Gold Exploration using Representations from a Multispectral Autoencoder

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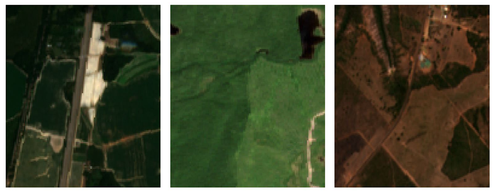
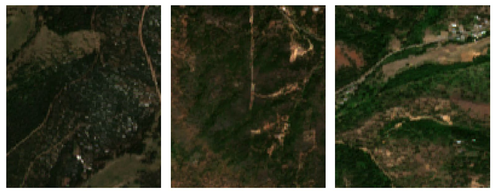
Motivation

- ➔ Mineral Exploration is the process of identifying mineral deposits.
- ➔ Field campaigns are expensive and slow; **satellite data** covers large inaccessible areas.
- ➔ Labeled satellite data is scarce, so **supervised methods are weak**.
- ➔ Goal: test whether generative-model embeddings improve gold detection.



Non Gold Samples



Gold Samples

Representation Learning

Dataset

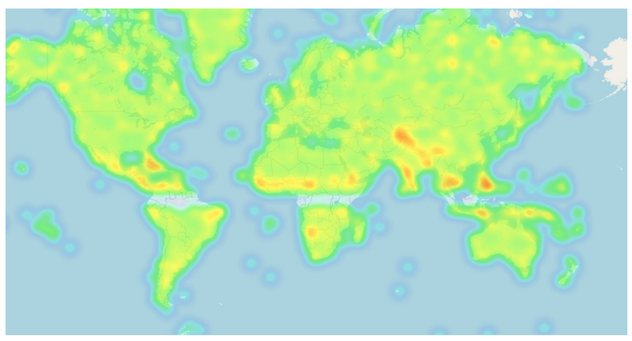
FalconSpace-S2v1.0

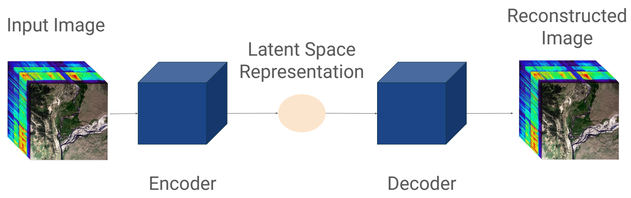
- ➔ 1.15M Sentinel-2 samples (128×128×12).
- ➔ Uniform temporal sampling 2020-2025.
- ➔ Uniform spatial sampling (global).
- ➔ Low cloud coverage (<30%).

Model

Masked Autoencoders

- ➔ SpectralGPT: 90% masking, shallow decoder, semantic focus.
- ➔ Isometric: 40% masking, deep decoder, optimized reconstruction.





Model \ Metric	MSE ↓	SAM ↓	ERGAS ↓	PSNR ↑	SSIM ↑
SpectralGPT	0.062 ± 0.037	0.217 ± 0.248	17.993 ± 49.820	21.890 ± 3.971	0.612 ± 0.0918
Isometric	**0.006 ± 0.005**	**0.093 ± 0.261**	**8.359 ± 35.024**	**32.784 ± 3.015**	**0.942 ± 0.056**

Gold Exploration

Dataset

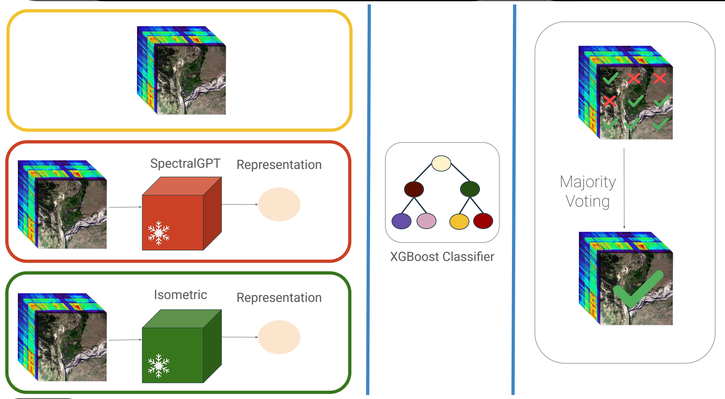
- ➔ 63 gold-deposit Sentinel-2 scenes + 33 random scenes (summer 2023).
- ➔ Each image → 1024 patches → ~64k labeled samples.
- ➔ Split 80/20 at image level to avoid leakage.
- ➔ Extract embeddings using frozen foundation model (Isometric best).

Model

Frozen Encoder

XGBoost

- Patch level classification.
- Image label via majority voting on patch predictions.



Patch

Approach	Patch Accuracy	Patch Precision	Patch Recall	Patch F1 score
Raw	0.517 ± 0.010	0.513 ± 0.012	0.512 ± 0.012	0.508 ± 0.012
SpectralGPT	0.630 ± 0.011	0.642 ± 0.012	0.628 ± 0.014	0.618 ± 0.015
Isometric	**0.681 ± 0.043**	**0.692 ± 0.042**	**0.680 ± 0.041**	**0.674 ± 0.04**

Image

Approach	Image Accuracy	Image Precision	Image Recall	Image F1 score
Raw	0.554 ± 0.101	0.551 ± 0.205	0.541 ± 0.098	0.488 ± 0.130
SpectralGPT	0.635 ± 0.039	0.683 ± 0.064	0.626 ± 0.049	0.600 ± 0.068
Isometric	**0.733 ± 0.130**	**0.752 ± 0.141**	**0.733 ± 0.129**	**0.729 ± 0.131**

Conclusions

- ➔ Our Isometric model outperforms the SpectralGPT model in terms of reconstruction.
- ➔ Generative representations + simple classifier outperform raw spectral inputs.
- ➔ Method scales, is label-efficient, and generalizes well.
- ➔ **Next:** larger datasets, hyperspectral/SAR, multi-temporal analysis.