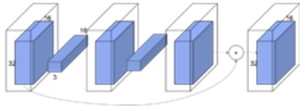
MultiPriNTF Architecture Overview

(a) Privacy-Preserving Feature Processing

Visual Processing

Modified ResNet

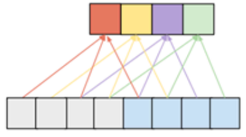


Noise Layer

Privacy Auditor

Transaction Processing

Temporal Conv



Privacy Layer

Secure Aggregation

Differential Privacy Layer

$(\varepsilon = 0.1, \delta = 1e\text{-}5)$

Privacy-Preserved Features

(b) Cross-Modal Integration Architecture

Visual Features (v)

Transaction Features (t)

Secure Attention Mechanism

Q_v K_t V_t

$$A_{v2t} = \text{softmax}\left(\frac{Q_v K_t^T}{\sqrt{d}} + \mathcal{N}(0, \sigma^2)\right) \rightarrow Z_{v2t}$$

Q_t K_v V_v

$$A_{t2v} = \text{softmax}\left(\frac{Q_t K_v^T}{\sqrt{d}} + \mathcal{N}(0, \sigma^2)\right) \rightarrow Z_{t2v}$$

Feature Fusion Strategy

$$g = \sigma\left(W_g[Z_{v2t} \parallel Z_{t2v}] + b_g + \mathcal{N}(0, \sigma_g^2)\right)$$

$$Z = g \odot Z_{v2t} + (1 - g) \odot Z_{t2v}$$

Fused Features

(c) Market Analysis System

Fused Representations

Price Prediction Framework

$$p(\hat{y}_i|z_i) = \int p(\hat{y}_i|h_i)p(h_i|z_i)dh_i$$

$$\hat{y}_i^{(t)} = (1 - \alpha)\hat{y}_i^{(t-1)} + \alpha f_\theta(z_i^{(t)}) + \mathcal{N}(0, \sigma_p^2)$$

Distributed Processing Architecture

GPU 0 $L_0 = \{x_i \mid i \bmod 3 = 0\}$

GPU 1 $L_1 = \{x_i \mid i \bmod 3 = 1\}$

GPU 2 $L_2 = \{x_i \mid i \bmod 3 = 2\}$

Resource Allocation Optimization

$$\pi^*(s) = \arg\max_a Q^*(s, a)$$

Market Predictions

Privacy-Guaranteed Market Metrics