# Image Quality Assessment for Partial Encryption using Modified Cyclic Bit Manipulation

**Parameshachari B. D., K. M. Sunjiv Soyjaudah, Sumithra Devi K. A.**

***Abstract*—Measurement of image quality is important for many image processing applications. Image quality assessment is closely related to image similarity assessment in which quality is based on the differences (or similarity) between a degraded image and the original, unmodified image. There are two ways to measure image quality by subjective or objective assessment. Subjective evaluations are expensive and time-consuming. It is impossible to implement them into automatic real-time systems. Objective evaluations are automatic and mathematical defined algorithm. Subjective measurements can be used to validate the usefulness of objective measurements. Therefore objective methods have attracted more attentions in recent years. Well-known objective evaluation algorithms for measuring image quality include mean squared error (MSE), peak signal-to-noise ratio (PSNR), and structural similarity (SSIM). MSE & PSNR are very simple and easy to use. In this paper Image Quality Assessment for Partial Encryption Using Modified Cyclic Bit Manipulation. Proposed* Partial Encryption algorithm based on the amount of encryption needed (i.e. percentage of encryption). *Various objective evaluation algorithms for measuring image quality like Mean Squared Error (MSE), Peak Signal-To-Noise Ratio (PSNR) and Structural Similarity (SSIM) etc. will be studied and their results will be compared.***

***Index Terms*—Image Quality, MSE, PSNR,**

## I. INTRODUCTION

Image quality assessment (IQA) evaluates how good an image is. It can be classified into two types: subjective and objective. The former is better than the latter because the quality of an image or video is eventually assessed according to the human visual perception. However, such subjective quality assessments are troublesome and expensive, thus not suitable for practical use in real applications. Therefore, the latter is desirable as the practical IQA and thus many objective IQA methods have been developed [1–28]. The objective IQA methods are considered better if they are as closer as to the subjective IQA.

The goal of the objective IQA is to evaluate the image quality that is similar to the quality as people perceive. Thus, the mean square error (MSE) and peak signal to noise ratio (PSNR) that use only the intensity difference for assessing the quality cannot effectively reflect the human perception properties and thus cannot assess the image quality coincidentally with the subjective quality like the mean opinion score (MOS). This reason leads to the development of the objective IQA algorithms. Conventional IQA algorithms can be classified into several approaches depending on the usage of the reference image and the kind of the information used for IQA. In this paper, we classify the convention IQA algorithms into three categories as in [1]. Three categories are structural information based [2–14], human perception/visual attention based [15–25], and information theoretical approaches [26, 27]. Motivation of structural information based IQA is that the structural information of an image changes if an image is distorted. The universal quality index (UQI) [2] was presented as a full reference (FR) IQM using the structural information of an image. The structural similarity (SSIM) [3], a modified version of the UQI, was also developed. Somdip Dey [29] presents an advanced version of image encryption technique, which is itself an upgraded version of SD-EI image encryption method. In this new method, SD-EI Ver-2, there are more bit wise manipulations compared to original SD-EI method. In [30] we analyzed Image encryption techniques and Partial image encryption techniques and present the comparative results. Partial image encryption method as given best results than fully layered image encryption. In [31] we implemented a partial image encryption technique involves two methods, the first is by pixel value manipulation and other second is by using SCAN mapping method. The development and implementation of partial image encryption based on percentage of encryption.

The rest of the paper is structured as follows. In Section II, we describe the problem formulation and brief overview of MSE, PSNR, SSIM are presented. In Section III presents methodology of our proposed method. In Section IV, experimental results are shown with discussions. Finally, in Section V a conclusion is given.

## II. PROBLEM FORMULATION

Measurement of visual quality is of fundamental importance to numerous image processing applications. Due to inherent physical limitations and economic reasons, the quality of images and videos could visibly degrade right from the point when they are captured to the point when they are viewed by a human observer. Identifying the image quality measures that have highest sensitivity to these distortions would help systematic design of coding, communication and imaging systems and of improving or optimizing the image quality for a desired quality of service at a minimum cost i.e. image and video quality could degrade in almost all systems of practical importance, it is crucial for designers and developers to keep the tradeoffs between visual quality and system cost in mind, and to optimize systems for providing maximum visual quality at a minimum cost. Very often the quality of an image needs to be quantified.

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Optimizing the performance of digital imaging systems with respect to a wide variety of distortions during acquisition, processing, storage, transmission and reproduction, any of which may result in a degradation of visual quality. So, measurement of image quality is very important to numerous image processing applications in this domain. Any imaging system can use the quality metric to adjust itself automatically for obtaining improved quality images. It can be used to compare and evaluate image processing systems and algorithms. This can be done by subjective testing sessions, or by objective – computational metrics. The only "correct" method of quantifying visual image quality is through subjective evaluation. In subjective evaluation, a number of observers are selected, tested for their visual capabilities, shown a series of test scenes and asked to score the quality of the scenes. It is the only "correct" method of quantifying visual image quality. However, subjective evaluation is usually too inconvenient, time-consuming and expensive. On the other hand objective evaluations are automatic algorithms for quality assessment that could analyse images and report their quality without human involvement. Such methods could eliminate the need for expensive subjective studies.

### *A. Objective*

On the bases of these ideas the goal of this thesis work is to compare objective image quality matrices for image assessment and their analysis that can automatically predict image quality. Image quality assessment is closely related to image similarity assessment. So, the emphasis in this thesis will be on image fidelity, i.e., how close an image to given original or reference image. Some commonly used methods to evaluate image quality are given below:

**(i)** ***Mean Squared Error (MSE)***

One obvious way of measuring this similarity is to compute an error signal by subtracting the test signal from the reference, and then computing the average energy of the error signal. The mean-squared-error (MSE) is the simplest, and the most widely used. This metric is frequently used in signal processing and is defined as follows [2]:-

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j)-y(i,j))^2 \quad \text{...... (2.1)}$$

Where $x(i, j)$ represents the original (reference) image and $y(i, j)$ represents the distorted (modified) image and i and j are the pixel position of the M×N image. MSE is zero when $x(i, j) = y(i, j)$ .

**(ii)** ***Peak Signal to Noise Ratio (PSNR)***

The PSNR is evaluated in decibels and is inversely proportional the Mean Squared Error. It is given by the equation [2]:-

$$PSNR = 10\log_{10}\frac{(2^n-1)^2}{\sqrt{MSE}} \quad \text{............. (2.2)}$$

**(iii)** ***SSIM (Structural Similarity Index Metric)***

The SSIM is the best method to evaluate image quality and the SSIM is given by equation 2.3 below [2].

$$SSIM = \frac{(2\times\bar{x}\times\bar{y}+C1)(2\times\sigma_{xy}+C2)}{(\sigma_x^2+\sigma_y^2+C2)\times((\bar{x})^2+(\bar{y})^2+C1)} \quad \text{........(2.3)}$$

Where C1 and C2 are constants. $\bar{x}$, $\bar{y}$, $\sigma^2_x$, $\sigma^2_y$ and $\sigma_{xy}$ are given as:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N}x_i \quad \text{..................................(2.3.1)}$$

$$\bar{y} = \frac{1}{N}\sum_{i=1}^{N}y_i \quad \text{....................................(2.3.2)}$$

$$\sigma_x^2 = \frac{1}{N-1}\sum_{i=1}^{N}(x_i-\bar{x})^2 \quad \text{.....................(2.3.3)}$$

$$\sigma_y^2 = \frac{1}{N-1}\sum_{i=1}^{N}(y_i-\bar{y})^2 \quad \text{.................. (2.3.4)}$$

$$\sigma_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}(x_i-\bar{x})(y_i-\bar{y}) \quad \text{.... (2.3.5).}$$

## III. METHODOLOGY

The proposed Image Quality Assessment for Partial Encryption Using Modified Cyclic Bit Manipulation. Proposed Partial Encryption algorithm based on the amount of encryption needed (i.e. percentage of encryption). The basic algorithm for the Modified Cyclic Bit Manipulation method is as follows:

**Step 1**: Choose consecutive 8 pixels

**Step 2**: Convert each pixel value to their corresponding 8 bit binary value

**Step 3**: Form a 8X8 matrix with the 8 bit values of 8 pixels

**Step 4**: Perform multi-directional matrix Cyclic operation on that matrix "code" number of times

**Step 5**: Convert the modified 8 bit value of each pixel to their corresponding decimal value

**Step 6**: Put the newly generated value in place of the old value of that pixel

**Step 7**: Go to Step 1, and continue until and unless all the pixel values of the image are modified

Figure1 shows the diagrammatic Representation of Modified Cyclic Bit Manipulation. Let the following be the matrix comprising of 8 bit value of 8 pixel:

*Note:* a, b, c, d….h represent each pixel and 1, 2, 3…8 represent the 8 bit binary value of each pixel.

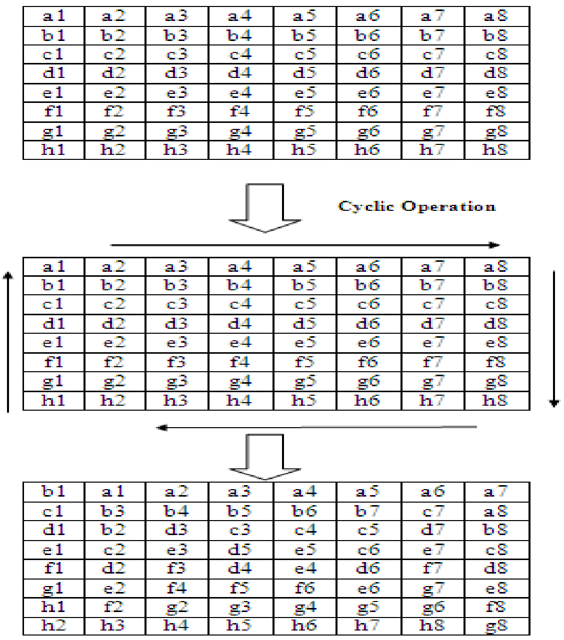


**Figure1: Diagrammatic Representation of Modified Cyclic Bit Manipulation.**



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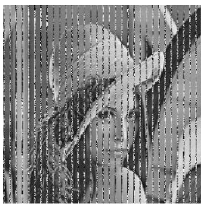
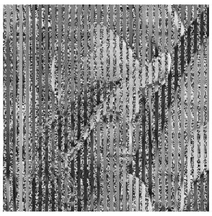
Thus, the new pixel values are:
Pixel 1: b1 a1 a2 a3 a4 a5 a6 a7,
Pixel 2: c1 b3 b4 b5 b6 b7 c7 a8,
Pixel 3: d1 b2 d3 c3 c4 c5 d7 b8,
Pixel 4: e1 c2 e3 d5 e5 c6 e7 c8
Pixel 5: f1 d2 f3 d4 e4 d6 f7 d8
Pixel 6: g1 e2 f4 f5 f6 e6 g7 e8
Pixel 7: h1 f2 g2 g3 g4 g5 g6 f8
Pixel 8: h2 h3 h4 h5 h6 h7 h8 g8

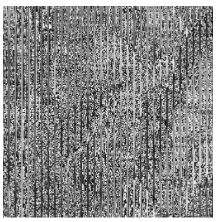
## IV. RESULTS

The proposed method has been designed using MATLAB software. In partial encryption, only part of image (i.e. percentage of encryption: 25%, 50%, 75% and 100%) (Important part) is encrypted whereas the remaining part (unimportant part) is transmitted without encryption. Image quality assessment can be done either by subjective or objective assessment. Subjective evaluations are expensive and time-consuming. It is impossible to implement Subjective evaluations into automatic real-time systems. Objective evaluations which are automatic and mathematical defined algorithms are used for the experiment. Well-known objective evaluation algorithms for measuring image quality such as mean squared error (MSE), peak signal-to-noise ratio (PSNR), and structural similarity index metric (SSIM) have been used. Lena has been used as standard test image. Four different parts of image are chosen for this experiment, which are 25%, 50%, 75% and 100%. After applying percentage of encryption (25%, 50%, 75% and 100%) on standard test image, MSE, PSNR, SSIM are calculated and the results are compared. Figure 2 shows the results of the proposed method. Table 1 shows the Comparison of MSE, PSNR, SSIM for Lena Image.


Original Image


25% encryption


50% encryption


75% encryption

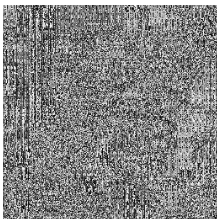

100% encryption

**Figure 2: Results of partial encryption on the standard Lena Image (percentage of encryption)**

**Table 1: Comparison of MSE, PSNR, SSIM for Lena Image**

| *Percentage of encryption* | *MSE* | *PSNR* | *SSIM* |
|---|---|---|---|
| ***25%*** | 26.7312 | 33.8427 | 0.8917 |
| ***50%*** | 53.8247 | 30.8455 | 0.8516 |
| ***75%*** | 81.8768 | 29.1157 | 0.7913 |
| ***100%*** | 111.3127 | 27.7643 | 0.1673 |

## V. CONCLUSION

Image quality measurement plays an important role in various image processing application. A great deal of effort has been made in recent years to develop objective image quality metrics. In this paper proposed Image Quality Assessment for Partial Encryption Using Modified Cyclic Bit Manipulation. Proposed Partial Encryption algorithm based on the amount of encryption needed (i.e. percentage of encryption). Experimental results indicate that MSE and PSNR are very simple, easy to implement and have low computational complexities. But these methods do not show good results. SSIM is widely used method for measurement of image quality. SSIM works accurately better quality as compared to MSE and PSNR.

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