Real-time SOS Signal Recognition System Using Dlib and Haar Cascade

Wonbyung Lee
Department of Applied Artificial Intelligence, Sungkyunkwan University
2024711013

Seoyeon Baek
Department of Immersive Media Engineering, Sungkyunkwan University
2024710838

1. Introduction

Real-time SOS signal recognition systems are designed to identify intentional blinking patterns, enabling swift and structured emergency requests. This system utilizes Dlib's traditional machine learning models and Haar Cascade libraries to detect facial features and monitor blinking patterns. Specifically, it recognizes eye blinks in pre-defined patterns, such as the SOS Morse code ("...—..."), to interpret distress signals effectively.

This approach is particularly beneficial for situations where verbal or direct emergency requests are not feasible. The system can be integrated with real-time video monitoring platforms, such as CCTV, allowing the detection of SOS signals remotely and unobtrusively. By providing an efficient and accessible solution, this system aims to enhance emergency response capabilities in critical scenarios.

2. Methods

To detect intentional SOS blinking patterns, this study integrates two complementary algorithms: Dlib for precise facial landmark detection and Haar Cascade for efficient real-time eye region detection. By combining these two algorithms, the system achieves both accuracy and computational efficiency, enabling the reliable identification of blinking patterns, even in real-time video streams. This integration is tailored to detect the SOS Morse code pattern ("...—...") with high precision.

2.1. Haar Cascade

The Haar Cascade[1] algorithm, provided by OpenCV, is another key component of this system, designed for efficient real-time object detection. This algorithm is used to rapidly detect eye regions and determine whether the eyes are open or closed, a critical requirement for tracking blinking events. Haar Cascade is particularly well-suited for video stream analysis due to its high computational efficiency and straightforward implementation.

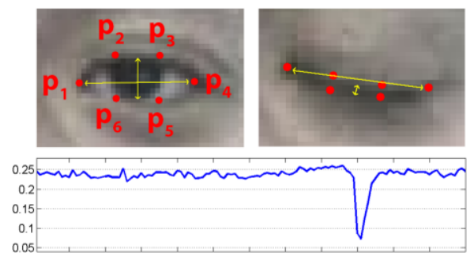

Figure 1. Example of facial landmarks using Dlib [1]

The strength of Haar Cascade lies in its cascading structure, which enables rapid and accurate detection through multiple stages of classifiers. It utilizes Haar-like features, which compare the contrast between pixel regions, and applies an Adaboost classifier to detect eyes or faces [3]. By leveraging integral images, Haar Cascade can perform these calculations at multiple scales quickly, ensuring robust real-time performance.

2.2. Dlib

The Dlib[2] library is a powerful tool for real-time facial detection and landmark extraction. In this study, Dlib is utilized to identify facial regions and accurately extract points around the eyes, which are crucial for detecting blinking patterns. Dlib's 68 facial landmark model is particularly effective in pinpointing the exact positions of the eyes, enabling precise tracking of intentional blinking. By using

[1] source : https://github.com/opencv/opencv/tree/4.x/data/haarcascades

[2] source : https : / / huggingface . co / spaces / asdasdasdasd / Face - forgery - detection / blob / ccfc24642e0210d4d885bc7b3dbc9a68ed948ad6 / shape _ predictor_68_face_landmarks.dat

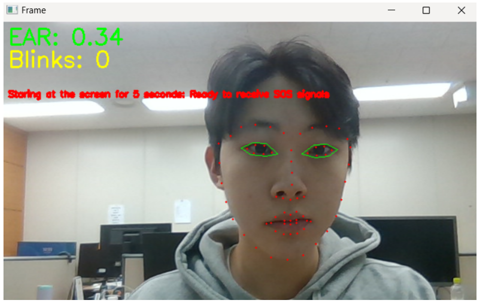

Figure 2. Example of data, landmarks of face and eyes

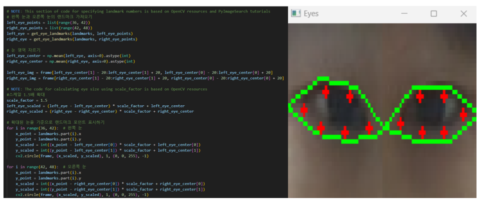

Figure 3. Code and example of scaling eye regions

its advanced algorithms, the system can monitor subtle eye movements, making it suitable for analyzing complex patterns like the SOS Morse code [2].

Figure 1 demonstrates how Dlib detects key landmarks around the eyes, labeled *p1* through *p6*, to define the eye region. Using these points, the Eye Aspect Ratio (EAR)[3] is calculated as the ratio of vertical to horizontal distances. A significant drop in the EAR value, as shown in the accompanying graph, indicates an eye blink, enabling accurate and real-time blink detection.

Dlib achieves this precision through a combination of robust techniques. It employs a Histogram of Oriented Gradients (HOG) feature extractor to identify facial outlines and a linear Support Vector Machine (SVM) classifier for detecting faces. Once a face is identified, Dlib's shape predictor extracts detailed facial landmarks, including those around the eyes, allowing for comprehensive tracking and analysis.

3. Experimental Setup

Data In this experiment, eye blink recognition was conducted using a real person's face. First, the human face is primarily recognized in real time by running the webcam of a PC or laptop. As shown in Figure 2, landmarks of the face and eyes are displayed. After that, it is determined whether or not to blink based on the Eye Aspect Ratio (EAR) value of the detected eye landmark coordinates. If only the webcam is prepared, anyone can run and test it.

Eye Blinking Recognition To detect the SOS signal, we increased the accuracy of the detection by specifying two

[3]source : https://pyimagesearch.com/2017/04/24/eye-blink-detection-opencv-python-dlib

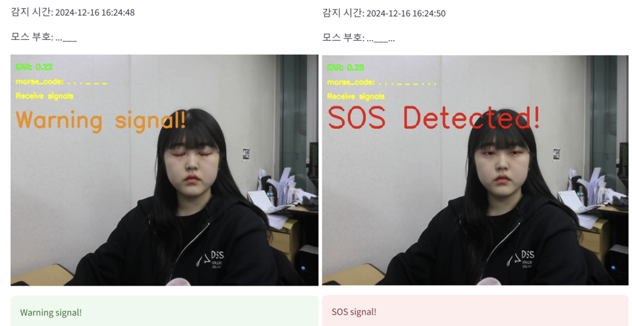

Figure 4. Our system operating screen

thresholds. In the dlib library, if EAR is lower than 0.2, it is judged that the eye blinked. It also recognizes '.' and '_' of the SOS Morse code ("...—...") by classifying short and long blinks based on 0.35 seconds.

We tested various EAR thresholds across different head angles and lighting conditions to determine the optimal value. Through these tests, we set the EAR threshold as THRESHOLD_EAR = 0.2, which effectively distinguishes between natural and intentional blinks. Further parameter adjustments were performed to ensure that only deliberate and sufficiently pronounced blinks were recognized, maintaining the reliability of the system for SOS signal detection.

We implemented the web through streamlit for users' convenient service use. You can run our code by entering the "streamlit run file_name.py" command. In addition, the operating standards of the signal recognition system were set. After running a real-time camera, if a face is detected for more than 5 seconds, the process for detecting the sos signal is designed to proceed. This is to distinguish whether someone is actually in an emergency situation, just joking, or looking as they pass.

Scaling and Visualization of Eye Regions To analyze the eye area, the center was calculated based on the average value of eye landmark coordinates and magnification was applied based on this to expand the eye area. The enlarged eye area increases the accuracy of the EAR calculation and enables visual verification. After that, the fixed area around the center of the eye was cut out and used for analysis and display. Figure 3 shows the scaling technique code and examples we applied.

4. Results

In this project, we create a system that can quickly detect a user's sos signal. Especially in an emergency situation, it recognizes signals by using the blink recognition algorithm, which can send signals the fastest among human body parts.

4.1. SOS Code Detection

When the user runs the streamlit system, it detects the signal by recognizing the user's eyes. ('...—') When a signal of a pattern is recognized, a notification that a danger signal has been detected prior to the SOS signal is output. After that, when an SOS Morse code ('...—...') is detected by adding a pattern ('...—'), the phrase 'SOS Detected!' is output and a rescue signal is requested shown in Figure 4.

4.2. Evaluation

We evaluated the system through the human annotation process. Various threshold values for eye blink recognition were experimented and tested and implemented as optimized values. We also tested to determine whether natural and intentional blinking could be recognized separately. In addition, our SOS Morse code recognition service has the advantage of being able to recognize even when wearing glasses.

5. Discussions

This study demonstrates the effectiveness of using Dlib and Haar Cascade to accurately detect SOS signals through intentional blinking patterns. By combining precise landmark detection and efficient eye region analysis, the system achieves reliable performance in real-time applications. The implementation of EAR thresholds and scaling techniques enhances the detection of short and long blinks, allowing seamless recognition of the SOS Morse code. Additionally, the system's ability to function even with users wearing glasses highlights its versatility and adaptability. Future improvements could focus on optimizing detection in various user's environments and extending its application to other distress signal patterns.

References

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