Realtime Energy Efficient Digital Image Watermarking on Mobile Devices using Android

Durgansh Sharma *durgansh.sharma@jaipuria.ac.in*
Ph.D. Student, UPES, Dehradun India
Asst. Professor, Jaipuria Institute of Management, Noida, India

Manish Prateek *mprateek@ddn.upes.ac.in*
Professor, Centre For Information Technology,
College of Engineering Studies, UPES, Dehradun, India

Tanushyam Chattopadhyay *t.chattopadhyay@tcs.com*
Senior Scientist, R&D, Innovation Lab,
Tata Consultancy Services, Kolkata, India

Abstract

This paper proposes a real time and energy efficient image watermarking scheme using DCT – DWT hybrid transformation. The proposed method is using a 2 – level of quantization on the Y component of true color image captured in real time and low frequency band coefficients are selected for the dataset prepared of size 256 * 10 using these coefficients, which is supplied to Extreme Learning Machine (ELM) a single layer feed forward network. A normalized column vector of size 256 * 1 is generated by ELM for its usage as key sequence for embedding the watermark. This hybrid transforms provide a better imperceptibility and reduction in the time taken by entire watermarking process i.e. within a second, makes it energy efficient and suitable for the proposed smart phone android app for a real time image watermarking.

Keywords: Real Time, Smart Phone, Android, Image Watermarking, Extreme Learning Machine (ELM), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT).

1. INTRODUCTION

Exponential rise in generation and sharing of digital images using smart phones has created an influx of multimedia data, which needs to be processed, stored, and transmitted on battery operated mobile devices. Rights and validation of this data has been a major challenge, where mobile devices with converged multimedia features, content authorization and ownership of an image has raised an issue of immense concern in this era of data explosion, for which the authors propose a real time and energy efficient digital watermarking technique to embed and extract watermark for digital images using the android based mobile platform. Growth of mobile phones and wearable mobile devices has outnumbered the growth pattern of laptop and desktop PCs. They are growing on a fast pace, and providing infinite data streams to deal with. Current mobile devices are the perfect example of convergence of all features required for any ICT application. Mostly, the data captured and shared using social media is in the form of photos and images. The problem was to create energy efficient image watermarking technique for mobile phone with various resource constraints mainly battery and time to execute for an application. Proposed model shows fast and energy efficient technique for watermark embedding and extraction from images, thus, signifying a great potential in designing futuristic intelligent mobile devices.

2. REVIEW

Immense research work has been done in the field of image watermarking. The authors found an interesting and upcoming research work done by Miao, N. et al.[16] by creating an android based app ‘hymnmark’ for offline image watermarking. It has supported while extending the work for real time image watermarking, which needs a technique of fast processing for the same, the research work by Mishra, A. et al.[3] for hybrid transform using DCT-DWT including ELM for a fast algorithm has raised the scope of its usage in mobile devices. Another research work by Sharma, D. et al. [2] which has used fuzzy logic to incorporate HVS while image watermarking in gray scale images with an updated algorithm was designed to work upon color images in the realtime using Simulink and webcam Sharma, D. et al.[1] its real time watermarking is further enhanced and applied in the proposed paper.

Research work proposed by Madhesiya, S. et al.[4], Rajab, L. et al.[8] and Liu, R. et al.[12] showcased other efficient way of factorization used in the watermarking techniques through singular value decomposition (SVD), Rajab, L. et al.[8] has also provided the scope of color image watermarking by performing the video watermarking using SVD. Ramamurthy, N. et al.[5] and Isac B. et al.[6] enhanced the techniques of image and video watermarking using Fuzzy Logic and Neural networks. Lin, T. C. et al.[7] has given an insight regarding wavelet based copyright protection for images. Huang, G. B., et al.[10,11] has provided the way of fast learning using Single Layer Feed forward Network (SLFN) commonly known as Extreme Learning Machine, it has become the most useful means for this study as realtime learning on a mobile phone platform is essentially needed to be fast.

The concept hidden image copyright labeling provided by Koch, E. et al.[13] is used by the author in this research work of real time image watermarking using the most important concept of Kejariwal, A. et al.[9] has provided the concept of energy efficient image watermarking using mobile devices and Miao, N. et al.[16] showcased the runtime watermarking technique using Android platform in the mobile devices.

Discrete Cosine Transformation (DCT) and Discrete Wavelet Transformation (DWT) [2,3,4] are used for image transformation from spatial domain to the frequency domain where signal processing for the watermarking process could be done on host image. Extreme Learning Machine (ELM) [3] is designed with a Single hidden Layer Feed forward Network (SLFN) architecture. The results acquired by using ELM are having a good accuracy and computationally extremely fast as compared with Back Propagation (BP) based algorithms. Android [21] is an open-source software stack for a wide range of mobile devices and a open-source project led by Google. Digital image watermarking is a technique to embed any information in an image to prove confidentiality and ownership in a covert manner. It aims for imperceptibility and robustness as a part of its process.

3. MODELING & ANALYSIS

In continuation to the work done by author, the next step comes out to be incorporation and implementation of the proposed model [1]. Initially, android based mobile “LG Optimus P970” was narrowed down to be used as the hardware component because of its good camera handling capabilities. The camera App namely CameraPHD labeled as “Next Gen Cam!” was initially designed for the purpose of real time image watermarking for Android Froyo (2.2) available in the hardware device, then upgraded to Android Gingerbread (2.3) and finally to Ice Cream Sandwich (4.0).

The image captured by the camera aperture of any android mobile phone through the “Next Gen Cam!” will be processed through the algorithm designed by author for real time energy efficient image watermarking. In this work Koch’s algorithm [13] is used as a base for the workflow design due to low power consumption and small execution time which further supports in real time performance of the proposed work.

Embedding process comprises of the Host image captured in real time, information needed to embed as watermark and key for the positioning of watermark. The captured host image is loaded for color space transformation into YUV instead of RGB, as Y component is used for the embedding digital watermark. The proposed method is using DWT for 2 – level of quantization on the Y component of true color image converted from the RGB image captured in real time.

Equation 1: RGB to YUV Conversion

$$\begin{bmatrix} Y' \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.14713 & -0.28886 & 0.436 \\ 0.615 & -0.51499 & -0.10001 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Flow Chart for Watermark Embedding

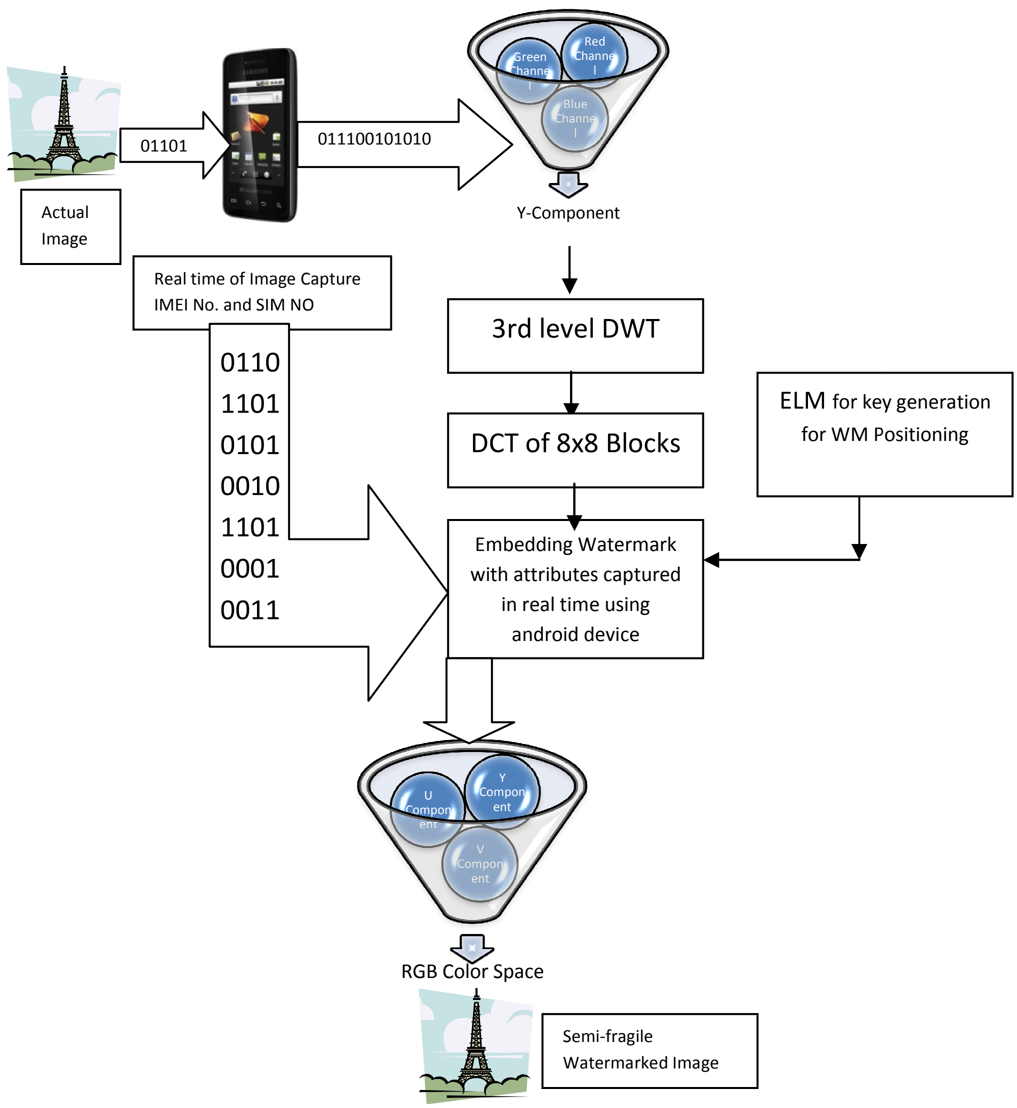

FIGURE 1: Watermark Embedding.

Its low frequency band coefficients are selected for the dataset prepared by DCT of 8x8 blocks integrating to the size 256 * 10 using these coefficients, which is supplied to Extreme Learning

Machine (ELM) a single layer feed forward network. The ELM produces a normalized column vector of size 256 * 1 to be used as key sequence for embedding the watermark consisting of attributes like time of capturing the image, IMEI No. of mobile device, SIM No. of the first carrier captured in real time using the camera app installed in any android mobile device. Further, once the watermarked image is created after embedding process, it leads towards de-quantization and inverse DCT (IDCT) of every block. It is needed to multiplex the embedded blocks to create the Y-component layer and loaded for color space transformation from YUV to RGB to get watermarked image.

Equation 2: YUV to RGB Conversion

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1.13983 \\ 1 & -0.39465 & -0.58060 \\ 1 & 2.03211 & 0 \end{bmatrix} \begin{bmatrix} Y' \\ U \\ V \end{bmatrix}$$

Flow Chart for Watermark Extraction

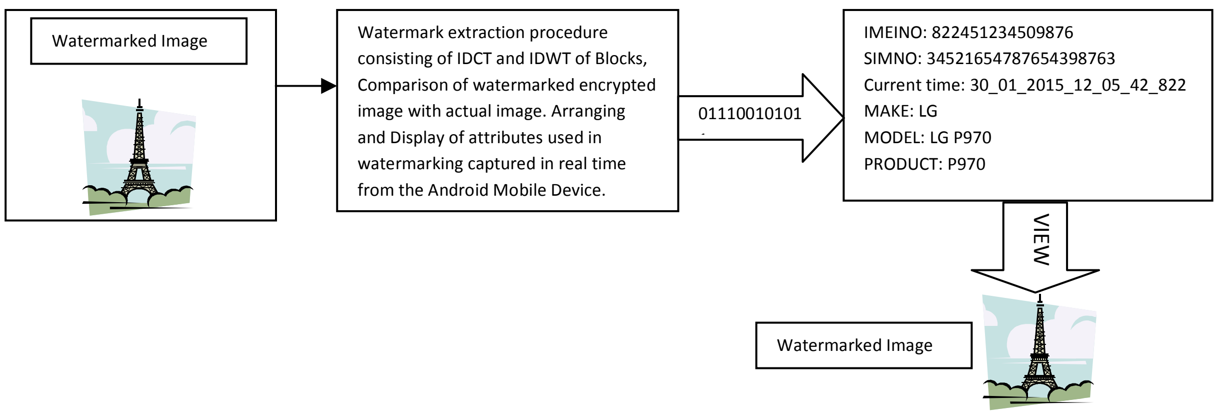

FIGURE 2: Watermark Extraction.

4. RESULTS

Analysis of Time complexity and Energy Efficiency and steps used in image watermarking using Camera App designed by the author are mentioned as following steps:

Initialization: Landing Interface or Layout of Camera App (Fig. 3).

Step 1: Screen after clicking Retrieve Information (Fig. 4)
Step 2: This Screen is shown after clicking File Explorer to showcase the path of image saved. (Fig. 5)
Step 3: If you click Original Image for Retrieval, you won't find any watermark and above information screen will be showcased. (Fig. 6)
Step 4: If encrypted image is clicked for retrieving watermark, you find above information screen showcasing the watermark embedded in the image. (Fig. 7)
Step 5: Once you click "View" you will be able to see the watermarked image. (Fig. 8)
"Original Image" (Fig. 9), Watermarked Image (Fig. 10) for the following energy consumption results by the camera app. Storage path for saving captured and watermarked images. 4th Col, 2nd Row indicates the name of folder "durgansh camera" (Fig. 11).

Results for Energy Consumption calculated by Android App for Real-time system and application power monitor "PowerTutor" referred from [16].

- Overall Energy Consumption by CameraPHD is **34.4 J** (Fig. 12)
- Energy Consumption by CameraPHD for for LCD usage is **31.5 J** (Fig. 13)

- Energy Consumption by CameraPHD for CPU usage is **2.9 J** (Fig. 14)

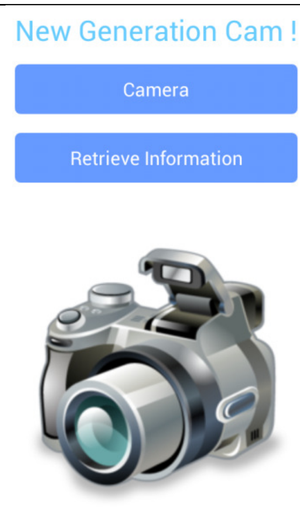

Figure 3: Landing Layout

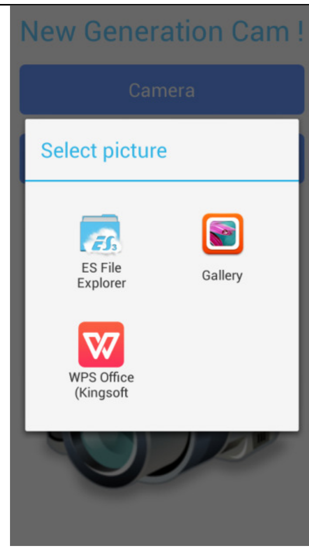

Figure 4: Step 1

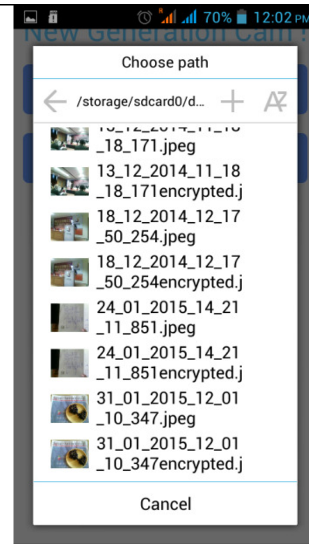

Figure 5: Step 2

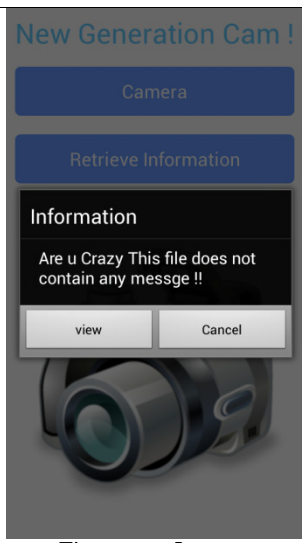

Figure 6: Step 3

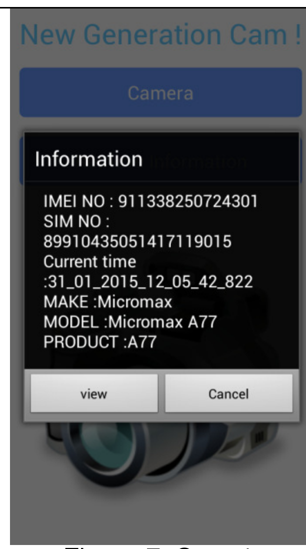

Figure 7: Step 4

Figure 8: Step 5

Figure 9: Original Image

Figure 10: Watermarked Image

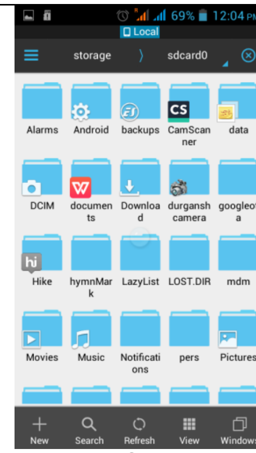

Figure 11: Storage Path

Figure 12: Overall Energy Consumption by Camera App

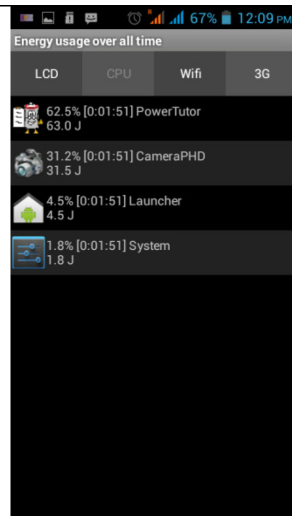

Figure 13: Energy Consumption by LCD for Camera App

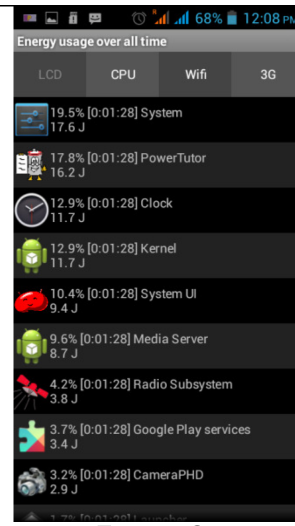

Figure 14: Energy Consumption by CPU for Camera App

5. CONCLUSION

The camera App is successfully tested and working in Android Jelly Bean 4.2.2 providing energy efficient and realtime image watermarking of the ownership credentials which can be extracted using the application installed.

6. FUTURE SCOPE

This research work of energy efficient and real time image watermarking in mobile devices could be further enhanced for various upcoming versions of Android and Models of next generation camera enabled android devices. Extraction of the image watermark could be made generic where essential credentials once provided through cloud services can extract the necessary information from the encrypted image for proving the ownership of the image. This research work could be used in various other camera oriented applications.

7. REFERENCES

[1] Sharma, D., Prateek, M., & Chattopadhyay, T. (2014). DCT and Simulink Based Realtime Robust Image Watermarking. International Journal of Image Processing (IJIP), 8(4), 214-219.

[2] Sharma, D., Prateek, M., & Chattopadhyay, T. (2014). DCT Based Fuzzy Image Watermarking. Global Journal of Enterprise Information System (GJEIS), 6(2), 90-95.

[3] Mishra, A., & Goel, A. (2014). A Novel Image Watermarking Scheme using Hybrid DWT-DCT-ELM Technique. International Journal of Computer Applications, 98(18), 28-33.

[4] Madhesiya, S., & Ahmed, S. (2013). Advanced Technique of Digital Watermarking based on SVD-DWT-DCT and Arnold Transform. International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), 2(5), pp-1918.

[5] Ramamurthy, N., & Varadarajan, D. S. (2012). Robust Digital Image Watermarking Scheme with Neural Network and Fuzzy Logic Approach.International Journal of Emerging Technology, Advanced Engineering, 2(9).

[6] Isac, B., & Santhi, V. (2011). A study on digital image and video watermarking schemes using neural networks. International Journal of Computer Applications, 12(9), 1-6.

[7] Lin, T. C., & Lin, C. M. (2009). Wavelet-based copyright-protection scheme for digital images based on local features. Information Sciences, 179(19), 3349-3358.

[8] Rajab, L., Al-Khatib, T., & Al-Haj, A. (2009). Video watermarking algorithms using the SVD transform. European Journal of Scientific Research, 30(3), 389-401.

[9] Kejariwal, A., Gupta, S., Nicolau, A., Dutt, N. D., & Gupta, R. (2006). Energy efficient watermarking on mobile devices using proxy-based partitioning. Very Large Scale Integration (VLSI) Systems, IEEE Transactions on, 14(6), 625-636.

[10] Huang, G. B., Zhu, Q. Y., & Siew, C. K. (2006). Extreme learning machine: theory and applications. Neurocomputing, 70(1), 489-501.

[11] Huang, G. B., Zhu, Q. Y., & Siew, C. K. (2006). Real-time learning capability of neural networks. Neural Networks, IEEE Transactions on, 17(4), 863-878.

[12] Liu, R., & Tan, T. (2002). An SVD-based watermarking scheme for protecting rightful ownership. Multimedia, IEEE Transactions on, 4(1), 121-128.

[13] Koch, E., & Zhao, J. (1995, June). Towards robust and hidden image copyright labeling. In IEEE Workshop on Nonlinear Signal and Image Processing (pp. 452-455). Neos Marmaras, Greece.

[14] D. Sharma, M. Prateek, T. Chattopadhyay, “Optimized Robust Image Watermarking”, Proceedings of 4th International Conference on Emerging Trends in Engineering & Technology, October 25th-27th, 2013, IETET (2013), pp 99-106.

[15] Mishra, A., Goel, A., Singh, R., Chetty, G., & Singh, L. (2012, June). A novel image watermarking scheme using extreme learning machine. In Neural Networks (IJCNN), The 2012 International Joint Conference on (pp. 1-6). IEEE.

[16] Miao, N., He, Y., & Dong, J. hymnMark: Towards Efficient Digital Watermarking on Android Smartphones.WORLDCOMP’12, ICWN’12: 2012, pp348-355

[17] Agarwal, C., Mishra, A., & Sharma, A. (2011, May). Digital image watermarking in DCT domain using fuzzy inference system. In Electrical and Computer Engineering (CCECE), 2011 24th Canadian Conference on (pp. 000822-000825). IEEE.

[18] R.C. Gonzalez, R.E. Woods and S.L. Eddins, Digital Image Processing Using MATLAB, Pearson Education (2005), pp 406 and 467.

[19] http://www.extreme-learning-machines.org/

[20] http://www.ntu.edu.sg/home/egbhuang/elm_codes.html

[21] http://source.android.com/

[22] http://developer.android.com/guide/topics/media/camera.html