

CS 398 Deep Learning @ UIUC

Homework 6 Understanding CNNs and Generative Adversarial Networks

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HW6 Description:

The assignment consists of training a Generative Adversarial Network on the CIFAR10 dataset as well as a few visualization tasks for better understanding how a CNN works.

- Train a baseline model for CIFAR10 classification (~2 hours training time)
- Train a discriminator/generator pair on CIFAR10 dataset utilizing techniques from [ACGAN](#) and [Wasserstein GANs](#) (~40-45 hours training time)
- Use techniques to create synthetic images maximizing class output scores or particular features as a visualization technique to understand how a CNN is working (<1 minute)

Test Accuracy for discriminators

Trained without the Generator

Test Accuracy: **89.29%** after 100 epochs.

```
Accuracy Test -- Epoch 88: 89.31
Epoch 89: loss = 0.0001994482869654894
Epoch 90: loss = 0.0002041691859997809
Accuracy Test -- Epoch 90: 89.26
Epoch 91: loss = 0.00019804691856727005
Epoch 92: loss = 0.00020082003425806762
Accuracy Test -- Epoch 92: 89.32
Epoch 93: loss = 0.0002010068211145699
Epoch 94: loss = 0.00019349182888865472
Accuracy Test -- Epoch 94: 89.27
Epoch 95: loss = 0.00019986008137464522
Epoch 96: loss = 0.00019792585773393512
Accuracy Test -- Epoch 96: 89.27
Epoch 97: loss = 0.00020059758072718978
Epoch 98: loss = 0.00018969833901152014
Accuracy Test -- Epoch 98: 89.21
Epoch 99: loss = 0.00019273784773424268
Epoch 100: loss = 0.00019801771560683847
Accuracy Test -- Epoch 100: 89.29
Training finished and final models saved!
Application 77668100 resources: utime ~11002s, stime ~962s, Rss ~1568412, inblocks ~1604477, outblocks ~339689
```

Trained with the Generator

Test Accuracy: **75.62%** after 200 epochs.

```
Epoch: 198 Batch: 0 0.15 -5.61 -4.76 0.98 0.32 65.84
Epoch: 198 Batch: 50 0.15 -5.61 -4.76 0.98 0.32 65.85
Epoch: 198 Batch: 100 0.15 -5.61 -4.76 0.98 0.32 65.86
Epoch: 198 Batch: 150 0.15 -5.61 -4.76 0.98 0.32 65.87
Epoch: 198 Batch: 200 0.15 -5.61 -4.76 0.98 0.32 65.88
Epoch: 198 Batch: 250 0.15 -5.61 -4.76 0.98 0.32 65.89
Epoch: 198 Batch: 300 0.15 -5.61 -4.76 0.97 0.32 65.89
Epoch: 198 Batch: 350 0.15 -5.61 -4.76 0.97 0.32 65.90
Testing Accuracy: 76.41416139240506 Time: 128434.95544195175
Temp models saved!
Epoch: 199 Batch: 0 0.15 -5.61 -4.76 0.97 0.32 65.91
Epoch: 199 Batch: 50 0.15 -5.61 -4.76 0.97 0.32 65.92
Epoch: 199 Batch: 100 0.15 -5.61 -4.76 0.97 0.32 65.93
Epoch: 199 Batch: 150 0.15 -5.61 -4.76 0.97 0.32 65.93
Epoch: 199 Batch: 200 0.15 -5.61 -4.76 0.97 0.32 65.94
Epoch: 199 Batch: 250 0.15 -5.61 -4.76 0.97 0.32 65.95
Epoch: 199 Batch: 300 0.15 -5.61 -4.76 0.97 0.32 65.96
Epoch: 199 Batch: 350 0.15 -5.61 -4.76 0.97 0.32 65.97
Testing Accuracy: 75.62302215189874 Time: 129075.59551787376
Temp models saved!
Training finished and final models saved!
```

Output

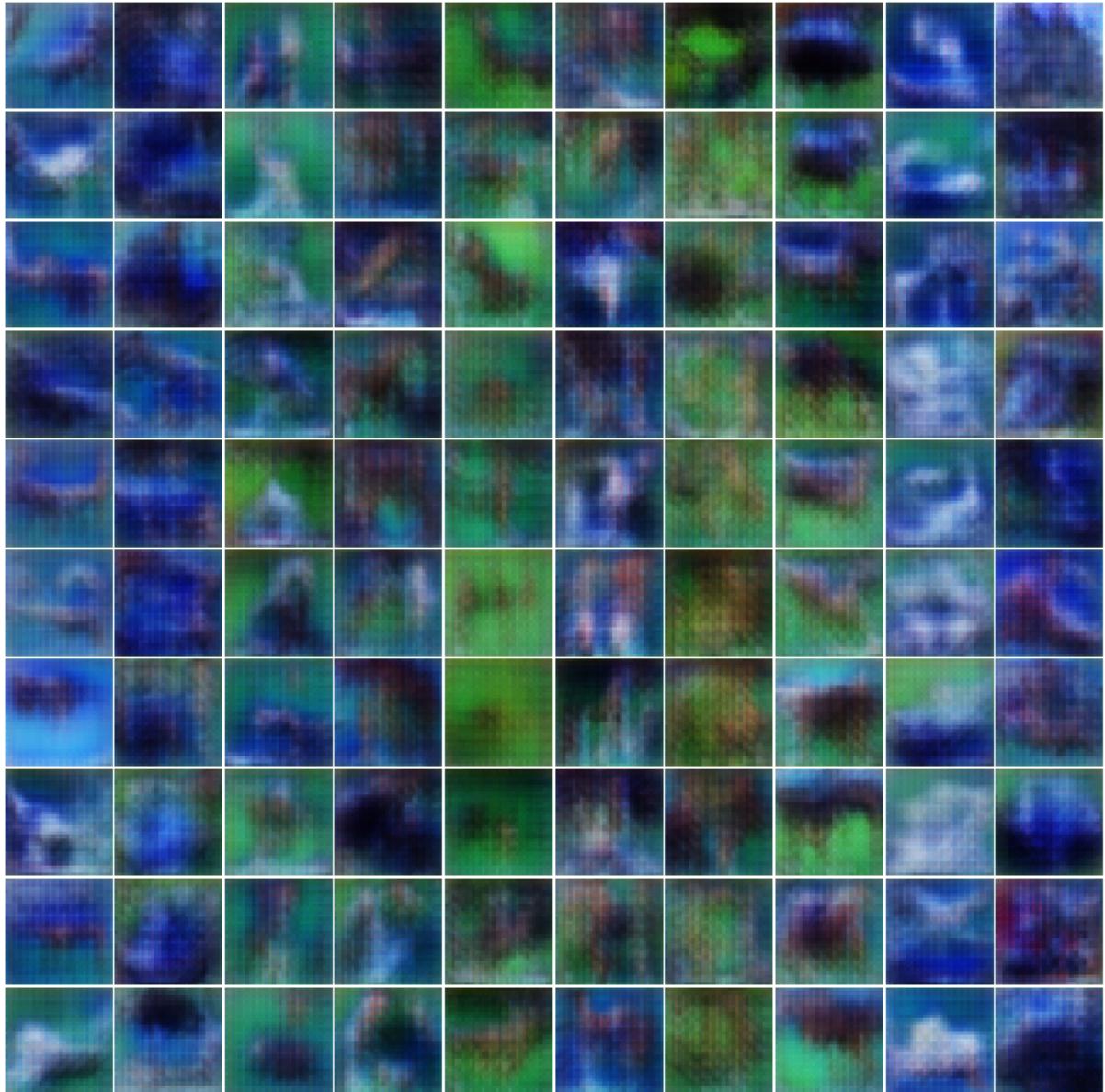
Generator

- I trained the discriminator/generator pair for 200 epochs. Below are some samples of generated images.

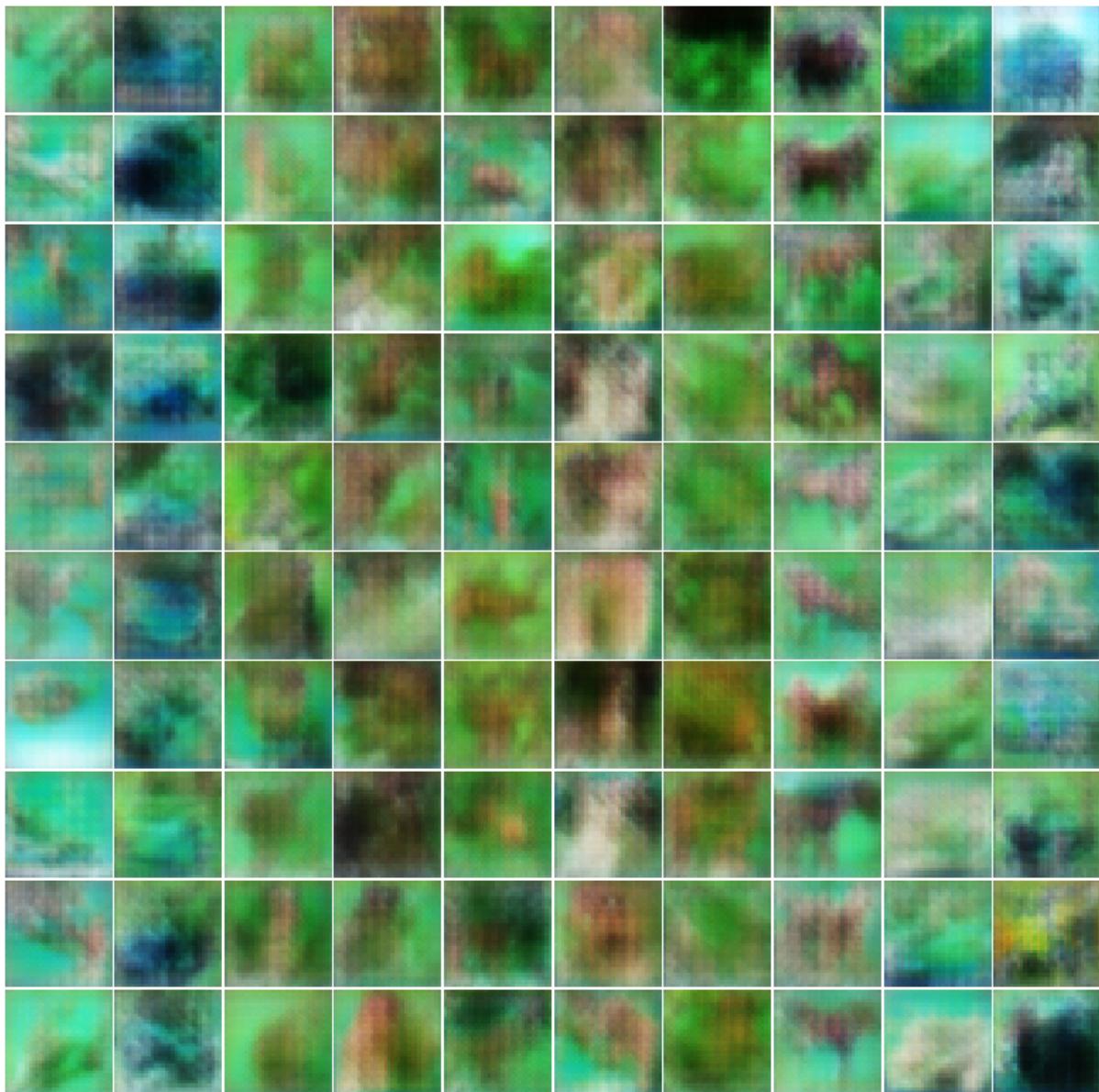
Epoch 0



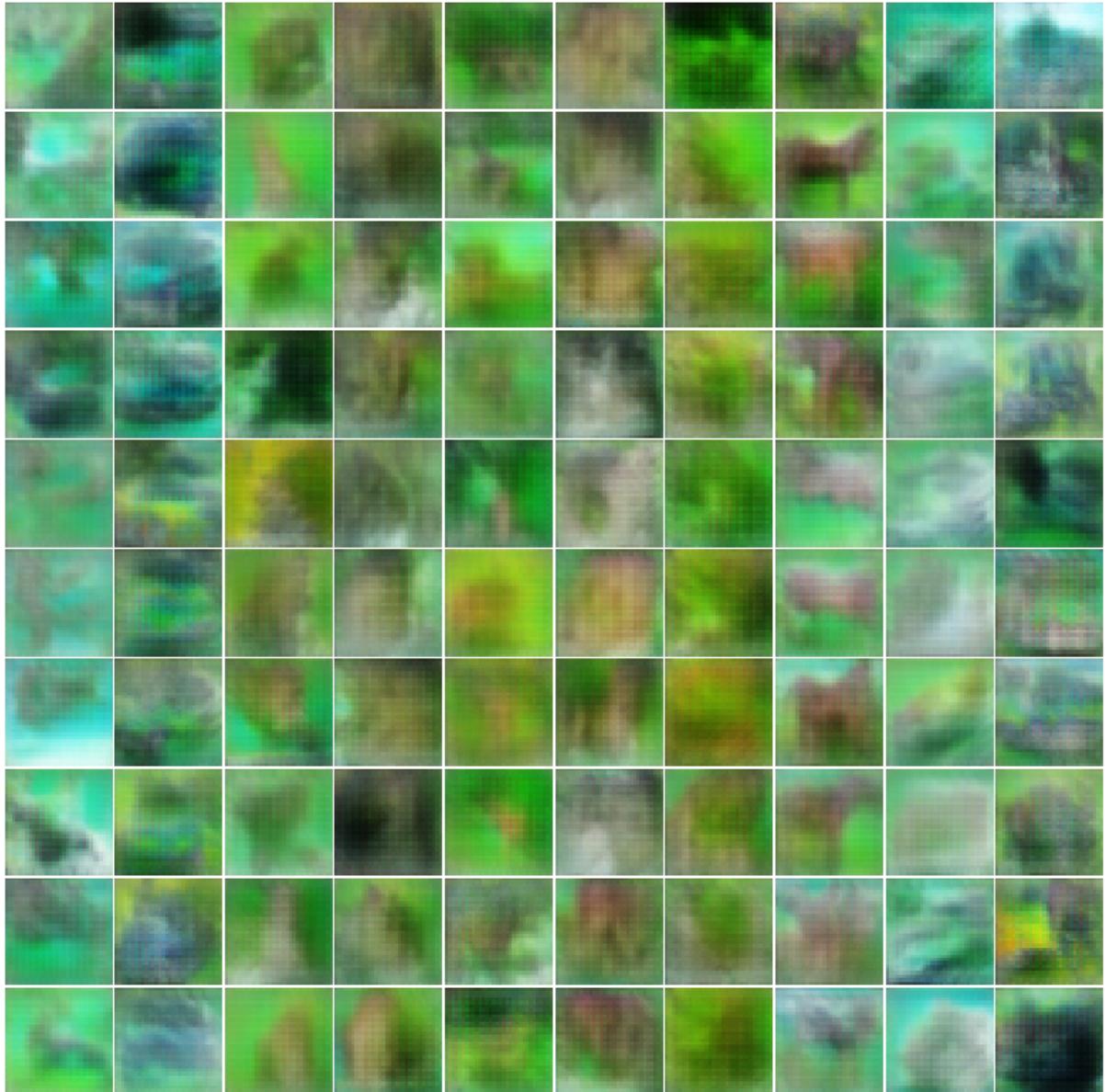
Epoch 40



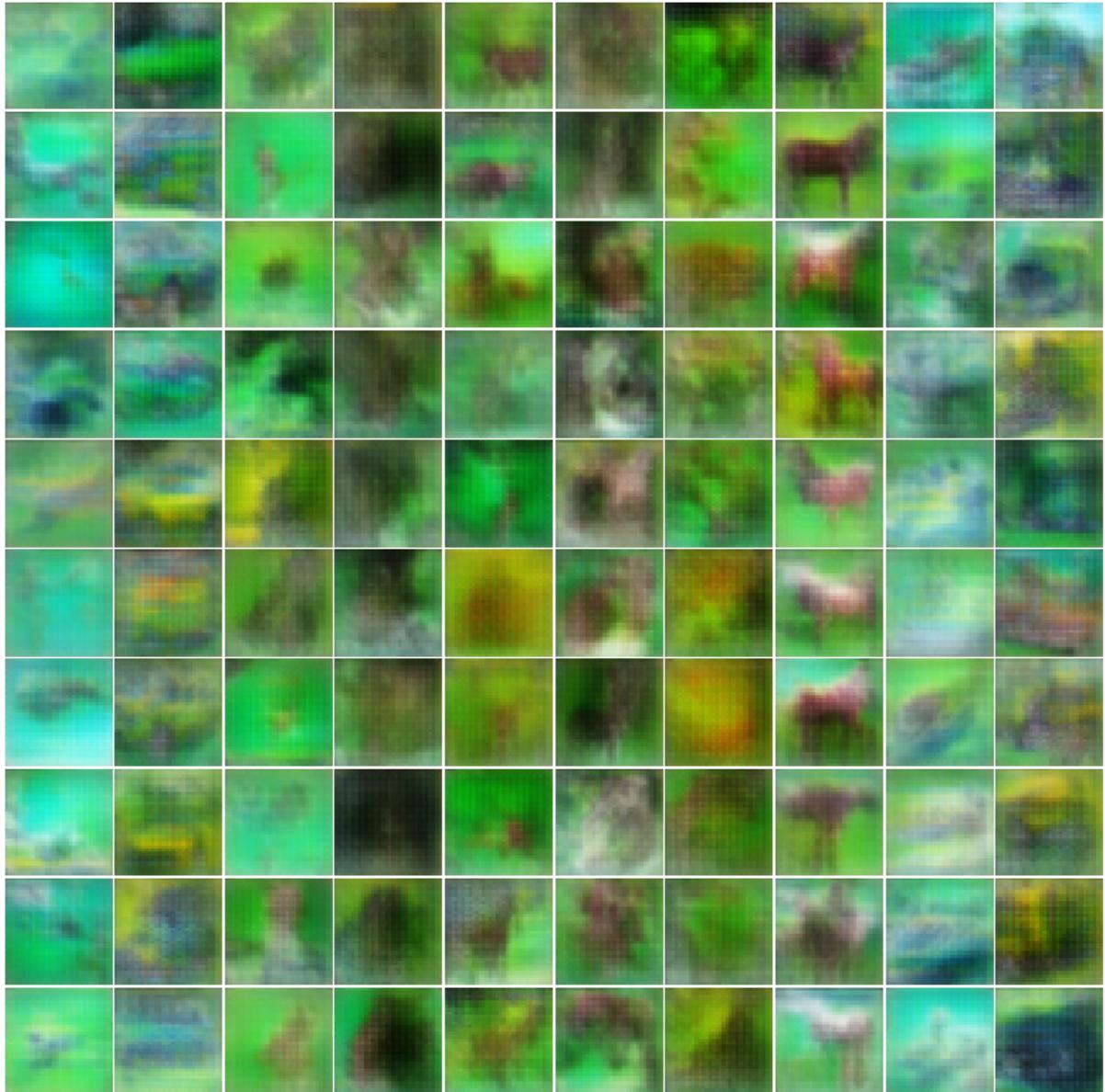
Epoch 80



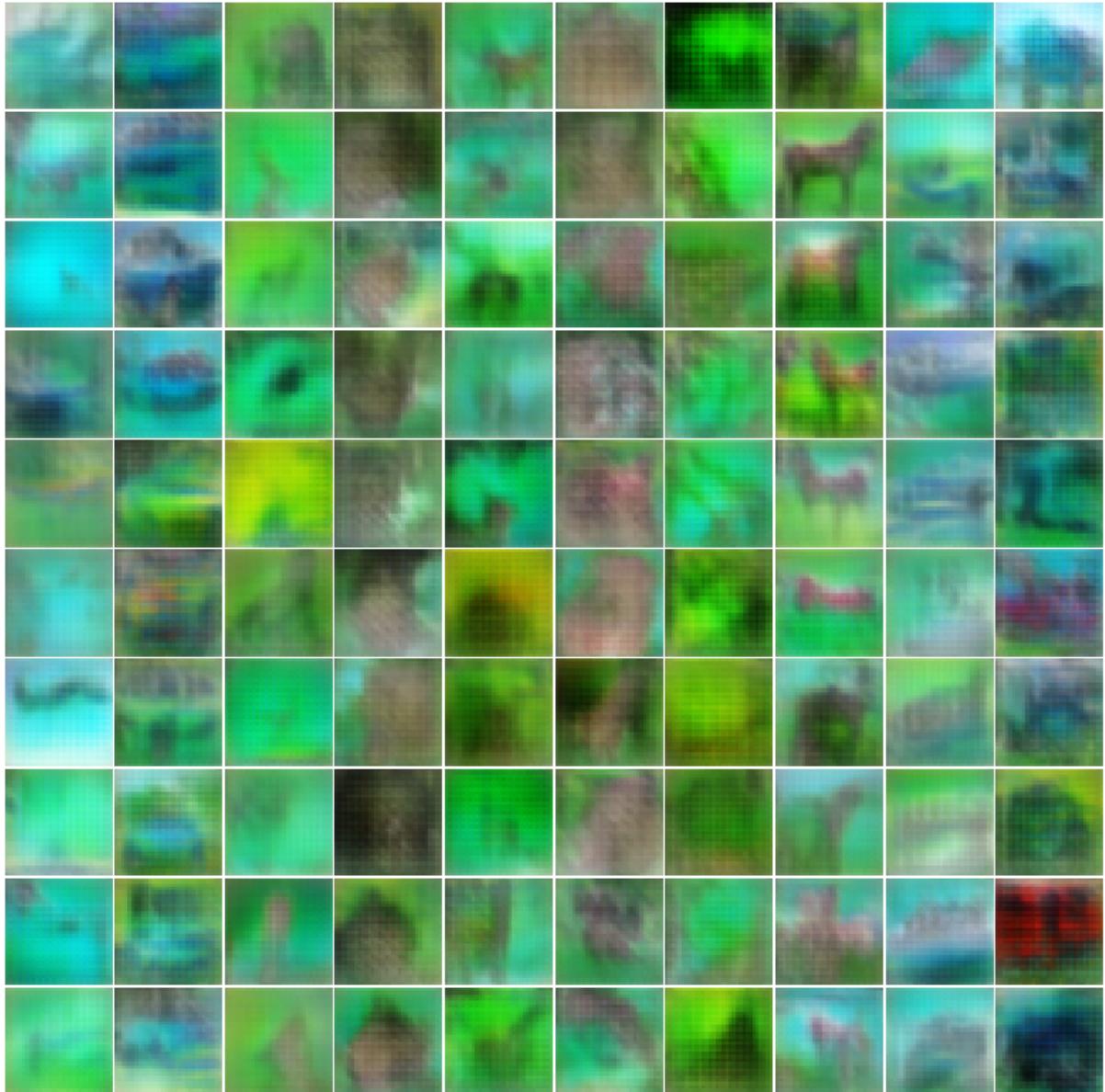
Epoch 120



Epoch 160



Epoch 200

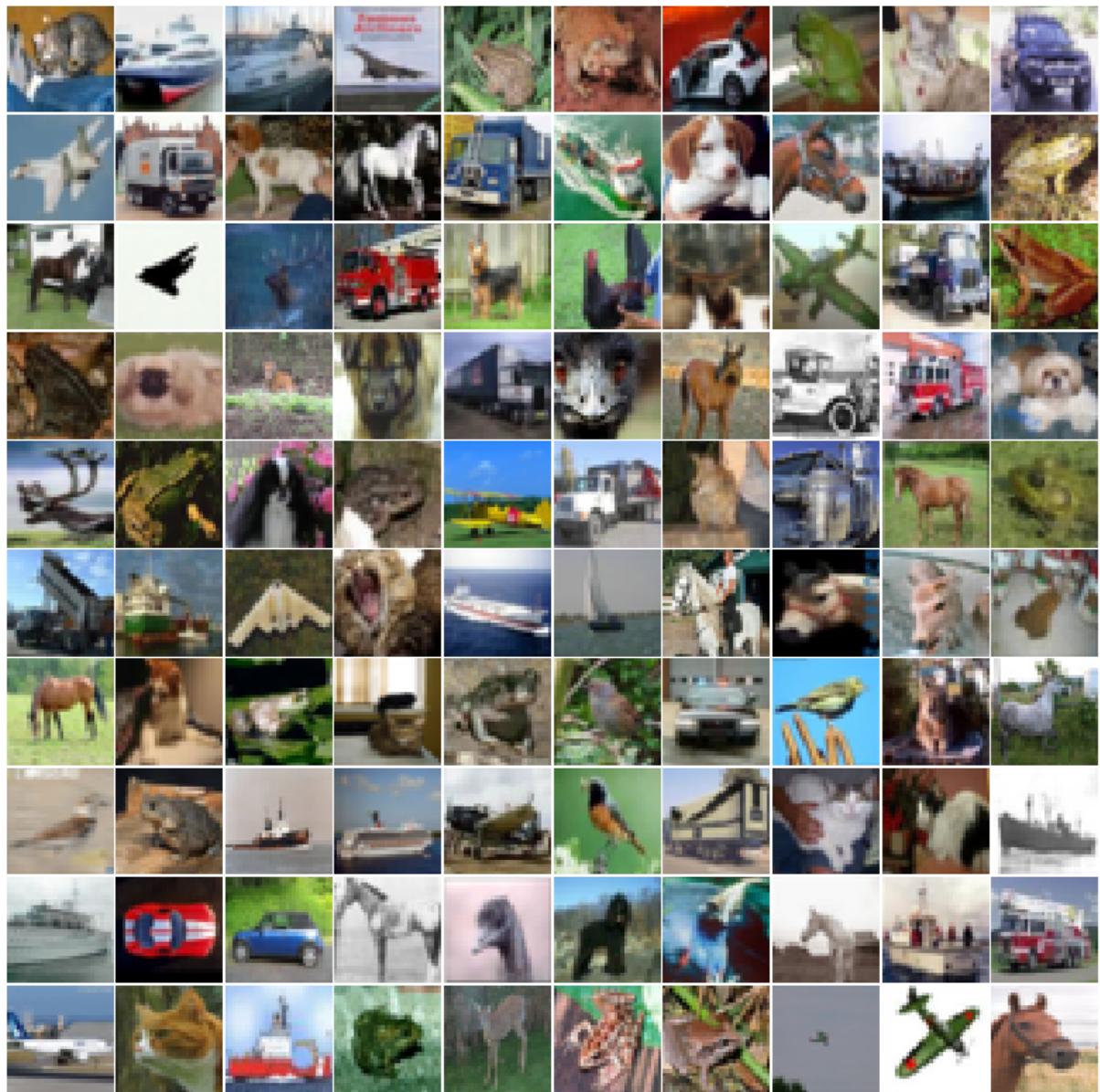


Perturb Real Images

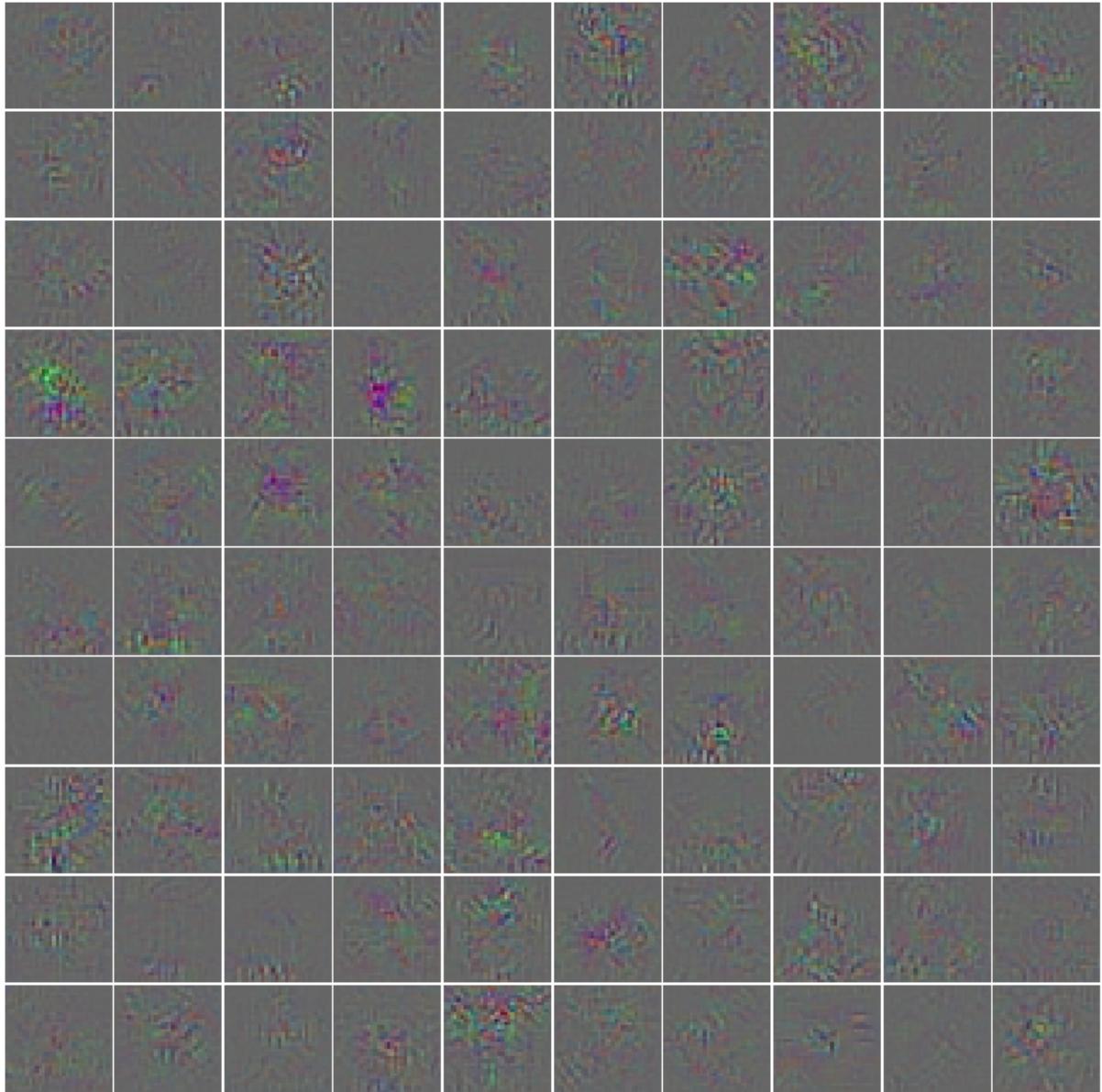
- From **Perturb Real Images**. A batch of real images, a batch of the gradients from an alternate class for these images, and the modified images the discriminator incorrectly classifies.

Below are the images and processed images we retrieved. We found that the classification accuracy on real images is **92.97%**, but that on jittered images is **10.94%**.

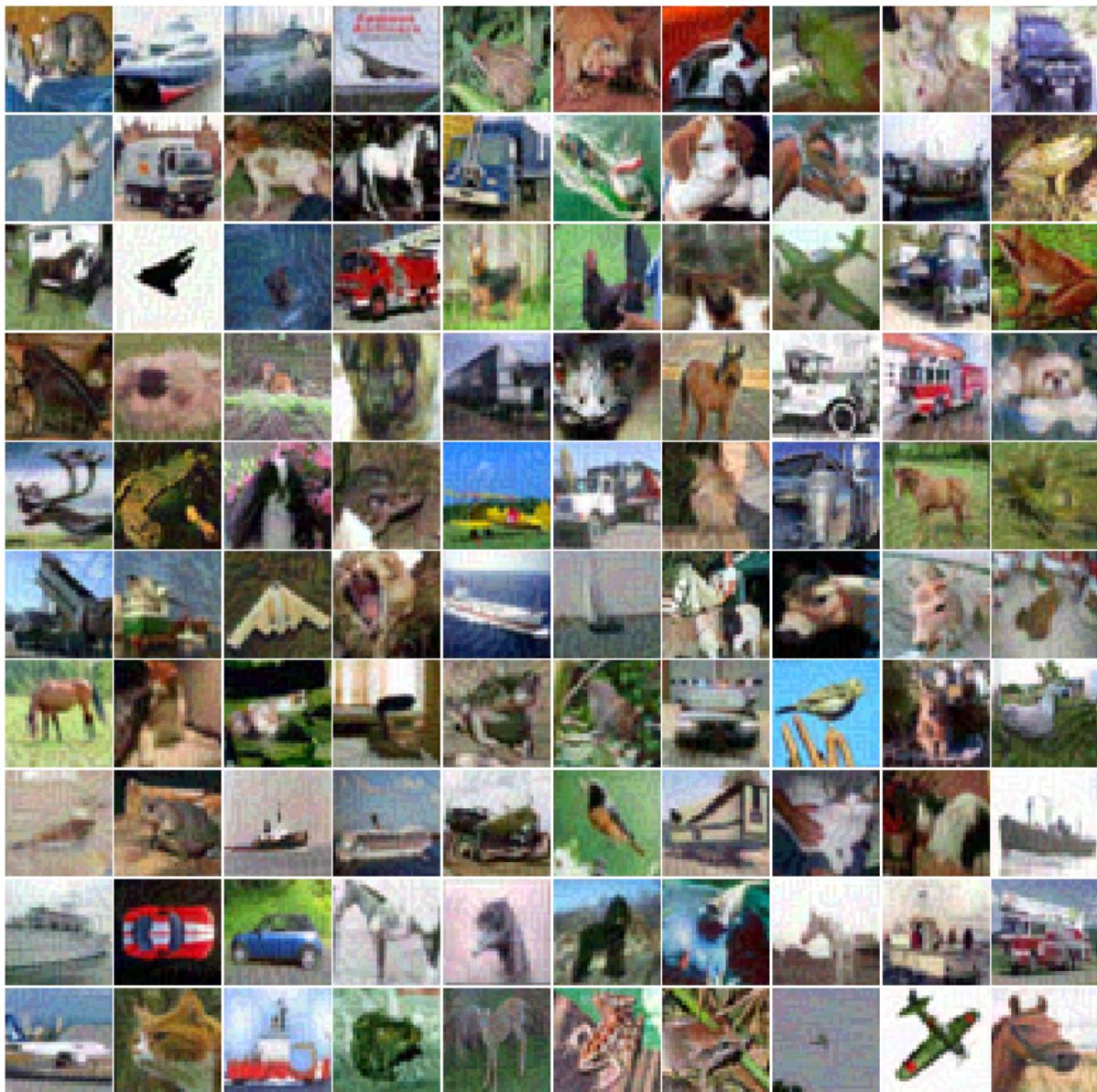
Real images



Gradients



Jittered images



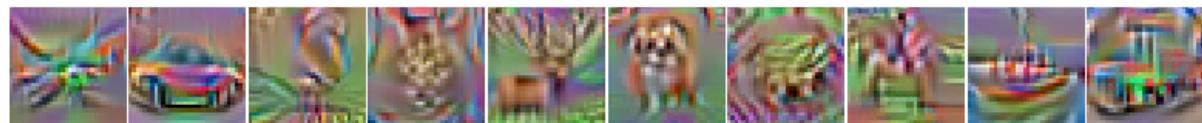
Synthetic Images Maximizing Classification Output

- From **Synthetic Images Maximizing Classification Output**. Synthetic images maximizing the class output. One for the discriminator trained without the generator and one for the discriminator trained with the generator.

Synthetic images maximizing class output for discriminator trained without the generator:



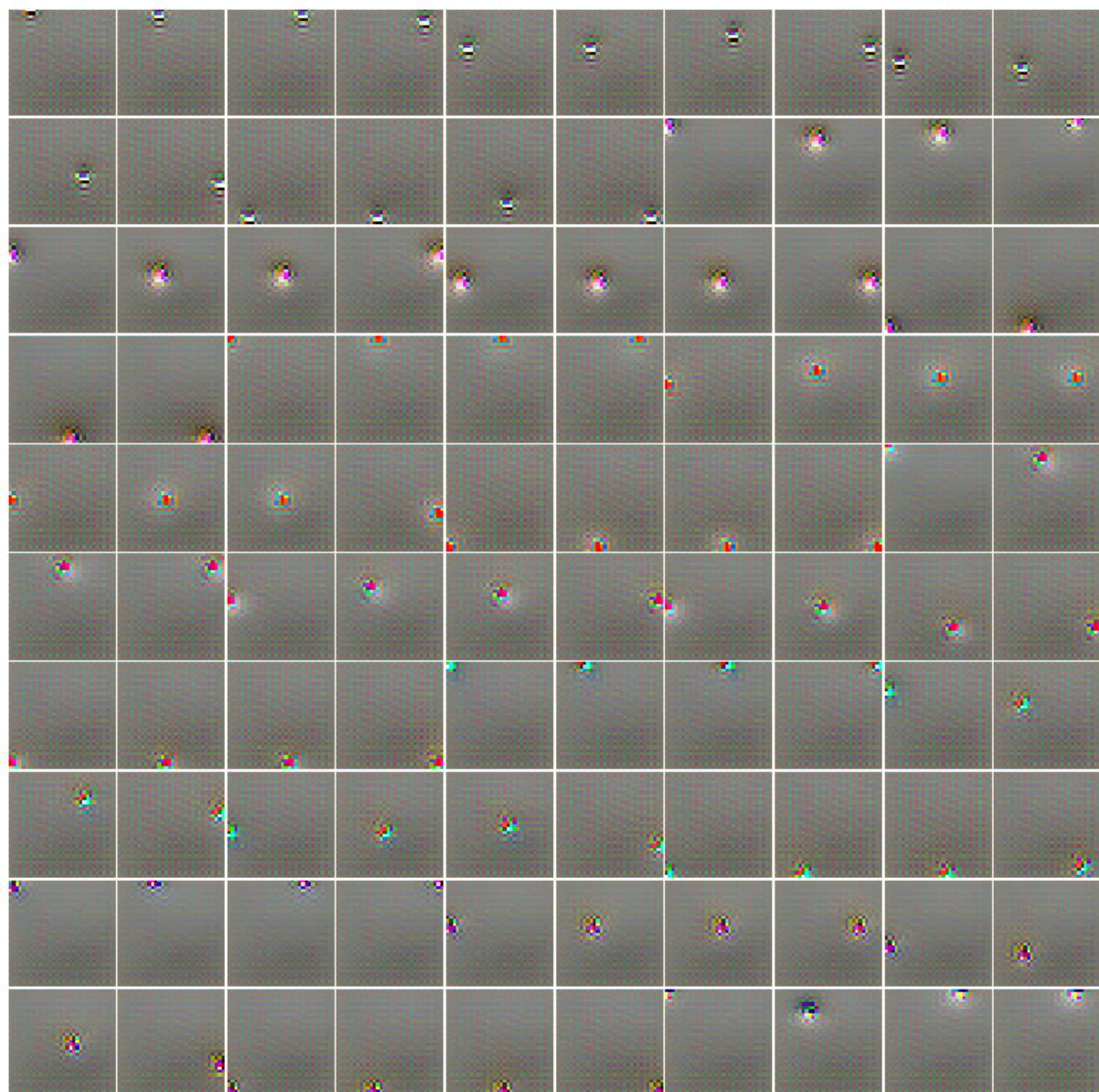
Synthetic images maximizing class output for discriminator trained with the generator:



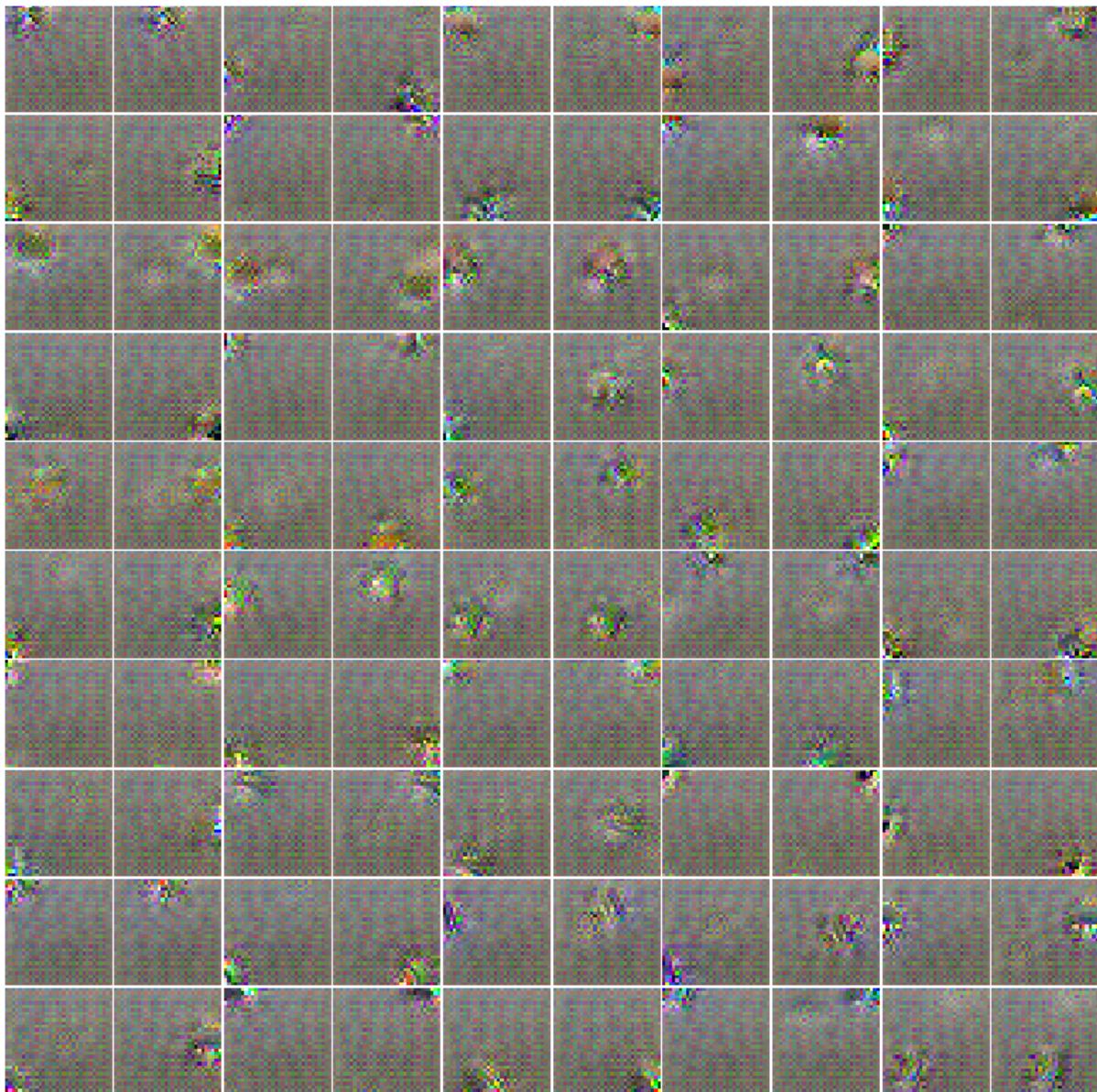
Synthetic Features Maximizing Features at Various Layers

- From **Synthetic Features Maximizing Features at Various Layers**. Synthetic images maximizing a particular layer of features. Below are the layer 2,4,6,8 features for discriminator trained with and without the generator.

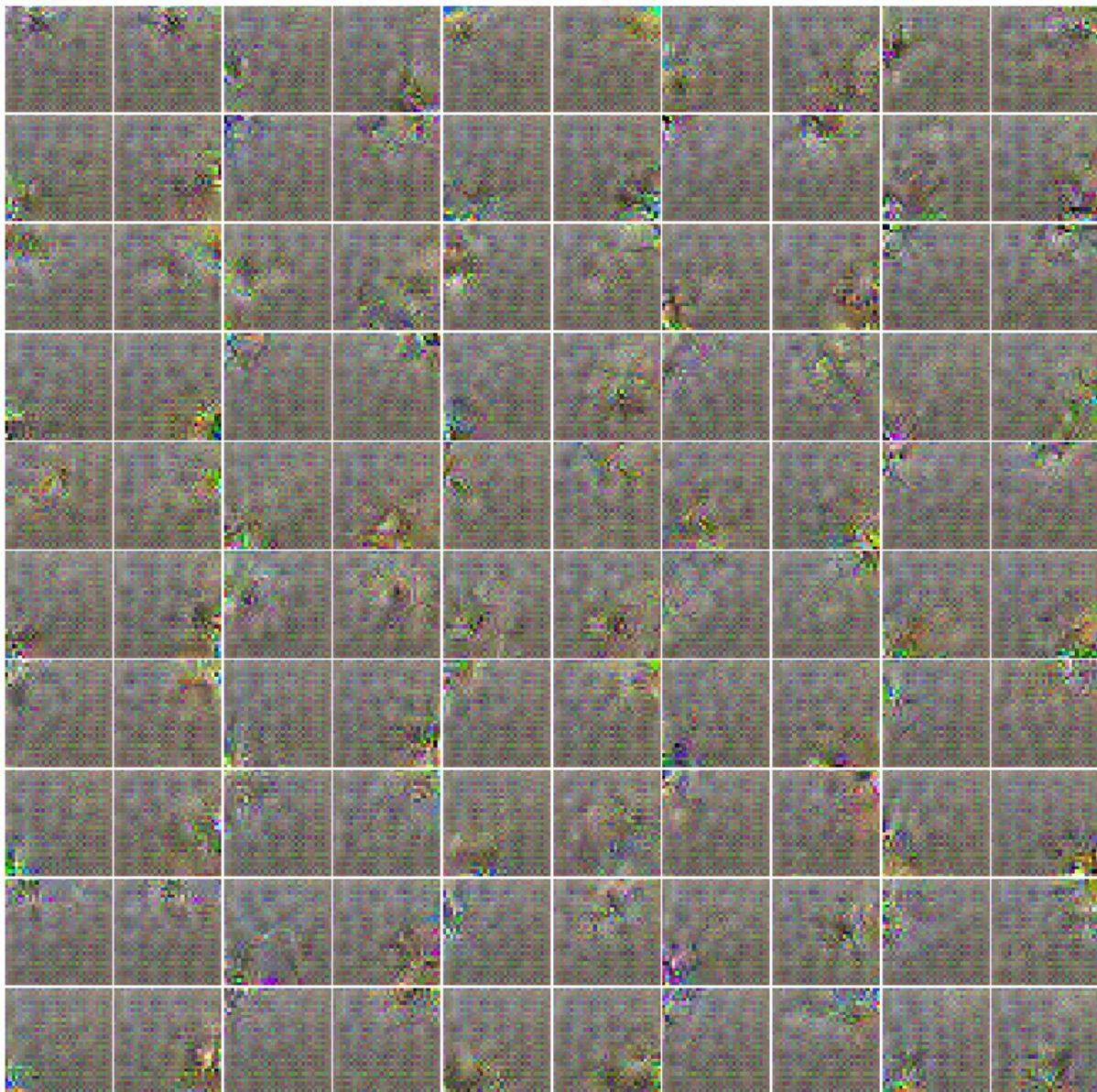
Layer 2 features for discriminator trained without the generator:



Layer 4 features for discriminator trained without the generator:



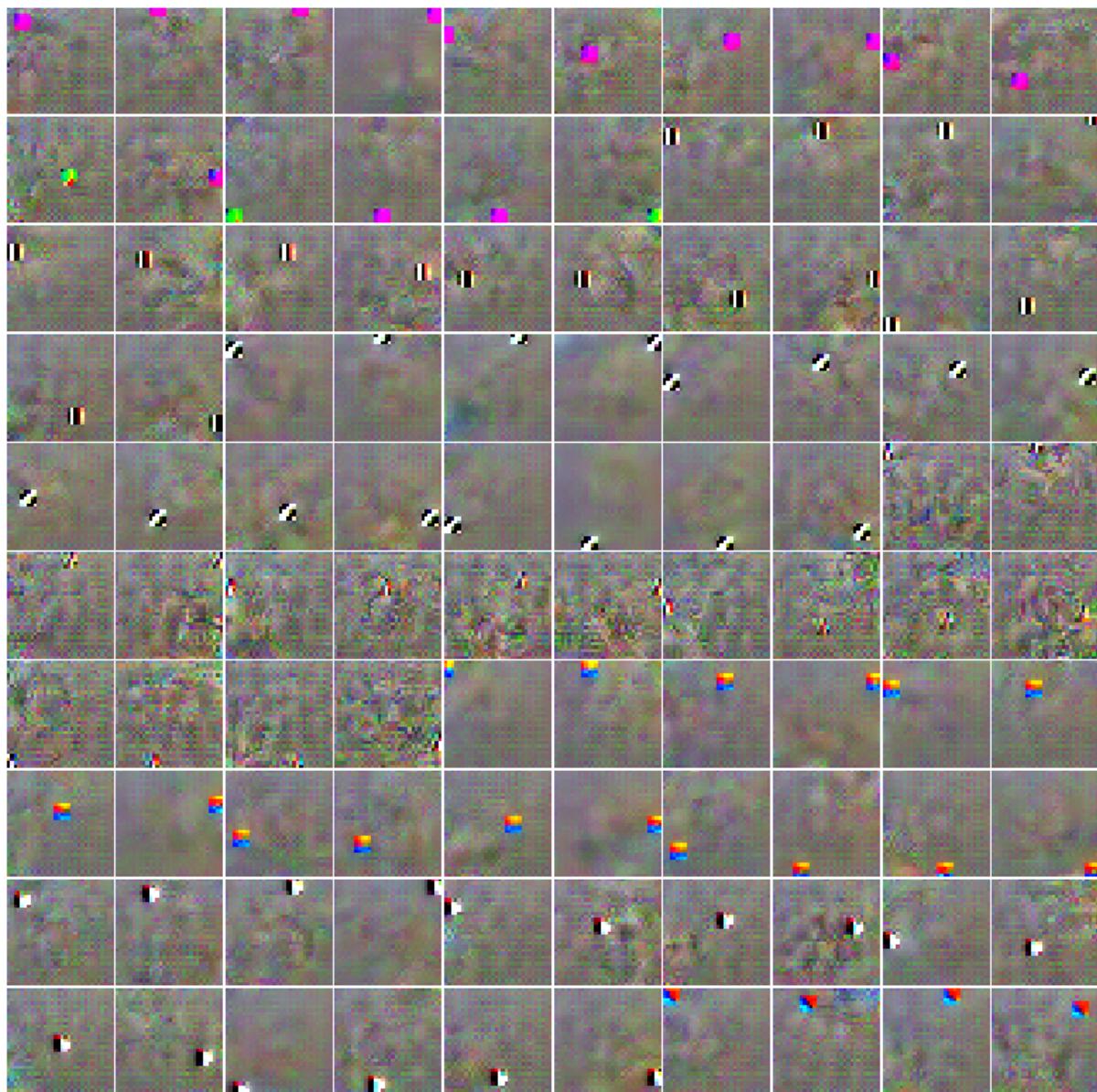
Layer 6 features for discriminator trained without the generator:



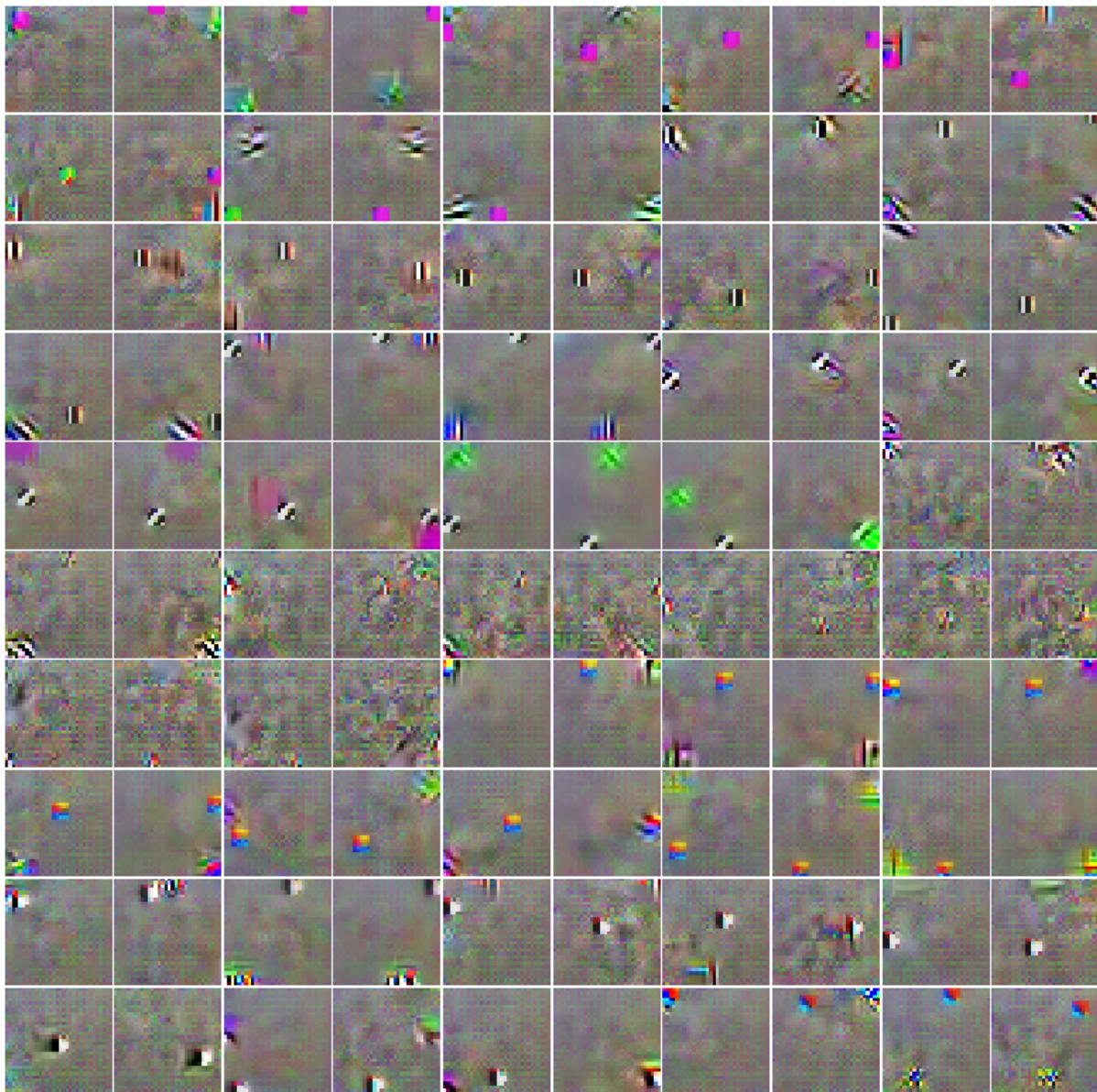
Layer 8 features for discriminator trained without the generator:



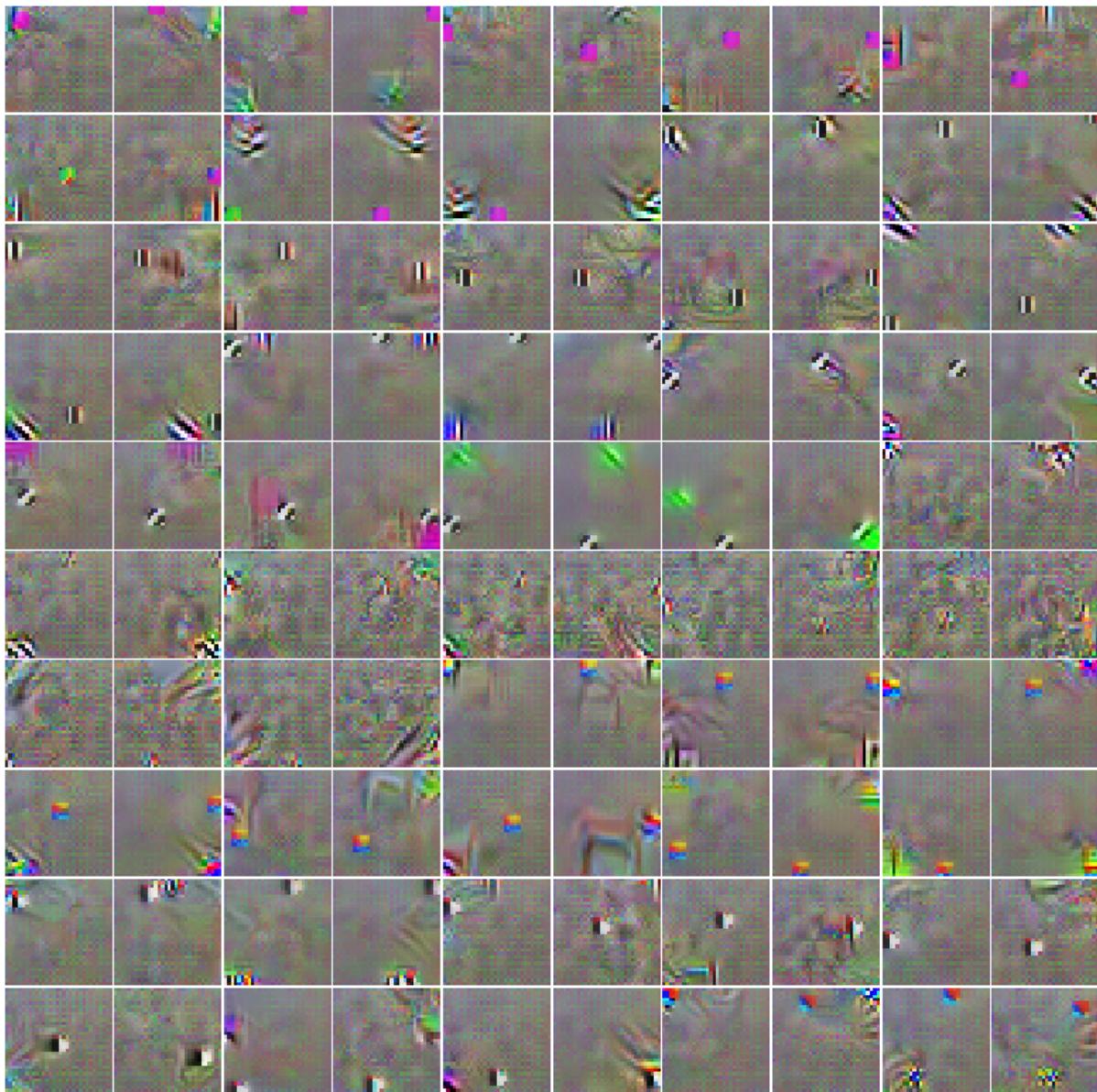
Layer 2 features for discriminator trained with the generator:



Layer 4 features for discriminator trained with the generator:



Layer 6 features for discriminator trained with the generator:



Layer 8 features for discriminator trained with the generator:

