GIS Data Compression Based On Block-Encoding and Quadtree Approach

Phyo Phyo Wai, and Nyein Aye

Abstract**—**Geographical Information System (GIS) is rapidly developing and then compression techniques for sensor image data are becomes an active research area in the field of GIS. Raster data images are very large size. So, it needs to compress these images for save storage space and effective transition on current network. A Digital Elevation Model (DEM) is any raster representation of a terrain surface. When it is important that the original and the decompressed data be identical, lossless compression is used. The purpose of this paper is to get best solution of GIS data compression for information collection. This paper mentions the compression approaches of block-encoding and quadtree. Compression techniques are very important for GIS.

Keywords**—** Compression Techniques, DEM, GIS, Raster

I. Introduction

WITH the development of GIS technology, the compression techniques of image data are very important. Raster image data are heavy size. So, it needs to compress.

Large amounts of data can create enormous problems in storage space and transmission time. The main reasons of data compression could be summarized as:

- Multimedia data have large data volume
- Difficulty sending real-time uncompressed data over current network

Compression data principle is to eliminate data redundancy and try to find a code with less data volume. All image compression techniques try to get rid of the inherent redundancy, which may be spatial (neighboring similarity or equal pixels), spectral (pixels in different spectral bands in a color image) or temporal (correlated images in a sequence, e.g. television) [3].

Compressing elevation data is not recommended to apply conventional lossy compression techniques to elevation grids [9].

In this paper, it presents the compression approaches. These methods are block-encoding and Quadtree approach. By performing block-encoding compression, each block can have its own compressed bitsream.

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Quadtree is a class of hierarchical data structures which contains two types of nodes: non-leaf node and leaf node, or you can call them internal node and external node. Owing to its "Divide and Conquer" strategy, it is most often used to partition a two dimensional space by recursively subdividing it into four quadrants or regions [4].

II. Related Work

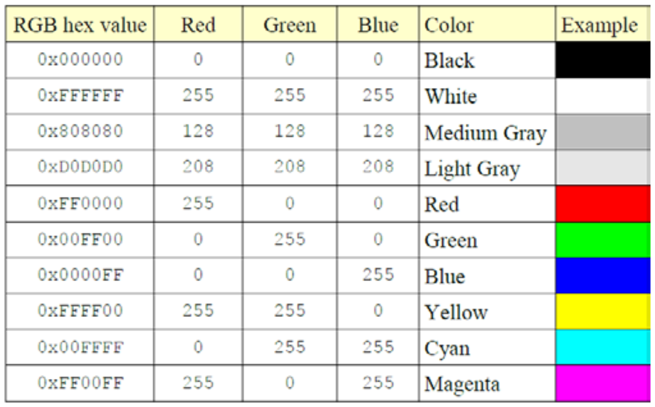
The maintenance of large raster images under spatial operations is still a major performance bottleneck. For reasons of storage space, images in a collection, such as satellite pictures in geographical information systems, are maintained in compressed form [2].

Raster data structure expresses spatial objects in the form of grid cells or pixels into a matrix. It is convenient for spatial analysis and it can be easily integrated with DTM and digital remote sensed images in geographical information system (GIS). This structure is one of the effective models to represent spatial objects in GIS. When raster data structure is used, the smaller the size of pixel or grid cell is, the higher resolution of spatial data comes and the more cells with the same attribute value are resulted in, which causes a large amount of redundant information. The memory space required to store spatial data is large. This requirement causes other problems for a GIS. As there are heavy loads for both spatial data processing and communication, much research is concerned with the storage problem. A quadtree is a well-known hierarchical data structure applied to represent geometric data. It is especially useful for raster-based data processing and important for many applications, such as computer vision, computer graphics, image processing, cartography, and so on (Samet, 1990) [1].

III. Theoritical Background

A. Raster Imagery Foundations

Technically speaking a raster image is a two-dimensional rectangular matrix of individual pixels. Each pixel corresponds (directly or indirectly) to some well defined **color**. And colors are defined as RGB values, i.e. as a triplet of values indicating the Red, Green and Blue relative intensity. Most usually an 8-bit color depth is used, and so a 0 value corresponds to "*completely off*", i.e. black, and 255 to "*completely on*", i.e. pure red or pure green or pure blue. Any real color can be encoded using an appropriate RGB value: an 8-bit color depth allows RGB to represent 16,777,216 different colors, i.e. the so called true color commonly used by digital cameras, screens, color printers and other well known digital imagery equipments. This is also known as the RGB color space (*commonly used on color digital photography*): each pixel requires 3 bytes, i.e. *24 bits* to be represented into this color space [5].



RGB hex value	Red	Green	Blue	Color	Example
0x000000	0	0	0	Black	⬛
0xFFFFFF	255	255	255	White	⬜
0x808080	128	128	128	Medium Gray	▨
0xD0D0D0	208	208	208	Light Gray	▨
0xFF0000	255	0	0	Red	🟥
0x00FF00	0	255	0	Green	🟩
0x0000FF	0	0	255	Blue	🟦
0xFFFF00	255	255	0	Yellow	🟨
0x00FFFF	0	255	255	Cyan	🟦
0xFF00FF	255	0	255	Magenta	🟪

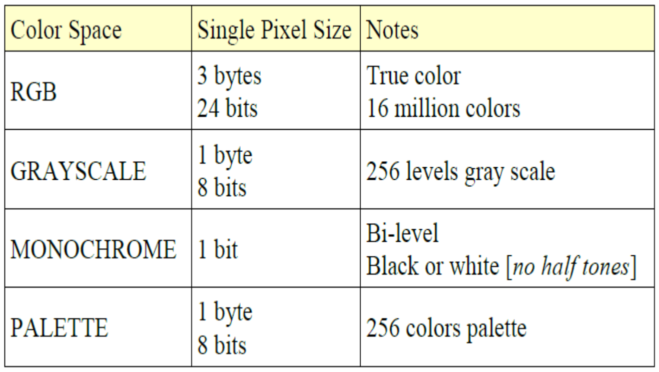
Fig.1 Color Table

As it can easily notice from the above table, a full 256-levels gray scale can always be represented using a single channel, because any gray value always has identical values for Red, Green and Blue. And this defines the GRAYSCALE color space (commonly used on black and white digital photography): each pixel requires a single byte, i.e. 8 bits to be represented into this color space.

In the MONOCHROME color space only two colors are supported (usually, black and white): each pixel requires a single bit, i.e. one single byte can store 8 pixels.

As an alternative way, it can define a PALETTE-based color space. The palette stores a limited set of RGB values (usually, max. 256), and consequently each pixel doesn't requires any longer a full RGB value: it will simply store a palette index, thus indirectly retrieving the corresponding RGB value: consequently, each pixel requires a single byte, i.e. 8 bits to be represented into this color space.

Quite obviously, a lot of different color spaces exist: but they aren't too much widespread, so we can ignore them at all [5].



Color Space	Single Pixel Size	Notes
RGB	3 bytes 24 bits	True color 16 million colors
GRAYSCALE	1 byte 8 bits	256 levels gray scale
MONOCHROME	1 bit	Bi-level Black or white [*no half tones*]
PALETTE	1 byte 8 bits	256 colors palette

Fig.2 Color Space and their single pixel size

B. Raster Data Model

The raster data model represents the Earth's surface as an array of two-dimensional grid cells, with each cell having an associated value.

Most raster formats are digital image formats. Most GISs accept TIF (Tagged Image File Format), GIF(*Graphics* Interchange Format), JPEG (Joint Photographic Experts Group) or encapsulated PostScript, which are not georeferenced. DEMs (Digital Elevation Model) are true raster data formats [13].

C. Digital Elevation Model

The term digital elevation model or DEM is frequently used to refer to any digital representation of a topographic surface. However, most often it is used to refer specifically to a raster or regular grid of spot heights.

Digital terrain model or DTM may actually be a more generic term for any digital representation of a topographic surface, but it is not so widely used.

The DEM is the simplest form of digital representation of topography and the most common a variety of DEMs are available, including coverage of much of the US from the US Geological Survey.

The resolution, or the distance between adjacent grid points, is a critical parameter the best resolution commonly available is 30 m, with a vertical resolution of 1 m coverages of the entire globe, including the ocean floor, can be obtained at various resolutions [8].

D. Compression Techniques

The goal of data compression is to represent an information source as accurately as possible using the smallest storage space (=number of bits). Purpose of image compression is to remove image redundancy such that storage and/or transmission efficiency be increased.

Data compression principles are listed. Data compression:

- Is the substitution of frequently occurring data items, or symbols, with short codes that require fewer bits of storage than the original symbol.
- Saves space, but requires time to save and extract.
- Success varies with type of data.
- Works best on data with low spatial variability and limited possible values.
- Works poorly with high spatial variability data or continuous surfaces.
- Exploits inherent redundancy and irrelevancy by transforming a data file into a smaller one.

The compression ratio is the ratio of the two file sizes. e.g., original image is 100MB, after compression, the new file is 10MB. Then the compression ratio is 10:1.

Two compression techniques are mostly used: Lossless and Lossy compression [7].

a) Loseless Compression

A lossless compression algorithm eliminates only redundant information, so that one can recover the data exactly upon decompression of the file. Lossless data compression is compression without any loss of data quality. The decompressed file is an exact replica of the original one. Lossless compression is used when it is important that the original and the decompressed data be identical. It is done by re-writing the data in a more space efficient way, removing all kinds of repetitions (compression ratio 2:1). Some image file formats, notably PNG, use only lossless compression, while those like TIFF may use either lossless or lossy methods.

Examples of LOSSLESS METHODS are:

- Run-length coding
- Huffman coding
- Lempel-Ziv-Welsh (LZW) method [7].

b) Lossy Compression

A lossy compression method is one where compressing data and then decompressing it retrieves data that may well be different from the original, but is "close enough" to be useful in some way. The algorithm eliminates irrelevant information as well, and permits only an approximate reconstruction of the original file. Lossy compression is also done by re-writing the data in a more space efficient way, but more than that: less important details of the image are manipulated or even removed so that higher compression rates are achieved. Lossy compression is dangerously attractive because it can provide compression ratios of 100:1 to 200:1, depending on the type of information being compressed. But the cost is loss of data. The advantage of lossy methods over lossless methods is that in some cases a lossy method can produce a much smaller compressed file than any known lossless method, while still meeting the requirements of the application.

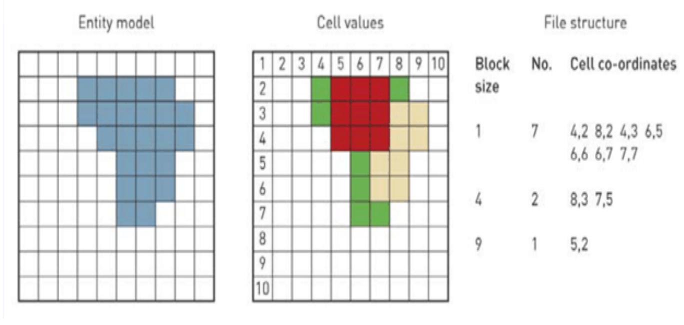
Examples of LOSSY METHODS are:

- PCM
- JPEG
- MPEG [7]

E. *Block-Encoding*

Block-encoding extends the run-length encoding idea to two dimensions by using a series of square blocks to store data [10].

A method of block-encoding a raster image by successive two-dimensional decompositions of blocks of the image in a base of functions using a combined application of a one dimensional core of vertical decomposition of 11 pixels and of a one-dimensional core of horizontal decomposition of p pixels. In the method the horizontal dimension P of each block is determined as a multiple of p, P=k.p, and a decomposition at $\log_P(P)$ level(s) of resolution is accomplished using the horizontal decomposition core, and the vertical dimension N of each block is determined as a multiple of n, NII-n, and a decomposition at $\log_P(N)$ level(s) of resolution is accomplished using the vertical decomposition core. For given values of n and p, the values of k and l are chosen such that the vertical dimension N is strictly less than the horizontal dimension P [11].



Block size	No.	Cell co-ordinates
1	7	4,2 8,2 4,3 6,5 6,6 6,7 7,7
4	2	8,3 7,5
9	1	5,2

Fig.3 Block-encoding

F. *Quandtree Coding*

The quad tree compression technique is the most common compression method applied to raster data. Quad tree coding stores the information by subdividing a square region into quadrants, each of which may be further subdivided in squares until the contents of the cells have the same values [6].

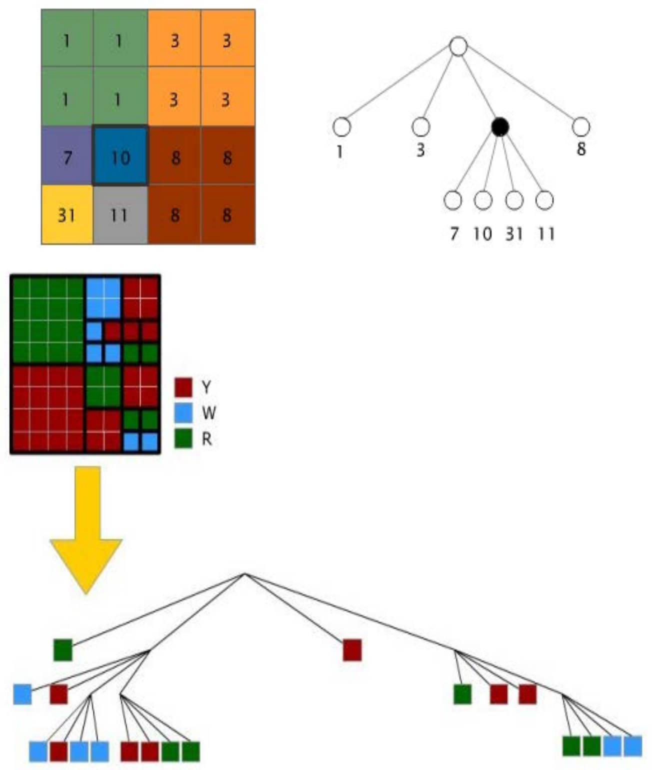


Fig. 4 Quadtree Coding

According to Samet, the types of quadtrees can be classified by following three principles:

1) the type of data that they are used to represent,
2) the principle guiding the decomposition process, and
3) the resolution (variable or not)

Currently, quadtrees can be classified according to the type of data they represent, including areas, points, lines and curves. More generally, quadtrees have been categorized by whether the shape of the tree is independent of the order data is processed. Some common types of quadtrees in this kind of classification are: region quadtree, point quadtree, and edge quadtree [7].

a)Point Quadtree

Point quadtrees are a combination of uniform grid and binary search trees. They were introduced by Finkel and Bently and are useful for spatial data structures, indexing data structures, and low-dimensional points. They seem to be the simplest quadtrees to understand but are usually not the most simple to implement. Point quadtrees are a lot like binary trees but they use x and y coordinates instead of data to decide where to put the data which is where the name point quadtree came from. Point quadtrees contain nodes with four children where binary trees have nodes with only two children. The four children of the point quadtree are usually called northeast, southeast, southwest, and northwest.

To construct a point quadtree you must place the first point at the root and then split the underlying space into 2^d smaller regions or quadrants. Each of these regions corresponds with one of the 2^d subtrees of the root. The remaining points are directed to the quadrants and subtrees are constructed recursively. The nodes are inserted by finding the quadrant in which a point belong to relative to the root of the subtree. So if the current node is (0,0) and you want (1,1), you would go to the northeast child. When you reach and empty node you can then insert the point. So just like a binary tree, the structure of the Point quadtree is dependent on the values which are inserted into it. There are algorithms that have been developed for deleting nodes, but they are not considered the greatest. To perform proximity searches, Point quadtrees are the way to go. They are great at finding points that are closer to one point than another [12].

IV. Propose System

In this propose system, the input data may be GIS image data especially like raster data. And then it takes the action of preprocessing such as removing noise data, image resizing according to the need of this system. After these steps, the compression operation is start. In this step, quadtree coding method will be divide the image into 4 blocks. The block-encoding method has neighboring boundary pixel problem and the quadtree coding method has multi-tree level problem. So, it will be define a limit the level of quadtree dividing. And then to get definite data of image, it will use block-encoding method. Because block-encoding is doing according to the bitstream of the image. By embedding block-encoding method in quadtree coding method, we will solve these problems, effective the processing time and get high accuracy images results. In next step, it saves the compress image file. And then decompress the image file and show the image like originally.

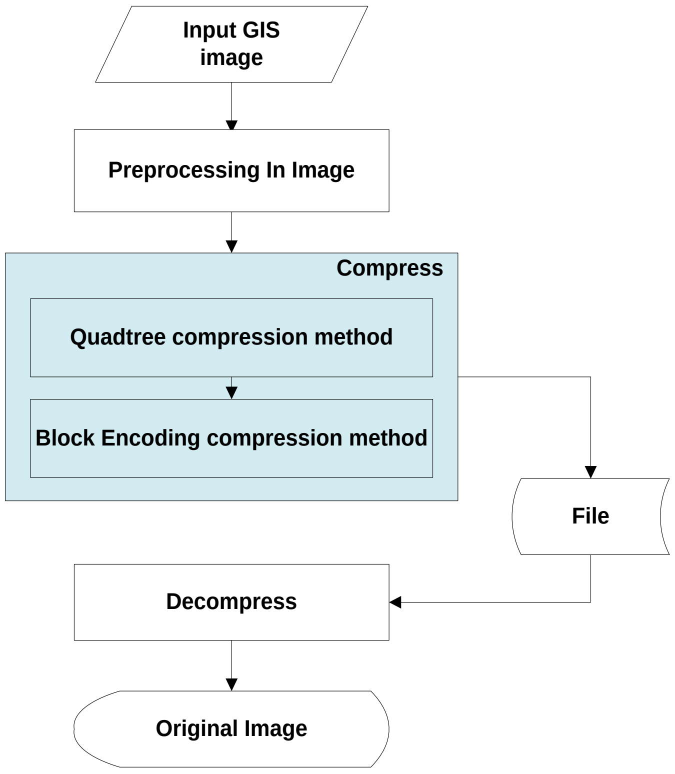


Fig.5 Propose System

V. Conclusion

The compression of image is save the storage space and it is effective the sending data over current network.

This paper presents the propose system of GIS image compression using quad tree method that embedded with block-encoding method. This system is more suitable and more compress than other compression idea.

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