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Answer the following questions briefly (no more than a few sentences), and provide output images where requested.

Show final results from training both your GAN and LSGAN (give the final 4x4 grid of images for both):

Attached below are final images from training, the first one is from the GAN model and the second one is from the LSGAN model.

Iter: 24500, D: 0.02577, G:4.939

Iter: 24500, D: 0.01059, G:1.003

Discuss any differences you observed in quality of output or behavior during training of the two GAN models.

- The discriminator and generator losses in LSGANs do not have high fluctuations in their values. They lie in the range of 0-1.8. However, in the case of GANs we observed that the losses show highly fluctuating values ranging from 0-11.
- The quality images produced by LSGANs and regular GANs cant be accurately compared as results vary greatly with each epoch.

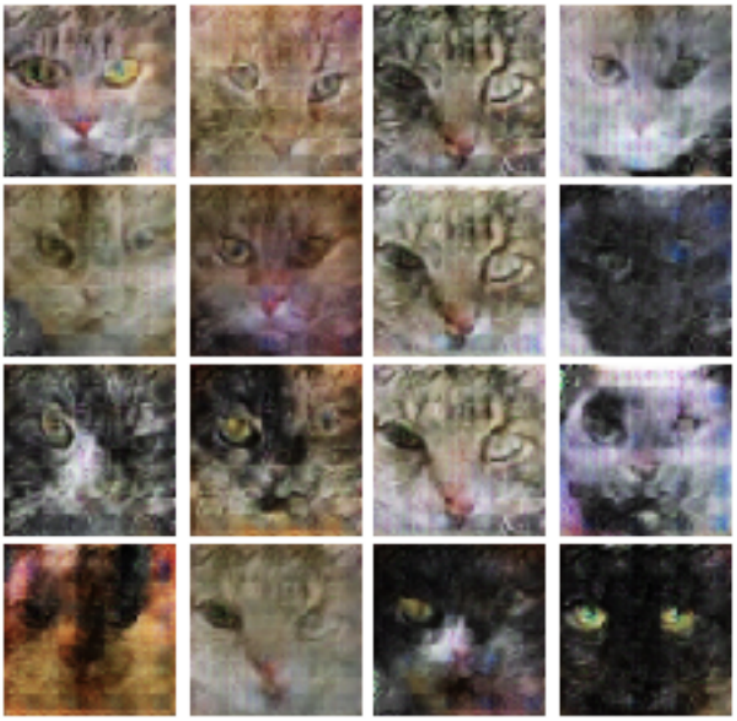
Do you notice any instances of mode collapse in your GAN training (especially early in training)? Show some instances of mode collapse (if any) from your training output.

Yes, we observed multiple instances of mode collapse where the generated images show low diversity, with the same identical image or same small subset of identical images repeating many times.

EPOCH: 5
Iter: 2000, D: 0.3582, G:2.266

EPOCH: 13
Iter: 6000, D: 0.04154, G:4.824

Iter: 18000, D: 0.05432, G:6.221



```
Iter: 13750, D: 0.03198, G:5.224
```


```
Iter: 21000, D: 0.003143, G:7.974
```

Discuss briefly how/whether spectral normalization helps generate higher quality images in your implementation. Ideally, you should show samples from models with and without normalization.

We believe that spectrally normalizing our convolution layers contributed to improving the quality of images we generated with our GAN as can be seen in our images(below). This is because Spectrally normalized(SN) GANs are believed to have better quality images compared to those without this normalization technique as SN controls two important failure modes with GAN training: exploding and vanishing gradients. In our model, we think SN plays an important role in stabilizing the model during training and hence, we are able to obtain better quality and crisp images.

Attaching images for epochs- 10, 25, 50 for the following:

1. GAN (with spectral normalization) Samples

EPOCH: 10
Iter: 4500, D: 0.07991, G:3.642

EPOCH: 25
Iter: 12000, D: 0.01915, G:3.488

```
Iter: 24500, D: 0.02577, G:4.939
```

2. GAN (without spectral normalization) Samples

```
EPOCH:  10
Iter: 4500, D: 0.04916, G:5.268
```

```
EPOCH:  25
Iter: 12000, D: 0.003946, G:4.846
```

```
Iter: 24500, D: 0.000932, G:9.624
```

<u>Extra credit:</u> If you completed the extra credit for this portion, explain what you did (describing all model changes and hyperparameter settings) and provide output images.

For extra credit, we implemented the WGAN.

Hyperparameters: We used the default hyperparameters in the paper (https://arxiv.org/pdf/1701.07875.pdf), stated below:

Learning rate = 0.00005

Batch size = 64
Number of critic iterations = 5
Weight clipping = (-0.01 , 0.01)
Epochs for training = 50
Noise dimension = 100

Model changes: We removed the last non-linearity layer while training the WGAN. This is the recommendation of the author. We maintained every other convolutional layers used in DCGAN

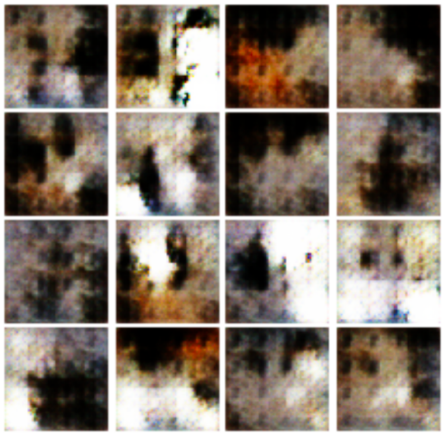
Optimizers: We used RMSprop for our optimizers in both critic and generator

Train: we created a new training function for the WGAN critic and generator

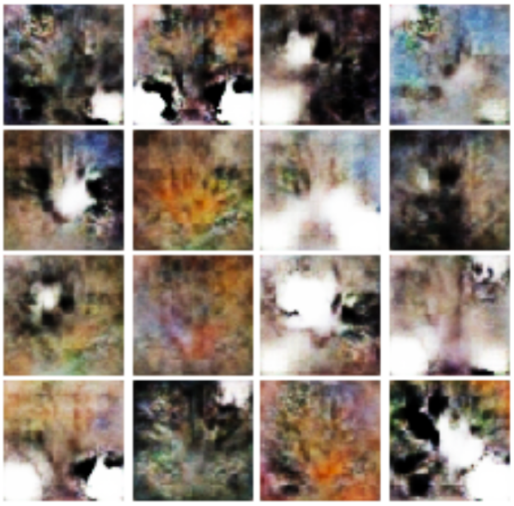
Observation: We noticed, WGAN takes longer to train as the first reasonable result was observed at epoch 18. The quality of final output is similar to LSGAN and DCGAN and may be improved with parameter tuning.

Output images from WGAN

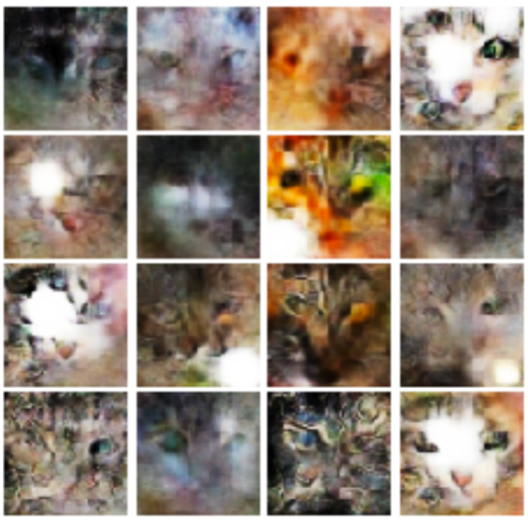
Iter: 1250, Critic: -0.9213, G:0.4571



Iter: 7750, Critic: -0.7307, G:0.366



EPOCH: 45
Iter: 21750, Critic: -0.4191, G:-0.1112



EPOCH: 46
Iter: 22250, Critic: -0.2877, G:0.03783

EPOCH: 49
Iter: 23750, Critic: -0.376, G:0.09056

EPOCH 50:

Iter: 24500, Critic: -0.357, G:-0.2428