Greeks in AI 2025

Any-Resolution AI-Generated Image Detection by Spectral Learning

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https://mever-team.github.io/spai

Too many GenAI models, too brittle artifacts!

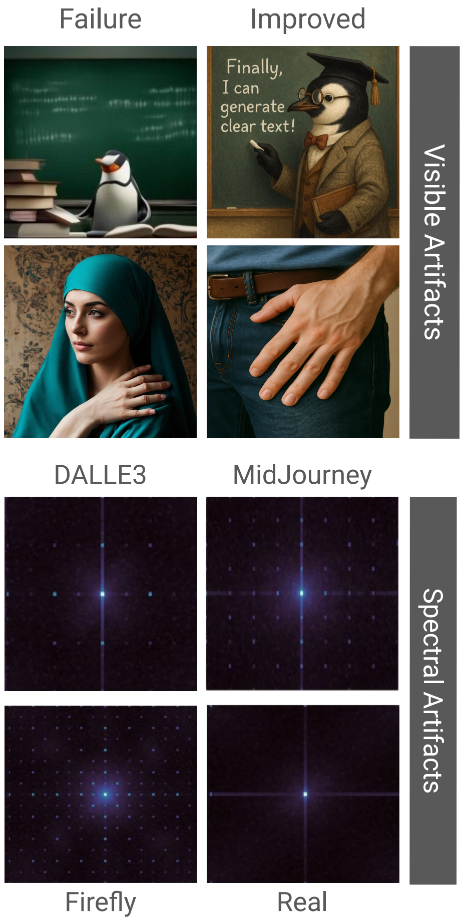
- **An abundance of GenAI approaches is currently available. More get released daily!**
  - LoRA finetunes → even more models!

Literature has established that generated images differ in some aspects from the real ones. Yet, these aspects are totally unpredictable.

- **Visible inconsistencies** are fixed in newer models. → Not very effective.
- **Spectral inconsistencies** → Significant discriminative power, but totally differ among different generative models (Bammey et al., 2023).

Key Issue

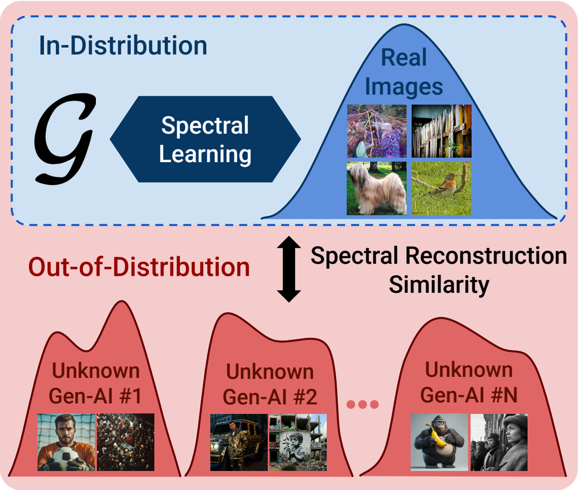
Any learned assumptions quickly become obsolete and detectors fail to generalize on unseen generative approaches!



SPAI: Any-Resolution AI-Generated Image Detection by Spectral Learning

Key Idea: The spectral distribution of real images constitutes an invariant and highly-discriminative pattern for the task of AI-Generated Image Detection.

→ **Corollary**: Given a model of the spectral distribution of real images, AI-Generated images can be detected as Out-Of-Distribution (OOD) samples of this model.



Key Questions

1. How can we craft a suitable spectral model of real images?
2. How can we detect its Out-Of-Distribution samples?

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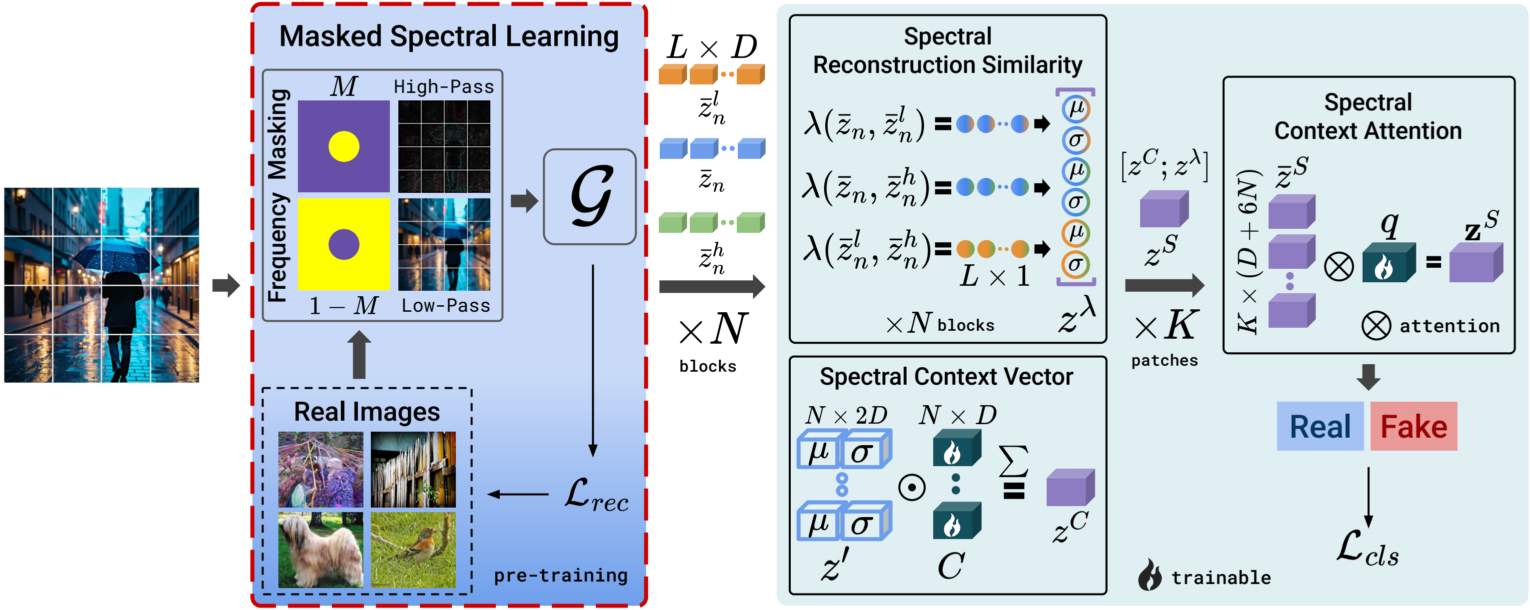
Masked Spectral Learning: Learning the spectral distribution of real images



- **Self-supervised training on real images using the pre-text task of frequency reconstruction.**
- Inputs are generated by low/high frequency filtering. – Model reconstructs missing frequencies.
- Reconstruction loss is computed on the DFT domain.
- A vision transformer is used for the model $\mathcal{G}$.

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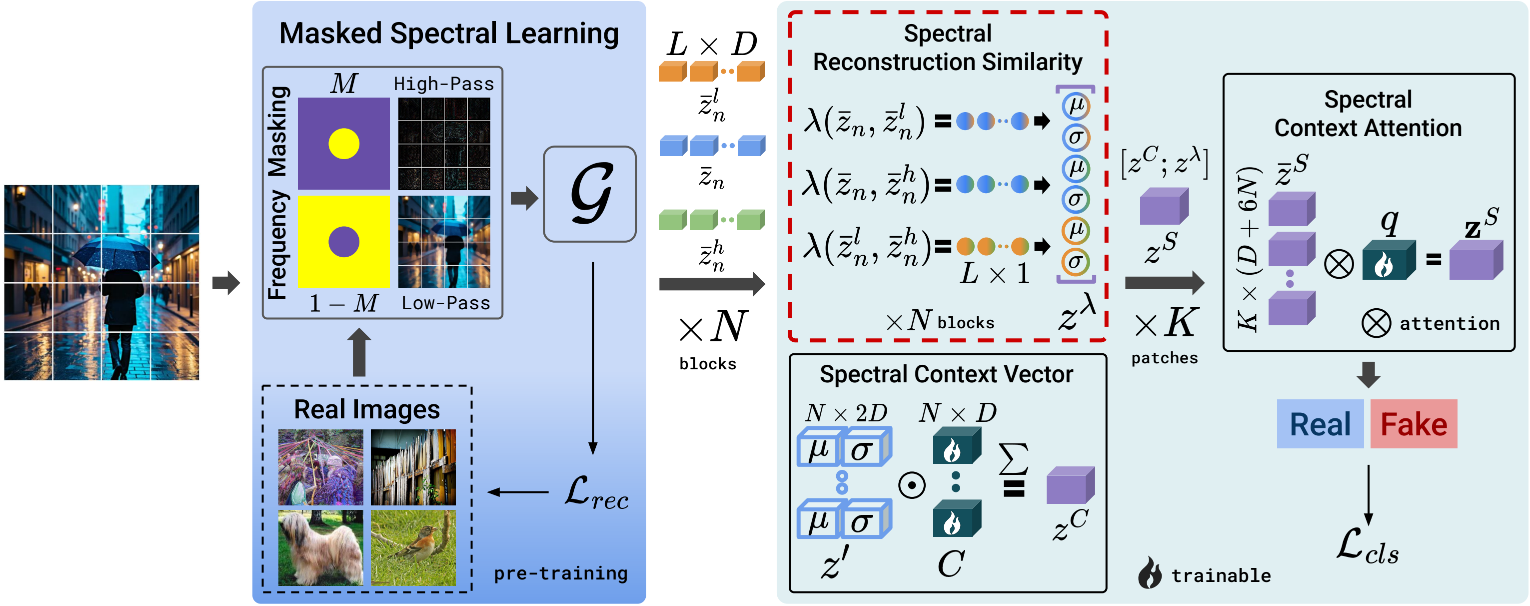
Spectral Reconstruction Similarity (SRS): Detecting OOD images



- **Low- & high-pass filtered images** are embedded using the learned spectral model.
- Cosine similarity among the three pairs of original, low-pass and high-pass filtered images.
- Spectral reconstruction similarity is computed for the features of each transformer block of $\mathcal{G}$.

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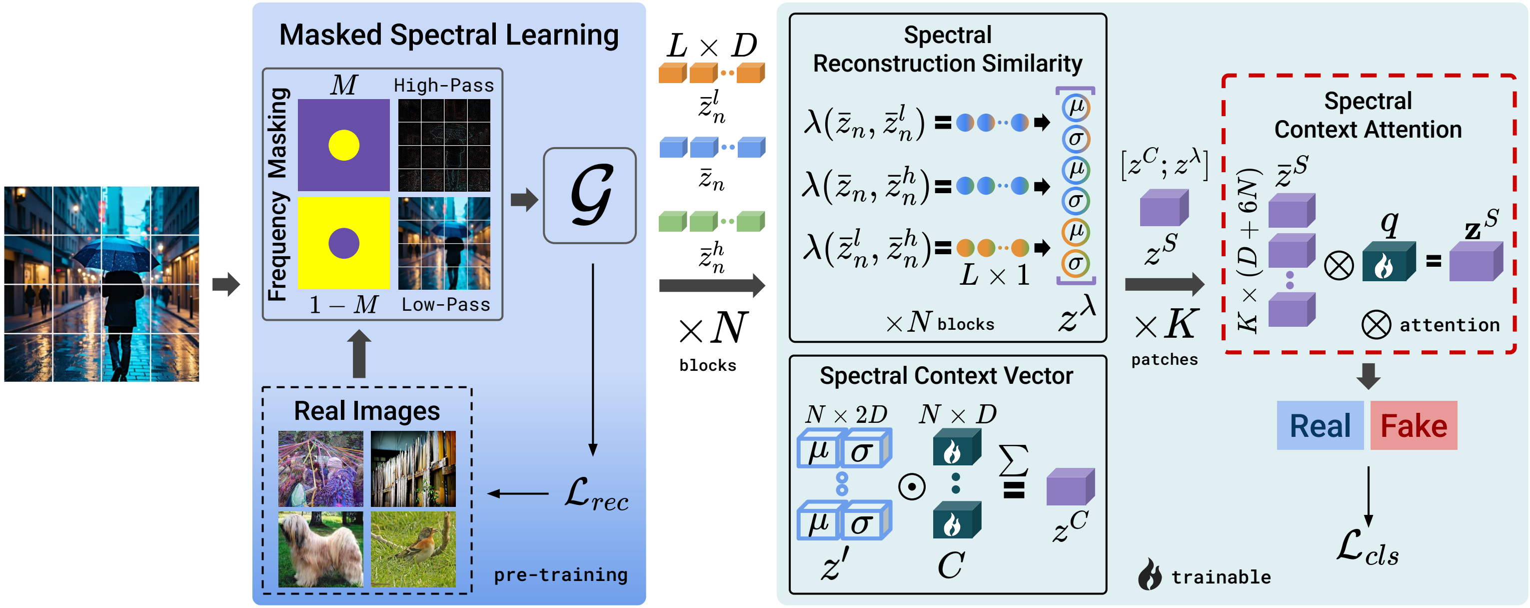
Spectral Context Attention: Embedding arbitrary resolution images



- Image is split into patches (ViT resolution – 224x224).
- The most discriminative SRS values according to the spectral context of each patch are considered.
- Subtle details are captured, as images are processed in their native resolution, with linear complexity.

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Comparison against state-of-the-art

Generalization on generators of different architectures, resolution, image quality, open-source & commercial.

Image Size	< 0.5 MPixels			0.5 - 1.0 MPixels						> 1.0 MPixels				AVG
Approach	**Glide**	**SD1.3**	**SD1.4**	**Flux**	**DALLE2**	**SD2**	**SDXL**	**SD3**	**GigaGAN**	**MJv5**	**MJv6.1**	**DALLE3**	**Firefly**	
NPR [66]	72.2	89.6	60.5	19.8	3.9	12.5	18.1	60.6	83.2	15.3	19.8	97.1	38.0	45.4
Dire [72]	33.3	59.9	61.3	45.7	52.2	68.5	46.9	49.2	36.3	41.9	50.3	65.2	49.9	50.8
CNNDet. [71]	59.2	59.0	61.2	39.8	71.5	57.5	67.4	30.2	73.4	48.8	56.7	23.5	73.4	55.5
FreqDet. [23]	43.6	92.3	92.7	36.5	47.4	42.5	66.5	69.8	63.2	36.9	27.5	42.2	80.9	57.1
Fusing [34]	63.0	62.8	62.2	57.5	76.7	66.9	62.1	38.8	80.4	64.0	74.0	25.2	76.3	62.3
LGrad [65]	76.5	82.4	83.4	74.9	85.7	60.7	70.2	12.7	89.9	69.2	79.6	30.0	42.0	65.9
UnivFD [52]	63.3	80.8	81.2	36.3	91.4	84.3	78.3	28.6	86.2	57.1	60.5	31.0	95.5	67.3
GramNet [48]	78.2	83.9	84.3	78.6	85.2	66.7	77.8	19.2	85.0	63.8	84.9	42.9	38.0	68.4
DeFake [63]	86.1	64.2	63.6	90.5	41.4	66.2	52.3	87.7	71.7	67.0	87.5	93.3	39.4	70.1
PatchCr. [77]	78.4	95.7	96.2	86.9	81.8	95.7	96.7	33.8	98.0	79.0	96.1	28.1	79.1	80.4
DMID [7]	73.1	100.0	100.0	97.2	54.3	99.7	99.6	67.9	67.9	99.9	94.4	41.3	90.2	83.5
RINE [39]	95.6	99.9	99.9	93.0	93.0	96.6	99.3	39.1	92.9	96.4	81.2	41.8	82.9	85.5
SPAI (Ours)	90.2	99.6	99.6	83.0	91.1	96.5	97.4	75.9	85.4	94.5	84.0	90.2	96.0	**91.0**

While several detectors achieve high performance on specific Gen-AI models, they catastrophically fail to others.

□ **SPAI achieves consistent performance across Gen-AI models of different type!**

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Beyond binary detection and Open Challenges

Spectral context attention natively provides a mechanism to understand which regions of the image were more important for the final decision.

6-fingers case correctly spotted

Attending texture-rich regions.

Figure 4. Qualitative analysis of spectral context attention. A cool-warm overlay has been applied on each patch. Red color indicates significant patches for deciding whether the image is AI-generated (high attention values), while blue color indicates irrelevant patches (low attention values). The attention values have been normalized in [0, 1].

AI-Generated content commonly appears online in the form of derivative images, i.e. screenshots of posts, photos of a screen etc.

The intermediate medium (digital or analog) heavily distorts the spectral distribution of the AI-generated images.

Detecting such images remains an open issue for any detector that relies on the image signal.

Detection: 86%

Detection: 79%

Detection: 0%

Detection: 2%

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We open-source SPAI's code, weights and data:

https://mever-team.github.io/spai

For any questions you can contact:

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