Robust Face Recognition Under Visual Distortions Using ArcFace

This project presents a robust and adaptive system for face recognition under real-world visual distortions using ArcFace embeddings, designed for high-performance identity verification without requiring additional training. The task is framed as a multi-class face matching problem, where each identity in a clean reference set is compared against distorted versions of that identity in the test set. The dataset comprises two main components: a directory containing clean, frontal face images representing enrolled identities, and a directory containing distorted facial images across various degradation types including blur, fog, low-light, resized, noise, rain, and sunlight. Each test image is associated with its corresponding identity and a known distortion label based on its folder structure.

The core model uses the Buffalo_L variant of ArcFace, a state-of-the-art face recognition model based on a ResNet50 backbone, pretrained to generate highly discriminative 512-dimensional embeddings. These embeddings are robust to intra-class variations and optimized using an angular margin loss, which enhances identity separation in the embedding space. For each test image, the model computes an embedding and compares it to embeddings from reference identities using cosine similarity. A tunable threshold (default 0.5) is used to determine if the test image matches a reference identity.

An innovative aspect of this pipeline is the use of a dynamic denoising preprocessing module. This module automatically detects the distortion type from the image's path and applies appropriate traditional enhancement techniques—such as Gaussian blurring, contrast normalization, and median filtering—to improve visual quality before embedding extraction. This conditional preprocessing significantly boosts recognition performance in degraded conditions without requiring model retraining. Additionally, the system supports both manual verification via command-line input (one distorted image vs. one reference), and batch evaluation across the entire test set for large-scale analysis.

Comprehensive evaluation shows the pipeline achieves a Top-1 Accuracy of 97.30% and a Macro F1 Score of 82.67% on the distorted dataset, demonstrating strong generalization and robustness. The project also includes visualization tools that allow users to inspect positive and negative match pairs, aiding in interpretability and debugging. The system is lightweight, deployable, and inference-only, making it suitable for edge devices or real-time surveillance environments. Overall, the proposed solution effectively bridges the gap between clean training data and real-world, noisy test scenarios without the cost of retraining or fine-tuning the embedding model.