Module 8: Portfolio Project Option 1 Part 2

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Colorado State University Global

CSC580 Applying Machine Learning and Neural Networks - Capstone

Pubali Banerjee

10/05/2025

Training a generative adversarial network (GAN) rarely succeeds upon first attempt. Successive improvements driven through competitive discrepancies of the generator versus discriminator developed as the training progressed. In this case, the training of the GAN on CIFAR-10 dataset went through several iterations and hyperparameter tunings.

Initially, the GAN was with the DCGAN framework trained only on one class for a fairly short duration 20 epochs a few times and then 50. The second iteration was much higher for epochs set, it was increased from 50 to 250, however on this iteration the discriminator made much faster progress and the generator's losses increased and the discriminator was able to guess the generated images at nearly a perfect rate. This resulted in both vanishing gradients and also poor image quality. Adversarial stability was revealed as being the first challenge (Goodfellow et al., 2014).

To adjust the next iteration we started increasing the batch size, and switched from Binary Cross Entropy loss to hinge loss function to prevent the accuracy of the discriminator getting stuck at one. This proved slightly better, the GAN didn't fail at either the discrimination or generation steps, however the images that were created weren't that accurate. Other stabilization techniques were introduced in the next phase in order to keep the discriminator from dominance, label smoothing for example where real labels were set to 0.9 instead of 1.0.

Up to that point training had been on a single class of CIFAR-10 eight, which is ships. After seeing the generator not improving as much in quality after many epochs it was decided to try two additional approaches, flipping the labels every once in a while (say 5–10% of batches) to force the discriminator to be less overconfident and using a conditional GAN adding class labels as extra input to both generator and discriminator (Mirza & Osindero, 2014). However, under this change the discriminator risked overpowering the generator again because it had

access to richer conditional information.

The switch to prioritizing update dynamics was made and learning rates were decoupled. The rations for training a generator multiple steps at times for each discriminator step were played to find the optimum. These adjustments went toward equilibrium since they ensured that not either network converged with quickness at the expense of the other.

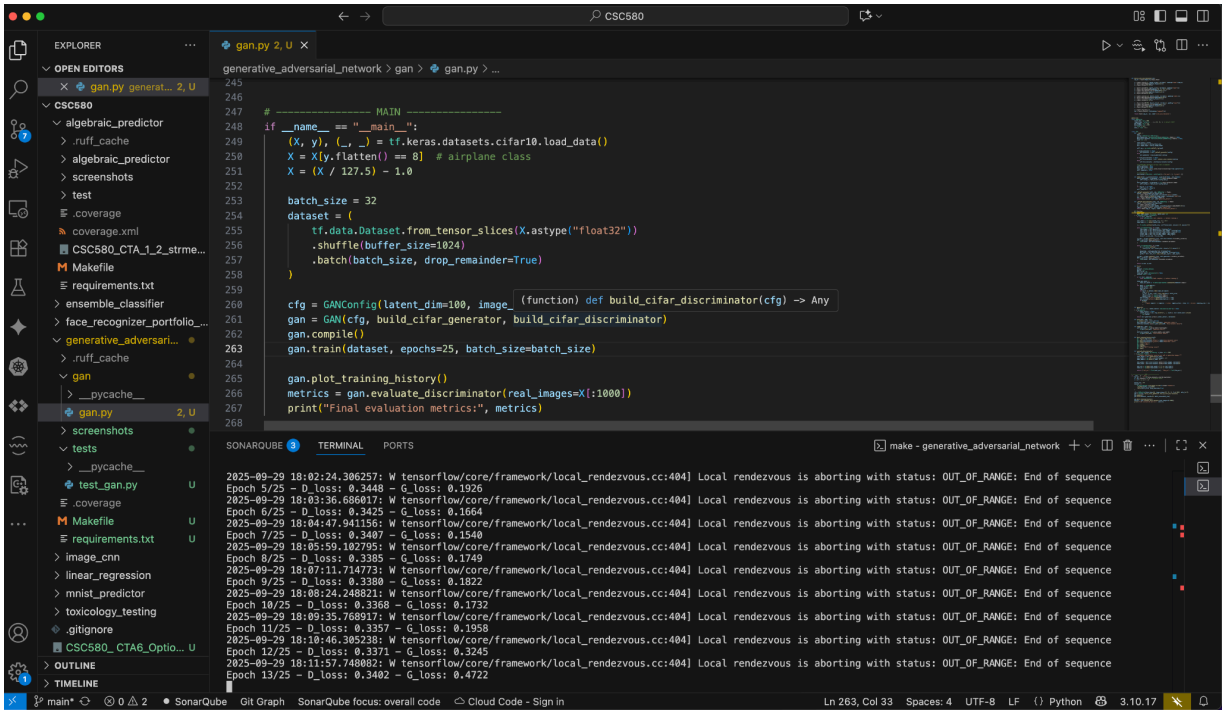
To monitor progress systematically, quantitative metrics beyond raw loss were added. Counterfeit data to generator failure so the F1 scores with fake gave us a clearer model balance picture. Visualization added qualitative evidence about improvements that numbers alone could not capture.

Through this evolution, the project moved in the direction of a training regime more stable and interpretable starting from a fragile baseline. Observed imbalances in the adversarial process prompted each modification. Each modification got done via label smoothing, loss function changes, conditioning, or update balancing. These steps depict the broader principle that GAN training is all about iterative negotiation between just two competing models instead of about just a single recipe.

References

Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A., & Bengio, Y. (2014). *Generative adversarial nets.* In Advances in Neural Information Processing Systems (pp. 2672–2680).

Mirza, M., & Osindero, S. (2014). *Conditional generative adversarial nets*. arXiv preprint arXiv:1411.1784.


CSC580
EXPLORER
OPEN EDITORS
gan.py 2, U
generative_adversarial_network > gan > gan.py > ...
# ---------- MAIN ----------
if __name__ == "__main__":
(X, y), (_, _) = tf.keras.datasets.cifar10.load_data()
X = X[y.flatten() == 8] # airplane class
X = (X / 127.5) - 1.0
batch_size = 32
dataset = (
tf.data.Dataset.from_tensor_slices(X.astype("float32"))
.shuffle(buffer_size=1024)
.batch(batch_size, drop_remainder=True)
)
cfg = GANConfig(latent_dim=100, image_
(function) def build_cifar_discriminator(cfg) -> Any
gan = GAN(cfg, build_cifar_generator, build_cifar_discriminator)
gan.compile()
gan.train(dataset, epochs=25, batch_size=batch_size)
gan.plot_training_history()
metrics = gan.evaluate_discriminator(real_images=X[:1000])
print("Final evaluation metrics:", metrics)
SONARQUBE 3
TERMINAL
PORTS
make - generative_adversarial_network
2025-09-29 18:02:24.306257: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 5/25 - D_loss: 0.3448 - G_loss: 0.1926
2025-09-29 18:03:36.686017: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 6/25 - D_loss: 0.3425 - G_loss: 0.1664
2025-09-29 18:04:47.941156: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 7/25 - D_loss: 0.3407 - G_loss: 0.1540
2025-09-29 18:05:59.102795: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 8/25 - D_loss: 0.3385 - G_loss: 0.1749
2025-09-29 18:07:11.714773: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 9/25 - D_loss: 0.3380 - G_loss: 0.1822
2025-09-29 18:08:24.248821: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 10/25 - D_loss: 0.3368 - G_loss: 0.1732
2025-09-29 18:09:35.768917: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 11/25 - D_loss: 0.3357 - G_loss: 0.1958
2025-09-29 18:10:46.305238: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 12/25 - D_loss: 0.3371 - G_loss: 0.3245
2025-09-29 18:11:57.748082: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 13/25 - D_loss: 0.3402 - G_loss: 0.4722
main*
SonarQube
Git Graph
SonarQube focus: overall code
Cloud Code - Sign in
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Spaces: 4
UTF-8
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Python
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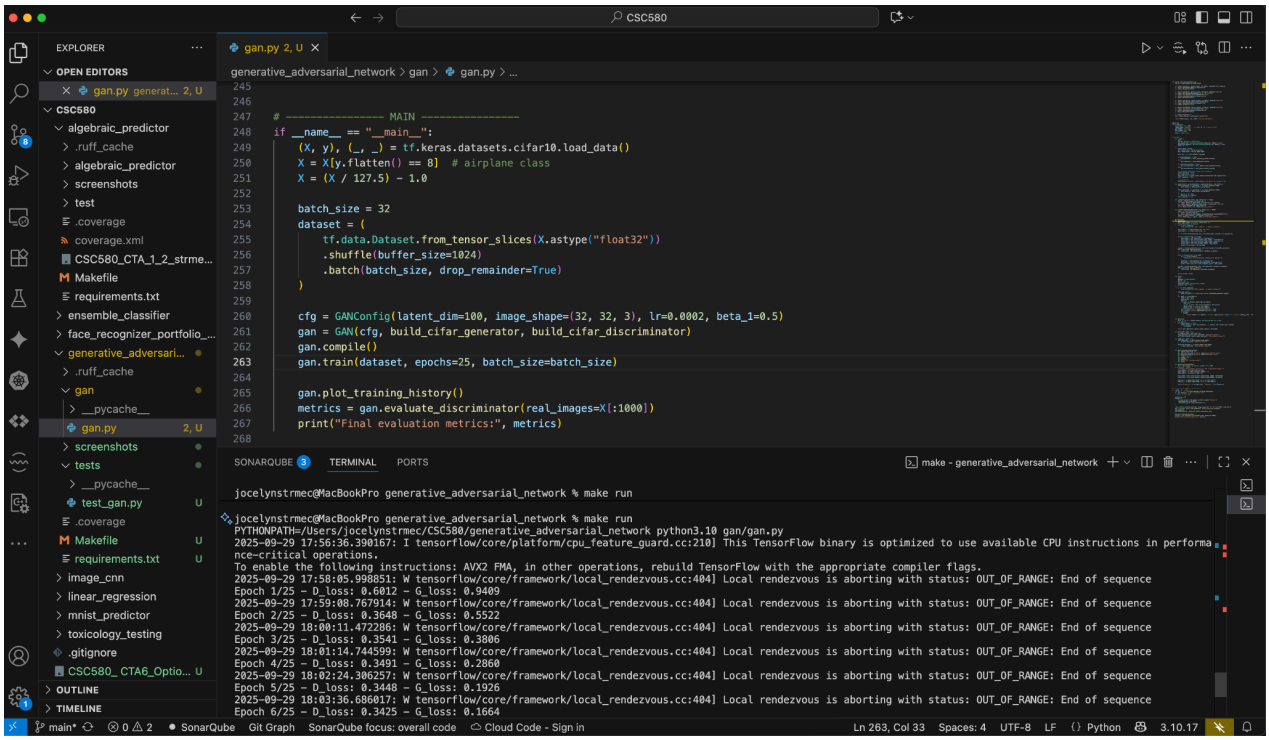
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gan.py 2, U
generative_adversarial_network > gan > gan.py > ...
# ---------- MAIN ----------
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X = X[y.flatten() == 8] # airplane class
X = (X / 127.5) - 1.0
batch_size = 32
dataset = (
tf.data.Dataset.from_tensor_slices(X.astype("float32"))
.shuffle(buffer_size=1024)
.batch(batch_size, drop_remainder=True)
)
cfg = GANConfig(latent_dim=100, image_shape=(32, 32, 3), lr=0.0002, beta_1=0.5)
gan = GAN(cfg, build_cifar_generator, build_cifar_discriminator)
gan.compile()
gan.train(dataset, epochs=25, batch_size=batch_size)
gan.plot_training_history()
metrics = gan.evaluate_discriminator(real_images=X[:1000])
print("Final evaluation metrics:", metrics)
SONARQUBE 3
TERMINAL
PORTS
make - generative_adversarial_network
jocelynstrmec@MacBookPro generative_adversarial_network % make run
jocelynstrmec@MacBookPro generative_adversarial_network % make run
PYTHONPATH=/Users/jocelynstrmec/CSC580/generative_adversarial_network python3.10 gan/gan.py
2025-09-29 17:56:36.390167: I tensorflow/core/platform/cpu_feature_guard.cc:210] This TensorFlow binary is optimized to use available CPU instructions in performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.
2025-09-29 17:58:05.998851: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 1/25 - D_loss: 0.6012 - G_loss: 0.9409
2025-09-29 17:59:08.767914: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 2/25 - D_loss: 0.3648 - G_loss: 0.5522
2025-09-29 18:00:11.472286: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 3/25 - D_loss: 0.3541 - G_loss: 0.3806
2025-09-29 18:01:14.744599: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 4/25 - D_loss: 0.3491 - G_loss: 0.2860
2025-09-29 18:02:24.306257: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
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Epoch 6/25 - D_loss: 0.3425 - G_loss: 0.1664
main*
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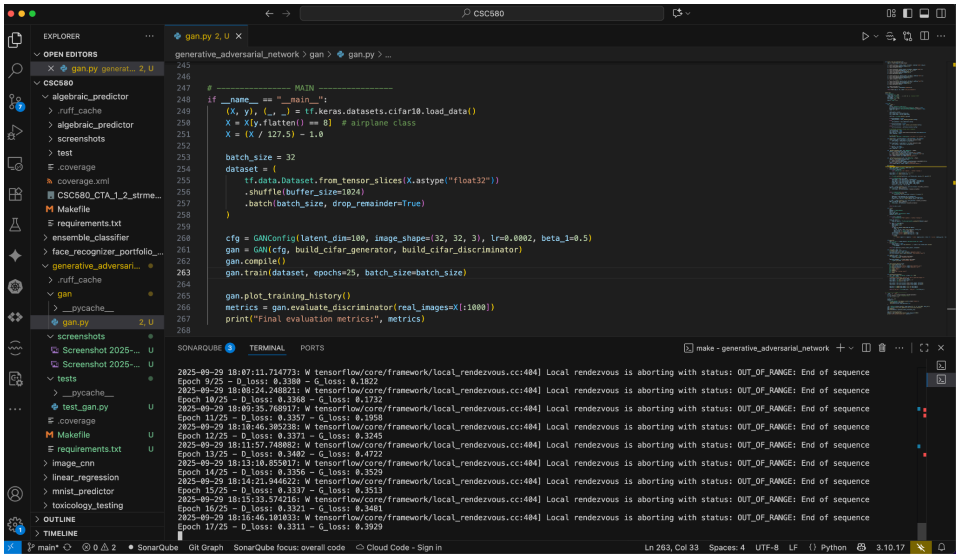
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generative_adversarial_network > gan > gan.py > ...
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Epoch 9/25 – D_loss: 0.3388 – G_loss: 0.1822
2025-09-29 18:08:24.248821: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 10/25 – D_loss: 0.3368 – G_loss: 0.1732
2025-09-29 18:09:35.760917: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 11/25 – D_loss: 0.3357 – G_loss: 0.1958
2025-09-29 18:10:46.385238: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
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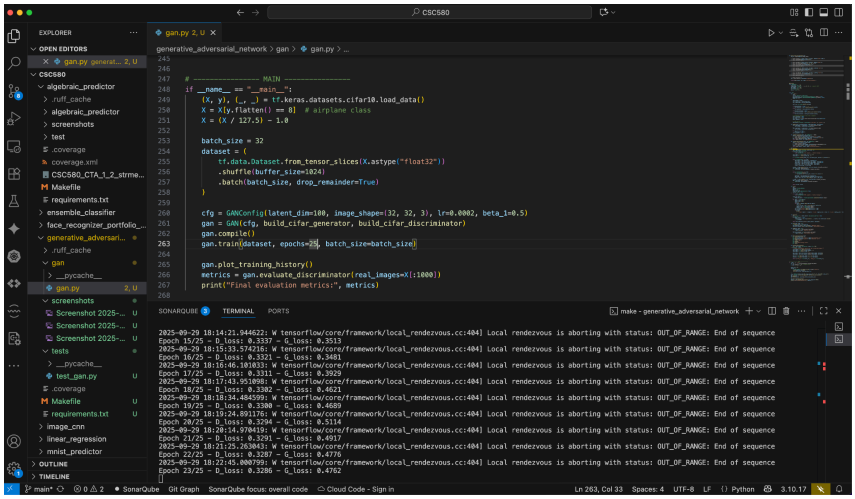
2025-09-29 18:13:10.855017: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 14/25 – D_loss: 0.3356 – G_loss: 0.3529
2025-09-29 18:14:21.944622: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 15/25 – D_loss: 0.3337 – G_loss: 0.3513
2025-09-29 18:15:33.574216: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 16/25 – D_loss: 0.3321 – G_loss: 0.3401
2025-09-29 18:16:46.101833: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 17/25 – D_loss: 0.3311 – G_loss: 0.3929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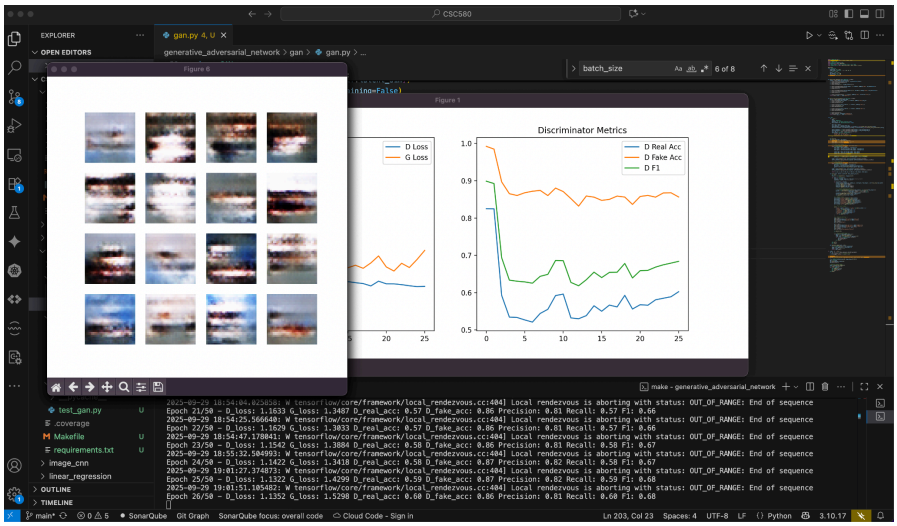
Epoch 16/25 – D_loss: 0.3321 – G_loss: 0.3401
2025-09-29 18:16:46.101833: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 17/25 – D_loss: 0.3311 – G_loss: 0.3928
2025-09-29 18:17:41.951098: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 18/25 – D_loss: 0.3382 – G_loss: 0.4621
2025-09-29 18:18:34.484599: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 19/25 – D_loss: 0.3380 – G_loss: 0.4689
2025-09-29 18:19:24.891176: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 20/25 – D_loss: 0.3294 – G_loss: 0.5114
2025-09-29 18:20:14.970419: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 21/25 – D_loss: 0.3291 – G_loss: 0.4917
2025-09-29 18:21:25.263043: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 22/25 – D_loss: 0.3287 – G_loss: 0.4775
2025-09-29 18:22:45.000799: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 23/25 – D_loss: 0.3286 – G_loss: 0.4762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Discriminator Metrics
D Loss
G Loss
D Real Acc
D Fake Acc
D F1
TERMINAL
Epoch 21/50 – D_loss: 1.1633 G_loss: 1.3407 D_real_acc: 0.57 D_fake_acc: 0.86 Precision: 0.81 Recall: 0.57 F1: 0.66
Epoch 22/50 – D_loss: 1.1629 G_loss: 1.3833 D_real_acc: 0.57 D_fake_acc: 0.86 Precision: 0.81 Recall: 0.57 F1: 0.66
Epoch 23/50 – D_loss: 1.1542 G_loss: 1.3884 D_real_acc: 0.58 D_fake_acc: 0.86 Precision: 0.81 Recall: 0.58 F1: 0.67
Epoch 24/50 – D_loss: 1.1422 G_loss: 1.3418 D_real_acc: 0.58 D_fake_acc: 0.87 Precision: 0.82 Recall: 0.58 F1: 0.67
Epoch 25/50 – D_loss: 1.1322 G_loss: 1.4299 D_real_acc: 0.59 D_fake_acc: 0.87 Precision: 0.82 Recall: 0.59 F1: 0.68
Epoch 26/50 – D_loss: 1.1352 G_loss: 1.5298 D_real_acc: 0.60 D_fake_acc: 0.86 Precision: 0.81 Recall: 0.60 F1: 0.68

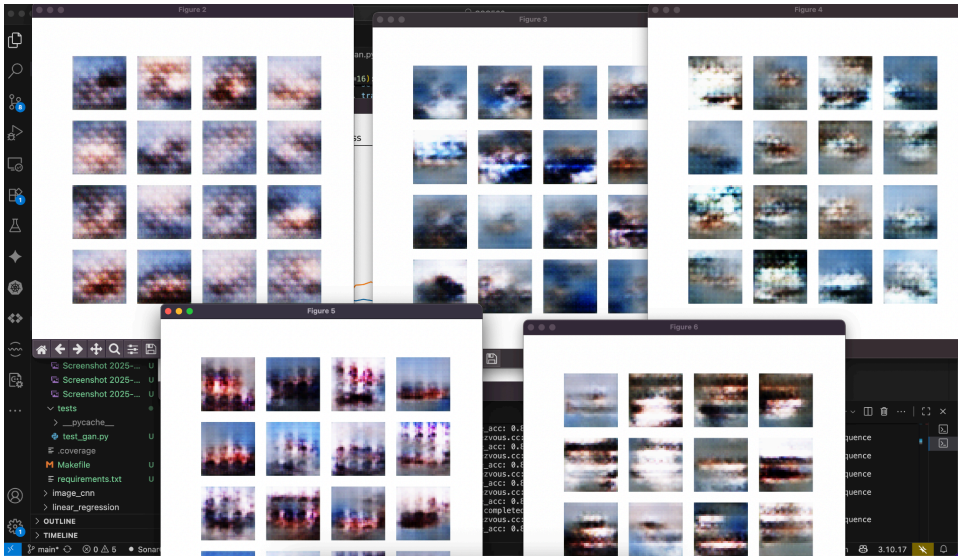
Figure 2
Figure 3
Figure 4
Figure 5
Figure 6
Screenshot 2025-...
tests
__pycache__
test_gan.py
.coverage
Makefile
requirements.txt
image_cnn
linear_regression
OUTLINE
TIMELINE
3.10.17

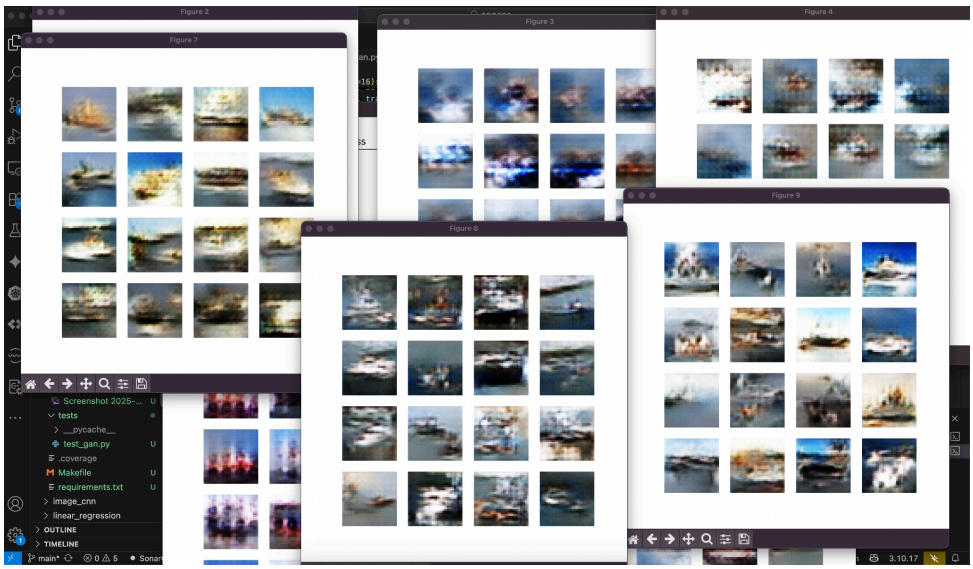
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Figure 9
Screenshot 2025-...
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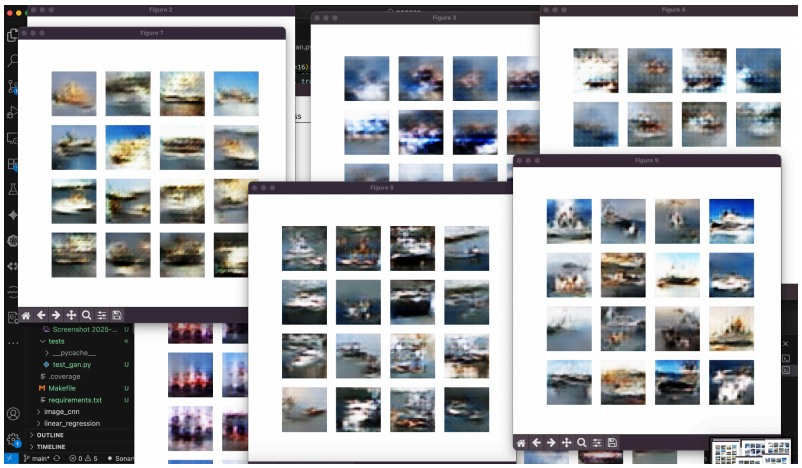
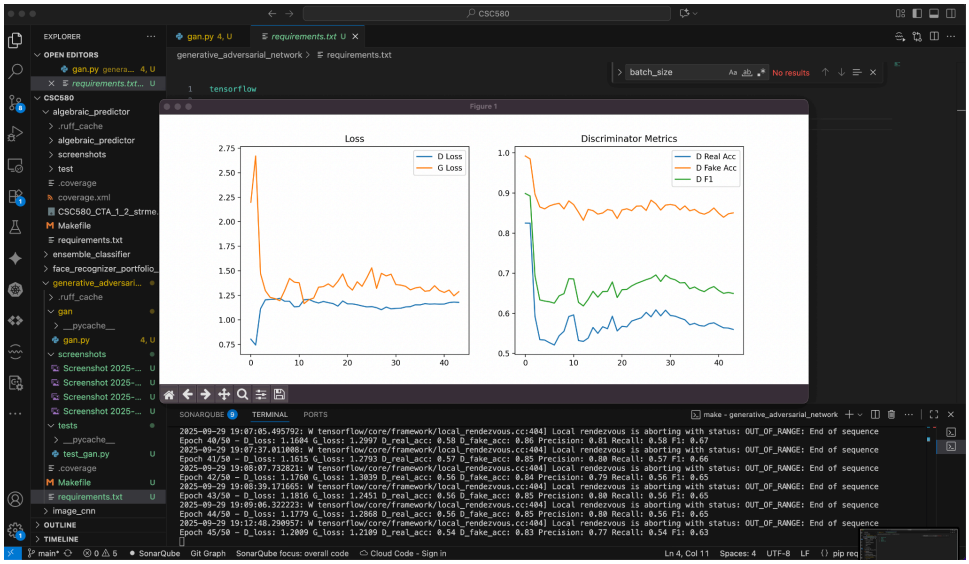
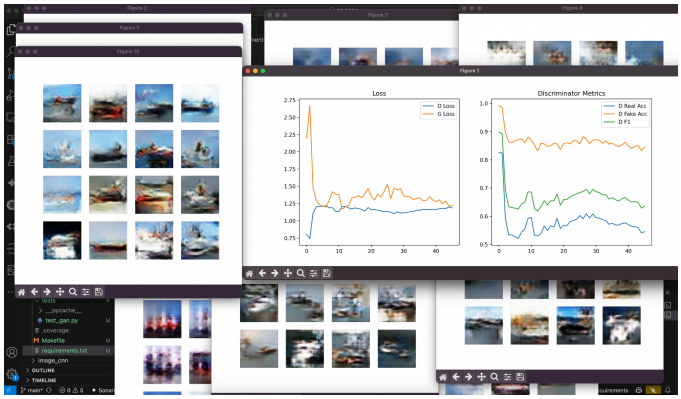
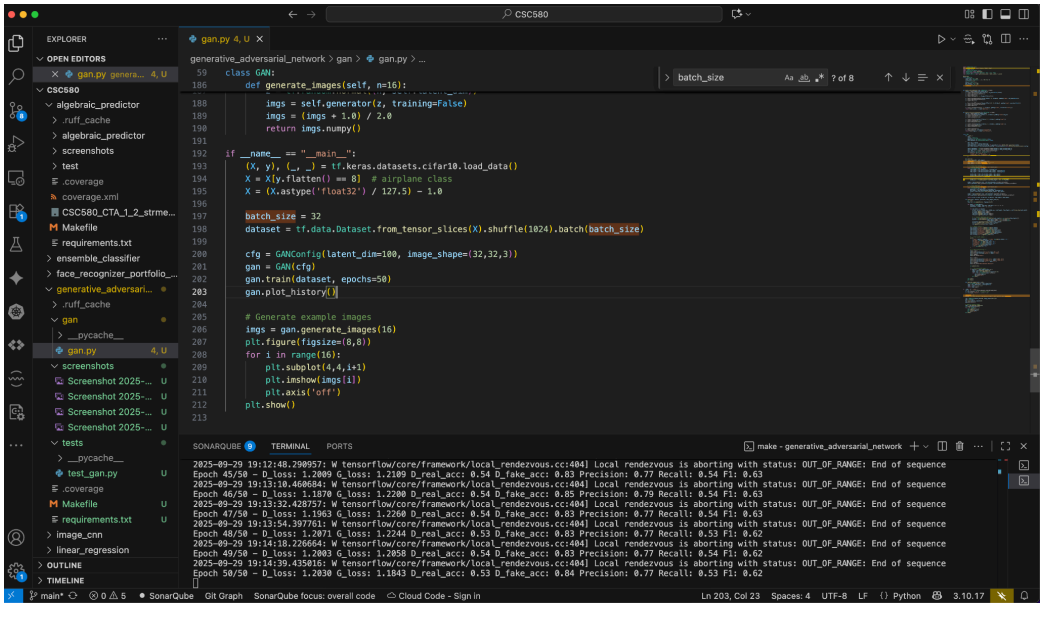



Loss
D Loss
G Loss
Discriminator Metrics
D Real Acc
D Fake Acc
D F1





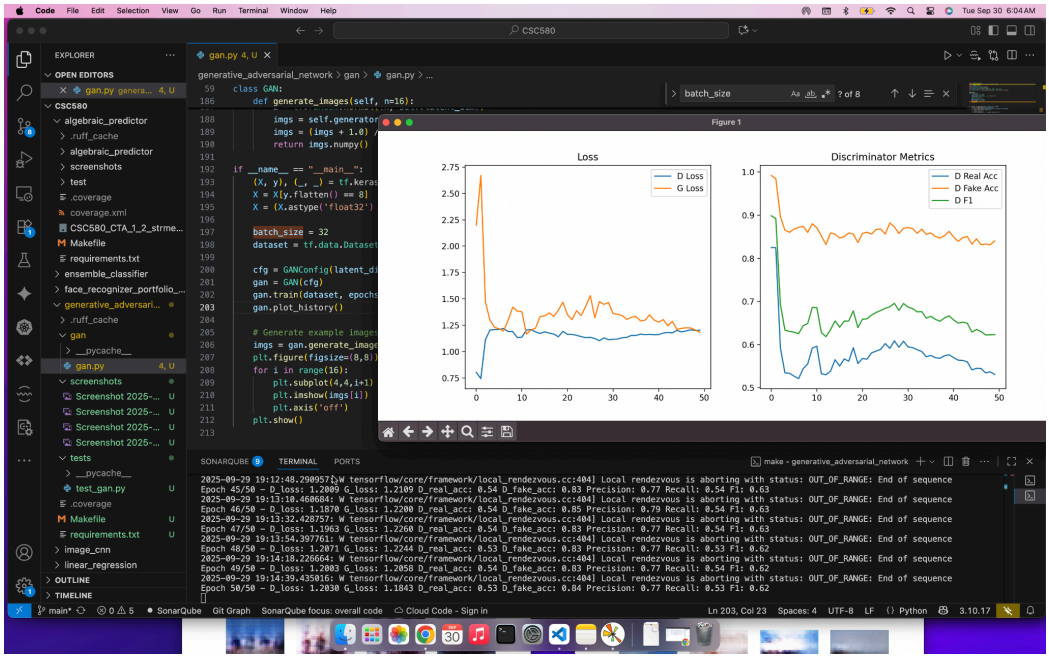
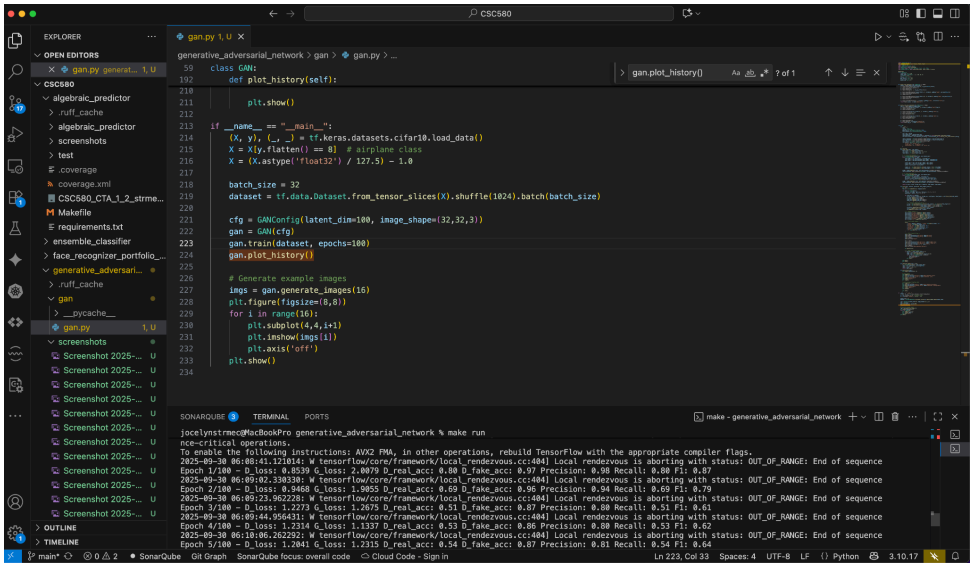
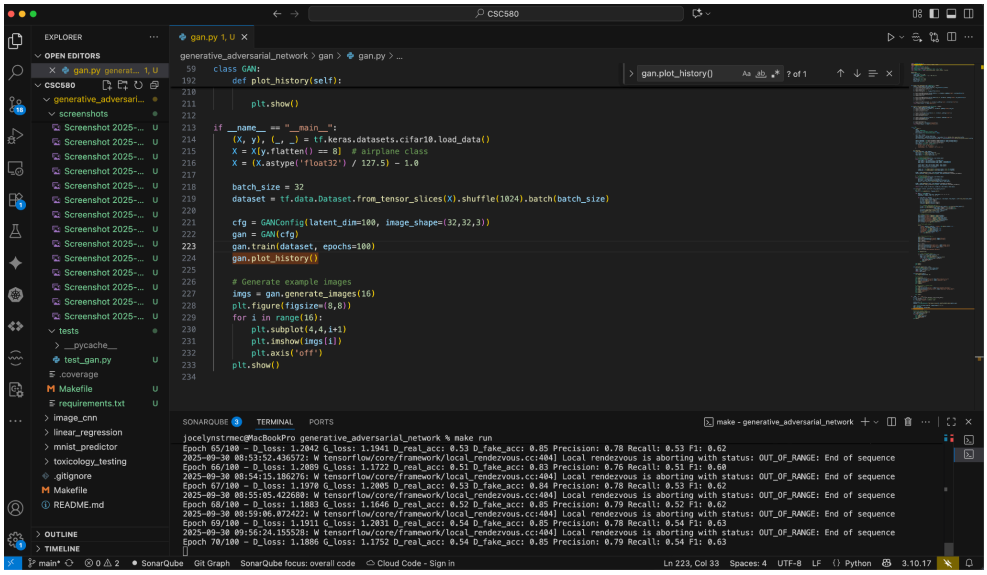


Figure 1
Loss
D Loss
G Loss
Discriminator Metrics
D Real Acc
D Fake Acc
D F1





```
class GAN:
    def plot_history(self):

        plt.show()

if __name__ == "__main__":
    (X, y), (_, _) = tf.keras.datasets.cifar10.load_data()
    X = X[y.flatten() == 8]  # airplane class
    X = (X.astype('float32') / 127.5) - 1.0

    batch_size = 32
    dataset = tf.data.Dataset.from_tensor_slices(X).shuffle(1024).batch(batch_size)

    cfg = GANConfig(latent_dim=100, image_shape=(32,32,3))
    gan = GAN(cfg)
    gan.train(dataset, epochs=100)
    gan.plot_history()

    # Generate example images
    imgs = gan.generate_images(16)
    plt.figure(figsize=(8,8))
    for i in range(16):
        plt.subplot(4,4,i+1)
        plt.imshow(imgs[i])
        plt.axis('off')
    plt.show()
```

```
jocelynstrmec@MacBookPro generative_adversarial_network % make run
Epoch 65/100 - D_loss: 1.2042 G_loss: 1.1941 D_real_acc: 0.53 D_fake_acc: 0.85 Precision: 0.78 Recall: 0.53 F1: 0.62
2025-09-30 08:53:52.436572: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 66/100 - D_loss: 1.2089 G_loss: 1.1722 D_real_acc: 0.51 D_fake_acc: 0.83 Precision: 0.76 Recall: 0.51 F1: 0.60
2025-09-30 08:54:15.186276: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 67/100 - D_loss: 1.1970 G_loss: 1.2005 D_real_acc: 0.53 D_fake_acc: 0.84 Precision: 0.78 Recall: 0.53 F1: 0.62
2025-09-30 08:55:05.422680: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 68/100 - D_loss: 1.1883 G_loss: 1.1646 D_real_acc: 0.52 D_fake_acc: 0.85 Precision: 0.79 Recall: 0.52 F1: 0.62
2025-09-30 08:59:06.072422: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 69/100 - D_loss: 1.1911 G_loss: 1.2031 D_real_acc: 0.54 D_fake_acc: 0.85 Precision: 0.78 Recall: 0.54 F1: 0.63
2025-09-30 09:56:24.155528: W tensorflow/core/framework/local_rendezvous.cc:404] Local rendezvous is aborting with status: OUT_OF_RANGE: End of sequence
Epoch 70/100 - D_loss: 1.1886 G_loss: 1.1752 D_real_acc: 0.54 D_fake_acc: 0.85 Precision: 0.79 Recall: 0.54 F1: 0.63
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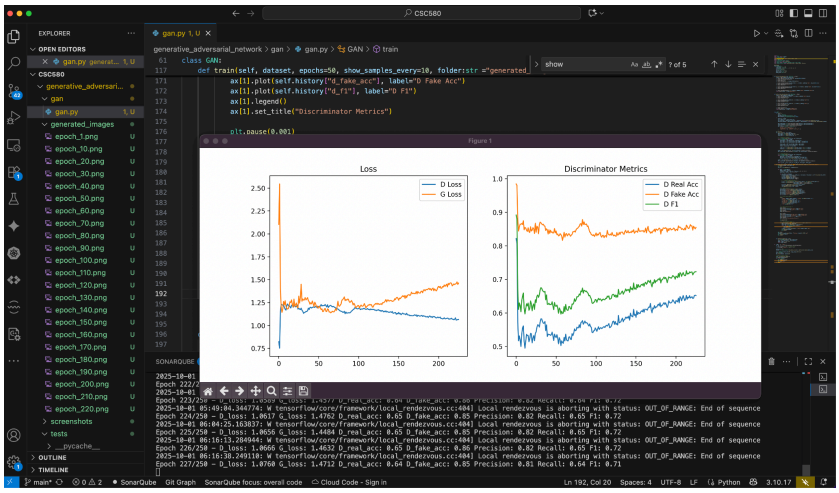
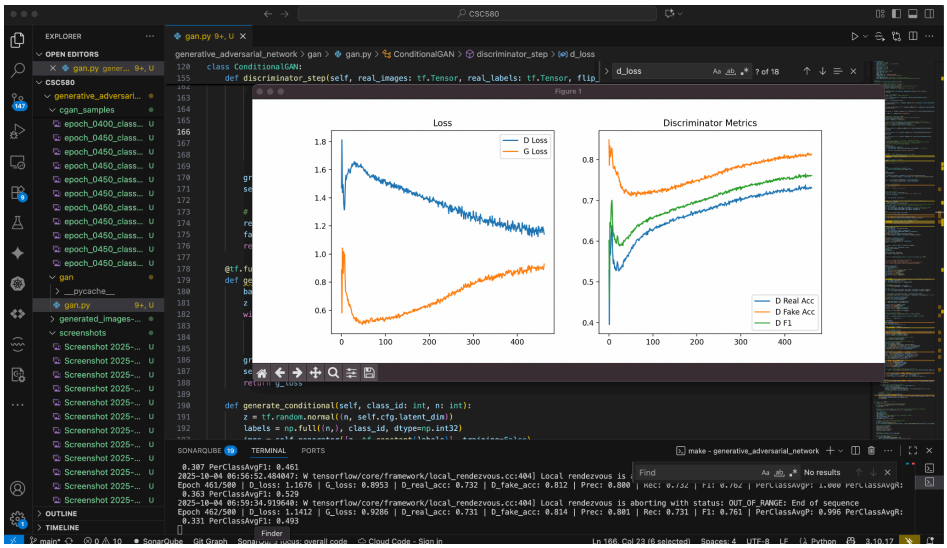
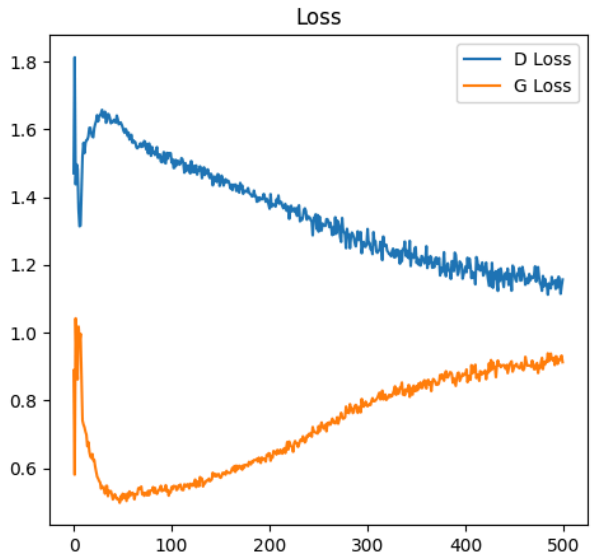
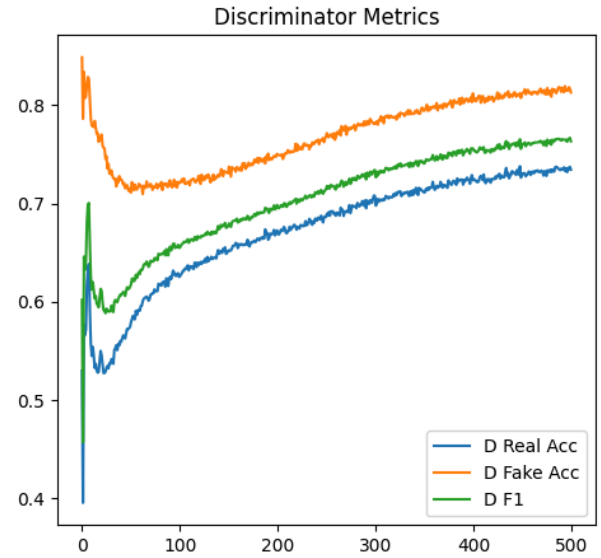
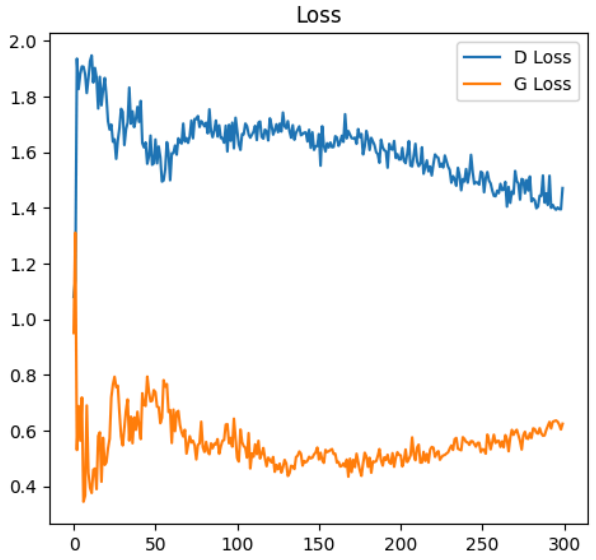
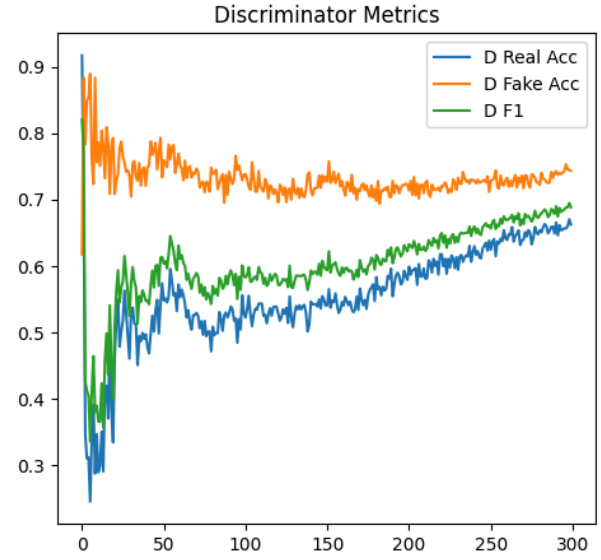





Loss
D Loss
G Loss
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0
100
200
300
400
500


Discriminator Metrics
D Real Acc
D Fake Acc
D F1
0.8
0.7
0.6
0.5
0.4
0
100
200
300
400
500


Loss
D Loss
G Loss
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
50
100
150
200
250
300


Discriminator Metrics
D Real Acc
D Fake Acc
D F1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
50
100
150
200
250
300