ISSN: 2321-7782 (Online)
Volume 3, Issue 9, September 2015
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Colored Image Watermarking: A Basis

Achintya Singhal[1]
Department of Computer Science,
Banaras Hindu University,
Varanasi, India

Kamred Udham Singh[2]
DST-CIMS
Banaras Hindu University,
Varanasi, India

Abstract: In order to protect copyrighted material, especially digital images, researchers have focused on the technique termed as digital watermarking. In the proposed paper, the basis of colored image watermarking is discussed followed by a basic technique for watermarking colored images have been proposed in transformed domain.

Keywords: DCT, PSNR Normalized Correlation, Image watermarking.

I. INTRODUCTION

The success of the Internet and digital consumer devices has profoundly changed our society and daily lives by making the capture, transmission, and storage of digital data extremely easy and convenient. However, this raises a big concern in how to secure these data and preventing unauthorized use. This issue has become problematic in many areas. For example, there are many studies showing that the music and video industry loses billions of dollars per year due to illegal copying and downloading of copyrighted materials from the Internet. Digital images, in particular, are one type of digital media that warrants extra attention. Researchers have focused on methods and algorithms to address this issue—digital watermarking. The basic idea is to embed some secret data in digital content that is to be protected, and "seal" it within the content.

A digital image is composed of a set of pixels, which can be conveniently captured by many electronic devices, such as digital cameras, scanners, and camcorders. Due to the ease of network connectivity and the proliferation of digital image capture devices, the access and sharing of images has become extremely feasible and convenient. However, some access and sharing may be unauthorized or illegal. Thus, digital image watermarking has become an active research area focused on battling these types of activities [7][10].

One of the main challenges of the watermarking problem is to achieve a better tradeoff between robustness and perceptivity. From an engineering perspective, these are two conflicting requirements that cannot be satisfied at the same time. Robustness can be achieved by increasing the strength of the embedded watermark, but the visible distortion would be increased as well. Since, image quality is one of the prominent factors; the strength of watermark cannot be increased significantly. To deal with this problem effectively, the characteristics of the HVS have to be considered thoroughly in order to increase the perceptivity.

II. HUMAN VISUAL SYSTEM AND COLOR THEORY

Human visual system is certainly one of the most complex biological devices far from being exactly described. But each person has daily experience of the main phenomena that influence the ability of the HVS to perceive (or not to perceive) certain stimuli. These above observations about HVS are:

1. Disturbances are less visible in highly textured regions than in uniform areas;
2. Noise is more easily perceived around edges than in textured areas, but less easily than in flat regions;
3. The human eye is less sensitive to disturbances in dark and bright regions or colors.

Color is the sensation caused by light as it interacts with the eye, brain, and our experience. The perception of color is also greatly influenced by nearby colors in the visual scene. The use of color in image processing is motivated by two principal factors. First, color is a powerful descriptor that facilitates object identification and extraction from a scene. Second, humans can discern thousands of color shades and intensities, compared to about only two dozen shades of gray [2].

A. Color Theory

Color is the perceptual characteristic of light described by a color name. Specifically, color is light, and light is composed of many colors—those we see are the colors of the visual spectrum: red, orange, yellow, green, blue, and violet. Objects absorb certain wavelengths and reflect others back to the viewer. We perceive these wavelengths as color.

A color is described in three ways: by its name, how pure or tainted it is, and its value or lightness. Although pink, crimson, and brick are all variations of the color red, each hue is distinct and differentiated by its chroma, saturation, intensity, and value. Hue is described as describing color: red, purple, blue, etc. Hue is more specifically described by the dominant wavelength in the color models. Chroma, intensity, saturation and luminance/value are inter-related terms and have to do with the description of a color. Shade, tint and tone are terms that refer to a variation of a hue. Color & Contrast terms refer to figure-ground relationships. This relationship between a subject or figure and its surrounding field (ground) will evidence a level of contrast; the more an object contrasts with its surrounds, the more visible it becomes.

B. The Spectral Basis for Color

Visible light, ultraviolet light, x-rays, TV and radio waves, etc are all forms of electromagnetic energy which travels in waves. The wavelength of these waves is measured in a tiny unit called the Angstrom, equal to 1 ten billionth of a meter. Another unit sometimes used to measure wavelength of light waves is nanometers (nm) which are equal to 1 billionth of a meter. Each of these wavelengths, from approximately 4000 Angstroms to 7000 Angstroms, is associated with a particular color response. For example, the wavelengths near 4000 Angstroms (400 nm) are violet in color while those near 7000 (700 nm) are red.

C. Color spaces

A color space specifies colors as tuple of (typically three) numbers that conforms certain specifications. Color spaces lend themselves to (in principle) reproducible representations of color, particularly in digital representations, such as digital printing or digital electronic display. One can describe color spaces using the notion: perceptual uniformity. Perceptually uniform means that two colors that are equally distant in the color space are perceptually equally distant [2]. Some of the commonly known color spaces are RGB color space, CMYK color space, HSV color model etc.

III. WATERMARKING BASIS

All Watermark Embedding in the transform domain offer many advantages including robustness against unintentional image processing attacks like brightness and contrast adjustment, gamma correction, filtering, blurring etc. It also shows resistance against compression. This is achieved by understanding and incorporating JPEG compression mechanism into watermark embedder. JPEG compression is based on discrete cosine transformation (DCT) and quantization. Discrete Cosine Transformation (DCT) [6] is a frequency domain transform action coding where a reversible, linear transform action is used to map an image into a set of transformed coefficients, which are then quantized and coded. In general, for the applications of image processing, the definition of two dimensional DCT, block-sized n×n, is given by:

$$F(u,v) = \sum_{j=0}^{n-1}\sum_{k=0}^{n-1} f(j,k)\alpha(u)\alpha(v) * \cos[\frac{(2j+1)u\Pi}{2n}] \cos[\frac{(2k+1)v\Pi}{2n}]$$

for u,v=0,1,. . . ,n;

$$\alpha(u),\alpha(v) = \begin{cases} \sqrt{\frac{1}{n}} & u,v=0 \\ \sqrt{\frac{2}{n}} & u,v=1,2,\ldots,n-1 \end{cases}$$

Here each transformed coefficient in an n×n DCT block is denoted as F(u,v).

Characteristic of DCT Coefficients

1. Magnitude of DC component of an 8x8 block DCT coefficient is proportional to the average grey level of the corresponding block [3].
2. Provides excellent signal approximation with few coefficients.
3. Frequency components are ordered in a sequential order, starting with low frequency, mid frequency and high frequency components. Proper components can be selected based on this.
4. If most of the high frequency coefficients that are zero then it represents a smooth blocks [4].
5. If the low frequency AC coefficients have large absolute values they normally refer to an edge blocks [4].
6. It is faster and can be implemented in O (n log n) operations.

Embedding in the transform domain by modifying the DCT coefficients offer many advantages including robustness against unintentional image processing attacks like brightness and contrast adjustment, gamma correction, filtering, blurring etc. It also shows resistance against compression. Another advantage of using DCT for watermarking is the extensive study of human visual system in this domain, so watermarking can be more adaptive to HVS in this domain [5][8].

IV. Model For Colored Image Watermarking And Evaluation Metrics

All the colored images can be represented in set of three distinct images. Each image will correspond to Red component, Green component and Blue component of the image respectively. These components can be converted to any color space i.e. HSI, YCbCr, CMY etc. subjected to better watermarked image quality and sustainability to attacks. The values of each component at each pixel can be approximated as a discrete quantity. The value of each component can be in the range either in [0,255], if represented in integer or in [0, 1], if represented in double.

The original image will be partitioned into equally spaced compartments that can accommodate the watermark uniformly. The compartmentalization will ensure that the watermark is being embedded throughout the image universally and multiple copies of it being embedded. This will provide resistance to cropping as some distinguishable traces of the watermark can still be recovered. Each image compartments are subjected to discrete cosine transformation. The watermark to be inserted is also subjected to same compartmentalization and transformation for better embedding results. Once the embedding is done, the reverse process for re-generation of image is followed i.e. inverse DCT transformation, conversion from the used color model back to RGB and then joining of RGB components to generate the watermarked colored image.

For watermark retrieval, original image and watermarked image both are required. Both the images are subjected to component breaking, identifying the blocks where watermark is embedded, if any as per the algorithm, DCT transformation and finally extracting the watermark.

For evaluating the quality [11] of the generated watermarked image against the original image, following metrics are used:

» PSNR (Peak Signal to Noise Ratio).

» PSNR-HVS (Peak Signal to Noise Ratio with DCT & Contrast Sensitivity Factor) [1].

» NC (Normalized Correlation)

Universal Image Quality Index, Q, a new image quality index that considered being a step towards human visual system model [9].

V. ALGORITHM

a) Watermark Insertion

Input	a $2^n \times 2^n$ original image, F; a $2^w \times 2^w$ watermark, W, to be embedded where w << n
Output	a signatured image, F'
Step 1	Divide the image and the watermark into equi-sized blocks in RGB color space (8x8).
Step 2	Watermark is redundantly embedded to blocks in layers using frequency domain transformation $F'_T(u, v, i) = F_T(u, v, i) + \alpha \times W_T(x, y, i)$ where X_T =transform(X) u, v=0,1,. . . ,n; x, y=0,1,...,w; $i \propto layers$; α is strength
Step 3	Watermarked image is generated by inverse transforming F'_T

b) Watermark Extraction

Input	a $2^n \times 2^n$ original image, F; the signatured image, F', $2^n \times 2^n$.
Output	a $2^w \times 2^w$ watermark, W, that to be extracted where w << n.
Step 1	Divide the original image and the watermarked image into equi-sized blocks (8 x 8).
Step 2	Convert watermarked image (F') and original image (F) into transform domain F'_T and F_T respectively.
Step 3	Watermark is extracted from the image using frequency domain transformation $W_T(x, y, i) = \{F'_T(u, v, i) - F_T(u, v, i)\} / \alpha$ where F_T =transform(F) u,v=0,1,. . . ,n; x,y=0,1,. . . ,w; $i \propto layers$; α is strength as calculated in algorithm 1.
Step 4	Watermark is regenerated by inverse transforming the extracted watermark.

VI. RESULTS AND DISCUSSION

The proposed model had been deployed to the images and studied the outcome of it for the verification of the model. The results depict multiple copies, high quality watermark retrieval.

Original Image Watermarked Image

NC	0.9998
Q	0.9958
PSNR	34.697db
PSNR-HVS	90.046db

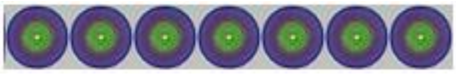
watermark extracted

Extracted watermark from JPEG compressed image (100% quality)

Extracted watermark from JPEG compressed image (70% quality)

Original Image Watermarked Image

NC	0.9992
Q	0.9917
PSNR	34.65db
PSNR-HVS	87.633db



watermark extracted

Extracted watermark from JPEG compressed image (100% quality)

Extracted watermark from JPEG compressed image (70% quality)

VII. Conclusion

The proposed algorithm embeds watermark uniformly throughout the image thus achieving high number of insertions. Multiple insertions help against cropping attack. The extracted watermark from an unhampered image is of high quality and sustenance against to JPEG compression is quite significant. The mechanism can also be deployed with text watermarks.

References

1. Egiazarian, K., Astola, J., Ponomarenko, N., Lukin, V., Battisti, F., and Carli, M. (2006). New full-reference quality metrics based on HVS. Proceedings of the Second International Workshop on Video Processing and Quality Metrics, Scottsdale, 4 p.
2. Gonzales, R. C., and Woods, R.E., (2002). Digital image processing. Prentice-Hall, Inc., New Jersey, 2nd edition.
3. Huang, J., Shi, Y.Q., Cheng, W., (2000). Image watermarking in DCT: An embedding strategy and algorithm. Acta Electronica Sinica, vol. 28 (4), pp. 57–60.
4. Jellinek, B., (2000). Invisible watermarking of digital images for copyright protection. Thèse, University of Salzburg, Australia.
5. Li, X., and Xue, X. (2004). Improved robust watermarking in DCT domain for color images. Proceedings of the 18th International Conference on Advanced Information Networking and Application, AINA'04, vol. 1, pp. 53–58.
6. Rao, K. R., and P. Yip (1990), Discrete Cosine Transform: Algorithms, Advantages, Applications, New York: Academic Press.
7. Ruanaidh, J.J.K.Ó., Dowling, W.J., and Boland, F.M. (1996, August). Watermarking digital images for copyright protection. IEE Proceedings on Vision, Signal and Image Processing, vol. 143(4), pp. 250–256.
8. Tang, W., and Aoki, Y. (1997). A DCT-based coding of images in watermarking. Proceedings of International Conference on Information, Communications and Signal Processing, ICICS97, vol. 1, pp. 510–512.
9. Wang, Z., and Bovik, A.C. (2002). A Universal Image Quality Index. IEEE Signal Processing Letters, vol. 9(3), pp. 81–84.
10. Woda, K., and Seitz, J. (2002). The role of digital watermarking to the protection of rights for digital media assets. Proceedings of the fifth International Conference Business Information Systems BIS 2002, pp. 107–112.
11. Zhihui, W., and Liang, X. (2000, July). An evaluation method for watermarking techniques. IEEE International Conference on Multimedia and Expo, ICME 2000, vol. 1, pp. 373–376.