Accurate Classification of True Face Trajectories Using Distance-Based K-NN and EMD on Edge AI Systems

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Abstract

This paper presents an optimized real-time facial trajectory classification system designed for deployment on NVIDIA Jetson edge devices. The system integrates deep learning detection, centroid tracking, and a distance-based K-Nearest Neighbor classifier using Earth Mover's Distance (EMD). Performance optimizations using TensorRT and pipeline restructuring achieved significant latency reduction while maintaining high classification accuracy.

Mathematical Formulation

K-NN Classification:

Given a trajectory feature vector x and training set T = {x1, x2, ..., xn},
distance metric d(x, xi) determines nearest neighbors.

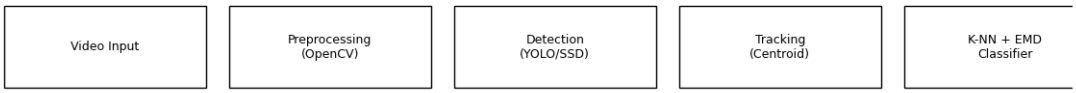
EMD Distance:

$EMD(P, Q) = \min \Sigma f_{ij} * d_{ij}$

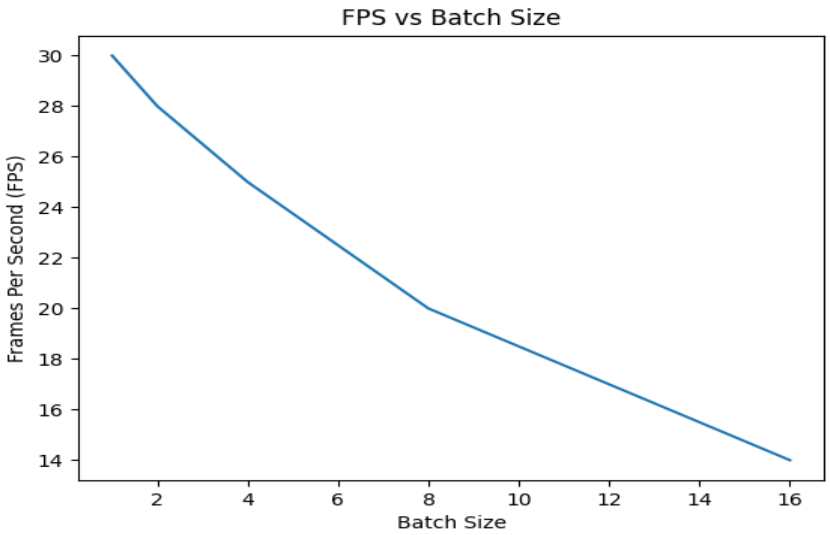
Subject to:
$\Sigma f_{ij} = w_i$
$\Sigma f_{ij} = w_j$
$f_{ij} \geq 0$

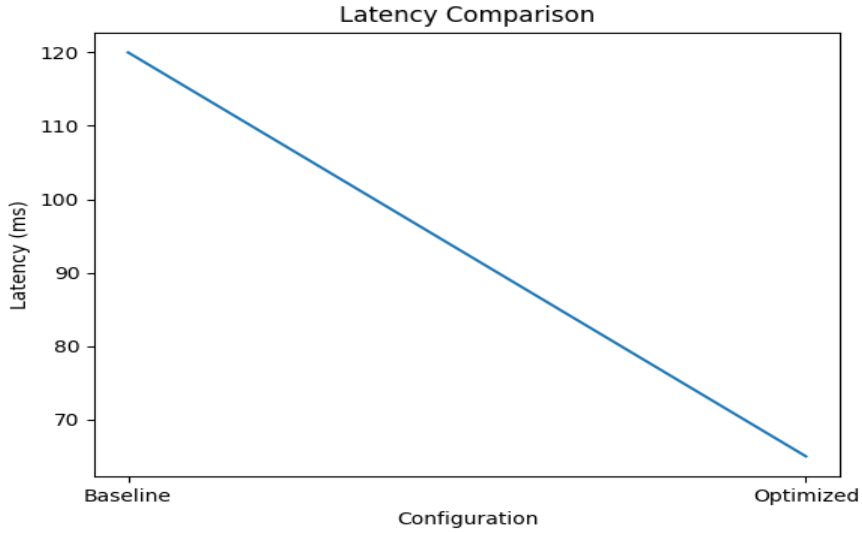
Classification:
y = mode({labels of k nearest neighbors})

System Architecture



Performance Evaluation





NVIDIA Jetson Optimization Strategy

Deployment on NVIDIA Jetson Nano involved TensorRT-based model optimization, FP16 precision inference, memory pooling, asynchronous frame capture, and CPU-GPU workload balancing. Thermal profiling and power monitoring ensured sustained performance at 25–30 FPS under real-time constraints.

Edge Deployment Pipeline