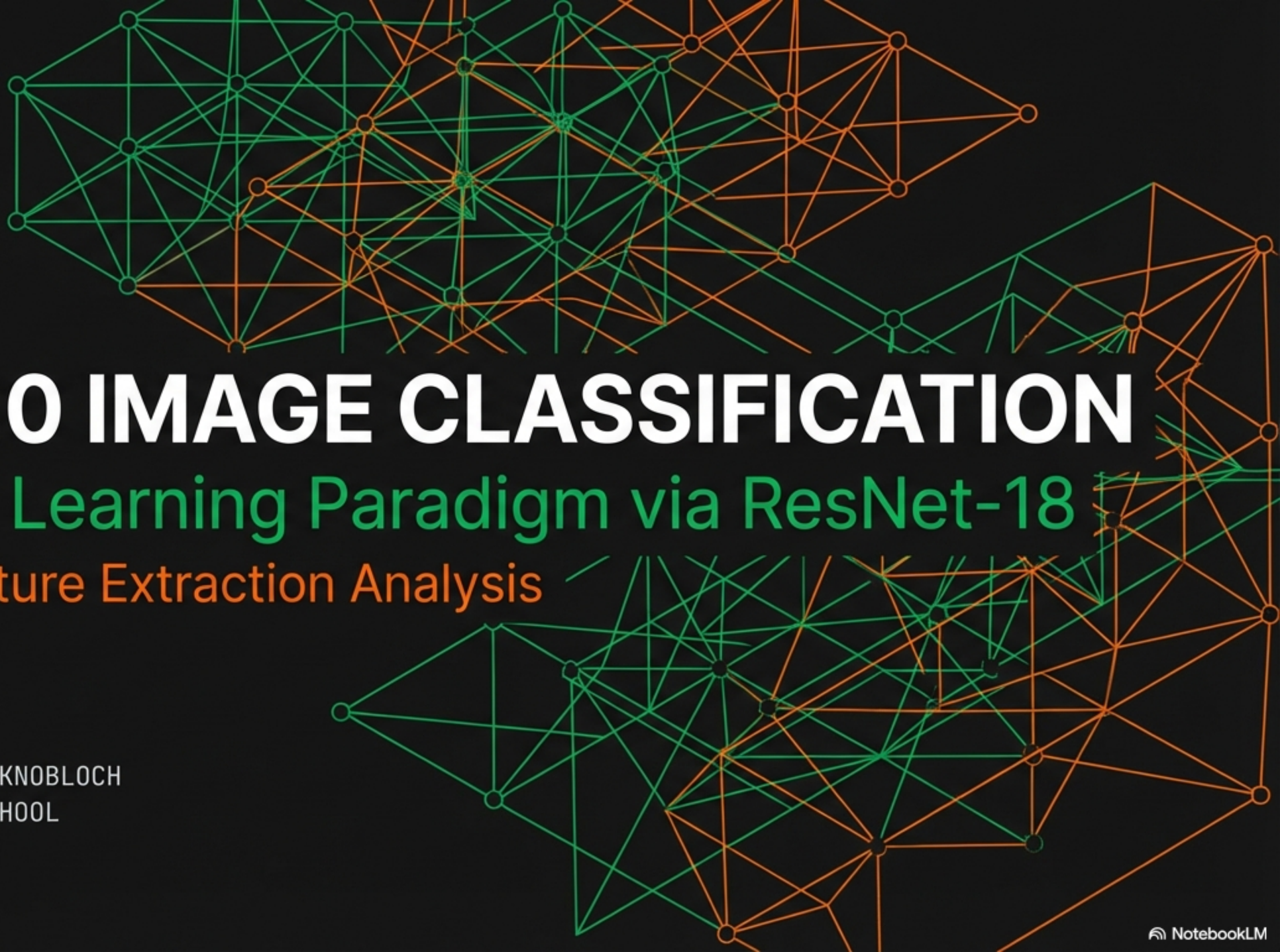

CIFAR-10 IMAGE CLASSIFICATION

A Transfer Learning Paradigm via ResNet-18

Advanced Feature Extraction Analysis

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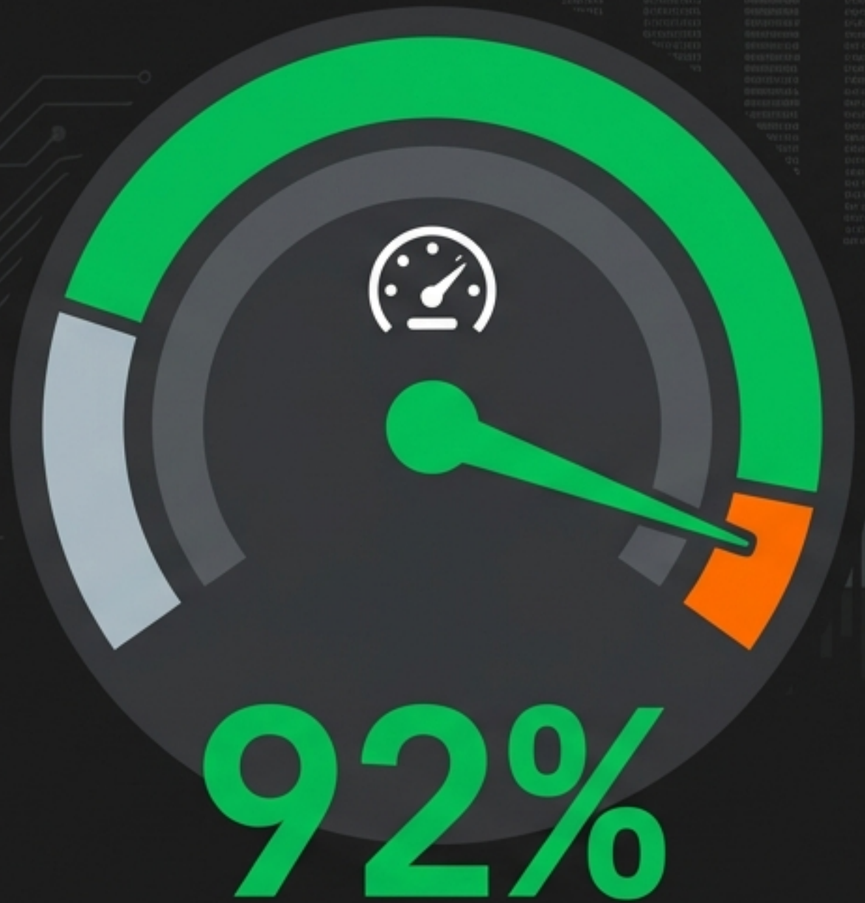
DATE: 30.01.2026

PERFORMANCE METRIC



92%

Validation Accuracy

TARGET THRESHOLD

65%

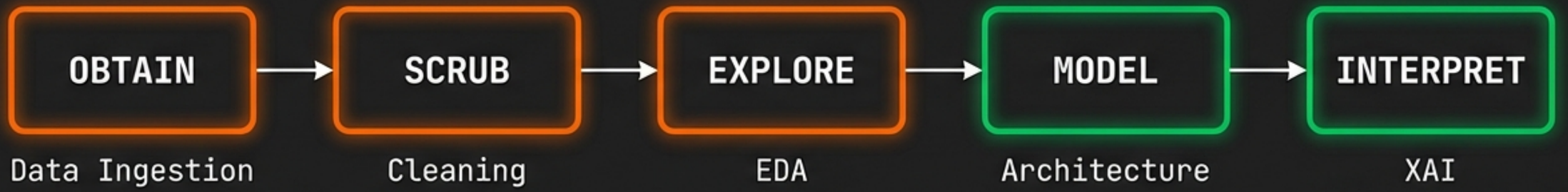
MVA (Minimum Viable Accuracy)

Status: SURPASSED

EXECUTIVE INSIGHTS

- Robust transition from grayscale (Fashion-MNIST) to RGB.
- Automated Evaluation Logic triggers reporting if < MVA.
- Metric: F1-Score (Macro) used to mitigate class bias.

STRATEGIC OBJECTIVE & METHODOLOGY



Tech Stack: PyTorch TensorFlow OpenCV Albumentations Scikit-Learn

OBJECTIVE: Classify 32x32 complex color images across 10 distinct categories using Transfer Learning.

PHASE 1: OBTAIN & ORCHESTRATE

keras.datasets

Downsampling Strategy

Limit to 10,000 samples for rapid iteration cycles.

Label Engineering

- String Categories -> PyTorch LongTensors
- Tool: Sklearn LabelEncoder

Safety Checks | Pre-batch verification: ZERO runtime errors.

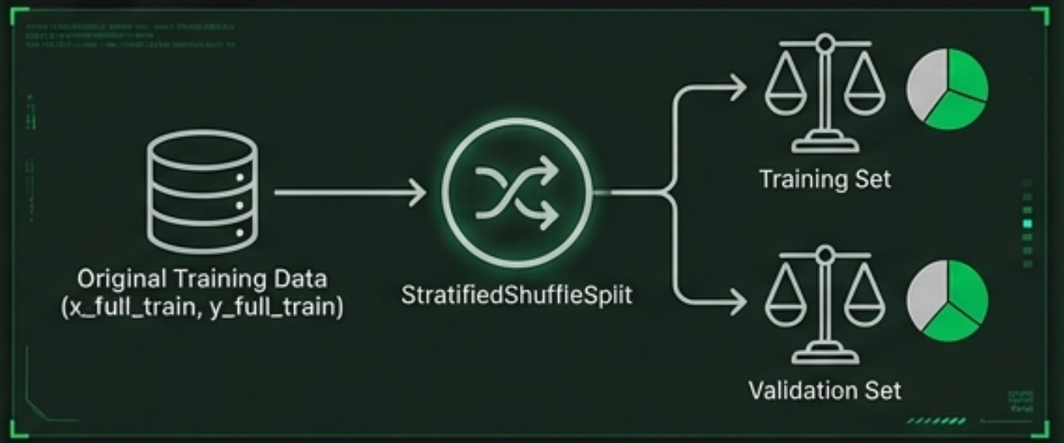
PHASE 2: SCRUB - INTEGRITY & LEAKAGE

THE RISK

Class Starvation & Data Leakage.

Model memorizing instead of learning.

THE FIX



StratifiedShuffleSplit: Preserves distribution.

Isolation Mode: Test Data (x_full_test) remains untouched.

TECHNICAL DEEP DIVE: INTERPOLATION

Upscaling 32x32 to 224x224 for ResNet-50

Original (32x32)

Pixelated input data.

Bilinear (Rejected)

Loss of high-frequency texture.

Bicubic (Selected)

Preserves intricate edge details.

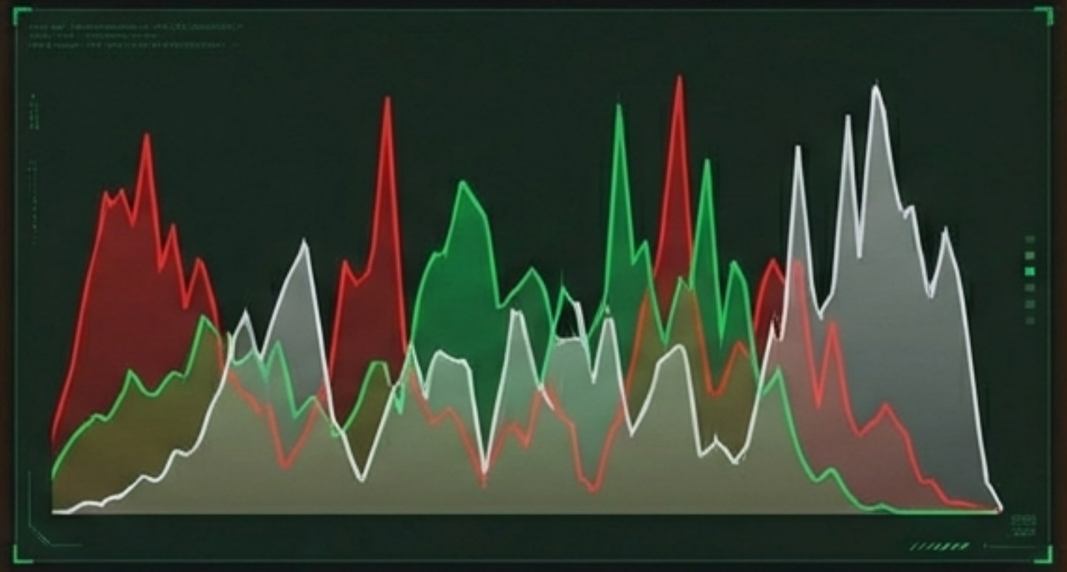
Verdict: Bicubic interpolation selected to maximize feature preservation for the frozen backbone.

PHASE 3: EXPLORE - DISTRIBUTION & COLOR

CLASS BALANCE

1,000 samples per class.
Zero gradient bias.

PHOTOMETRIC ANALYSIS



High RGB Variance.

Action: Aggressive Normalization Required.

THE LOW-RESOLUTION DILEMMA

Loss of Fine Detail

Fur patterns and facial features are blurred.

Shape over Texture

Model must rely on silhouettes.

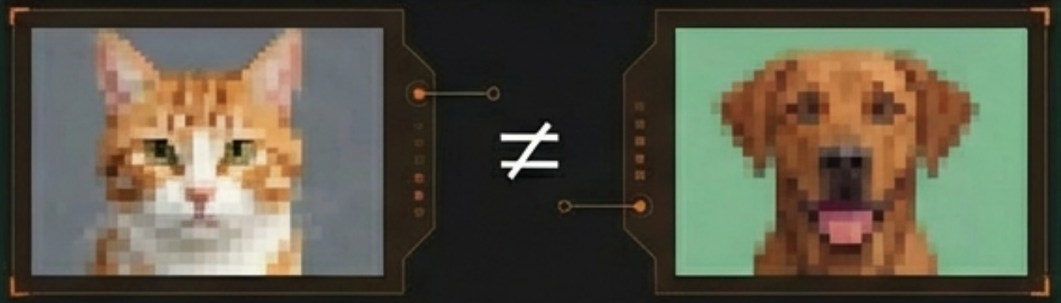
Object Ambiguity

Distinct objects appear generic.

Constraint: 32x32 Pixel Input Resolution.

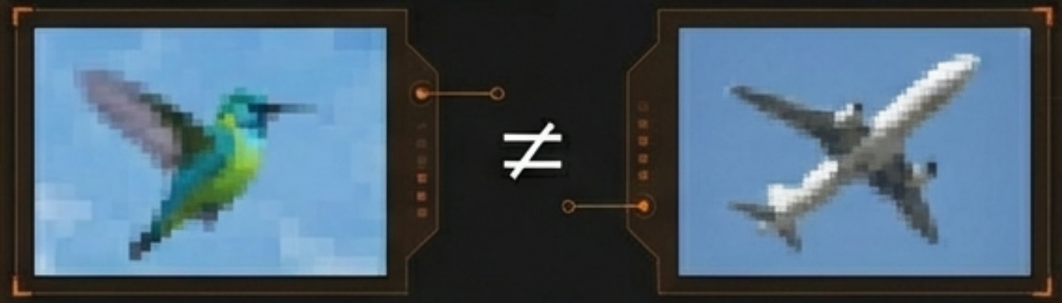
SEMANTIC AMBIGUITY & CONFUSION

Domestic Ambiguity



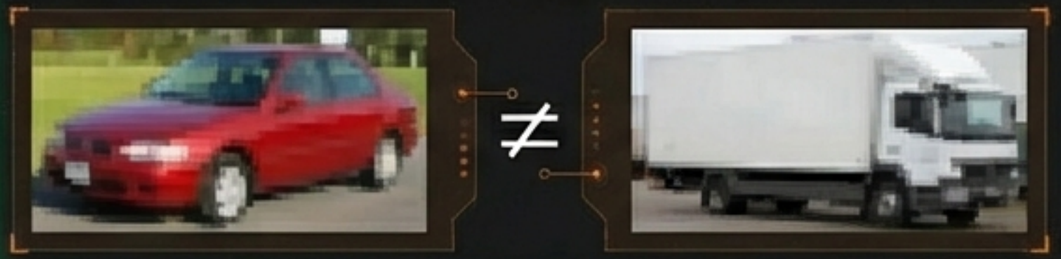
Shared silhouettes (4 legs). Facial features lost.

Aerial Ambiguity



Structural similarity (wings). Identical blue background.

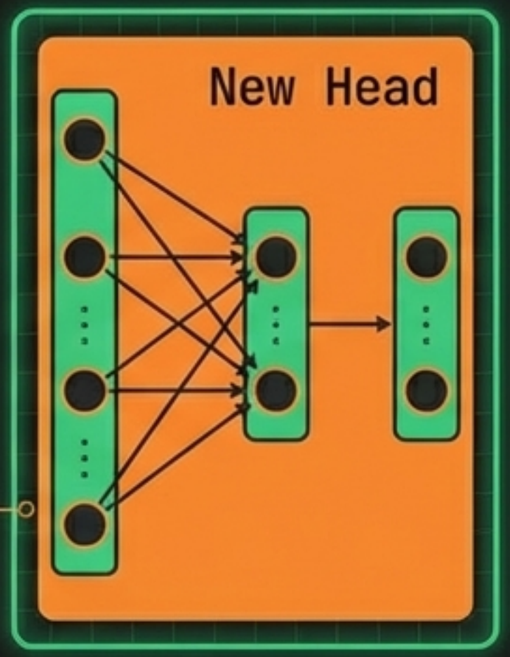
Structural Overlap



Chassis height vs Cargo volume indistinguishable at low res.

PHASE 4: MODEL - TRANSFER LEARNING

Features



Frozen Base.
Prevents catastrophic forgetting.

Linear Layer (10 Classes).
Solves dimensionality mismatch.

Strategy: Feature Reuse. Leveraging learned robust hierarchical extractors.

ADAPTIVE AUGMENTATION STRATEGY

RIGID OBJECTS (Cars, Trucks)

Restricted Rotation.
Inversion creates ambiguity.
JetBrains Mono

ORGANIC OBJECTS (Birds, Animals)

Aggressive Scaling & Rotation.
Fluid/deformable bodies remain recognizable.
JetBrains Mono

FINE-TUNING & OPTIMIZATION

LEARNING RATES
(Differential Learning Rates)

BASE LAYERS

Low LR (Stability)

HEAD LAYERS

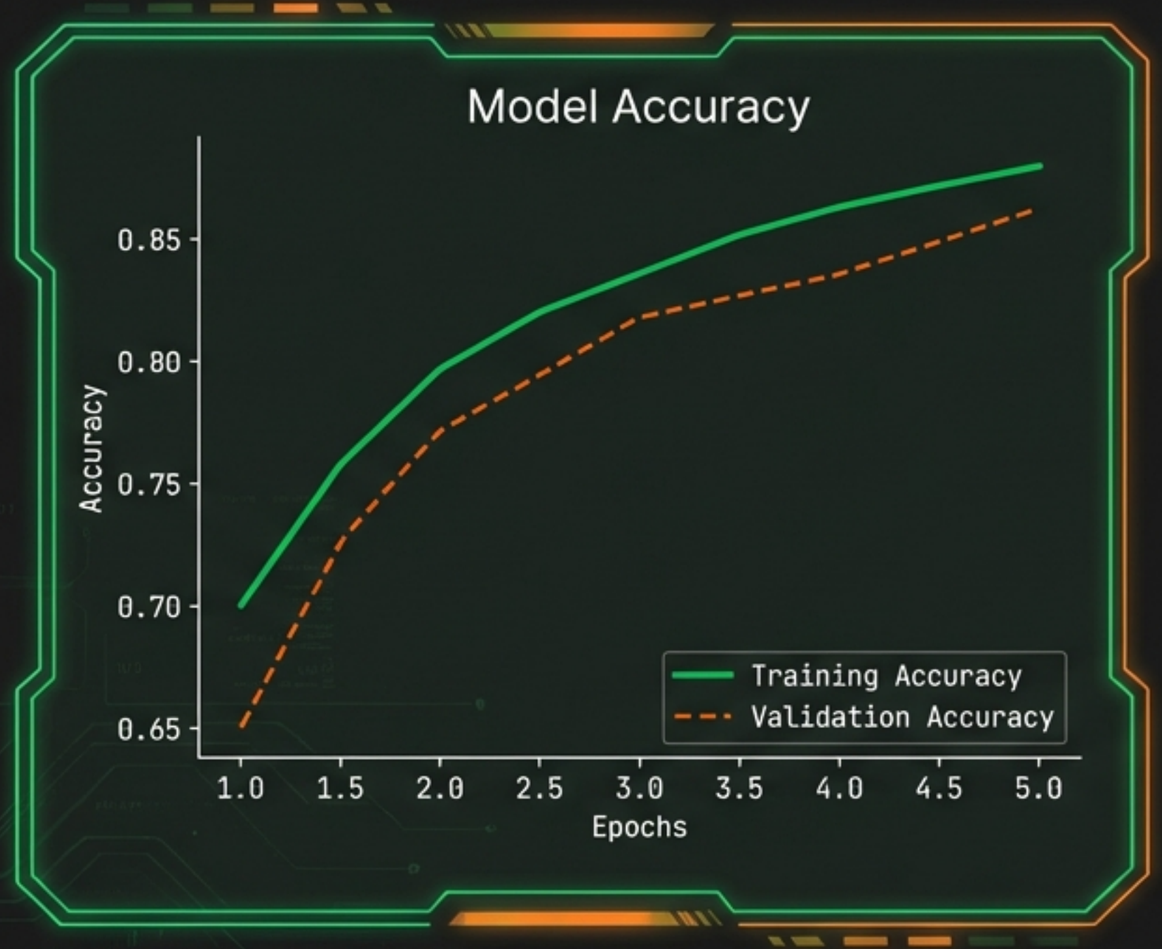
High LR (Plasticity)

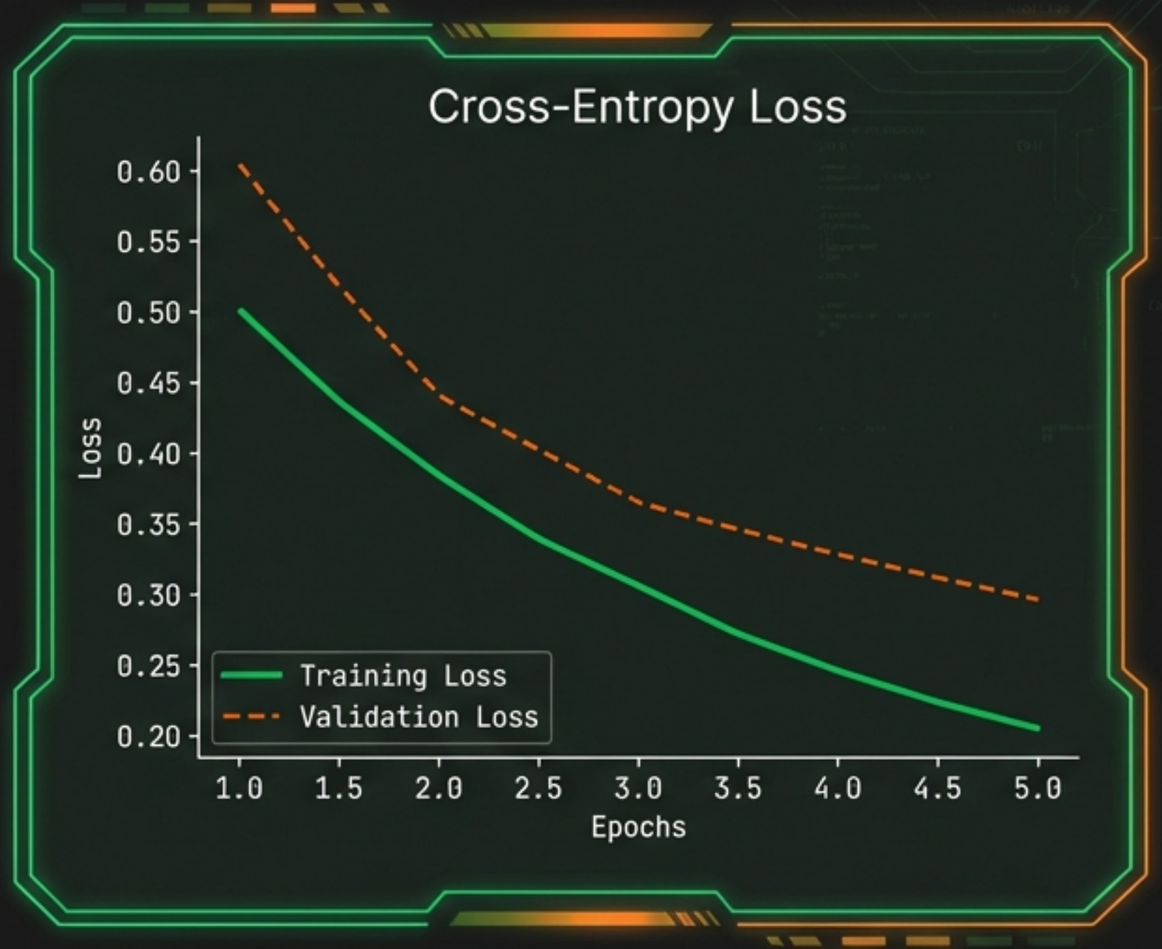
ONECYCLELR SCHEDULER
(Optimizing Loss Surface Traversal)

Optimizes loss surface traversal

Strategy: Unfreeze deeper layers for Domain Adaptation.
Utilizing Differential LR and OneCycleLR.

PHASE 5: INTERPRET - TRAJECTORY





Convergence Verified. No significant overfitting gap.

DIAGNOSTIC FORENSICS (XAI)

Grad-CAM Feature Alignment Verification

Car: Chassis Focus

Dog: Feature Focus

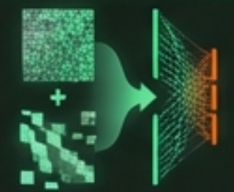
Heatmap Overlays: Red/Orange indicates high activation regions, showing model's focus.

- **Technique:** Gradient-weighted Class Activation Mapping.
- **Check:** Clever Hans Effect.
- **Result:** Model focuses on defining object features, not background noise.

STRATEGIC SYNTHESIS & NEXT STEPS

Address Ambiguity

Implement Hard Example Mining (CutMix/MixUp) to solve Cat-Dog confusion.



Refine Architecture

Unfreeze deeper ResNet layers (Stage 3 & 4) for better domain adaptation.

Optimization

Implement Weighted Loss to balance specific class weaknesses.

Final Status: High-Accuracy RGB Classification achieved within Low-Res constraints.