Group Fourier Transform

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Contents

Method

- Data Structure
- Features

Data Structure

- Load images
- 3 Lists
  - Class 1 (genuine)
  - Class 0 (synthetic)
  - Sort (here we use spoofed and genuine images)
- Calculate FFT of images
- Apply bandpass filter to images(n bands)
  - List of ImageFFT objects
  - One n-list per object
  - n = 30 in most of the tests

Image: Shutterstock 30.01.2024

Features and KNN

- Energy (Square sum of absolute values of the fourier coefficients)

- Calculate energy of all bands
- For every image in “sort”
  - Sort genuine and synthetic images by energy difference
  - Take k nearest neighbours
  - Compare which class is more common
- Leave one subject out / Leave one out Cross Validation

Results

- Expectations
- PLUS
- VERA (IDIAP)
- SCUT

Expectations

- Energy of spoofed is closer to synthetic than to genuine
- Algorithm distinguishes between spoofed/synthetic and genuine

Findings

- Energy of spoofed is closer to genuine
- Algorithm distinguishes between real and AI generated images

PLUS

Distinguishing between spoofed and genuine images (no synthetic images)

baseline		Actual	
		1	0
Predicted	1	46.53%	0.68%
	0	3.48%	49.31%

k = 10

PLUS

Distinguishing between spoofed and genuine (using synthetic images)

003		Actual	
		1	0
Predicted	1	50%	50%
	0	0%	0%

004		Actual	
		1	0
Predicted	1	50%	50%
	0	0%	0%

Same results for all GANs

PLUS

Distinguishing only between genuine and synthetic

cycle 003		Actual	
		1	0
Predicted	1	50.00%	0.00%
	0	0.00%	50.00%

k = 10

VERA / IDIAP

Distinguishing between spoofed and genuine images (no synthetic images)

Influence of the k value

baseline (k=10)		Actual	
		1	0
Predicted	1	31.18%	18.68%
	0	18.82%	31.32%

baseline (k=13)		Actual	
		1	0
Predicted	1	30.79%	12.11%
	0	19.21%	37.89%

baseline (k=37)		Actual	
		1	0
Predicted	1	35.66%	25.39%
	0	14.34%	24.61%

VERA / IDIAP

Distinguishing between spoofed and genuine (using synthetic images)

009		Actual	
		1	0
Predicted	1	50%	50%
	0	0%	0%

Same results for all GANs

SCUT

Distinguishing between spoofed and genuine images (no synthetic images)

baseline		Actual	
		1	0
Predicted	1	34.03%	19.72%
	0	15.97%	30.28%

k = 10

SCUT

Baseline: Leave One Out vs Leave One Subject Out Cross Validation

k	LOO	LOSO
3	65.30%	65.30%
7	64.25%	64.25%
10	64.31%	64.31%
15	69.40%	69.40%
19	68.18%	68.18%
25	69.09%	69.09%

SCUT

Distinguishing between spoofed and genuine images (using synthetic images)

007		Actual	
		1	0
Predicted	1	50%	50%
	0	0%	0%

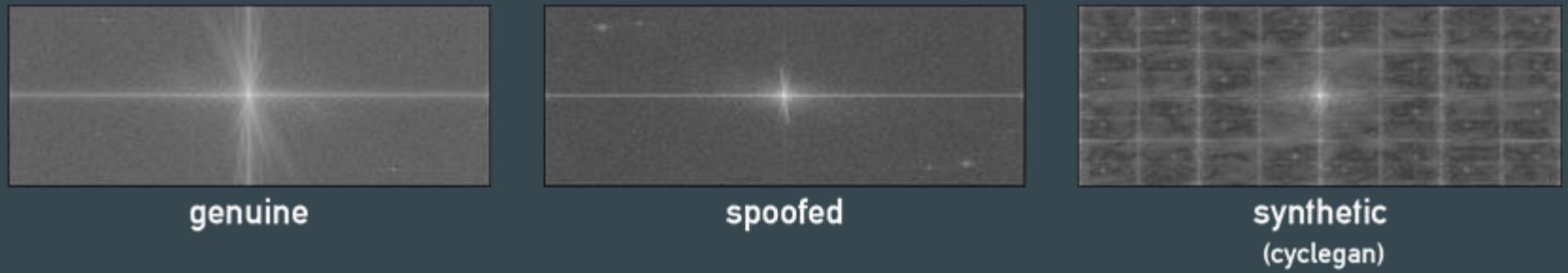
008		Actual	
		1	0
Predicted	1	50%	50%
	0	0%	0%

Same results for all GANs

Explanation

- Synthetic images contain artifacts in the Fourier (frequency) domain

- These artifacts are “learned”

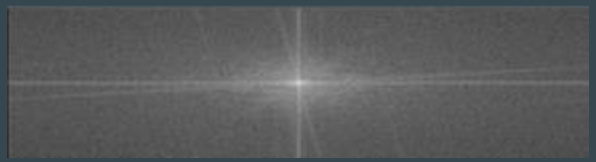


VERA/IDIAP
001_L_1

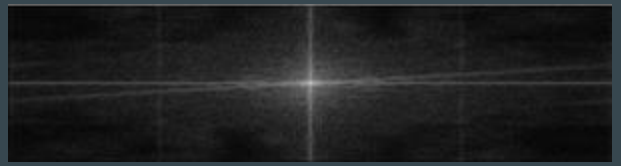
Visualizations for all Datasets

PLUS

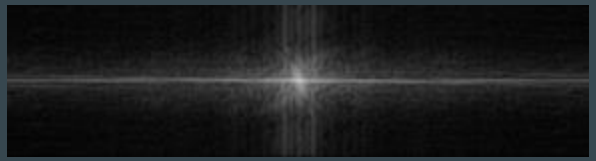
genuine



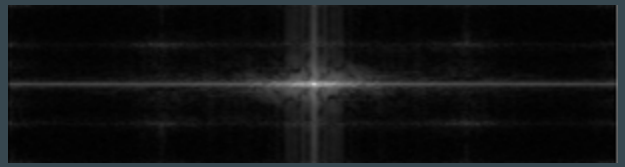
spoofed



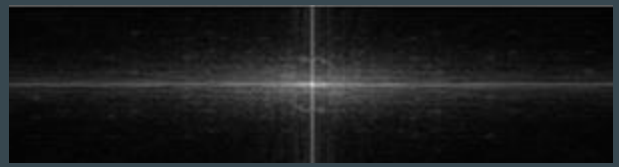
cyclegan



distancegan

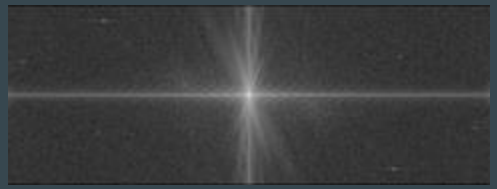


drit

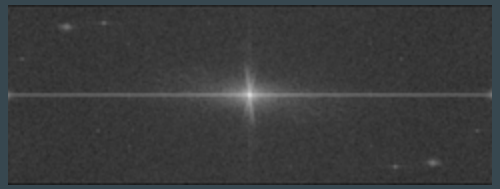


stargan

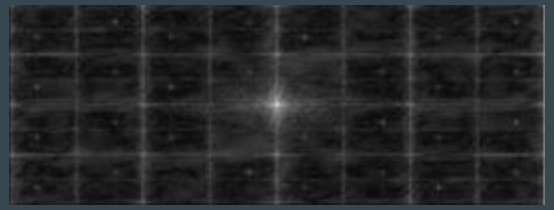
VERA / IDIAP



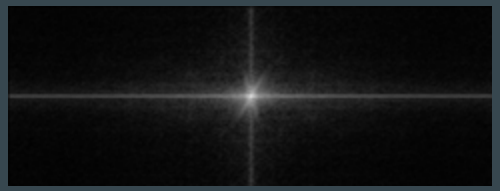
genuine



spoofed

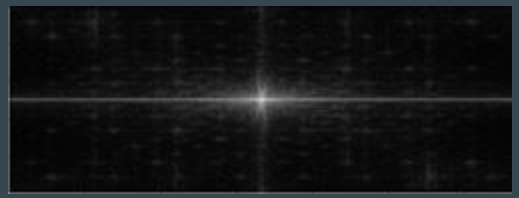


cyclegan



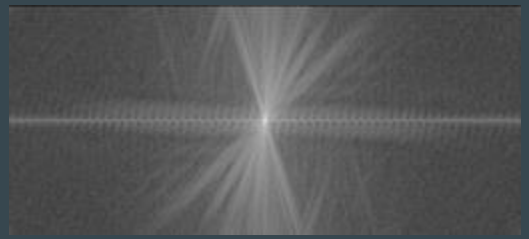
distancegan

drit

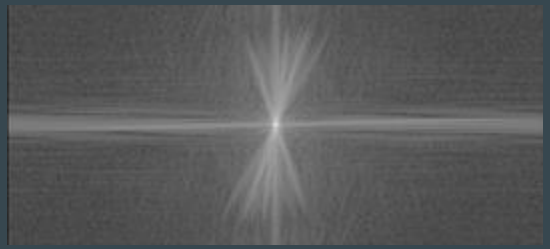


stargan

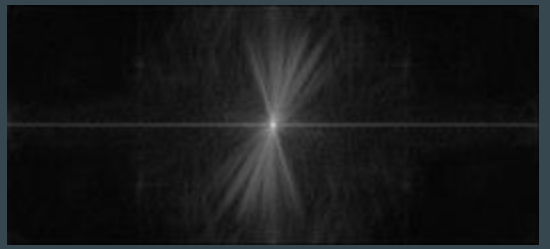
SCUT



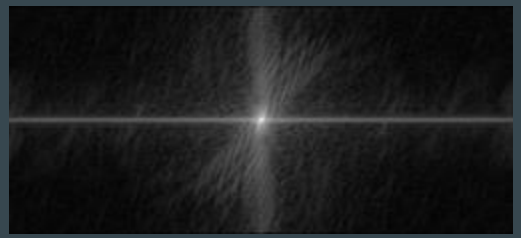
genuine



spoofed



cyclegan



distancegan

drit

stargan

Band Subsets

- FFT split into 30 bands
- Energy difference differs by band
- Biggest difference between real and synthetic images at
  - Band 0 - 15
  - Band 25 - 30
- Between genuine and spoofed images
  - Difference is descending
  - Largest difference: band 1 - 5
- Testing with different band subsets

Band Subsets

- Using bands with as few artifacts as possible (e.g. bands between 15 and 25 from the last slide)

cycle 003 (k=25)		Actual	
		1	0
Predicted	1	50.00%	50.00%
	0	0.00%	0.00%

Input: genuine and synthetic / Sort: genuine and spoofed images

Energy difference genuine-spoofed is always smaller than synthetic-spoofed

Band Subsets for Baseline

VERA/IDIAP

baseline (k=15)		Actual	
		1	0
Predicted	1	32.37%	15.26%
	0	17.63%	34.74%

Bands 5-10

baseline (k=15)		Actual	
		1	0
Predicted	1	46.32%	2.11%
	0	3.68%	47.89%

Overall best results (accuracy of 94.21%) for Bands 5-10 and k=15

Band Subsets for Baseline

SCUT

k=10 baseline		Actual	
		1	0
Predicted	1	34.03%	19.72%
	0	15.97%	30.28%

Bands 7-10

k=25		Actual	
		1	0
Predicted	1	43.06%	11.11%
	0	6.94%	38.89%

k = 25 performed worse on all band baseline, but better than 10 when using bands 15-20.

Conclusion

- FT is useful for detecting AI images

- Non synthetic images can also be sorted
- Spoofed and synthetic together could not be distinguished from genuine

Sources

- Github Repository
- Result Tables
- Zeit Protokoll (Leon Andrassik)

- https://www.shutterstock.com/de/image-photo/apple-tree-isolated-on-white-background-267376982 (Tree on slide 4)

Thank you for your attention!