



INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact factor: 4.295

(Volume3, Issue1)

Available online at: www.ijariit.com

Advanced Fuzzy Logic Based Image Watermarking Technique for Medical Images

Kamalpreet Kaur

Computer Science Engineering,
Punjab Technical University
kml570@gmail.com

Er. Suppandeeep Kaur

Computer Science Engineering,
Punjab Technical University
suppandeeep@gmail.com

Abstract-The segmentation algorithms vary for the types of medical images such as MRI, CT, US, etc. The current study work can further be extended to develop a GUI tool based approach for separating the ROI. Additionally, a new technique of separating ROI from the original image that will be applicable for all type of medical images can be evolved. Separated ROI can be stored with xmin, xmax, ymin and ymax value so that at the end of embedding process before transmitting watermarked image, the segmented ROI can be attached with watermarked image. Any medical image watermarking approach will be suitable, if we segment the ROI from medical image with the four values, then embedding of watermark can be done on whole medical image, in this paper work on different scan like ctscan ,brain scan etc. our results significant high than other.

Keywords- MRI, CT, US, Fuzz.

1. Introduction

Recent development of the Internet and the digital revolution caused significant change in the global society. It is very easy for users to access digital multimedia on internet. This has created an urgent need for protecting intellectual property in the digital media. Digital watermarking is one of the best solutions for this purpose. We are living in the domain of information where billions of bits of data is created in every fraction of second and with upcoming into the place of internet, creation and delivery of data (Image, Audio, video , Web publishing data) has grown many fold. so here copying of digital content without quality loss is not so difficult. Due to this, there are more chances of copying of such digital information. So, there is great need of prohibiting such illegal copyright of digital media during communication. Digital watermarking (DWM) is the powerful solution to this problem. Digital Watermark is the digital content such as Text, Audio, Logo, and Graphics that are hidden in such a way that it's not visible to human eye.

Nowadays, with the development of internet network and digital technology around the world, the availability and usage of digital information has increased quickly. People can process, exchange and store digital contents more simply than ever. However, against this advantage, a new set of problems concerning security such as unrestricted duplication, manipulating and distributing of multimedia have arisen. Therefore, ownership protection and content verification have become a significant issue.

Digital Watermarking

The term "Digital Watermark" was coined by Andrew Tirkel and Charles Osborne in December 1992. The first successful embedding and extraction of a steganographic spread spectrum watermark was demonstrated in 1993 by Andrew Tirkel, Charles Osborne and Gerard Rankin. Digital watermarking is a process of embedding digital information called watermark into the digital multimedia data. Watermarking technique is used for several purposes including content authentication, owner identification, and data integrity and copy control. According to the original data needed during watermark extraction, digital watermarking can be roughly categorized into non-blind, semi-blind and blind schemes. Non-blind schemes require original image to extract the embedded watermark. The semi-blind watermarking schemes usually require the watermark or auxiliary information like keys to detect or recover the watermark. Finally, a watermarking technique is referred to as blind if neither the original image nor the watermark is needed during extraction phase. Depending on the watermark embedding domain, digital watermarking methods can be categorized into two broad main classes: spatial domain and transform domain.

Applications of Watermarking

Digital watermarks have been broadly and successfully deployed in billions of media objects across a wide range of applications. The following application areas are described in detail with information of how the technology works, case studies highlighting some of the most prevalent real world uses and links to related information that you may find useful.

- [1] Content identification and management
- [2] Content protection for audio and video content
- [3] Forensics and piracy deterrence
- [4] Content filtering (includes blocking and triggering of actions)
- [5] Communication of ownership and copyrights
- [6] Document and image security
- [7] Authentication of content and objects (includes government IDs)
- [8] Broadcast monitoring
- [9] Locating content online
- [10] Rich media enhancement for mobile phones
- [11] Audience measurement
- [12] Improved auditing

Fuzzy Logic

Fuzzy logic is an extension of Boolean logic by Lotfi Zadeh in 1965 based on the mathematical theory of fuzzy sets, which is a generalization of the classical set theory. Fuzzy logic provides a very valuable flexibility for reasoning, which makes it possible to take into account inaccuracies and uncertainties. One advantage of fuzzy logic in order to formalize human reasoning is that the rules are set in natural language. Membership functions classify elements in the range $[0, 1]$, with 0 and 1 being no and full inclusion, the other values being partial membership.

To understand the reasons for this extensive development, there are two main aspects worthy to be mentioned. First, the notion of fuzzy sets is important as a tool for modeling intermediate grades of belonging that occur in any concept, especially from an applications point of view. Second, a variety of tools incorporated in the framework of fuzzy sets, allow the planner to find suitable concepts to cope with reality. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.

I. LITERATURE REVIEW

[1] Rayachoti Eswaraiiah , Edara Sreenivasa Reddy et.al (2015) in “Robust medical image watermarking technique for accurate detection of tampers inside region of interest and recovering original region of interest” In this paper a novel medical image watermarking method was proposed based on integer wavelet transform (IWT). This proposal verifies the integrity of ROI, precisely identifies tampered blocks inside ROI, provides robustness to the data embedded inside region of non-interest (RONI) and recovers original ROI. In the proposed method, the medical image is segmented into ROI and RONI regions. Hash value of ROI, recovery data of ROI and data of patient are embedded into RONI using IWT. Experimental results show that the proposed method provides robustness to the watermark data embedded inside RONI and accurately detects and localizes tampered areas inside ROI and recovers the original ROI.

[2] Zolotavkin et.al (2015) in “A new two-dimensional quantization method for digital image watermarking” In this paper a novel secured reversible watermarking technique was proposed for medical images. To enhance high level of security of cover image, the image is partitioned into blocks. The higher correlation is inherent in neighboring pixels. This approach is used to create difference between fixed point pixel and its neighbor pixels in vertical, horizontal and diagonal direction for that block. The difference between neighboring pixels is used as a data embedding space; i.e. global peak of the difference histogram is used to embed watermark. Multiple iterations of the embedding process increase the data hiding capacity. Extraction is done in inverse manner and original image and original watermark can be obtained as a result.

[3] Sakthivel S.M, Dr. Ravi Sankar et.al (2015) in “A Real time watermarking of grayscale images without altering its content” In this paper a new spatial domain watermarking of greyscale images was proposed and has also shown its VLSI implementation without altering its content in real time using a secret key. The secret key is generated by searching the watermark pixel values in host image content and the location maps are marked in secret key. Therefore this algorithm is called PVSA- Pixel Value Search Algorithm. The proposed algorithm does not make any change in the host image. Thus it shows high robustness to signal processing attacks. The watermark extraction process is simple as the host content is extracted based on key and has evaluated the robustness of the algorithm against several signal processing attacks using MATLAB.

[4] Nidhi Divecha, Dr. N. Jani et.al (2015) in “Reversible watermarking technique for medical images using fixed point pixel” This paper proposes a novel secured reversible watermarking technique for medical images. To enhance high level of security of cover image, the image is partitioned into blocks. The higher correlation is inherent in neighbouring pixels. This approach is used to create difference between fixed point pixel and its neighbour pixels in vertical, horizontal and diagonal direction for that block. The difference between neighbouring pixels is used as a data embedding space; i.e. global peak of the difference histogram is used to embed watermark. Multiple iterations of the embedding process increase the data hiding capacity. Extraction is done in inverse manner and original image and original watermark can be obtained as a result.

[5] Ghosh, Sudip, Subhojit, Santi, Rahaman et.al (2015) in “A new algorithm on wavelet based robust invisible digital image watermarking for multimedia security” This paper presents a new algorithm on wavelet based robust and invisible digital image

watermarking for multimedia security. The proposed algorithm has been designed, implemented and verified using MATLAB R2014a simulation for both embedding and extraction of the watermark and the results of which shows significant improvement in performance metrics like PSNR, SSIM, Mean Correlation, MSE than the other existing algorithms in the current literature. The cover image considered here in our algorithm is of the size (256x256) and the binary watermark image size is taken as (16x16).

[6] Panchal, Rohit Srivastava et.al (2015) in “A comprehensive survey on digital image watermarking techniques” In this paper image watermarking adds additional information about host image in the form of logo/audio/video or text. Main aim of watermarking is to provide copyright protection, Content authentication, Ownership identification, data integrity. Watermarking does not only protect content from modification only but also provide data integrity and content authentication. Main requirements of watermarking are high imperceptibility, Strong robustness, security, capacity that varies according to different application. Techniques in spatial domain are simple, have lower complexity and can embed more number of bits but they are not resistant to some geometric attacks. While techniques in frequency transform domain are resistant to both geometric and image processing attacks but when frequency is corrupted robustness decreases and cannot embed more number of bits because quality gets degraded. These techniques cannot embed more bits as it degrades the quality of host image. So these techniques must be used with other techniques of spatial domain which has high capacity.

[7] Seenivasagam, Velumani R et.al (2014) in “Inversion attack resilient zero-watermarking scheme for medical image authentication” In this paper an inversion attack resilient zero-watermarking system, in the hybrid Contourlet transform singular value decomposition domain was proposed for medical image authentication. This scheme preserves the fidelity of the host image without introducing any artefacts and employs triangular number generating function and Hu’s image invariants to confront inversion attacks. The performance of the system is evaluated with medical images of different modalities and a quick response code watermark that contains patient data. The experimental results demonstrate the robustness of the system against ‘ambiguity attacks’ and signify its appropriateness for secured medical image exchange between remote radiologists.

[8] Nisar Ahmed, Asmatullah, Mushtaq, Zulfiqar et.al (2014) in “Hybrid watermarking of medical images for ROI authentication and recovery” In this paper, a hybrid watermarking method was proposed which embeds a robust watermark in the region of non-interest (RONI) for achieving security and confidentiality, while integrity control is achieved by inserting a fragile watermark into the region of the interest (ROI). First the information to be modified in ROI is separated and is inserted into RONI, which later is used in recovery of the original ROI. Secondly, to avoid the underflow and overflow, a location map is generated for embedding the watermark block-wise by leaving the suspected blocks. This avoids the pre-processing step of histogram modification. The image visual quality, as well as tamper localization, is evaluated. We use weighted peak signal to noise ratio for measuring image quality of watermarked images. Experimental results show that the proposed method outperforms the existing hybrid watermarking techniques.

[9] Xiaohong, Zhigang, Zeng, Zhang, Mao et.al (2013) in “Authentication and recovery of medical diagnostic image using dual reversible digital watermarking” This paper proposes a new region-based tampering detection and recovering method that utilizes both reversible digital watermarking and quad-tree decomposition for medical diagnostic image’s authentication. Firstly, the quad-tree decomposition is used to divide the original image into blocks with high homogeneity, and then we computer pixels’ linear interpolation as each block’s recovery feature. Secondly, these recovery features as the first layer watermarking information is embedded by using simple invertible integer transformation. In order to enhance the proposed method’s security, the logistic chaotic map is exploited to choose each block’s reference pixel. The second layer watermark comprises by the quad-tree information and essential parameters for extraction are embedded by LSB replacement. In the authentication phase, the embedded watermark is extracted and the source image is recovered, and the similar linear interpolation technique is utilized to get each block’s feature. Therefore, the tampering detection and localization can be achieved through comparing the extracted feature with the recomputed one, and the extracted feature can be used to recover those tampered regions with high similarity to their original state. Experimental results show that, compared with previous similar existing scheme, the proposed method not only achieves high embedding capacity and good visual quality of marked and restored image, but also has more accuracy for tampering detection.

[10] Husain, Boles, Colin et.al (2013) in “Utilizing least significant bit-planes of RONI pixels for medical image watermarking” In this paper a computationally efficient image border pixel based watermark embedding scheme was proposed for medical images. We considered the border pixels of a medical image as RONI (region of non-interest), since those pixels have no or little interest to doctors and medical professionals irrespective of the image modalities. Although RONI is used for embedding, our proposed scheme still keeps distortion at a minimum level in the embedding region using the optimum number of least significant bit-planes for the border pixels. These not only ensure that a watermarked image is safe for diagnosis, but also help minimize the legal and ethical concerns of altering all pixels of medical images in any manner (e.g., reversible or irreversible). The proposed scheme avoids the need for RONI segmentation, which incurs capacity and computational overheads. The performance of the proposed scheme has been compared with a relevant scheme in terms of embedding capacity, image perceptual quality (measured by SSIM and PSNR), and computational efficiency.

[11] Xiao Wei Li, Seok Tae Kim et.al (2013) in “Optical 3D watermark based digital image watermarking for telemedicine” This paper presents a 3D watermark based medical image watermarking scheme. In this paper, a 3D watermark object is first decomposed into 2D elemental image array (EIA) by a lenslet array and then the 2D elemental image array data is embedded into

the host image. The watermark extraction process is an inverse process of embedding. The extracted EIA through the computational integral imaging reconstruction (CIIR) technique, the 3D watermark can be reconstructed. Because the EIA is composed of a number of elemental images possess their own perspectives of a 3D watermark object. Even though the embedded watermark data badly damaged, the 3D virtual watermark can be successfully reconstructed. Furthermore, using CAT with various rule number parameters, it is possible to get many channels for embedding. So our method can recover the weak point having only one transform plane in traditional watermarking methods. The effectiveness of the proposed watermarking scheme is demonstrated with the aid of experimental results.

[12] Siau-Chuin, Siau-Way, Jasni Zain et.al (2013) in “Tamper localization and lossless recovery watermarking scheme with ROI segmentation and multilevel authentication” In this paper, a tamper localization and lossless recovery scheme that used region of interest (ROI) segmentation and multilevel authentication was proposed. The watermarked images had a high average peak signal to noise ratio of 48.7 dB and the results showed that tampering was successfully localized and tampered area was exactly recovered. The usage of ROI segmentation and multilevel authentication had significantly reduced the time taken by approximately 50 % for the tamper localization and recovery processing.

[13] Sudeb Das, Malay et.al (2013) in “Effective management of medical information through ROI-lossless fragile image watermarking technique” In this paper, a blind, fragile and Region of Interest (ROI) lossless medical image watermarking (MIW) technique had proposed, providing an all-in-one solution tool to various medical data distribution and management issues like security, content authentication, safe archiving, controlled access retrieval, and captioning. The proposed scheme com-bines lossless data compression and encryption technique to embed electronic health record (EHR)/DICOM metadata, image hash, indexing keyword, doctor identification code and tamper localization information in the medical images. Extensive experiments (both subjective and objective) were carried out to evaluate performance of the proposed MIW technique. The findings offer suggestive evidence that the proposed MIW scheme is an effective all-in-one solution tool to various issues of medical information management domain. Moreover, given its relative simplicity, the proposed scheme can be applied to the medical images to serve in many medical applications concerned with privacy protection, safety, and management.

[14] Lavanya, Natarajan et.al (2012) in “Data hiding using histogram modification of difference in medical images based on block division” In this paper data hiding method by modifying histogram of medical images and differences based on block division is proposed. Reversible data hiding by using histogram modification method considers the differences of the pixels which increases data hiding capacity. In our present study to enhance the data hiding capacity the block division method is preferred. In comparison to current algorithms, the proposed method shows a simple and effective data hiding for medical images with high image quality.

II. RESULT AND DISCUSSION

Image Attacking

There are four medical images i.e. brain, lower back, abdomen and lung which are used for image attacking with different modalities. Modalities of medical images are as follows: CT scan, MRI Scan, Ultrasound and PET Scan. Results of applying various types of attacks on the medical image of different modalities:

No Attack

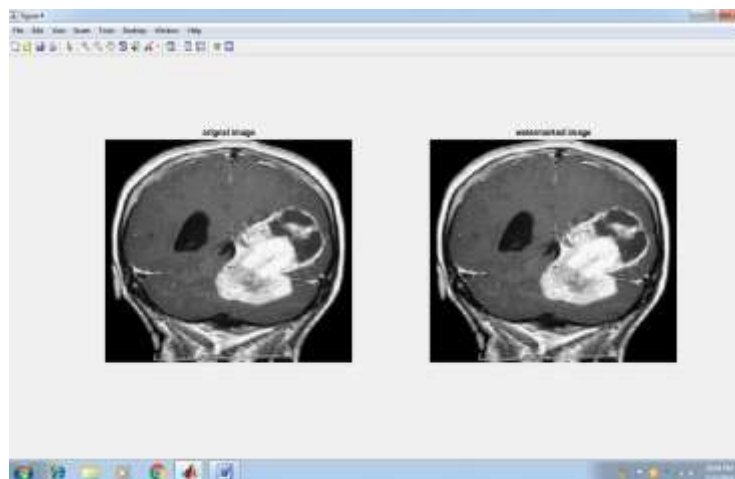


Figure 1 Watermarked image with no attack performed on it.

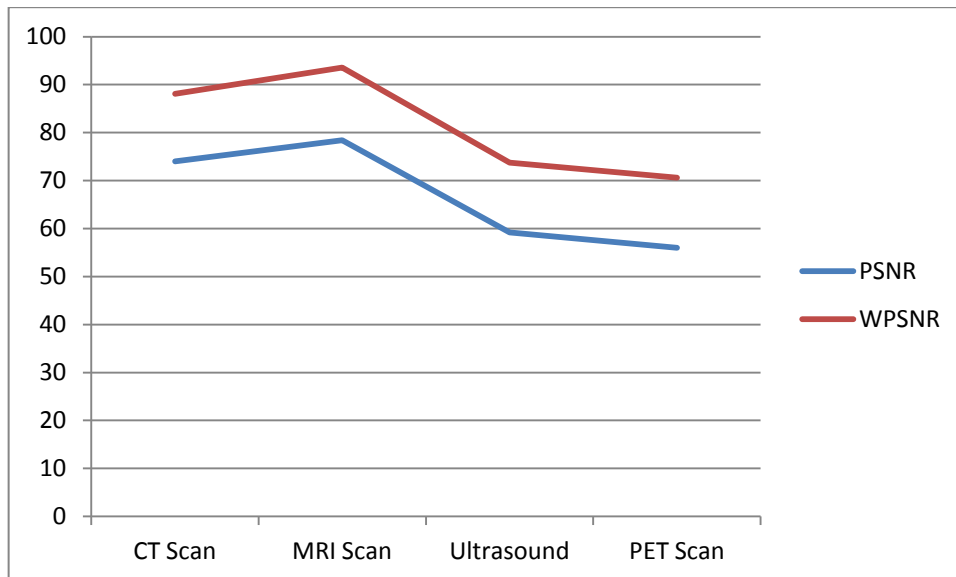
Results of applying various types of attacks on the watermarked medical images of different modalities

Modality of watermarked image	Type of attack	Value of NC
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CT Scan	No attack	1
	JPEG compression (compression ratio 90%)	0.99954
	Salt and Pepper noise (density=0.005)	0.98938
	Gaussian noise (variance=0.001)	0.99932
	Low-pass filtering	0.99905
MRI Scan	No attack	1
	JPEG compression (compression ratio 90%)	0.97563
	Salt and Pepper noise (density=0.005)	0.96015
	Gaussian noise (variance=0.001)	0.97155
	Low-pass filtering	0.98394
Ultrasound	No attack	1
	JPEG compression (compression ratio 90%)	0.98828
	Salt and Pepper noise (density=0.005)	0.96746
	Gaussian noise (variance=0.001)	0.95858
	Low-pass filtering	0.98285
PET Scan	No attack	1
	JPEG compression (compression ratio 90%)	0.98969
	Salt and Pepper noise (density=0.005)	0.96924
	Gaussian noise (variance=0.001)	0.97727
	Low-pass filtering	0.99212

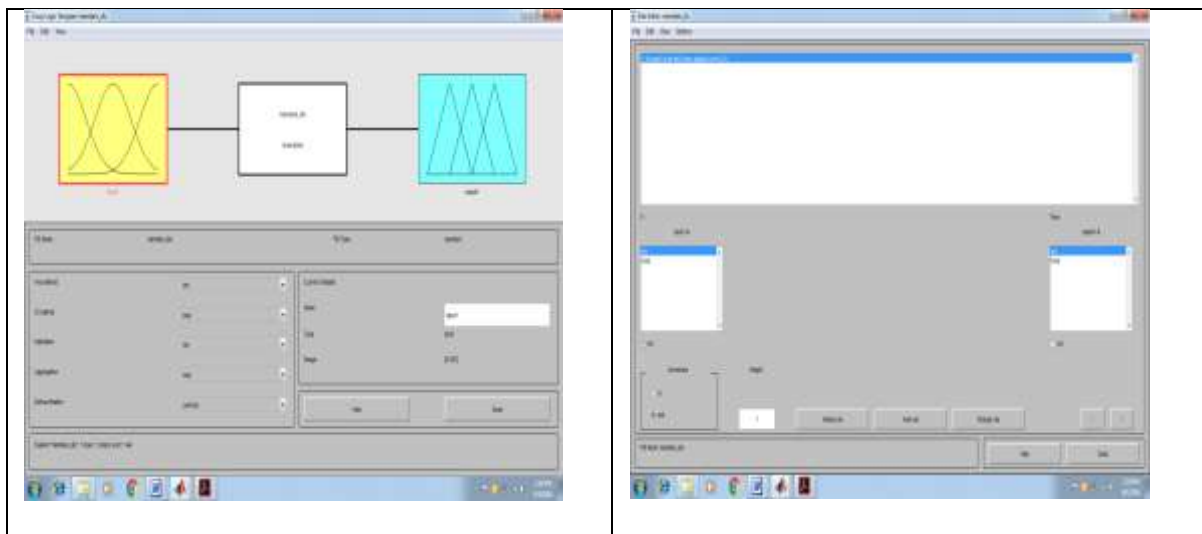
Average performance of the proposed method

Modality of medical image	Average PSNR	Average WPSNR	Average MSSIM	Average TPE
CT Scan	74.0111	88.0917	0.9977	0.000099
MRI Scan	78.4402	93.5402	0.9971	0.000043
Ultrasound	59.2146	73.7126	0.9928	0.000214
PET Scan	56.0170	70.5786	0.9937	0.000373



The Fuzzy Logic Designer and Rule editor of proposed technique i.e. Mamdani_dis.fis in which 1 input and 1 output having their name, type and range of input and output i.e.

- A. Name of input and output is mf1
- B. Type of input and output is trimf
- C. Range of input is [0 255] and output is [0 1]
- D. On the other hand, Rule editor in which rule is: **If (input1 is not mf1) then (output1 is mf1)**



CONCLUSIONS

There exist various medical image watermarking algorithms and different existing segmentation algorithms to segment ROI. The segmentation algorithms vary for the types of medical images such as MRI, CT, US, etc. The current study work can further be extended to develop a GUI tool based approach for separating the ROI. Additionally, a new technique of separating ROI from the original image that will be applicable for all type of medical images can be evolved. Separated ROI can be stored with xmin, xmax, ymin and ymax value so that at the end of embedding process before transmitting watermarked image, the segmented ROI can be attached with watermarked image. Any medical image watermarking approach will be suitable, if we segment the ROI from medical image with the four values, then embedding of watermark can be done on whole medical image. Therefore, space for watermark embedding will be more in such case.

- I. Proposed algorithm solves our problem definition.
- II. Proposed algorithm improves the accuracy as compared to existing techniques.

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