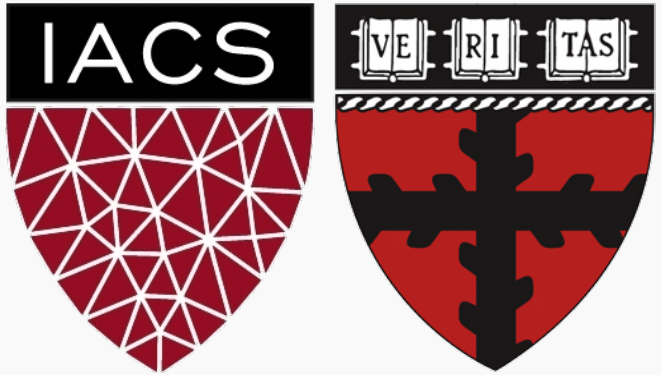
Lecture 21: Adversarial Networks

CS109B Data Science 2

Pavlos Protopapas and Mark Glickman



How vulnerable are Neural Networks?

Uses of Neural Networks

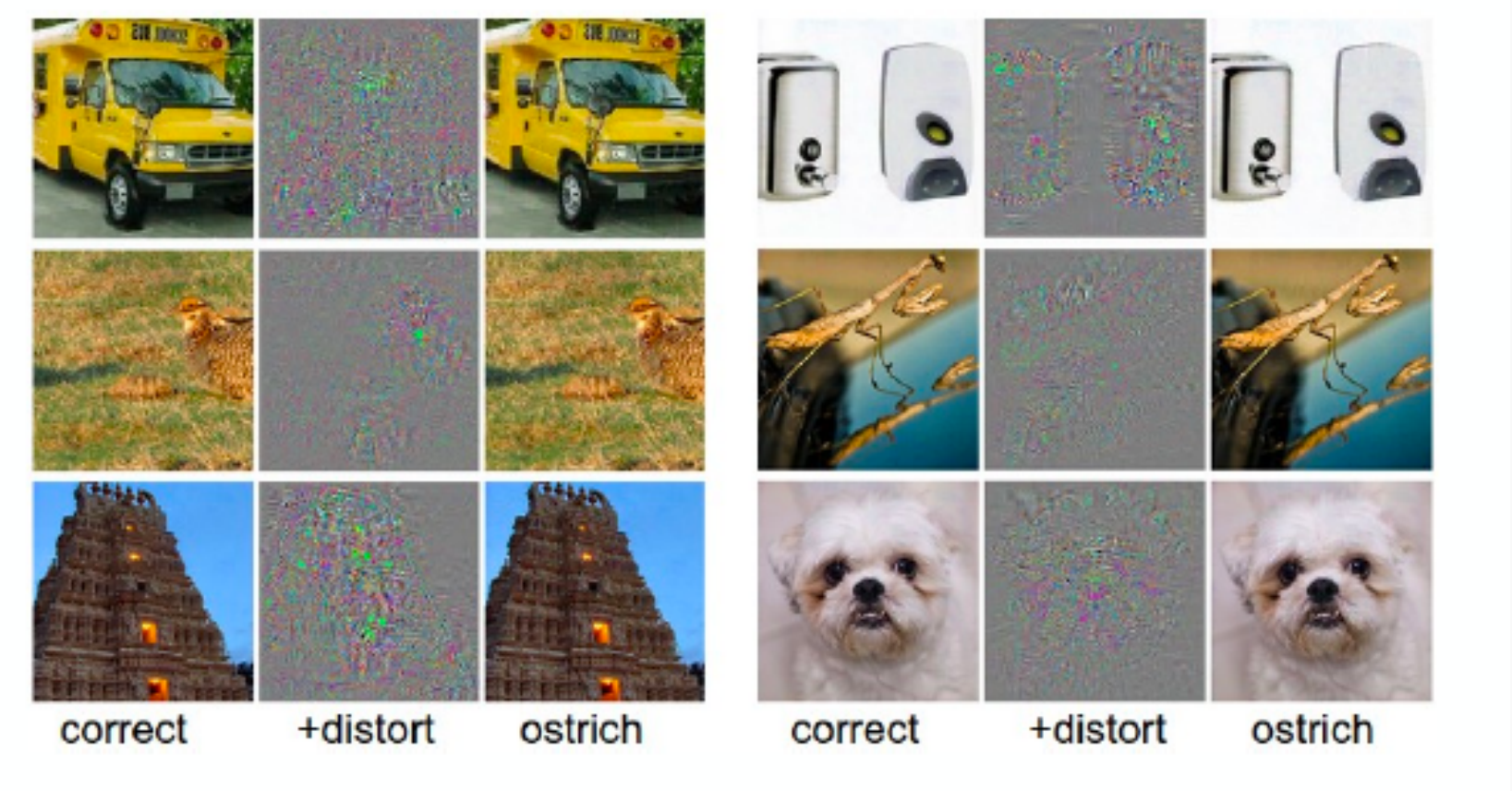
How vulnerable are Neural Networks?

Explaining Adversarial Examples

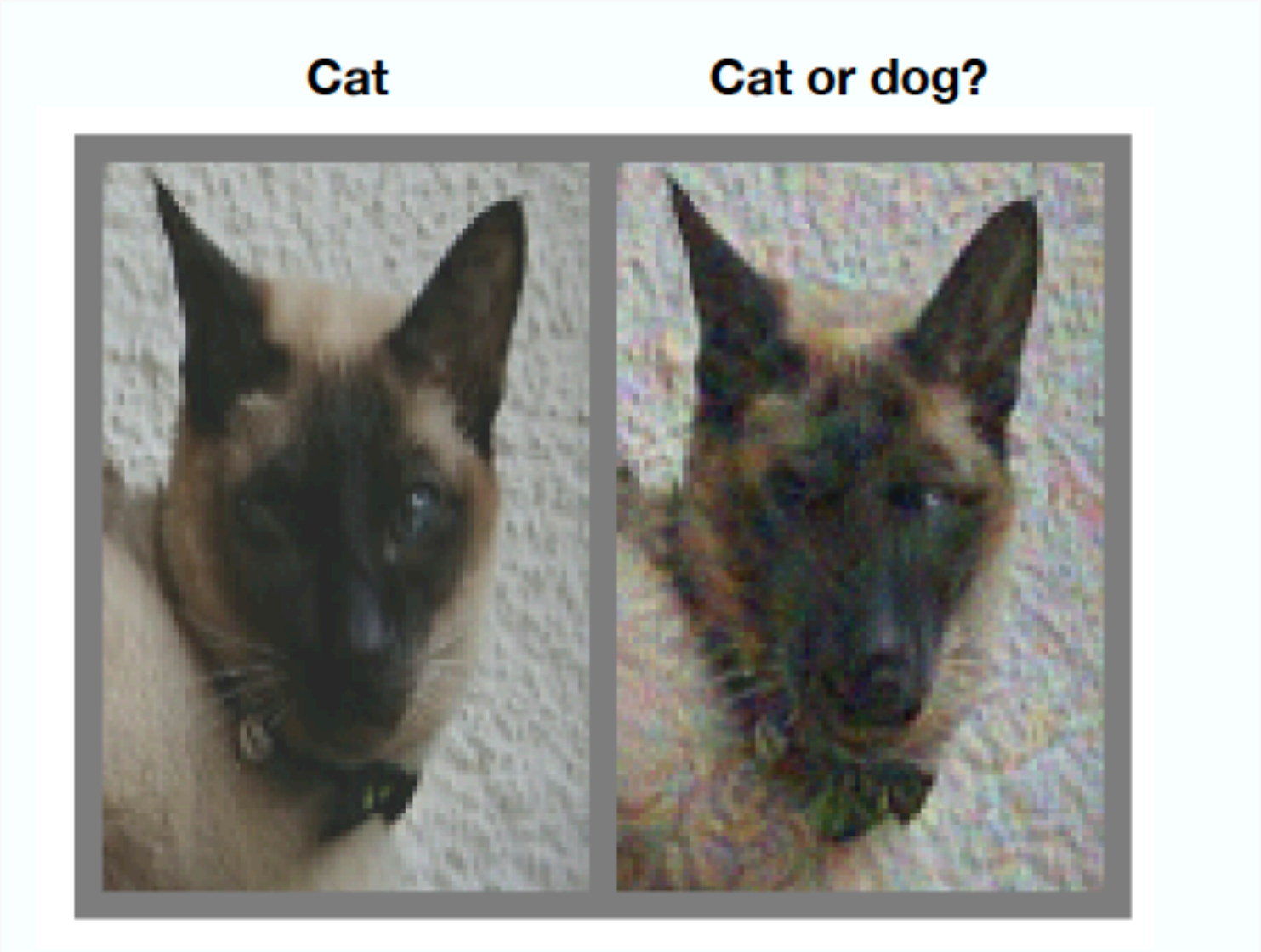
[Goodfellow et. al '15]

1. Robust attacks with FGSM
2. Robust defense with Adversarial Training

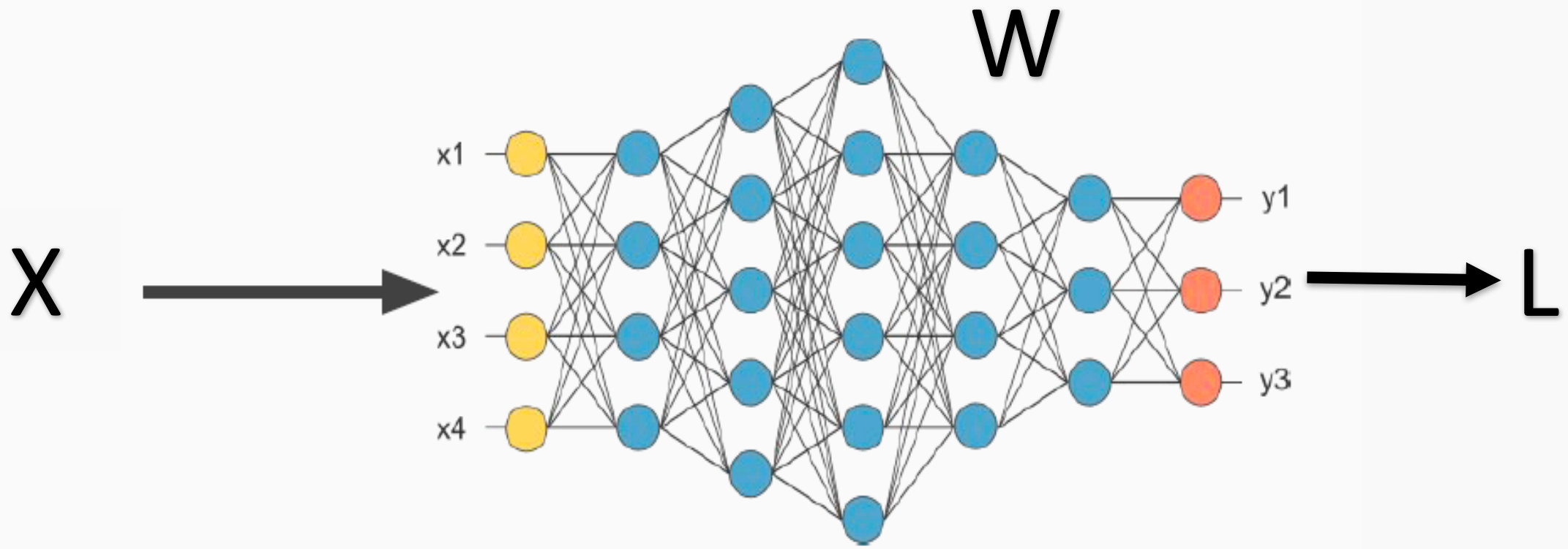
Explaining Adversarial Examples



Some of these adversarial examples can even fool humans:

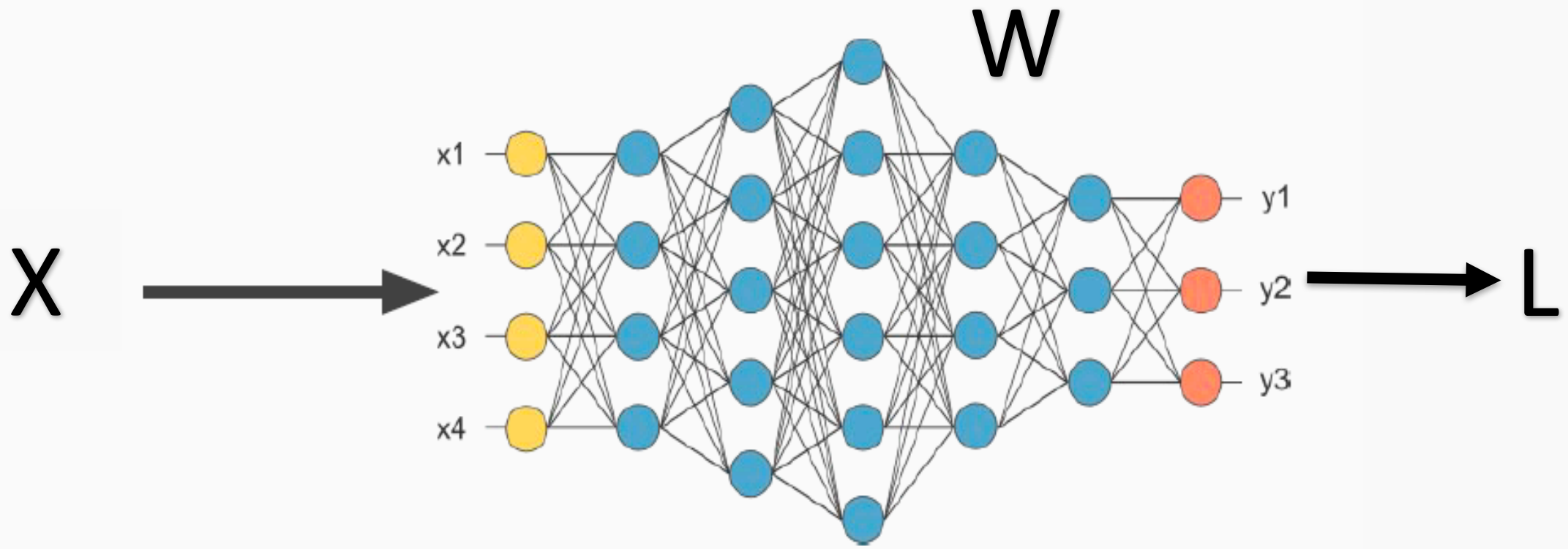


Attacking with **F**ast **G**radient **S**ign **M**ethod (FGSM)



$$x + \lambda \cdot \text{sign}(\nabla_{\text{x}} \text{L}) \Rightarrow \text{x}^*$$

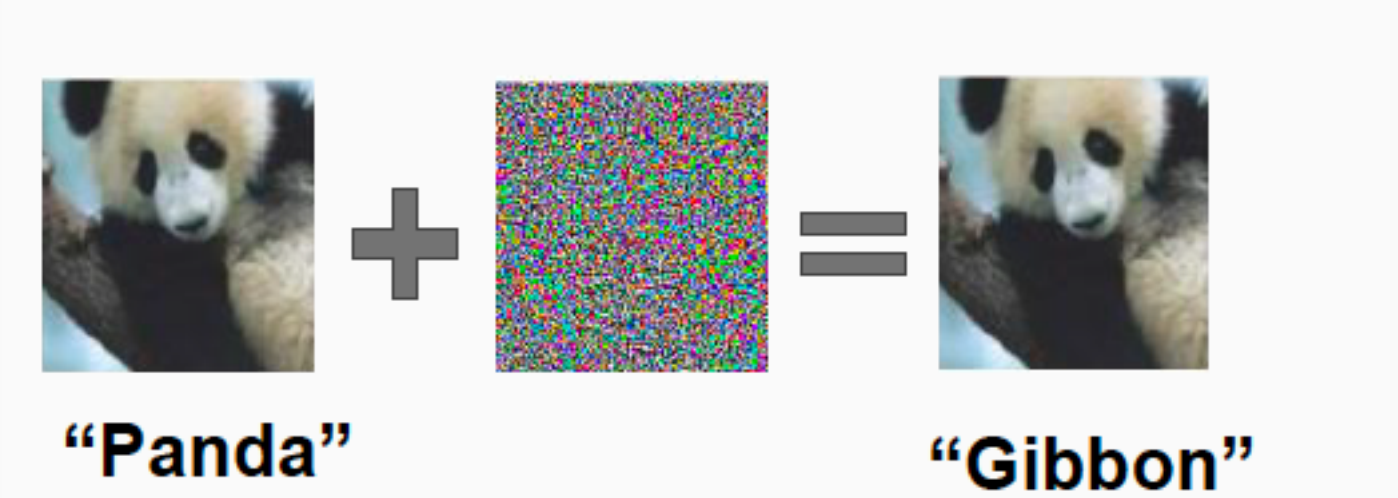
Attacking with **F**ast **G**radient **S**ign **M**ethod (FGSM)



$$x + \lambda \cdot \text{sign}(\nabla_x \text{L}) \Rightarrow \text{x}^*$$

$$x + \lambda \cdot \text{sign}(\nabla_x L) \Rightarrow x^*$$

Defending with Adversarial Training



1. Generate adversarial examples
2. Adjust labels

Defending with Adversarial Training

1. Generate adversarial examples
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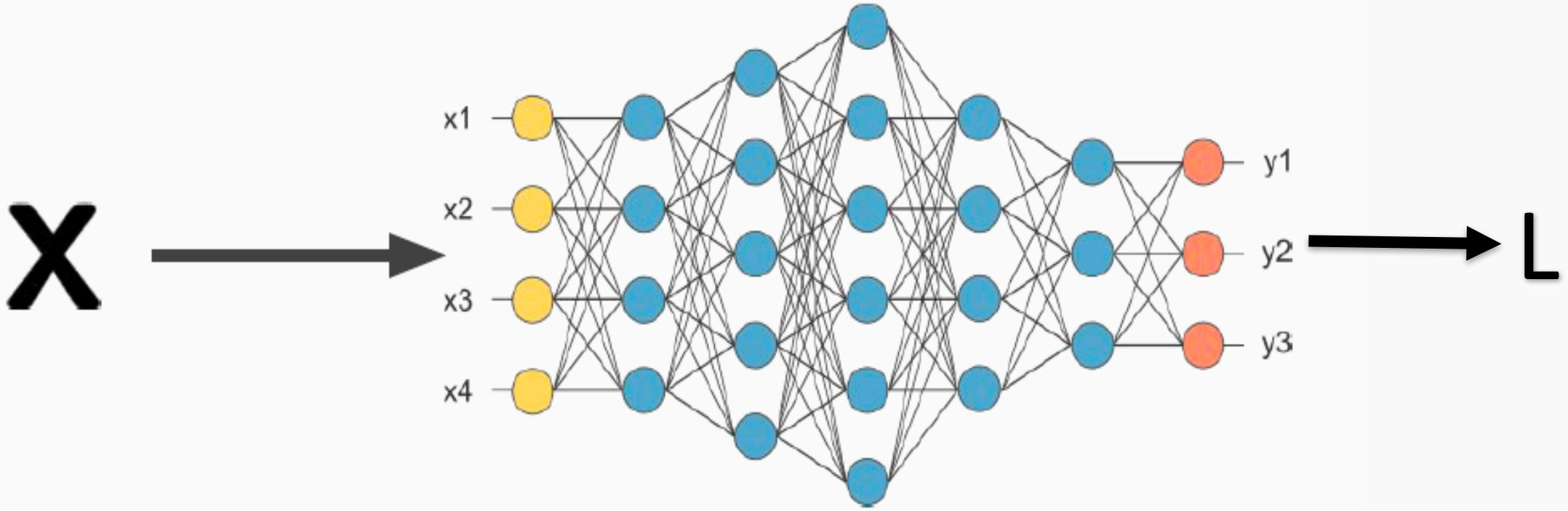
Defending with Adversarial Training

1. Generate adversarial examples
2. Adjust labels
3. Add them to the training set
4. Train new network

Attack methods post GoodFellow 2015

- FGSM [Goodfellow et. al ‘15]
- JSMA [Papernot et. al ‘16]
- C&W [Carlini + Wagner ‘16]
- Step-LL [Kurakin et. al ‘17]
- I-FGSM [Tramer et. al ‘18]

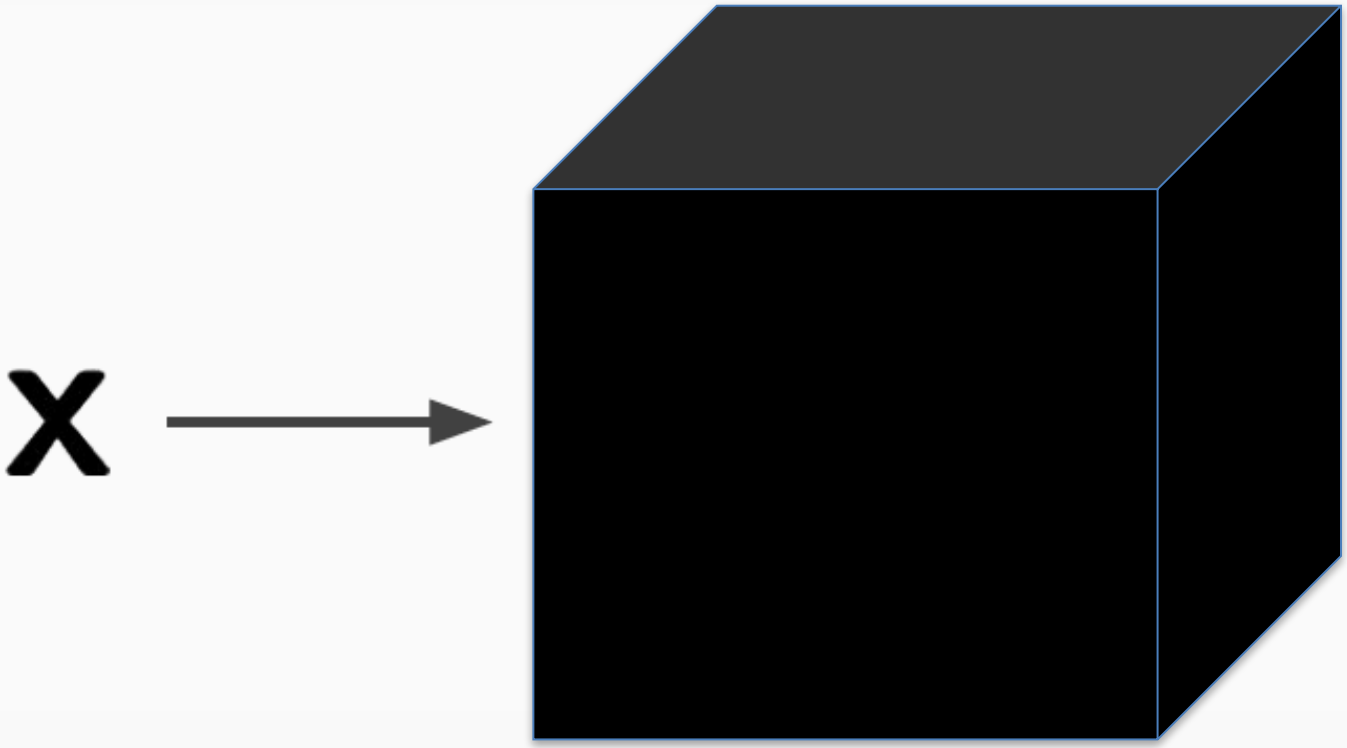
White box attacks



$$x + \lambda \cdot \text{sign}(\nabla_x \text{L}) \Rightarrow \text{x}^*$$

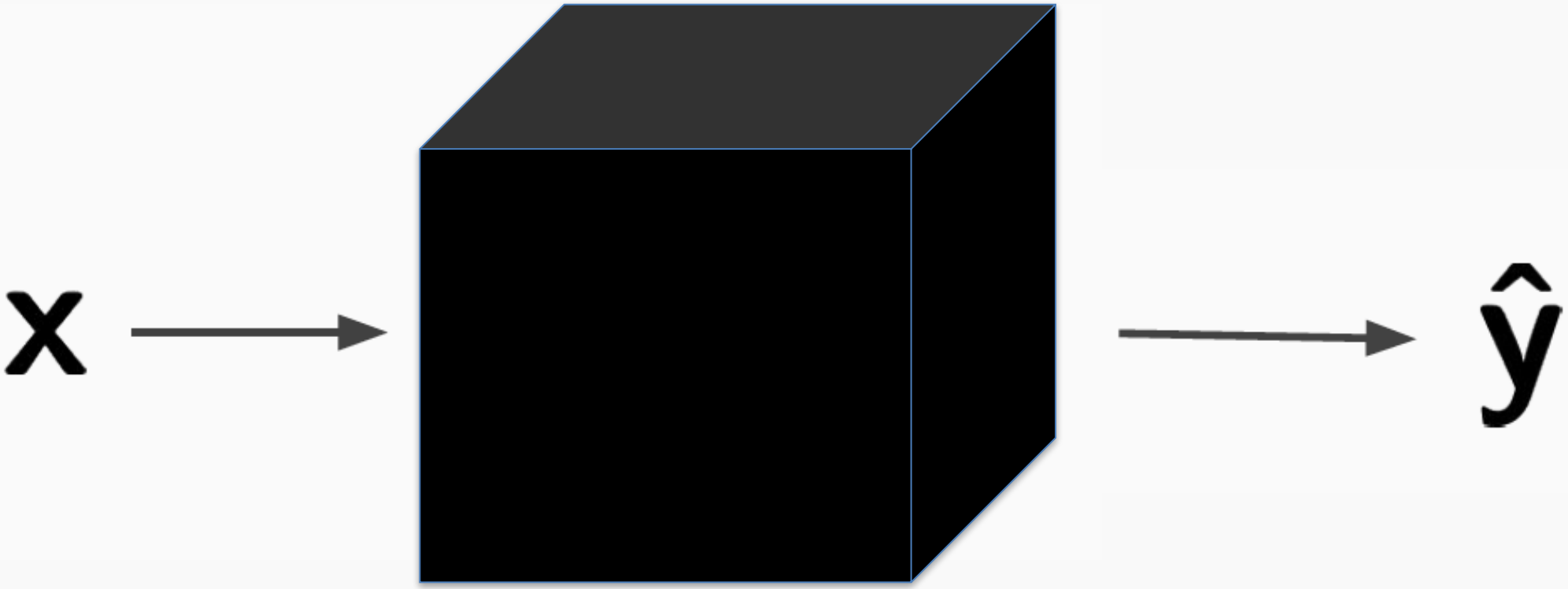
“Black Box” Attacks

“Black Box” Attacks [Papernot et. al ‘17]



“Black Box” Attacks

Examine inputs and outputs of the model

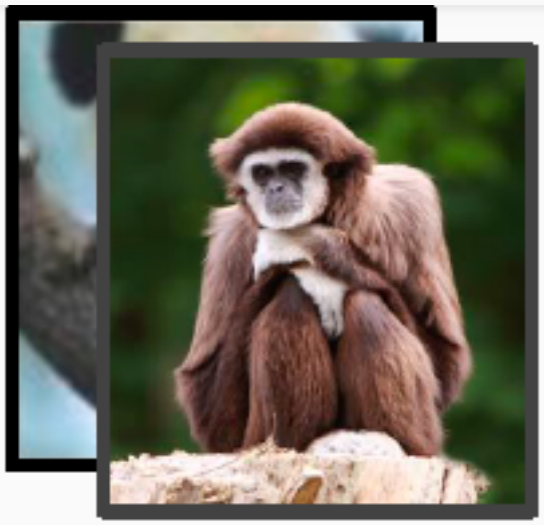


“Black Box” Attacks

Panda

x → [ ] → $\hat{y}$

“Black Box” Attacks



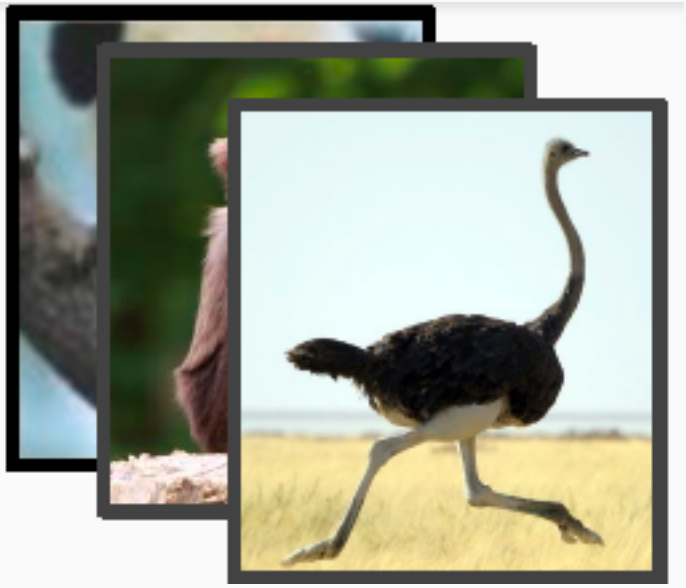
Panda

Gibbon

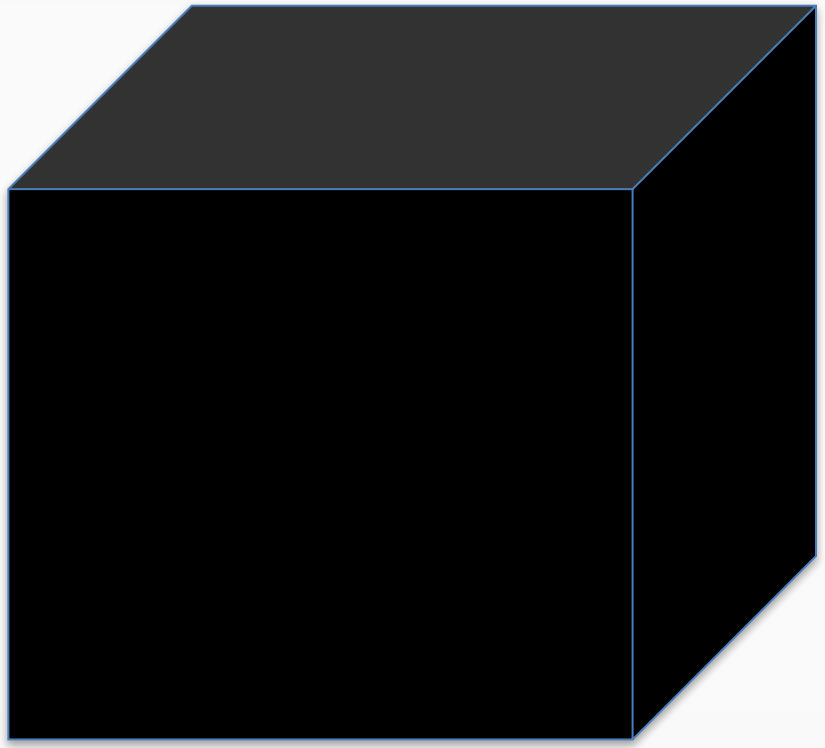
x

$\hat{y}$

“Black Box” Attacks



x



Panda
Gibbon
Ostrich

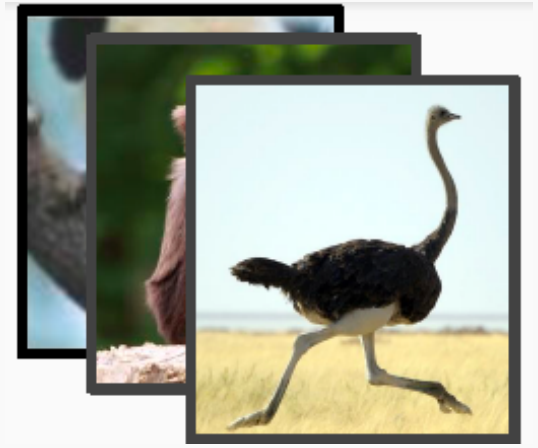
$\hat{y}$

“Black Box” Attacks

Train a model that performs the same as the black box

“Black Box” Attacks

Train a model that performs the same as the black box



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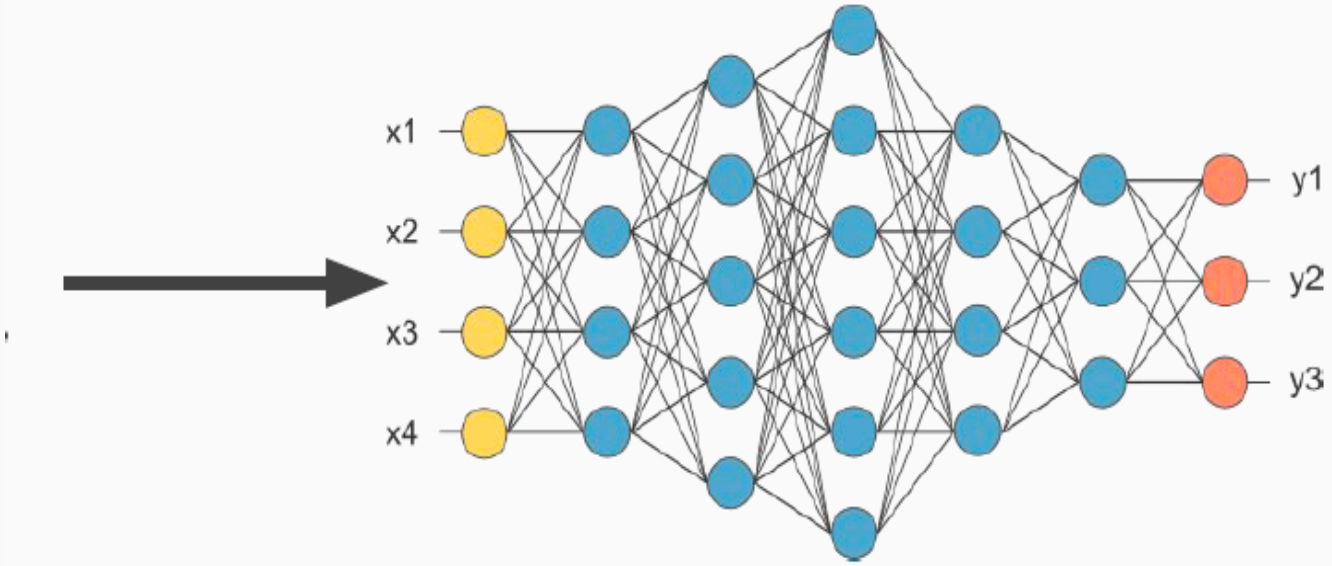
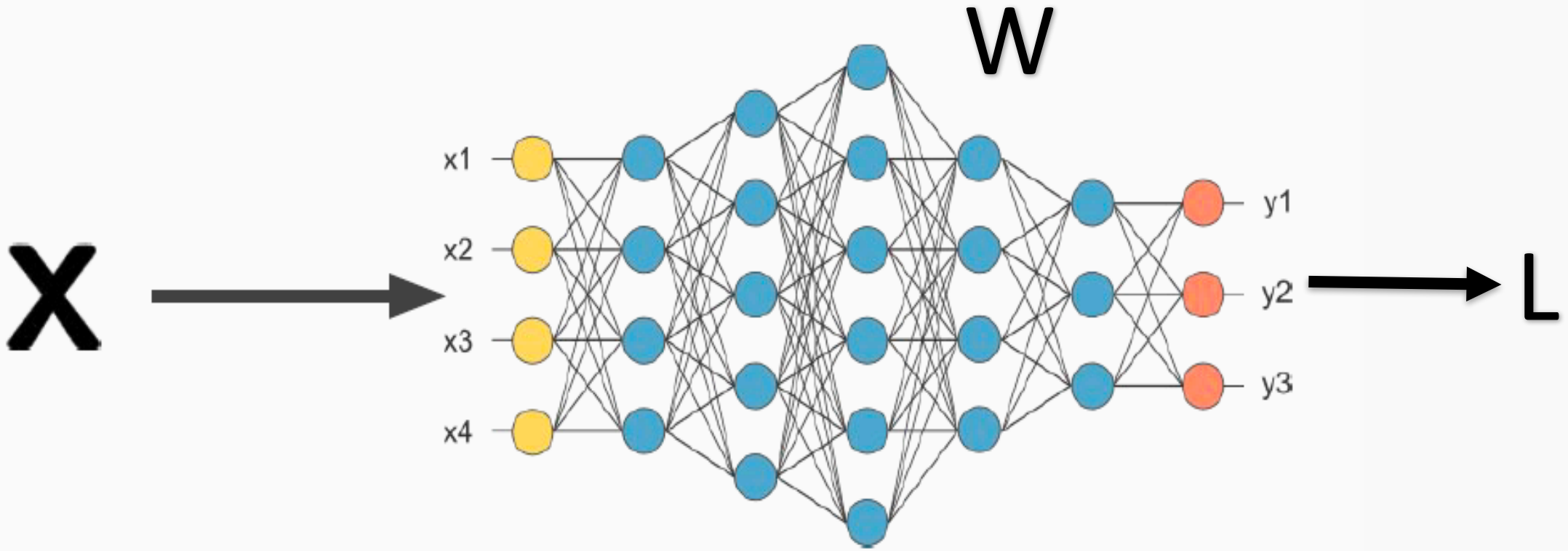


“Black Box” Attacks

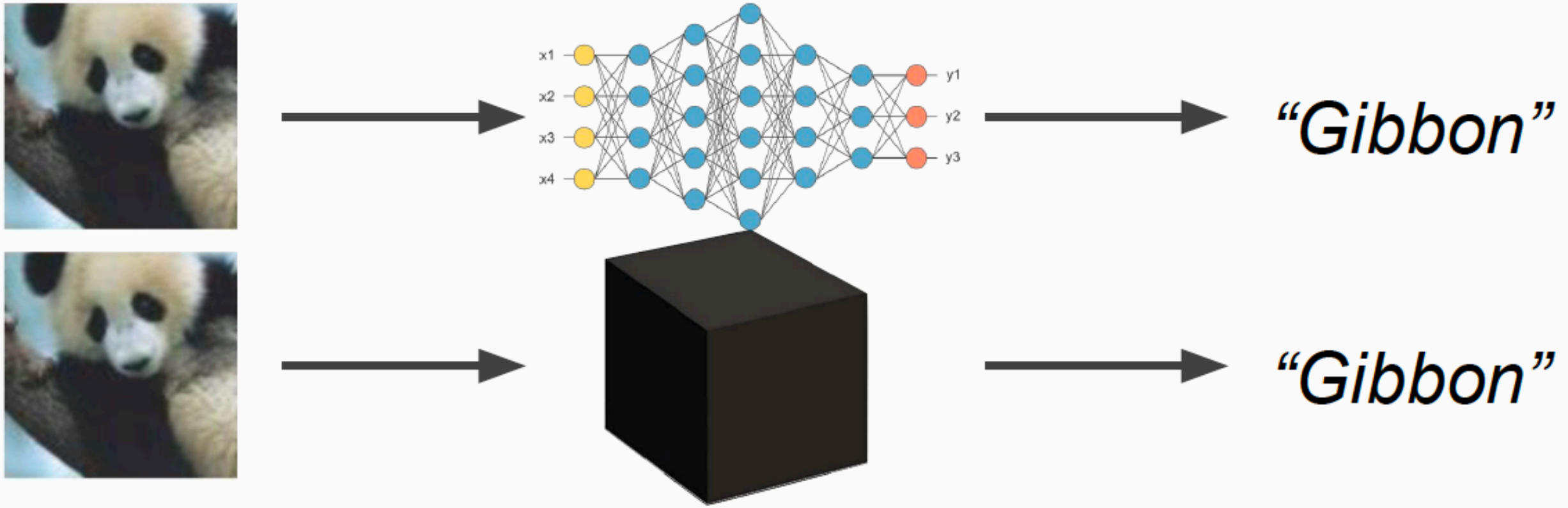
Now attack the model you just trained with “white” box attack



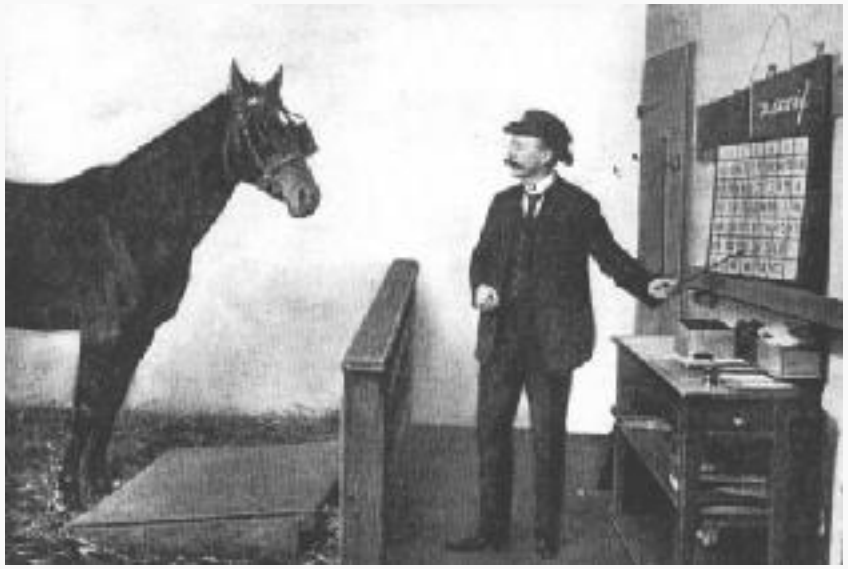
$$x + \lambda \cdot \text{sign}(\nabla_x L) \Rightarrow x^*$$

“Black Box” Attacks

Use those adversarial examples to the “black” box



CleverHans



A Python library to benchmark machine learning systems' vulnerability to adversarial examples.

https://github.com/tensorflow/cleverhans
http://www.cleverhans.io/

More Defenses

Mixup:

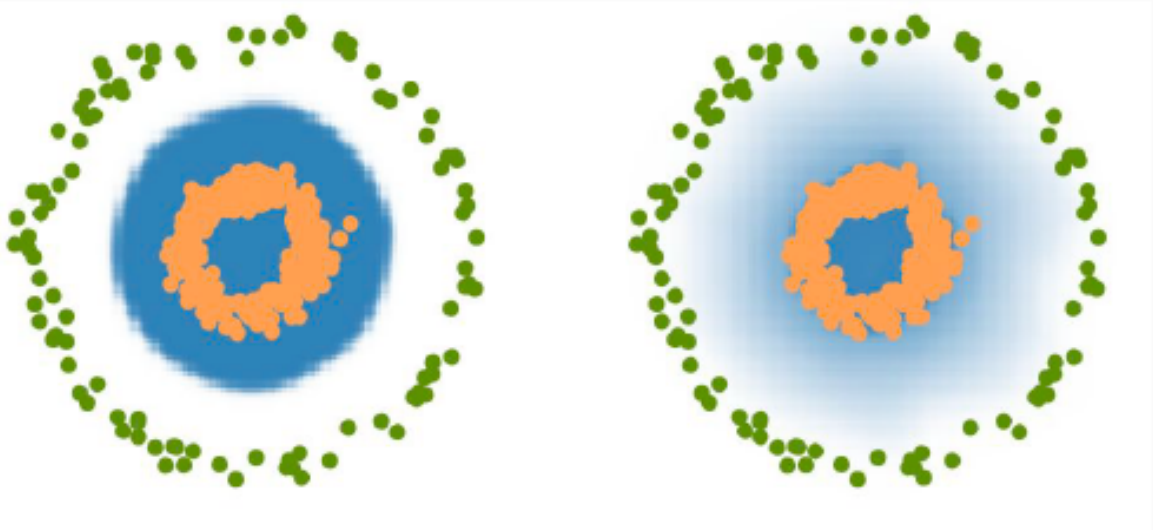
- Mix two training examples
- Augment training set

$$\tilde{x} = \lambda x_i + (1-\lambda)x_j$$

$$\tilde{y} = \lambda y_i + (1-\lambda)y_j$$

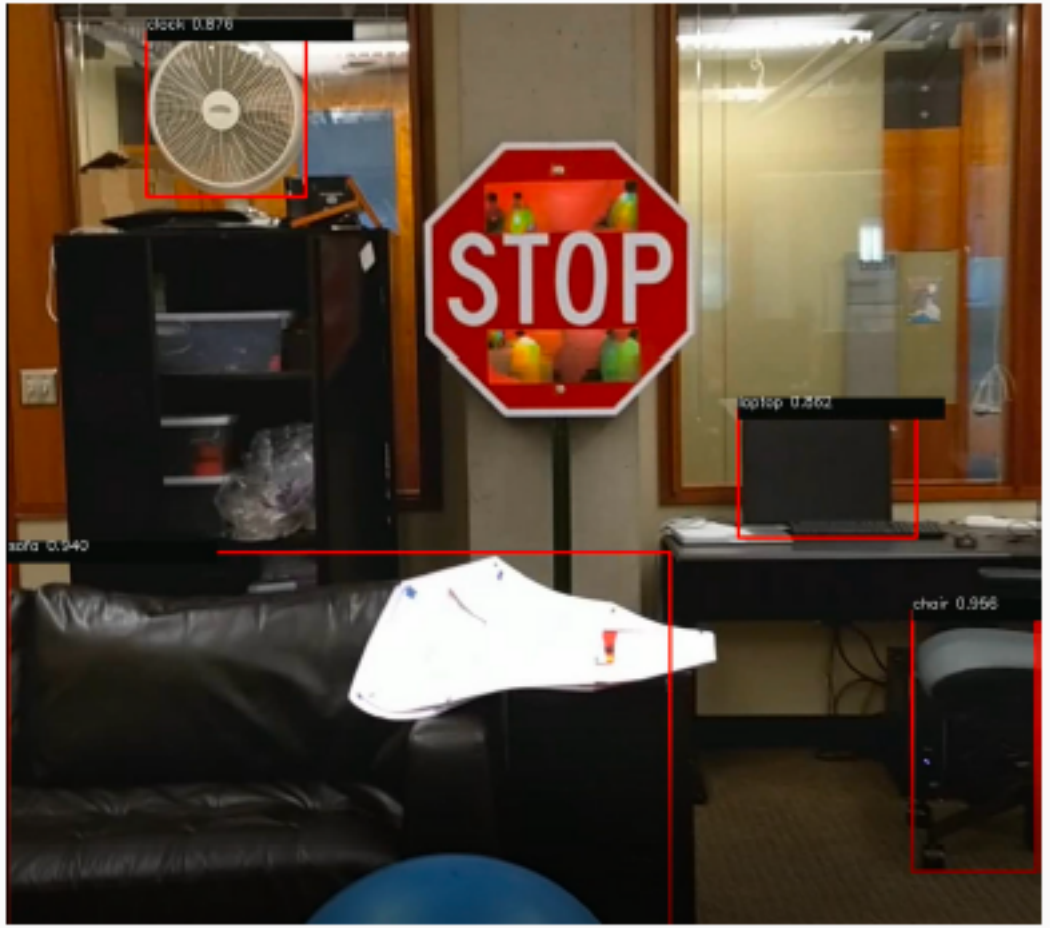
Smooth decision boundaries:

- Regularize the derivatives wrt to x



Physical attacks

- Object Detection
- Adversarial Stickers



Thank you.