Asian Journal of Applied Science and Technology (AJAST)
(Open Access Quarterly International Journal) Volume 2, Issue 1, Pages 196-204, 2018

Integer to Integer Wavelet Transform Based Watermarking Scheme for Fusion of Visual and Thermal Images

Keerthanaa R[1], Madhumitha R[2] and Mathankumar K[3]

[1,2,3]*Sree Sowdambika College of Engineering, India.*
Email Id: keerthanaaramesh24@gmail.com , madhumitharavindhran25@gmail.com , mk.mathankumar@gmail.com

Article Received: 27 November 2017 *Article Accepted: 24 January 2018* *Article Published: 29 March 2018*

ABSTRACT

Thermography is a noninvasive methodology for getting the thermal profile of a subject in the analysis and surgical systems. The superimposition of thermograms with comparing visual picture of the subjects is a system took after by clinicians to relate the thermal picture with the surface life structures to limit the ailing parts. Validation is a basic security viewpoint in medicinal services frameworks to dodge restorative blunders. This paper centers around the combination and confirmation of thermograms. The Integer to Integer watermarking framework proposed in this paper exhibits a watermarking plan that inserts the visual facial picture of the patient inside the facial thermogram in an undetectable way to both confirm and to ensure the protection of the patient. The watermark is extricated later to distinguish the patient and to produce a composite picture for cross reference. The exploratory outcomes shown for the test images exhibit the adequacy of the proposed system.

Keywords: Thermogram, authentication, overlay, reversible watermarking.

1. INTRODUCTION

Therapeutic thermography is a non-obtrusive method utilized in the pre-clinical determination of numerous clutters. The proficiency and effortlessness of the thermographic frameworks empower their acquisitions of various body parts and subsequent transmission to remote specialists and social insurance experts. Being a noninvasive and an easy method, thermography has picked up notoriety among the doctors in screening pathologies. Authentication is a vital security perspective in the exchange of pictures between healthcare providers.

The cost of restorative mistakes due to mistaken patient recognition has been extravagantly talked about in various investigations particularly, illustrating a case history by Leslie [1]. It emphasizes the usage of bar coding and radio frequency devices, for patient identification and deploying systems for patient authentication. A research with the radiology [2] experts has shown that, including the photograph of the patient along with the radiology images creates empathy on the patient and improves the diagnosis. Hence, the proposed work is focused on authentication of thermograms with visual images of corresponding subjects. The proposed system embeds the facial thermograms of a subject with that of the visual facial image.

The visual image serves as a watermark for authentication of the thermogram upon extraction and for alignment with the thermogram to localize the pathology. The proposed system is implemented in the wavelet domain employing Integer to Integer transform. The rest of the paper is organized as follows. The background of the proposed work is presented in Section 2. The proposed system is described in detail in Section 3. The experimental results and discussion are described in Section 4 and Section 5 respectively. The paper is concluded in Section 6 followed by references.

2. BACKGROUND

2.1 Thermal Image Fusion

This section gives a succinct overview of medical image fusion schemes proposed by various researchers. Toet, A., et al. [3] have introduced an image fusion method intended for human observation. The composite images produced by this method preserve the details, most relevant to visual perception. Bebis et al. [4] have presented and compared two different fusion schemes to combine IR and visible imagery for face recognition. The first one is pixel-based and operates in the wavelet domain, while the second one is feature-based and operates in the Eigen space domain. The outcomes of this work testify that IR and visible imagery combination is a suitable approach for pathology localization.

According to Hanif, M., & Ali, U. [5] image fusion techniques employing Gabor filter for face recognition can measure the effectiveness of the fusion. A comparative study of thermal face recognition methods is presented by Seal, A. et al. [6] in which, two local-matching techniques, one based on Haar wavelet and the other based on Binary Pattern are analyzed. These methods are used to extract features from the cropped images. Then Principal Component Analysis (PCA) is performed on the individual feature set for dimensionality reduction. Finally, two different classifiers, a multi-layer feed forward neural network and minimum distance classifier are used to classify face images.

Alldieck et al. [7] have proposed a method to observe the activity scene utilizing a few sensors, from various modalities. It combines RGB and thermal video streams data from the recordings and the accessible logical data of a scene. Ban et al. [8] have made an extensive research on smartphone-based thermal imaging and assessed for its utility in the identification of peritonsillar abscesses. The paper presented by Dai et al.[9] demonstrates the combination of X-ray and CT images, taking the cerebral infraction-endured patients' pictures as case. It is shown that intertwined picture not just has wealthier points of interest yet additionally more obviously features the sores of cerebral dead tissue.

Muhammad et al. [10] focus on the reversible blind data hiding method to increase the privacy and security employing both cryptography and steganography. Their technique utilizes Fresnelet transform to create an unintelligible representation of the secret image data to be embedded in the cover image. Then the secret data and the original image are retrieved blindly and reversibly in the retrieving phase without the original cover image.

2.2 Wavelet-based Image Fusion

More recently, with the development of wavelet theory, people began to apply wavelet multiscale decomposition to take the place of pyramid decomposition for image fusion. Wavelet transform can be taken as one special type of pyramid decompositions. It retains most of the advantages for image fusion but has much more complete theoretical support. The block diagram of a generic wavelet-based image fusion scheme is shown in Figure 1. Wavelet transform is first performed on each source images then, the fusion decision map is generated based on a

set of fusion rules. The fused wavelet coefficient map can be constructed from the wavelet coefficients of the source images according to the fusion decision map. Finally the fused image is obtained by performing the inverse wavelet transform.

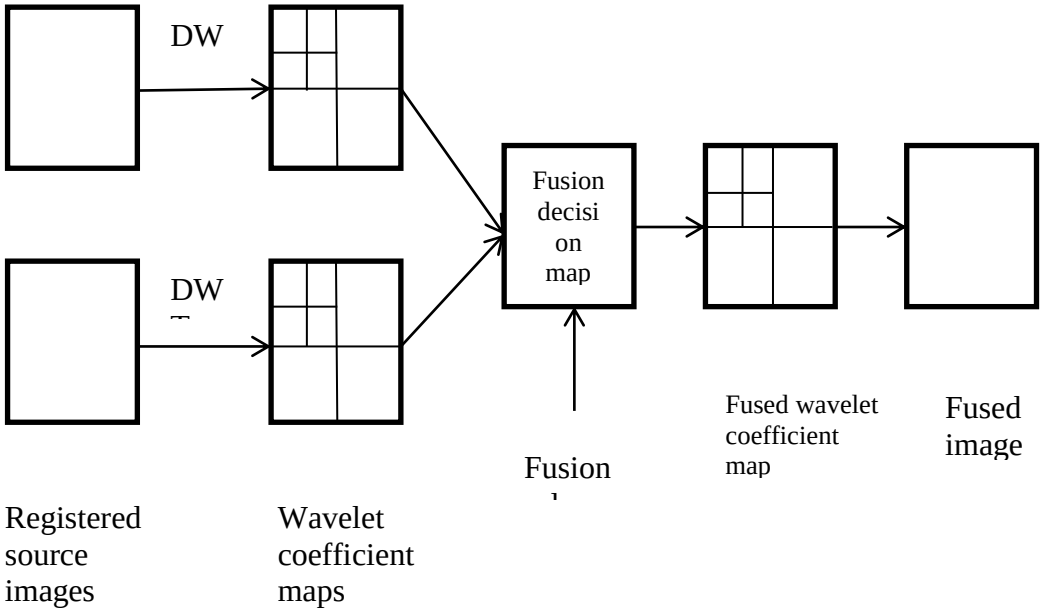


Figure.1.Block diagram of a generic wavelet-based image fusion approach

3. PROPOSED SYSTEM

The proposed system applies Integer Wavelet Transform (IWT) on the candidate visual and thermal images and combines the coefficients to generate the fused image. At the other end, the visual and thermal images are extracted back from the fused image by inverse IWT. The schematic of the proposed system is given in Figure.2.

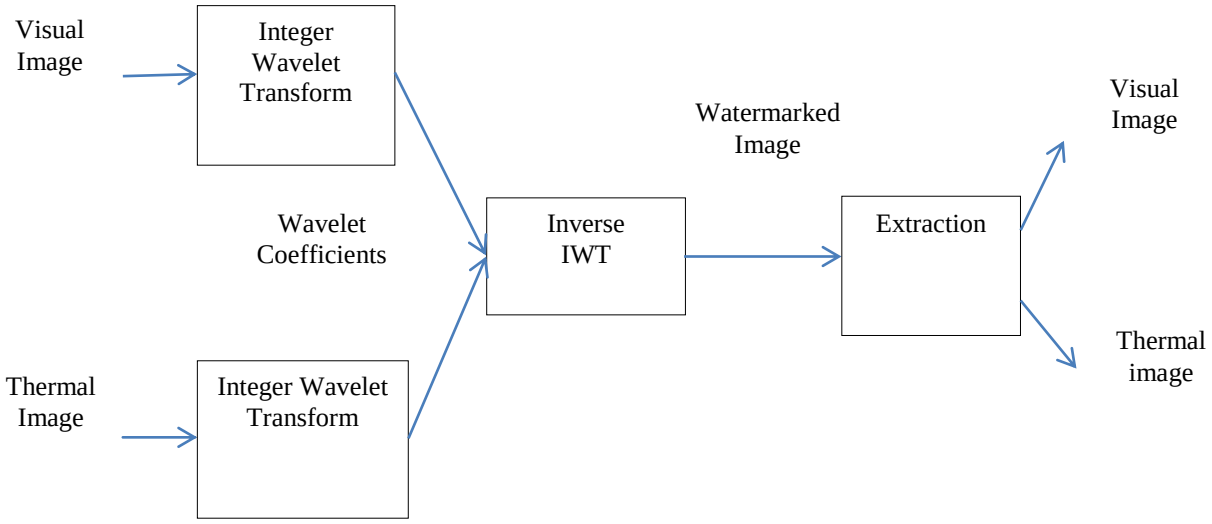


Figure.2.Proposed System

3.1 Detailed Architecture

The detailed architecture for image fusion is given in Figure .3. The visual and thermal images are subjected to two-level IWT. The coefficients in the LL, LH, HL and HH coefficients of the thermal image are combined with that of the visual image to generate the watermarked image.

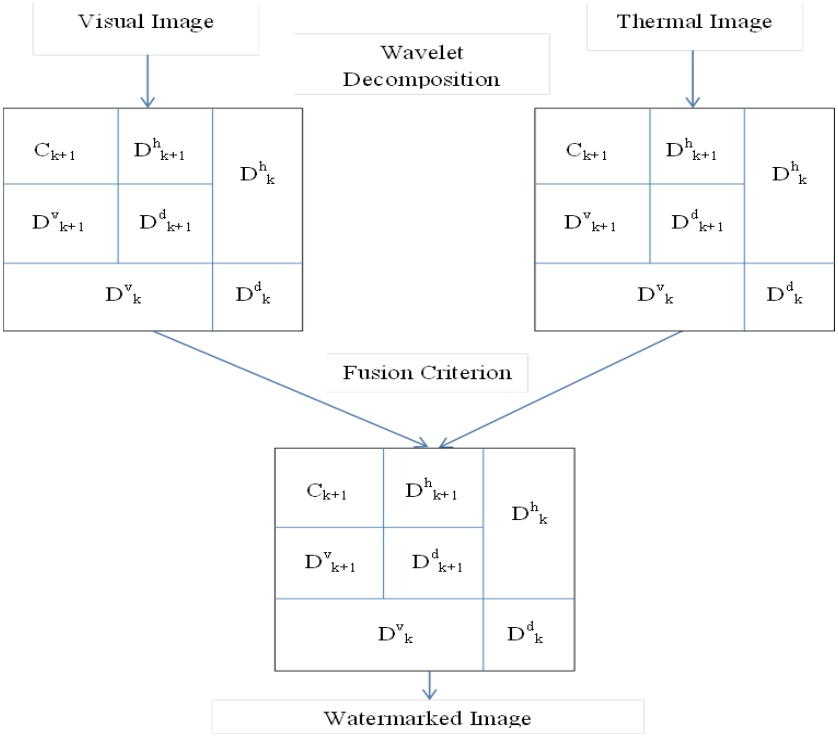


Figure.3. Detailed Architecture-Watermarking

The algorithm for watermark embedding and extraction and superimposition are given in subsections 3.2 and 3.3 respectively.

3.2 Watermark Embedding and Extraction

The algorithms are based on the application of a triangular number generator function. A Triangular Number Generator (TNG) is a function as in (1) which uniquely encodes a pair of integers (a,b) into a triangular number T. The number T can be factored back to a and b exactly by applying the extraction procedure. We are exploiting this reversible and blind nature of the TNG in our algorithm.

$$T = f(a,b) = [(a+b)\text{^}2 + 3a + b]/2 \quad (1)$$

Any integer encoded with TNG function can be factored back into (a,b) pair as shown in Equations (2) to (4).

$$C = [sqrt(8T + 1) - 1] / 2 \quad (2)$$

where $C = a + b$

$$a = T - C(C+1)/2 \quad (3)$$

$$b = C(C+3)/2 - T \quad (4)$$

From the Equations (2) to (4), it is seen that a and b are recovered from T without any side information. Watermark embedding is performed by combining n number of LSB planes of the

thermal and visual images by (1). As the combination leads to an integer whose magnitude cannot be expressed in n bits, modulo n operation is performed on the resultant integer. While the n remainder is appended with 8-n bit planes, the quotient is preserved as a key. Similarly, on watermark extraction, the combination is reconstructed by combining the key and the n LSB planes of the watermarked image. The watermark embedding and extraction algorithms are given assuming n=4.

Watermark Embedding
1. Extract 4 MSBs and 4 LSBs of Thermal Image to form matrices MSBT and LSBT
2. Extract 4 MSBs of Visual Image to form a matrix MSBV and shift it right 4 times
3. Combine LSBT & shifted MSBV using triangular number generator to form matrix TR
4. Perform Modulo 16 arithmetic operation on TR to generate remainder and quotient matrices RemTR and QuoTR respectively
5. Combine MSBT and RemTR to form the watermarked image WMI; preserve QuoTR

Watermark Extraction
1. Extract 4 MSBs and 4LSBs of the watermarked image to form matrices MSBTR and LSBTR respectively; LSBTR is RemTR
2. Multiply key/quotient matrix QuoTR by 16 and add the resultant matrix with RemTR to recover matrix TR
3. Extract the LSBT & shifted MSBV from TR; Left shift MSBT 4 times to extract the watermark
4. Combine with LSBT with MSBWMI to recover the Thermal image

3.3 Superimposition of Visual and Thermal Images

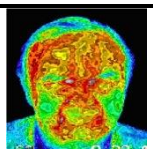
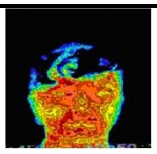
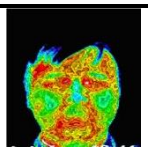
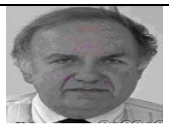
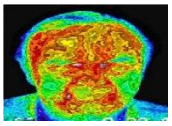
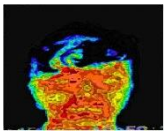
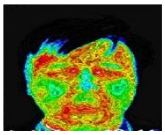
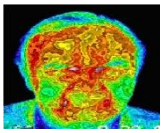
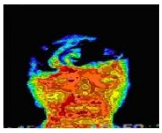
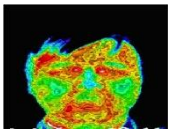
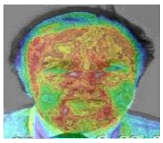
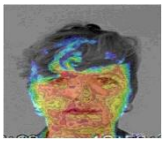
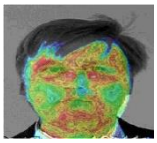
The overlay of visual and thermal images is constructed by computing the weighted summation of the intensity values of the thermal and visual image pairs. As the purpose of fusion is to localize the area of pathology in the human anatomy, the pixel intensity values of the thermal and visual images are scaled down by a factor α and β respectively. The resultant value is added with the pixel intensity value in the same spatial orientation of the visual image to get the composite intensity value.

Thermal and Visual Image Overlay
1. Select a bit plane of the Thermal Image T and Visual Image V
2. Select the value of α
3. Compute Overlay(i,j)= T(i,j)* α + V(i,j)* β for each pixel position (i,j)
4. Repeat steps 1 to 3 for all 3 color planes of the Thermal and Visual images
5. Combine the 3 color planes of Overlay to generate the composite image

4. EXPERIMENTAL RESULTS

We have implemented our algorithms with the visual and thermal images from the Science Photo Library produced by Mikos Biotek in Virginia, USA. All the images are of the size 512x512x3. The results are illustrated with performance metrics in Table 1 as below. The quality of the recovered watermarks and reconstructed images are evaluated with the Peak Signal to Noise Ratio (PSNR) and that of composite images is evaluated with the Feature Mutual Information (FMI).

Table1.Test Images and Performance Metrics

Image Type / Images with Performance Metrics			
Thermal Image			
Visual Image			
Watermarked Image with PSNR in dB	 42.173	 42.521	 41.476
Extracted Watermark PSNR in dB	 36.781	 37.154	 36.901
Recovered Thermal Image with PSNR in dB	 35.071	 36.015	 37.013
Composite Image with FMI	 0.9098	 0.9122	 0.9275

The composite images are given in the last row of the tables. In our experiments we have assumed $\alpha = 0.5$ and $\beta = 0.5$ invariably for all images.

5. DISCUSSION

It is evident from the experimental results that the proposed system provides authentication of the thermogram for patient identification without ambiguity. The PSNR values of the watermarked images are around 36 dB for all the

images which is the universally agreed value for medical images. Further, the PSNR values of the reconstructed thermal image and the extracted watermarks signify the meticulous recovery of the original image and the intactness of the watermark. Similarly, the FMI values clearly indicate that reasonable quality is possessed by the overlays. This system provides a good degree of freedom to highlight the visual or thermal component in the composite image. In addition to the above, the method for superimposition presented in the paper seems to be a promising one for generating the overlays as separate registration of images is not a prerequisite for superimposition.

6. CONCLUSION AND FUTURE WORK

In this paper, we have proposed an Integer to Integer wavelet transform based watermarking scheme for authenticating the thermograms which also facilitates the construction of a perfect overlay of the thermal and visual images. From test results, it is evident that the system can be extended to diverse thermal images captured for different pathologies such as fine scale dermatitis, melanoma etc. which require precise localization to administer surgical drugs. The framework can be upgraded by disposing of the requirement for the key. Further, this system can be tested with different wavelet families to evaluate the quality of the fused image. Since the low frequency features are dominant in thermal images, suitable transforms can be applied to combine exclusively the approximation coefficients.

7. REFERENCES

[1] Leslie. W. Hall: Mistaken Identity, Surgery/ Anesthesia, Morbidity and Mortality rounds on the Web, http://www.webmm.ahrq.gov/case.aspx?caseID=187, (2008)

[2] Muhammad, N., Bibi, N., Mahmood, Z., Akram, T., & Naqvi, S. R. (2017). Reversible integer wavelet transform for blind image hiding method. PloS one, 12(5), e0176979.

[3] Muthukumaran. N and Ravi. R, 'Hardware Implementation of Architecture Techniques for Fast Efficient loss less Image Compression System', Wireless Personal Communications, Volume. 90, No. 3, pp. 1291-1315, October 2016, SPRINGER.

[4] Muthukumaran. N and Ravi. R, 'The Performance Analysis of Fast Efficient Lossless Satellite Image Compression and Decompression for Wavelet Based Algorithm', Wireless Personal Communications, Volume. 81, No. 2, pp. 839-859, March 2015, SPRINGER.

[5] Toet, A., Van Ruyven, L. J., & Valeton, J. M. (1989). Merging thermal and visual images by a contrast Pyramid. Optical engineering, 28(7), 287789.

[6] Muthukumaran. N and Ravi. R, 'VLSI Implementations of Compressive Image Acquisition using Block Based Compression Algorithm', The International Arab Journal of Information Technology, vol. 12, no. 4, pp. 333-339, July 2015.

[7] Muthukumaran. N and Ravi. R, 'Simulation Based VLSI Implementation of Fast Efficient Lossless Image Compression System using Simplified Adjusted Binary Code & Golumb Rice Code', World Academy of Science, Engineering and Technology, Volume. 8, No. 9, pp.1603-1606, 2014.

[8] Bebis, G., Gyaourova, A., Singh, S., & Pavlidis, I. (2006). Face recognition by fusing thermal infrared and visible imagery. Image and Vision Computing, 24(7), 727-742

[9] Hanif, M., & Ali, U. (2006, July). Optimized visual and thermal image fusion for efficient face recognition. In Information Fusion, 2006 9th International Conference on (pp. 1-6). IEEE

[10] Ruban Kingston. M, Muthukumaran. N, Ravi. R, 'A Novel Scheme of CMOS VCO Design with reduce number of Transistors using 180nm CAD Tool', International Journal of Applied Engineering Research, Volume. 10, No. 14, pp. 11934-11938, 2015.

[11] Muthukumaran. N and Ravi. R, 'Design and analysis of VLSI based FELICS Algorithm for lossless Image Compression', International Journal of Advanced Research in Technology, Vol. 2, No. 3, pp. 115-119, March 2012.

[12] Manoj Kumar. B, Muthukumaran. N, 'Design of Low power high Speed CASCADED Double Tail Comparator', International Journal of Advanced Research in Biology Engineering Science and Technology, Vol. 2, No. 4, pp.18-22, June 2016.

[13] Seal, A., Ganguly, S., Bhattacharjee, D., Nasipuri, M., & Basu, D. K. (2013). A Comparative Study of Human thermal face recognition based on Haar wavelet transform (HWT) and Local Binary Pattern (LBP). arXiv preprint arXiv:1309.1009.

[14] N. Muthukumaran, 'Analyzing Throughput of MANET with Reduced Packet Loss', Wireless Personal Communications, Vol. 97, No. 1, pp. 565-578, November 2017, SPRINGER.

[15] P.Venkateswari, E.Jebitha Steffy, Dr. N. Muthukumaran, 'License Plate cognizance by Ocular Character Perception', International Research Journal of Engineering and Technology, Vol. 5, No. 2, pp. 536-542, February 2018.

[16] N. Muthukumaran, Mrs R.Sonya, Dr.Rajashekhara and Chitra V, 'Computation of Optimum ATC Using Generator Participation Factor in Deregulated System', International Journal of Advanced Research Trends in Engineering and Technology, Vol. 4, No. 1, pp. 8-11, January 2017.

[17] Keziah. J, Muthukumaran. N, 'Design of K Band Transmitting Antenna for Harbor Surveillance Radar Application', International Journal on Applications in Electrical and Electronics Engineering, Vol. 2, No. 5, pp. 16-20, May 2016.

[18] Alldieck, T., Bahnsen, C. H., & Moeslund, T. B. (2016). Context-aware fusion of RGB and thermal imagery for traffic monitoring. Sensors, 16(11), 1947.

[19] Ban, M. J., Nam, Y., & Park, J. H. (2017). Detection of peritonsillar abscess using smartphone-based thermal imaging. Pakistan journal of medical sciences, 33(2), 502.

[20] Akhil. M.S and Muthukumaran. N, 'Design of Optimizing Adders for Low Power Digital Signal Processing', International Journal of Engineering Research and Applications, Vol. 5, pp. 59-65, March 2014.

[21] Muthukumaran. N and Ravi. R, 'Quad Tree Decomposition based Analysis of Compressed Image Data Communication for Lossy and Lossless using WSN', World Academy of Science, Engineering and Technology, Volume. 8, No. 9, pp. 1543-1549, 2014.

[22] Marvin Mark. M and Muthukumaran. N, 'High Throughput in MANET using relay algorithm and rebroadcast probability', International Journal of Engineering Research and Applications, Vol. 5, pp. 66-71, March 2014.

[23] Dai, Y., Zhou, Z., & Xu, L. (2017). The application of multi-modality medical image fusion based method to cerebral infarction. EURASIP Journal on Image and Video Processing, 2017(1), 55.