Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

CS7GV1 Computer Vision Project

Frequency Based Deepfake Detection through Frequency Space Learning
Based off a paper by Chuangchuang Tan et al. 2024 [arXiv:2403.07240v1]

By:
Daniel Farushev
Ramy El-Sherbiny

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Problem Definition

- **Deepfake (AI generated) image recognition**

- **Generalizable model (most learn artifact patterns of a specific GAN)**

Datasets

Utilised multiple datasets for training, evaluation, and testing

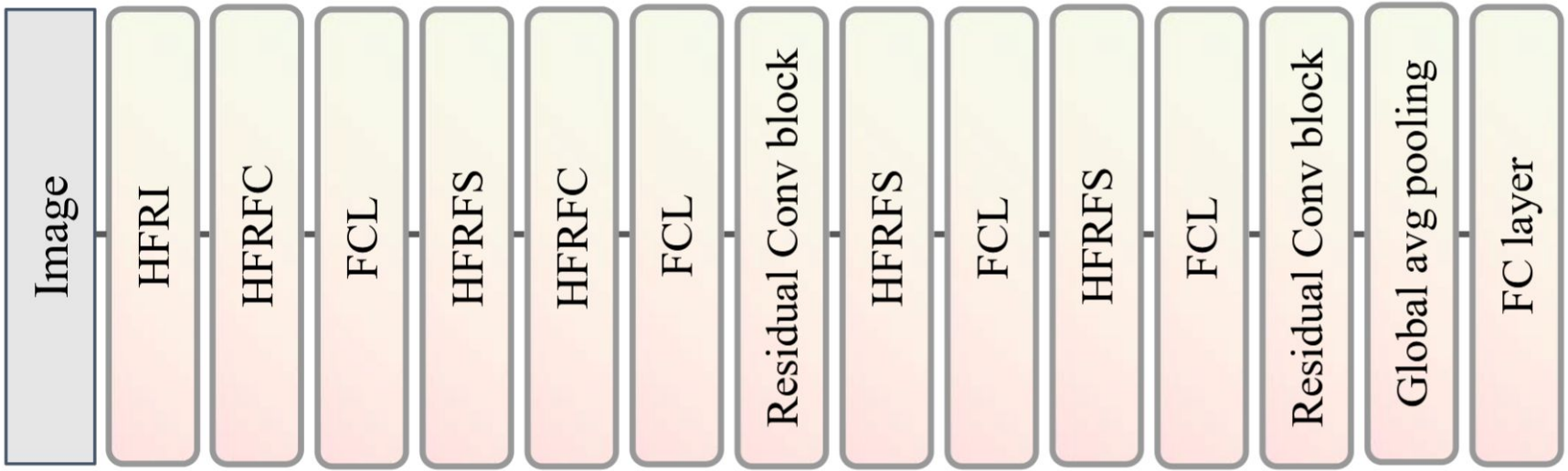
- Training and Evaluation: ForenSynths (Wang et al.2020)
  - Real: LSUN
  - Fake: generated by ProGAN
- Testing:
  - Curated test set by Chuangchuang Tan et al. 2024

- Test set of ForenSynths for evaluation includes fake images generated by 8 generation models (ProGAN, StyleGAN, StyleGAN2, BigGAN, CycleGAN, StarGAN, GauGAN, Deepfake).
- Test set by Chuangchuang Tan et al. 2024 consists of a dedicated face test set comprising 20,000 real images sourced from Celeba-HQ (Karras et al. 2018), and 60,000 fake face images from ProGAN (Karras et al. 2018), StyleGAN (Karras et al. 2019), and StyleGAN2 (Karras et al. 2020).

Preprocessing

- Most dataset images already pre-processed by dataset creators
- The rest:
  - Resizing and Cropping
  - Random Horizontal Flip (randomly only for training)
  - JPEG compression (randomly only for training)
  - Normalization

Architecture (high level view)



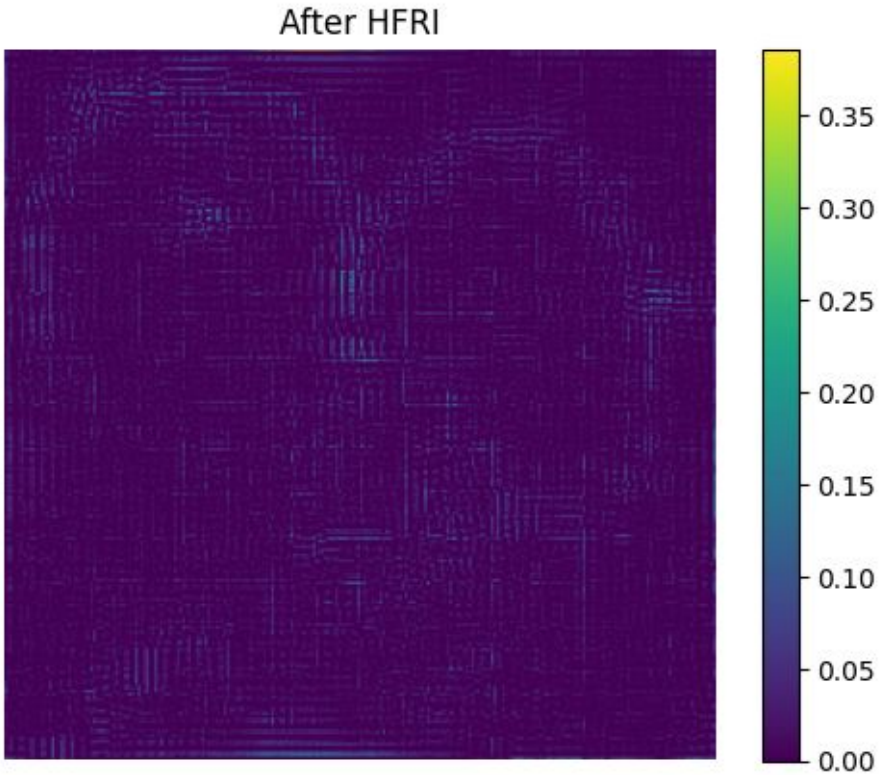
N.B. FCL refers to Frequency Convolutional Layer, not Fully Connected Layer

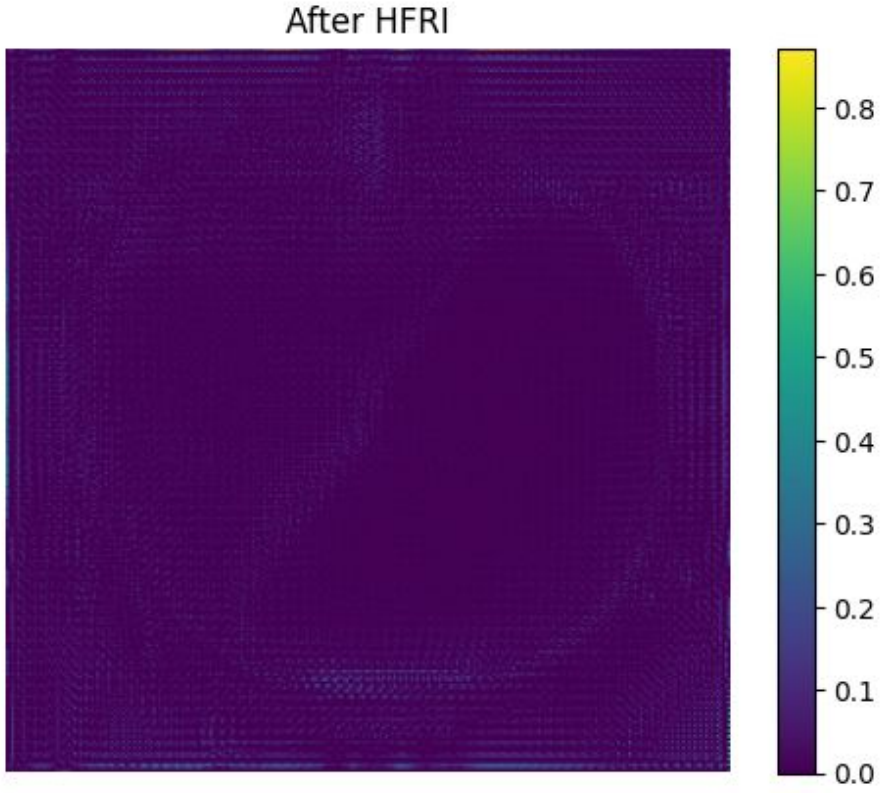
Frequency space representation

Real

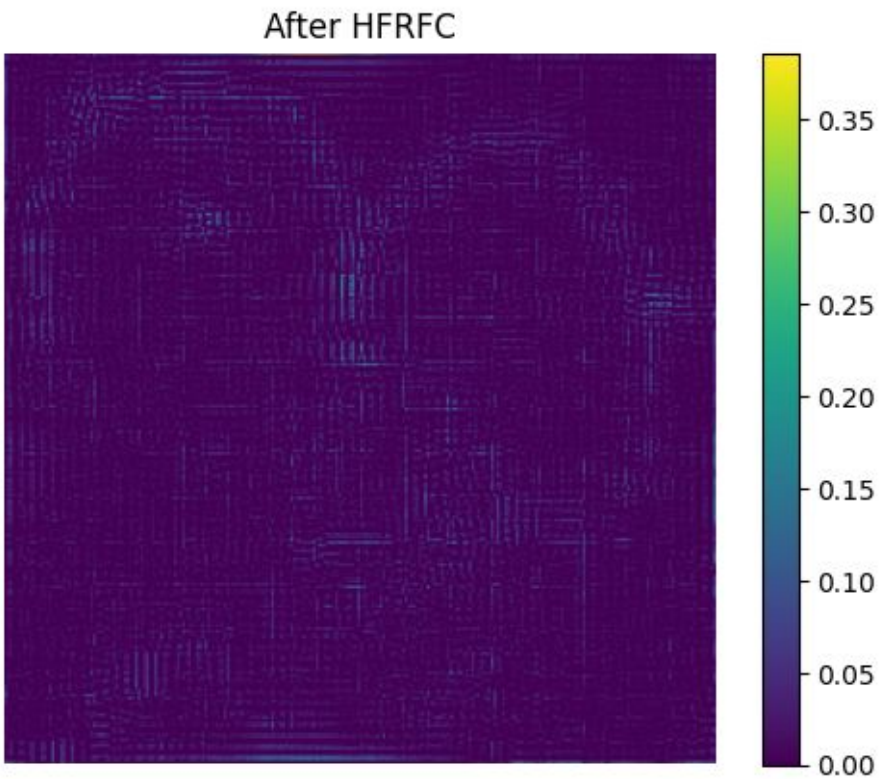
Fake

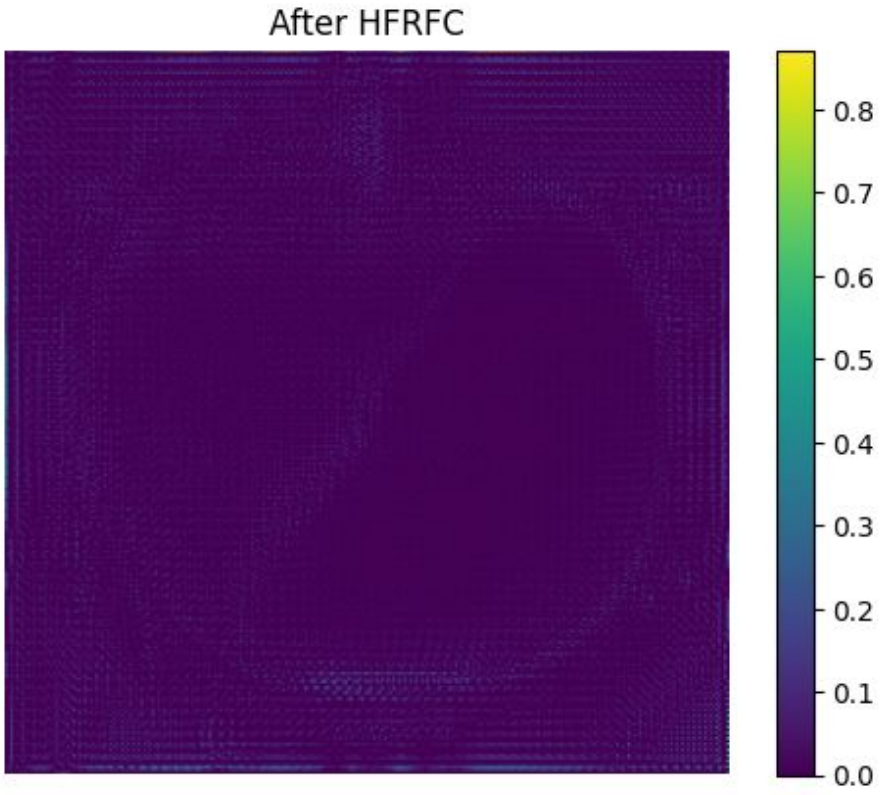
Frequency space representation



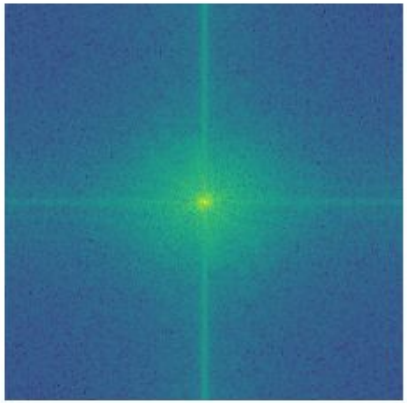


Frequency space representation

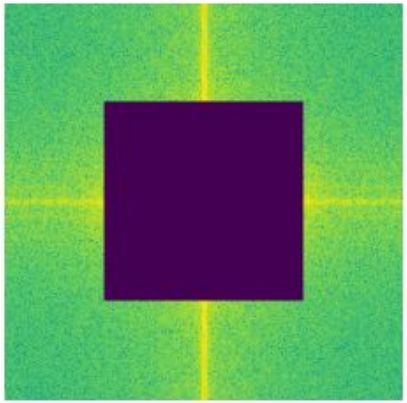




After FFT



After High-Pass Filter

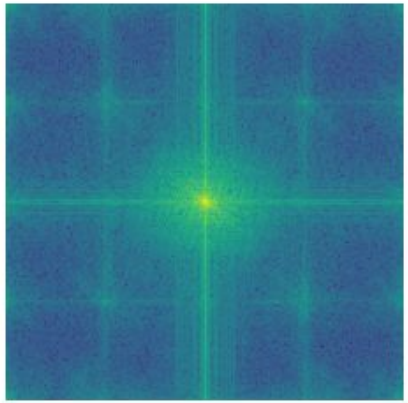


← Real

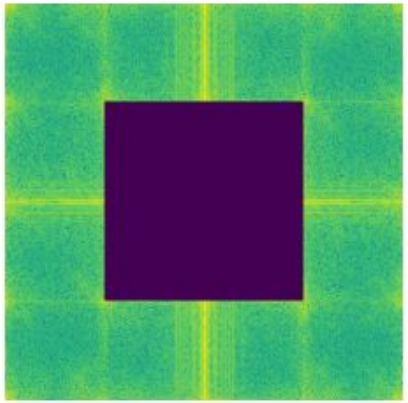
Fake →

Artifacts visible

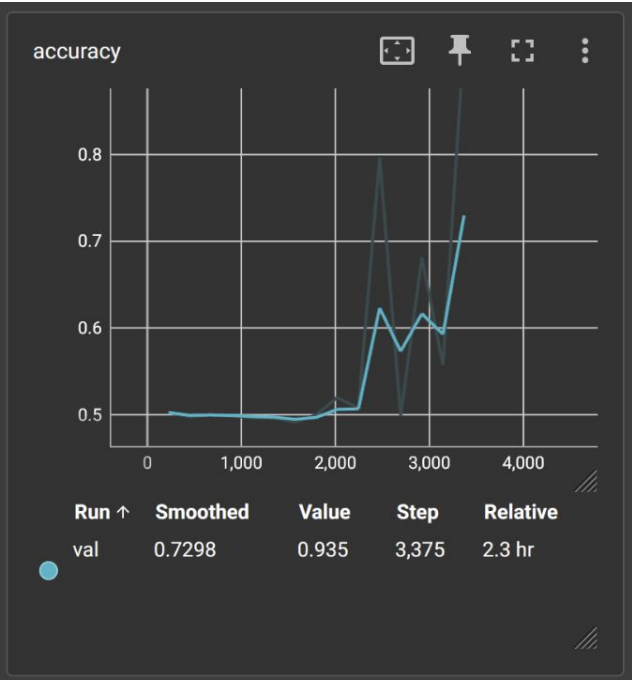
After FFT

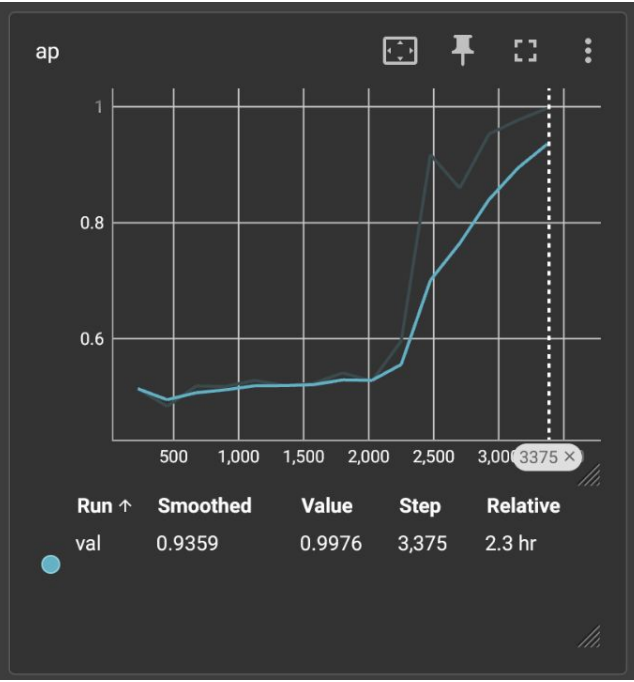


After High-Pass Filter



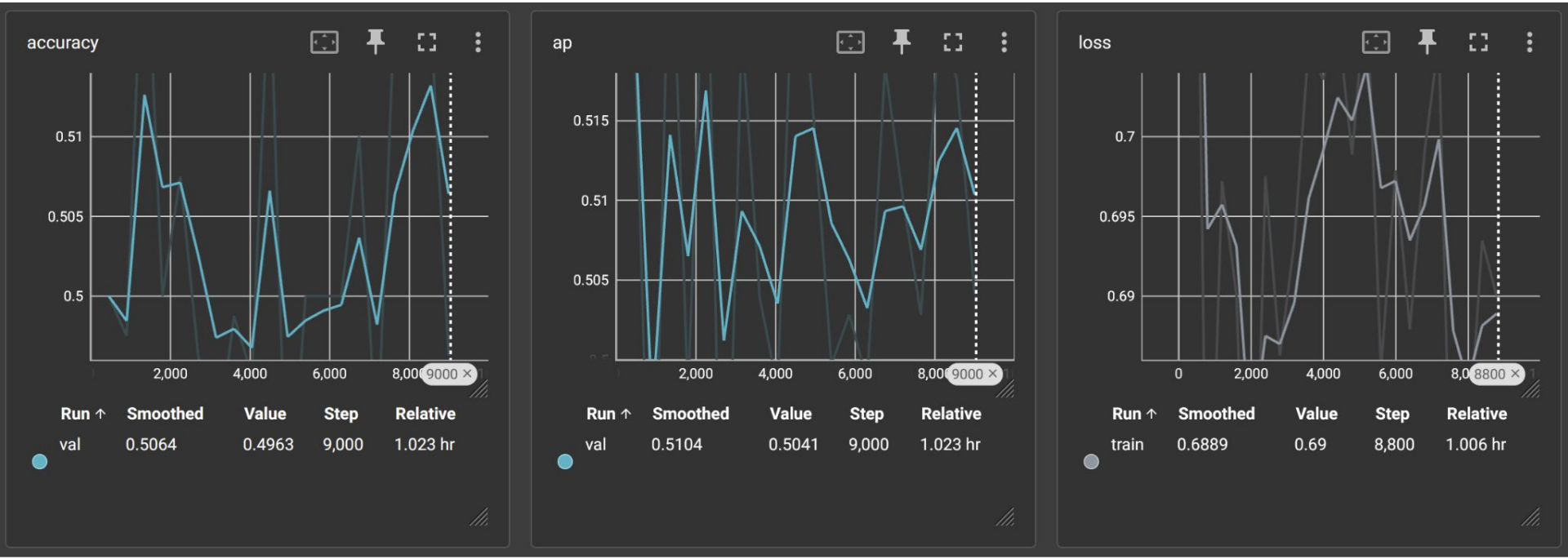
Training: Base Model





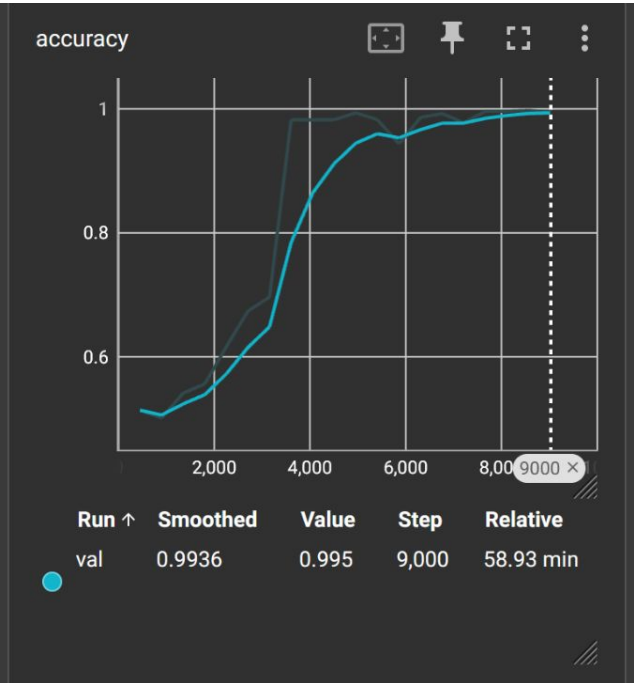
Base Model = final model presented in Chuangchuang Tan et al. 2024

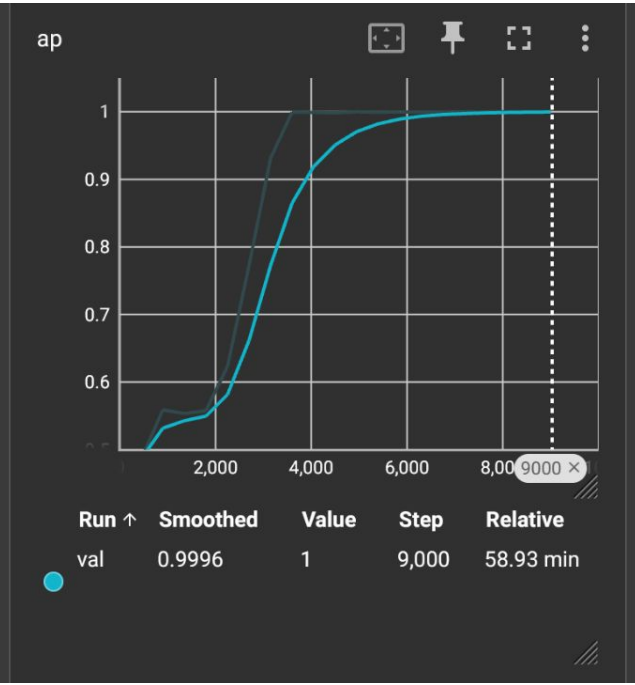
Training: Attention Model

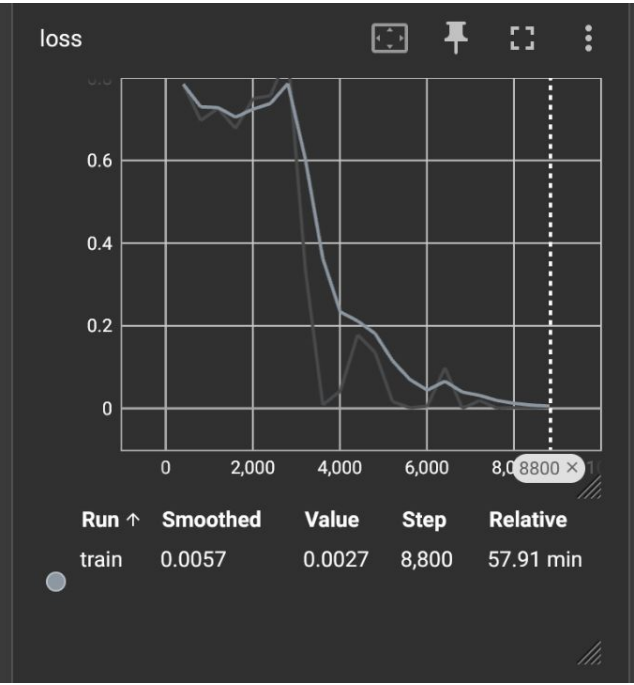


Base Model = final model presented in Chuangchuang Tan et al. 2024

Training: HFRI Ablation Model







Base Model = final model presented in Chuangchuang Tan et al. 2024

Quantitative Results

	Base Model		Attention Model		HFRI Ablation		Paper (200 epochs, 5x data)	
	Acc	AP	Acc	AP	Acc	AP	Acc	AP
ProGAN	93.1	99.4	50.9	49.4	98.0	99.9	99.6	99.9
StyleGAN	82.2	96.1	51.2	53.3	74.0	91.7	90.4	98.9
StyleGAN2	83.5	95.6	51.4	54.6	70.4	93.0	85.8	98.1
BigGAN	75.6	85.2	49.9	54.6	88.2	94.9	89.0	96.0
CycleGAN	76.0	89.1	49.8	46.7	83.6	93.8	96.7	99.8
StarGAN	54.3	56.0	50.8	53.8	62.8	91.9	97.5	100.0
GauGAN	77.0	96.6	49.9	49.0	83.0	97.7	88.0	98.8
Deepfake	52.0	87.2	49.8	52.3	58.0	55.6	80.7	92.0
Mean	74.21	88.15	50.46	51.71	77.25	89.81	91.0	97.9

Base Model = final model presented in Chuangchuang Tan et al. 2024

Caveats

- Due to lack of compute power needed to do full trainings:
  - Training, validation, and testing datasets cut down to 1/5th
  - Trained for less epochs (20 vs 200)
- To allow for comparison, retrained a base model using the same architecture
- These may have influenced the effectiveness of the HFRI Ablation model

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Questions ?

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Thank You

Citations

- FreqNet Chuangchuang Tan et al. 2024
- ForenSynths (Wang et al. 2020)

HFRI (High Frequency Rep. of Image) Block