KU LEUVEN

Evasive and efficient distributed adversarial attacks using PSO

Intermediate presentation II

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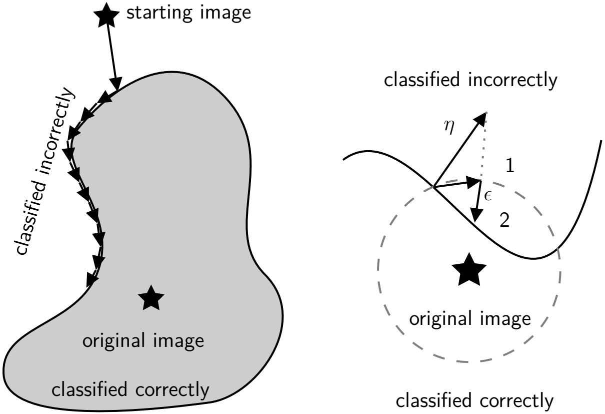
0 Outline

1. Background
2. Research
3. Threat model
4. Evaluation
5. Future work

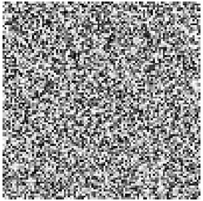
1 Boundary attack[1]

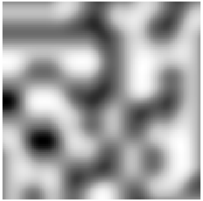


[1] Wieland Brendel, Jonas Rauber, and Matthias Bethge. “Decision-Based Adversarial Attacks: Reliable Attacks Against Black-Box Machine Learning Models”. In: *arXiv:1712.04248 [cs, stat]* (Feb. 2018). arXiv: 1712.04248. URL: http://arxiv.org/abs/1712.04248 (visited on 08/04/2021).

1 Biased boundary attack[2]

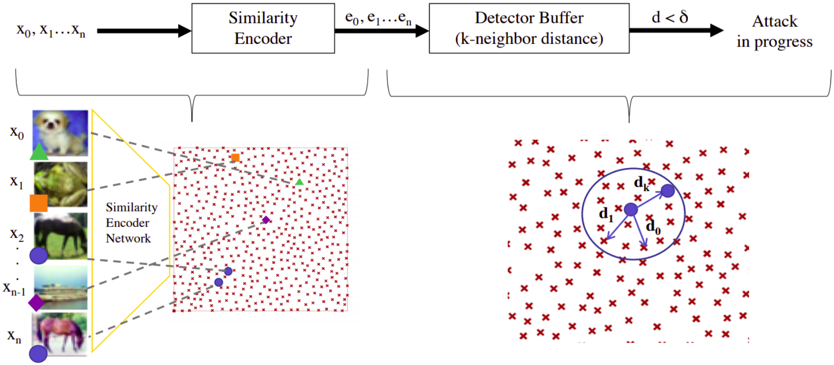
- Improvement on boundary attack
  - Low frequency noise sampling
  - Regional masking
  - Gradients of surrogate models





[2] Thomas Brunner et al. "Guessing Smart: Biased Sampling for Efficient Black-Box Adversarial Attacks". In: *2019 IEEE/CVF International Conference on Computer Vision (ICCV)* (Oct. 2019). arXiv: 1812.09803, pp. 4957–4965. DOI: 10.1109/ICCV.2019.00506. URL: http://arxiv.org/abs/1812.09803 (visited on 08/04/2021).

1 Stateful defense[3]



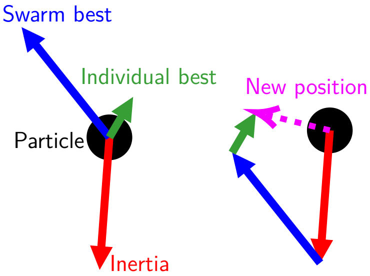
$x_0, x_1 \ldots x_n$ → Similarity Encoder → $e_0, e_1 \ldots e_n$ → Detector Buffer (k-neighbor distance) → $d < \delta$ → Attack in progress

[3] Steven Chen, Nicholas Carlini, and David Wagner. "Stateful Detection of Black-Box Adversarial Attacks". In: *arXiv:1907.05587 [cs]* (July 2019). arXiv: 1907.05587. URL: http://arxiv.org/abs/1907.05587 (visited on 08/04/2021).

1 Particle swarm optimization

$$v_t = \underbrace{w v_{t-1}}_{\text{Inertia}} + \underbrace{c_p r_p (p_{t-1} - x_{t-1})}_{\text{Individual best}} + \underbrace{c_g r_g (g_{t-1} - x_{t-1})}_{\text{Swarm best}}$$

$$x_t = x_{t-1} + v_t$$



2 Goal

- Propose new family of attacks
- Define threat model
- Experiment with the proposed attack
- Answer the following research questions:
  - What are the (dis)advantages of using PSO in relation to vanilla adversarial attacks?
  - How can PSO be combined with state of the art adversarial attacks?
  - What are the (dis)advantages of distributing an adversarial attack?

3 Threat model

- Decision based attack
- Targeted attack
- Stateful detection mechanism
  - Query bounded buffer
  - One buffer per account
- Cost per account
- Cost per query

4 Evaluation protocol

- MNIST[4] and CIFAR-10[5]
- Black box model[6]

[4] Y. Lecun et al. “Gradient-based learning applied to document recognition”. In: *Proceedings of the IEEE* 86.11 (1998), pp. 2278–2324. DOI: 10.1109/5.726791.

[5] Alex Krizhevsky. “Learning Multiple Layers of Features from Tiny Images”. In: (2009), pp. 32–33. URL: https://www.cs.toronto.edu/~kriz/learning-features-2009-TR.pdf.

[6] Nicholas Carlini and David Wagner. *Towards Evaluating the Robustness of Neural Networks*. 2017. arXiv: 1608.04644 [cs.CR].

4 Model architectures

Layer type	MNIST Model	CIFAR Model
Convolution + ReLU	$3 \times 3 \times 32$	$3 \times 3 \times 64$
Convolution + ReLU	$3 \times 3 \times 32$	$3 \times 3 \times 64$
Max Pooling	2×2	2×2
Convolution + ReLU	$3 \times 3 \times 64$	$3 \times 3 \times 128$
Convolution + ReLU	$3 \times 3 \times 64$	$3 \times 3 \times 128$
Max Pooling	2×2	2×2
Fully Connected + ReLU	200	256
Fully Connected + ReLU	200	256
Softmax	10	10

4 Evaluation protocol

- MNIST and CIFAR-10
- Black box model
- List of experiments
  - Original image (+label)
  - Target label
  - Starting position(s)
- Query bounded detector buffer of size 1000
- Number of neighbors is 50
- Query budget of 25000

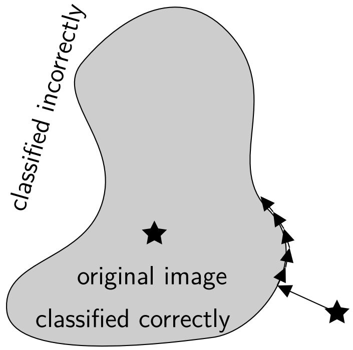
4 Baseline results

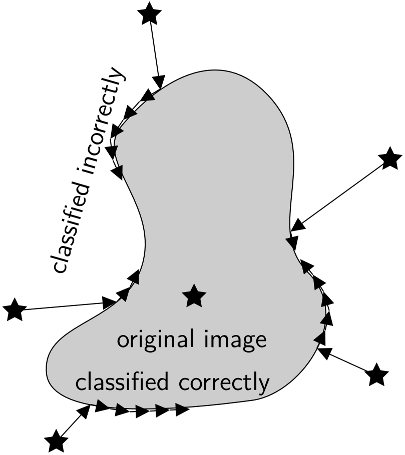
- Determine baseline distance (L_2) and number of detections for biased boundary attack
- Hyperparameters as suggested in original paper[7]

	MNIST		CIFAR	
Attack	Distance	Detections	Distance	Detections
Baseline BBA	2.807	413	1.306	474

[7] Brunner et al., "Guessing Smart".

4 Combining BBA and PSO





4 Combining BBA and PSO

- Multiple starting positions
- More aggressive
- Communication between particles
- Fitness function

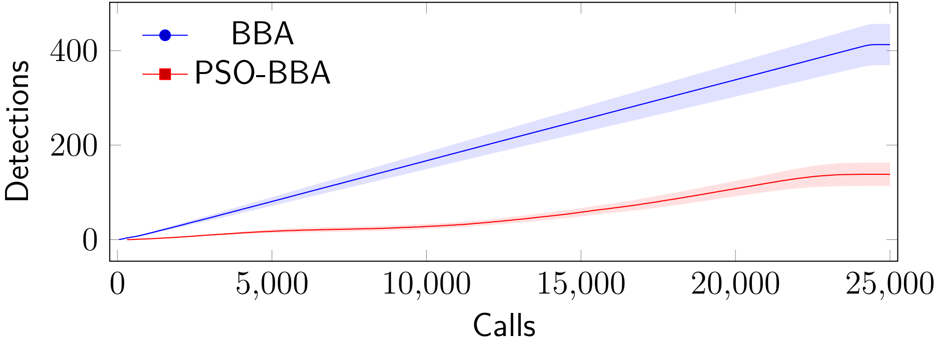
$$f(x) = \begin{cases} \|x - x'\|_2, & \text{if } x \text{ is adversarial} \\ +\infty, & \text{else} \end{cases}$$

4 Combining BBA and PSO

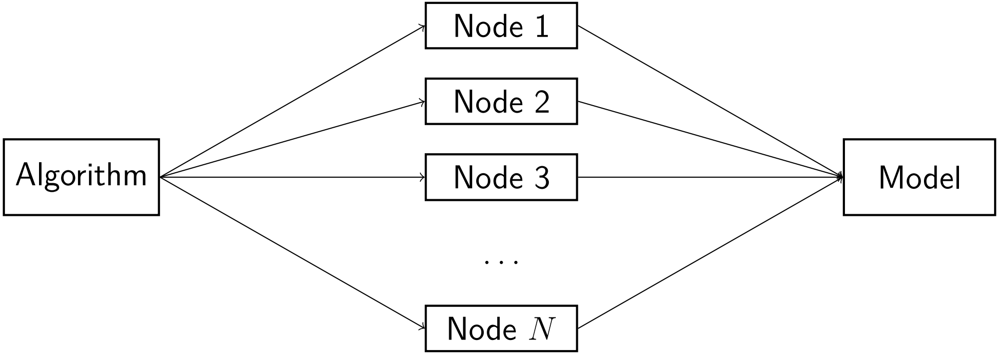
	MNIST		CIFAR	
Attack	Distance	Detections	Distance	Detections
Baseline BBA	2.807	413	1.306	474
PSO-BBA (5 particles)	2.712	138	1.239	257
PSO-BBA (10 particles)	3.157	44	2.290	184

4 Combining BBA and PSO

- Detections happen at the end of attack

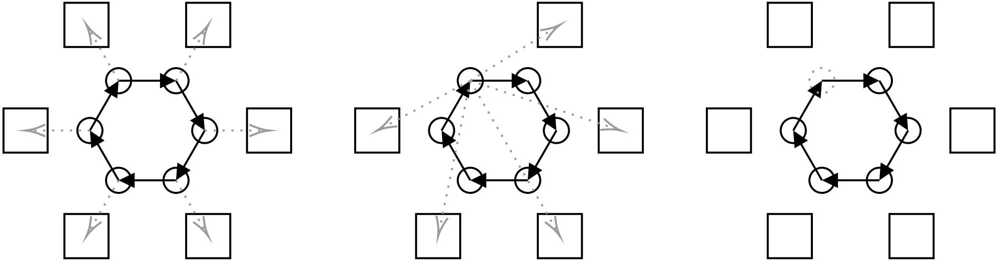


4 Distributing the query submission



4 Distributing the query submission

- Round-Robin (RR)
- Modified Round-Robin (MRR)



4 Distributing the query submission

- Round-Robin (RR)
- Modified Round-Robin (MRR)
- Distance based (DB)
- Embedded distance based (EDB)

4 Distributing the query submission

	MNIST		CIFAR	
Attack	Distance	Detections	Distance	Detections
Baseline BBA	2.807	413	1.306	474
PSO-BBA	2.712	138	1.239	257
RR-PSO-BBA (5 nodes)	2.712	124	1.239	224
RR-PSO-BBA (10 nodes)	2.712	104	1.239	**202**
MRR-PSO-BBA (5 nodes)	2.712	110	1.239	227
MRR-PSO-BBA (10 nodes)	2.712	93	1.239	206
DB-PSO-BBA (5 nodes)	2.712	107	1.239	230
DB-PSO-BBA (10 nodes)	2.712	**87**	1.239	207
EDB-PSO-BBA (5 nodes)	2.712	108	1.239	229
EDB-PSO-BBA (10 nodes)	2.712	88	1.239	205

5 Future work

- Inserting random queries
- Optimizing hyperparameters
- Running optimized attack on larger test sample
- Comparing with HopSkipJump attack