Real-time facial recognition technology and crowd search application

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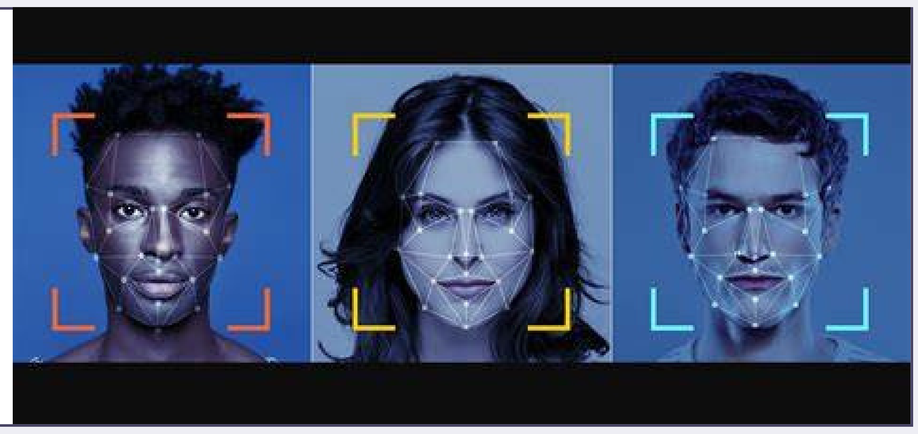
Introduction

In recent years, the application of AI and Machine Learning technologies in image classification and processing has been rapidly developing. These technologies are critical in identifying and tracking individuals in large crowds, especially for public security management and searching for missing persons. This project explores the deployment of a real-time face recognition system and its application in identifying individuals in crowded environments.



Objectives

The main objectives of this project are to develop a real-time face recognition system and to apply this system for searching and identifying individuals in a crowd using advanced algorithms such as YOLOv5 and ArcFace.

Method

To achieve the project objectives, I employed advanced techniques in machine learning and computer vision. I used YOLOv5 for real-time face detection, leveraging its speed and accuracy with augmentation techniques like Mosaic and MixUp. For face recognition, I utilized ArcFace, which uses Additive Angular Margin Loss (AAM Loss) to enhance feature discrimination.

Expected results

The real-time facial recognition system using YOLO and ArcFace is expected to achieve higher accuracy, reducing false positives and negatives. It will provide rapid detection and recognition of faces, meeting real-time application demands. The system will perform reliably under various conditions, such as different lighting and angles, and will efficiently handle large volumes of data and multiple faces simultaneously.

YOLO

YOLO (You Only Look Once) is a real-time object detection model that balances speed and accuracy, making it ideal for applications such as face detection, security surveillance, and autonomous vehicles.

Technical Highlights:

- **Loss Function**:

$$\text{Loss} = \text{Localization Loss} + \text{Confidence Loss} + \text{Class Probability Loss}$$

  - **Localization Loss**: Measures the accuracy of predicted bounding boxes.
  - **Confidence Loss**: Evaluates the model's confidence in object presence.
  - **Class Probability Loss**: Assesses the accuracy of predicted class probabilities.
- **Architecture: YOLO** uses a simple yet effective neural network architecture, typically involving convolutional layers and advanced data augmentation techniques like Mosaic and MixUp.

Identify and identify individuals in the crowd using YOLO

ArcFace

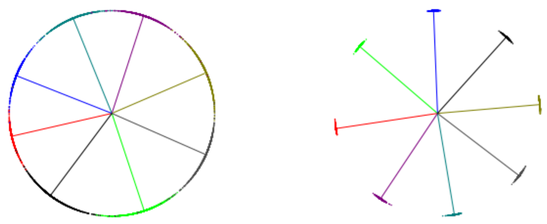
ArcFace is a face recognition model that improves upon traditional methods by introducing the Additive Angular Margin Loss (AAM Loss). This enhancement helps in achieving more discriminative features, which significantly boosts the performance in face verification and recognition tasks.

Technical Highlights:

- **Additive Angular Margin Loss (AAM Loss)**:

$$L_{\text{arcface}}(x_i, y_i) = -\log\left(\frac{\exp\left(s_{y_i} \cdot \cos\left(m\theta_{y_i}\right)\right)}{\sum_{j=1}^{N} \exp\left(s_j \cdot \cos\left(m\theta_j\right)\right)}\right)$$

  - **Margin** (m): Increases the angular margin between different classes, enhancing feature discrimination.
  - **Scale** (s): Amplifies the cosine values to better highlight differences between classes.
- **Architecture**:
  - Typically uses a ResNet or similar backbone to extract deep facial features.
  - Employs fully connected layers followed by normalization and AAM Loss for training.



(a) Norm-Softmax (b) ArcFace

Compare the regular Softmax function and AAML in Arcface

Conclusion

In this study, I explored YOLO and ArcFace for real-time face recognition systems. YOLO, a powerful object detection model, offers fast and accurate detection, making it ideal for real-time applications. ArcFace, using Additive Angular Margin Loss (AAM Loss), provides highly accurate face recognition with enhanced discrimination. Both models demonstrate significant potential in improving the performance of real-time face recognition systems, highlighting the importance of continued development in deep learning technologies.

Reference

[1] Redmon, J., & Farhadi, A. (2016). YOLO: Real-Time Object Detection GeeksforGeeks.
[2] Deng, J., Guo, J., Xue, N., & Zafeiriou, S. (2019). ArcFace: Additive Angular Margin Loss for Deep Face Recognition. arXiv preprint arXiv:1801.07698
[3] Kevin P. Murphy, (2012). "Machine Learning: A Probabilistic Perspective".