1 Description

This software is an implementation of various alternative metrics for hyperspectral images. Metrics are grouped in two families of metrics: statistical and classification-based.

The family of statistical metrics are basically extensions of alternative bi-dimensional metrics from [1]. An analysis of the performance of such metrics for progressive lossy-to-lossless hyperspectral image coding is provided in [2]. The following statistical metrics are implemented:

Minimum Spectral Pearson’s Correlation

$$\text{Pearson} = \min_{x,y} \{\rho_{x,y}\}$$

Maximum Spectral Similarity (MSS) [3]

$$\text{MSS} = \max_{x,y} \left\{ \frac{||I_{x,y} - R_{x,y}||_2^2}{\text{size}_z} + (1 - \rho_{x,y}^2)^2 \right\}$$

where

$$\rho_{x,y} = \frac{\sigma(I_{x,y}, R_{x,y})}{\sigma(I_{x,y})\sigma(R_{x,y})}$$

and $\sigma$ is the sample variance or covariance function.

It is used to ensure class homogeneity in an unsupervised classifier. It measures changes in spectral magnitude and direction.

Maximum Spectral Angle (MSA)

$$\text{MSA} = \max_{x,y} \left\{ \cos^{-1} \left( \frac{\langle I_{x,y}, R_{x,y} \rangle}{||I_{x,y}||_2 \cdot ||R_{x,y}||_2} \right) \right\}$$

The MSA quantifies the peak angular distortion. It is brightness invariant, and is usually presented in degrees.

Spectral Wang-Bovik Q [4, 1]

$$Q_{\lambda} = \min_{x,y} \{Q(I_{x,y}, R_{x,y})\}$$

$$Q_{\text{stack}} = \min_z \{Q(I_z, R_z)\}$$

$$Q_m = Q_{\lambda} \cdot Q_{\text{stack}}$$

where

$$Q(U, V) = \frac{4\sigma(U, V)\mu(U)\mu(V)}{\left(\sigma(U)^2 + \sigma(V)^2\right)\left(\mu(U)^2 + \mu(V)^2\right)}$$

and $\mu$ is the mean function.
Spectral Fidelities \[ F_{\text{cube}} = 1 - \frac{||I - R||_2^2}{||I||_2^2} \]

\[ F_\lambda = \min_{x,y} \left\{ \frac{||I_{x,y} - R_{x,y}||_2^2}{||I_{x,y}||_2^2} \right\} \]

\[ F_{\text{stack}} = \min_{z} \left\{ \frac{||I_{z} - R_{z}||_2^2}{||I_{z}||_2^2} \right\} \]

It is intended to evaluate the distortion in the three following properties: correlation, luminance, and contrast.

Two classification-based measures are also implemented:

**k-Means classification** k-Means is a very common clustering approach [6]. The following classification distances are used: the spectral angle, the Euler distance, and the Manhattan distance. The spectral angle is usually selected as classification distance for its brightness invariance. The number of desired cluster is set to 10.

**Reed Xiaoli (RX) anomaly detection** This is also a very common procedure in remote sensing [7]. While the direct application is very straightforward, it requires the inverse of the spectral covariance matrix, which does not always exist. We use an alternative method based on the computation of the Mahalanobis distance in the Karhunen-Loève Transform (KLT) space [8]. As for the threshold selection, we consider the top 1% locations to be anomalies.

## 2 Requirements

This software is programmed in Java, so you might need a JAVA Runtime Environment (JRE) to run this application. We have used SUN JAVA 1.5.

### JAI
The Java Advanced Imaging (JAI) library is used to load and save images in formats other than raw or pgm. The JAI library can be freely downloaded from http://java.sun.com. **Note:** You don’t need to have this library installed in order to compile the source code.

### GSL
Eigendecomposition functions are from the GNU Scientific Library (GSL) and have been translated into Java. The authors of the original code are Gerard Jungman and Brian Gough. (see source files for details)

## 3 Usage

The application is provided in a single file, a jar file (dist/iemetrics.jar), that contains the application. Along with the application, the source code is also provided. If you need to rebuild the jar file, you can use the ant command.

To launch the application you can use the following command:

```bash
$ java -Xmx1200m -jar dist/iemetrics.jar --help
```

In a GNU/Linux environment you can also use the shell script iemetrics situated at the root of the iemetrics directory.

```bash
$ ./iemetrics --help
```

The output is a double-colon-delimited list with the following fields:

- Maximum Spectral Similarity
- Maximum Spectral Angle
• Maximum Spectral Information Divergence
• Minimum Pearsons Correlation
• Wang Index Lambda
• Wang Index Stack
• Wang Index Both
• Eskicioglu Cube Fidelity
• Eskicioglu Spectral Fidelity
• Eskicioglu Stack Fidelity
• POC k-MEANs SAM
• POC k-MEANs Dot
• POC k-MEANs Euler
• POC k-MEANs Manhattan
• POC ISODATA SAM (disabled)
• POC ISODATA Dot (disabled)
• POC ISODATA Euler (disabled)
• POC ISODATA Manhattan (disabled)
• POC RX

Two examples of usage are provided below:

• Compare two images using the alternative metrics.

```bash
$ ./iemetrics -i1 "$INFILE-16bpppb-bigendian.raw" -ig1 $Z $Y $X 3 0 \
   -i2 "$OUTFILE-16bpppb-bigendian.raw" -ig2 $Z $Y $X 3 0
```

• Compare two images using the alternative metrics, and dump some visual results of the comparison.

```bash
$ iemetrics -i1 "$INFILE-16bpppb-bigendian.raw" -ig1 $Z $Y $X 3 0 \n   -i2 "$OUTFILE-16bpppb-bigendian.raw" -ig2 $Z $Y $X 3 0 \n   -dr "$PARTIAL_RESULT_DUMP_FOLDER/"
```

4 Notes

If you need further assistance, you might want to contact us directly.

References


