Research and Application of Parameter-Efficient Adaptation (LoRA) on Vision-Language Models for Industrial Anomaly Detection

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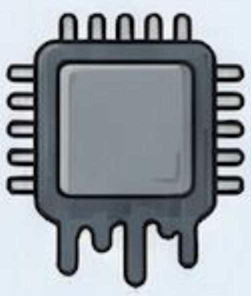
THE CHALLENGE IN INDUSTRIAL QUALITY CONTROL

Traditional AI is Inflexible and Expensive
Standard models (CNNs, Autoencoders) need extensive, labeled defect data and must be retrained from scratch for new products, increasing time and cost.

Foundation Models Face a "Domain Gap"
A model like CLIP, trained on web images, understands "a bottle" but fails to recognize a "bottle with a microscopic scratch," which is critical in industrial settings.



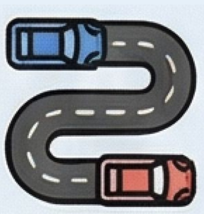
Full Fine-Tuning is Impractical
Retraining the entire CLIP model (be of millions of parameters) requires powerful GPUs and daks catastrophic forgetting, where the model loses its original powerful knowledge.

How can we adapt CLIP for Industrial tasks efficiently?
The goal is to achieve high accuracy in a iow-data (few-chot) environment while minimizing computational costs.

EXPERIMENTAL FRAMEWORK

Dataset: MVTec AD
A comprehensive, real world benchmark dataset for unsupervised anomaly detection, featuring 15 different industrial object categories.

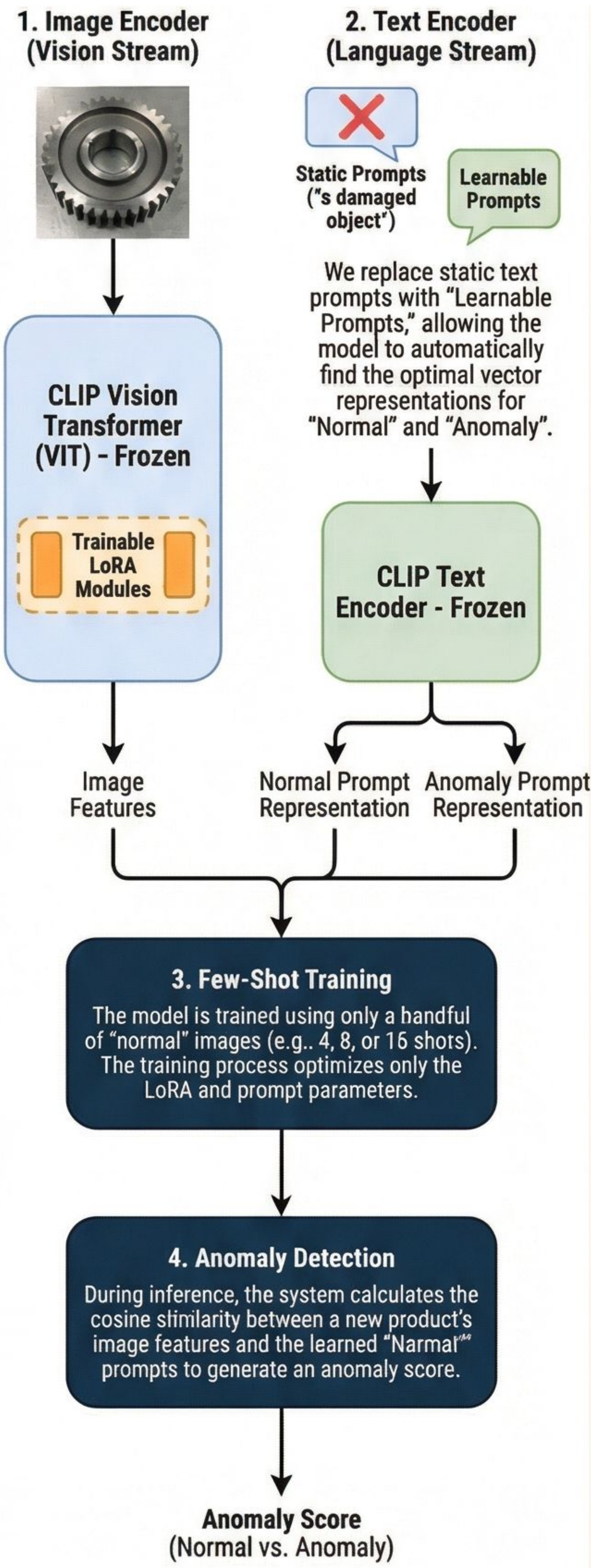
Evaluation Metric: AUROC
The model's performance will be measured by the Area Under the Receiver Operating Characteristic (AUROC) corve, a standard for classification tasks.



Benchmarking Against State-of-the-Art:
The proposed method results will compared against leading models in the field, including WinCLIP and AnomalyCLIP.

PROPOSED SOLUTION: AN EFFICIENT TWO-STREAM ADAPTATION

Core Idea: Low-Rank Adaptation (LoRA)
Instead of retraining the whole model, we froze the original CLIP weights and insert small, trainable "LoRA" modules into its vision encoder.



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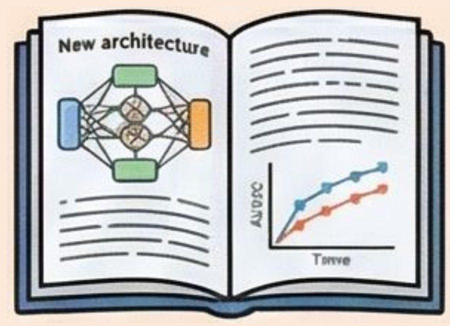
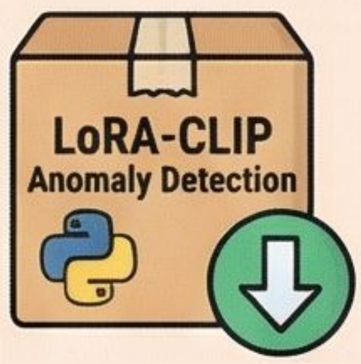
High Accuracy: AUROC > 90%
The model is expected to achieve an image-level AUROC score exceeding 90% on the MVTec AD dataset.

Proven Efficiency
The method will be validated to run on consumer-grade GPUs (like NVIDIA T4 or RTX 3060) with a training time of less than 30 minutes per product class.



Scientific Contribution
The research will deliver a novel, effective architecture combining CLIP and LoRA, along with an ablation study analyzing the impact of shot count on accuracy



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