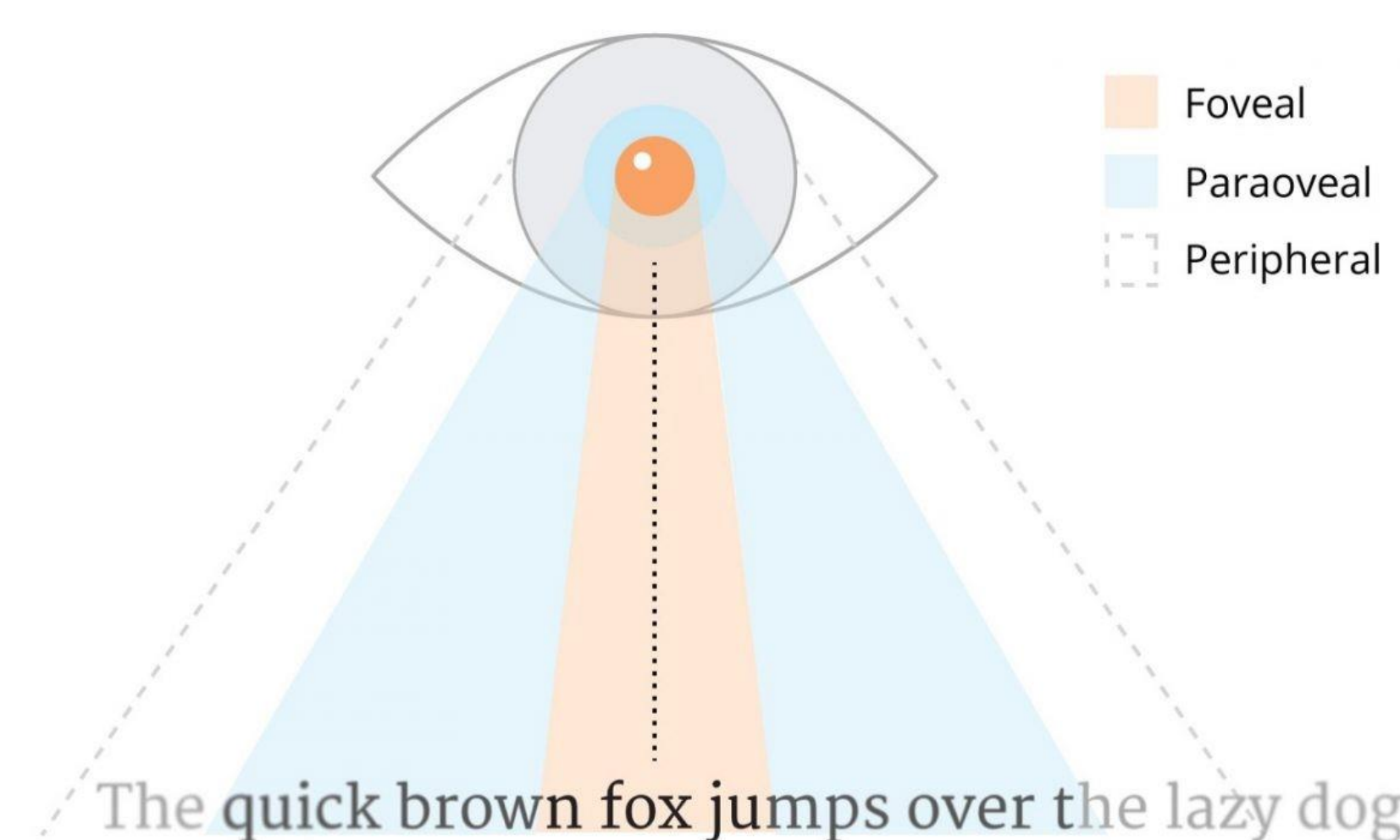# Towards using Adversarially Robust Features as alternative features for rendering of Full-Field Foveated Metamers

Raphi Kang, Arturo Deza

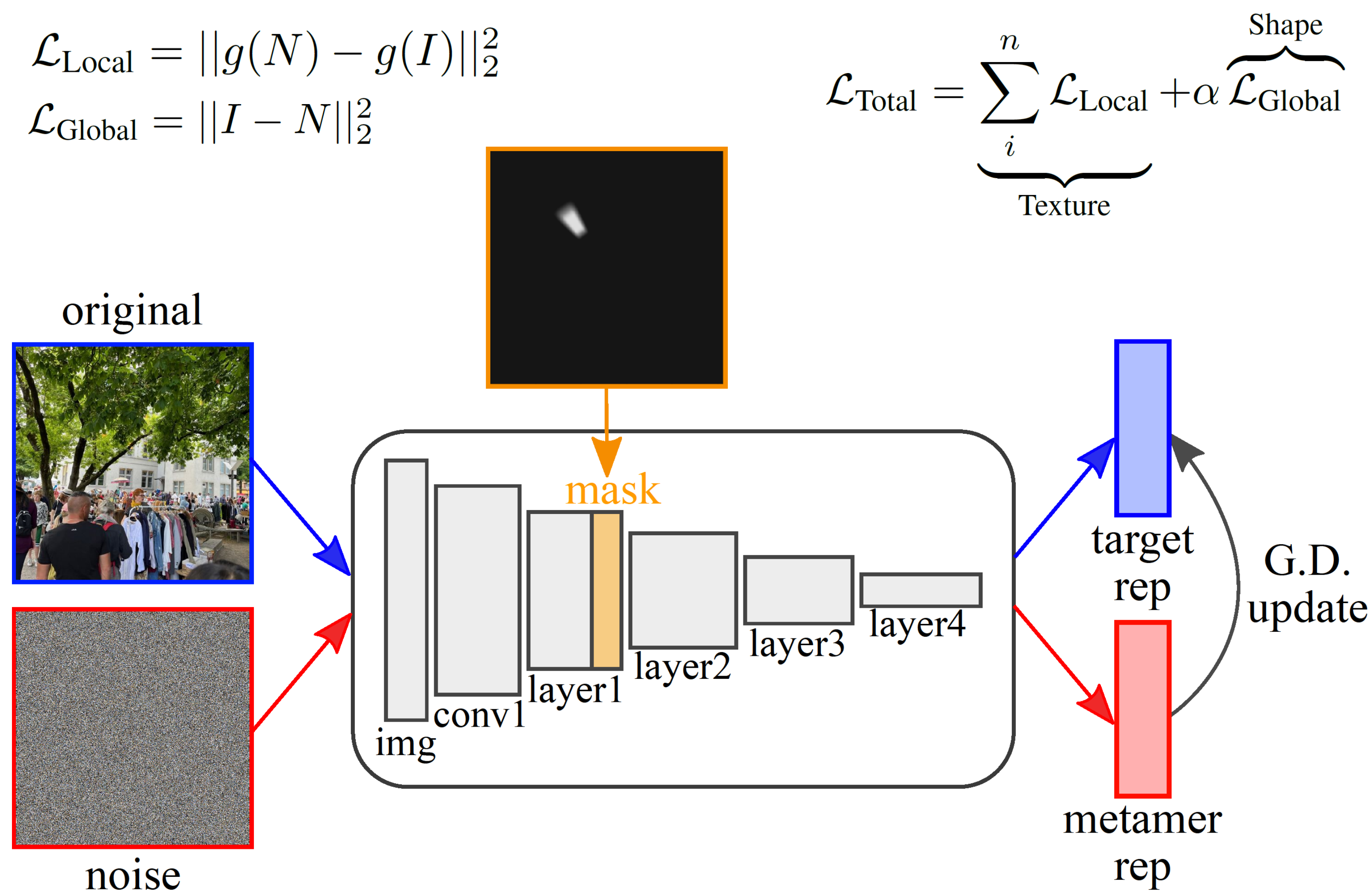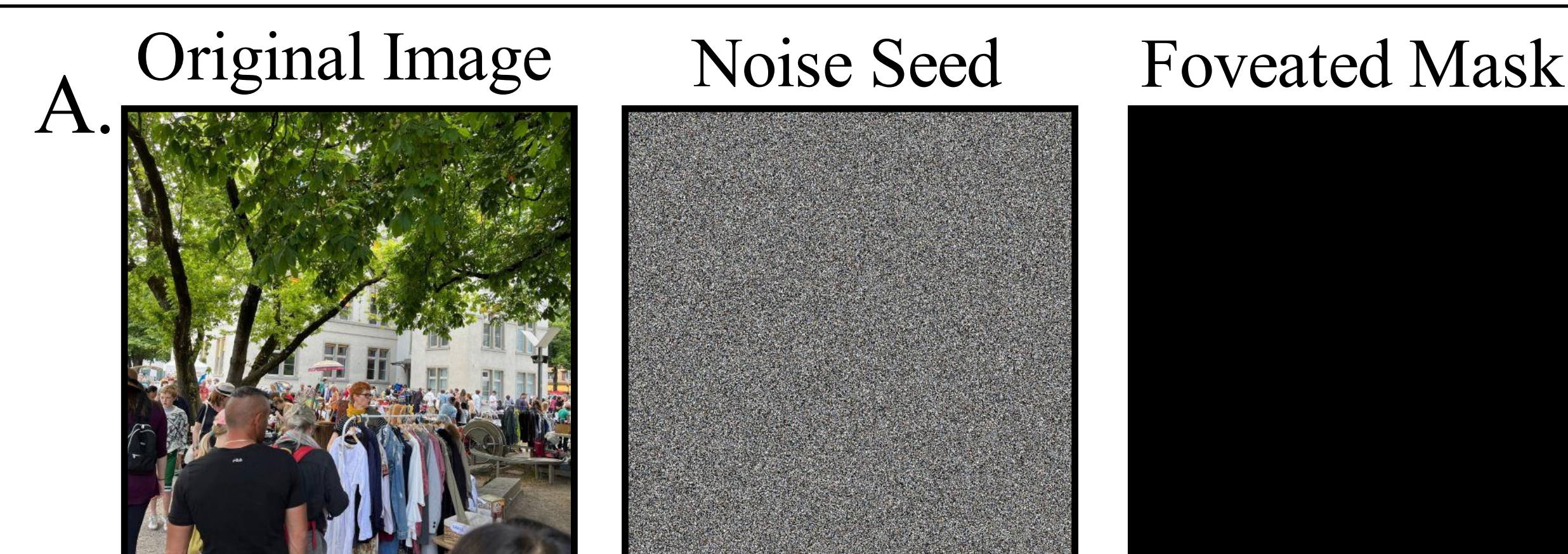## Foveated Perceptual Metamers

Definition: The fovea (a pit in the inner retinal surface) has a higher density of cones than the periphery, and in subsequent processing of visual signals is continually overrepresented. Foveated metamers are visual stimuli that capture the losses perceived in the periphery successfully fooling a human observer into not noticing the difference between an original sample.

Motivation for Using Adversarially Robust Features: Insight into robust high-level embeddings, study of how metamerism arises in human vision, training pipeline for innately robust networks

- Foveal
- Paraoveal
- Peripheral

The quick brown fox jumps over the lazy dog

Design of a Foveated Metamer based on Adversarially Robust Features

Method Overview: Iterate through each region in the foveated map from the center outward. For each region, the network is masked such that the effect of the gradient descent towards minimizing the deep network feature loss only alters the noise seed in that region. Each local loop is followed by a small global update to adjust image statistics based on the original image, the result of which is used as the next noise seed for the subsequent local synthesis loop.

A. Original Image | Noise Seed | Foveated Mask

B.

$$\mathcal{L}_{\text{Local}} = ||g(N) - g(I)||_2^2$$
$$\mathcal{L}_{\text{Global}} = ||I - N||_2^2$$

$$\mathcal{L}_{\text{Total}} = \underbrace{\sum_i^n \mathcal{L}_{\text{Local}}}_{\text{Texture}} + \alpha \overbrace{\mathcal{L}_{\text{Global}}}^{\text{Shape}}$$

original
mask
noise
img | conv1 | layer1 | layer2 | layer3 | layer4
target rep
metamer rep
G.D. update

Comparison with State of the Art

Flea Market | Campus | Bikes | Building

Reference

Our Model (Layer 5, 7 loops)

Freeman & Simoncelli (2011)

Texture Tiling Model (2012)

NeuroFovea (2019)

	Freeman & Simoncelli (2011) Metamer Localized DISTS from original	Adversarially Robust Metamer Localized DISTS from original
Flea Market	0.6149	0.5070
Buildings	0.6139	0.5204
Campus	0.7548	0.5391
Bikes	0.7898	0.5932

| 1 Local Loop DISTS: 0.2737 MSE: 0.1520 | 2 Local Loops DISTS: 0.2378 MSE: 0.1058 | 3 Local Loops DISTS: 0.2167 MSE: 0.0766 | 4 Local Loops DISTS: 0.1756 MSE: 0.0443 | 7 Loca Loops DISTS: 0.1434 MSE: 0.0258 | FS 50 Loops DISTS: 0.2262 MSE: 0.1088 |

Conclusion & Future Direction

- Adversarially robust features can induce crowding-like behavior in the periphery
- Our model is more computationally efficient and has an increased degree of controllability in the periphery than previous works (for specified analysis)
- Psychophysical evaluations needed to strongly claim metamerism
- Integration into DNN as a pipeline module after input, or replace optimization process with adaptive normalization, to overcome iterative procedure