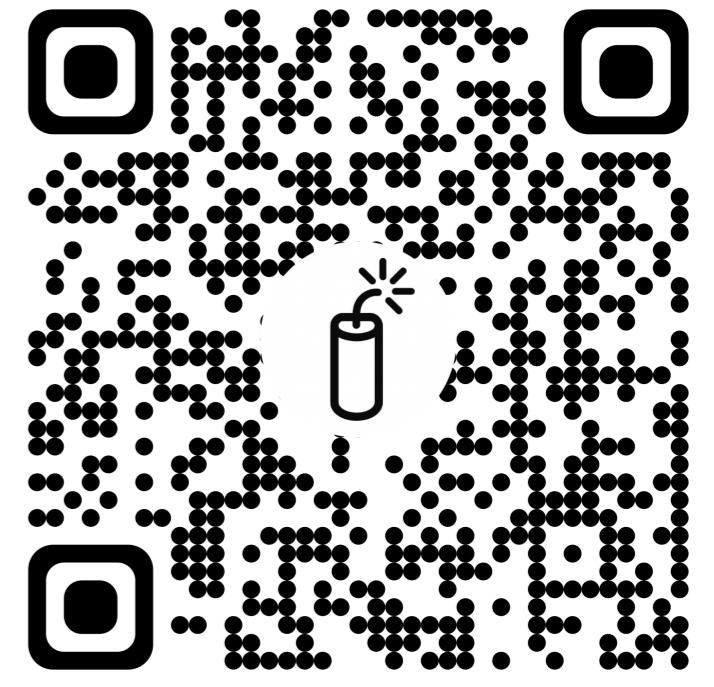


# DINOmite: Adversarial Robustness of DINov3 Vision Transformers

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## Abstract

**Problem:** DINov3 Vision Transformers achieve state-of-the-art accuracy but remain vulnerable to adversarial attacks.  
**Contribution:** We present a comprehensive evaluation framework for DINov3, testing robustness against gradient-based and optimization-based attacks. We compare standard fine-tuning against advanced adversarial defense strategies.

## Motivation

### Why It Matters

- Safety-Critical Systems:** Autonomous driving, medical imaging.
- Physical Threats:** Adversarial patches work in reality.

### Research Questions

- Does self-supervised DINov3 offer inherent robustness?
- Which defense strategy minimizes the accuracy trade-off?

## Problem Definition

We formulate the attack as a constrained optimization problem:

$$\max_{\delta} L(f(x + \delta), y) \quad \text{s.t.} \quad \|\delta\|_{\infty} \leq \epsilon$$

## Threat Model

- White-box:** Full access to gradients.
- Constraint:**  $\epsilon = 8/255$ .
- Goal:** Misclassification with minimal perturbation.

## Experimental Setup

### Model Architecture

- Backbone:** DINov3 ViT-S/16 (Frozen for Classification).
- Head:** Linear Classification Head (Trainable).

### Datasets

- CIFAR-10:** Primary benchmark.

### Evaluation

- Metric:** Clean vs. Robust Accuracy (PGD-40).
- Delta:**  $\delta \in \{0, \dots, 8/255\}$ .
- Attacks:** FGSM, PGD, C&W.
- Defenses:** PGD-AT, TRADES.

## Conclusions

### Main Takeaways

- Adversarial Training Effectiveness:** DINO-pretrained ViTs are vulnerable to attacks like PGD. However, defenses like PGD-AT or TRADES significantly enhance robustness, mirroring Madry et al.'s findings for CNNs.
- Trade-offs:** Increased robustness introduces a performance penalty on clean data, causing a noticeable drop in standard accuracy.
- Visual Differences:** C&W attacks generate perturbations that are less perceptible to the human eye than those produced by PGD and FGSM.

### Future Work

- Evaluating Certified Robustness.
- Scaling to ImageNet-1k and GTSRB.
- Testing diverse attack methods (e.g., AutoAttack).
- Exploring advanced defenses (e.g., MART).

## Attack Methods

We focus on three primary attack vectors representing different threat levels:

### FGSM (Fast Gradient Sign Method)

A single-step attack assuming linear loss surface.

$$x_{adv} = x + \epsilon \cdot \text{sign}(\nabla_x L(\theta, x, y))$$

*Note: Fast, but weak against iterative training.*

### PGD (Projected Gradient Descent)

The "Universal First-Order Adversary". Iterative FGSM with projection.

$$x^{t+1} = \Pi_{x+\mathcal{S}}(x^t + \alpha \cdot \text{sign}(\nabla_x L(\theta, x^t, y)))$$

*Note: The strongest defense benchmark. We use 40 steps.*

### C&W (Carlini & Wagner)

Optimization-based attack minimizing distance and loss term.

$$\min_{\delta} \|\delta\|_2 + c \cdot f(x + \delta)$$

*Note: Finds adversarial examples with minimal visible perturbation.*

## Defense Strategies

Standard training yields 0% robustness. We evaluate two state-of-the-art defenses:

### PGD-AT (Adversarial Training)

A min-max game formulation (Madry et al.). The inner loop generates strong adversarial examples, while the outer loop updates the model to resist them.

$$\min_{\theta} \mathbb{E}_{(x,y) \sim D} [\max_{\|\delta\|_{\infty} \leq \epsilon} L(f_{\theta}(x + \delta), y)]$$

*Key Idea: Train directly on the worst-case examples.*

### TRADES

Separates loss into natural accuracy and robustness regularization (Zhang et al.). It minimizes KL-divergence between predictions on clean and adversarial inputs.

$$\min_{\theta} \mathbb{E}_{\substack{\text{Natural} \\ \text{Robustness}}} [L(f(x), y) + \beta \cdot \text{KL}(f(x) \| f(x + \delta))]$$

*Key Idea: Enforce smoothness of the decision boundary.*

## Defense Results

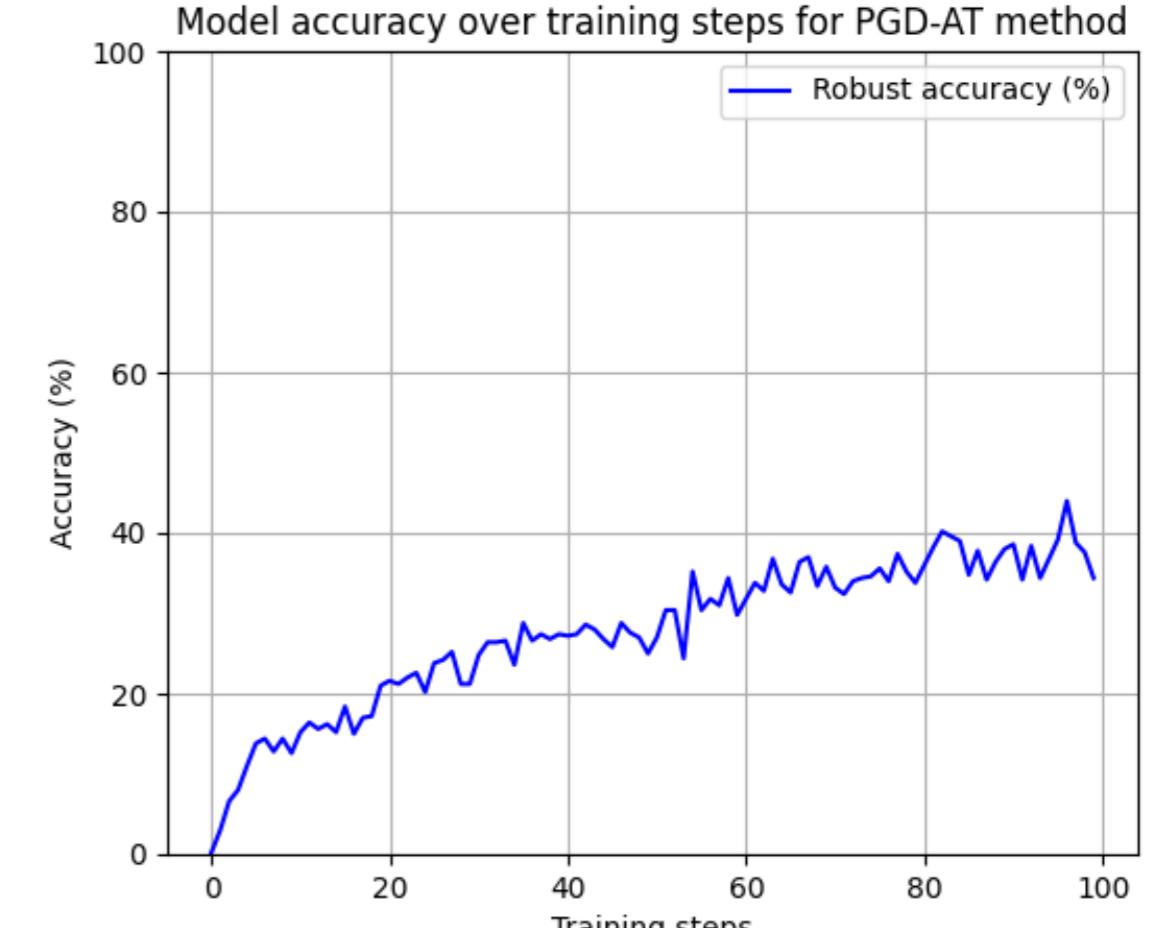
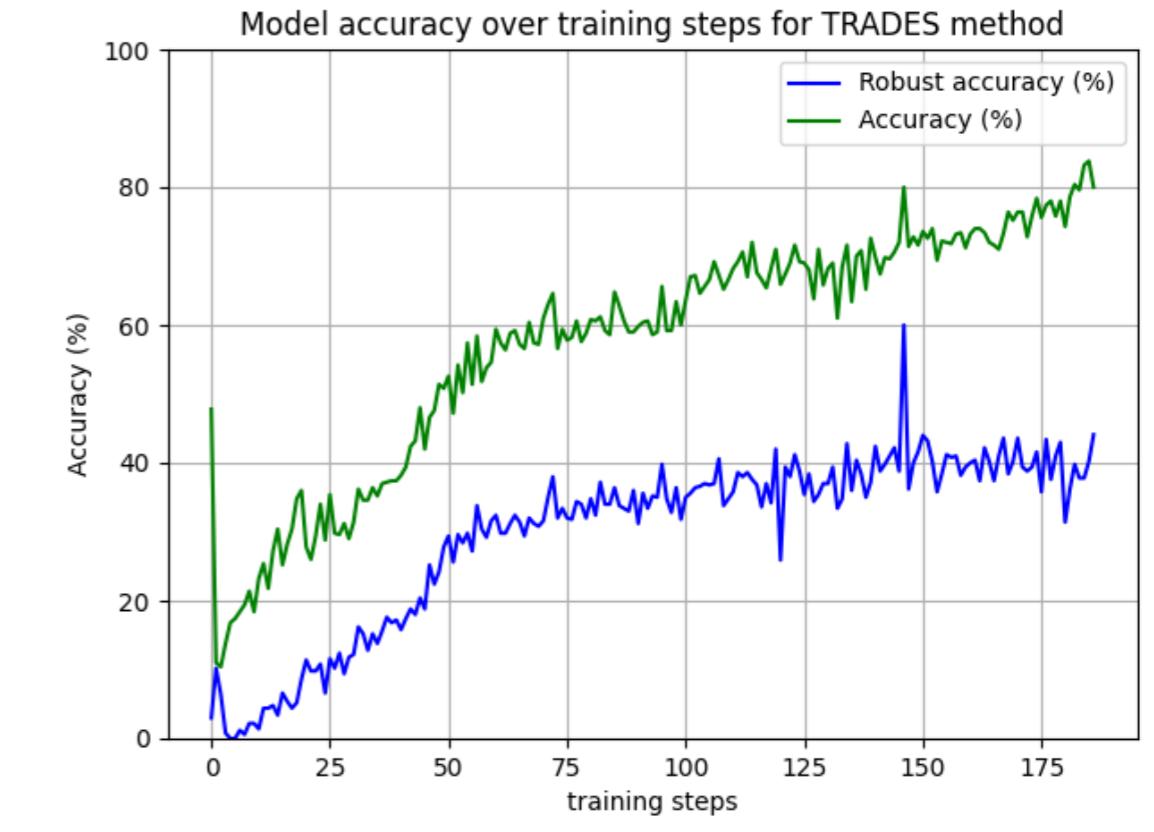


Figure 1: Robustness and accuracy across defense methods.

## Quantitative Results

Comparison on CIFAR-10 ( $\epsilon = 8/255$ ).

Model	Clean	PGD
Standard	<b>96.56%</b>	0.00%
PGD-AT	77.19%	<b>40.62%</b>
TRADES	81.25%	35.94%

## References

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