# Lossless Image Compression and Secure Storage of Medical Images

**Vivekananda Panigrahy**

**Department of Computer Science and Engineering**
**National Institute of Technology Rourkela**
**Rourkela-769 008, Orissa, India**

# Lossless Image Compression and Secure Storage of Medical Images

*Thesis submitted on MAY 2012 in partial fulfilment*
*of the requirements for the degree of*

**Bachelor of Technology**

*in*

**Computer Science and Engineering**

*by*

**Vivekananda Panigrahy**
**(Roll: 108CS022)**

*under the guidance of*

**Prof. B. Majhi**
**NIT Rourkela**

**Department of Computer Science and Engineering**
**National Institute of Technology Rourkela**
**Rourkela-769 008, Orissa, India**
**Academic Year: 2011-12**

**Department of Computer Science**
**National Institute of Technology Rourkela**
Rourkela-769 008, Orissa, India.

May 14, 2012

# Certificate

This is to certify that the work in the thesis entitled ***Lossless Image Compression and Secure Storage of Medical Images*** by ***Vivekananda Panigrahy*** is a record of an original research work carried out under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering. Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

**B. Majhi**
Professor
CSE department of NIT Rourkela

# Acknowledgement

I express my sincere gratitude to Prof. B. Majhi for his motivation during the course of the project which served as a spur to keep the work on schedule.

I convey my regards to all the other faculty members of Department of Computer Science and Engineering, NIT Rourkela for their valuable guidance and advices at appropriate times. Finally, I would like to thank my friends for their help and assistance all through this project.

*Vivekananda Panigrahy*

# Abstract

This thesis presents a new methodology which performs both lossless compression and secure storage of binary and gray scale images. The compression is based on SCAN language and it is lossless in nature. The SCAN is a formal language-based two-dimensional spatial-accessing methodology which can efficiently specify and generate a wide range of scanning paths or space filling curves. Prior to the compression, a framework is presented which ensures the secure storage of images on basis of division of knowledge. Finally, QR code is used for efficient indexing of the secure images. QR codes are 2-dimensional barcodes which can store huge amount of data as compared to 1-dimensional barcodes. The results are analysed constrained to medical images in the hope of getting better results than that of the generic domain. Thus, this paper presents compression specific SCAN language, compression-decompression algorithms, framework ensuring security and indexing, and test results of the methodology.

***Keywords:*** Medical Images, Lossless Compression, SCAN Language, QR Code

# Contents

**Certificate** **iii**

**Acknowledgement** **iv**

**Abstract** **v**

**List of Figures** **viii**

**List of Tables** **ix**

**1 Introduction** **1**

1.1 Objective . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1

1.2 Image Compression . . . . . . . . . . . . . . . . . . . . . . . . . 2

1.3 Image Security . . . . . . . . . . . . . . . . . . . . . . . . . . . 3

1.4 Medical Imaging . . . . . . . . . . . . . . . . . . . . . . . . . . 4

1.5 Quick Response Code . . . . . . . . . . . . . . . . . . . . . . . . 4

1.6 Organization of the Thesis . . . . . . . . . . . . . . . . . . . . . 6

**2 SCAN based Language** **7**

2.1 Definition of Compression specific SCAN . . . . . . . . . . . . . . 8

2.2 Semantics of Compression specific SCAN . . . . . . . . . . . . . . 8

2.3 Encoding of Compressed Image . . . . . . . . . . . . . . . . . . . 10

2.4 Example of encoding of compressed image . . . . . . . . . . . . . 11

**3 Compression and Decompression** **13**

3.1 Compression . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13

3.2 Decompression . . . . . . . . . . . . . . . . . . . . . . . . . . . . 14

**4 Constructing the Framework** **15**

**5 Results and Analysis** **17**

5.1 Time Complexity . . . 17

5.2 Output Results . . . 18

5.3 Analysis . . . 22

**6 Conclusion** **24**

**Bibliography** **25**

# List of Figures


2.1 Basic Scan Patterns for SCAN Language . . . . . . . . . . . . . . . . . 9
2.2 Basic Partition Patterns for SCAN Language . . . . . . . . . . . . . . . 9
2.3 Encoding frame for Compression . . . . . . . . . . . . . . . . . . . . . . 10
2.4 A 8 ×8 binary image with SCAN word C0 . . . . . . . . . . . . . . . . 11

3.1 Block diagram for proposed compression algorithm . . . . . . . . . . . 14

4.1 Framework for proposed algorithm . . . . . . . . . . . . . . . . . . . . 16
4.2 Indexing system for Secure Image Retrieval . . . . . . . . . . . . . . . . 16

5.1 Bit plane images and corresponding compressed images . . . . . . . . . 19
5.2 Grayscale lenna image . . . . . . . . . . . . . . . . . . . . . . . . . . . 21
5.3 Comparision of diffrenet algorithms . . . . . . . . . . . . . . . . . . . . 21

# List of Tables

1.1 Comparision of various Image Encryption algorithms . . . . . . . . . . 3

2.1 Scheme for encoding bit sequence . . . . . . . . . . . . . . . . . . . . . . 11

5.1 Compression factor of each bit plane . . . . . . . . . . . . . . . . . . . . 20
5.2 Compression factor in different image formats . . . . . . . . . . . . . . 20
5.3 Comparision of different Algorithms . . . . . . . . . . . . . . . . . . . . 22
5.4 Proposed Algorithm implemented on 20 Medical Images . . . . . . . 22

# Chapter 1

# Introduction

Medical images include information about human body which are used for different purposes such as surgical and diagnostic plans. Imaging devices improve everyday and generate more data per patient. In the field of profiling patients data, medical images need long-term storage. Also, we need to transfer the medical image files in the network which requires high bandwidth. Here the need of compression is realized. Thus, compression of medical images is used in the applications such as profiling patients data and transmission systems. As per the importance of medical images, lossless or near-lossless compression is preferred. Therefore, images need compression and compression ratio is important. However, in real time processes such as telemedicine and online diagnosis systems which need hardware implementation, simplicity of compression algorithm plays an important role. It can accelerate computation process. Further, security is also a matter of concern in case of medical images where the privacy of patient records has to be done.

## 1.1 Objective

Addressing the concerns mentioned earlier we present a framework that directly deals with the requirements using a new methodology and helps us to build a global clinical storage adopting client-server architecture. In the framewrok, we present:

- A lossless compression technique with improved compression factor.
- An approach for the secure stoarge of medical images.

- An indexing mechanism to access to secure images stored in a remote server from the local site

The focus is constrained to only gray scale images considering most of images generated from different modalities of medical equipments to be gray scale. In this framework, the indexing mechanism for the retrieval of secure images is described using Quick Response (QR) code. The purpose of using QR codes is to hold the data in a compact format and easily access in the secure image database.

## 1.2 Image Compression

Image compression is the application of data compression and is a technique of reducing the redundancies in image and represents it in shorter manner. Image compression can be lossy or lossless. There are both lossy as well as lossless compression schemes. Depending upon the requirement we chose different techniques. For high value images such as medical images where loss of critical information is not acceptable, lossless or visually lossless compression is preferred.

JPEG is a very famous ISO/ITU-T standard that was created in the late 1980s. Lossless JPEG is one of the several JPEG standards.In lossless mode, the image is transformed by differential pulse code modulation (DPCM), and then Huffman is applied for encoding. DPCM is based on predicting the image pixels from the neighboring pixel by a specific equation and calculating the error of prediction.

JPEG-LS standard of coding still images provides lossless and near-lossless compression. The baseline system or the lossless scheme is achieved by adaptive prediction, context modeling, and Golomb coding.

JPEG2000 is based on the discrete wavelet transform (DWT), scalar quantization, context modeling, arithmetic coding, and post-compression rate allocation. JPEG2000 works well and gives a good compression ratio especially for high-detail images, because it analyzes the details and the approximation in the transformation step and decorrelates them. However, JPEG2000 has high computational complexity.

## 1.3 Image Security

With the fast progression of data exchange in electronic way, information security is becoming more important in data storage and transmission. Because of widely using images in industrial process, it is important to protect the confidential image data from unauthorized access. Image encryption has applications in internet communication, multimedia systems, medical imaging, telemedicine, military communication, etc.Images are different from text. Although we may use the traditional cryptosystems to encrypt images directly, it is not a good idea for two reasons. One is that the image size is almost always much greater than that of text. Therefore, the traditional cryptosystems need much time to directly encrypt the image data. The other problem is that the decrypted text must be equal to the original text. However, this requirement is not necessary for image data. Due to the characteristic of human perception, a decrypted image containing small distortion is usually acceptable.

Here in the Table 1.1 we compare the pros and cons of different image encryption algorithms.

Table 1.1: Comparision of various Image Encryption algorithms

| Algorithm | Pros | Cons |
|---|---|---|
| SCAN | Lossless compression | Longer processing time |
| VQ | Simple hardware, less time | High storage |
| MIE/CIE | Robust encryption | No compression |
| VC | No computation, visual perception | Lossy compression |

VQ = Vector Qunatization

MIE = Mirror Image Encryption

CIE = Chaotic Image Encryption

VC = Visual Cryptography

## 1.4 Medical Imaging

Medical imaging is the technique and process used to create images of the human body (or parts and function thereof) for clinical purposes. It is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. In this restricted sense, medical imaging can be seen as the solution of mathematical inverse problems. This means that cause (the properties of living tissue) is inferred from effect (the observed signal).

Medical imaging techniques produce very large amounts of data, especially from CT, MRI and PET modalities. As a result, storage and communications of electronic image data are prohibitive without the use of compression. JPEG 2000 is the state-of-the-art image compression DICOM standard for storage and transmission of medical images. The cost and feasibility of accessing large image data sets over low or various bandwidths are further addressed by use of another DICOM standard, called JPIP, to enable efficient streaming of the JPEG 2000 compressed image data.

There has been growing trend to migrate from PACS to a Cloud Based RIS. A recent article by Applied Radiology said, "As the digital-imaging realm is embraced across the healthcare enterprise, the swift transition from terabytes to petabytes of data has put radiology on the brink of information overload. Cloud computing offers the imaging department of the future the tools to manage data much more intelligently."

## 1.5 Quick Response Code

The QR code was a kind of two dimensional barcode, and developed with a main objective of "Code read easily for the reader" in 1994 by Denso wave.

Bar codes have become widely popular because of their reading speed, accuracy, and superior functionality characteristics. As bar codes became popular and their convenience universally recognized, the market began to call for codes capable of storing more information, more character types, and that could be printed in a smaller space.

QR Code provides the following features compared with conventional bar codes:

- High Capacity Encoding of Data
- Small Printout Size
- Kanji and Kana Capability
- Dirt and Damage Resistant
- Readable from any direction in 360
- Structured Append Feature

QR Code is capable of handling all types of data, such as numeric and alphabetic characters, Kanji, Kana, Hiragana, symbols, binary, and control codes. Up to 7,089 characters can be encoded in one symbol. The symbol versions of QR Code range from Version 1 to Version 40. Each version has a different module configuration or number of modules. Modules commence with Version 1 ($21 \times 21$ modules) up to Version 40 ($177 \times 177$ modules). Each higher version number comprises 4 additional modules per side.

Although initially used to track parts in vehicle manufacturing, QR Codes are now (as of 2012) used over a much wider range of applications which are mentioned as follows:

- Commercial tracking
- Entertainment and Transport ticketing
- Product/Loyalty marketing (examples: mobile couponing where a company's discounted and per cent discount can be captured using a QR Code decoder which is a mobile app.

- Storing a company's information such as address and related information alongside its alpha-numeric text data as can be seen in Yellow Pages directory.

- Storing personal information for use by government. An example of this is Philippines National Bureau of Investigation (NBI) where NBI clearances now come with a QR Code.

- Mobile tagging, Users may receive text, add a vCard contact to their device, open a Uniform Resource Identifier (URI), or compose an e-mail or text message after scanning QR Codes.

QR Codes storing addresses and Uniform Resource Locators (URLs) may appear in magazines, on signs, on buses, on business cards, or on almost any object about which users might need information. Users with a camera phone equipped with the correct reader application can scan the image of the QR Code to display text, contact information, connect to a wireless network, or open a web page in the mobile browser. This act of linking from physical world objects is termed as hard linking or object hyperlinking.

ZXing (pronounced "zebra crossing") is an open-source, multi-format 1D/2D barcode image processing library implemented in Java, with ports to other languages. Its focus is on using the built-in camera on mobile phones to scan and decode barcodes on the device, without communicating with a server.

## 1.6 Organization of the Thesis

This thesis is organized as follow. Our compression method, its structure and specifications are presented in Chapter 2. Further, Chapter 3 presents the proposed algorithm on basis of which we construct a framework subsequently presented in Chapter 4. provides Experimental Results and analysis have been reviewed in Chapter 5. Finally, Capter 6 gives concluding remarks and scope for future work.

# Chapter 2

# SCAN based Language

The SCAN is a formal language based on two dimensional spatial accessing methodologies which can represent and generate a large number of wide variety of scanning paths or space filling curves easily. There are a family of formal languages such as Simple SCAN, Extended SCAN, and Generalized SCAN, each of which can represent and generate a specific set of scanning paths.

The SCAN methodology compresses a given binary image, by specifying a scanning path of the image in an encoded form, and by specifying the bit sequence along the scanning path in an encoded form. Note that a scanning path of an image is simply an order in which each pixel of the image is accessed exactly once. At the core of the compression method is the algorithm which determines a near optimal or a good scanning path which minimizes the total number of bits needed to represent the encoded scanning path and the encoded bit sequence along the scanning path. A given gray-scale image can be compressed by slicing each bit plane.

A scanning of a two dimensional array $P_{mn} = p(i, j) : 1 \leq i \leq m, 1 \leq j \leq n$ is a bijective function from $P_{mn}$ to the set {1, 2,  mn-1, mn}.

## 2.1 Definition of Compression specific SCAN

The compression specific SCAN language is formally defined by the context free grammar:

$$G = (Q, \sum, A, \prod)$$

$$Q = (A, S, P, I, U, V, T, W)$$

$$\sum = \{0, 1\}$$

Start symbol is A and the production rules are given by:

- A →S|P|I
- S →10UT
- P →11VTAAAA
- I →OW
- U →00|01|10|11
- V →00|01|10
- T →000|001|010|011|100 |101 |110 |111
- W →Binary strings of length $2^{2n}$

## 2.2 Semantics of Compression specific SCAN

The semantics of the grammar production rules are given as follows:

- A →S|P|I means process region by basic scan S or partition P or store image I.
- S →10UT means scan the region with basic scan pattern U and transformation T. Prefix 10 indicates basic scanning.
- P →11VTAAAA means partition the region with partition pattern V and transformation T, and recursively process each of the four sub regions in partition order using as from left to right. Prefix 11 indicates partition.

- I →OW means store the original image of the region. Prefix 0 indicates storing image region.

- U →00|01|10|11 means scan with basic scan pattern continuous raster C or continuous diagonal D or continuous orthogonal 0 or spiral S respectively. These four basic scan patterns are shown in the Figure 2.1.

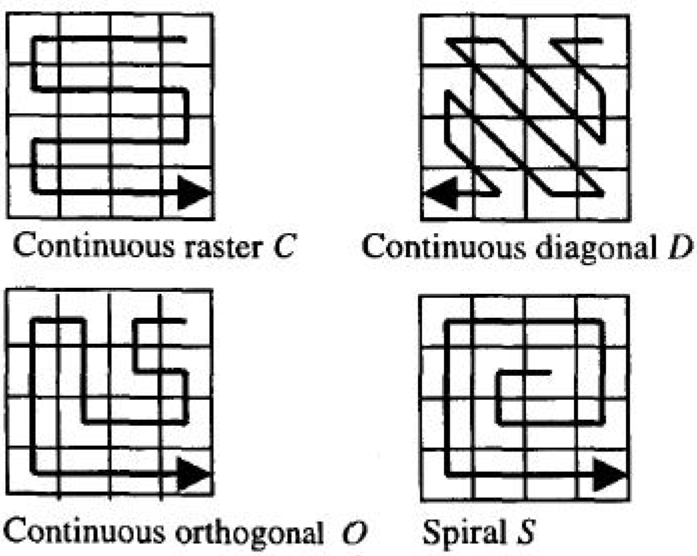



Figure 2.1: Basic Scan Patterns

- V →00|01|10 means partition with partition pattern B or Z or X respectively. These three partition patterns are shown in the Figure 2.2.

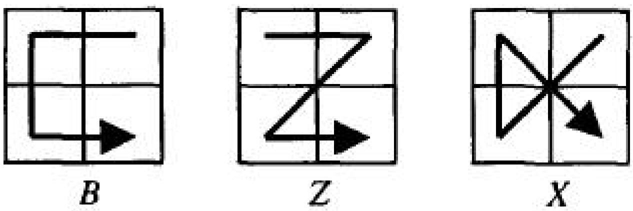



Figure 2.2: Basic partition patterns

- T →000|001|010|011|100 |101 |110 |111 means use one of the eight transformations with scanning or partitioning. The eight transformations 0 to 7 are encoded as three digit binary numbers. These transformations are defined as follows. For all scan and partition patterns, transformation 0 means identity transformation. For scan patterns C, 0, and S and partition patterns B and X, transformation 2, 4, and 6 means counter clockwise rotation by 90”, 180”, and 270” respectively. For scan pattern D and partition pattern Z, transformation 2, 4, and 6 means clockwise rotation by 90”, clockwise rotation by 90” followed by horizontal reflection, and horizontal reflection respectively. For all scan and partition patterns, transformation 1, 3, 5, and 7 means reverses of scan and partition patterns specified by transformation 0,2, 4, and 6 respectively.

- W →Binary strings of length $2^{2n}$ means to store the original image of the region. Image will be stored in the usual raster scan order. We assume that maximum image size is 512×512. Since any image region obtained by subdivision has size $2^n \times 2^n$

## 2.3 Encoding of Compressed Image

The methodology assumes that an input image has size $2^n \times 2^n$ where $2 \leq n \leq 9$. If the image size is $2^n \times 2^n$ then it is encoded as binary form of n-2 using three bits. The compression algorithm first searches and finds a near optimal or a good scanning path which minimizes the number of bits needed to encode the scanning path and the bit sequence along the scanning path. After a good scanning path is determined, the scanning path is encoded in binary form using its corresponding compression specific SCAN word. Next, the first bit of the scanning path and the number of segments of 0’s and 1’s along the scanning path are determined. The first bit is either 0 or 1 and it is encoded as itself using one bit. The number of segments is encoded as its binary form using $2^n$ bits if the image size is $2^n \times 2^n$. Next, the bit sequence along the scanning path is determined. The bit sequence is then encoded using a modified run length encoding scheme which can be seen in Figure 2.3.

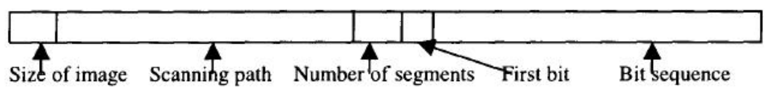



Figure 2.3: Encoding frame for Compression

Table 2.1: Scheme for encoding bit sequence

| Segment size | Low Limit | Prefix | Bits used to encode segment size | Total bits |
|---|---|---|---|---|
| 1-4 | 1 | 0 | 2 | 3 |
| 5-12 | 5 | 10 | 3 | 5 |
| 13-28 | 13 | 110 | 4 | 7 |
| 29-60 | 29 | 1110 | 5 | 9 |
| 61-316 | 61 | 11110 | 8 | 13 |
| 317-1340 | 317 | 111110 | 10 | 16 |
| 1341-($2^{18}$-1) | 1341 | 111111 | 18 | 24 |

## 2.4 Example of encoding of compressed image

Consider the 8×8 binary image shown in Figure 2.4.

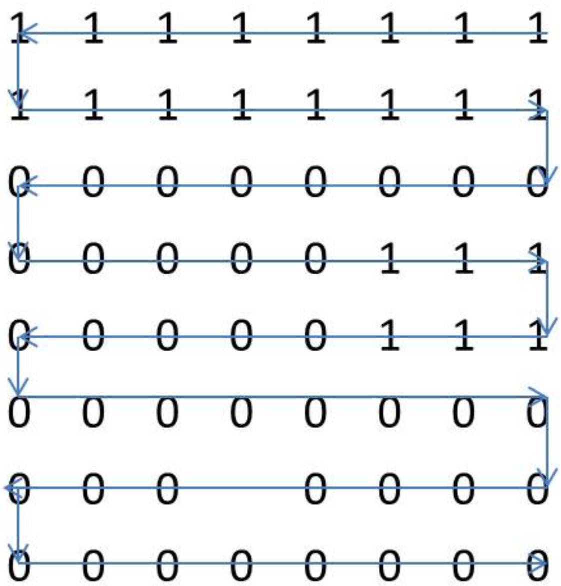



Figure 2.4: A 8 ×8 binary image with SCAN word C0

- The image size is 8 ×8 and it is encoded using 3 bits as binary form of 4-2 which is 001.
- The scanning path is encoded using its corresponding compression specific SCAN word. Here the scan pattern is C and transformation is taken is 0. The SCAN word is 1000000.

- The number of segments is encoded using 6 bits i.e. 000100.
- The first bit is 1.
- The bit sequence along the scanning path is determined next. The bit sequence is 1100011110000010001111000000.

# Chapter 3

# Compression and Decompression

In this section, we present the algorithms and block diagrams that were adapted to the use of lossless compression medical images.

## 3.1 Compression

For a given binary image, a near optimal or a good scanning path which minimizes the number of bits needed to encode the scanning path and the bit sequence along the scanning path is determined. Once such a path is determined, all other components of the compressed image can be determined and encoded.

**Input**: Original image I of Size N
**Output**: Compressed image having near optimal or a good scanning path of the image I

Represent the input gray scale image in gray code form;

**foreach** *bit plane sliced from the gray image* **do**
  **foreach** *scan letter s ε (C, D, 0, S) and transformation t ε (O, 1, 2, 3, 4, 5, 6, 7)* **do**
    Determine the bit sequence $B_{st}$ along the scanning path st;
    Determine the total number of bits $N_{st}$ in the encodings of st and $B_{st}$
  **end**
  Choose the st which has the minimum $N_{st}$ value;
  Encode the binary image using the minimal scanning path determined;
**end**

**Algorithm 1:** Algorithm for hybrid compression

This algorithm is clearly illustrated using the block diagram shown in Figure 3.1.

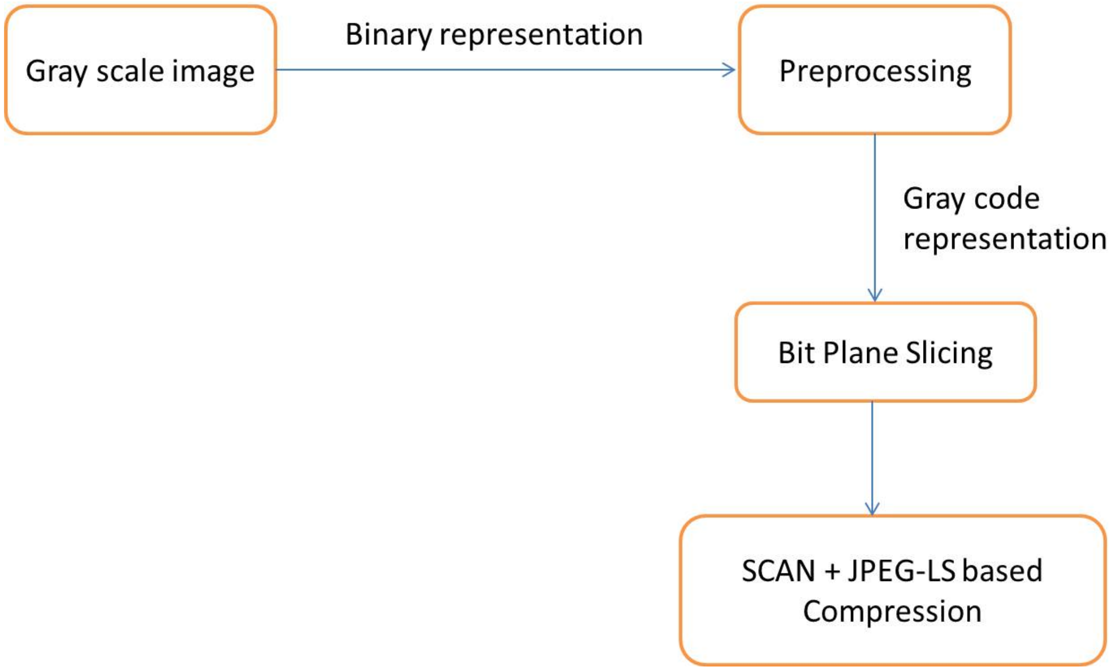



Figure 3.1: Block diagram for proposed compression algorithm

## 3.2 Decompression

Decompression of a compressed image is done by decoding each of the five components of the compressed image. The image size, the first bit, and the number of segments are decoded using their encoding rules. The scanning path is decoded by parsing the one dimensional binary SCAN word using the grammar rules given definition. The bit sequence is decoded by decoding each bit segment in the sequence using the run length encoding rules.

Once all five components are decoded, the original image can be reconstructed by first creating a two dimensional empty array for the image, and then scanning the array with the decoded scanning path and filling the array elements along the scanning path with bits from the decoded bit sequence.

# Chapter 4

# Constructing the Framework

Until now, we have discuessed the lossless compression procedure using SCAN language which ultimately uses the RLE algorithm. After the compression has been done, the secure storage is proposed in the framework. It uses the concept of divsion of knowledge to achieve security i.e. It stores the gray scale image (8 bits/pixel) into 8 bit plane compressed images. The total information can be obtained only by fetching all 8 bit plane compressed images, decompressing all of them and then reconstructing back to gray scale image. The framework has been illustarted in the block diagram shown in Figure 4.1. So the compressed images are stored in the remote site where the local site would be able to retrieve to it. To solve this requirement QRcode is constructed generating a random number from each bit plane image and combning 8 random numbers corresponding to a gray scale image into a single QR code which is demonstrated in the Figure 4.2. The random number genration can be message dependent or independent as per the user's requirement. The genaration of perfect random numbers is beyond the scope of this thesis.

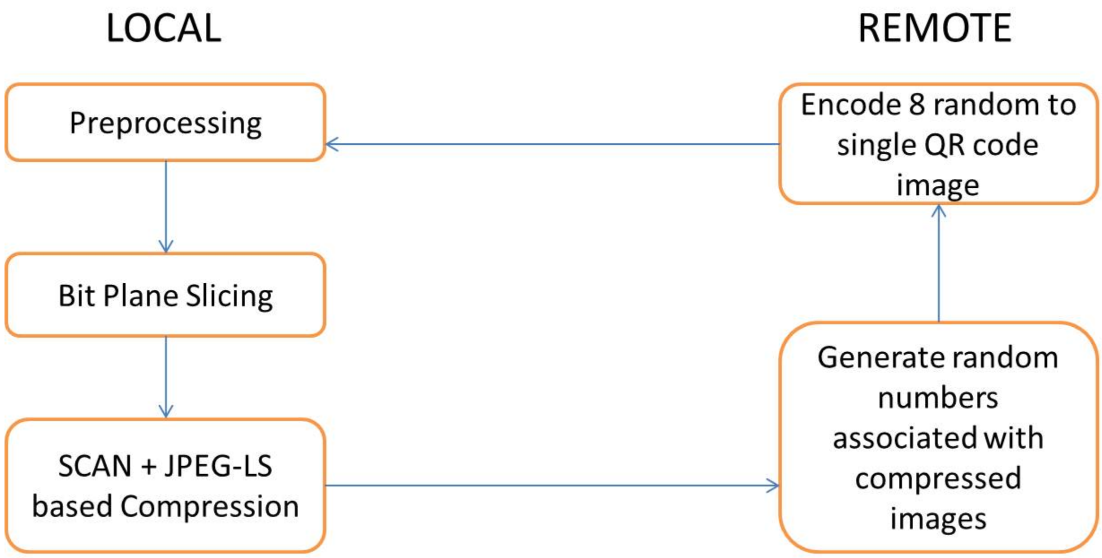



Figure 4.1: Framework for proposed algorithm

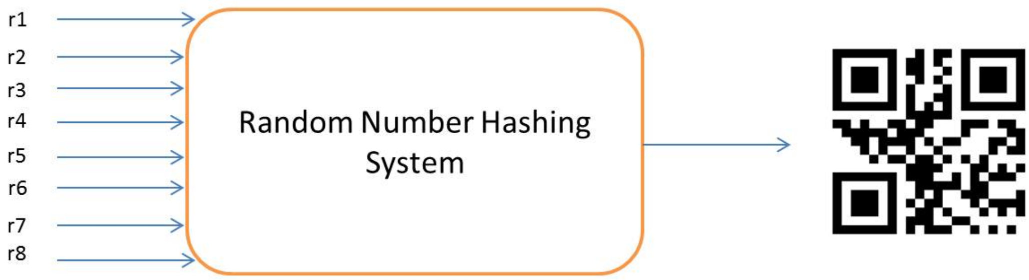



Figure 4.2: Indexing system for Secure Image Retrieval

# Chapter 5

# Results and Analysis

The proposed algorithm was implemented on software using MATLAB R2011a. For comparision purpose we have taken twenty gray scale images(8 bits/pixel) and their corresponding compression and secure storage has been achieved. First we match the time complexitity of existing and proposed algorithm before proceeding further.

## 5.1 Time Complexity

- For the existing algorithm

$$T(n) = 8 * (32 * cp(n) + fm(n))$$

- For the proposed algorithm

$$T(n) = 4 * (pp(n) + 32 * cp(n) + fm(n)) + 4 * J(n)$$

n = image size

T(n) = Time complexity

cp(n) = Comparison time

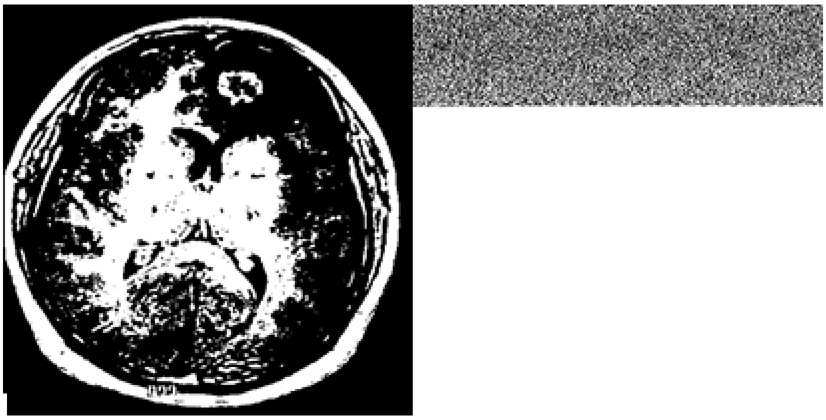
fm(n) = Frame encoding time

J(n) = Time required in JPEG-LS

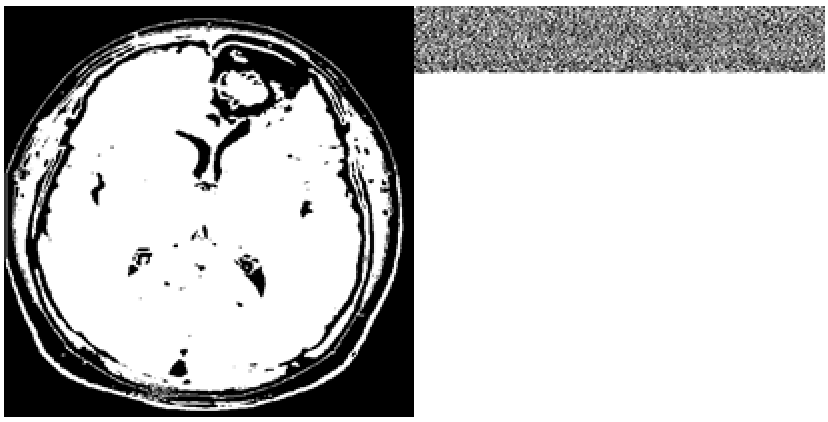
pp(n) = Preprocesing time

## 5.2 Output Results

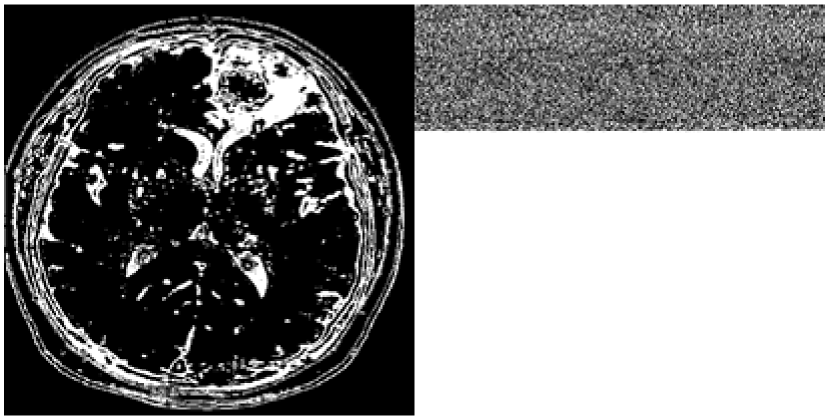
Now we take one sample gray-scale medical image and apply the proposed compression algorithm i.e. the four most significant bit planes are processed using SCAN language and four lower significant planes are processed using JPEG-LS compression mode. The SCAN based compression is illustrated in the Figures 5.1.



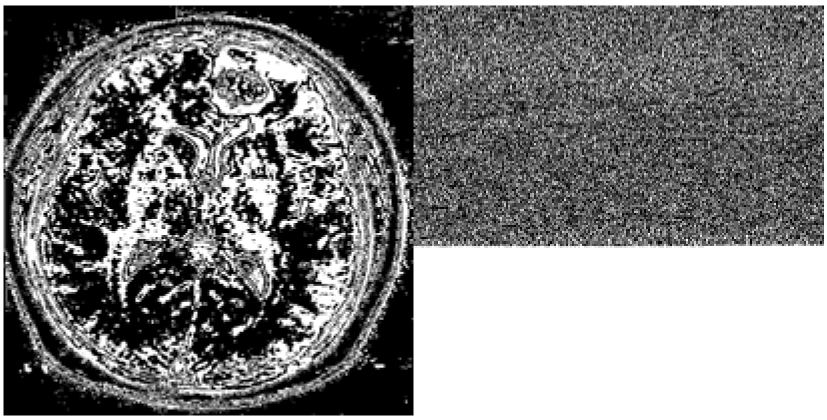
(a) (b)



(c) (d)



(e) (f)



(g) (h)

Figure 5.1: (a) and (b ) correspond to 8th bit plane uncompressed and compressed images. (c) and (d ) correspond to 7th bit plane uncompressed and compressed images. (e) and (f) correspond to 6th bit plane uncompressed and compressed images. (g) and (h) correspond to 5th bit plane uncompressed and compressed images

As the lower bit planes are compressed using JPEG-LS, the compression factors are found to be on an average of 1.6.

Table 5.1: Compression factor of each bit plane

| Bit plane (512 ×512) | Compression factor |
|---|---|
| Bit plane 8 | 4.06 |
| Bit plane 7 | 6.16 |
| Bit plane 6 | 3.26 |
| Bit plane 5 | 1.71 |
| Bit plane 4 | 1.6 |
| Bit plane 3 | 1.6 |
| Bit plane 2 | 1.6 |
| Bit plane 1 | 1.6 |

$$\text{Total compression} = \frac{8}{(1/4.06)+(1/6.16)+(1/3.26)+(1/1.71)+(4/1.6)} = 2.11$$

For the same image, the proposed algorithm output is also compared with various different image formats.

Table 5.2: Compression factor in different image formats

| Image format | Compression factor |
|---|---|
| Proposed algorithm | 2.11 |
| PNG | 1.93 |
| JPEG-LS | 1.62 |
| GIF | 1.13 |
| TIF | 1.06 |
| BMP | 1.0 |

To take comparative analysis of the proposed algorithm with the existing ones, we take standard 512 ×512 lenna image and apply all the algorithms on each bit plane. The gray scale lenna image is depicted as in Figure 5.2 and the comparision of plot is depicted in Figure 5.3 respectively.

Figure 5.2: Grayscale lenna image

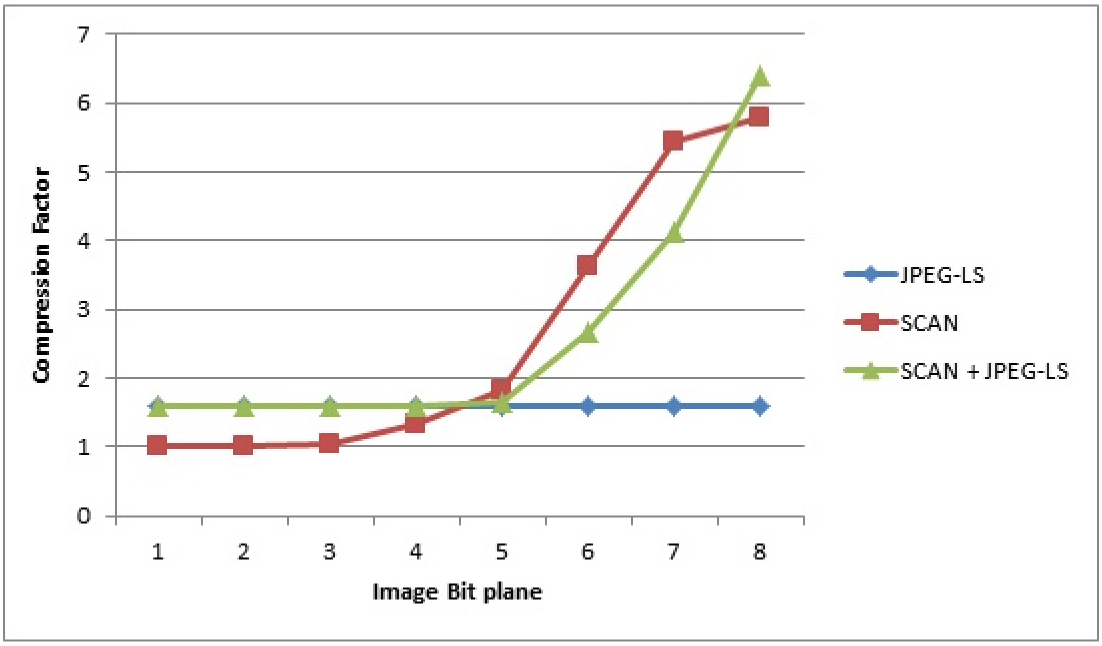



Figure 5.3: Comparision of compression factor on 8 bit planes applying diffrenet algorithms

We calculate total compression achieved for each algorithm which serves our comparision purpose which is summarized in the Table 5.3.

Table 5.3: Comparision of different Algorithms

| Algorithm | Compression factor |
|---|---|
| JPEG-LS | 1.6 |
| SCAN (existing) | 1.63 |
| JPEG-LS + SCAN (proposed) | 2.06 |

Finally a general analysis is being conducted taking twenty input gray-scale medical images. The images are presampled and made to a standard form of 512 $\times$512 each of them and then passed into the system.

Table 5.4: Proposed Algorithm implemented on 20 Medical Images

| Figure Index | $8^{th} bitplane$ | $7^{th} bitplane$ | $6^{th} bitplane$ | $5^{th} bitplane$ | Total Compression |
|---|---|---|---|---|---|
| Fig 1 | 4.06 | 6.17 | 3.27 | 1.71 | 2.11 |
| Fig 2 | 15.19 | 5.55 | 4.99 | 2.47 | 2.39 |
| Fig 3 | 4.32 | 3.07 | 1.95 | 1.49 | 1.89 |
| Fig 4 | 8.91 | 6.19 | 3.67 | 2.66 | 2.34 |
| Fig 5 | 8.56 | 4.11 | 3.81 | 2.67 | 2.29 |
| Fig 6 | 18.55 | 10.40 | 4.32 | 3.58 | 2.53 |
| Fig 7 | 6.27 | 4.90 | 3.22 | 2.05 | 2.18 |
| Fig 8 | 7.00 | 6.29 | 3.82 | 2.54 | 2.31 |
| Fig 9 | 8.98 | 6.89 | 6.50 | 3.60 | 2.51 |
| Fig 10 | 5.10 | 3.68 | 2.35 | 1.80 | 2.03 |
| Fig 11 | 4.57 | 3.27 | 2.18 | 1.44 | 1.92 |
| Fig 12 | 18.54 | 5.34 | 5.55 | 2.72 | 2.43 |
| Fig 13 | 7.33 | 3.93 | 2.81 | 1.73 | 2.09 |
| Fig 14 | 9.66 | 4.89 | 3.39 | 2.29 | 2.26 |
| Fig 15 | 8.72 | 5.53 | 3.41 | 2.45 | 2.29 |
| Fig 16 | 7.87 | 6.48 | 3.64 | 2.15 | 2.27 |
| Fig 17 | 18.54 | 5.34 | 5.55 | 2.72 | 2.43 |
| Fig 18 | 5.01 | 3.81 | 2.59 | 1.66 | 2.03 |
| Fig 19 | 5.10 | 3.68 | 2.35 | 1.80 | 2.03 |
| Fig 20 | 5.14 | 3.22 | 1.94 | 1.35 | 1.88 |

## 5.3 Analysis

By introducing gray codes the 8th bit plane compression factor remains the same as that would have been represented in binary form but it shows significant increase in compression factor for other bit planes. The proposed algorithm is not considered beyond 5th bit plane because for most of the cases it gives a compression factor $\geq$ 1.6 is only up to 5th bit plane. The JPEG-LS mode compression factor 1.6 is used a threshold value.

If there is 1000 input gray scale images in the local site, then after all the execution of steps there would be 1000 QR hash codes and 8000 binary bit plane images in the Remote site. Now for a proper matching of the input image the third person has to fetch 8 images out of 8000 images in the remote site to make one proper image. The no of unit operations is 4.14 $\times 10^{26}$. If one unit operation takes $1\mu S$, then total time required will be $10^{20}$.

Well, this framework provides a better structure for lossless compression and secure storage but with the cost of increasing time.

# Chapter 6

# Conclusion

This thesis presented a new methodology which ensures both lossless compression and security in the case of medical gray-scale images. The proposed algorithms uses cobine effect of SCAN and JPEG-LS techniques to produce better compression. The drawback of the methodology is that compression-encryption takes longer time. Also we have indexed the remote location of encrypted images using QR codes which are stored locally and make process of accessing faster. The methodology can be made real time through hardware implementation.

There is also many future scopes in this field. The most coomon feature in medical images is that a small region holds most significant and required information. So instead compressing the whole image in lossless mode we can concentarte our focus on the Region of Interest (ROI) and can adapt other high compression ratio algorithms for the compliment region. Segmentation of medical images and then applying the technique may also improve the system efficieny.

# Bibliography


[1] S.S. Maniccam and N.G. Bourbakis. Scan based lossless image compression and encryption. In *Information Intelligence and Systems, 1999. Proceedings. 1999 International Conference on*, pages 490 –499, 1999.

[2] N.G. Bourbakis. Image data compression-encryption using g-scan patterns. In *Systems, Man, and Cybernetics, 1997. Computational Cybernetics and Simulation., 1997 IEEE International Conference on*, volume 2, pages 1117 –1120 vol.2, oct 1997.

[3] Rafael C. Gonzalez and Richard E. Woods. *Digital Image Processing (3rd Edition)*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA, 2006.

[4] David Salomon. *Data Compression: The Complete Reference*. 2007. With contributions by Giovanni Motta and David Bryant.

[5] Documentation, `http://code.google.com/p/zxing/`.

[6] Documentation, `http://www.mikety.net/Articles/ImageComp/ImageComp.html`.

[7] C.M. Thompson and L. Shure. *Image Processing Toolbox: For Use with MATLAB;[user's Guide]*. MathWorks, 1995.

[8] Documentation, `http://www.mikety.net/Articles/ImageComp/ImageComp.html`.