Face Mask Detection Using Deep Learning

Introduction

In today's world, face mask detection plays a crucial role in public health and safety. With the widespread need for automatic monitoring in crowded places such as transport hubs, malls, and workplaces, a reliable system for identifying mask usage is essential. This project implements a deep learning approach for detecting face masks in real time using a webcam, leveraging transfer learning and computer vision techniques.

Project Objective

The goal of this project is to develop a Python-based application that:

- Detects faces in both images and live video streams.
- Classifies each detected face as "mask" or "no mask" with high accuracy.
- Provides instant visual feedback to support monitoring or safety enforcement.

Technology Stack

- **Programming Language:** Python 3
- **Libraries:** TensorFlow, Keras, OpenCV, imutils, scikit-learn, NumPy, Matplotlib
- **Neural Network Architecture:** MobileNetV2 with transfer learning
- **Development Environment:** Visual Studio Code

Methodology

1. Data Collection and Preparation

Images of people wearing masks and without masks were collected and stored in two categories. Each image was resized and normalized to match the input size required by the deep learning model (224x224 pixels).

2. Model Training

The MobileNetV2 model, pre-trained on the ImageNet dataset, was used as the core feature extractor. The original classification layers were replaced with a new, smaller network tailored for the binary mask/no-mask task. The model was trained on the prepared dataset, with data augmentation applied (such as rotation, zoom, and flip) to enhance robustness. The dataset was split into training and testing subsets for evaluation.

3. Model Evaluation and Export

After training, the model's performance was evaluated using standard metrics, including accuracy, precision, and recall. The trained model was then saved in the Keras format for use in the real-time detection phase.

4. Real-Time Detection

For live video detection, OpenCV's deep learning-based face detector was used to find faces in each webcam frame. Each detected face region was preprocessed and classified by the trained model. The application displays bounding boxes and labels ("Mask" or "No Mask") in real time on the video stream for each detected face.

Results

The resulting system can detect multiple faces and classify mask usage accurately in real time through a webcam. The model's speed and lightweight design (thanks to MobileNetV2) make it suitable for everyday computers and practical deployment scenarios.

Conclusion

This project demonstrates an effective end-to-end workflow for real-time face mask detection using deep learning and computer vision. Transfer learning with MobileNetV2 allowed for efficient training on limited data, while OpenCV's tools made live detection feasible. The finished application can help in safety compliance in various environments where mask-wearing is recommended or required.

Future Enhancements

- Expand the dataset to include a wider variety of face coverings and lighting conditions.
- Integrate the system with external alerting or access control mechanisms.
- Deploy the solution to edge devices or web applications for broader use.

Files Included

- `train_mask_detector.py`: Script for training and saving the mask classification model.
- `detect_mask_video.py`: Application for real-time mask detection using the webcam.
- `mask_detector.keras`: Saved deep learning model for mask detection.
- `plot.png`: Training and validation accuracy/loss graph.
- Model files for face detection: Caffe `.prototxt` and `.caffemodel` files.

References

- TensorFlow and Keras documentation
  https://www.tensorflow.org/

- OpenCV documentation
  https://docs.opencv.org/

- MobileNetV2 research paper
  https://arxiv.org/abs/1801.04381

- Mask detection datasets (publicly available)

- YouTube tutorials and guides on deep learning, transfer learning, and mask detection
  (Various channels such as CodeBasics, freeCodeCamp.org, PyImageSearch, and others)