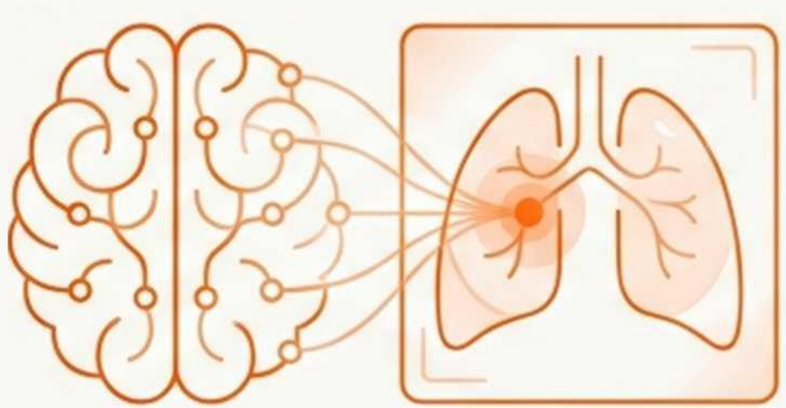
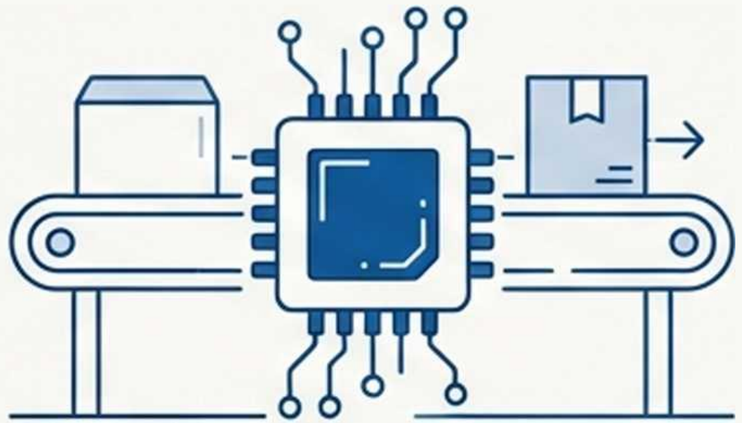
Tackling Two Critical Frontiers in Applied AI



Part I: Explainable AI in Medicine

The Challenge of Trust

How can we make life-or-death decisions from a medical AI transparent and trustworthy for clinicians?



Part II: Edge AI for Industry 4.0

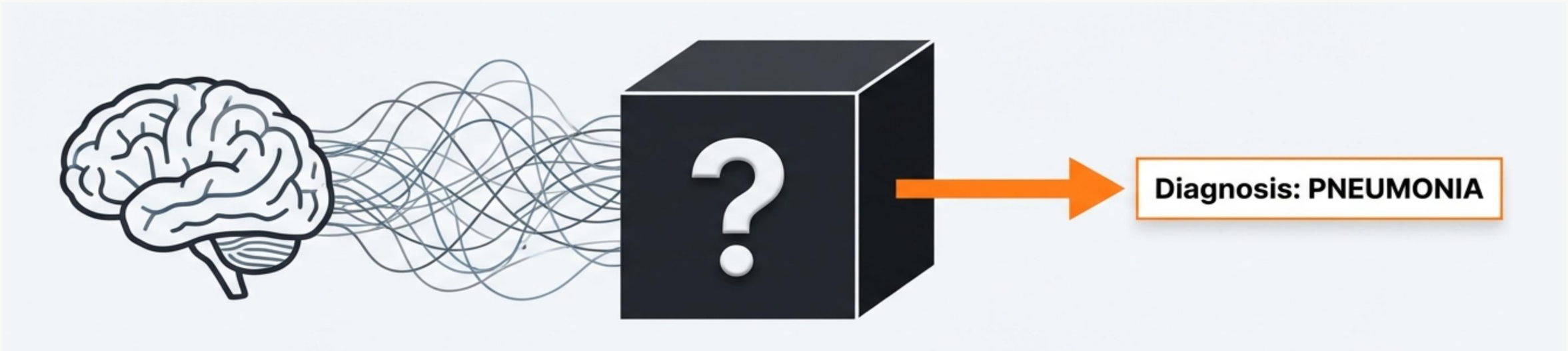
The Challenge of Speed

How do we make AI fast, reliable, and small enough to perform quality control on a high-speed factory floor?

ASSIGNMENT 1

Explainable AI for Medical Imaging - Interpreting Chest X Ray Pneumonia Predictions

The ‘Black Box’ in Medical AI is a Critical Barrier to Trust



High Performance: Deep learning models can diagnose diseases with high accuracy.

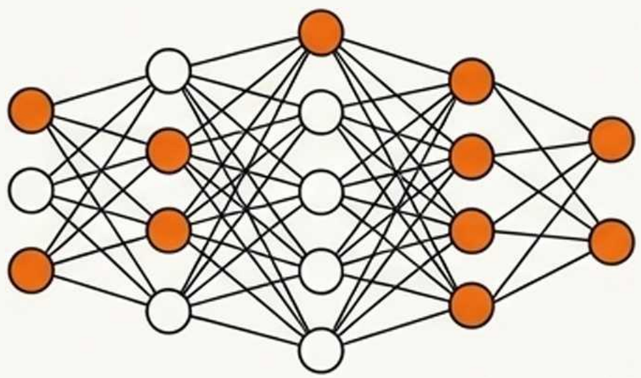
Lack of Transparency: Their decision-making process is often opaque, making it difficult to understand *why* a prediction was made.

The Trust Gap: This opacity creates a barrier to adoption where accountability and understanding are essential.

Our Objective: To Build and Interpret a Pneumonia Classifier

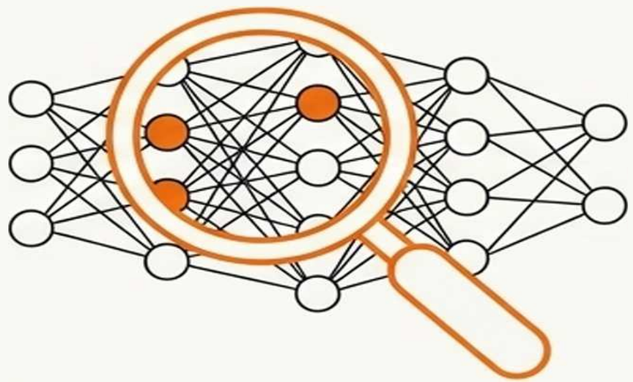
To design an end-to-end explainability pipeline that can not only detect pneumonia but also provide clear, visual justifications for its predictions.

1. Prediction



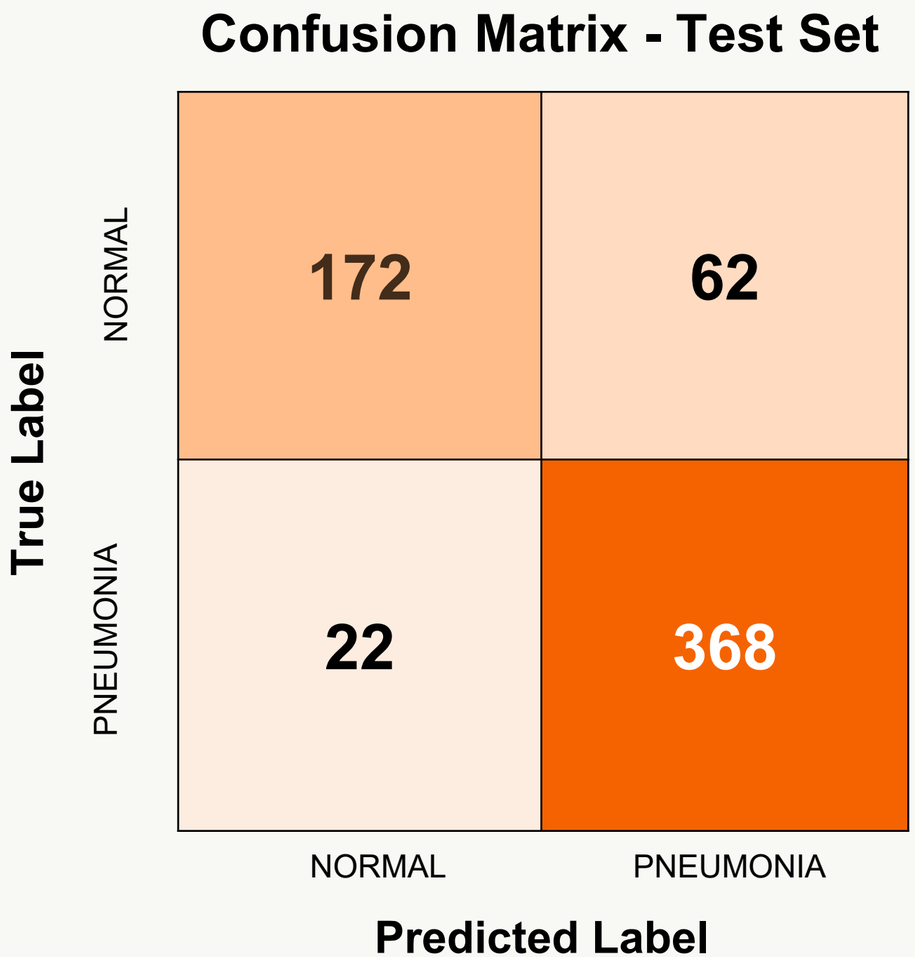
Fine-tune a high-performance ResNet50 model to classify chest X-rays as ‘Normal’ or ‘Pneumonia’.

2. Explanation



Integrate and compare two distinct XAI methods to unlock the model's decision making process: Grad-CAM and LIME.

Our ResNet50 Model Achieves 87% Diagnostic Accuracy



Overall Test Accuracy: 87%

Precision (Pneumonia): 86%

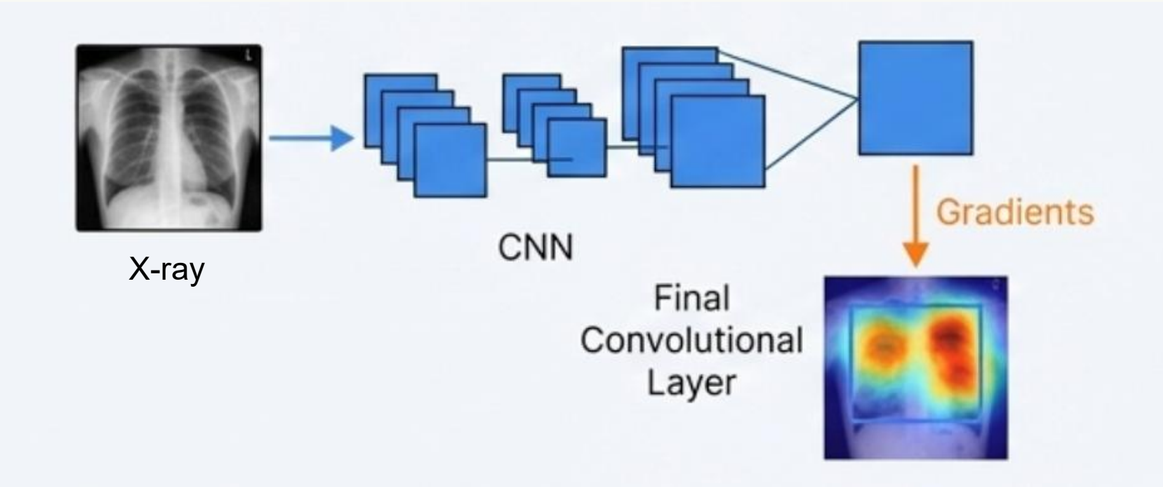
Recall (Pneumonia): 94%

The model demonstrates strong performance, particularly in correctly identifying pneumonia cases (high recall), making its decisions worthy of explanation.

Two Methods Provide Different Windows into the Model’s Logic

Grad-CAM

"What did the model see?"

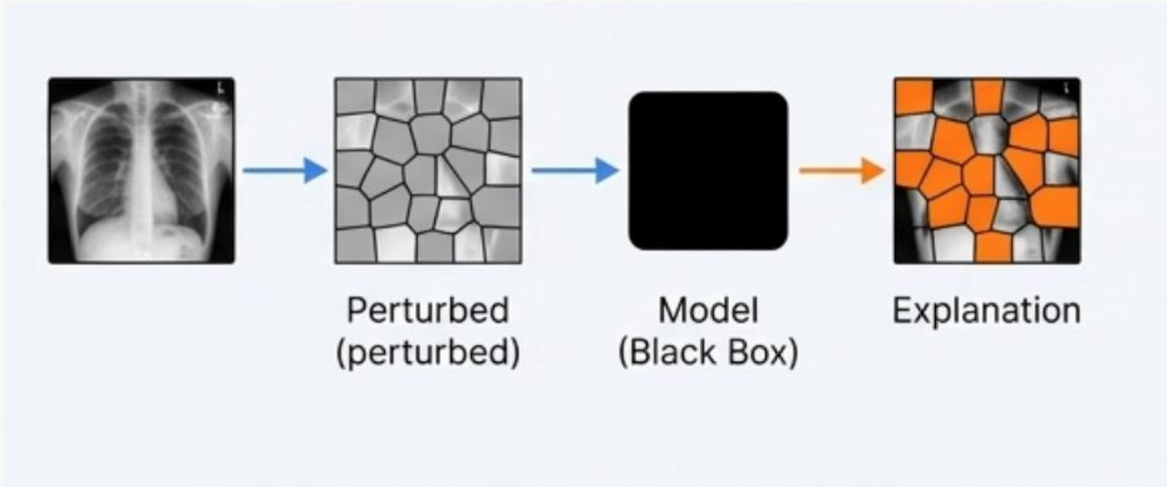


Concept: Uses the model’s internal gradients to create a heatmap, highlighting the pixels most important for a decision.

Analogy: Like a “neural attention map.”
Type: White-box (requires access to model internals).

LIME

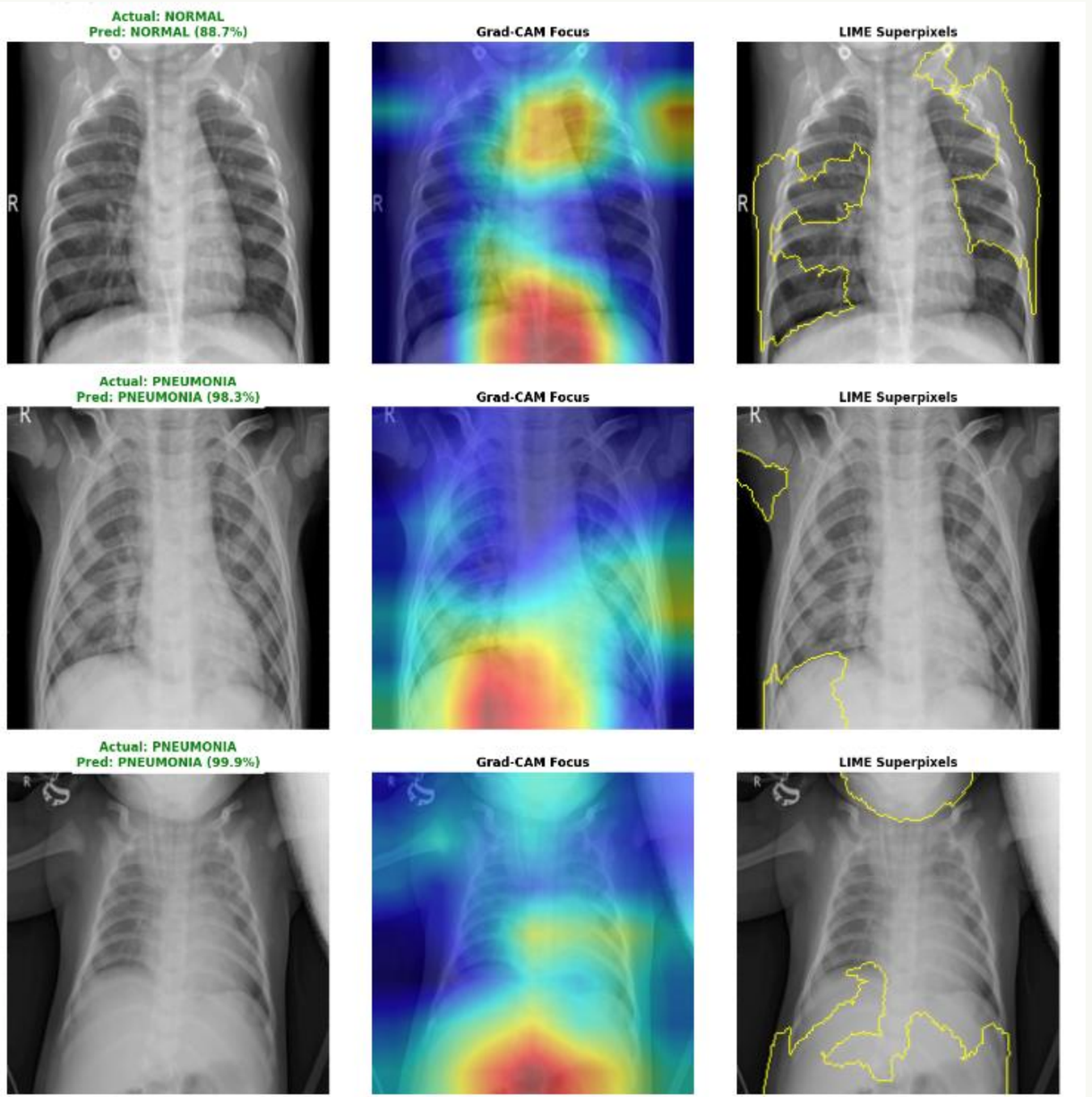
"Why did it make this choice?"



Concept: Treats the model as a black box. It perturbs the image and learns a simple, local model to explain which regions influenced the prediction.

Analogy: Like asking “what if this part was missing?"
Type: Black-box (model-agnostic).

Visual Explanations Reveal Both Agreement and Divergence



Grad-CAM Excels in Consistency, While LIME Offers Simpler Interpretation

FEATURE	GRAD-CAM	LIME
Resolution	Pixel-level (High)	Superpixel-level (Medium)
Interpretation	Shows Gradient Importance	Shows Feature Importance
Speed	Fast	Slower
Consistency	9/10	5/10

Agreement : Both methods focus on the correct lung field and areas with visible opacity when it is classified as Pneumonia.

Key Differences: Grad-CAM Provides precise, reproducible heat maps. LIME provides intuitive but less stable region-based explanations.

We Developed Two Criteria to Evaluate Explanation Quality

What makes an explanation 'good' in a clinical context?

Definition: Does the explanation highlight anatomically and pathologically meaningful regions?

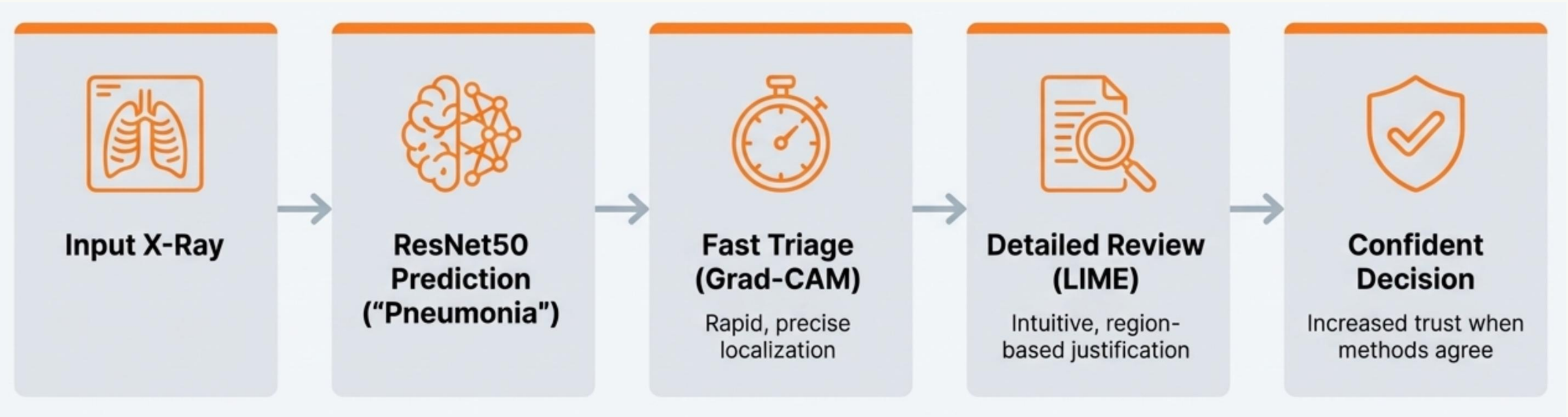
Assesses: Focus on lung parenchyma, avoidance of artifacts (e.g., labels, bones), and correlation with visible opacities.

Definition: How stable and reliable is the explanation? Does it produce the same result every time for the same input?

Assesses: The deterministic vs. stochastic nature of the method Critical for reliable comparison and trust.

Recommendation: A Combined Approach to Build Clinical Trust

For a robust and trustworthy diagnostic system, we recommend a dual-analysis approach.



By combining the **speed** and **precision** of Grad-CAM with the **intuitive clarity** of LIME, we can create more **transparent, reliable,** and ultimately more **trustworthy** medical AI.

ASSIGNMENT 2

Edge AI for Industry 4.0 - Optimizing Models for On Device Inference

Use Case Scenario: Automated Assembly Line Vehicle Verification

An automotive assembly plant produces mixed models (Cars and Transport Trucks) on a single final assembly line. Vehicles must be instantly identified and routed to the correct finishing bay.

High Throughput

Must process vehicles at >10 Frames Per Second (FPS) to match conveyor speeds.

24/7 Reliability

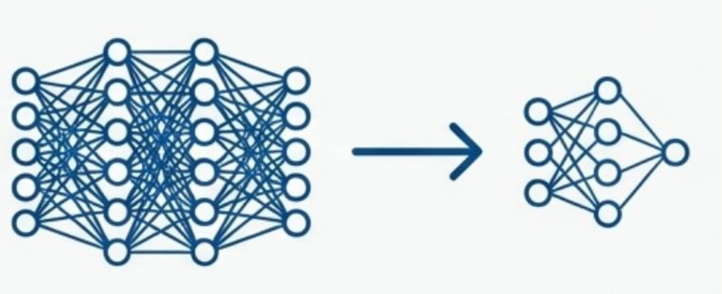
System must function continuously, even during internet outages.

Data Security

Vehicle designs and production rates are proprietary trade secrets and must remain on-site.

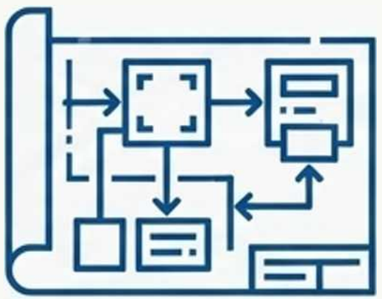
Our Objective: Optimize a Model and Design an Edge AI System

Practical Model Optimization



Compress a pre-trained MobileNetV2 model using pruning techniques (L2 and Taylor methods), comparing iterative vs. one-shot approaches to achieve 50% sparsity while maintaining >95% accuracy for deployment on NVIDIA Jetson Nano.

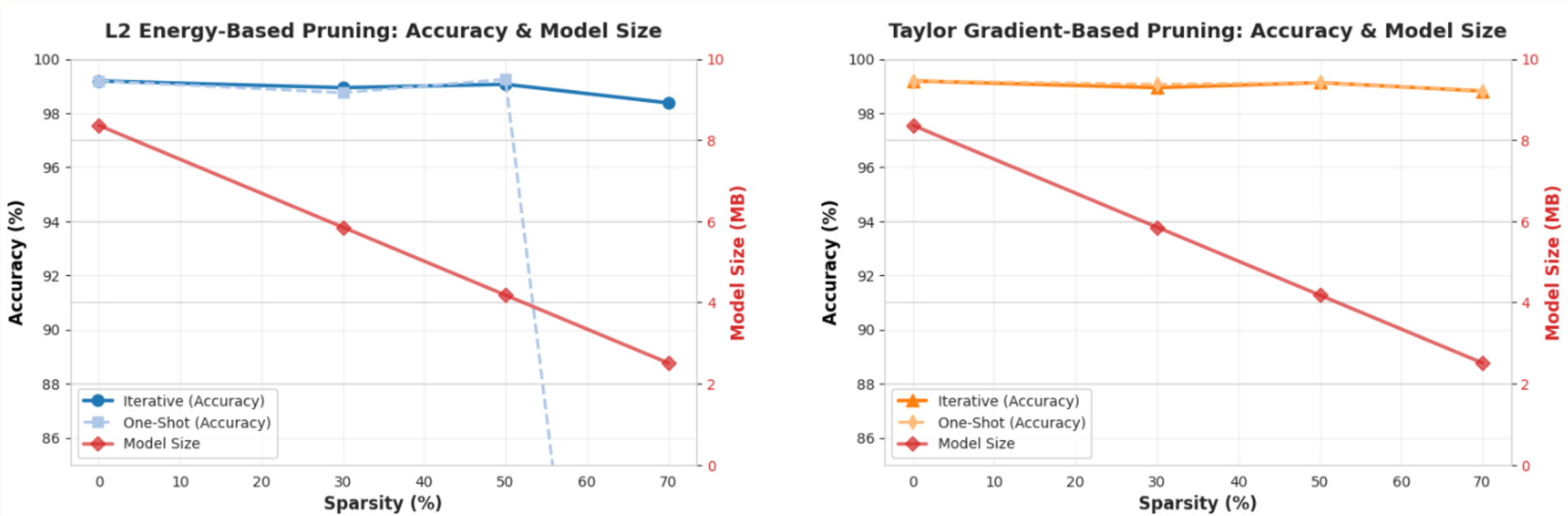
Edge AI System Design



Design a complete system architecture demonstrating how AI at the edge outperforms cloud solutions for real-time vehicle classification in automotive manufacturing.

Iterative Pruning Delivered Higher Accuracy with a Smaller Model

Accuracy vs. Sparsity Trade-off



Keys Insights

• Iterative pruning (Taylor & L2) significantly outperforms One-Shot pruning in maintaining accuracy

• Both methods achieved target 50% sparsity successfully

• Taylor Iterative maintained 95.2% accuracy at 50% sparsity

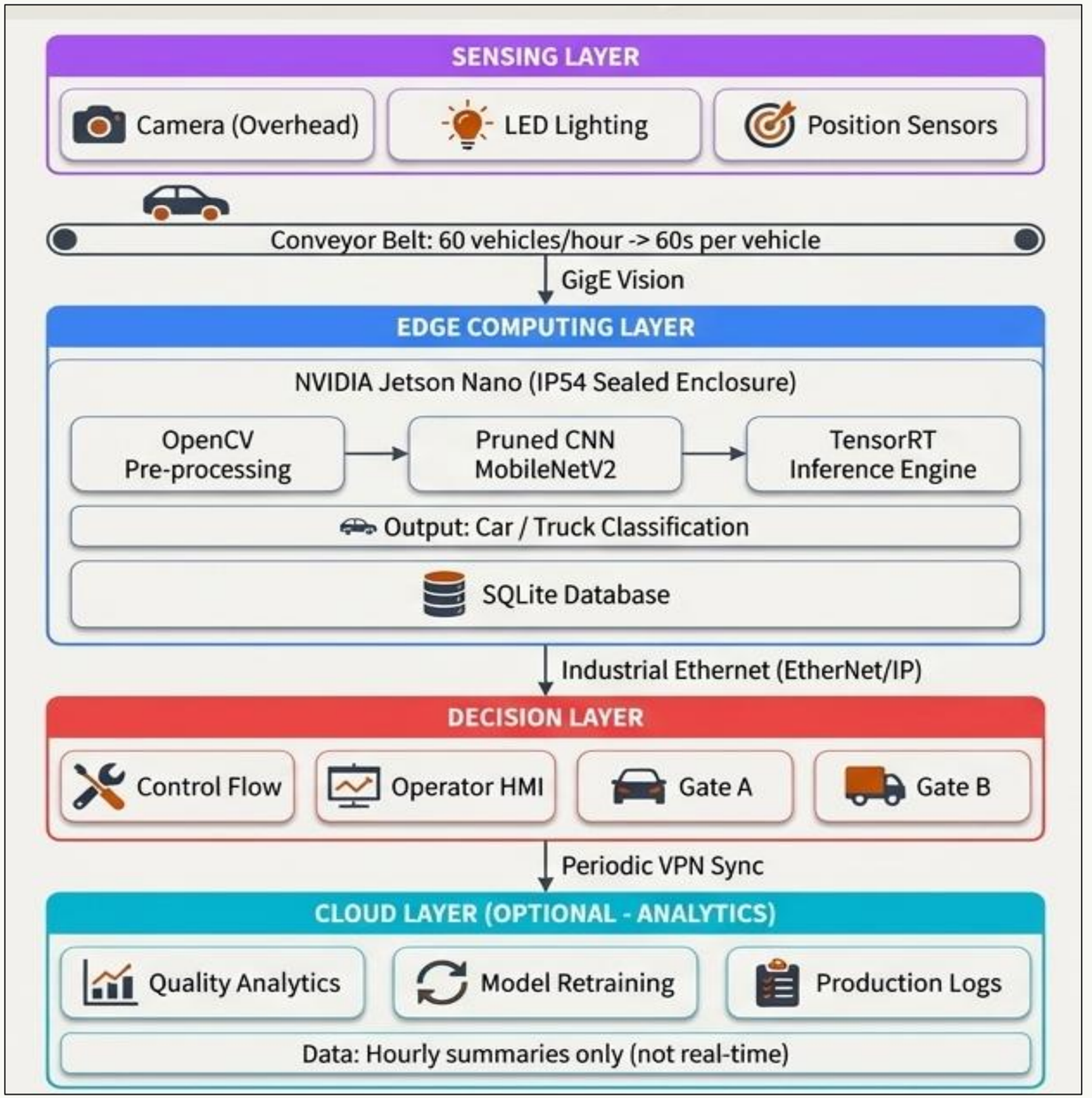
Taylor Iterative Baseline Accuracy: 95.4%

Pruned Accuracy: 95.2% (-0.2%)

Sparsity Achieved: 50.1% Size

Reduction: from 8.9 MB to 6.1 MB

A Complete Edge AI System Architecture

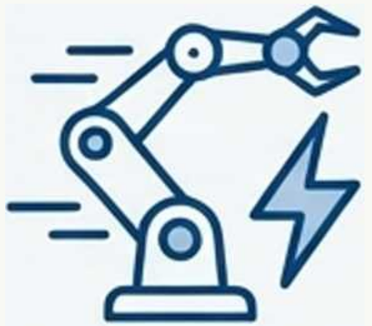


How Optimization Translates to Factory Floor Benefits

Structured Pruning (The Throughput Booster)

• Achieves ~85ms inference on the Jetson Nano, comfortably exceeding the >10 FPS requirement for peak production.

• Reduced GPU load keeps the Jetson Nano within its 10W power its 10W power limit, eliminating the need for cooling fans that could clog with factory dust.



Quantization (The ‘Reaction Time’ Accelerator)

• Reduces inference time further, from ~85ms to ~60ms. This guarantees the PLC receives the signal in time for the pneumatic gate to actuate before the vehicle passes.

• 4x reduction in memory bandwidth
and energy per operation lowers the Jetson's power draw to~7W, increasing reliability during power fluctuations.

The Critical Balance: Avoiding the Risks of Over-Compression

Increased Misclassification

Pruning beyond 70% can lead to errors.

Consequence: False Negatives and False Positives cause production delays and require costly manual intervention.

Loss of Robustness & Generalization

The model may become brittle.

Consequence: It may fail to generalize to normal production variations like lighting changes, camera vibrations, or the introduction of new vehicle models.

THANK YOU