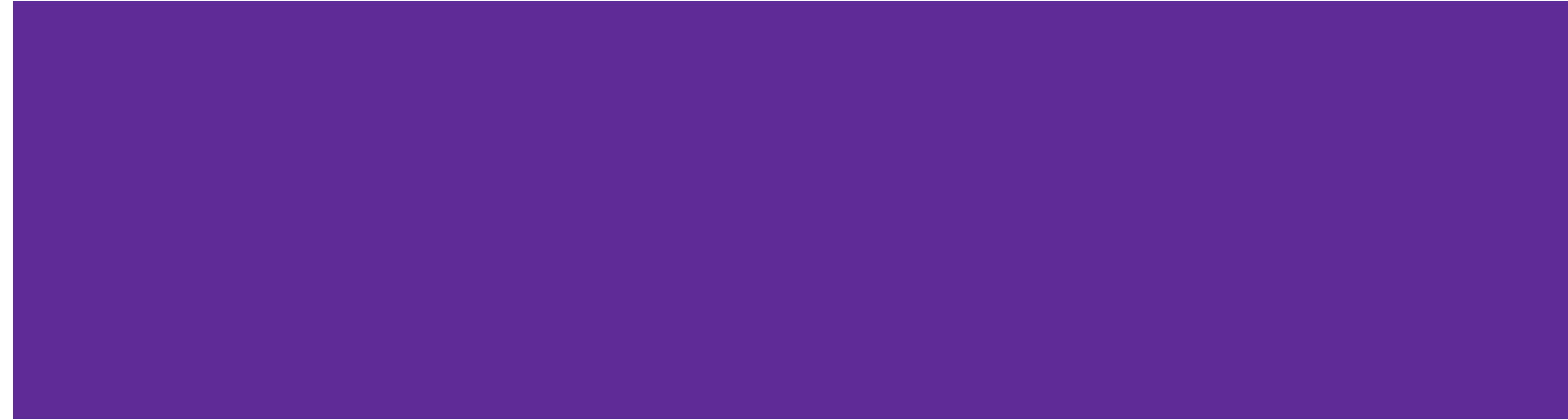


# PANSHARPENING: PANCHROMATIC AND MULTISPECTRAL IMAGE FUSION FOR REMOTE SENSING AND EARTH OBSERVATION

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# Intensity-Hue-Saturation

## IHS Fusion Overview:

- ★ Upsampling:
  - Multispectral image (hs) is upsampled using `upsample_interp23` with a specified ratio.
- ★ Intensity Calculation (I):
  - Mean intensity image (I) is calculated from the upsampled multispectral image.
- ★ Panchromatic Adjustment:
  - Adjust panchromatic image based on mean and standard deviation of the intensity image.
- ★ IHS Fusion:
  - Adjusted panchromatic image is subtracted from upsampled multispectral image and added to the intensity image.
- ★ Adjustment:
  - Pixel values of the fused image are adjusted to be within  $[0, 1]$ .
- ★ Output Format:
  - Fused image converted to `uint8` format and scaled to  $[0, 255]$ .

# Brovey

## Brovey Fusion Overview:

### ★ Upsampling:

- Multispectral image (hs) is upsampled using `upsample_interp23` with a specified ratio.

### ★ Intensity Calculation (I):

- Mean intensity image (I) is calculated from the upsampled multispectral image.

### ★ Brovey Fusion:

- Each band in multispectral image is adjusted using Brovey method, considering panchromatic image and mean intensity.

### ★ Adjustment:

- Pixel values of the fused image are adjusted to be within  $[0, 1]$ .

### ★ Output Format:

- Fused image converted to uint8 format and scaled to  $[0, 255]$ .

# Principal Component Analysis

## PCA Fusion Overview:

- ★ Upsampling:
  - Multispectral image (hs) is upsampled using `upsample_interp23` with a specified ratio.
- ★ PCA Transformation:
  - PCA applied to reshape multispectral image and reduce dimensionality.
- ★ Intensity Calculation (I):
  - Intensity image (I) obtained from first principal component of PCA-transformed multispectral image.
- ★ Panchromatic Adjustment:
  - Panchromatic image adjusted based on statistics of intensity image.
- ★ Equalization:
  - Equalization performed by adjusting mean of fused image.
- ★ Adjustment:
  - Pixel values of the fused image are adjusted to be within  $[0, 1]$ .
- ★ Output Format:
  - Fused image converted to `uint8` format and scaled to  $[0, 255]$ .

# Wavelet

## Wavelet Fusion Overview:

### ★ Upsampling:

- Multispectral image (hs) is upsampled using `upsample_interp23` with a specified ratio.

### ★ Wavelet Transform:

- Panchromatic image (pan) undergoes a 2-level wavelet transform using 'haar' wavelet.

### ★ Wavelet Fusion:

- For each band in multispectral image:
  - Corresponding band extracted after 2-level wavelet transform.
  - Low-frequency coefficients from panchromatic image substituted into corresponding band.
  - Inverse wavelet transform applied to reconstruct fused image.

### ★ Adjustment:

- Pixel values of the fused image are adjusted to be within  $[0, 1]$ .

### ★ Output Format:

- Fused image converted to uint8 format and scaled to  $[0, 255]$ .

# Adaptive Gram Schmidt

## GSA Fusion Overview:

- ★ Upsampling:
  - Multispectral image (hs) is upsampled using `upsample_interp23` with a specified ratio.
- ★ Mean Removal:
  - Means of upsampled multispectral image (`u_hs`) are removed.
- ★ Intensity Calculation (I):
  - Synthetic intensity image (I) calculated using estimated alpha coefficients.
- ★ Coefficient Calculation:
  - Coefficients (g) calculated based on covariance between synthetic intensity and each band of low-resolution multispectral image.
- ★ Detail Extraction:
  - Detail information extracted by computing difference between high-resolution intensity and synthetic intensity.
- ★ Fusion:
  - Fused image (`I_GSA`) obtained by combining synthetic intensity and adjusted detail information.
- ★ Adjustment:
  - Pixel values of the fused image are adjusted to be within  $[0, 1]$ .
- ★ Output Format:
  - Fused image converted to `uint8` format and scaled to  $[0, 255]$ .

# Metric

The PSNR is a metric used to quantify the quality of an image by comparing it to a reference image. It measures the ratio between the maximum possible power of a signal and the power of corrupting noise, expressed in decibels. PSNR is commonly used in image and video processing to assess the fidelity of a reconstructed or processed image.

Where:

Dynamic Range: Dynamic Range is the maximum possible pixel value (e.g., 255 for 8-bit images).

RMSE: RMSE is the Root Mean Squared Error, which measures the average difference between corresponding pixel values of the two images.

**Formula:**

$$PSNR = 20 \cdot \log_{10} \left( \frac{\text{Dynamic Range}}{\text{Root Mean Squared Error (RMSE)}} \right)$$

# PSNR Algorithm

## → Function Definition:

- ◆ The function `psnr` takes two images (`img1` and `img2`) and an optional parameter for dynamic range (default is 255).

## → Data Type Conversion:

- ◆ Images (`img1` and `img2`) are converted to `float64` to handle decimal values in calculations.

## → Dimension Check:

- ◆ Ensures that both input images have the same dimensions; raises an error if not.

## → Mean Squared Error (MSE) Calculation:

- ◆ MSE is computed by finding the mean of the squared differences between corresponding pixel values of the two images.

## → PSNR Calculation:

- ◆ PSNR is calculated using the formula, ensuring a small constant (`float64(1e-10)`) is added to avoid division by zero.

## → Handling Perfect Match:

- ◆ If the MSE is very close to zero (indicating a perfect match), PSNR is set to infinity.



# Comparison of Peak Signal-to-Noise Ratio

Pansharpening algorithm	PSNR
Intensity-Hue-Saturation	29.92
Brovey	25.73
Principal Component Analysis	24.47
Wavelet	23.06
Adaptive Gram Schmidt	24.78