



**AIN SHAMS UNIVERSITY**  
**FACULTY OF ENGINEERING**  
Electronics and Communications Engineering  
Department

## **Satellite Data Compression for Ultra/Hyper Spectral Images**

### **A Thesis**

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## **ABSTRACT**

Hyperspectral imaging and Ultraspectral imaging are of a great interest these days; as remote sensing earth observation technology and applications are migrating from just plane imaging in few spectral bands toward intensive spectral imaging, mainly for the purpose of object identification.

Few satellites are carrying hyperspectral and / or Ultraspectral imagers are now operational in orbit, earth observation mission 1 (EO-1) from NASA is the most famous one; it carries Hyperion imager, which provides the scientific community with tremendous amount of data and information.

The need to compress this data represents a new challenge for researchers and designer of such space systems. Lossy and lossless compression algorithms are very well fitting the images and video scenes, as it exploits the redundancy in a very good way; on the other hands hyperspectral and Ultraspectral data has a new dimension of redundancy not well exploited by these techniques.

We introduce a new concept of compression that combines lossless and lossy algorithms; where part of the

bands of hyperspectral data cube is compressed in lossless mode, while the other is lossy compressed.

On the other hand, a new lossless technique is proposed; it enhances the average bit rate required to encode the data.

Selection of lossless and lossy bands for compression is based on cross correlation analysis between bands; high correlated bands are lossless compressed, this increases the compression ratio as homogenous data is easily compressed; on the other hand, uncorrelated bands are lossy compressed.

Classification of the bands to be compressed lossy or lossless are carried out by calculating the spectral cross correlation matrix for the data cube; this matrix gives a complete picture about the similarity of band in the cube.

The effect of compressing part of the data cube by lossy compression is certainly less than compressing the whole data cube in a lossy mode; we investigated this effect to measure the losses, using Signal to noise ratio and RX anomaly detection.

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# LIST OF ABBREVIATIONS

|          |                                                   |
|----------|---------------------------------------------------|
| AIRS     | Atmospheric Infrared Sounder                      |
| AIS      | Airborne Imaging Spectrometer                     |
| AVIRIS   | Airborne Visible Infra-Red Imaging Spectrometer   |
| CALIC    | Context-Based, Adaptive, Lossless Image Codec     |
| CDF      | Cohen-Daubechies-Feauveau                         |
| COTS     | Component Of The Shelf                            |
| DWT      | Discrete Wavelet Transform                        |
| Envi-Sat | Environmental Satellite                           |
| ERS      | European Remote Sensing Satellite                 |
| FLOSS    | Fast Lossless Free/Libre and Open Source Software |
| GOB      | Group Of Bands                                    |
| GRB      | Global Reference Band                             |
| GSD      | Ground Sampling Distance                          |
| IBCS     | Inter-Band Correlation Square                     |
| IBCT     | Inter-Band Correlation Triangle                   |
| IWT      | Integer Wavelet Transform                         |
| JPEG     | Joint Photographic Experts Group                  |
| JPL      | Jet Propulsion Spectrometer                       |
| KLT      | Karhunen–Loève Transform                          |
| LOCO-I   | Low Complexity Lossless Compression For Images    |
| LPD      | Low Probability Detection                         |
| LSCM     | Local Spectral Correlation Mapper                 |
| MSE      | Mean Square Error                                 |
| NASA     | National Aeronautics and Space Administration     |
| NCC      | Normalized Cross Correlation                      |
| PAR      | Preservation Of Application Results               |
| PCA      | Principal Component Analysis                      |

|      |                                |
|------|--------------------------------|
| POC  | Preservation Of Classification |
| PSNR | Peak Signal To Noise Ratio     |
| ROI  | Region Of Interest             |
| RX   | Reed and X.Yu Algorithm        |
| SCM  | Spectral Correlation Matrix    |
| TM   | Thematic Mapper                |
| VQ   | Vector Quantization            |