PeerAiD: Improving Adversarial Distillation from a Specialized Peer Tutor

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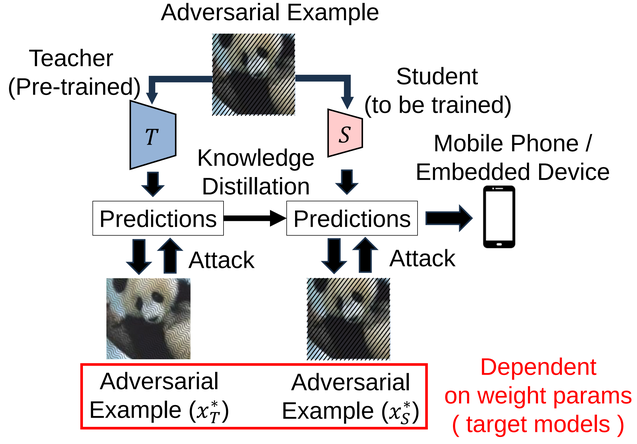
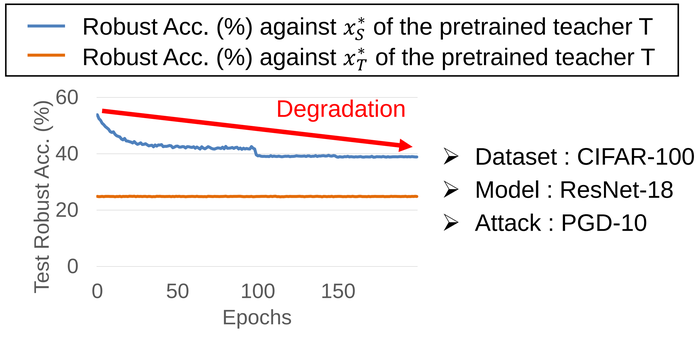
Background

- Adversarial Distillation (AD)
  - Adversarial distillation transfers the knowledge of the teacher to make the small student robust against adversarial examples.



Motivation

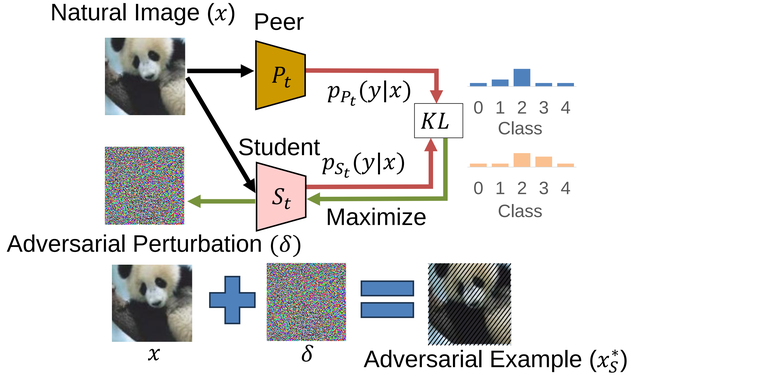
- The pretrained robust teacher model keeps losing its ability to defend against adversarial examples of the student model.



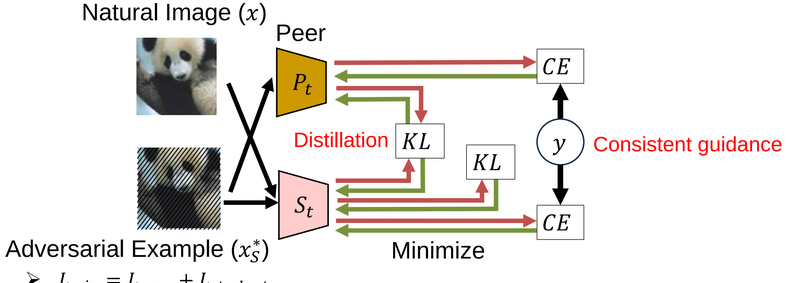
- Dataset : CIFAR-100
- Model : ResNet-18
- Attack : PGD-10

Method

- Peer Tutoring
  - PeerAiD proposes using the peer, which interactively learns with the student during adversarial distillation.
- Adversarial Example Generation (Inner Maximization)
  - The student model uses the predictions of **the peer model** as guidance.



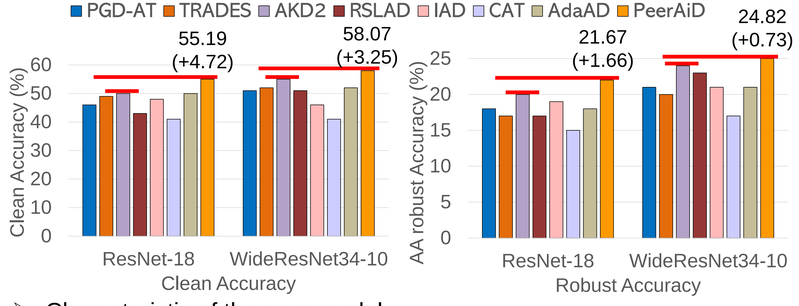
- $L_{max} = KL(P_t(x)||S_t(\tilde{x}))\ where\ \ \tilde{x} \in B(x,\epsilon),\ B(x,\epsilon) = \{\tilde{x} \mid \|x - \tilde{x}\|_\infty \leq \epsilon\}$
- Weight Optimization (Outer Minimization)
  - The student and the peer transfer their own knowledge to each other.



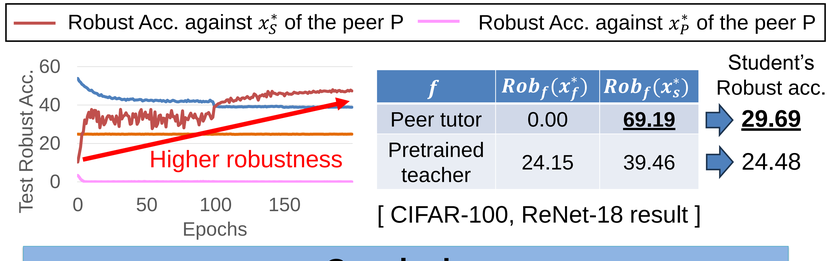
- $L_{min} = L_{peer} + L_{student}$
- $L_{peer} = \gamma_1 H(y, P_t(x_S^*)) + \gamma_2 \tau^2 KL(S_t^\tau(x_S^*)||P_t^\tau(x_S^*))$, τ : temperature
- $L_{student} = \lambda_1 H(y, S_t(x_S^*)) + \lambda_2 \tau^2 KL(P_t^\tau(x_S^*)||S_t^\tau(x_S^*)) + \lambda_3 \tau^2 KL(S_t^\tau(x)||S_t^\tau(x_S^*))$

Results

- TinyImageNet result
  - PeerAiD shows the highest AutoAttack robust accuracy compared to other baselines, while also providing higher clean accuracy.



- Characteristic of the peer model
  - ① Specialist who defends against adversarial examples of the student.
    - No tradeoff between the robustness and clean accuracy.
  - ② High clean accuracy
    - 75.63 (Peer) > 75.48 (Naturally trained)



f	$Rob_f(x_f^*)$	$Rob_f(x_S^*)$	Student's Robust acc.
Peer tutor	0.00	**69.19**	**29.69**
Pretrained teacher	24.15	39.46	24.48

[CIFAR-100, ReNet-18 result]

Conclusion

- We propose a novel online adversarial distillation method, PeerAiD
- The peer model specializes in defending against the student model's attack samples.
- PeerAiD improves AA robust accuracy by 1.66%p and clean accuracy by 4.72%p.

Profile