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# Conceptualization of Remote Sensing Images Using Fractal Image Compression on Spiral Architecture

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**Abstract:** The rapid growth of remote sensing applications needs an effective and standardized image compression technique. The practices based on fractals results better in the field of image understanding and visualization of high complexity data.The spiral architecture based on hexagonal structure to represent digital images is chosen over a square structure due to the uniformly connected and close-packed form, greater angular resolution, higher sampling efficiency and better performance. Since there is no established hardware for hexagonal-based image capture and display, square to hexagonal image conversion is mandatory before hexagonal-based image processing. In this paper, general reason for choosing spiral architecture is introduced. Then, SA based image processing design on remote sensing images are arrived.

**Key words:** Remote sensing, fractal image compression, spiral architecture, represent, complexity

## INTRODUCTION

Geographic Information System (GIS) (Maracchi *et al*., 2000) is essential to acquire knowledge about the earth and its resources. The various data for GIS are provided by remote sensing via satellites in the form digital images. It necessary to process the images further with restoration, formation, enhancement, integration and computer-assisted interpretation/management of remotely sensed images.

Image management plays a vital role with inclusion of compression, archiving, retrieval and communication, in which the compression is much more important. The fundamental principle of image compression is to reduce the amount of data required to represent a digital image. It is achieved by the removal of redundant data.

In Remote sensing images the reduction of redundancy is attained through Quad tree based image compression, Transform based coding and Fractal Image Compression (FIC). Among which FIC (Jacquin, 1993) is chosen because of the self- similarity property, resolution independence and fractal interpolation features. The drawback in Pure FIC (Fisher, 2012) is it needs more time for Encoding and the qualities of retrieved images are poor when compressing corrupted images. So, a hybrid FIC, incorporating better partitioning structure with suitable optimization techniques can result in better.

**Remote sensing:** Remote sensing (Morgan and Falkner, 2001) is a science and technology of gathering (via Sense-observe, measure, interpret, analyze, monitor) information about an area, object or phenomenon, from a distance within the instantaneous-field-of-view without physical contact, using airborne or satellite sensors and deriving digital patterns. These digital patterns are termed as Remote Sensing Images (RSI). RSI is obtained using Sensors. Sensor may be either Passive or Active (Fig. 1).

Our eyes are an excellent remote sensing device. We are able to gather- sense information about our surroundings by determining the amount and nature of the reflectance of visible light energy from some external source as it reflects off objects in our field of view.

**Fractal image compression:** Mandelbrot, 1982 identified fractal as a shape made up of parts similar to the whole image. The key behavior of a fractal is its self-similarity. A fractal object is selfsimilar or self-affine at any scale (Hata, 1991). Barnsley *et al.* (1988) proposed the FIC by representing image as a collection of Affine Transformations, Iterated Functions and derived the Contractive Mapping Transform (CMT) applied to IFS's called the Collage (Fisher, 2012) employed the Partitioned or Local Iterated Function System (PIFS/LIFS) to describe images utilizing the property of selfsimilarity.

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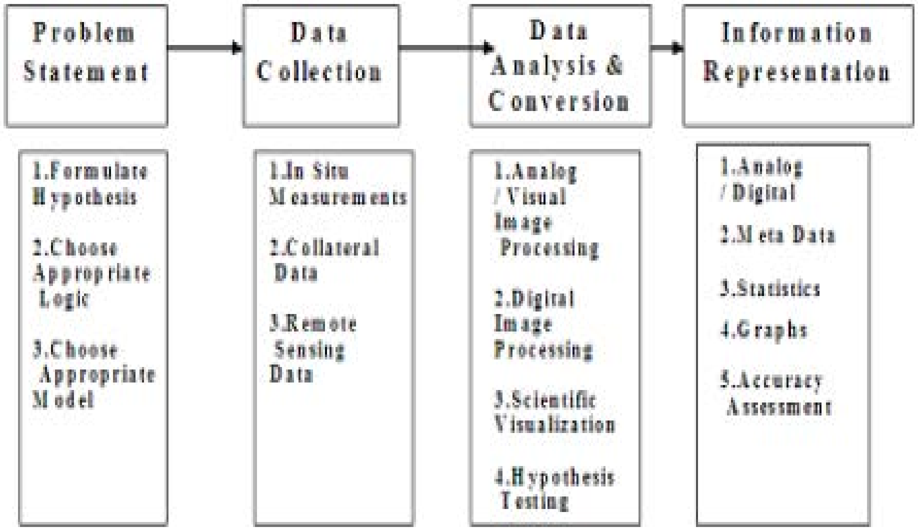


Fig. 1: Remote sensing process

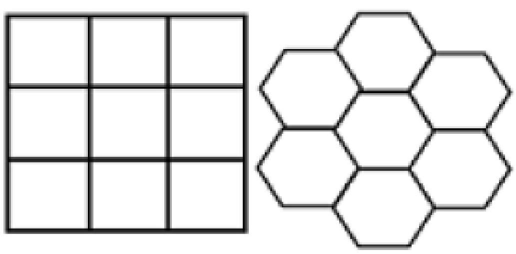

Fig. 2: Square structure and hexagonal structure

Barnsley *et al.* (1989) converted PIFS/LIFS fractal image compression to Recurrent Iterated Function System (RIFS).

Fractal geometry, denotes partitioned image as a collection of shrunken copies, a structure equivalent to RIFS. First practical FIC approach implemented by Jacquin (1992, 1993) based on the Baseline Fractal Image Compression (BFIC) principle, partitions an image into Range Blocks (uniform size, non-overlapping) and the Domain Block (optional size, overlapping) and suggested the square shape of blocks by insisting the domain size as twice that of the range size. FIC (Jacquin, 1993; Mallat, 1989; Hartenstein *et al.*, 2000) employs affine redundancy present in natural images to achieve high compression ratio while maintaining good image quality with resolution independence.

**FIC approach:** The fundamental principle behind FIC (Wohlberg and de Jager, 1999; Saupe and Ruhl, 1996) is formation of range blocks by image partition techniques (right-angled partition approach, triangular and polygonal partition approach and hexagonal approach), selection of domain pool by improvements (using code books), class of block transforms applied on domain pools, Searching the suitable domain pool for formation of particular range block and Optimizing the search strategies.

**Spiral architecture:** Vision unit (Schwartz, 1980) is represented in two different image structures, Square and Hexagonal shown in Fig. 2. Traditional square elements can be mapped into hexagonal by resampling method, pseudo hexagonal pixel, virtual hexagonal structure, mimic hexagonal structure, spiral architecture. Spiral Architecture (Sheridan, 1996, Sheridan *et al.*, 2000) is inspired from anatomical considerations of the primate's vision. On SA, an image is a collection of hexagonal structure. The significance of the hexagonal representation is property of distribution that any hexagonal pixel has only six adjacent pixels which have the same distance to the central hexagon of the seven-hexagon unit of vision as shown in Fig. 3.

**Basics of SA:** Basically there are four steps in building a SA (Sheridan, 1996). They are namely Spiral Addressing, Spiral Counting, Spiral Addition (translation of image) and Spiral Multiplication (scaling rotation of image).

**Spiral addressing:** Spiral addressing (Sheridan, 1996) is the technique that labels each hexagonal pixel with a unique positive number called Spiral Address. The property concentrated here is the physical proximity of the hexagonal pixels with adjacent addresses. This is achieved by successively labelling seven hexagons with addresses 0-6 as in Fig. 4.

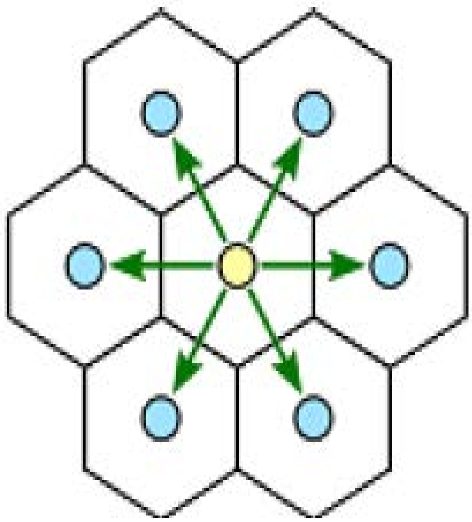

Fig. 3: Property of distribution

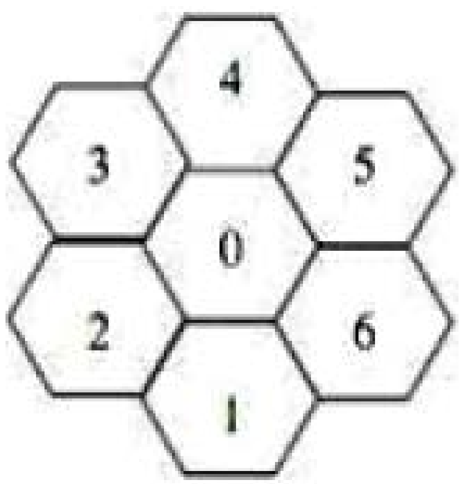


Fig. 4: Spiral adressing

The address of innermost pixel is 0 and its adjacent 6 pixels have address 1-6, respectively. The complete addressing of hexagonal pixels is done by using base seven addresses only. This means that after 6 the next address will be 10. Figure 5 shows the complete addressing of cluster of 72 = 49 square pixels. This hexagonal structure retains the property of distribution. Thus, almost there will be no image distortion. The repetition of the above steps permits the collection of hexagons to grow in powers of seven with uniquely assigned addresses. This pattern of growth of addresses produces the Spiral Architecture.

**Spiral counting:** Sheridan (1996) approach allocates a sequence of hexagons in SA which is considered as a

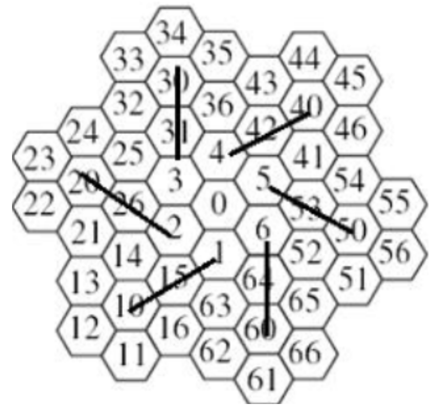


Fig. 5: The $7^2$ = 49 hexagonal pixels with spiral adresses

Spiral movement that gives a commencing hexagon, counts for a predetermined key and terminates at another certain hexagon. Solid line represents main rotating direction, whereas, dotted line represents secondary rotating direction in Fig. 6. Any hexagon can be reached by Spiral counting (He *et al*., 1999) from any other interested hexagon in the same image. A key is the first hexagon to be reached in an instance of a Spiral counting determines the distance and the orientation parameters. The angle is used to represent the orientation. Spiral counting leads to Spiral Addition and a Spiral multiplication. Consider “a” and “b” are the Spiral addresses of two arbitrarily chosen hexagons in SA.

**Spiral addition:** Spiral addition (Sheridan, 1996; Wang *et al*., 2007 ) is denoted by a+b is the Spiral address of the hexagon found by Spiral counting “b” hexagons in the key of Spiral address “1” from the hexagon with Spiral address “a” (Fig. 7).

**Spiral multiplication:** Spiral multiplication (Sheridan, 1996; Wang *et al*., 2008) is denoted by a x b, found by Spiral counting “b” hexagons in the key of Spiral address “a” makes use of variable key for spiral counting with the constant starting address “0” referring scalar multiplication Table 1. It gives the one dimensional representation.

For two dimensional representations (Thakur and Kakde, 2007; Seeli and JeyaKumar, 2013), the values are divided into separate digits and then each digit of the first value is spiral multiplied with each digit of the second value. The spiral multiplication employs again a special multiplication table for each pair of digits. Decimal powers are multiplied in normal fashion. Later the results for each digit of the first address are spiral added (Fig. 8).

The uniform image partitioning uses a novel image processing based on Spiral Architecture. On SA, an image can be partitioned into a few sub-images each one of

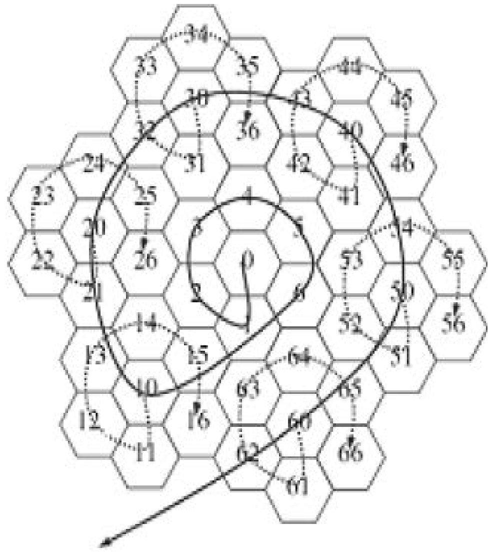

Fig. 6: Spiral counting

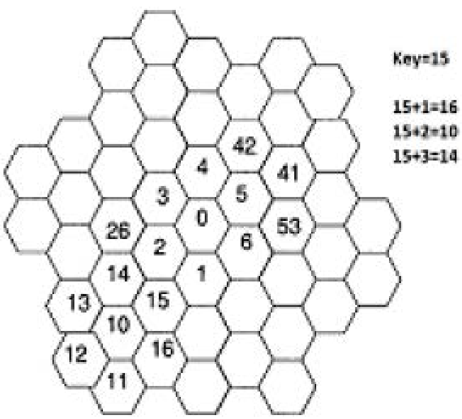


Fig. 7: Spiral adddition

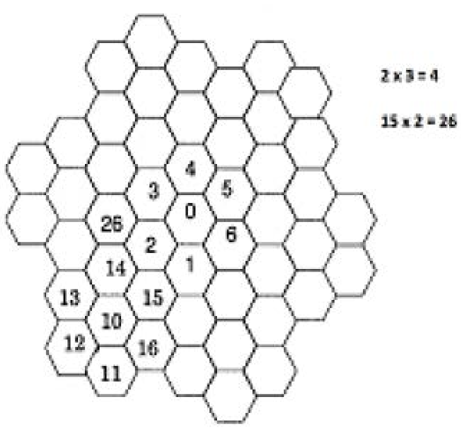


Fig. 8: Spiral multiplication

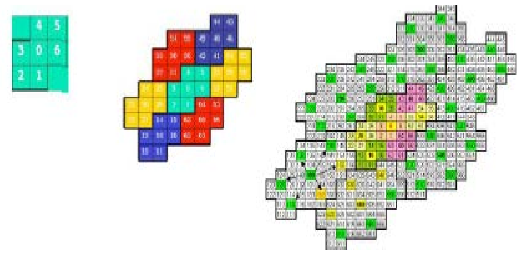

Fig. 9: Pseudo model of spiral architecture

Table 1: Spiral multiplication table

| Keys | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 2 | 0 | 2 | 3 | 4 | 5 | 6 | 1 |
| 3 | 0 | 3 | 4 | 5 | 6 | 1 | 2 |
| 4 | 0 | 4 | 5 | 6 | 1 | 2 | 3 |
| 5 | 0 | 5 | 6 | 1 | 2 | 3 | 4 |
| 6 | 0 | 6 | 1 | 2 | 3 | 4 | 5 |

which is a scaled down close to copy of the original image, each of them holds all the representative intensity information contained in.

**Representation of SA:** SA can be represented (Truong *et al*., 2004; Wang *et al*., 2007) using the following methods Mimic model, Pseudo model and Visual model. Because of the less computational complexity and pixelto-pixel representation, we choose the Pseudo Model Fig. 9.

**Fractal image compression on spiral architecture:** The fundamental idea of image compression on SA is that each hexagon with property of distribution. The variation of light intensities between pixels is closely described (Umbaugh, 1996) by the distance between them. Minimal distance detects few variations. The light intensity of a hexagonal pixel is equally affected by the light intensities of its neighbouring pixels (He, 1999).

Adopting FIC on Spiral Architecture, separate the image into range blocks of seven pixels and define the domain blocks of seven times more in Fig. 9. Each pixel in the image can be the centre of domain block. Then we include the first 48 pixels around it based on Spiral counting to form a domain block unless any pixel of this domain block is out of the given image.

A tendency for a range block (Belloulata and Konrad, 2002) to be spatially close to the matching domain block, based on the observed tendency for distributions of spatial distances between range and matching domain blocks to be highly peaked at zero . Motivated by this observation, the domain pool for each range block may be restricted to a region about the range block or a spiral search path may be followed outwards from the range block position.

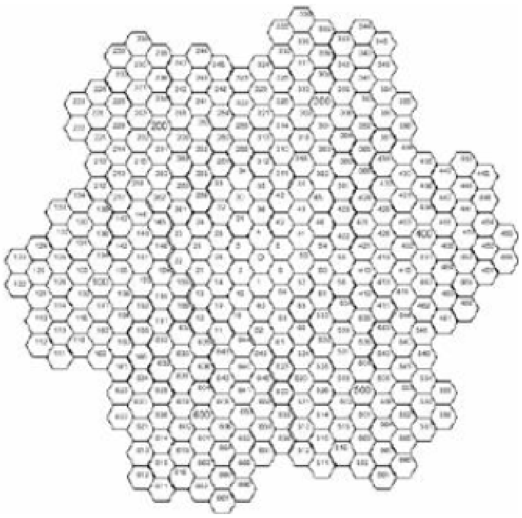

Fig. 10: A collection of 343 hexagonal pixels

Therefore, in order to reduce the computational complexity for each range block we only search for up to 343 domain blocks (Wang *et al*., 2007) which are around this range block. Each of those range blocks has at most 343 domain blocks in the domain pool and the centres of domain blocks in the pool are the first 343 pixels counting from the centre of range block through the Spiral direction (Fig. 10).

SA in FIC is chosen because of the uniformly connected and close-packed form, greater angular resolution, higher efficiency and better performance

## CONCLUSION

This concept is focused on remote sensing images. In mathematical point of view, it is found that the alternative to traditional square structure by the spiral architecture has great potential in improving fractal image compression. Generation of local and global spiral code book for a large scale image can increase the compression ratio. This conceptualization can be useful for the huge image data transmission on web based applications. The compression can be influenced by spatial complexity of remote sensing images from different platforms such as SPOT, RADAR, IKONOS, LIDAR, SONAR etc. and for different band images.

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