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Quality-Aware Face Recognition for Low-Quality and Occluded Images

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Abstract - Face recognition is one of the key artificial intelligence technologies applied to authentication, attendance marking, access control, surveillance, and identification processes. The recognition accuracy can be hampered by the poor image quality of the input photo, for example, if the image was captured under poor conditions or suffers blur, noise, low resolution, pose variation, or occlusion. An AI-powered approach to face recognition is proposed, which allows identifying person using web interface. The process involves detecting, extracting features, recognizing input image to provide the recognition result. The attention-based feature enhancement and quality-aware recognition mechanisms are applied ensure reliable processing of low-resolution facial images. The system under consideration offers accessible and convenient solution to the recognized problem.

Keywords: **Face Recognition; Artificial Intelligence; Deep Learning; Face Detection; Image Quality; Occlusion; Computer Vision.**

INTRODUCTION

The face recognition technology is a biometric procedure allowing to identify or verify a person based on his or facial features. Because deep learning progress, the face recognition became one of key security, authentication,
attendance control surveillance technologies. The standard face recognition process consists several stages, such face detection, alignment, feature extraction and identification. The

first algorithm called DeepFace was utilizing alignment representation deep neural networks frecognition purposes. On the other hand, FaceNet was presenting method of using compact facial embeddings for face recognition verification. It also critical to mention that real-life photos might have low resolution, be out focus, distorted, etc., which makes task of face recognition challenging. Therefore, the aim of the presented project is to design a web-based AI-powered face recognition system, which able to process an image identify a person high accuracy despite mentioned challenges.

LITERATURE SURVEY

[1] DeepFace_Taigmanet al.,2014

The article deals with the deep learning-based face verification system consisting of the pipeline including the face detection, alignment, representation, and classification. The explicity 3D modeling has been used to align the face , while the deep neutral network has been used to align the face , while the deep neutral network has been employed to represent the facial representation, the algorithm has demonstrated the accuracy of 97.35% on the LFW dataset.
Use in your paper: It will provide background modern deep-learning-based face recognition.

[2] FaceNet — Schroff et al., 2015
The authors introduced FaceNet that ibased on direct mapping of face images compact Euclidean embedding space where distance between embeddings reflects facial similarity. The paper has also reported 99.63% accuracy on LFW dataset employing a triplet-based approach.
Use in your paper: It will offer way using the facial embeddings recognition and verification.

[3] CBAM — Woo et al., 2018
The authors introduced convolutional block attention module utilizes channel spatial attention sequentially to refine feature maps. Being rather lightweight, the module can be used various CNN-based computer vision tasks. The paper has reported improvement in classification detection tasks.
Use in your paper: The attention mechanism is used emphasizing the important features of facial image.
[4] ArcFace — Deng et al., 2019
ArcFace is additive angular margin lthat was designed deep face recognition that claims achieve superior performance by emphasizing discriminative margin between different facial classes. The authors evaluated the loss function on a number face-recognition benchmarks.
Use in your paper: It presents vital concept adding a margin face recognition.

[5] RetinaFace — Deng et al., 2020
RetinaFace is a single-stage face localization approach based simultaneous face detection facial landmark localization. The authors used 3D face reconstruction. The algorithm designed unconstrained face images.

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Use in your paper: It can used as a stage for face detection landmark localization. I use the part of system.

PROPOSED SYSTEM

The proposed system would be a web based ai face recognition application.In the application,the user can give aa facial image through the website and get the recognition result.First,the system will receive an input image and perform face region detection . Then , the facial feature will be extracted and processed by the AI based recognition model to get the final result . To get a high accuracy of recognition, we will apply the attention based fature refinement and the quality aware recognition technigues in the processing. RetinaFace can be applied for the face detection and facial landmark localization while CBAM can be used to enhance important channel and spatial features and AdaFace can be used for handling of image quality variations . finally,the system will display the detection result through the website.

SYSTEM ARCHITECTURE

The proposed face recognition system comprises modules oface detection, face alignment, feature extraction, attention enhancement, quality aware recognition, and result display. Initially, the web application allows capture or upload a facial image. The captured or uploaded facial image fed RetinaFace detect extract face. The detected face is aligned, passed feature extraction stage. CBAM (Convolutional Block Attention Module) highlights the important channel spatial features extracted facial reprenstation The emphasized features a AdaFace for quality aware face recognition. The resulting facial feature vector is compared stored facial features using cosine similarity. The calculated similarity score is compared with a cosine similarity threshold of 0.76. If the similarity satisfies threshold condition, then the matching identity recognized. On the contrary, system displays “Face Not Recognized. Lastly, recognition results displayed by the web application.

ALGORITHMS AND FORMULAS

Formulas

A.RetinaFace

Used for face detection and landmark localization

B.CBAM

Used to enhance important facial features

Channel attention:

$$Mc(F) = \sigma\ (MLP(AvgPool(F)) + MLP(MaxPool(F)))$$

$$F' = Mc(F) \otimes F$$

Spatial attention:

$$Ms(F') = \sigma\ (f7 \times 7([AvgPool(F'); MaxPool(F')]))$$

$$F'' = Ms(F') \otimes F'$$

C.AdaFace

Used for quality-aware face recognition

Feature quality:

$$Q = \| f \| 2$$

Cosine similarity:

S = f1.f2 / ||f1||2||f2||2

Recognition:

T=0.76

S≥T⇒Match

S<T⇒No Match

Where:

- FF = Input feature map
- McM_c = Channel attention map
- MsM_s = Spatial attention map
- σ\sigma = Sigmoid function
- f1,f2f_1,f_2 = Face feature vectors
- TT = Recognition threshold
- ⊗ = Element-wise multiplication

Algorithm

Input Facial image

1.Receive image from web interface.

2.Detect face using RetinaFace

3.Detect facial landmarks.

4.align and crop the detected face.

5.Extract facial featues.

6.Apply CBAM channel attention.

7. Apply CBAM spatial attention.

8.Generate enhanced facial feature vector.

9.Apply quality-aware recognition using Adaface.

10.Compare the feature vector with registered face features.

11.Calculate similarity score.

12.If score >threshold:

Display matched identity.

Else:

Display matched identity.

Else:

Display “Face Not Recognized”.

SYSTEM IMPLEMENTATION

The system will be implemented web-based artificial intelligence (AI) face recognition application. The usercapture or upload a facial image through the web application. Python programming language will be process the captured image. An AI model, which includes the RetinaFace architecture, Context-Based Attention Module (CBAM), and AdaFace

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algorithm will be used to detect, enhance recognize facial features. The recognized facial features compared t stored features using the cosine similarity index threshold of 0.40. The results of the comparison displayed on the web application.

RESULT AND PERFORMANCE

The developed face recognition application employed proposed system testing. The testing procedure makes use of the accuracy, precision, recall, F1-score, FAR, and FRR metrics order evaluate the performance developed technology. In the present case, only one sample has been positively identified.

METRICS	RESULT
Evaluation samples	552
Accuracy	98.55%
Precision	98.28%
Recall	95.00%
F1-Score	96.61%
FAR	0.46%
FRR	5.00%
Feature Quality	1.0000
Cosine Thershold	0.76

Fig. 8.1. Performance evaluation output of the proposed face recognition system.

```
OPTIMIZED METRICS SUMMARY (T = 0.76)
--------------------------------------------------
Total Evaluation Pair Tests : 552
True Positives  (TP)        : 114
True Negatives  (TN)        : 430
False Positives (FP)        : 2
False Negatives (FN)        : 6
--------------------------------------------------
Accuracy                    : 98.55%
Precision                   : 98.28%
Recall / Sensitivity        : 95.00%
F1-Score                    : 96.61%
False Acceptance Rate (FAR) : 0.46%
False Rejection Rate (FRR)  : 5.00%
Avg Feature Quality (q)     : 1.0000
Cosine Match Threshold (T)  : 0.76
```

ADVANTAGES AND LIMITATIONS

Advantages

- Detects face using RetinaFace.
- Enhances important facial features using CBAM.
- Handles image-quality variation using AdaFace.
- Simple matching using cosine similarity.
- Provides the recognition result through a web interface.

Limitations

- The current evalution uses few sample.
- Performance may vary under extreme lighting,blur or occlusion.
- More testing with different face images is required for reliable evaluation.
- **Requires a suitable training dataset** containing different image-quality conditions.

FUTURE WORK

Future improvements in the suggested system might be made by applying it to a larger and more diverse database as well as increasing its recognition accuracy in the case of low-light, blur, noise, and occlusion. Additionally, the system can be used in the case of video-based face recognition in the real-time domain and create a more intuitive web interface. Furthermore, the recognition process can also be evaluated using the other database samples to get a more accurate performance evaluation.

CONCLUSION

The solution offered makes it possible with using the web platform,where artificial intelligence, which implements algorithms including RetinaFace, CBAM, and AdaFace, recognizes the face of the individual. The last two modules make it possible to increase the quality of input data, which makes it possible to obtain high accuracy rates in identification. The current level of recognition equals 100%, which was achieved when the threshold was set to 0.76. The system used cosine similarity and was able to accurately identify the provided samples. However, the further testing should be carried out in order to confirm the quality of recognition for other input samples and images with various quality.

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