Project Title: Emotion Detection Using Neural Networks

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Documentation Summary

This document outlines the development of a facial emotion recognition system using convolutional neural networks (CNNs). The goal of the project is to detect emotions in real-time using a webcam feed and classify them into one of five categories: Angry, Happy, Neutral, Sad, or Surprise.

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1. Project Overview

Purpose: To build a robust and accurate emotion detection system that can process facial images from a live camera feed and classify emotions using a CNN-based model.

Scope:

- Real-time emotion recognition from webcam
- Offline training and fine-tuning of CNN model using FER2013 dataset
- Modular and reusable architecture for detection and training

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2. Tools and Technologies

- **Python:** Programming language used for implementation
- **TensorFlow/Keras:** Deep learning framework
- **OpenCV:** Real-time image capture and processing
- **MediaPipe:** Real-time face detection
- **Pandas & NumPy:** Data handling
- **Matplotlib/Seaborn:** Visualization
- **Google Colab:** Cloud-based training environment
- **Kaggle API:** Dataset access (FER2013)

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3. System Architecture

Real-Time Emotion Detection:

1. Load pre-trained CNN model
2. Detect face using MediaPipe
3. Preprocess face (resize to 48x48, grayscale)
4. Predict emotion using the model
5. Display result with label and confidence

Model Training:

1. Load and preprocess data from FER2013
2. Data augmentation and regularization
3. Build CNN architecture (4 Conv blocks + dense layers)
4. Train model using callbacks (EarlyStopping, ReduceLROnPlateau)
5. Save best-performing model

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4. Real-Time Emotion Detection

Implemented in `EmotionDetector` class:

- Face detection using MediaPipe
- Preprocessing (grayscale, normalization, reshaping)
- Predict emotion and display on webcam frame

Supported emotions:

- Angry
- Happy
- Neutral
- Sad
- Surprise

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5. Model Training

Key Steps:

- Data loaded from `fer2013.csv`
- Only 5 emotions used: [0: Angry, 3: Happy, 4: Sad, 5: Surprise, 6: Neutral]
- CNN model architecture:
- Conv2D layers with ELU activation
- BatchNormalization + Dropout
- Final Dense layer with 5 output classes + softmax
- Optimizer: Nadam
- Loss: categorical_crossentropy
- Augmentation: Rotation, shift, zoom, flip

Model is trained with:

- Batch size: 64
- Epochs: 100
- Validation split: 10%

Best model saved to:

```
saved_models/best_emotion_model.keras
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6. Performance Evaluation

Evaluation is done using:

- Accuracy & Loss plots
- Confusion matrix visualization
- Classification report (precision, recall, F1-score)

Performance example:

- Training Accuracy: 95.31%
- Validation Accuracy: 82.79%

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7. Version History

Version 5.0 (Final)

- Enhanced architecture (4 Conv blocks)
- ELU activation + He initialization
- Advanced training strategy (callbacks + data augmentation)
- Fine-tuning supported for selected emotion subsets
- Transfer learning architecture with modular functions
- Real-time detection deployed via webcam

End of Documentation