

FACE AGING USING Cycle-GAN

(Cycle-Generative adversarial networks)

A Deep Learning Approach to Age Progression

EAI 6020- FINAL PROJECT

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Degree: Master of Professional Studies In Analytics



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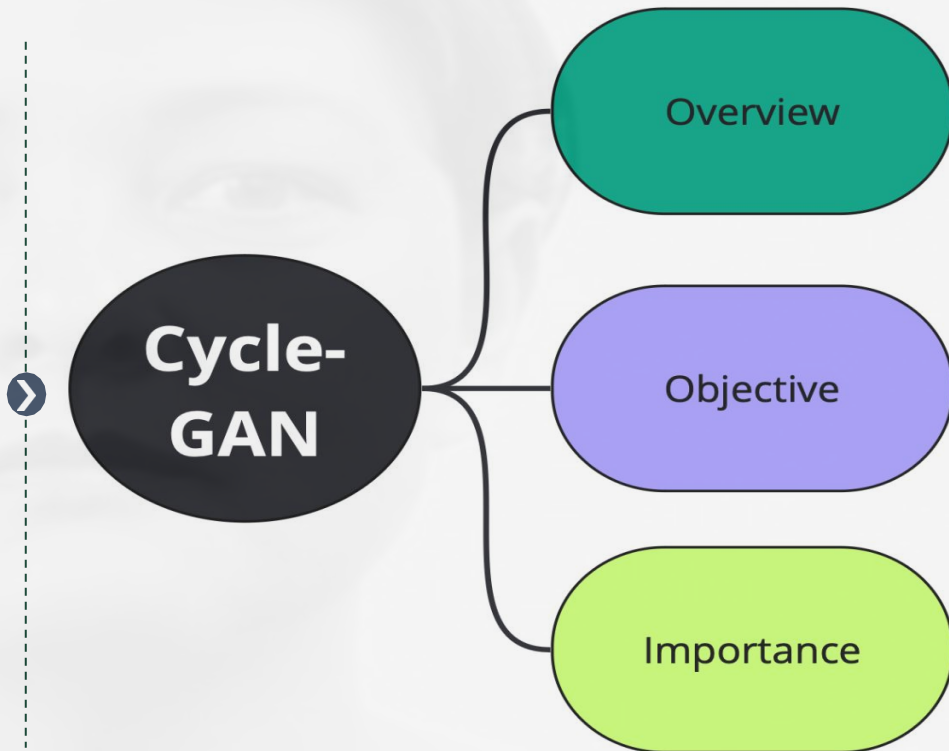


Abhilash Dikshit

Introduction & Modelling

Age Estimation Tool for performance evaluation.

- Overview of the project: Proposed a **CycleGAN** based model for predictive aging.
- Objective: Generate predictive images of people's appearance after certain years based on their current images using CycleGAN
- Importance: No need for a paired dataset; Ensures original and translated images represent the same person. Enables domain knowledge transfer without paired examples.



Face Aging Using GANs - Why CycleGAN?

Benefits of CycleGAN for Face Aging

- **No Need for Paired Data:** Overcomes challenges of obtaining paired images of the same individual at different ages.
- **Cycle-Consistency Loss:** Ensures translated images maintain the identity of the original input.
- **Captures Subtle Facial Features:** Effective in learning and translating complex facial characteristics associated with aging.
- **Flexible Architecture:** Allows incorporation of transfer learning and fine-tuning for enhanced performance.

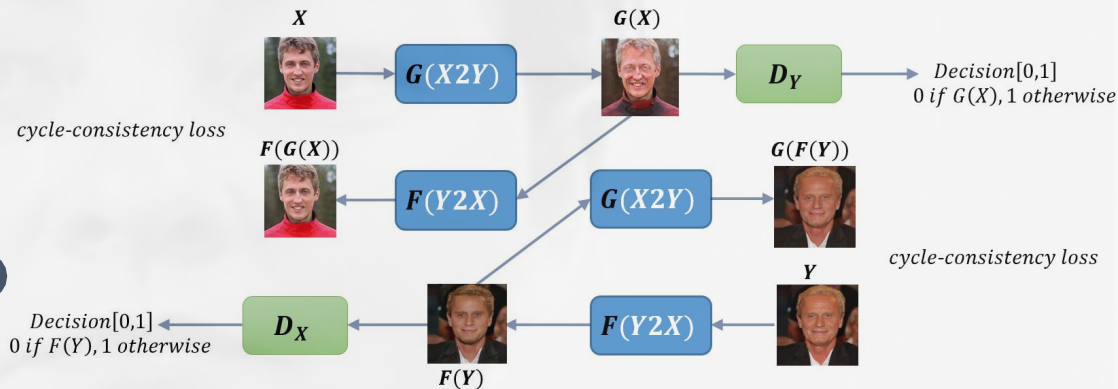


Fig: Cycle GAN Model Architecture

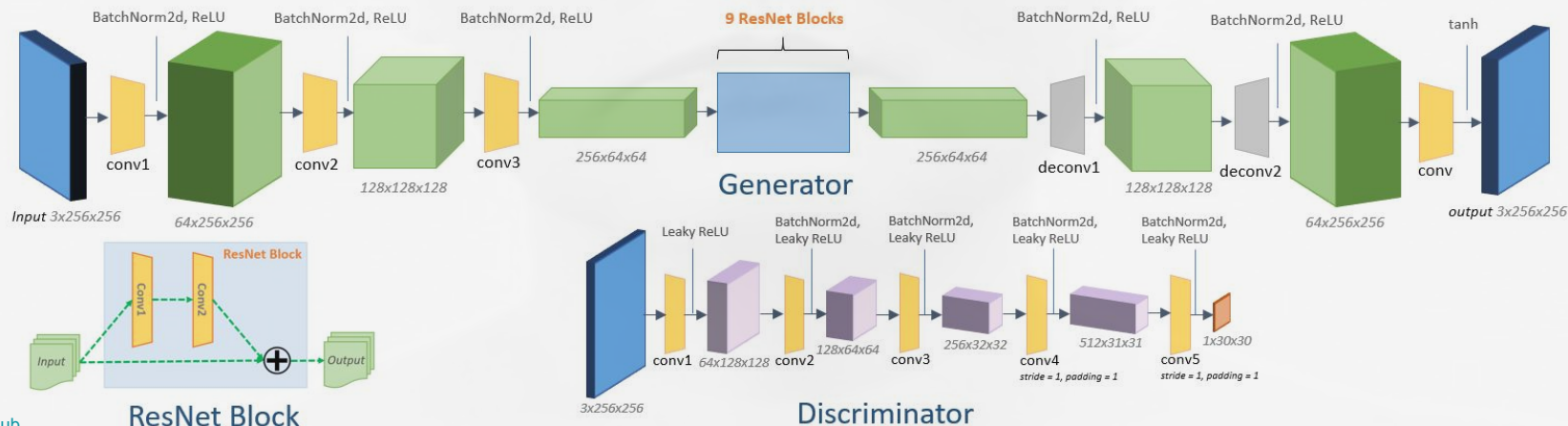
Generator-ResNetBlock-Discriminator

ResNetBlock:

- Stands for "Residual Network Block".
- Helps in building deeper networks without facing the vanishing gradient problem.
- Contains skip connections that allow the gradient to flow more directly during backpropagation.
- Enhances the stability and speed of training, leading to better convergence.

Discriminator:

- Differentiates between real and translated/generated images.
- Enhances the quality of generated images by providing feedback to the generator.
- Utilizes adversarial loss to train the generator to produce more realistic images.
- Acts as a critical component in the adversarial training process of CycleGAN.

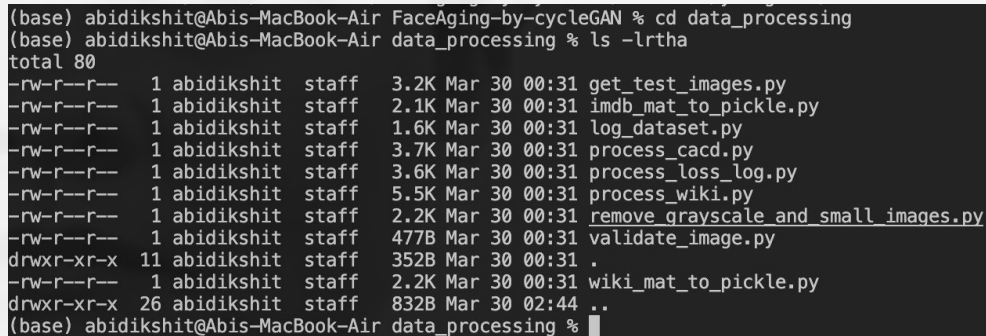




Dataset & Data Processing

Contribution & Data Processing

- Based on **Original CycleGAN** implementation.
- Extended functionalities to handle datasets and support transfer learning.
- Data processing utilities:
 - `get_test_images.py`
 - `imdb_mat_to_pickle.py`
 - `wiki_mat_to_pickle.py`
 - `process_cacd.py`
 - `process_wiki.py`
 - `log_dataset.py`
 - `remove_grayscale_and_small_images.py`
 - `validate_image.py`
 - `process_loss_log.py`

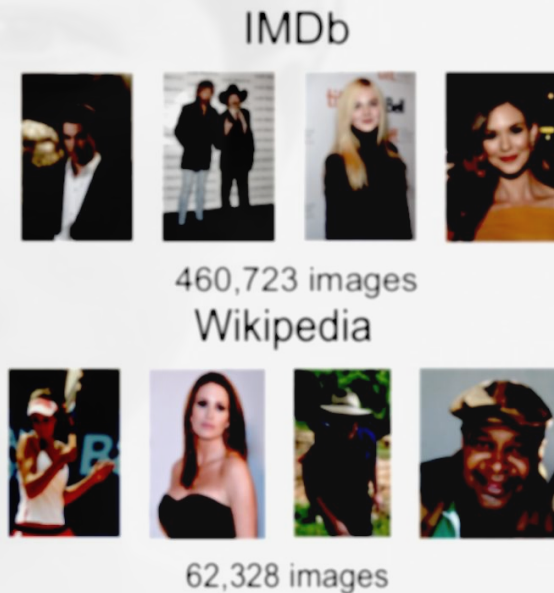
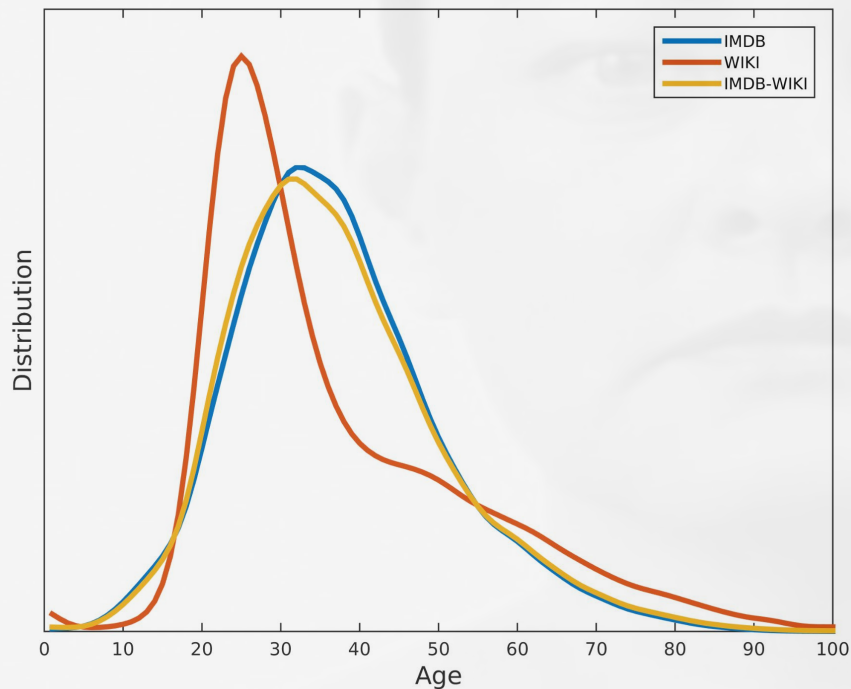


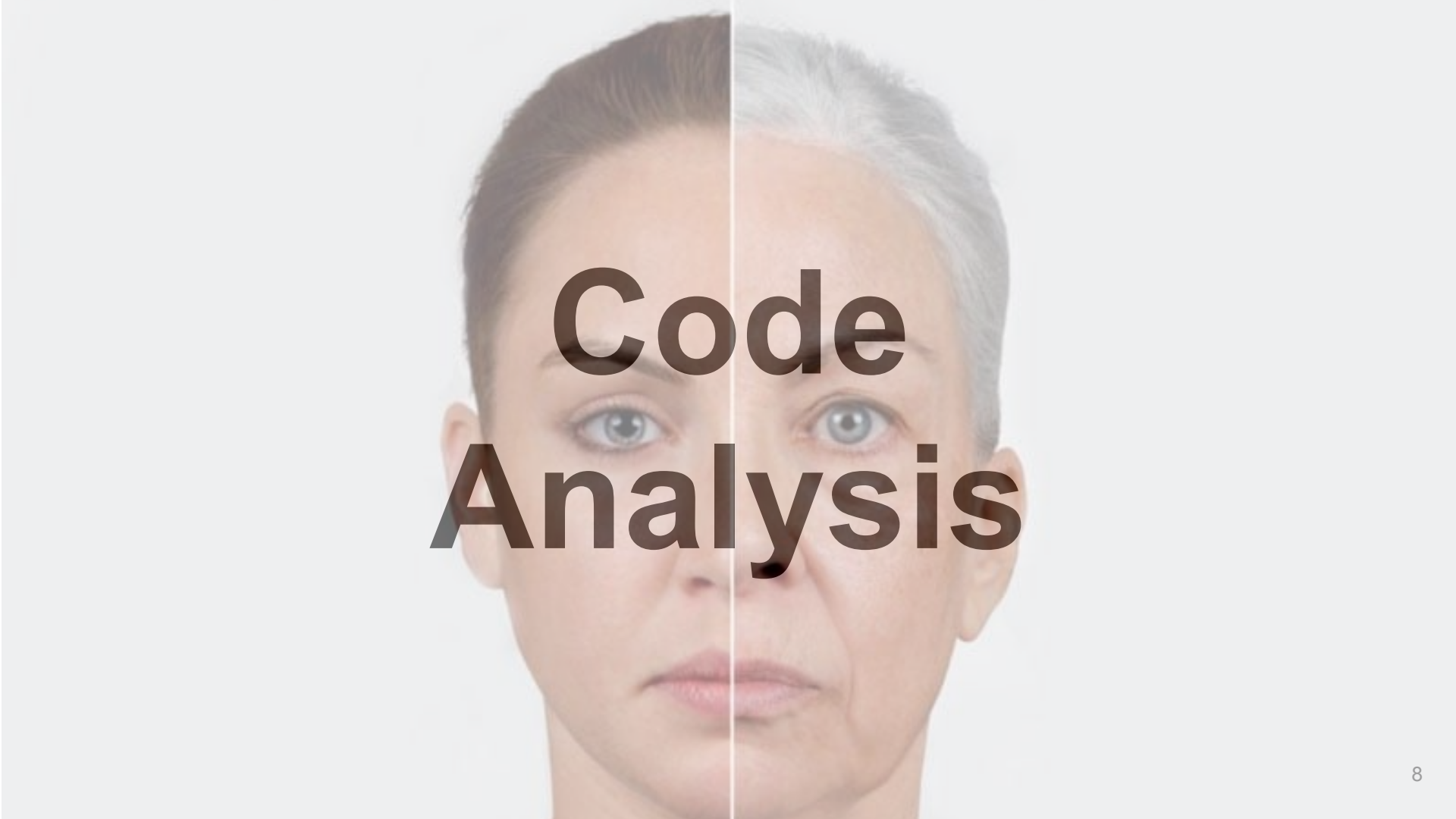
A terminal window showing the directory listing of the `data_processing` folder. The prompt is `(base) abidikshit@Abis-MacBook-Air FaceAging-by-cycleGAN %`. The command `cd data_processing` is entered, followed by `(base) abidikshit@Abis-MacBook-Air data_processing % ls -lrtha`. The output shows a list of files with their permissions, sizes, dates, and names. A blue arrow points from the list of utilities in the previous block to this terminal output.

```
(base) abidikshit@Abis-MacBook-Air FaceAging-by-cycleGAN % cd data_processing
(base) abidikshit@Abis-MacBook-Air data_processing % ls -lrtha
total 80
-rw-r--r--  1 abidikshit  staff   3.2K Mar 30 00:31 get_test_images.py
-rw-r--r--  1 abidikshit  staff   2.1K Mar 30 00:31 imdb_mat_to_pickle.py
-rw-r--r--  1 abidikshit  staff   1.6K Mar 30 00:31 log_dataset.py
-rw-r--r--  1 abidikshit  staff   3.7K Mar 30 00:31 process_cacd.py
-rw-r--r--  1 abidikshit  staff   3.6K Mar 30 00:31 process_loss_log.py
-rw-r--r--  1 abidikshit  staff   5.5K Mar 30 00:31 process_wiki.py
-rw-r--r--  1 abidikshit  staff   2.2K Mar 30 00:31 remove_grayscale_and_small_images.py
-rw-r--r--  1 abidikshit  staff   477B Mar 30 00:31 validate_image.py
drwxr-xr-x 11 abidikshit  staff   352B Mar 30 00:31 .
-rw-r--r--  1 abidikshit  staff   2.2K Mar 30 00:31 wiki_mat_to_pickle.py
drwxr-xr-x 26 abidikshit  staff   832B Mar 30 02:44 ..
(base) abidikshit@Abis-MacBook-Air data_processing %
```

Dataset

- **IMDB-WIKI-500k**: 500k+ celebrity face images with age and gender labels
- **Cross-Age Celebrity Dataset (CACD)**: 163 k+ images of 2,000 celebrities





Code Analysis

The screenshot displays a Jupyter Notebook environment. The main plot, titled "aging_cyclegan loss over time", shows the training loss for various components over 2000 epochs. The y-axis represents the loss, ranging from 0 to 4.5, and the x-axis represents the epoch number, ranging from 1.1 to 1.9. The legend identifies the following series: D_A (blue), G_A (orange), cycle_A (green), idt_A (red), D_B (purple), G_B (brown), cycle_B (pink), and idt_B (grey). A specific point on the cycle_A curve is highlighted with a green box and labeled "(1.206612, 4.386067) cycle_A".

On the right side of the notebook, there is a terminal window showing the execution of a training script. The output includes configuration parameters, dataset initialization, and a detailed log of training progress for each epoch, including time taken and loss values for different components.

Training Output



Model Testing


```
MINGW64/g/FaceAging-by-cycleGAN
junja@MSI MINGW64 /g/FaceAging-by-cycleGAN (master)
$ python test.py --dataroot ./datasets/young2old --name aging_cyclegan --model cycle_gan
-----
Options
D_A_freeze_layer: 0
D_B_freeze_layer: 0
G_A_freeze_layer: 0
G_B_freeze_layer: 0
aspect_ratio: 1.0
batch_size: 1
checkpoints_dir: ./checkpoints
dataroot: ./datasets/young2old [default: None]
dataset_mode: unaligned
direction: AtoB
display_winsize: 256
epoch: latest
eval: False
fineSize: 256
gpu_ids: 0
init_gain: 0.02
init_type: normal
input_nc: 3
isTrain: False [default: None]
loadSize: 256
max_dataset_size: inf
model: cycle_gan [default: test]
n_layers_D: 3
name: aging_cyclegan [default: experiment_name]
ndf: 64
netD: basic
netG: resnet_9blocks
nff: 64
no_dropout: True
no_flip: False
norm: instance
ntest: inf
num_test: 50
num_threads: 4
output_nc: 3
phase: test
pretrained_model_epoch: 1
pretrained_model_name:
pretrained_model_subname:
  resize_or_crop: resize_and_crop
  results_dir: ./results/
  serial_batches: False
  suffix:
use_pretrained_model: False
verbose: False
-----
End -----
dataset [UnalignedDataset] was created
initialize network with normal
initialize network with normal
model [CycleGANModel] was created
loading the model from ./checkpoints/aging_cyclegan/latest_net_G_A.pth
loading the model from ./checkpoints/aging_cyclegan/latest_net_G_B.pth
-----
Networks initialized
[Network_G_A] Total number of parameters : 11.378 M
[Network_G_A] Total number of trainable parameters : 11.378 M
[Network_G_B] Total number of parameters : 11.378 M
[Network_G_B] Total number of trainable parameters : 11.378 M
-----
processing (0000)-th image... [./datasets/young2old/testA/10000217_1981-05-05_2009.jpg]
processing (0005)-th image... [./datasets/young2old/testA/10016223_1988-02-03_2012.jpg]
processing (0010)-th image... [./datasets/young2old/testA/1006407_1980-07-07_2005.jpg]
processing (0015)-th image... [./datasets/young2old/testA/10084176_1989-03-21_2014.jpg]
```

The screenshot displays a Windows File Explorer window with the address bar showing the path: This PC > New Volume (G:) > FaceAging-by-cycleGAN > results > aging_cyclegan > test_latest >. The main area shows a grid of 100 generated face images, each with a filename and a timestamp. The images are arranged in a 10x10 grid. The filenames are as follows:

Row	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	
1	10996600.1988-06-15.2008.jpg	10997985.1982-07-30.2011.jpg	10996607.1983-02-16.2013.jpg	12201685.1984-08-20.2012.jpg	12210236.1988-12-29.2009.jpg	12220183.1987-05-20.2011.jpg	12251591.1985-05-17.2011.jpg	12266278.1982-08-09.2011.jpg	12296396.1983-10-10.2009.jpg	12247002.1988-03-12.2014.jpg	12253254.1987-06-21.2012.jpg
2	12266212.1985-05-18.2010.jpg	12271528.1981-04-10.2010.jpg	12274789.1983-11-25.2013.jpg	12281355.1986-12-12.2009.jpg	12282820.1985-07-12.2012.jpg	12295184.1983-07-10.2011.jpg	12299543.1989-12-25.2015.jpg	13001672.1973-02-27.2000.jpg	13003011.1983-07-12.2012.jpg	13016000.1987-01-20.2009.jpg	13024882.1983-02-15.2008.jpg
3	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg
4	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg
5	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg
6	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg
7	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg
8	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg
9	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg
10	13072884.1984-03-23.2009.jpg	13073298.1983-05-03.2011.jpg	13076091.1985-08-18.2014.jpg	13101535.1988-02-14.2014.jpg	13121006.1982-06-26.2010.jpg	13121888.1986-08-22.2010.jpg	13121509.1983-11-18.2011.jpg	13121565.1986-07-31.2011.jpg	13121645.1988-04-07.2013.jpg	13130181.1988-12-01.2014.jpg	13132809.1984-04-23.2008.jpg

At the bottom of the window, there are six larger images labeled 'real_A', 'fake_B', 'real_A', 'real_B', 'fake_A', and 'real_B'. These images show the original faces and the generated faces, demonstrating the effectiveness of the FaceAging-by-cycleGAN model.





Result & Conclusion

Result & Conclusion

- **Model Comparison** and quantitative results.
- Visual representation of aging transformations.

#	Source	Mix	Epochs	Preloaded?	Freeze until	G Size	Max	Avg	10+	15+	20+
0	CACD	All	200	N/A	N/A	9 blocks	25.8	6.7	22%	5.5%	1.7%
1	WIKI	All	200	N/A	N/A	9 blocks	31.2	8.8	37%	14%	5.8%
2	WIKI	Female	200	N/A	N/A	9 blocks	19.5	4.6	7.1%	2.5%	0.0%
3	WIKI	Male	200	N/A	N/A	9 blocks	27.3	10.3	50%	19%	5.1%
4	WIKI	Male	200	N/A	N/A	6 blocks	N/A	N/A	N/A	N/A	N/A
5	WIKI	All	200	horse2zebra	8th block	9 blocks	27.4	11.0	55%	20%	6.3%
6	WIKI	All	200	summer2winter	8th block	9 blocks	25.0	8.9	36%	10%	1.7%
7	WIKI	All	200	monet2photo	8th block	9 blocks	20.1	6.6	15%	2.5%	0.4%
8	WIKI	Male	100	horse2zebra	N/A	9 blocks	25.8	9.9	46%	12%	1.3%
9	WIKI	Male	100	Model #2	N/A	9 blocks	32.8	10.3	51%	18%	6.0%



References

References

AgingGAN: Age Progression with CycleGAN

Jie Chen (jiechen8), Junwen Bu (junwenbu), and Yu Zhao (zhaoyu92)

CS230 Deep Learning, Stanford University

Introduction

Age progression, the process of aesthetically rendering a facial image with simulated effect of growing old, has attracted much attention from the Deep Learning and Computer Vision community. It is a challenging task because it requires a single input image to generate a target image.

- Face aging with conditional generative adversarial networks. (2017, September 1). IEEE Conference Publication |

IEEE Xplore. <https://ieeexplore.ieee.org/document/8296650>

- Ai, N. (2022, April 7). GAN for Face Aging problem | Neurond AI | Medium. Medium.

Dataset & Features

IMDb-WIKI [2]

- Group A (age 20-30)
 - 2,779 images (2,209 male, 1,839 female).
 - Age difference > 3.

[68299adfd](https://www.kaggle.com/datasets/jiechen8/imdb-wiki)

- Group B (age 50+)
 - 2,779 images (2,209 male, 570 female)

- Wikipedia contributors. (2024, March 20). Generative adversarial network. Wikipedia.

Cross-Age Celebrity (CACD) [3]

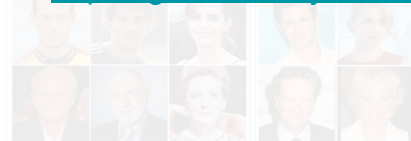
- Group A (age 20-30)
 - 2,200 images randomly taken from pool of 33,872.
- Group B (age 50+)
 - 2,200 images randomly taken from pool of 33,872.

Modifications

- Removed Gray-scale images
- Removed images that are not pictures (e.g., drawings)

- Jiechen. (n.d.). *GitHub - jiechen2358/FaceAging-by-cycleGAN*. GitHub.

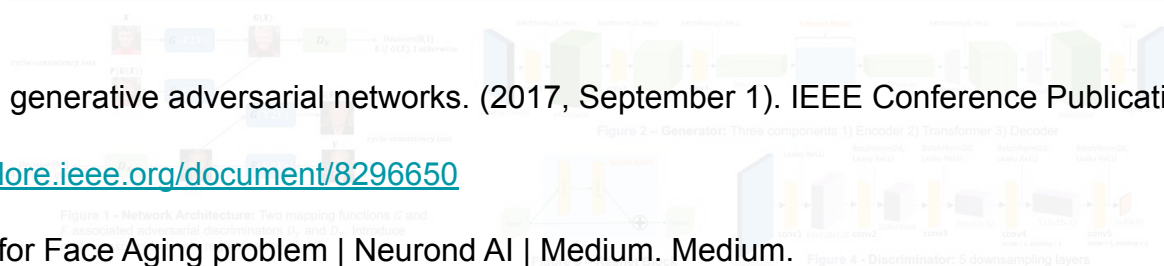
<https://github.com/jiechen2358/FaceAging-by-cycleGAN/tree/master?tab=readme-ov-file>



IMDb-WIKI dataset

CACD dataset

Method and Model



In practice, using least-squares loss, e.g. $\mathcal{L}_{GAN}(G, D, X, Y) = \mathbb{E}_{x \sim P_{data}(x)} [\log D(x)] + \mathbb{E}_{y \sim P_{data}(y)} [\log (1 - D(y))]$

Results

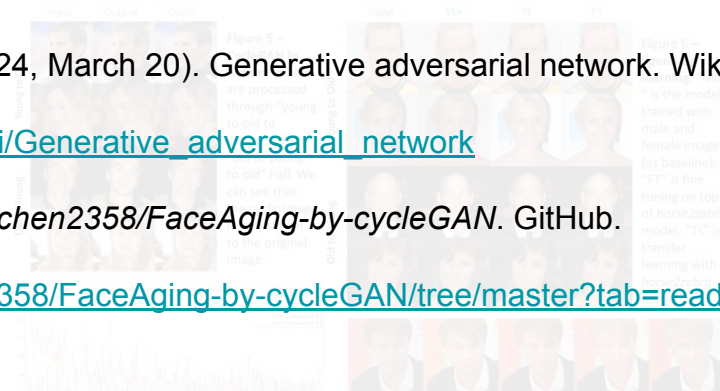


Figure 5 – Growing Old: cross epoch effects

Acknowledgements: CS230 teaching staff

Conclusions

1. CycleGAN can generate quality age progression images.
2. The aging effects will increase as # of epoch increases, but overfitting effect become less and less apparent after 200 epochs.
3. Pre-training and fine-tuning using other trained model (horse2zebra model in our case) can be applied to accelerate training but will slightly compromise the quality of the output.
4. The choice of dataset can severely affect the performance of the model (CACD dataset has horrible results).

Future Work

- Investigate the correlation between the Cycle-Consistency cost and image quality.
- Increase training set size to 20-50K.
- Explore models support facial geometric changes.

References

1. J.-Y. Zhu, T. Park, P. Isola, and A. A. Efros. Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks. in ICCV, 2017.
2. IMDb-WIKI – 500k+ face images with age and gender labels. <https://data.vision.ee.ethz.ch/cv/datasets/imdb-wiki/>
3. Cross-Age Reference Coding for Age-Invariant Face Recognition and Retrieval. <https://github.com/jiechen2358/carc>



**Any
Questions?**