Brightness and Contrast Adaptive Face Recognition System

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***Abstract*—Recently, artificial intelligence has made remarkable advances and is being extensively utilized in many fields. However, there are challenges in adapting to real-world conditions in the field of face recognition where even minor errors are not tolerated. To address this, we propose a face recognition system that can remove brightness and contrast from images, which are common real-world conditions, without retraining the model. Our system can adapt to brightness and contrast accordingly using a brightness and contrast removal algorithm. The algorithm generates nearly identical images for comparison by removing brightness and contrast. Experimental results demonstrate high face recognition accuracy compared to existing systems, improving true positive and false negative accuracy by 4.55% and 10.34%, respectively, with a minimal computing overhead of only 1.40%. Overall, the face recognition accuracy improved by 4.60%.**

***Index Terms*—Face Recognition, Brightness and Contrast, Face Dataset, Artificial Intelligence**

I. Introduction

Artificial intelligence has received significant attention and continuous research and development. As a result, advanced artificial intelligence has become an essential component in various fields. It is already being utilized in tutoring and chatbots that replace customer service representatives. Cutting-edge technologies, such as self-driving cars [1], face recognition, and security systems [2], [5] are also being researched for future use.

Face recognition and security systems have the potential to be employed in several fields, including criminal investigations, missing person searches, and security inspections. To achieve high face recognition accuracy, many companies and schools are collaborating to establish publicly accessible face datasets [3], [4] and conduct artificial intelligence research. However, high face recognition accuracy can only be achieved in the training the face dataset.

In practical environments, various conditions can affect outcomes, and brightness and contrast are among the most prominent factors. Degradation of face recognition accuracy due to brightness and contrast is unacceptable in the face recognition field. As it is impractical to construct a training dataset that accounts for all brightness and contrast variations, face recognition techniques that can mitigate brightness and contrast differences without modifying training data or retraining artificial intelligence are crucial.

In this paper, we propose a face recognition system capable of accurate face recognition regardless of image brightness and contrast. Our face recognition system comprises the following:

- We propose a brightness and contrast removal algorithm to generate nearly identical images from two images with identical content, except for brightness and contrast differences.
- We propose a face recognition system that can adapt to brightness and contrast conditions using the brightness and contrast removal algorithm from two different images and comparing them without additional training.

Our system allows for adaptation to brightness and contrast and is not limited to existing training datasets. Experimental results demonstrate high face recognition accuracy compared to the existing face recognition system. Our approach is expected to greatly assist in the development of face recognition technology in practical environments.

II. BACKGROUND & MOTIVATION

A. Face Dataset

Commercially available face datasets commonly used in face recognition research have been created through large-scale projects. For example, there are CelebA [4] and LFW [3], which are generally composed of tens of thousands of face images for thousands of individuals. These datasets contain a diverse range of photographs of people, including children and the elderly, males and females, individuals with short and long hair, and those with and without glasses.

B. Face Recognition model

A face recognition model is an artificial intelligence model that recognizes face images to accurately determine a person's identity. It is possible to accurately recognize whether the face in the two images is the same person by converting each face image to a float array and comparing them. The smaller the difference between the two results, the more likely they are the same person. The model can also discriminate between different facial features, allowing it to recognize individuals without prior training. The main goal of face recognition research is to improve face recognition accuracy using a common face dataset. Through vigorous research, the state-of-art research [2] reports an accuracy of up to 99.7%.

C. Motivation

Although face datasets created through large-scale projects aim to include as many various conditions as possible, it is impossible to capture all possible conditions that may occur in practical environments. One of the representative conditions that exist in practical environments is brightness and contrast, which has a significant impact on recognition accuracy.

Fig. 1 shows photographs from the LFW dataset, one of the representative available face datasets, and the same photographs with modified brightness and contrast. The face recognition system was conducted using the state-of-the-art face recognition model, RetinaFace [2].

Fig. 2 shows the recognition accuracy of the system for both datasets. Recognition accuracy is categorized into three types. True positive accuracy means accurately recognizing two images of the same person as the same individual. False negative accuracy means accurately recognizing two images of different people as distinct individuals. Face recognition accuracy represents the rate of successfully recognizing the target person among the test images.

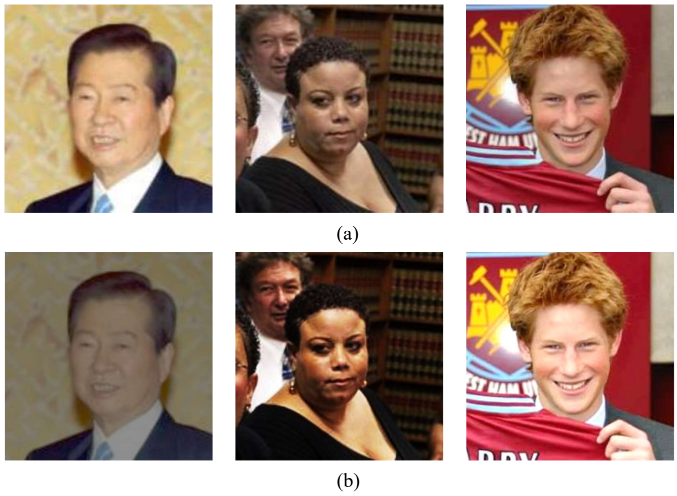

Fig. 1. Example image from LFW dataset (a) Non-modified images, (b) Brightness and contrast modified images

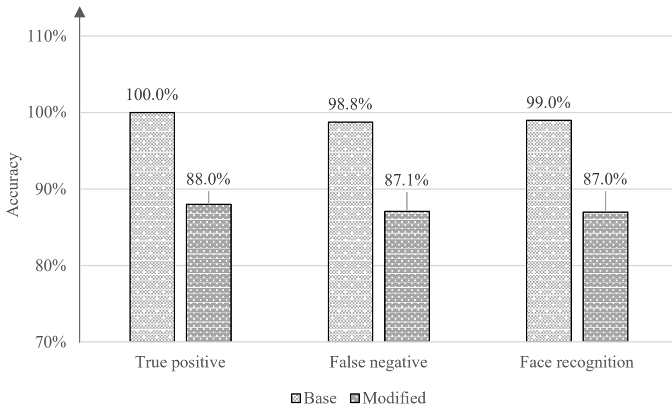

Fig. 2. Recognition accuracy of face recognition system with non-modified dataset(base) and modified dataset(Modified)

The recognition accuracy of the unmodified base image is remarkably high at 100%, 98.75%, and 99%, respectively. The recognition accuracy of images with modified brightness and contrast significantly declines to 88%, 87%, and 87%, respectively. Therefore, it is important to achieve high face recognition accuracy that can adapt to brightness and contrast.

Adapting to brightness and contrast requires new face recognition systems with additional image preprocessing algorithms. The system should be able to adapt to any brightness and contrast conditions without retraining the face recognition model.

III. PROPOSED

Our face recognition system includes an algorithm for removing brightness and contrast. This algorithm reduces image contrast and normalizes brightness by

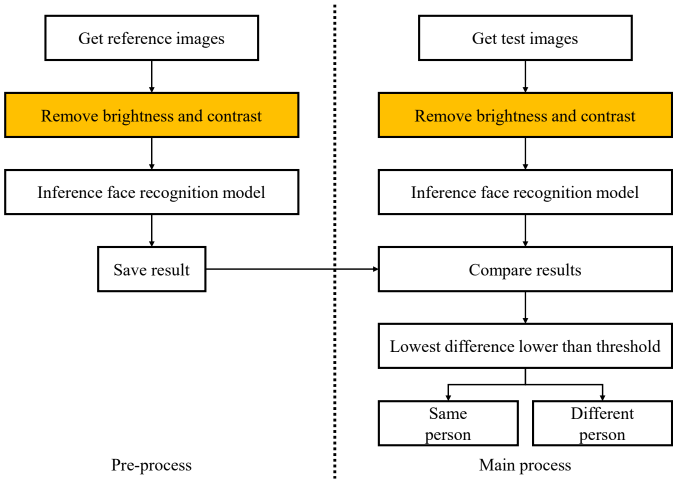

Fig. 3. Flowchart of independent brightness and contrast adaptive face recognition System

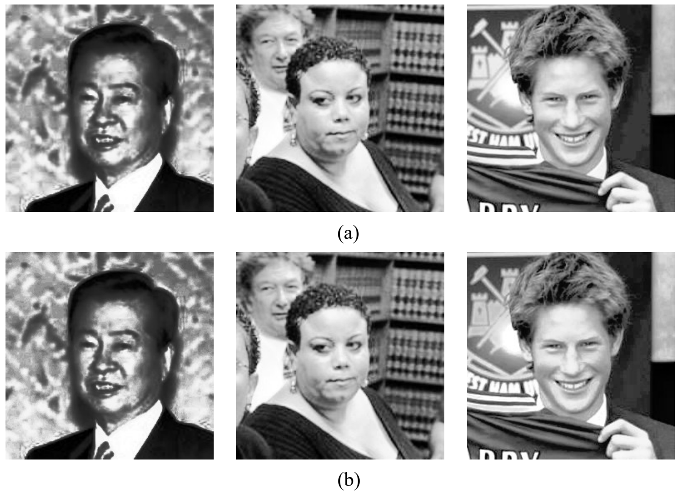

Fig. 4. Output results of brightness and contrast removal algorithm. (a) Non-modified images, (b) Brightness and contrast modified images

moving pixels toward the median value. Pixels farther from the median value are shifted more to remove subtle differences between adjacent pixels and effectively reduce contrast.

Thus, the new pixel value, denoted as p_{new}, is obtained by adjusting the existing pixel value, p_{old}, using the median value of the pixel, p_{mid}, and an appropriate adjustment value, C_{adj}.

$$p_{new} = \frac{p_{old} - p_{mid}}{C_{adj}} + p_{mid} \tag{1}$$

The face recognition system using the brightness and contrast removal algorithm is shown in Fig. 3. The face recognition model takes as input test images with brightness and contrast removed. Faces can be recognized by comparing the output results with the output results of reference images with brightness and contrast removed. The output results of the reference images are saved together when loading the model, so there is no need to output it during runtime. This improves recognition accuracy by allowing test and reference images to be compared without differences in brightness and contrast.

The proposed system can cope with practical environmental conditions, such as brightness and contrast in face datasets, and can achieve higher recognition accuracy without retraining the face recognition model.

IV. Evaluation

A. Brightness and contrast removal algorithm

To evaluate the performance of the brightness and contrast removal algorithm, we experimented with images with various brightness and contrast. After applying the removal algorithm to images with various brightness and contrast, they were compared.

Fig. 4 shows the images in Figure 1 processed with the brightness and contrast removal algorithm. The results demonstrate that the algorithm can effectively remove brightness and contrast, producing images that are almost identical.

B. Experimental setup

A face recognition experiment was established to evaluate the effectiveness of the proposed face recognition system. The LFW, a prominent face dataset consisting of 13,233 face images of 5,749 individuals, was used as the dataset. Test images were generated by randomly modifying the brightness and contrast of LFW data consisting of 5,000 images, one image per individual. 500 images were used so that 500 individuals could be recognized using some of the unmodified images as reference images.

The experiment compares two environments: one that includes a brightness and contrast removal algorithm in the face recognition system, and one that does not. Then, evaluates the performance of the environment including the brightness and contrast removal algorithm. Performance metrics evaluated include true positive accuracy, false negative accuracy, face recognition accuracy, and computing overhead.

C. Performance

Fig. 5 demonstrates the performance of the configured base and proposed systems. The proposed environment

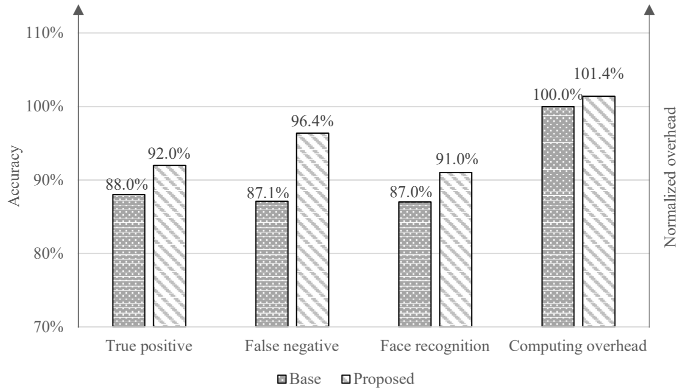

Fig. 5. Recognition accuracy and computing overhead of base and proposed systems

showed improvements in all accuracy metrics. The true positive accuracy for recognizing the same person increased by 4.55%, from 88% to 92%. The false negative accuracy for recognizing different individuals improved by 10.34%, from 87% to 96%.

As misrecognizing different individuals as the same person poses a far greater risk in security systems than misrecognizing the same individual as different people, the significant improvement in false negative accuracy is particularly valuable.

Moreover, the false negative accuracy observed in the proposed environment is 96.38%, closely approaching the ideal environment's 98.75%. While the face recognition accuracy may not be perfect, it is evident that the risk of recognition failure is substantially mitigated.

The face recognition accuracy improved by 4.60%, from 87% to 91%. In contrast, the computing overhead of the proposed environment, normalized to the base environment, was merely 1.0140, representing a mere 1.40% increase.

As these results indicate, the proposed identity recognition system can effectively adapt to differences in brightness and contrast with minimal overhead.

V. Conclusion

The current face recognition system is vulnerable to brightness and contrast conditions that are present in practical environments. In order to solve this, a new face recognition system that can adapt to brightness and contrast was needed. The proposed brightness and contrast removal algorithm-based face recognition system was able to achieve this sufficiently without significant computing overhead. It is possible to achieve higher face recognition accuracy if perfectly removes brightness and contrast by using more powerful techniques like AI. However, it will be necessary to adjust computing overhead accordingly.

Acknowledgment

This research was supported by the MOTIE(Ministry of Trade, Industry & Energy (1415181094) and KSRC(Korea Semiconductor Research Consortium) (20019956) support program for the development of the future semiconductor device.

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