Assignment No 2

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Problem Statement:

Facial recognition using OpenCV and deep learning for binary classification.

Objective

The objective is to develop a system for facial recognition using OpenCV and deep learning to classify images into two categories (binary classification), such as authorized vs unauthorized user or mask vs no mask. The goal is to integrate image preprocessing with OpenCV and leverage deep learning models for accurate decision-making.

Theory

Facial recognition combines computer vision and deep learning to identify or verify a person from digital images.

Key theoretical concepts:

* OpenCV: An open-source computer vision library used for image acquisition, preprocessing, and face detection (Haar cascades, DNN face detectors).
* Deep Learning Models: Convolutional Neural Networks (CNNs) are commonly used due to their ability to extract spatial features from images.
* Binary Classification: Output layer has a single neuron (with sigmoid activation), producing either class 0 or 1.

Typical pipeline:

1. Face Detection → Locate the face region from an image/video.
2. Preprocessing → Resize, normalize, and convert to grayscale if required.
3. Feature Extraction (CNN) → Automatically learn spatial features of the face.
4. Classification Layer → Decide whether the face belongs to one of two categories.

Methodology

1. Data Collection: Collect face images belonging to two categories (e.g., known vs unknown).
2. Preprocessing with OpenCV:
   * Detect faces using Haar cascade or DNN face detector.
   * Align, crop, and resize images to a standard dimension.
   * Normalize pixel values.
3. Model Building:
   * Use CNN architecture with convolutional, pooling, and dense layers.
   * Final layer uses sigmoid activation for binary output.
4. Training:
   * Train model on labeled dataset with backpropagation and optimization algorithms.
   * Use binary cross-entropy as the loss function.
5. Evaluation:
   * Test model on unseen images for accuracy, precision, and recall.
6. Prediction/Deployment:
   * Real-time classification using webcam/video stream with OpenCV.

Advantages

* High accuracy in distinguishing between two facial classes.
* Can be integrated with real-time video streams.
* OpenCV ensures efficient image handling and preprocessing.
* Deep learning automates feature extraction (no need for manual feature engineering).

Limitations

* Requires a large, balanced dataset for reliable training.
* Sensitive to variations in lighting, pose, and occlusion.
* Computationally expensive for training deep models.
* Privacy and ethical concerns in real-world applications.

Applications

* Security Systems: Access control by verifying authorized personnel.
* Attendance Systems: Automatic presence marking in classrooms/offices.
* Healthcare: Detecting mask compliance (mask vs no mask).
* Banking & Finance: User authentication for secure transactions.
* Smart Devices: Unlocking smartphones and laptops.

Working / Algorithm

1. Capture image or video frame using OpenCV.
2. Detect the face region and preprocess it (resize, normalize).
3. Pass the processed image into the deep learning model.
4. CNN extracts features and sends them through fully connected layers.
5. Output layer generates probability (between 0 and 1).
6. Threshold applied → classify into Class 0 or Class 1.
7. Display result in real time with bounding boxes.

Conclusion

Facial recognition using OpenCV and deep learning provides a robust solution for binary classification tasks such as authentication, surveillance, and compliance monitoring. The integration of OpenCV for preprocessing and CNNs for classification makes the system efficient and scalable. However, challenges related to data requirements, ethical concerns, and real-world variability must be addressed for practical deployment.