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**Assignment 2:**

**Facial Recognition using OpenCV**

**Problem Statement**

Facial Recognition Using OpenCV and Deep Learning for Binary Classification.

**Objective**

* Learn face detection, preprocessing, and feature extraction.
* Build and train a deep learning model for binary classification (face / no face).
* Evaluate model accuracy and visualize performance.

**Requirements**

* **OS**: Windows/Linux/MacOS
* **Python Version**: 3.x
* **Tools**: Jupyter Notebook, Anaconda, Google Colab
* **Hardware**: CPU (4GB RAM minimum); optional GPU
* **Libraries**:  
   TensorFlow / Keras, OpenCV, Dlib, face\_recognition, NumPy, Pandas, Matplotlib, Scikit-Learn

**Theory**

Facial recognition detects faces from images/videos and classifies them as face/no face using:

1. **Face Detection** (e.g., Haar Cascades).
2. **Feature Extraction** (CNN-based).
3. **Binary Classification** (face vs no face).

Key Concepts:

* **Activation Functions**: ReLU, Sigmoid, Softmax
* **Backpropagation**: Updates CNN weights by minimizing prediction error.

**Methodology**

1. **Data Collection**: Images of faces and non-faces.
2. **Preprocessing**: Resize (128x128), normalize, grayscale.
3. **Label Encoding**: One-hot encode classes.
4. **Train-Test Split**: 80%-20%.
5. **CNN Model**:  
    - 3 Conv layers (32, 64, 128 filters), ReLU + MaxPooling.  
    - Flatten → Dense (256 units) → Dropout → Output (Softmax).
6. **Compile & Train**:  
    Binary cross-entropy loss, Adam optimizer, accuracy metric, 15 epochs.
7. **Evaluate & Save Model**.
8. **Prediction**: Test on new images.

**Advantages**

* High accuracy and real-time detection.
* Automates tasks like authentication.

**Limitations**

* Requires large, quality datasets.
* Affected by pose, lighting, occlusion.
* Privacy and adversarial attack risks.
* High computational cost.

**Applications**

* Security & Surveillance
* Biometric Authentication
* Law Enforcement
* Healthcare Diagnosis
* Retail Personalization
* Time & Attendance Systems
* Smart City Monitoring

**Conclusion**

OpenCV-based facial recognition is fast, scalable, and effective for real-time applications such as surveillance and access control. Proper dataset preparation and model optimization are crucial to handle limitations like varying lighting and adversarial inputs.