ISSN (Online): 2456-5717
International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

This work by IJARBEST is licensed under Creative Commons Attribution 4.0 International License. Available at https://www.ijarbest.com/Archive

Secured transmission of Secret Information using SVD transformation and QR code in Image Steganography

Jeenu Phaneendra[1], Boppa Manohar Samuel[2], and B. Lakshmi Sirisha[3]
Student, Department of ECE, V. R. Siddhartha Engineering College, Vijayawada, India[1]
Student, Department of ECE, V. R. Siddhartha Engineering College, Vijayawada, India[2]
Assistant Professor, Department of ECE, V. R. Siddhartha Engineering College, Vijayawada, India[3]

***Abstract*— Singular Value Decomposition (SVD) has recently emerged as a new technique for processing different types of images. SVD is an attractive linear algebraic transform for image processing applications. In the proposed steganographic technique by using SVD with a concept of Quick Response (QR) code is presented here. In the presented method, first a QR code will be generated based on secret information. The generated QR code is embedded into cover image using SVD, to get two stego images with good quality and embedding capacity. The proposed method satisfies the reversibility property. That means, both the cover image and secret information gets retrieved without occurrence of any loss in the information. The quality and embedding capacity of the stego images were assessed with the help of image metrics and achieves good results compared to other existing methods**

***Index Terms*— Eigenvalues and Eigenvectors, Image Metrics, QR code, SVD.**

I. INTRODUCTION

The word Steganography is taken from the Greek word ‘steganos’ which means “covered or protected” and ‘graphei’ which means “writing” [1]. The art of hiding the information is known as steganography. It is the study of hiding the data or information with the intensive purpose, to send the secret information more securely and secretly. Since, in the last few years digital media were more in use, it was providing abundant space for hiding the information. In general, the image steganographic techniques hide the secret information using the redundancy of cover image.

The stego image is formed by combining the cover image and secret information which will appear as cover image since the secret information doesn’t cause any noticeable changes to the cover image. Hiding the secret information was in use from long time but these days, there is a rapid growth in file transfers through electronic formats and to hide these the concepts of steganography and watermarking came into existence. By using these concepts there is a rapid growth in hiding the secret information irremovably and undetectably in images, audios, and videos [2], [3]. More often, there is a possibility to detect the secret information by any other means but the human naked eye can’t detect the secret information. Steganalysis [4] is the study of detecting the hidden secret information.

Classification of steganography techniques

- *Text Steganography:* In this technique, text is used as the cover media to hide the messages and it is one of the most difficult technique among the steganography techniques. Hiding the text behind HTML coding is example for text steganography.

- *Audio Steganography:* In this technique to hide the information audio signal is used as the cover media. Audio steganography means hiding some secret information in a host message and is most challenging task to hide the information.
- *Video Steganography:* In this technique to hide the cover media is video. In comparison with other steganography techniques, video steganography is the most difficult and challenging task.
- *Image Steganography:* In this technique, image is used as cover media to hide the messages and it is one of the most widely used technique since images have abundant redundancy to hide the secret information.

In the proposed method, hiding of secret information with QR code is based on the principles of SVD. The concept of SVD [5] was used to hide the information in a cover image. The combination of cover image and secret information will produce the stego image.

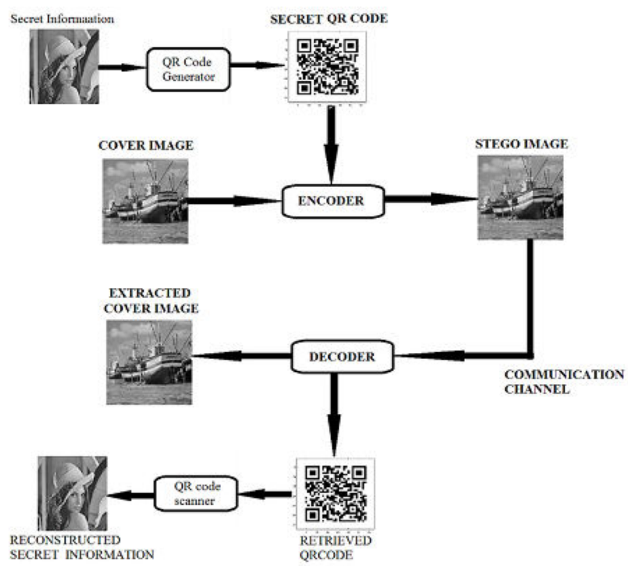

Fig 1. Block diagram of proposed method

The block diagram for the proposed method is shown in Fig-1. The main aim of the proposed method is to provide more data hiding capacity for cover image and more security for the secret information.

- *Cover-Image:* To hide the secret information the image that was used is the cover image. The term "*cover*" represents the original, innocent message, data, audio, still image, video etc...
- *Secret-Image:* It is the image which holds the secret information and is hided using cover image. The secret information may be image, text message or other forms.
- *Stego-Image*: The word "*stego*" represent the image containing both the cover image and embedded information. The stego image will appear as if the cover image appears.
- *QR Code*: QR means Quick Response code which is a two-dimensional bar code. It is widely used to store large amount of information in easy access manner through smartphone and it also provide high security to the information.

II. Theory On QR Code And SVD

A. Overview of Quick Response Code

QR code is an array used to store the information. It is a two-dimensional bar code. Denso, one of the major Toyota group companies, invented the QR code in the year 1994. QR code was approved as an ISO international standard (ISO/IEC18004) in June 2000 [6]. QR code can be read by a machine like QR code reader or a smartphone. Since QR code is a two-dimensional array it can be used to store the information such as Uniform Resource Locator (URL) which can be read by QR code readers [7]. At first QR code was used to control the production of automotive parts, but soon it has become popular various other fields also. QR code has become common day-to-day life because of its various advantages and some of which are listed below:

1. The characteristics of QR code are superior to linear barcodes. The data density of QR code is higher than linear barcodes. Unlike linear barcodes a QR code can store different types of characters.
2. Anybody can use the QR code without any cost because the license of the QR code has been released into public domain.
3. If current usages are considered the standard of data structure is not an essential condition.
4. The information present in the QR code can be accessed very easily by using QR code reader. A smart phone camera is the best example of QR code reader. Since now-a-days everyone has a smartphone the information present in a QR code can be easily accessed.

B. General Applications of QR code

1. QR code is used for Passenger Management.
2. Document management and general marketing.
3. One time password authentication protocol using QR code.
4. QR code can be used for issuing pass to the Bus commuters.
5. QR codes on boarding and in advertisements enable the users to directly know more information regarding that organization to which the advertisement belongs to, if the QR code was linked with the website of that organization or some other such kind of information.
6. Now-a-days we can make the payments for train tickets, Airline services, bill payments and much more just by scanning the QR code and then transferring the amount into the account linked with the QR code from our account.

C. Overview of Singular Value Decomposition

The SVD is the optimal matrix decomposition which packs the maximum signal energy into few coefficients as described in [8, 9]. Singular value decomposition (SVD) is a numerical technique which is used to diagonalize matrices in numerical analysis [10, 11]. SVD is an efficient algebraic transform for image processing as it has many advantages such as maximum energy packing which is usually used in compression [12,13], the ability to manipulate the image under the support of two different subspaces such as data and noise subspaces [13,14,15]. Each of these applications use key properties of the SVD. SVD is an efficient and reliable orthogonal matrix decomposition method, which is due to its conceptual and stability reasons and is becoming popular in signal processing domain area [10, 11]. The useful feature of SVD is that it can adapt to the variations in the local statistics of an image [12]. SVD properties are attractive but are not fully utilized. The SVD based image processing techniques that were developed focused on image fidelity, data hiding capacity and security for embedded information. This paper contributes in using the generous properties of SVD which are not exploited in image processing.

D. Concept of Singular Value Decomposition

The singular value decomposition (SVD) is a mathematical tool used for analyzing and mapping from one vector space into another vector space, possibly with a different direction. The SVD is based on a theorem from linear algebra which says that a rectangular matrix A of m×n size can be factored into three matrices. SVD has many practical and theoretical values; Special feature of SVD is that it can be performed on any real (m, n) matrix. Let's say we have a matrix A with m rows and n columns, with rank R and R ≤ n ≤ m. Then the A can be factorized into three matrices:

$$A = USV^T \quad (1)$$

$$[A]_{m\times n} = [U]_{m\times m}[S]_{m\times n}\left[V^T\right]_{n\times n} \quad (2)$$

Where U is orthogonal m×m matrix ($U^TU = I$) (where I is identity matrix) and the columns of U are the orthonormal eigenvectors of AA^T.

$$U = [u_1, u_2, \ldots, u_r, u_{r+1}, \ldots, u_m] \quad (3)$$

Column vectors u_i, for i=1, 2,…, m, form an orthogonal set:

$$u_i^T u_j = \delta_{ij} = \begin{cases} 1, \ldots, i = j \\ 0, \ldots, i \neq j \end{cases} \quad (4)$$

Likewise, V is orthogonal n×n matrix ($V^TV = I$) and the rows of V^T are the eigenvectors of A^TA.

$$V = [v_1, v_2, \ldots v_r, v_{r+1}, \ldots, v_n] \quad (5)$$

Column vectors v_i, for i=1,2, …, n, form an orthogonal set:

$$v_i^T v_j = \delta_{ij} = \begin{cases} 1, \ldots, i = j \\ 0, \ldots, i \neq j \end{cases} \quad (6)$$

Here, S is an m×n diagonal matrix with singular values (SV) on the diagonal. The matrix S can be showed as

$$S = \begin{pmatrix} \sigma_1 & 0 & \cdots & 0 & 0 & \cdots & 0 \\ 0 & \sigma_2 & \cdots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_r & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 & \sigma_{r+1} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 & 0 & \cdots & \sigma_n \end{pmatrix} \quad (7)$$

For i = 1, 2, …, *n*, σ_i are called Singular Values(SV) of matrix A. It can be proved that

$$\sigma_1 \geq \sigma_2 \geq \ldots \geq \sigma_r \geq 0, \text{ and } \sigma_{r-1} = \sigma_{r-2} = \ldots = \sigma_n = 0 \quad (8)$$

For i= 1,2, …, n, σi are called singular values (SVs) of matrix A. The vi's and ui's are called right and left singular-vectors of A.

The eigenvectors of AA^T are called the left singular vectors of U, while the eigenvectors of AA^T are called the right singular vectors of V. The matrix S is diagonal and it has the same size as A. Its diagonal entries, known as sigma, σ_1, σ_2, σ_3, …, σ_r, arranged in non-increasing order are the square roots of the nonzero eigenvalues $\lambda_1, \ldots, \lambda_r$, where $\sigma_1 = \sqrt{\lambda_1}, \ldots, \sigma_r = \sqrt{\lambda_r}$, of both AA^T and A^TA. They are the singular values of matrix A and they fill the first r places on the main diagonal of S. r is the rank of A. Singular value vector has the entire energy of the matrix A, U and V represent the geometrical shape of the image. The factorization finds values or eigenvalues or characteristic roots that make the following characteristic equation singular. That is,

$$\left|AA^T - \lambda I\right| = 0 \qquad (9)$$

This polynomial that yields n-roots, is called characteristic polynomial, it comes from a more generalized eigenvalue equation, which has the form

$$AA^T x = \lambda x \qquad (10)$$

It can be written in matrix form as

$$AA^T x - \lambda x = 0 \text{ (or) } \left(AA^T - \lambda I\right)x = 0 \qquad (11)$$

This equation gives either

$$x = 0 \text{ (or) } \left|AA^T - \lambda I\right| = 0 \qquad (12)$$

E. Concept of Singular Value Decomposition

There are many properties and attributes of SVD, here we just present parts of the properties that we used in this project.

1. The factorization for the real valued matrix A is provided by U, S and V i.e., $A = USV^T$.
2. *S* is a diagonal matrix with real, nonnegative diagonal entries $\sigma_1, \sigma_2, \ldots, \sigma_r$ such that $\sigma_1 \geq \sigma_2 \geq \ldots \geq \sigma_r$. These singular values are unique.
3. $A^TA = VS^TSV^T$, which means that A^TA is diagonalized by V and the elements v_j's of V are the eigenvectors of A^TA .
4. $AA^T = USS^TU^T$, which means that AA^T is diagonalized by U and the elements v_j's of V are the eigenvectors of AA^T.
5. If the rank of *A* is *r* then the elements $v_1, v_2, \ldots, v_r$ form an orthonormal basis for A^T, $R(A^T)$, and the elements $u_1, u_2, \ldots, u_r$ form an orthonormal basis for *A*, *R*(*A*).
6. V is an orthonormal k×k matrix and hence $V^T=V^{-1}$.
7. The rank of the matrix A is equal to the number of nonzero singular values present in it.
8. The eigenvectors of U and V are not unique.
9. U and V^T must be real and orthogonal, which means that $V^TV = U^TU = I$, where I is the identity matrix. A matrix is also said to be orthogonal if its column vectors are pairwise orthogonal unit vectors.

Singular vectors of matrix A are the columns of U and V respectively called the left singular vectors and right singular vectors. Singular vectors for U and V will be pairwise orthogonal unit vectors individually

III. PROPOSED METHOD

A. Encoding Algorithm

1) Consider the secret information (S) which may be pdf, website link, mp3, vCard plus, images, android applications, multi URL or any text information. Here secret information is considered as image, the test images are shown in Fig 2

ISSN (Online): 2456-5717
International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

Fig 2 Test images for Encoding process

2) Quick Response code (S_{QR}) is generated for secret information using QR code Generator.
3) Consider a cover image (C) with the same size of QR code.
4) Compute the values of S, V, U using SVD method for the generated QR code
5) Embed the V value of QR code image into the cover image to obtain stego images(C^1)
6) Using embedding process, two stego images that were obtained as

$$C_1^1 = C + V \quad (13)$$

$$C_2^1 = C - V \quad (14)$$

7) The S, U values of the QR code were transmitted as support files.
8) So, will transmitting we need to send two stego images along with two supported files to retrieve the secret information.

B. Decoding Algorithm

1) Consider the two stego images for retrieving the V values and cover image as

$$C = (C_1^1 + C_2^1)/2 \quad (15)$$

$$V = C_1^1 - C \quad (16)$$

2) Now recover the values of S and U from the supported files and compute transpose for V matric.
3) The secret QR code can be reconstructed as

$$S_{QR} = U*S*V^T \quad (17)$$

4) The secret information is retrieved by scanning the S_{QR} with QR code scanner. The Reconstructed images were shown in Fig-3.

ISSN (Online): 2456-5717
International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

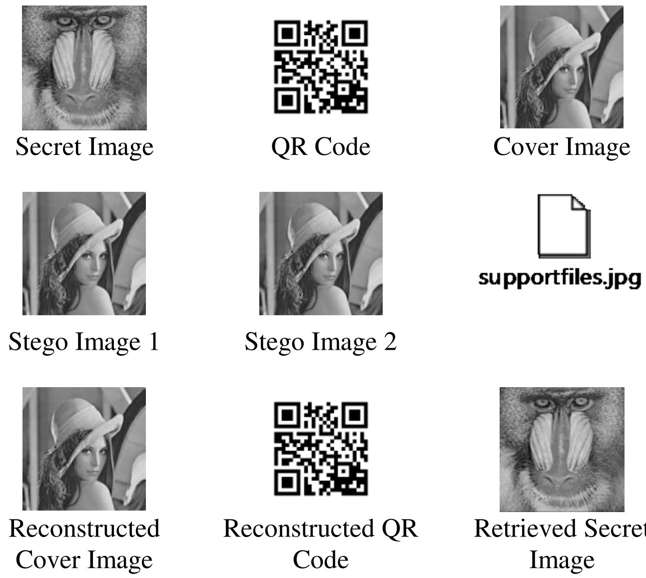

Fig- 3 Images of Encoding & Decoding process

C. Results and Discussion

In the proposed method, the visual perception of the generated stego images and its quality are the main considerations. Here Tables 1, 2 & 3 gives us the quality of generated stego images in comparison with cover image. The following measures will assess the quality of the stego images [16].

The Peak Signal to Noise Ratio between the cover and stego images is given by

$$PSNR = 10\log_{10}\left[255^2 / MSE\right] \qquad (18)$$

Where MSE represents the Mean square error between the cover and stego images. PSNR is measured in dB. MSE is given by

$$MSE = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}\left(c(x,y) - c^1(x,y)\right)^2 \qquad (19)$$

Here, c and c^1 are the cover and stego images of dimensions M×N. c(x, y) and c^1 (x.y) are the cover image and stego image pixel intensities.

Average Difference is the metric which gives the average of difference between the cover and stego images. It is calculated by

$$AD = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}\left(c(x,y) - c^1(x,y)\right) \qquad (20)$$

Structural Content is correlation based measurement which gives the similarity between the cover and stego images and is given by

$$SC = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(c^1(x,y)\right)^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(c(x,y)\right)^2} \qquad (21)$$

Normalized cross-correlation is the metrics that gives closeness between the cover and the stego images in terms of correlation function, it is given by

ISSN (Online): 2456-5717
International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

$$NK = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(c(x,y)\times c^{1}(x,y)\right)}{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(c(x,y)\right)^{2}} \qquad (22)$$

Maximum Difference represent the maximum of the error between the cover and stegoimages is given by

$$MD = MAX\left|c(x,y)-c^{1}(x,y)\right| \qquad (23)$$

The other parameters often used for performance measures are Laplacian Mean square error (LMSE) and Normalized Absolute error (NAE). Smaller the values of LMSE and NAE, better is the quality of image.

TABLE 1 QUALITY ASSESSMENT OF STEGO IMAGE 1

Secret Information	MSE	PSNR (in dB)	AD	SC	NK	MD	LMSE	NAE
Baboon	0.001953	75.223495	0.000077	1.000000	1.000000	0.993700	0.000103	0.000170
Barbara	0.001953	75.223482	0.000074	1.000000	1.000000	0.993700	0.000104	0.000170
Couple	0.001953	75.223523	0.000075	1.000000	1.000000	0.993700	0.000104	0.000170
Cameraman	0.001953	75.223483	0.000076	1.000000	1.000000	0.988800	0.000104	0.000170
Elaine	0.001953	75.223493	0.000075	1.000000	1.000000	0.993700	0.000104	0.000170
Gril	0.001953	75.223482	0.000076	1.000000	1.000000	0.993700	0.000103	0.000170
Peppers	0.001953	75.223485	0.000074	1.000000	1.000000	0.993700	0.000103	0.000169
Zelda	0.001953	75.223496	0.000074	1.000000	1.000000	0.993700	0.000103	0.000170

TABLE 2 QUALITY ASSESSMENT OF STEGO IMAGE 2

Secret Information	MSE	PSNR (in dB)	AD	SC	NK	MD	LMSE	NAE
Baboon	0.001953	75.223495	-0.000077	1.000000	1.000000	0.993700	0.000103	0.000170
Barbara	0.001953	75.223482	-0.000074	1.000000	1.000000	0.993700	0.000104	0.000170
Couple	0.001953	75.223523	-0.000075	1.000000	1.000000	0.993700	0.000104	0.000170

Cameraman	0.001953	75.223483	-0.000076	1.000000	1.000000	0.988800	0.000104	0.000170
Elaine	0.001953	75.223493	-0.000075	1.000000	1.000000	0.993700	0.000104	0.000170
Gril	0.001953	75.223482	-0.000076	1.000000	1.000000	0.993700	0.000103	0.000170
Peppers	0.001953	75.223485	-0.000074	1.000000	1.000000	0.993700	0.000103	0.000169
Zelda	0.001953	75.223496	-0.000074	1.000000	1.000000	0.993700	0.000103	0.000170

TABLE 3 A COMPARISON OF PROPOSED METHOD AND OTHER METHODS ON CAPACITY AND PSNR

Cover Image	Secret Image	2 — bit LSB		3 — bit LSB		Eigenvalues & Eigenvectors		SVD using QR code	
		Capacity	PSNR	Capacity	PSNR	Capacity	PSNR	Capacity	PSNR
Baboon	Bridge	524,288	44.37	786,432	37.16	2,097,152	48.38	8,388,608	75.223495
	Boat	524,288	44.52	786,432	37.17	2,097,152	48.61	8,388,608	75.223482
	Pentagon	524,288	44.51	786,432	37.10	2,097,152	48.48	8,388,608	75.223523
Lena	Bridge	524,288	44.37	786,432	37.03	2,097,152	47.92	8,388,608	75.223483
	Boat	524,288	44.51	786,432	37.05	2,097,152	47.86	8,388,608	75.223493
	Pentagon	524,288	44.52	786,432	36.97	2,097,152	48.01	8,388,608	75.223482
Peppers	Bridge	524,288	44.39	786,432	37.05	2,097,152	48.53	8,388,608	75.223485
	Boat	524,288	44.53	786,432	37.05	2,097,152	48.63	8,388,608	75.223496
	Pentagon	524,288	44.54	786,432	37.02	2,097,152	48.51	8,388,608	75.223423

From the above results, it is proved that the capacity and visual quality of the image for the proposed method is efficient compared to existing methods as shown in Table 3.

IV. CONCLUSION

An efficient and new method to hide the image using which the secret information can be embedded into cover image with the help of QR code is proposed. The proposed method satisfies the property of reversibility of steganography and hence the secret and cover images can be recovered more efficiently. The proposed method is superior to the existing steganographic method in terms of embedding capacity, speed, and computational cost.

V. ACKNOWLEDGMENT

I would also like to thank our guide Ms. B. L. Sirisha madam for the guidance and support she has provided to carry out this work. I would also like to thank the Management of Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada for supporting me.

REFERENCES

[1] Y. M. Behbahani, P. Ghayour, and A. H. Farzaneh, “Eigenvalue Steganography based on eigen characteristics of quantized DCT matrices,” Information Technology and Multimedia (ICIM).14-16 NOV.2011.

[2] Z. Ni, Y.Q. Shi, and N. Ansari, W. Su, “Reversible data hiding, circuits and system for video technology,” *IEEE Trans, No:16, pp:354- 362.2006.*

[3] V. Sachnev, H. J. Kim, J. Nam, S. Suresh, Y. Q. Shi, “Reversibel watermarking algorithm using sorting and prediction”, IEEE Trans. Circuits and Systems for video Technology Vol. 19, No. 7, pp. 989-999,2009.

[4] J. Silman, “Steganography and Steganalysis: An Overview”, SANS Institute, 2001.

[5] Liu, R and Tan, T. (2002). An SVD-Based Watermarking Scheme for Protecting Rightful Ownership. IEEE Transactions on Multimedia, Vol.4, No. 1, March 2002.

[6] ISO/IEC 18004:2000(E), “Information technology Automatic identification and data capture techniques Bar code symbology QR Code”, 2000.

[7] Xiong Zou, Guo-dong Liu, Jian-min Wang.” Study on the Sequence of step in the QR code Image processing”. M Moonen, P van Dooren, J Vandewalle, “Singular value decomposition updating algorithm for subspace tracking”, SIAM Journal on Matrix Analysis and Applications (1992)

[8] M Moonen, P van Dooren, J Vandewalle, “Singular value decomposition updating algorithm for subspace tracking”, SIAM Journal on Matrix Analysis and Applications (1992)

[9] T. Konda, Y. Nakamura, A new algorithm for singular value decomposition and its parallelization, Parallel Compute. (2009), doi: 10.1016/j.parco.2009.02.001

[10] H. C. Andrews and C. L. Patterson, “Singular value decompositions and digital image processing,” IEEE Trans. on Acoustics, Speech, and Signal Processing, vol. ASSP-24, pp. 26–53, 1976.

[11] Julie L. Kamm, “SVD-Based Methods For Signal And Image Restoration”, PhD Thesis (1998)

[12] J.F. Yang and C.L. Lu,” Combined Techniques of Singular Value Decomposition and Vector Quantization for Image Coding,” IEEE Trans. Image Processing, pp. 1141 - 1146, Aug. 1995.

[13] Xiaowei Xu, Scott D. Dexter, Ahmet M. Eskicioglu: A hybrid scheme for encryption and watermarking. Security, Steganography, and Watermarking of Multimedia Contents 2004: 725-736

[14] K. Konstantinides, B. Natarajan, and G.S. Yovanof,” Noise Estimation and Filtering Using Block-Based Singular Value Decomposition,” IEEE Trans. Image Processing, vol. 6, pp. 479- 483, March 1997.

[15] E. Ganic and A. M. Eskiciogulu, Secure DWT-SVD Domain Image Watermarking: Embedding Data in All Frequencies, ACM Multimedia and Security Workshop 2004, Magdeburg, Germany, September 20-21, 2004

[16] Vora, V.S., Suthar, A.C.," Analysis of Compressed Image Quality Assessments" International Journal of Advanced Engineering & Application, Jan 2010.

AUTHORS BIOGRAPHY

Jeenu Phaneendra was born at Pithapuram India on August 22, 1996. He is currently pursuing his B. Tech in the Department of Electronics and Communication Engineering from Velagapudi Ramakrishna Siddhartha Engineering College. His fields of interest are Image processing and Computer Networks.

Boppa Manohar Samuel was born at Godavarikhani, India on April 30, 1996. He is currently pursuing his B. Tech in the Department of Electronics and Communication Engineering from Velagapudi Ramakrishna Siddhartha Engineering College. His fields of interest are Image processing and Computer Networks.

Mrs. B. Lakshmi Sirisha received her AMIETE degree from Delhi University in 2005.Then she received her M Tech degree in “Communication and Signal Processing” from Acharya Nagarjuna University, Andhra Pradesh, India in 2007. She is currently pursuing her PhD in “Digital Image Processing” with a specialization of Steganography in Jawaharlal Nehru Technological University, Kakinada. At present, she is working as Assistant Professor in V R Siddhartha Engineering College, Vijayawada.