AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics and Communications Engineering Department

Satellite Data Compression for Ultra/Hyper Spectral Images

A Thesis

Submitted in Partial Fulfillment for the Requirements of the Degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering)

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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