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# STUDY & ANALYSIS ON USING JPEG2000 COMPRESSION STANDARD WITH HIGH RESOLUTION GEOSPATIAL IMAGERY PRODUCTS

Mohamed M. Hosny Abdelrahim

*Yanbu Industrial College – Saudi Arabia*

## ABSTRACT

Many Surveying/Geomatics related organizations are in the process of constructing huge high-resolution imagery databases which contain digital color images covering different areas of their interest. The sizes of such image databases are very large A typical problem of such database projects is the huge size of the imagery for storage and/or distribution. With the development of remote sensing technology, large swath width along with multi-wavebands make data size to increase greatly. Therefore, image compression becomes one of the most essential tasks in dealing with such imagery. Several techniques exist on the market to compress such imagery. The compression market is now overwhelmed by Standard & non-standard compression tools and software. Each vendor pretends to have the most reliable compression techniques.

This paper is devoted to examine (subjectively and objectively) the effect of using the new *JPEG2000* standard compression algorithm -*Joint Photographic Experts Group*- in the market in dealing with high resolution spatial imagery & to recommend the optimum compression ratio to be used when using JPEG2000 standard in compressing high resolution imagery. The testing procedure considered the spectral as well as the spatial effect of the new market standard on the image pixels and to recommend the optimum compression ratio for such cases.

تهتم العديد من المنظمات و الهيئات المساحية بتطبيقاتها المختلفة ببناء قواعد بيانات لصور الاستشعار عن بعد ذات درجة الوضوح العالية حيث تحتوي هذه الصور علي المعلومات التي قد تغطي أو تفيد كمنبع إستخراج المعلومات للعديد من التطبيقات لهذه الهيئات و عملائها. العائق الأساسي لانشاء مثل هذه القواعد هو الحجم الهائل للصور الجوية أو صور الأقمار الاصطناعية. نظرا" لتطور التكنولوجيا السريع في هذا المجال زادت دقة و قوة تحليل الصور على حساب الحجم. لذايصبح استخدام تقنيات ضغط الصور ضرورة ملحة لمثل هذه المشاريع. توفرت فى الأسواق حديثا" العديد من التقنيات و البرامج المخصصة (المعتمدة و غير المعتمدة) في مجال ضغط الصور و التي تحمل معها العديد من التأثيرات على دقة و جودة الصورة الناتجة من عملية الضغط.

يختص هذا البحث بدراسة تأثير إستعمال تقنيات(JPEG 2000)المعتمدة و التي تعتبر أحدث تقنية معتمدة في هذا المجال – و المنشأه بواسطة مجموعة خبراء التصوير المتحدة – في السوق في التعامل مع الصور الجوية أو صور الأقمار الاصطناعية ذاتِ درجة الوضوح العاليةِ و تشمل هذة الدراسة التأثير الهندسي و المرئي الحادث على الصورة و كذلك التوصيات بدرجة الضغط المناسبة في هذه الحالات.

*Keywords:* High-Resolution, Compression, Spatial Quality, Spectral Quality, JPEG2000.

## 1. INTRODUCTION

Nowadays, high-resolution spatial imagery products are being well emerged and integrated in our daily surveying and/or Geomatics related projects and measurements. Direct qualitative high resolution (<1m resolution) satellite imagery and very high quality aerial photograph orthophoto collections are being now of a great concern in any surveying and Geomatics related firm's global budget. Such imagery helps us to visualize actual situation accurately, take precise measurements, produce high quality spatial data forms (DTM for example), and or perform accurate spectral classification for change monitoring applications (see for example USGS, SNB [11, 13]). It is believed that different users of such imagery would employ the products in any of three different ways, namely, as an "image backdrop" to vector topographic mapping, property mapping and resource inventory data stored and accessed using GIS, as a base for interpreting and "on-screen" digitizing vector information for the purposes of updating data stored in a GIS, and/or as a base upon which more advanced image analysis and processing operations be made for advanced resource inventory applications.

A very recent example of such organization is the process that is been undertaken at the Urban Planning

& Surveying Departments within the ROYAL COMMISSIOIN OF JUBAIL & YANBU (RC-Saudi Arabia). RC is in the process of producing high resolution imagery database of IKONOS imagery and aerial photography projects that will cover approximately 700 $Km^2$ of the very promising developing city of YANBU.

A typical problem of such database projects is the huge size of the imagery for storage and/or distribution. With the development of remote sensing technology, large swath width along with multi-wavebands make data size to increase greatly. Therefore, image compression becomes one of the most essential tasks in dealing with such imagery. Several techniques exist on the market to compress such imagery. The compression market is now overwhelmed by Standard & non-standard compression tools and software. Each vendor pretends to have the most reliable compression techniques.

This paper is devoted to examine (subjectively and objectively) the effect of using the new *JPEG2000* standard compression algorithm -*Joint Photographic Experts Group' or JPEG(5) standard that has been established by ISO (International Standards Organization) and IEC (International Electro-Technical Commission)*- in the market in dealing with high resolution spatial imagery. The testing procedure considered the spectral as well as the spatial effect of the new market standard on the image pixels and to recommend the optimum compression ratio for such cases.

## 2. IMAGE COMPRESSION: A QUICK LOOK

Image compression techniques are used to remove redundancy exist within neighboring pixels in a typical digital image and consequently, reduce the data content size of a digital image file. In other words, we can say that "image compression is concerned with minimizing the number of bits required to represent an image" [8, 10].

Image compression reduces the image file size by removing the redundancy from the image data, i.e. extracting essential information from the image, so that it can be reconstructed with a certain degree of accuracy. Still image compression techniques deals with two main types of redundancy, namely:

- ***Spatial Redundancy:*** or correlation between neighboring pixel values.
- ***Spectral Redundancy:*** or correlation between different color planes or spectral bands.

Image compression/decompression operations are essential for large images archival and/or transmission [1, 9, 10, and 17].

### 2.1 Lossless Vs. Lossy Image Compression

In lossless compression schemes, the reconstructed image is numerically identical to the original image.Lossless compression or error-free compression is a technique used when the image applications require the reconstructed image to be numerically identical to the original image. One of these applications is the archival of medical or business documents. In these documents we need every single character to be reconstructed again without any loss of information [1, 3].

Error-free compression will give a very low compression ratio in comparison with the lossy compression. Examples of lossless image compression/encoding techniques have been developed include Run-Length Encoding, Huffman Coding, lossless Predictive Coding, lossless Block Coding. An extensive review of these methods can be found in 1, 3, 10, and 12)

However lossless compression can only achieve a modest amount of compression. An image reconstructed following lossy compression contains degradation relative to the original.In other words, lossy schemes cannot be used to exactly and precisely reconstruct the original image. Examples of lossy encoding techniques include Truncation Coding, Lossy Block Coding, Transform Coding, Lossy Predictive Coding. An extensive review of these methods can be found in 1, 3, and 10)

### 2.2 Standard/Non-Standard Image Compression Schemes

Image compression standards and non-standards has been developed to support the industry needs such as JPEG "Joint Photographic Experts Group", CCITT Group3 / 4 and Joint Bi-level Image Experts Group (JBIG), and Wavelets. For detailed discussions, please refer to [3, 9, 10, and 12].

### 2.3 JPEG2000

JPEG 2000 is the very recent compression standard techniques developed to compromise for deficiencies exist within the original JPEG technique. After evaluating a number of coding schemes, the JPEG members selected a Discrete Cosine Transform (DCT) based method. JPEG became a Draft International Standard (DIS) in 1991 and an International Standard (IS) in 1992. Ten years later, JPEG2000 was considered to focus efforts into a new standard for coding still images. JPEG2000 is based on discrete wavelet transform (DWT) that provides a promising road in the compression market. For more details, see [5,16].

## 3. RESEARCH SCOPE & OBJECTIVES

The main purpose and scope of this research is to examine (subjectively and objectively) the effect of using the new *JPEG2000* standard compression algorithm -*Joint Photographic Experts Group' or JPEG[19,20] standard that has been established by ISO (International Standards Organization) and IEC (International Electro-Technical Commission)*- in the

market in dealing with high resolution spatial imagery from different aspect. In addition, this research considered all the aspects the image may be used for and recommend the optimum compression ratio to be used when using JPEG2000 standard in compressing high resolution imagery. Visual quality of the image was considered subjectively and objectively to help use the image as a backdrop or for visual interpretation. Geometric quality was considered for direct surveying and generally spatial measurements. Spectral quality was tested to evaluate the compression effect on the classified imagery. In other words, the testing procedure considered the spectral as well as the spatial effect of the new market standard on the image pixels and to recommend the optimum compression ratio for such cases.

## 4. TEST IMAGE

In order to simulate a valid situation, a real high-resolution product image with a reasonable size (a one that is similar to the expected product by RC project) was used rather than a sample image. An orthophoto was obtained from Service New Brunswick that satisfies the following conditions:

- Covers wide varieties of ground features (buildings – roads –green – forest – water, etc.)
- Contains different textures
- Constitutes Gradual color features
- Includes Topographic Sheets for control points coordinates
- Has a typical size of such image sheet (~130MB).

Figure (1) shows the image selected for the testing procedure within this research.

In this research, the author utilized Lurawave software package (one of the leading compression package in the market) for image compression and Erdas imaging extension within ArcGIS 9.1 for classification and measurements from the image.

## 5. TESTING, RESULTS & ANALYSIS

In this section, the author will discuss the main steps in testing the JPEG2000 compression standard and the major results produced.

### 5.1 Visual Quality

One of the most important aspects when judging image quality is to consider the user him/herself. The quality of the image affects the user's decision on the diverse use of such an image in different applications. In order to judge the quality of the image from a real user perspective (Subjectively), a questionnaire was made, as shown in Figure (2). This questionnaire was designed to cover the most important image visual quality, namely:

- Detectable Color Loss or Change.
- Detectable Feature Edge Change.
- Detectable Loss of Clean &Uniform Color Across Color Patch.
- Detectable Change in Edge of Each Color Patch.
- Detectable Change in Feature Geometry.
- Detection of Blocking Pattern.
- Detectable Change or Loss in Ability To Interpret Image Features.
- Detectable Loss of Features.

In order to test the visual quality subjectively, color plots along with image quality questionnaire were prepared. We had the best opportunity to test those images by inviting Geomatics users from RC Surveying &Urban planning departments to participate in the test, participants were asked to evaluate the images based on the factors presented in the questionnaire and based on their experience in dealing with imagery. Figure (3) shows a sample portion of the plotted image with the effect of different compression factors.

**Fig. 1** Test Image Information

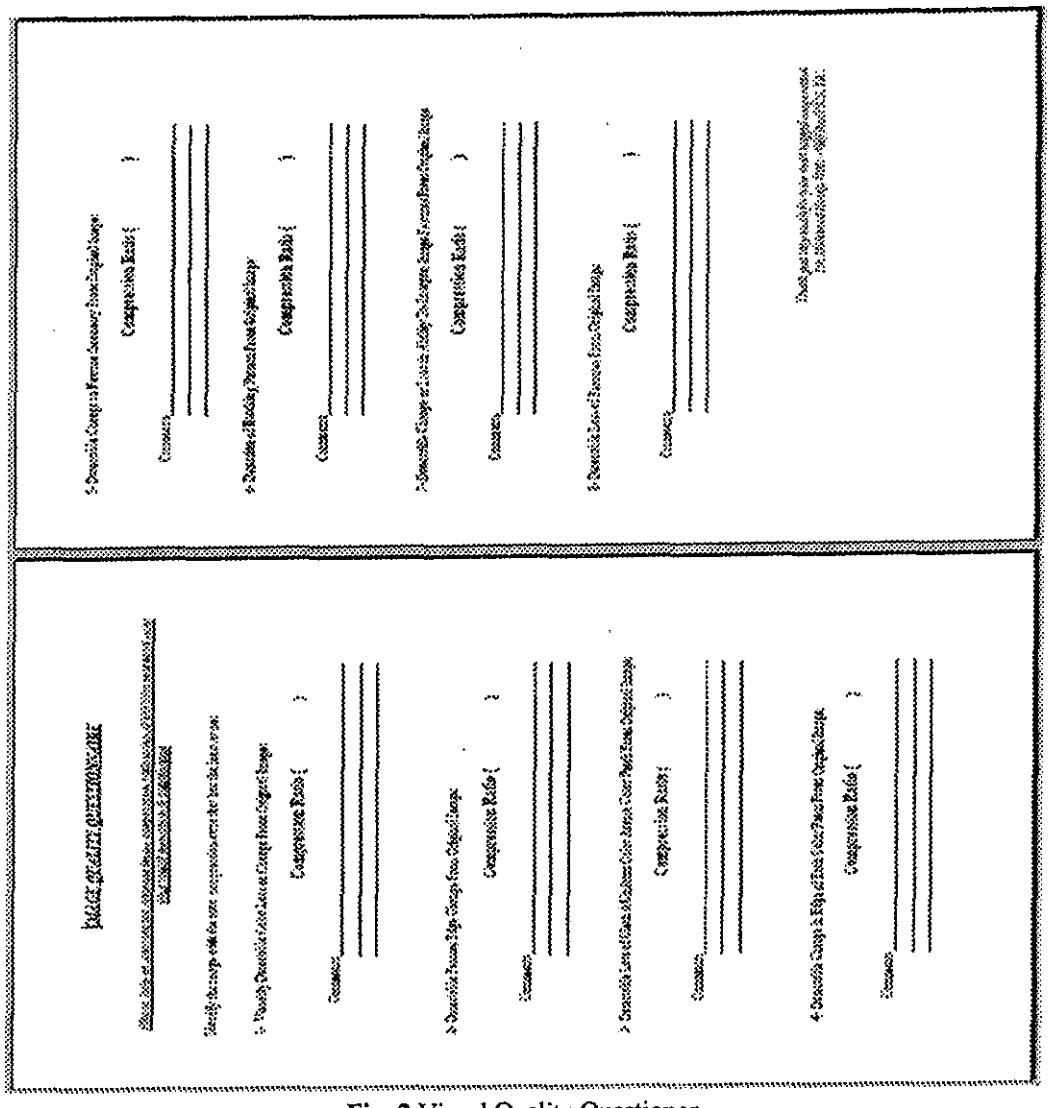

**Fig. 2** Visual Quality Questioner

Based on the previously designed testing aspects, the following results were obtained:

- 100:1 compressed/decompressed imagery acquired crispy-like noise across the entire image patterns
- 80:1 and above compressed/decompressed images were well recognized by some evaluators to acquire serious artificial smoothness patterns across the image
- Starting from a compressionratio of 70:1, slight degradation was apparent, in a densely detailed features and edges.
- Although the reviewers could identify the original image, almost nobody could distinguish any difference between the 20:1 compressed image & its 50:1 counterpart.

Based upon the previously demonstrated subjective testing, it was concluded that the image compressed to 40/50:1 ratio using JPEG2000 would be satisfactory for most applications using the image as a backdrop or as the base for subjective photo interpretation usage.

### 5.2 Objective Quality Measure

Objective image quality measure is the process of calculation of some standard image parameters for the reconstructed image. In other words, try to compare the original and constructed image numerically. Assume that we have an image of MxN rows and lines. The original image can be expressed as a function of F(x,y) and the compressed image as a function of F'(x,y).

The following statistical measures can be used, as used within the statistical module of Lurawave image compression package:

Those parameters were calculated for all the compressed images (5 -10 – 15 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 55 – 60 – 65 – 70 – 75 – 80 – 85 – 90 – 95 – 100 – 125 – 150 : 1).

Figure (4) shows some the calculated parameters.


**Fig. 3** Compressed Image Portion Examples