**Project Report: Facial Expression Recognition Using Deep Learning**

**1. Introduction**

Facial Expression Recognition (FER) plays a crucial role in human-computer interaction, emotion analysis, and behavioral studies. Traditional approaches to recognizing facial expressions rely on handcrafted features and classical machine learning techniques, which often struggle with complex variations in facial expressions. This project leverages deep learning models to automate the recognition of facial expressions with high accuracy.

**2. System Design**

The system is designed as a web-based application using Streamlit, allowing users to upload facial images for expression classification. The backend consists of multiple deep learning models trained to recognize seven different facial expressions:

* **Angry**
* **Disgust**
* **Fear**
* **Happy**
* **Neutral**
* **Sad**
* **Surprise**

**2.1 Architecture**

1. **Frontend:** Streamlit-based UI for uploading images and displaying results.
2. **Backend:** PyTorch-based deep learning models for classification.
3. **Dataset:** FER-2013 dataset containing labeled facial images.
4. **Processing:** Image transformation and normalization before feeding into the model.

**2.2 Streamlit Implementation**

The web-based application is developed using Streamlit, providing an interactive user interface for facial expression recognition. The key functionalities include:

* Image upload functionality for users.
* Preprocessing of images before passing them through the trained models.
* Real-time classification and displaying results .

**3. Methodology**

**3.1 Data Preprocessing**

* Images are resized to standard dimensions (48x48 pixels for FER-2013 dataset).
* Converted to grayscale to reduce complexity.
* Normalization applied for consistent input scaling.
* Augmentation techniques such as rotation and flipping applied to enhance model generalization.

**3.2 Model Training**

* Models are initialized with pre-trained weights (weights=None for fair comparison when retraining).
* Fully connected layers of pre-trained models are modified to match the number of expression categories (7 classes).
* Cross-entropy loss function and Adam optimizer are used.
* Models trained on GPU-enabled hardware to improve efficiency.

**3.3 Evaluation Metrics**

* **Accuracy**: Measures the percentage of correctly classified images.
* **Precision & Recall**: Evaluates model performance across different expression classes.

**4. Experimental Results**

* **ResNet50:** Achieved an accuracy of 76% on the test set.
* **EfficientNet V2:** Achieved an accuracy of 79%.
* **MobileNet V2:** Provided a lightweight alternative with an accuracy of 70%.
* **Custom CNN:** Achieved competitive performance with an accuracy of 77%.

**5. Conclusion**

This project demonstrates that deep learning models can effectively classify facial expressions with reasonable accuracy. EfficientNet V2 performed the best, while MobileNet V2 provided a lightweight alternative suitable for real-time applications. Future work includes:

* Expanding the dataset to include more diverse facial expressions across different demographics.
* Implementing real-time expression recognition on video streams.
* Exploring attention mechanisms to improve model interpretability and robustness.

This automated system can be used in various applications such as emotion-based recommendation systems, mental health analysis, and intelligent human-computer interactions.