Cairo University, Faculty of Computers
and Artificial Intelligence

Project Title: Facial Expression Recognition

IT443-Image Processing

Name	ID
Rana Esmail Zekery	**20220131**
Menna Tullah Hany	**20220343**
Nadine Hazem	**20220356**
Soha Ashraf	**20210589**
Alaa Azazi	**20210071**
Noha Mohammed	**20210425**

Domain Specific Project

1. Abstract

Facial Expression Recognition (FER) is a vital task in computer vision used to identify human emotions from facial images. This project implements a FER system using classical image processing and machine learning techniques. The pipeline includes preprocessing to enhance image quality, feature extraction using Histogram of Oriented Gradients (HOG) and Local Binary Patterns (LBP), dimensionality reduction using Principal Component Analysis (PCA), and classification using several machine learning models including SVM, Random Forest, and MLP. The system is trained and tested on the FER-2013 dataset. Augmentation techniques and visualization tools are also integrated to improve performance and interpretability.

2. Problem Definition and Objectives

Problem Statement:
Recognizing human emotions from facial images is essential for intelligent systems in fields like security, healthcare, and human-computer interaction. Variations in lighting, image quality, and facial pose make this a challenging problem.

Objectives:

- To preprocess grayscale facial images to enhance feature visibility.
- To extract meaningful features using HOG and LBP.
- To augment the dataset to improve model generalization.
- To reduce feature dimensionality using PCA.
- To evaluate various machine learning models for classification.
- To visualize both raw and preprocessed images for interpretability.

3. Methodology

3.1 Preprocessing Pipeline

The following steps are applied to each grayscale image:

- CLAHE: Enhances local contrast in darker regions.
- Gaussian Blur: Removes noise using a 5x5 kernel.
- Histogram Stretching: Adjusts intensity to use full [0–255] range.
- Gamma Correction: Corrects lighting imbalances.
- Sharpening: Enhances edge information.
- Normalization: Ensures pixel values are within the correct format.

- Augmentation: Images are augmented using horizontal flipping, rotation (15°), and resizing to improve diversity.

3.2 Feature Extraction

- HOG (Histogram of Oriented Gradients):
- Cell size: 8×8 pixels
- Block size: 2×2 cells
- Captures directional gradients and facial textures.
- LBP (Local Binary Patterns):
- Radius: 1, Points: 8
- Captures micro-patterns in facial texture

Extracted HOG and LBP features are combined into a single feature vector.

3.3 Dataset Preparation

- The dataset is FER-2013 (downloaded via KaggleHub).
- Images are resized to 48x48 and converted to grayscale.
- Data is split into training and testing sets using separate folders.
- Augmented and raw images are used to ensure class balance.
- Labels are encoded using LabelEncoder.

3.4 Dimensionality Reduction

- StandardScaler is used to normalize features.
- PCA reduces the dimensionality to 300 components to improve classification speed and performance.

3.5 Classification Models

The following classifiers were trained and evaluated:

- SVM (RBF Kernel): High accuracy and robustness to high-dimensional data.
- Random Forest: Ensemble method for stable performance.
- KNN (K-Nearest Neighbors): Simple and interpretable model.
- MLP (Multilayer Perceptron): Fully connected neural network.

Evaluation metrics include accuracy, precision, recall, F1-score, and confusion matrix.

3.6 Visualization

- Preprocessed images are compared with the original ones to highlight the improvements.
- Seaborn plots show class distribution and balance before and after undersampling.

- HOG and LBP visualizations provide interpretability into feature extraction.