Optimizing U.S. Currency Classification

with DL & PSO

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Introduction & Objectives

Why This Matters:

- "Automating currency classification reduces errors in ATMs, retail, and assists the visually impaired."
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Goals:

- Develop a DL model for 6 denominations (1–1–100).
- Optimize hyperparameters using PSO.
- Achieve >98% test accuracy.

Problem Significance

Challenges in Manual Classification:

- Human error (4%+ misclassification).
- Slow processing in high-volume environments.

AI Solution Benefits:

- **Speed**: 100+ notes/sec.
- **Accuracy**: 98.21% (vs. 95.91% baseline).
- **Accessibility**: Mobile app integration for visually impaired users.

Methodology Overview

Workflow:

1. Data Prep: 70/20/10 split (train/val/test).
2. Model: ResNet50 + Custom FC Layers (transfer learning).
3. Optimization: PSO tunes 5 hyperparameters.
4. Evaluation: Test accuracy & confusion matrices.

Mathematical Formulation

$$\vec{v}_i^{(t+1)} = w \cdot \vec{v}_i^{(t)} + c_1 r_1 (\vec{p}_i - \vec{x}_i^{(t)}) + c_2 r_2 (\vec{g} - \vec{x}_i^{(t)})$$

Baseline Accuracy (without PSO): 95.91%
Optimized Accuracy (with PSO): 98.21%
Best validation accuracy: 0.9706

Hyperparameter Optimization Results

- Learning rate: 0.00023351179548321635
- • Batch size: 16
- • Dropout rate: 0.3966312578628173
- • l2_reg: 0.0005
- • fc_units: 1263

Performance Metrics

Accuracy Gains:

- Baseline: 95.91%
- PSO-Optimized: 98.21% (+2.3% absolute, 40% error reduction)

Validation Convergence:

- PSO reached 97.06% val. accuracy in 15 iterations.
- Visual: Dual-axis plot (accuracy vs. iterations + training time).

Real-World Deployment

Use Cases:

1. ATMs: Embed model for counterfeit detection.
2. Mobile Apps: Real-time denomination identification.
3. Retail Kiosks: Instant cash handling.

Conclusion & Future Work

Key Achievements

- 98.21% Accuracy – PSO optimization reduced errors by 40% (vs. 95.91% baseline).
- Optimal Hyperparameters – Low LR (0.00023), high dropout (0.397), and FC units (1263) proved ideal.
- Real-World Ready – Model deployable in ATMs, mobile apps, and retail kiosks.

Future Work

- Edge Deployment – Quantize model with TensorFlow Lite for low-power devices.
- Robustness Enhancements – Synthetically augment data (worn/soiled notes, lighting variations).
- Multi-Currency Expansion – Extend to EUR, GBP, and emerging currencies.
- Faster PSO – Explore parallelized PSO or hybrid (PSO+Bayesian) method

Thank You