ISSN 2047-3338

Criminal Photograph Authentication Technique Based on Corner Detection and YCgCb, LUV Colorspaces

Baisa L. Gunjal[1] and Suresh N. Mali[2]
[1]Amrutvahini College of Engineering, Sangamner, Ahmednagar, Maharashtra, India
[2]Singhgad Institute of Technology and Science, Narhe, Pune, Maharashtra, India
[1]hello_baisa@yahoo.com, [2]snmali@rediffmail.com

***Abstract*– Critical crime investigations require transmitting sensitive criminal photographs across internet or by mobile phones. Transmission of such image data demands high and guaranteed security. The aim of this paper is to present multilayer, secured, robust criminal photograph authentication scheme based on Harries corner detection technique, YCgCb, LUV color spaces, wavelet domain and Arnold Transform. Harries Corner detection technique is used to generate key K which is further used to scramble watermark by Arnold transform. Discrete Wavelet Transform (DWT) decomposition is carried by simple, orthogonal wavelet, 'Haar'. The direct flexing factor K1 is used during embedding and extraction process. This technique gives maximum PSNR 54.32 and Normalized Correlation (NC) exactly 1 reflecting effectiveness and accuracy of the scheme. It is robust against various attacks like filtering, scaling, compression, rotation, resizing etc.**

***Index Terms*– Corner Detection, Peaks, YCgCb and LUV Color Spaces**

I. INTRODUCTION

MOST of the crimes investigations are based on database submitted to crime branches from remote locations via internet or mobile phones. When some unwanted crime happens, the criminal photograph is constructed according to preliminary information collected from eye witness persons where actual incidence happens. This sensitive criminal image data needs to be transmitted across network through internet or mobile phone for further investigation of the given case. Such sensitive image data needs high security. Digital Image Watermarking provides copyright protection to digital images by hiding important information to declare rightful ownership. Robustness, Perceptual transparency, capacity and blind watermarking are four essential factors to determine quality of watermarking scheme [12]. Special domain watermarking schemes do not provide enough security. Hence transform domain watermarking methods are used. One of the transform domain scheme is presented here.

The rest of the paper is organized as follows: Related work is given in Section II. Harries corner detection technique and RGB, YCgCb and LUV color spaces, DWT and Arnold Transform are described in Section III. Actual 'Criminal Authentication System' is explained in Section IV. Section V focuses on results and discussions while conclusion and future work is given in section VI.

II. RELATED WORK

Some of the special domain and transform domain methods are proposed by different researchers for embedding watermark in color images with RGB, YUV and YIQ color spaces. Few watermarking methods are mentioned here: In [7], Integer Wavelet Transform with Bit Plane complexity Segmentation is used with more data hiding capacity. This method used RGB color space for watermark embedding. In [8] DWT based watermarking algorithm of color images is proposed. The RGB color space is converted into YIQ color space and watermark is embedded in Y and Q components. This method gives correlation up to 0.91 in JPEG Compression attack. In [9], Watermarking Algorithm Based on Wavelet and Cosine Transform for Color Image is proposed. A binary image as watermark is embedded into green or blue component of color image. In [6], Color Image Watermarking algorithm based on DWT-SVD is proposed. The scrambling watermark is embedded into green component of color image based on DWT-SVD. The scheme is robust and giving PSNR up to 42.82. In [11], Pyramid Wavelet Watermarking Technique for Digital Color Images is proposed. This algorithm gives better security and better correlation in Noise and compression attacks.

III. BASIC FOUNDATIONS USED

A) Harris Corner Detection Method

Corner is important feature of image. There is basic difference between corners and edges: Corners are local image features characterized by locations where variation of intensity functions $f(x, y)$ in both x and y directions are high. Edges are locations where variation of intensity function $f(x, y)$ in certain direction is high while variation in orthogonal direction is low. The difference is shown in Fig. 1.

Harris Corner Detection Method calculates corner metric matrix and finds corners in images. The generalized process of Corner detection includes three major steps [3].

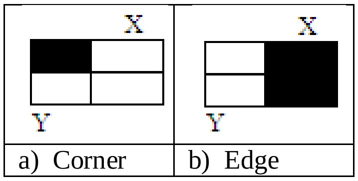


Fig. 1: Difference between corner and edge feature

1) Apply Corner Operator: For each pixel in the input image, the corner operator is applied to obtain a cornerness measure for this pixel. The cornerness measure is simply a number indicating the degree to which the corner operator believes this pixel is a corner.

2) Threshold Cornerness Map: Cornerness map will contain many local maximum that have a relatively small cornerness measure and are not true corners. To avoid reporting these points as corners, the cornerness map is typically thresholded. All values in the cornerness map below the threshold are set to zero.

3) Non-maximal Suppression: For each point in the thresholded cornerness map, non-maximal suppression sets the cornerness measure for this point to zero if its cornerness measure is not larger than the cornerness measure of all points within a certain distance. After non-maximal suppression is applied, the corners are simply the non-zero points remaining in the cornerness map. The overall process is depicted in Fig. 2:

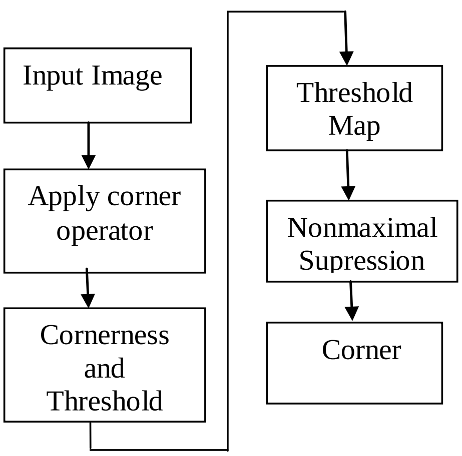


Fig. 2: Process of corner detection

The basic mathematical concept is given below:
The change of intensity for shift [u,v] is given by:

$$E[u,v] = \sum w(x,y)\,[I(x+u,y+v) - I(x,y)]^2 \quad (1)$$

Where $w(x,y)$ is window function like gaussian window, $I(x+u,y+v)$ is shifted intensity and $I(x,y)$ is the gray

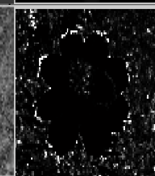
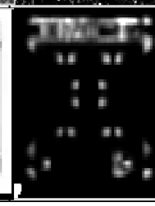
Image with size	a) Original Image	b) Corner Metric	c) Corner Points
Special Branch Logo 64x64 size			
Flower Image with 400x300 size			
Hospital Logo with 64x64 size			

Fig. 3: Original image with corner metric and corner points

level intensity. Average intensity change in direction [u, v] can be expressed as bilinear form

$$E(u,v) \simeq [u\ v]\ M \begin{bmatrix} u \\ v \end{bmatrix} \quad (2)$$

Where M is 2x2 matrix computed from image derivatives as follows [1], [2]:

$$M = \sum_{x,y} w(x,y) \begin{bmatrix} {I_x}^2 & I_x I_y \\ I_x I_y & {I_y}^2 \end{bmatrix} \quad (3)$$

Here, Haries method describes a point in terms of eigenvalues of M. Hence, measure of corner response Measure of corner response is given by:

$$R = \det M - k(trace\ M)^2 \quad (4)$$

$$R_{x,y} = A_{x,y}B_{x,y} - C_{x,y}^2 - k\left(A_{x,y} + B_{x,y}\right)^2 \quad (5)$$

where $\lambda_{1,}\lambda_2$ are Eigen values of M

$$\det M = \lambda_1 \lambda_2 \quad (6)$$

$$trace\ M = \lambda_1 + \lambda_2 \quad (7)$$

k is imperical constant =0.04. A good corner should have a large intensity change in all directions. In short, Harris corner detection method finds points with large corner response function R (R > threshold).

B. RGB Color Space

RGB colour space is the standard red-green-blue colour space used when constructing acolour image. The R, G and B values indicate the red, green and blue components respectively of colour of pixel. The R, G and B values can vary from 0 to 255, thus allowing for the construction of 24 bit colour images. Some of researches have used RGB color space for watermark embedding. First R, G, B planes are separated using equations 8,9,10 and either one of these planes or combination of two can be used for embedding.

$$R = rgb\_image(:,:,1) \quad (8)$$

$$G = rgb\_image(:,:,2) \quad (9)$$

$$R = rgb\_image(:,:,3) \quad (10)$$

The luminance is calculated using a weighted average of the R, G and B values such that the sum of the weights is unity. RGB color space is complex in describing the color pattern and has redundant information between each component, Since Pixel values in RGB color space are highly correlated, RGB color space is converted into YCgCb color space [6].

C) YCgCb Color Space

Kekre's YCgCb color space is a newly introduced color space and is related to the standard RGB color space as follows [4], [5]: The R,G,B components from RGB image are seperated using equations 11,12 and 13. The RGB color space is converted into Yc\CgCb colorspace using equations 4, 5 and 6.

$$Y = R + G + B \quad (11)$$

$$Cg = R - G \quad (12)$$

$$Cb = R - B \quad (13)$$

YCgCb colorspace can be converted into RGB colorspace using equations 14, 15, 16.

$$R = 1/3 * \mathrm{Y} + 1/3 * \mathrm{Cg} + 1/3 * \mathrm{Cb} \quad (14)$$

$$G = 1/3 * \mathrm{Y} - 2/3 * \mathrm{Cg} + 1/3 * \mathrm{Cb} \quad (15)$$

$$B = 1/3 * \mathrm{Y} + 1/3 * \mathrm{Cg} - 1/3 * \mathrm{Cb} \quad (16)$$

The Y/3 component provides the luminance values.

D) LUV Color Space

In Kekre's LUV color Space, L gives luminance and U and V gives chromaticity values of color image. Negative value of U indicates prominence of red component in color image and negative value of V indicates prominence of green component over blue [4]. To get Kekre's LUV components we need the conversion of RGB to LUV components. Equations 17, 18 and 19 convert RGB color soace to LUV color space.

$$\mathrm{L} = \mathrm{R} + \mathrm{G} + \mathrm{B} \quad (17)$$

$$\mathrm{U} = -2 * \mathrm{R} + \mathrm{G} + \mathrm{B} \quad (18)$$

$$\mathrm{V} = -\mathrm{G} + \mathrm{B} \quad (19)$$

The LUV to RGB conversion is done by equations 20, 21 and 22.

$$\mathrm{R} = 1/3 * \mathrm{L} - (0.1667 * 2) * \mathrm{U} \quad (20)$$

$$\mathrm{G} = 1/3 * \mathrm{L} + 0.1667 * \mathrm{U} - 0.5 * \mathrm{V} \quad (21)$$

$$\mathrm{B} = 1/3 * \mathrm{L} + 0.1667 * \mathrm{U} + 0.5 * \mathrm{V} \quad (22)$$

E) Wavelet Domain

DWT offers mutiresolution representation of image and DWT gives perfect reconstruction of decomposed image. Discrete wavelet can be represented as:

$$\psi_{j,k}(t) = a_0^{-j/2}\psi\,(a_0^{-j}t - k\,b_0) \quad (23)$$

For dyadic wavelets $a_0 = 2$ and $b_0 = 1$, Hence we have,

$$\psi_{j,k}(t) = 2^{-j/2}\psi\,(2^{-j}t - k\,),\ \mathrm{j, k} \in Z \quad (24)$$

When image is passed through series of low pass and high pass filters, DWT decomposes the image into sub bands of different resolutions [12]. Decompositions can be done at different DWT levels.

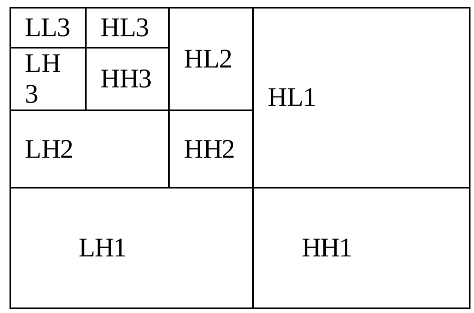


Fig. 4: Three Level Image Decomposition

At level 1, DWT decomposes image into four non overlapping multire solution sub bands: LL1 (Approximate sub band), HL1 (Horizontal sub band), LH1 (Vertical sub band) and HH1 (Diagonal Sub band). Here, LL1 is low frequency component whereas HL1, LH1 and HH1 are high frequency (detail) components To obtain next coarser scale of wavelet coefficients after level 1, the sub band LL1 is further decomposed. Three level image decomposition is shown in Fig:4. Embedding watermark in low frequency coefficients can increase robustness significantly but maximum energy of most of the natural images is concentrated in approximate (LL3) sub band. Hence modification in this low frequency sub band will cause severe and unacceptable image degradation. Hence watermark is not embedded in LL3 sub band. The good areas for watermark embedding are high frequency sub bands (HL3, LH3 and HH3), because human naked eyes are not sensitive to these sub bands. They yield effective watermarking without being perceived by human eyes. But HH3 sub band includes edges and textures of the image. Hence HH3 is also excluded. Most of the watermarking algorithms have been failed to achieve perceptual transparency and robustness simultaneously because these two requirements are conflicting to each other [10], [12]. The rest options are HL3 and LH3. But Human Visual System is less sensitive in horizontal than vertical. Hence Watermarking done in HL3 region.

F) Arnold Transform

Arnold Transform has special property of Arnold Transform is that image comes to it's original state after certain number of iterations [10]. These 'number of iterations' is called 'Arnold Period' or 'Periodicity of Arnold Transform'. Arnold Transform of image is:

$$\begin{pmatrix} x_n \\ y_n \end{pmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix} (mod\ N) \qquad (25)$$

Where, (x,y) ={0,1,.....N} are pixel coordinates from original image. (x_n,y_n) are corresponding results after Arnold Transform. The periodicity of Arnold Transform (P), is dependent on size of given image. From equation 3, we have:

x_n=x+y (26)

y_n=x+2*y (27)

If (mod (x_n, N) ==1 && mod (y_n, N) ==1)

then P=N (28)

IV. CRIMINAL AUTHENTICATION SYSTEM

Watermark embedding and extraction processed are depicted in Fig. 5 and Fig. 6 respectively.

A) *Embedding Algorithm*

Step 1: Read criminal photo as 'Cover_Image'.

Step 2: Separate R, G, B components using equations 8,9,10. Convert RGB to YCgCb color space using 11, 12 and 13.

Step 3: Apply 3 level DWT using 'Haar' wavelet and select HL3 region.

Step 4: Read watermark and generate key K using Harris corner detection technique as follows, with size m1xn1 where m1== n1 :

a) Read watermark. Find 'C' as cornermetric of watermark.

b) Using C find Corner _Peaks ' CP'.

c) Using CP find key K with equation 29.

$$K = mod(Size(cp, 1), m1) \qquad (29)$$

Step 5: Perform watermark embedding using equation 30

$$New\_HL3(I,J) = HL3(I,J) + K1 * watermark(I,J) \qquad (30)$$

Where K1 is flexing factor, watermark (I, J) implies scrambled watermark.

Step 6: Using inverse DWT, construct YCgCb Image with New_Cb component.

Step 7: Convert YCgCb to RGB color space using equations 14, 15, 16 to give 'watermarked photo'.

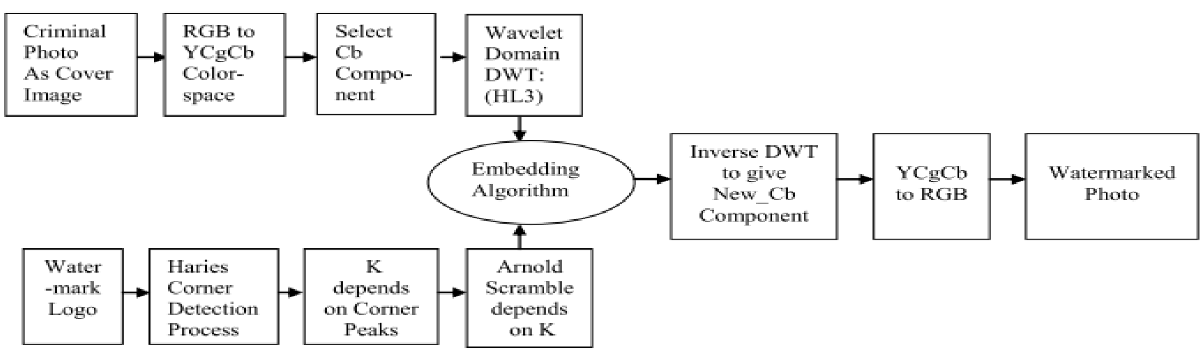


Fig. 5: Watermark embedding Process

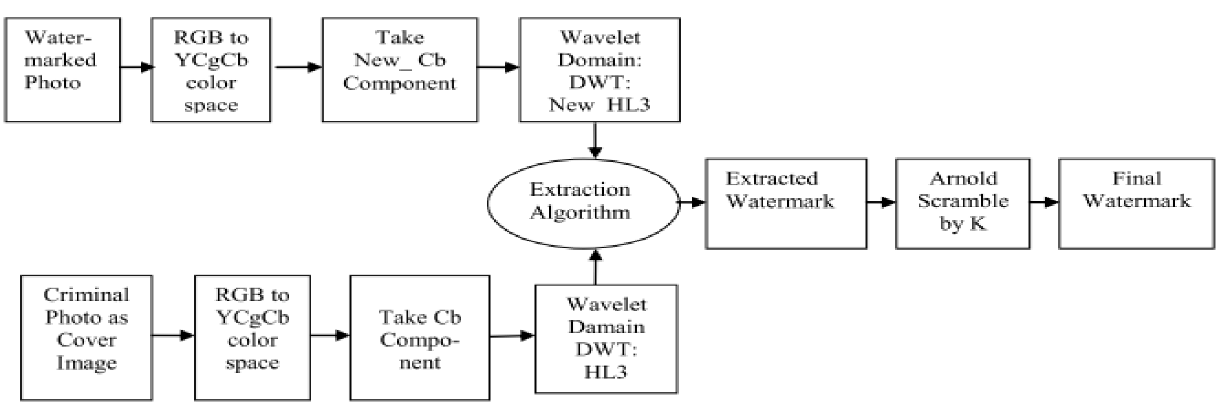


Fig. 6: Watermark Extraction Proc

B). Extraction Algorithm

Step 1: Consider Watermarked_photo and convert from RGB colorspace to YCgCb using equations 11, 12, 13.

Step 2: Consider New_Cb component in HL3 region using DWT transform upto 3 levels to give New_HL3 component.

Step 3: Decompose Cover_Image upto 3 levels to give HL3 component.

Step 4: Apply extraction formule as follows:

$$Value(I,J) = \frac{abs(New\_HL3(I,J), HL3(I,J)}{K1} \qquad (31)$$

where K1 is flexing factor. Let Threshold equals to 200;

If Value (I, J) < Threshold_Value then Extracted_Watermark (I, J) =0

Else Extracted_Watermark (I, J) =1.

Step 5: Apply Arnold Scrambling to Extracted watermark to give final_watermark.

Repeate above embedding and extraction algorithm for Y and Cg components. Similar steps of embedding algorithm and extraction algorithm are implemented for LUV colorspace.

V. RESULTS AND DISCUSSIONS

Implementation and testing of above technique is done using Matlab. Cover Image, Watermarked Image, Embedded and Extracted logos with Y, Cg, Cb and L, U, V components are shown in Fig. 7 with performance is measured based on Peak Signal to noise ratio (PSNR) and Coorelation factor (NC) given as ρ. PSNR for image with size MxN is expressed with equations 32 and 33. PSNR for grey scale image with size M x N is given by:

$$PSNR = lg\left(\frac{M*N*255^2}{\sum_x \sum_y e^2{}_{(x,y)}}\right) \qquad (32)$$

Where e(x, y) is the difference between original image and watermarked image. With size M*N, corresponding to color image, PSNR is expressed:

$$PSNR = 10 * lg\left(\frac{3*M*N*255^2}{\sum_{c=R,G,B} \sum_x \sum_y (e^2(c,x,y))}\right) \qquad (33)$$

Here, c indicates the color component which e belongs to. NC is expressed with equation 34, which is ideally 1.

$$\rho = \frac{\sum_{i=1}^{N} w_i w_i{}'}{\sqrt{\sum_{i=1}^{N} w_i}\sqrt{\sum_{i=1}^{N} w_i{}'}} \qquad (34)$$

Here, N is number of pixels in watermark, wi is original watermark, wi' is extracted watermark. PSNR and NC in YCgCb and LUV Color Spaces are recorded in table1 and table 2 while comparative analysis shown in table 3. Experimental demonstration shows that better results are obtained for flexing factor k1=0.06. Maximum PSNR is obtained with L and U components which are 54.32. NC obtained with all components is 1 which implies that this technique extracts exactly same logo which was embedded in cover_image.

Fig. 7: Various components of 512x512 size Leena Image in YCgCb and YUV Color Space

Table 1: PSNR and NC in YcgCb Color Space

K1	Y		Cg		Cb	
	PSNR	NC	PSNR	NC	PSNR	NC
0.06	54.26	1	54.255	1	54.26	1
0.07	53.32	1	53.32	1	53.32	1
0.08	53.28	1	53.28	1	53.28	1

Table 2: PSNR and NC in LUV Color Spaces

K1	L		U		V	
	PSNR	NC	PSNR	NC	PSNR	NC
0.06	54.32	1	54.32	1	54.28	1
0.07	53.32	1	53.32	1	53.33	1
0.08	53.28	1	53.27	1	53.28	1

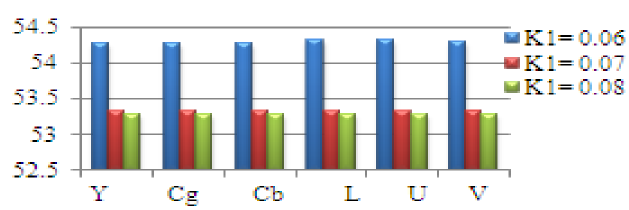


Table 3: Comparative analysis PSNR of YCgCb and LUV Spaces

VI. CONCLUSION AND FUTURE WORK

JPEG image compression standard has replaced DCT by DWT. Our technique is implemented using DWT including multilayer security which is implemented using Harris corner detection technique and Arnold transform. Kekre's YCgCb and LUV color spaces are used effectively to provide strong security and high robustness in criminal photograph detection and transmission across internet or mobile phones. Maximum PSNR 54.32 and NC reflect effectiveness and accuracy of this method. This paper implements provision of security for criminal photograph required during transmission form one location to other. The project can be further extended for PC (or LAN Server) to Mobile and Mobile to PC connectivity. The Technique presented here can be extended for videos' for authentication and copyright protection.

VII. ACKNOWLEDGMENT

This work is funded by Board of Colleges and University Development (BCUD), University of Pune with File Ref. No.-BCUD/OSD/390, dated 25/10/2010. We are thankful to BCUD, Pune for this support.

REFERENCES

[1] Mohamed Ali Hajjaji, Abdellatif Mtibaa, El-Bey Bourennane, "A Watermarking of Medical Image: Method Based LSB", Journal of Emerging Trends in Computing and Information Sciences, Vol.2, No.12, December 2011, 714-721.

[2] P.Bas,J.M. Chassery, B.Macq, "Geomet rically Invarient Watermarking Using feature Points", IEEETrans. Image Process, 11(9) (2002), 1014-1028.

[3] C.Harris and M.Stephens. "A Combined Corner and Edge Detector", Proc. Alvey Vision Conf., Univ. Manchester, pp. 147-151, 1988.

[4] Kekre, H.B.Thepade S.D, "Improving Color to Gray and Back using Kekre's LUV Color Space", Proceeding, IEEE Advance Computing International Conference, IACC, March 2009,Page(s): 1218-1223.

[5] H. B. Kekre, Sudeep D. Thepade, "Image Blending in Vista Creation using Kekre's LUV Color Space", In SPIT-IEEE Colloquium, SPIT Mumbai, INDIA, Feb 4-5, 2008.

[6] Guangmin Sun, Yao Yu, "DWT Based Watermarking Algorithm of Color Images", Second IEEE Conference on Industrial Electronics and Application", 2007, PP 1823-1826.

[7] Cheng-qun Yin et al, " Color Image Watermarking Algorithm Based on DWT-SVD", Proceeding of the IEEE International Conference on Automation and Logistiocs, August 18-21, 2007, Jinan, China, PP: 2607-2611.

[8] Guangmin Sun, Yao Yu, "DWT Based Watermarking Algorithm of Color Images", Second IEEE Conference on Industrial Electronics and Application", 2007, PP 1823-1826.

[9] Guangmin Sun, Yao Yu, " DWT Based Watermarking Algorithm of Color Images", Second IEEE Conference on Industrial Electronics and Application", 2007, PP 1823-1826.

[10] Wei-Min Yang, Zheng Jin, " A Watermarking Algorithm Based on Wavelet and Cosine Transform for Color Image", First International Workshop on Education Technology and Computer Science", 2009, pp: 899-903.

[11] B.L. Gunjal, R.R. Manthalkar, "Discrete Wavelet Transform Based Strongly Robust Watermarking Scheme for Information Hiding in Digital Images", Porceeding, IEEE Third International conference in Emerging Trends in Engineering and Technology, 19-21 November 2010 ,Goa, India. PP: 124-129.

[12] Wei-Min Yang, Zheng Jin, " A Watermark ing Algorithm Based on Wavelet and Cosine Transform for Color Image", First International Workshop on Education Technology and Computer Science", 2009, pp: 899-903.

[13] Baisa L. Gunjal, Suresh N. Mali, "Comparative Performance Analysis of DWT-SVD Based Color Image Technique in YUV, RGB and YIQ Color Spaces", in International Journal of Computer Theory And Engineering, Vol.3, No:6 ,December 2011, pp: 714-719.

Baisa L. Gunjal has completed M.Tech in I.T. and presently working as assistant Professor in Amrutvahini College of Engineer-ing Sangamner, A'nagar, MS, India. She has 14 years teaching experience and she is coordinator of seven postgraduate courses running in her college. She is also working on research project funded by BCUD, University of Pune and having more than 15 International publications including IEEE Explorer, IET-UK libraries etc.

Dr. Suresh N. Mali is Principal, Singhgad Institute of Technology and Science, Narhe, Pune, India. He has written 3 technical books and published 25 papers in various national and international journals and various conferences. He is Member of expert Committee of AICTE, New Delhi to visit at various newly opened institutes on behalf of for western region, BOS member for Computer Engineering at University of Pune, MS, India and worked as Member of Local Inquiry Committee on behalf of University of Pune. His areas of interest mainly include image processing and applications.