Gici ieMetrics Manual

(version 1.0)

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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

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

Maximum Spectral Similarity (MSS) [3]

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

where

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

and σ 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)

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

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

Spectral Wang-Bovik Q [4, 1]

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

$$Q_{stack} = \min_{z} \{Q(I_z, R_z)\}$$

$$Qm = Q_\lambda \cdot Q_{stack}$$

where

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

and μ is the mean function.

Spectral Fidelities [5, 1]

$$F_{cube} = 1 - \frac{||I - R||_2^2}{||I||_2^2}$$

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

$$F_{stack} = \min_{z} \left\{ \frac{||I_z - R_z||_2^2}{||I_z||_2^2} \right\}$$

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-Loêve 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 of 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:

```
$ 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.

```
$ ./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.

```
$ ./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.

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

4 Notes

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

References

[1] E. Christophe, D. Leger, and C. Mailhes, "Quality criteria benchmark for hyperspectral imagery," *IEEE Trans. Geosci. Remote Sens.*, vol. 43, no. 9, pp. 2103–2114, Sept. 2005.

[2] I. Blanes and J. Serra-Sagristà, "Quality evaluation of progressive lossy-to-lossless remote-sensing image coding," in *IEEE International Conference on Image Processing 2009 (ICIP 2009)*. IEEE Press, Nov. 2009.

[3] S. Rupert, M. Sharp, J. Sweet, and E. Cincotta, "Noise constrained hyperspectral data compression," *Int'l Geosci. Remote Sens. Symp. 2001. (IGARSS 01)*, vol. 1, pp. 94–96 vol.1, Jul. 2001.

[4] Z. Wang and A. Bovik, "A universal image quality index," *IEEE Signal Process. Lett.*, vol. 9, no. 3, pp. 81–84, Mar. 2002.

[5] A. Eskicioglu and P. Fisher, "Image quality measures and their performance," *IEEE Trans. Commun.*, vol. 43, no. 12, pp. 2959–2965, Dec 1995.

[6] J. B. MacQueen, "Some methods for classification and analysis of multivariate observations," in *Proc. 5th Berkeley Symp. Math. Statistics and Probability*, L. M. L. Cam and J. Neyman, Eds., vol. 1. University of California Press, 1967, pp. 281–297.

[7] I. Reed and X. Yu, "Adaptive multiple-band CFAR detection of an optical pattern with unknown spectral distribution," *IEEE Trans. Acoust., Speech, Signal Process.*, vol. 38, no. 10, pp. 1760–1770, Oct. 1990.

[8] R. D. Maesschalck, D. Jouan-Rimbaud, and D. L. Massart, "The mahalanobis distance," *Chemometrics and Intelligent Laboratory Systems*, vol. 50, no. 1, pp. 1 – 18, 2000. [Online]. Available: http://www.sciencedirect.com/science/article/B6TFP-3Y8VGYK-1/2/92ac3e8ac922320df9a62b096aca9bee