# Art of singular vectors and universal adversarial perturbations

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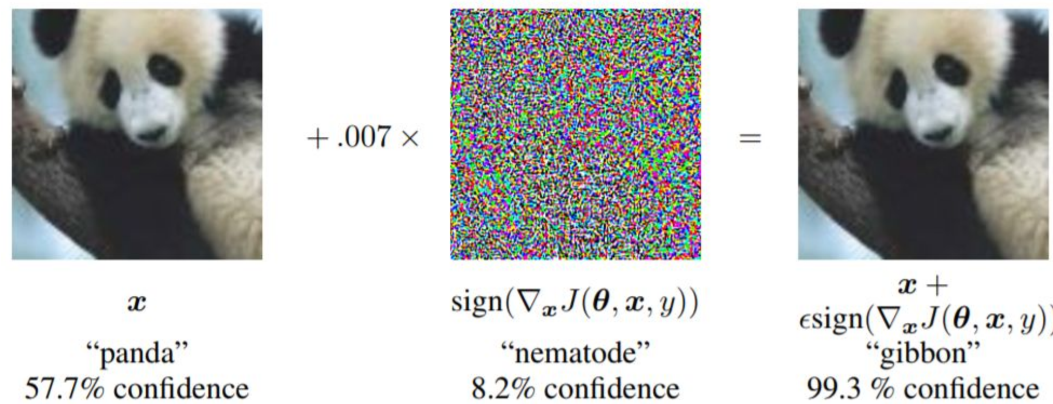
# Introduction

Adversarial attacks

- Negligible perturbations in input leads to misclassification
- Usually individual attack for an image
- What about universal perturbations?




$$\frac{|\{x \in \mathcal{D} : \arg\max p(x) \neq \arg\max p(x + \varepsilon)\}|}{|\mathcal{D}|} \to \max_{\varepsilon}$$

# Method

- Let's find small perturbation which cause the largest difference in some layer:

$$f_i(x+\varepsilon) - f_i(x) \approx J_i(x)\varepsilon$$

$$\|f_i(x+\varepsilon) - f_i(x)\|_q \approx \|J_i(x)\varepsilon\|_q$$

- Find best perturbation via the following problem:

$$\sum_{x_j \in X} \|J_i(x_j)\varepsilon\|_q^q \to \max \qquad \|\varepsilon\|_p = 1$$

- This problem is equivalent to the finding the (p, q) singular vector:

$$\|J_i(X_b)\varepsilon\|_q \to \max \qquad \|\varepsilon\|_p = 1$$

$$J_i(X_b) = \begin{bmatrix} J_i(x_1) \\ J_i(x_2) \\ \dots \\ J_i(x_b) \end{bmatrix}$$

# Method

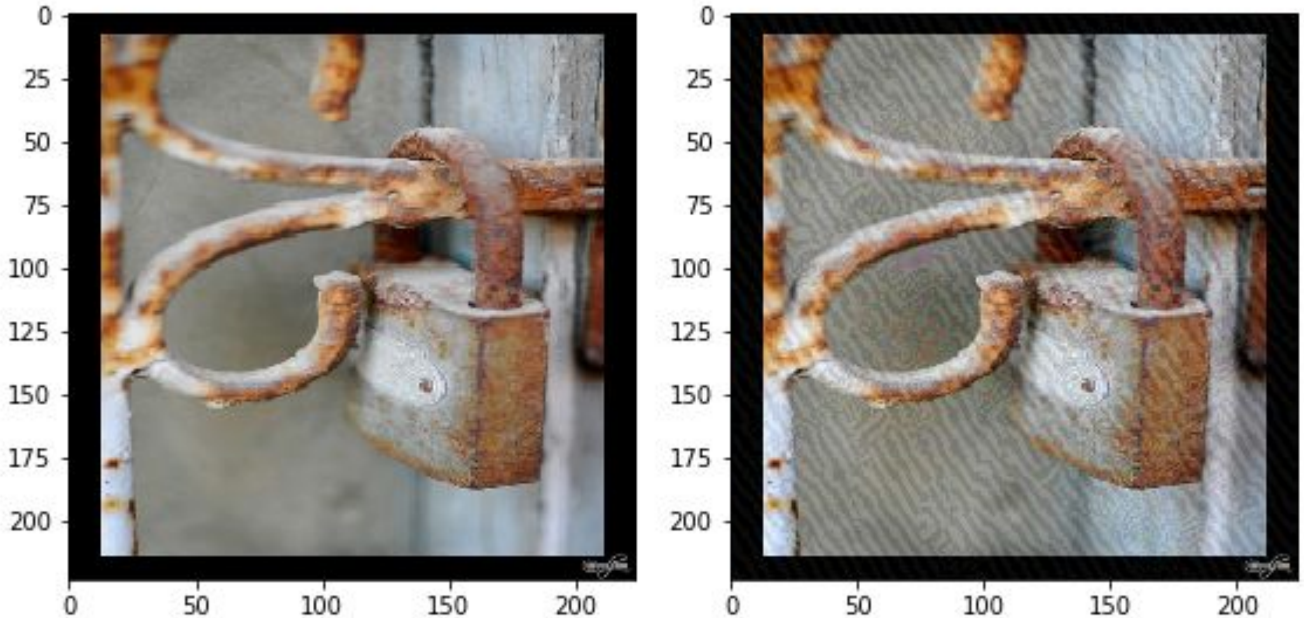
- How to deal with intractable Jacobi matrix?
- We only need matvec operation.

$$\boxed{\nabla\langle v_1, f_i(x)\rangle(x)} = \left(v_1^T J_i(x)\right)^T = J_i^T v_1$$

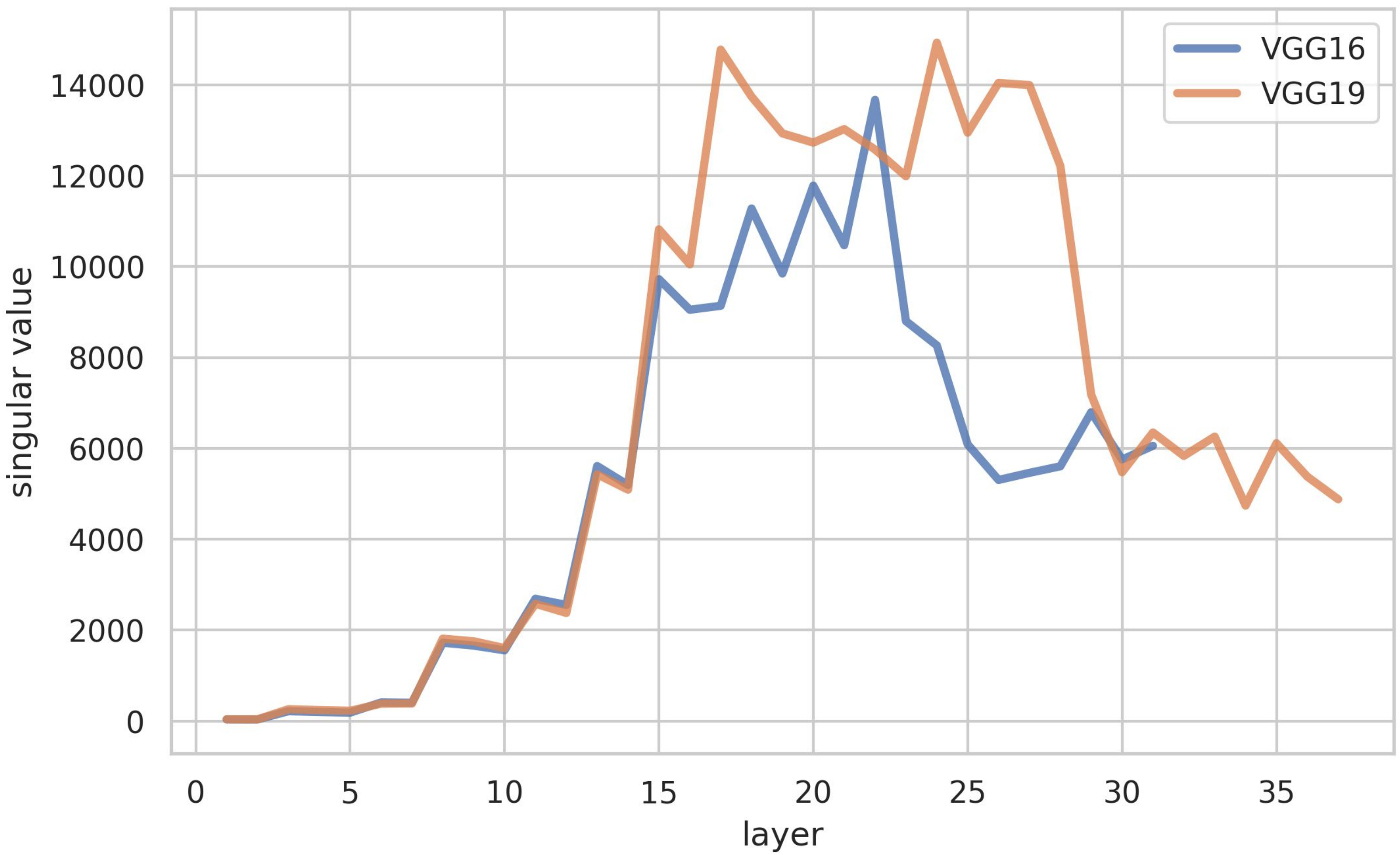
$$\boxed{\nabla\langle J_i(x)v_1, v_2\rangle} = J_i v_2$$

Automatic differentiation

# Example of the attack



# Singular values for different layers



# Fooling rates

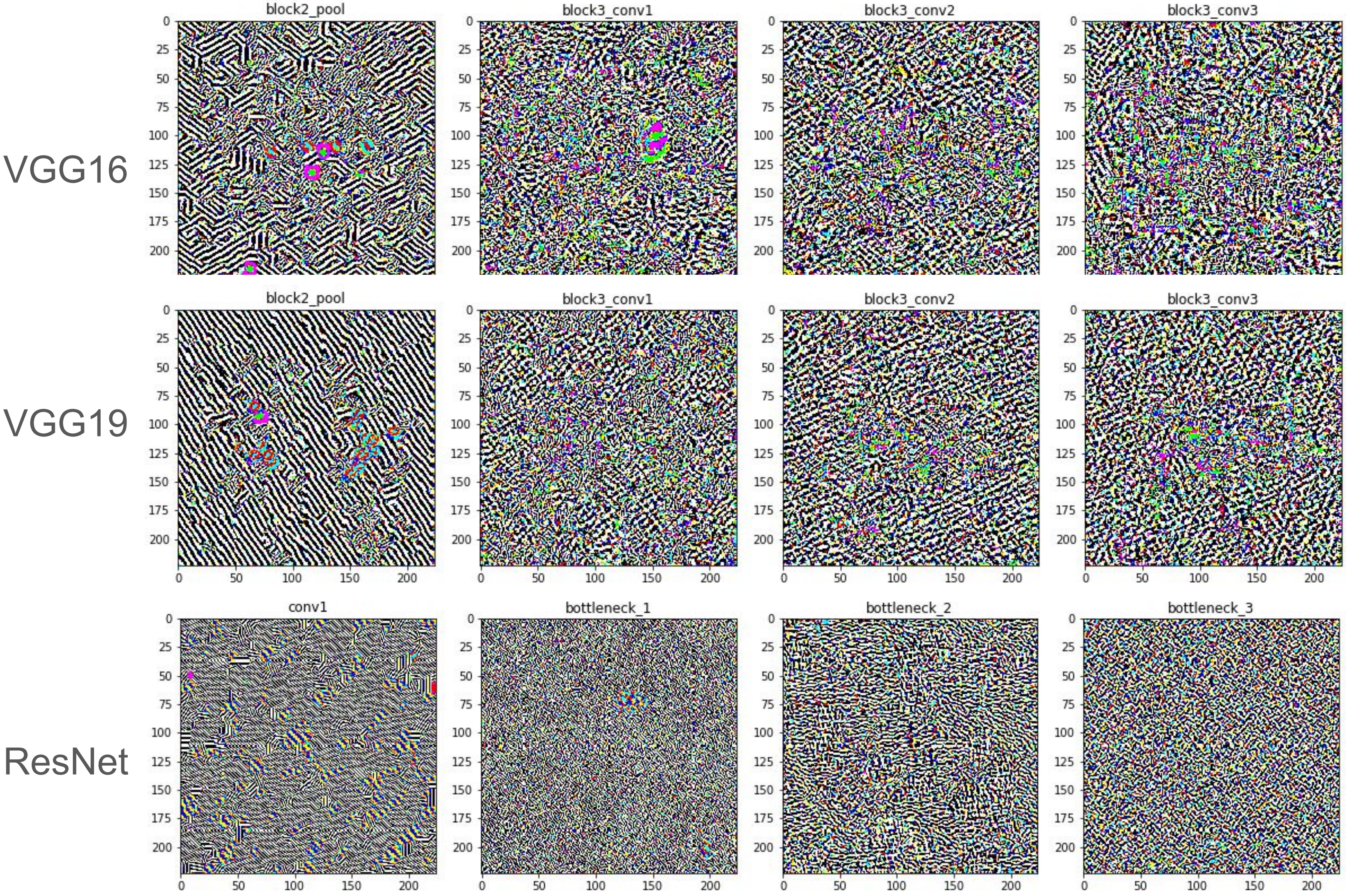
50.000 pictures in test, pretrained architectures from pytorch and inf norm of perturbation is 10

| **VGG16** | block2_pool | block3_conv1 | block3_conv2 | block3_conv3 |
|---|---|---|---|---|
| singular values | 1567.24 | 2446.83 | 5056.81 | 8585.74 |
| fooling rate | **55.99** | 43.3 | 46.8 | 44.31 |

| **VGG19** | block2_pool | block3_conv1 | block3_conv2 | block3_conv3 |
|---|---|---|---|---|
| singular values | 1630.61 | 2415.33 | 5044.3 | 10517.26 |
| fooling rate | **55.95** | 44.39 | 47.25 | 45.69 |

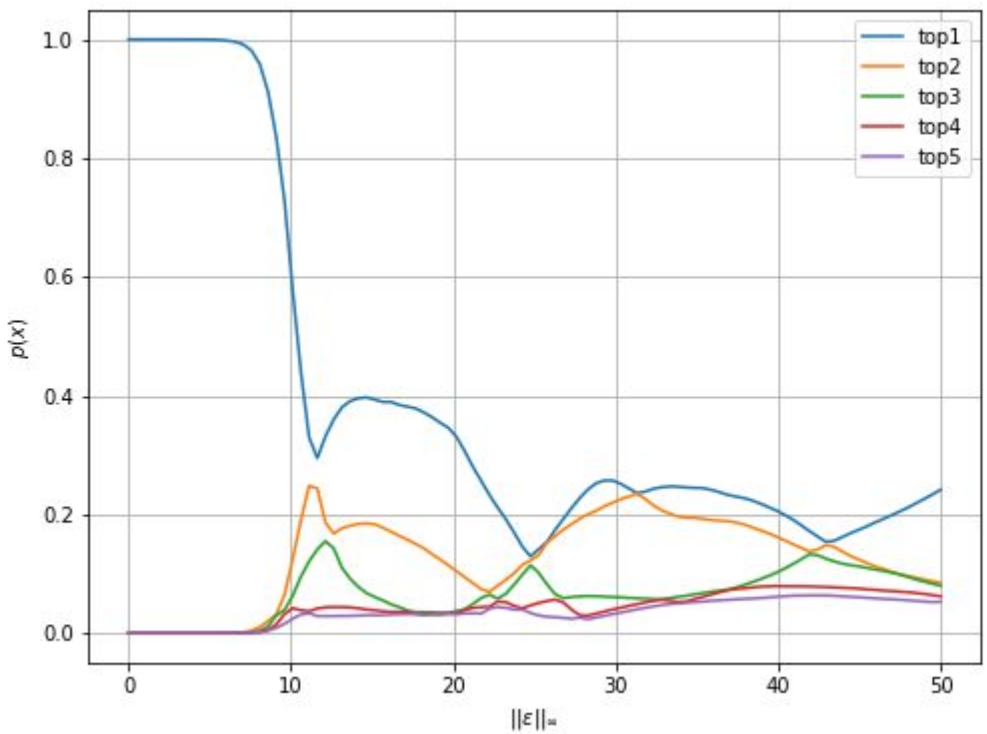
| **ResNet50** | conv1 | bottleneck_1 | bottleneck_2 | bottleneck_3 |
|---|---|---|---|---|
| singular values | 61.11 | 43.4 | 117.34 | 669.24 |
| fooling rate | **47.33** | 34.76 | 33.67 | 29.44 |

# Fooling rates



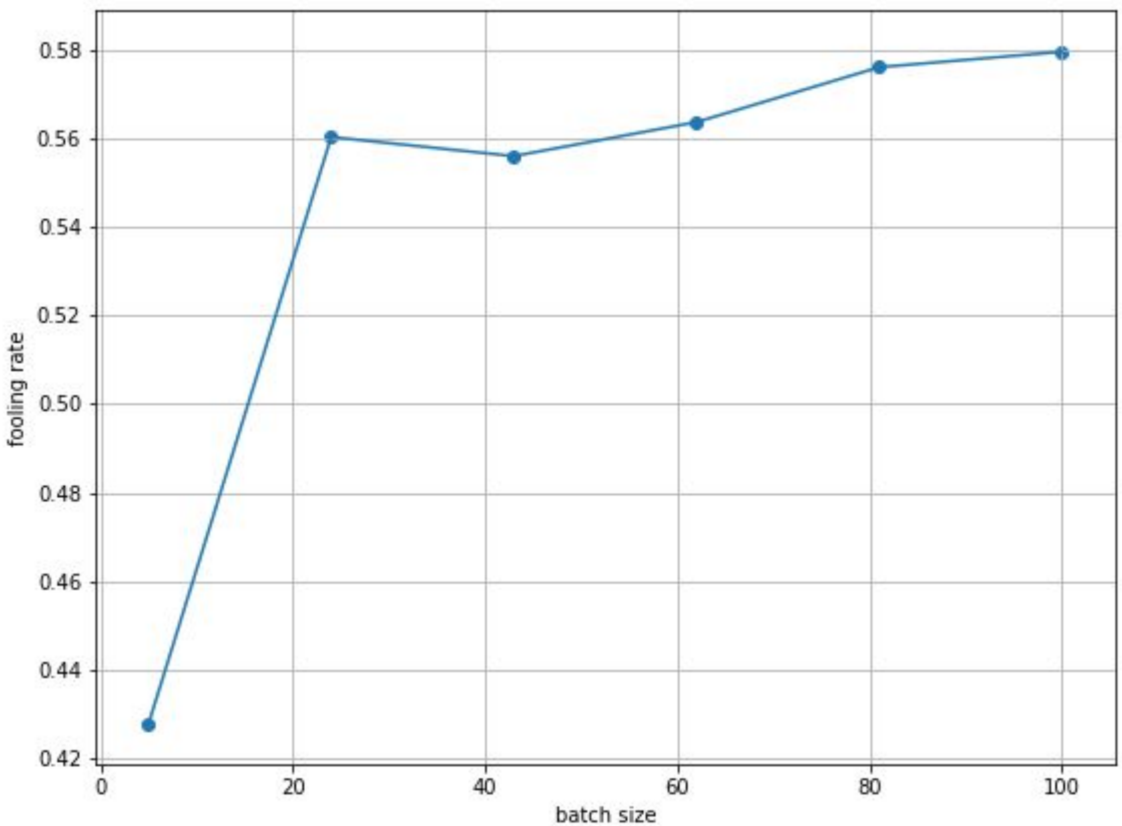
# Fooling rates

| **Generalization** | VGG16 | VGG19 | ResNet50 |
|---|---|---|---|
| VGG16 | 55.99 | 58.04 | **62.15** |
| VGG19 | **57.36** | 55.95 | 56.37 |
| ResNet50 | 37.3 | 36.65 | **47.33** |



# Fooling rate

Dependence of the fooling rate on the batch size block2_pool layer in VGG-19 was used.

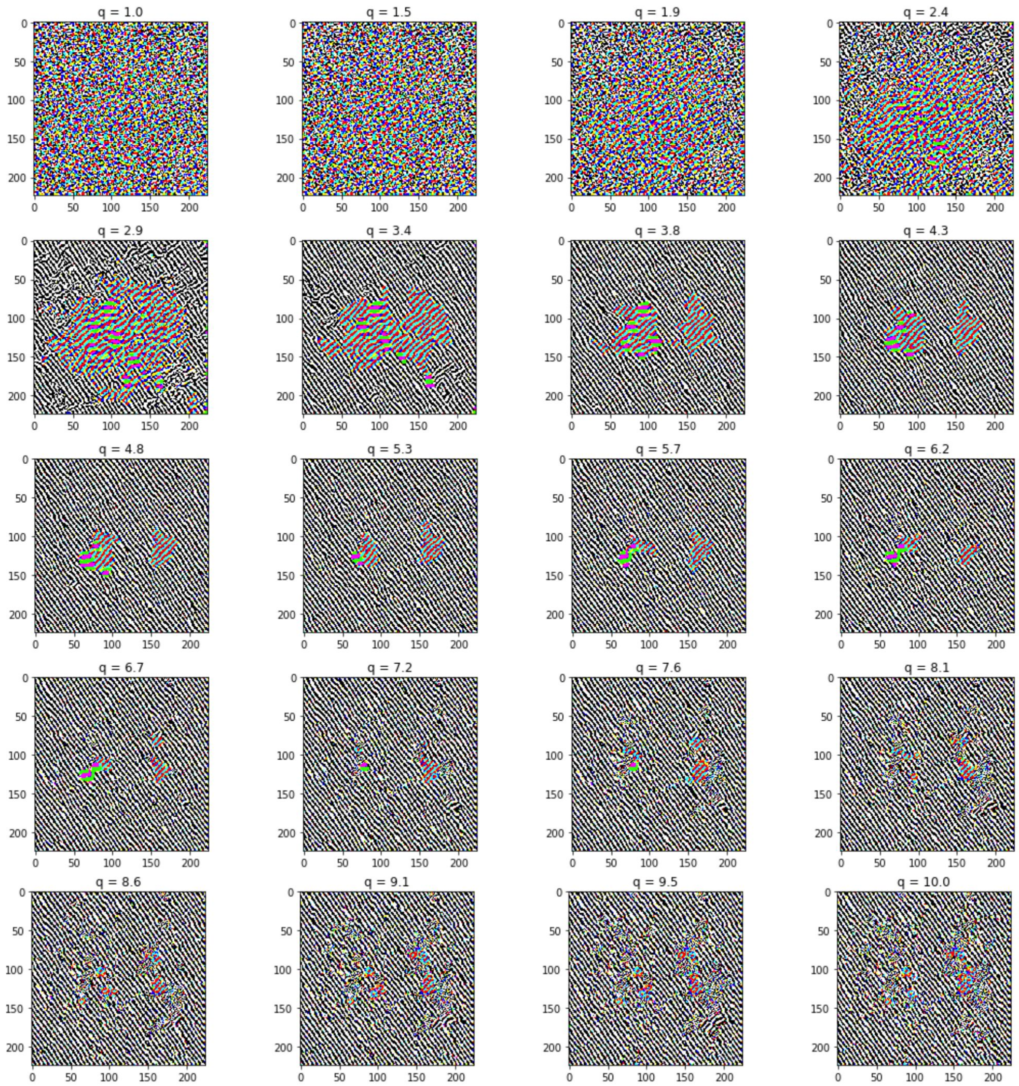


# Dependence of the fooling rate on the value of q

Adversarial perturbations constructed for various values of q.

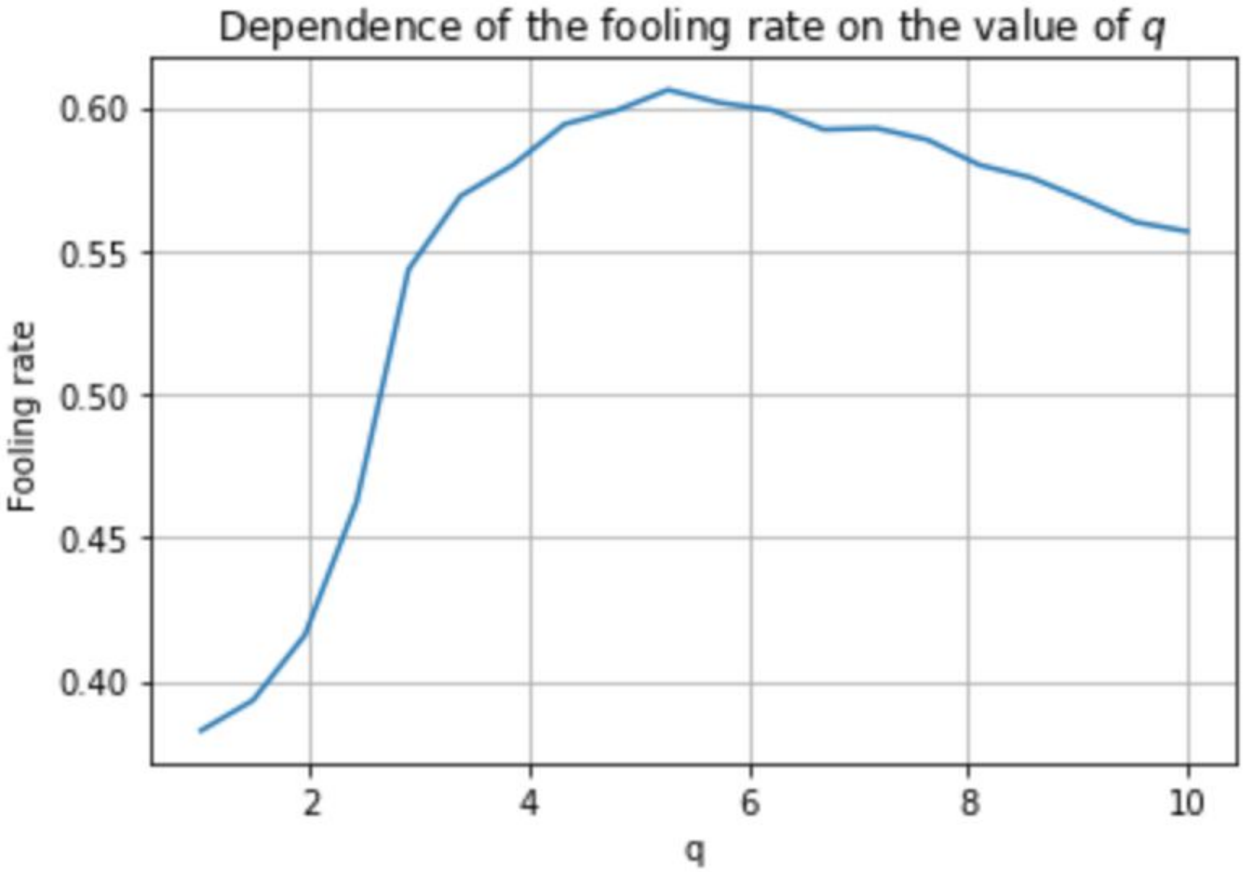
Presented images correspond to values q increasing from 1.0 to 10.0.

block2_pool layer of VGG-19 was used.



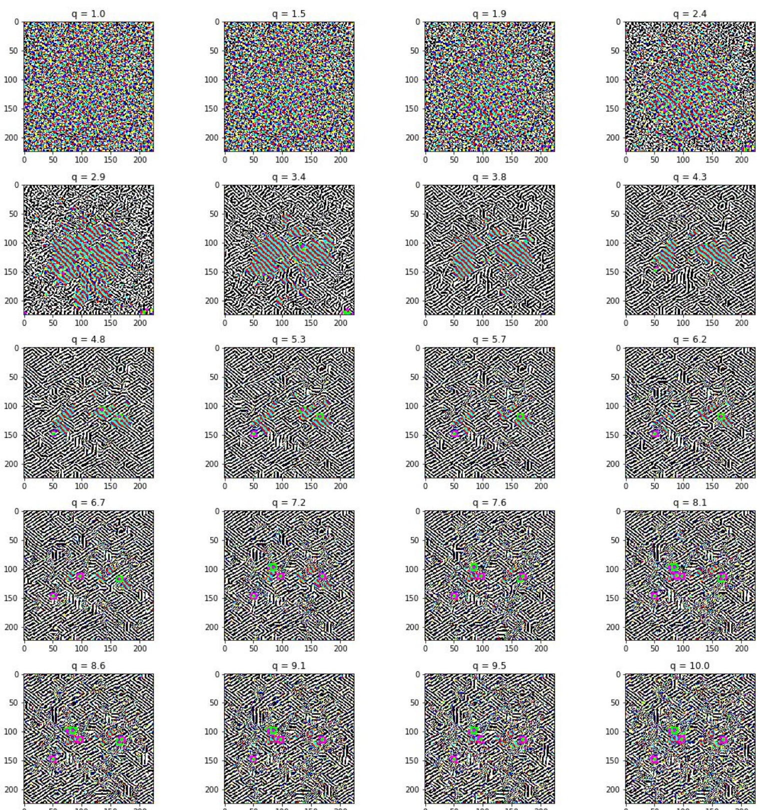
# Dependence of the fooling rate on the value of q

Dependence of the fooling rate on the value of q for block2_pool layer of VGG-19.

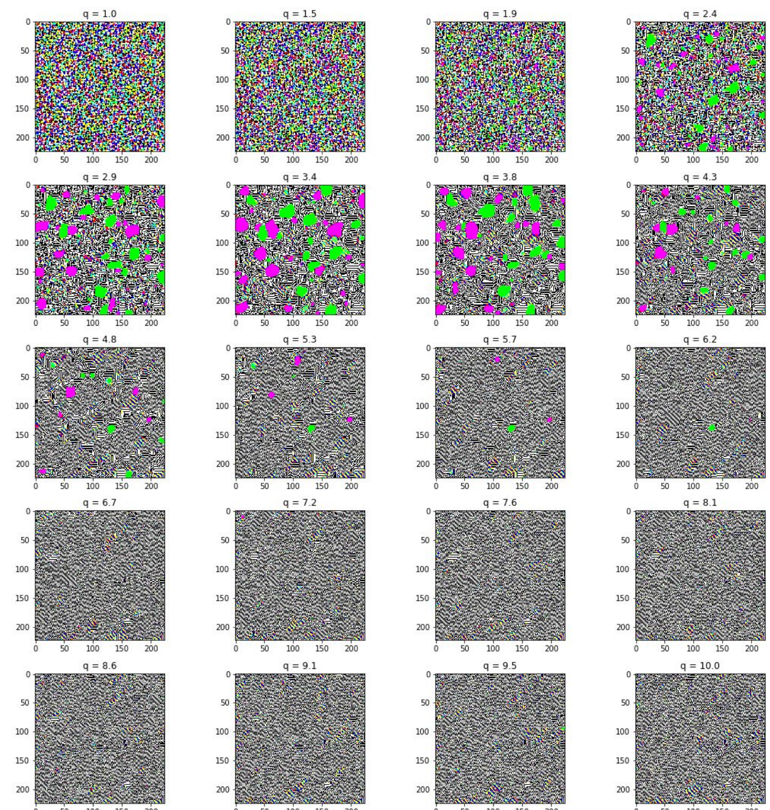


# Dependence of the fooling rate on the value of q

Adversarial perturbations constructed for various values of q for VGG-16 and ResNet50.



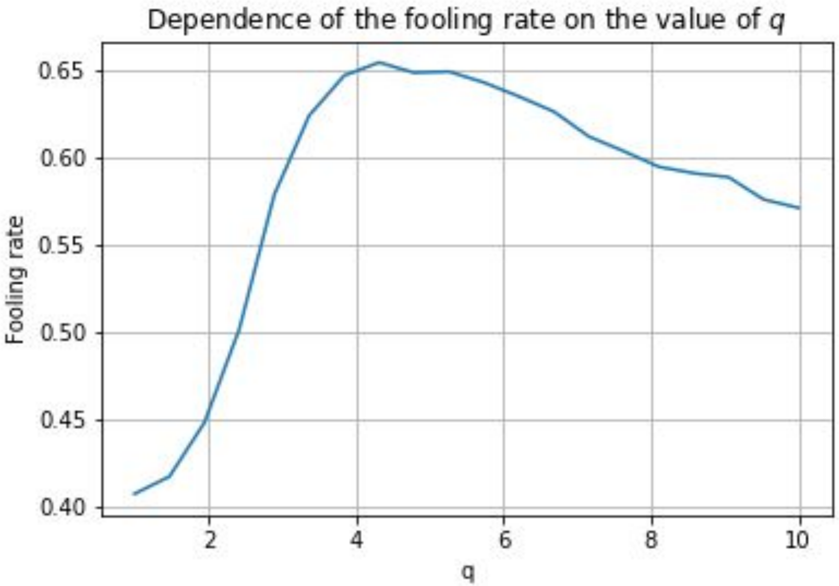

block2_pool VGG-16



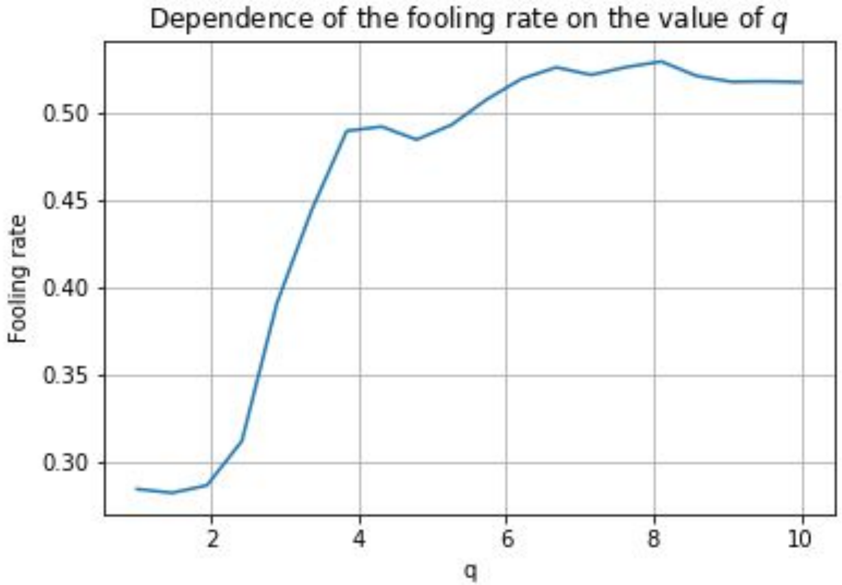

conv1 ResNet50

# Dependence of the fooling rate on the value of q

Dependence of the fooling rate on the value of q for VGG-16 and ResNet50.

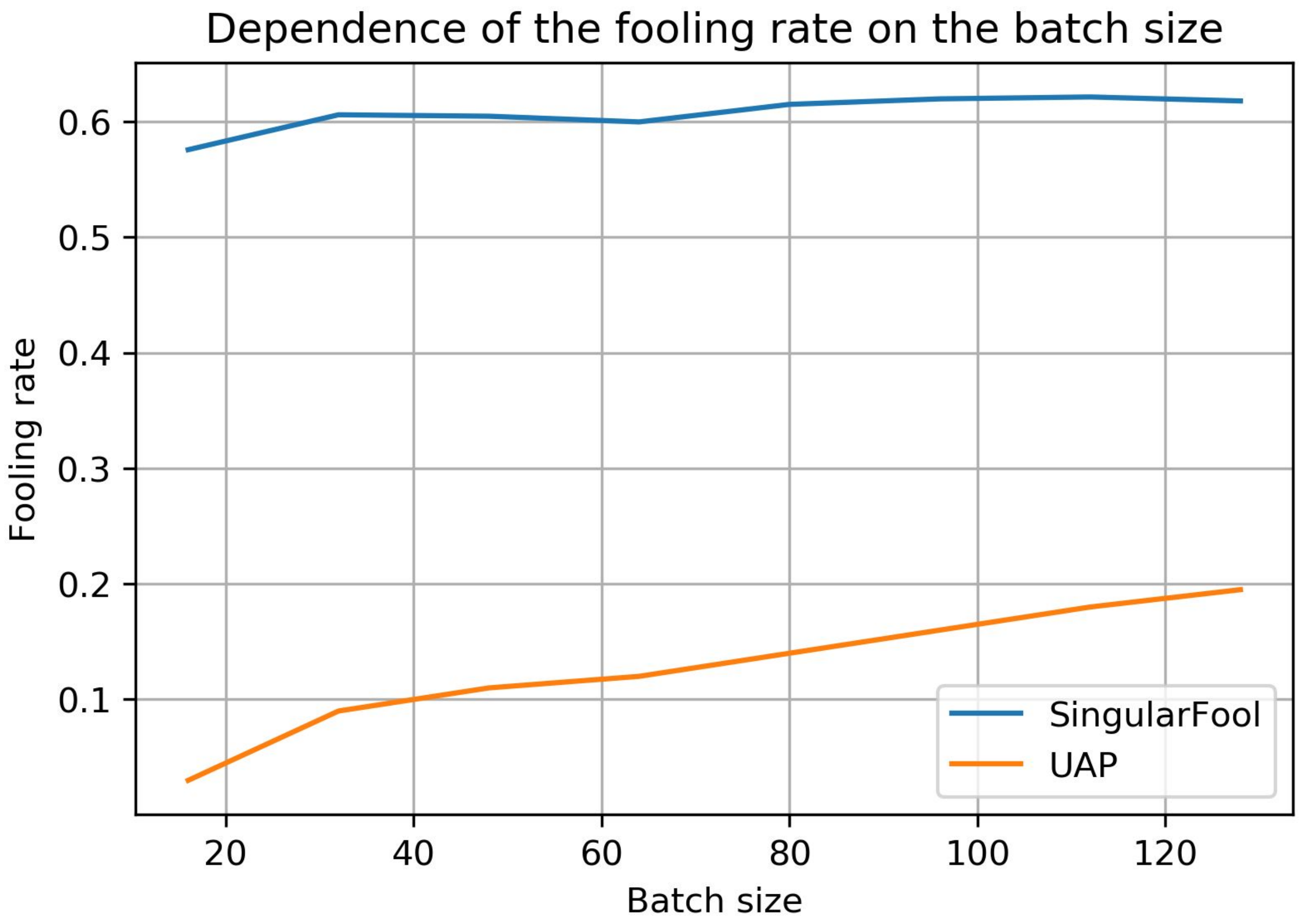



block2_pool VGG-16




conv1 ResNet50

# Dependence of the fooling rate on the batch size




S. Moosavi-Dezfooli*, A. Fawzi*, O. Fawzi, P. Frossard: *Universal adversarial perturbations*, CVPR 2017

# Conclusion

- Reproduced paper proposes a novel state of the art approach for universal adversarial attacks.
  - It is efficient in comparison with other approaches!
  - It needs only 64 images to produce adversarial attack for 60% fooling rate on all validation set of ImageNet (50k images)!

# Follow us on Github

goo.gl/Qu36y9