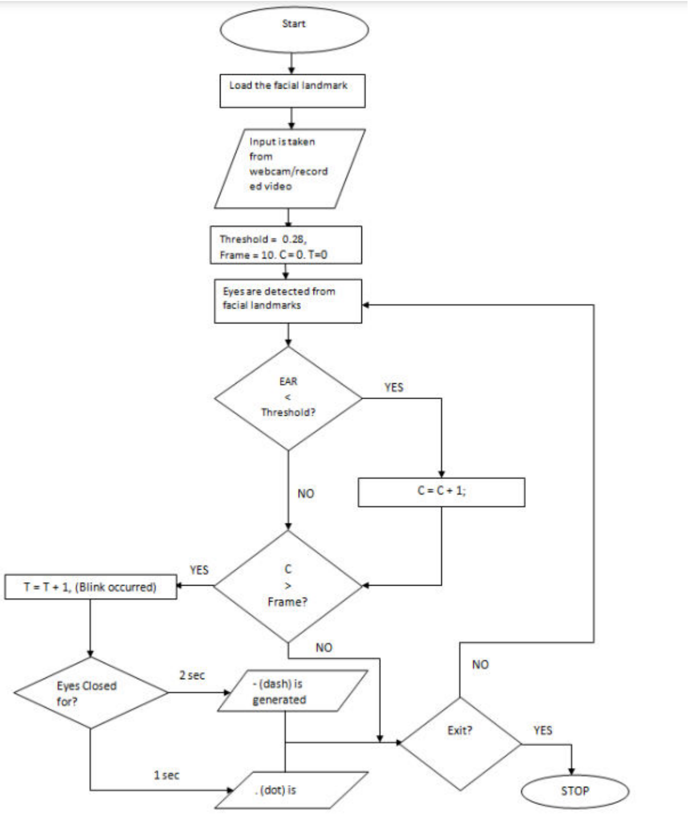

Figure 1 illustrates the system architecture and workflow.

III. FACE FEATURE DETECTION

The system uses the webcam to obtain the user's face image, OpenCV for basic image processing, the face anchor provided by Dlib to obtain the user's detailed face features, and finally sets the specific action to trigger the input signal according to Morse code.

3.1 Image Straightening

When the image captured with the camera is tilted, the system will automatically adjust the image to the vertical direction so that Dlib's image feature calculation can operate normally. When using Dlib to obtain the subject's facial feature anchor point, the confidence value returned by the Dlib function is used as the basis for whether to rotate the image. The confidence value is a number between 0 and 1. The system uses the function provided by OpenCV to rotate the image until the system obtains a confidence value of the face anchor point higher than the threshold, and then stops rotating the image. This system sets the image rotation correction threshold to 0.7, and the angle of each image rotation is ±5 degrees.

3.2 Image Compensation

In the image capture part of this study, a webcam with only 2 million pixels or more is required. The effectiveness of the AIMcT system might be susceptible to factors like the surrounding lighting conditions. This variable could affect the overall accuracy of the AIMcT system's outcomes. Regarding the impact of lighting, OPENCV provides relevant compensation functions designed to mitigate the destabilizing effects of varying light conditions on the system's reliability. In this study, logarithmic transformation and gamma transformation were employed for compensation in situations of excessive darkness and excessive brightness, respectively.

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Logarithmic transformation serves to expand the low gray value portion of the image, thereby revealing more details in that range, while compressing the high gray value portion to reduce excessive detail. This approach emphasizes the low gray value portion of the image, as described in Equation (1).

$S = c \times \log v + 1(1 + v \times r) \quad r \in [0,1]$ (1)

On the other hand, gamma transformation primarily serves for image correction, rectifying images with excessively high or low gray values to enhance contrast, as expressed in Equation (2).

$S = c \times r\gamma \quad r \in [0,1]$ (2)

S is the output gray level of the pixel, c and γ are constants, r is the input gray level of the pixel, and v + 1 is the base number.

This adjustment is aimed at enabling the Dlib module to acquire optimal facial recognition images, thereby enhancing the system's ability to accurately detect and track facial movements.

3.3. Dlib Module

Dlib is a modern C++ toolkit that encompasses machine learning algorithms and tools designed for developing complex software in C++ to address real-world problems. In the AI Face feature extraction component, we utilized the Dlib image recognition module (version 19.8.1) [30], as depicted in Figure 2, to identify the mouth and eye regions as areas for autonomous movements. A facial movement recognition algorithm was created using 68 feature points, with P0–P16 representing the facial contours, P17–P26 denoting the eyebrows, P27–P35 corresponding to the nose, and P36–P47 and P42–P47 assigned to the right and left eyes, respectively. The mouth region is delineated by P48–P54, which represent the upper lip contours, P61–P63 for the inner contours of the upper lip, P55–P60 and P64 for the outer contours of the lower lip, and P65–P67 capturing the inner contours of the lower lip.

Figure 2. Dlib image recognition module

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While the mouth was in motion, we calculated the distance h between P62 and P66 (Equation (3)). When h exceeds 10 pixels, it indicates an open mouth; otherwise, it signifies a closed mouth. We recorded the duration of both mouth opening and closing. We utilized the duration of both opening and closing times to dynamically adjust the judgment threshold for distinguishing between long and short durations through a fuzzy algorithm, thereby facilitating automatic identification. For instance, if the opening time falls below the threshold, it is categorized as a short opening time (dot), while durations above the threshold are classified as long opening times (dash). Subsequently, movement encoding is based on the amalgamation of long and short opening times, where a brief closing time signifies a command combination, while a prolonged closing time signifies a command

IV. ALGORITHM

4.1 Random forest:

Random Forest is an ensemble learning technique. An ensemble technique in itself means creations of multiple models and voting is done among this model and the label or the target is predicted based upon the highest voting factor. Similarly, a Random forest creates multiple tree models and does the prediction. The greater number of tree-models results to a more accurate output and it also helps to prevent over fitting problem. Random forest algorithm takes less training time when compared to other algorithms. It gives output with high accuracy, even when a large dataset is used or even a large part of the data is missing. In the study we have used 1000 random trees with a maximum depth as 2 and created the model.

When we run the program, first the webcam will open and starts capturing the video which will be taken as input. Then we do video processing and analysis how long the eye blinks are to convert that into dots and dashes which will be sent to a machine learning model to

4.2 Fuzzy Time Recognition Algorithm

The artificial intelligence-enhanced Morse code translation system's management of image command combinations hinges on the identification of mouth opening and closing states, as well as the duration of the intervals between them. The artificial intelligence Dlib module is used to detect the mouth opening and closing status. To enhance input efficiency and accuracy, and maintain the stability of these command combinations, the system dynamically adjusts the time threshold for opening/closing mouth movements. This study employed a fuzzy time recognition algorithm (FTR) for precise time threshold fine-tuning. Figure 3 illustrates the differentiation between long (dash) and short (dot) signals, determined by the duration between mouth opening and closing. The system combines the durations of closing and opening times to generate command combinations. For instance, if a long opening time repeats three times, the system produces the letter "o." This system can generate characters as specified in the Morse code table

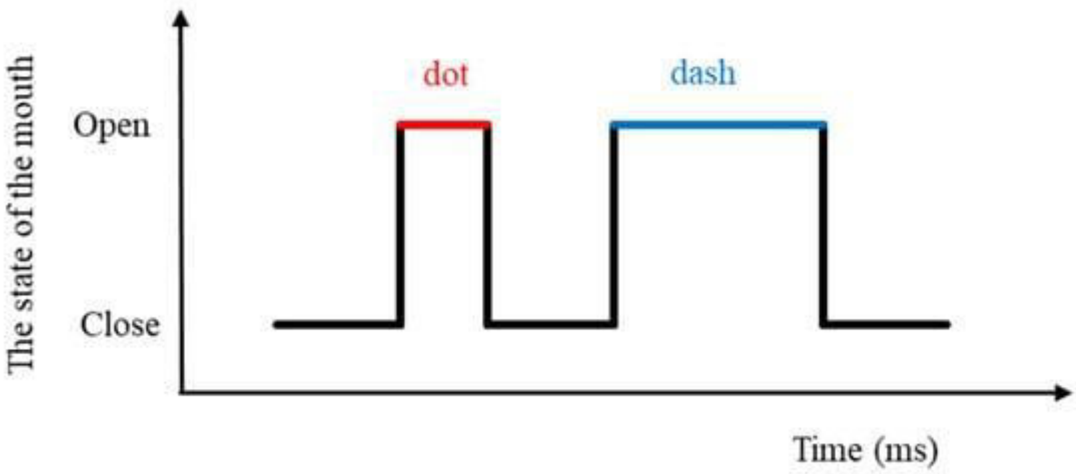

Figure 3. Schematic diagram of continuous mouth movements.

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The FTR [29] is described as follows:
The block diagram of the fuzzy motion recognition algorithm is shown in Figure 4. The variable z−1 is a unit delay for the next step.

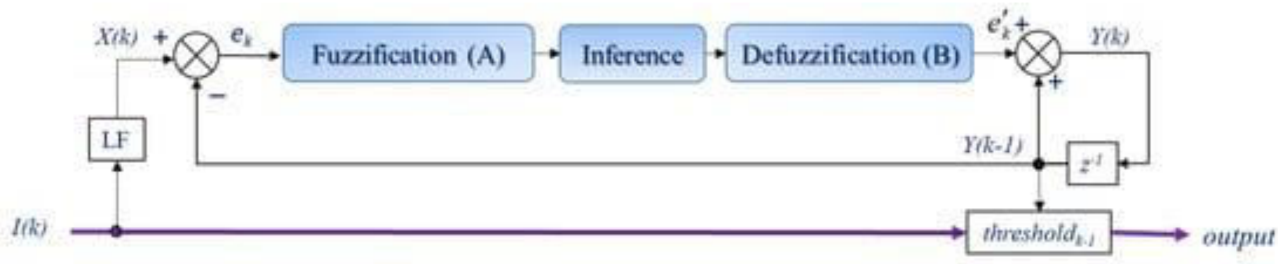

Figure 4. The structure of the FTR.

For the purpose of achieving stable and effortless typing, the duration between mouth opening and closing, designated as the input signal I(k), undergoes normalization and constraint through the limitation function (LF).

V. EYE-TRACKING DEVICE

The eye-tracking device serves as the input interface for the Morse code translator system. It captures and records the user's eye movements, including blinks, with high precision and accuracy. Various eye-tracking technologies can be employed, including infrared-based, video-based, or electrooculography (EOG) systems. The choice of device depends on factors such as cost, usability, and application requirements.

VI. SIGNAL PROCESSING SOFTWARE

The signal processing software analyzes the data captured by the eye-tracking device to detect and interpret eye blinks. It applies algorithms to distinguish between voluntary blinks (intended input) and involuntary blinks (e.g., due to fatigue or environmental factors). Once a blink is detected, the software translates it into corresponding Morse code signals based on predefined mapping rules.

VII. IMPLEMENTATION

The Morse code translator system was implemented using a commercial eye-tracking device and custom signal processing software developed in Python. The eye-tracking device, equipped with infrared sensors, captured the user's eye movements with high spatial and temporal resolution. The signal processing software processed the raw eye-tracking data in real-time, detecting blinks and converting them into Morse code signals.

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VIII. ENHANCED COMMUNICATION THROUGH CHAT APPLICATION

The Morse code translator system has been expanded into a chat application that facilitates improved communication between patients and caretakers. In this system, eye blinks are detected using facial landmark tracking and translated into Morse code. These Morse signals are then converted into either text messages or voice messages, allowing patients with speech or motor impairments to communicate effectively. The text messages are transmitted directly to the caretaker, while the voice messages are generated from the translated blinks and sent through the chat interface. This approach ensures that patients can express themselves efficiently in real-time, enabling better care and attention. The flexibility of both text and voice communication modes makes the application adaptable to various patient needs, significantly improving interaction in critical healthcare environments.

IX. EVALUATION

To evaluate the performance of the Morse code translator system, we conducted experiments with both able-bodied participants and individuals with disabilities. Participants were asked to input predefined Morse code messages using voluntary eye blinks, and the accuracy of message transmission was measured. Additionally, usability surveys were administered to assess the user experience and satisfaction with the system.

X. RESULTS

Experimental results demonstrated the feasibility and effectiveness of the Morse code translator system in converting eye blink signals into Morse code. High accuracy rates were achieved across different participants, with minimal errors in message transmission. Usability surveys indicated positive feedback from users, highlighting the intuitive interface and ease of use.

XI. APPLICATIONS

The proposed system has various applications in assistive technology, particularly for individuals with motor disabilities or communication impairments. It can be integrated into communication aids, such as augmentative and alternative communication (AAC) devices, enabling users to convey messages effectively using only their eye blinks. Additionally, the system may find use in military, emergency response, and other contexts where reliable communication is critical.

XII. CONCLUSION

In conclusion, we have presented a novel Morse code translator system utilizing eye blink signals as input. By combining an eye-tracking device with signal processing software, we have demonstrated the feasibility of converting eye blinks into Morse code messages with high accuracy and reliability. The system offers a promising alternative for individuals

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with disabilities, providing them with an intuitive and efficient means of communication. Future work includes further refinement of the system and exploration of additional applications in assistive technology.

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