## Title

Hyperspectral Diffusion Equivariant Imaging (HyDiff-EI): A Self-Supervised Framework for Hyperspectral Image Inpainting, Denoising, and Super-Resolution.

## Authors

Shuo Li, Mike Davies, Mehrdad Yaghoobi

Institute for Imaging, Data, and Communications, School of Engineering, University of Edinburgh, United Kingdom

## Abstract

Hyperspectral image (HSI) restoration is essential for reliable remote-sensing analysis; however, real-world acquisitions are frequently degraded by missing measurements, sensor noise, and limited spatial resolution. We present Hyperspectral Diffusion Equivariant Imaging (HyDiff-EI), a self-supervised diffusion framework that can either be optimized directly from a single degraded HSI or pre-trained using unlabelled measurement data. HyDiff-EI integrates equivariant imaging priors into a diffusion-based reconstruction process. By enforcing consistency under physically plausible spatial transformations, the framework exploits inherent geometric symmetries to regularize ill-posed inverse problems while preserving spatial structures and spectral signatures.

Originally developed for HSI inpainting, HyDiff-EI explicitly incorporates the measurement operator into the reverse diffusion process and employs a noise-aware update strategy for corrupted observations. Experiments on Chikusei, Botswana, and EMIT hyperspectral data show strong reconstruction quality in both noiseless and noisy inpainting settings, with improved spatial detail and spectral fidelity compared with representative self-supervised and diffusion-based baselines.

Beyond inpainting, the proposed algorithm naturally generalizes to hyperspectral denoising and super-resolution by replacing the masking operator with the corresponding degradation model. This unified perspective enables self-supervised recovery of clean, high-resolution hyperspectral data from noisy or spatially degraded measurements, while retaining adaptability across sensors with different spectral configurations. HyDiff-EI therefore offers a flexible framework with promising potential for robust hyperspectral image restoration in remote-sensing applications.