Comparative Analysis on DCT and SVD for Efficient Image Compression

[1]Amreen Saba, [2]Dr.Nagarathna

[1]Student (M.Tech), [2]Professor

[1,2]Department of Computer Science and Engineering

[1,2]PES College Of Engineering, Mandya, India

Abstract—

Internet of things can support Enormous applications and services in various sectors such as smart cities and smart homes. IOT smart objects and it's components interact with other components Ex: proxies, mobile devices and data collectors along with various sensors for management, data sharing and other activities in the context of provided services. In recent years Raspberry Pi is being used enormously for the implementation of IOT applications. Here in particular we use Raspberry Pi to capture and compress images. Raspberry Pi board is mounted with PIR sensor which detects the movements around it, and a Pi camera which captures the image when movement is encountered the captured image is compressed on the raspberry pi using SVD compression methodology after which the compressed image is transmitted over the network to the desktop application where it is enhanced on the receiving end. The primary aim of this paper is to achieve image compression which reduces considerable image size in terms of bytes during transmission to reduce latency and bandwidth issues during transmission of the image over the network and simultaneously preserve the useful features of the image. Comparative Analysis is performed over Discrete Cosine Transform (DCT) image compression.

Index Terms— Image Compression, Raspberry Pi, Singular value decomposition (SVD), Discrete Cosine Transform (DCT), PIR sensor, Pi camera, transmission, enhancement.

I. INTRODUCTION

Today betterment of security is just a click away of appropriate technology and with advancements happening we can strive for energy efficient security system which can reduce the amount of transmissions happening on the network over the internet.

This paper presents the implementation of the security system using a raspberry Pi board to detect the movement of the intruder using pyro electric infrared sensor. As soon as an intrusion is detected with the time bound of less than a second the Pi camera captures the image, Compresses the captured image and the compressed image is being sent over the network wirelessly to the owner's Email ID, where the images are being directly retrieved by the desktop application wherein the images are being enhanced

All Picture pressure implies limiting the size in bytes of an illustrations document without corrupting the nature of the picture to an unsuitable level. The decrease in record estimate permits more pictures to be put away in a given measure of plate more memory space. It additionally diminishes the time required for picture to be sent over the web or downloaded from site pages. The current development of information serious mixed media based web application have not just managed the requirement for additional effective approaches to encode flags and pictures however have made pressure of such flag key to capacity and correspondence innovation. Presently we compare Discrete Cosine Transform (DCT) which is a lossy image compression with Singular Value Decomposition(SVD) which is a lossless image compression technique. Inter pixel redundancy implies that any pixel value can be reasonably predicted by its neighbors. Usually the value of certain pixel in the image can be reasonably predicted from the values of group of other pixels in the image. For example the gray levels of neighboring pixels are roughly the same and by knowing gray level value of one of the neighborhood pixels one has a lot of information about gray levels of other neighborhood pixels. Thus the value of the individual pixel carries relatively small amount of information and much more information about pixel value can be inferred on the basis of its neighbor's values. These dependencies between pixels values in the image are called inter pixel redundancy. In order to reduce the inter pixel redundancies in the image, the 2-D pixel array of image values, used for image visualization should be transformed into another, generally "non-visual" representation. Transformations used to reduce the inter pixel redundancies are called mapping. Since in this paper we deal only with lossless compression, the mappings, which will be considered further, will be reversible. Scaling The theme of the technique of magnification is to have a closer view by magnifying or zooming the interested part in the imagery. By reduction, we can bring the unmanageable size of data to a manageable limit. To magnify an image by a factor of 2, each pixel of the original image is replaced by a block of 2x2 pixels, all with the same brightness value as the original pixel. Reduction To reduce a digital image to the original data, every row and column of the original imagery is selected and displayed. Another way of accomplishing the same is by taking the average in 'm x m' block and displaying this average after proper rounding of the resultant value.

II. METHODOLOGY AND DESIGN

The project is aimed around development using raspberry Pi, over the raspberry Pi is mounted pyro electric Infrared sensor to detect the intrusion with a time bound of less than a second, the image is captured by the webcam if any object movement is detected, the captured image is compressed using an effective compression technique called singular value decomposition [SVD] that reduces storage space by refactoring the digital images into 3 matrices , refactoring is achieved by using singular values and the image is represented with a smaller set of values. The primary aim is to achieve image compression which reduces considerable image size for transmission over the wireless network and simultaneously preserve the useful features of the original image. The compressed image is being sent to the user's mail id, the images can be retrieved from the mailbox to the desktop application where the images are enhanced and viewed using Matlab to detect the intruder.

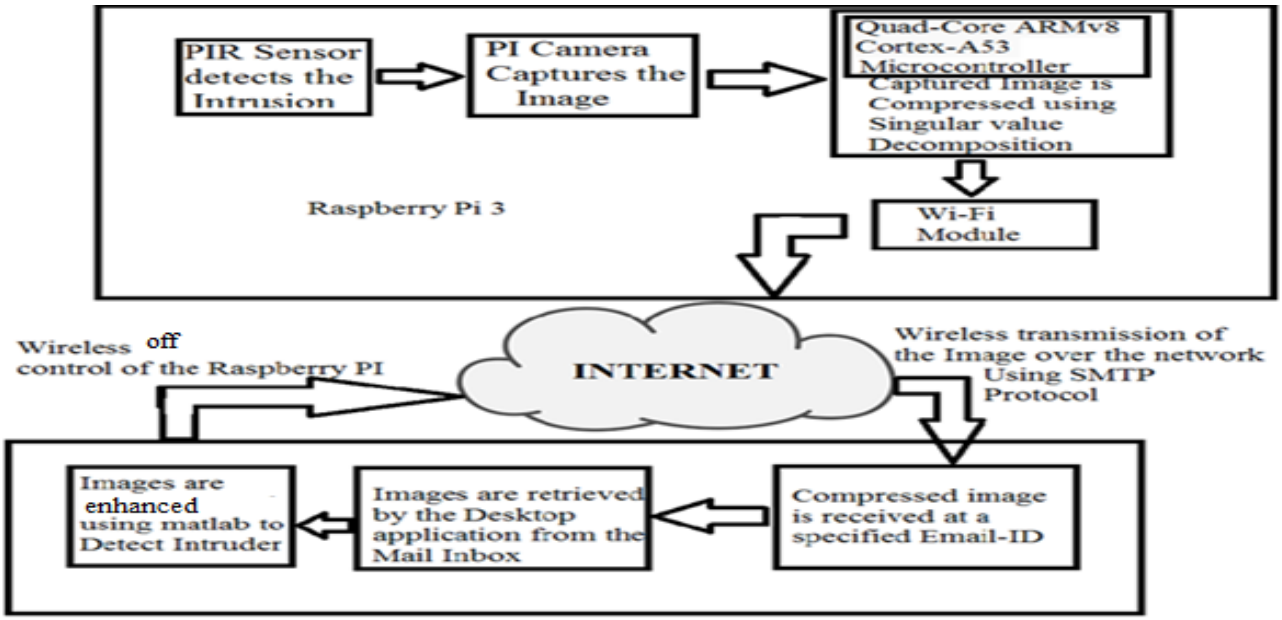


Figure 1 Block Diagram Of Energy Efficient Security System

III. SOFTWARE ANALYSIS

Software analysis deals with the Open CV platform which supports different programming languages like c/c++, python, Java, android etc. The implementation of the proposed system uses Python Scripting. It also helps to access MATLAB modules. We are using the Open CV 2.8.10 version. Open CV helps the Python coding much simpler by providing predefined modules which saves the processing time and memory. SciKit library is used extensively. Scikit-learn is a software machine learning library for the Python programming language. It features various classification, regression and clustering algorithms including support vector machines, random forests, gradient boosting, *k*-means and DBSCAN, and is designed to interoperate with the Python numerical and scientific libraries NumPy and SciPy.

IV. DISCRETE COSINE TRANSFORM

The The Discrete Cosine Transform (DCT) algorithm is well known and commonly used for image compression. DCT converts the pixels in an image, into sets of spatial frequencies. The DCT work by separating images into the parts of different frequencies. During a step called Quantization, where parts of compression actually occur, the less important frequencies are discarded. Then the most important frequencies that remain are used to retrieve the image in decomposition process.

The DCT can be extended to the transformation of 2D signals or images. This can be achieved in two steps: by computing the 1D DCT of each of the individual rows of the two-dimensional image and then computing the 1D DCT of each column of the image. If represents a 2D image of size x(n_1 , n_2) N × N , then the 2D DCT of an image is given by:

$$Y[j,k] = C[j]\,C[k]\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} x[m,n]\cos\left(\frac{(2m+1)j\pi}{2N}\right)\cos\left(\frac{(2n+1)k\pi}{2N}\right)$$

Where j, k, m, n = 0, 1, 2..., N −1 and

$$C[j] \text{ and } C[k] = \begin{bmatrix} \sqrt{\frac{1}{N}} & \text{for j,k} = 0 \\ \sqrt{\frac{1}{N}} & \text{for j,k} = 1,2,\ldots,N-1 \end{bmatrix}$$

Similarly the 2D IDCT can be defined as

$$x[m,n] = \sum_{j=0}^{N-1}\sum_{k=0}^{N-1} C[j]C[k]Y[j,k]\cos\left(\frac{(2m+1)j\pi}{2N}\right)\cos\left(\frac{(2n+1)k\pi}{2N}\right)$$

In the DCT compression algorithm

1. The input image is divided into 8-by-8 or 16-by-16 blocks
2. The two-dimensional DCT is computed for each block.
3. The DCT coefficients are then quantized, coded, and transmitted.
4. The receiver (or file reader) decodes the quantized DCT coefficients, computes the inverse two-dimensional DCT (IDCT) of each block.
5. Puts the blocks back together into a single image.

The above steps can be depicted using the block diagram as shown in Figure 1

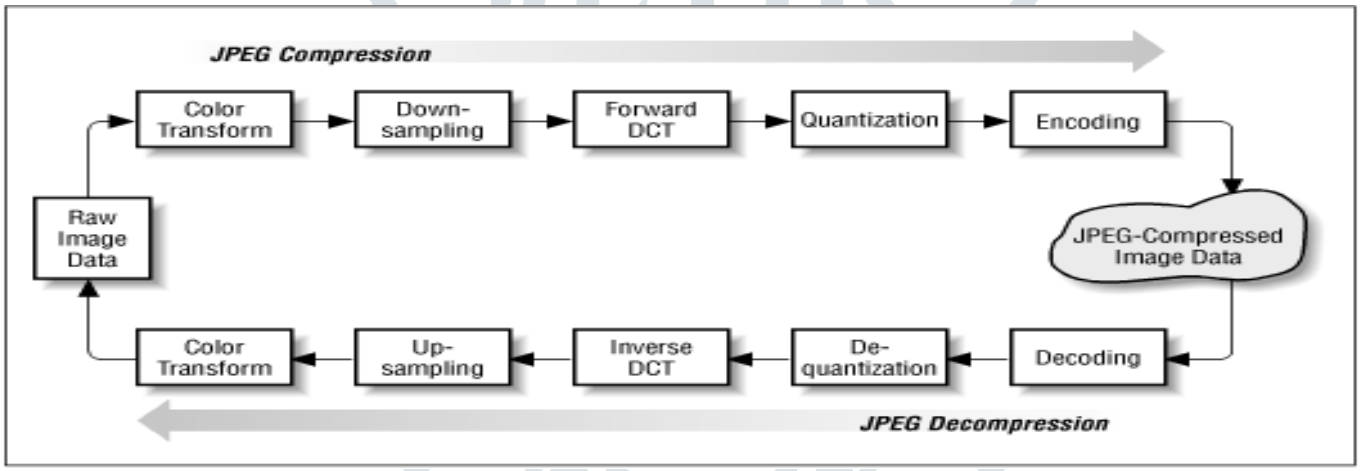


Figure 2 Block Diagram for DCT Image Compression

Compression can be performed by varying the number of co-efficient to be compressed and results can be obtained as below.

V. SINGULAR VALUE DECOMPOSITION

Singualr Value Decomposition (SVD) manages the disintegration of general networks which has turned out to be helpful for various applications in science and designing orders. The SVD is ordinarily utilized as a part of the arrangement of unconstrained straight slightest squares issues, grid rank estimation and accepted relationship investigation. Computational science misuses SVD for data recovery, seismic reflection tomography, and continuous flag preparing.

The objective of SVD is to locate the best estimate of the first information focuses that is of expansive measurements, utilizing less measurements. This is conceivable by recognizing areas of most extreme varieties. So when a high dimensional, very factor set of information focuses is taken, SVD is utilized to diminish it to a lower dimensional space that uncovered the substructure of the first information all the more unmistakably and requests it from most variety to the minimum. Along these lines, the area of most variety can be found and its measurements can be lessened utilizing the technique for SVD. At the end of the day, SVD can be viewed as a technique for information diminishment. solitary esteem disintegration is characterized as a factorization of a genuine or mind boggling, square or non-square network. Consider a lattice A with m lines, n segments and rank r. At that point A can be factorized into three grids:

$$A = U\Sigma VT$$

$$A = [u_1 \cdots u_r \cdots u_m] \begin{bmatrix} \sigma_1 & & & \\ & \ddots & & \\ & & \sigma_r & \\ & & & \ddots \\ & & & 0 \end{bmatrix} \begin{bmatrix} v_1^T \\ \vdots \\ v_r^T \\ \vdots \\ v_n^T \end{bmatrix}$$

Where U and V are orthonormal matrices and the matrix Σ is a diagonal matrix with positive real entries.

Steps to calculate SVD of a matrix

1) First, calculate AA^T and A^TA.
2) Use AA^T to find the eigen values and eigenvectors to form the columns of U.
3) Use A^TA to find the eigen values and eigenvectors to form the columns of V.
4) Divide each eigenvector by its magnitude to form the columns of U and V.
5) Take the square root of the eigen values to find the singular values, and arrange them in the diagonal matrix S in descending order: $\sigma 1 \geq \sigma 2 \geq \ldots \geq \sigma r \geq 0$

The Flow chart for SVD is as follows

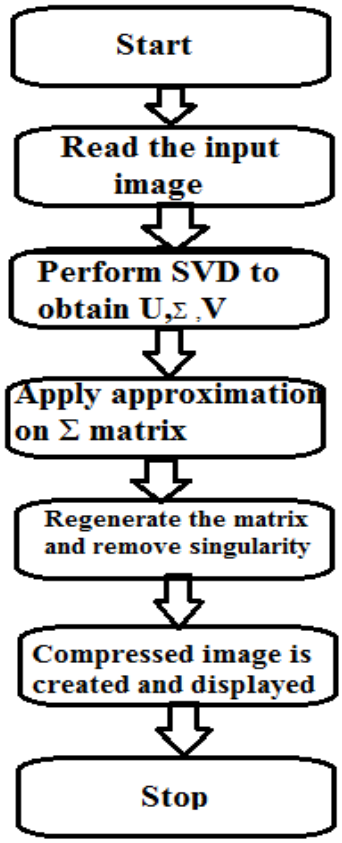


Figure 3 Flow Chart for Singular Value Decomposition

VI. COMPARISON

It is natural to raise the question of how much an image can be compressed and still preserve sufficient information for a given application. This section discusses some parameters used to measure the trade-off between image quality and compression ratio. Compression ratio is defined as the nominal bit depth of the original image in bits per pixel (bpp) divided by the bpp necessary to store the compressed image. The original image size is 421 KB. The comparative results can be

Table1 Results of DCT and SVD image compression

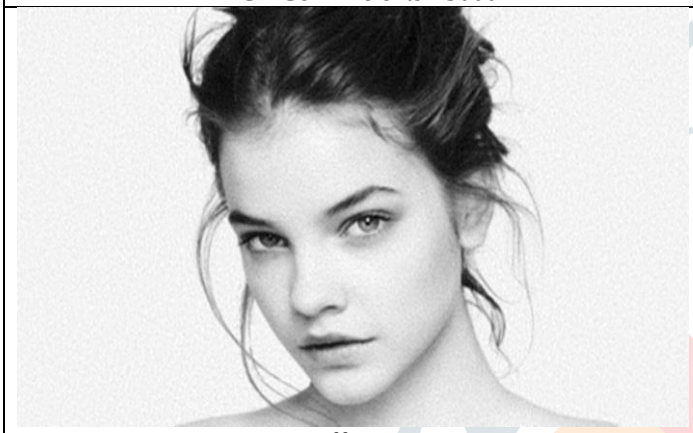
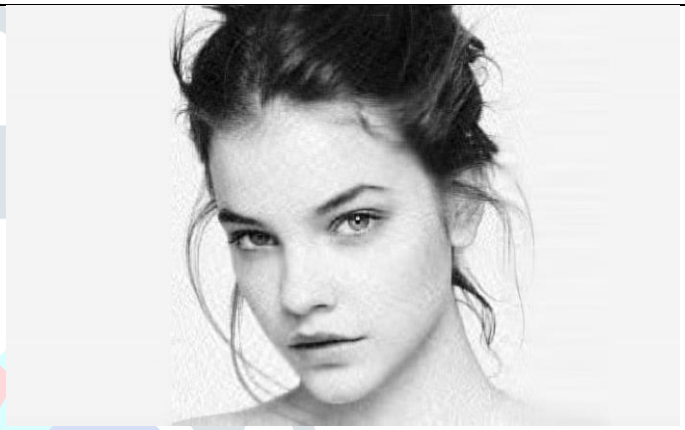
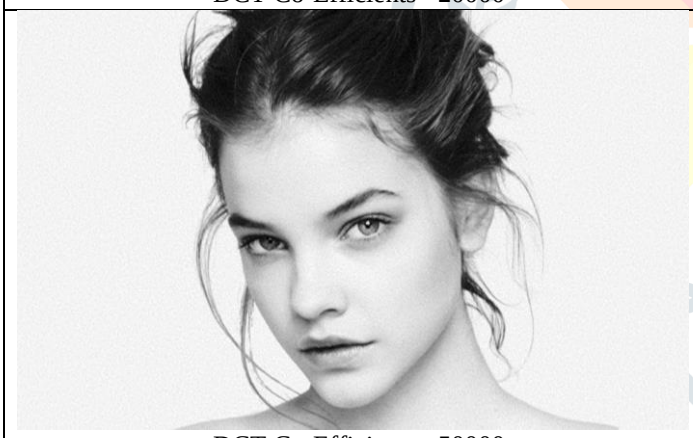
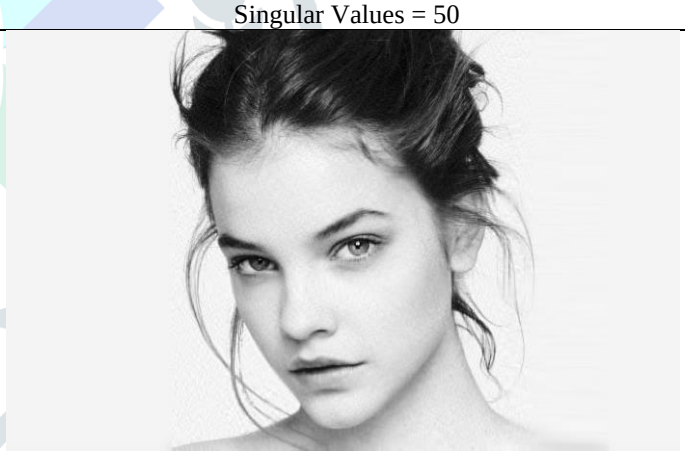
 DCT Co-Efficients= 5000	 Singular values = 20
 DCT Co-Efficients= 20000	 Singular Values = 50
 DCT Co-Efficients= 50000	 Singular Values = 100

Table 2 Results of DCT and SVD image compression with respect to image size

Discrete Cosine Transform (DCT)		**Singular Value Decomposition (SVD)**	
DCT Co-Efficients	Image Size in KB	Singular Values	Image Size in KB
5000	100	20	96
10000	116	30	108
15000	128	50	128
20000	144	80	148

50000	200	100	160
80000	228	120	168

VII. ACKNOWLEDGMENT

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