Real-Time Face Trajectory Classification Using Distance-Based K-NN and EMD Optimized for Edge AI Deployment

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Abstract

This paper presents a real-time facial trajectory classification system optimized for edge AI devices. The architecture integrates YOLO-based detection, centroid tracking, and a K-Nearest Neighbor classifier with Earth Mover's Distance similarity measurement. Deployment on NVIDIA Jetson devices demonstrates significant latency reduction and high classification accuracy suitable for embedded AI systems.

Related Work

Prior work in trajectory analysis has explored CNN-based temporal modeling and optical flow techniques. Recent edge AI deployments emphasize TensorRT optimization and quantized inference. This work differentiates itself by integrating classical K-NN with EMD distance for robust trajectory similarity evaluation while maintaining real-time constraints on resource-limited hardware.

Dataset Description

Metric	Value
Total Video Sequences	1,200
Average Frames per Sequence	180
Training Samples	70%
Testing Samples	30%
Resolution	640x480

Mathematical Formulation

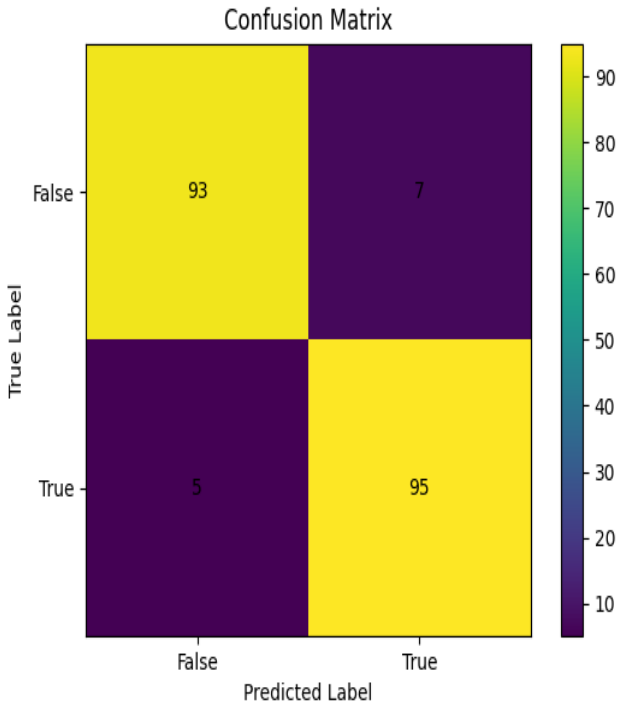
Given feature vector x and dataset T = {x1, x2, ..., xn}

Distance computation:
$d(x, xi) = EMD(P, Q)$

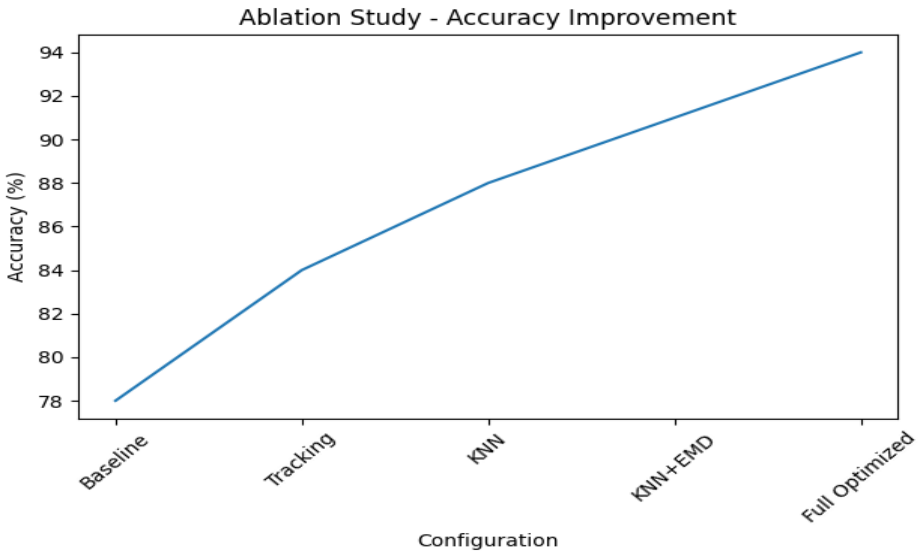
$EMD(P, Q) = \min \Sigma f_{ij} * d_{ij}$
Subject to flow constraints and non-negativity.
Classification:

$$y = \text{argmax}_c \Sigma I(\text{label}_i = c)$$

Confusion Matrix



Ablation Study



NVIDIA Jetson Edge Optimization

Deployment leveraged TensorRT acceleration, FP16 precision, asynchronous pipeline scheduling, memory pooling, and CPU-GPU workload balancing. Thermal profiling ensured stable inference performance at 25–30 FPS under constrained power envelopes.