Encrypted With Fuzzy Compliment-Max-Product Matrix in Watermarking

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***Abstract*—Watermark is used to protect copyright and to authenticate images. In digital media, today's world images are in electronic form available in the internet. For its protection and authentication invisible watermarking in encrypted form are used. In this paper encryption is done using fuzzy Compliment-Max-Product matrix and then encrypted watermark is embedded in the digital media at desired places using fuzzy rule. The Region of Interest (ROI) is decided with fuzzification. Then, watermark is inserted at the respective positions in the image. Robustness of watermark is judged for ROI. This method of watermarking is done on all image file formats and it is resistant for geometric, noise and compression attack.**

Keywords*—*Watermarking; Fuzzy Compliment-Max-Product Matrix, Fuzzification; Encryption

I. Introduction

Watermark is used to protect copyright and to authenticate images. In digital media, today's world images are in electronic form available in the internet. For its protection and authentication invisible watermark in encrypted form are used. Cryptography is an art of converting a message into cipher text and send to the destination. The authorized person can decipher the text and retrieve the original message. This technology is used from very beginning of the civilization. As the days go by we have new and recent technology coming up. Prior we had texts which are converted into cipher text by using some notion that A should read as B and B should be read as C and so on. Doing this we get a cipher text which is not easily readable unless one knows the conversion method. Public Key and Private Key method is used for cryptography. There are many methods like RSA, DES, Diffie-Hellmann and etc. for cryptography.

In 1976, Martin Hellman, a professor at Stanford University, and Whitfield Diffie, a graduate student, introduced the concept of asymmetric or public key cryptography. In this paper encryption is done using proposed Fuzzy Compliment-Max-Product matrix composition and then encrypted watermark is embedded in the digital media at desired places using fuzzy rule. The Region of Interest (ROI) is decided with fuzzification. Then, watermark is inserted at the respective positions in the image. Robustness of watermark is judged for ROI. Robustness is concerned about tracing or tampering of watermark by attacker. A good watermark should be against filtering process, noise addition, lossy compression, geometry transformation such as rotation, scaling and translation.

The proposed method of watermarking is done on all image file formats and it is resistant for geometric filters, noise and compression attack.

II. Fuzzy Rules and Compliment- Max-Product Matrix

The Fuzzy rules are consisting of rules defined on fuzzy set. Fuzzy set are acquired from Crisp Set using membership function. This process is known as fuzzification. Converting fuzzy set to Crisp set is called defuzzification. In Fuzzy sets the elements are from 0 to 1. Here, we will be using fuzzy Compliment-Max-Product matrix for encryption of the text/file. The encrypted file is then embedded into digital image as watermark. The embedding process also involves fuzzy rules. The encrypted watermark can be extracted from the digital image in unified format. The unified format is then decrypted using algorithm. If the watermarked image is tried to tamper or change, the information can be obtained from the image. The proposed rule is Fuzzy Compliment-Max-Product matrix composition. This rule is consisting of following method. Let A, B and C are fuzzy set with A(x1, x2), B(y1,y2) and C(z1,z2).Let us say,

$\mu_{A,B}(x1,y1)=0.2$

$\mu_{A,B}(x1,y2)=0.3$

$\mu_{A,B}(x2,y1)=0.2$

$\mu_{A,B}(x2,y2)=0.4$

$\mu_{B,C}(y1,z1)=0.3$

$\mu_{B,C}(y1,z2)=0.5$

$\mu_{B,C}(y2,z1)=0.2$

$\mu_{B,C}(y2,z2)=0.2$

The matrix of $\mu_{A,C}$ is

$\mu_{A,C}(x1,z1)=1-\max\{[\mu_{A,B}(x1,y1) * \mu_{B,C}(y1,z1)],[\mu_{A,B}(x1,y2) * \mu_{B,C}(y2,z1)]\}=0.94$

$\mu_{A,C}(x1,z2)=1-\max\{[\mu_{A,B}(x1,y1) * \mu_{B,C}(y1,z2)],[\mu_{A,B}(x1,y2) * \mu_{B,C}(y2,z2)]\}=0.90$

$\mu_{A,C}$ (x2,z1)=1- max{[$\mu_{A,B}$ (x2,y1) * $\mu_{B,C}$ (y1,z1)],[$\mu_{A,B}$ (x2,y2) * $\mu_{B,C}$ (y2,z1)]}=0.94

$\mu_{A,C}$ (x2,z2)=1- max{[$\mu_{A,B}$ (x2,y1) * $\mu_{B,C}$ (y1,z2)],[$\mu_{A,B}$ (x2,y2) * $\mu_{B,C}$ (y2,z2)]}=0.90

III. Proposed Encryption Algorithm

The encryption is done using fuzzy set values. The fuzzy rules are then used to decrypt the context. The encryption algorithm has following steps

Step 1: Choose two Fuzzy matrices appropriate for encryption according to the file size.

Step2: Find the Fuzzy Compliment-Max-Product Matrix Composition.

Step3: Generate random number using Fuzzy Matrix.

Step4: Retrieve the encrypted text/files.

There are various ways of encryption. Here, 2X2 fuzzy matrix is used and Compliment-Max-Product of the fuzzy matrix is obtained.

The text/files is encrypted by one of the matrix. File is divided into four parts and a11, a12, a21 and a22. Each part is encrypted using fuzzy matrix values by generating random number using the fuzzy values. The encrypted files are then used for watermarking.

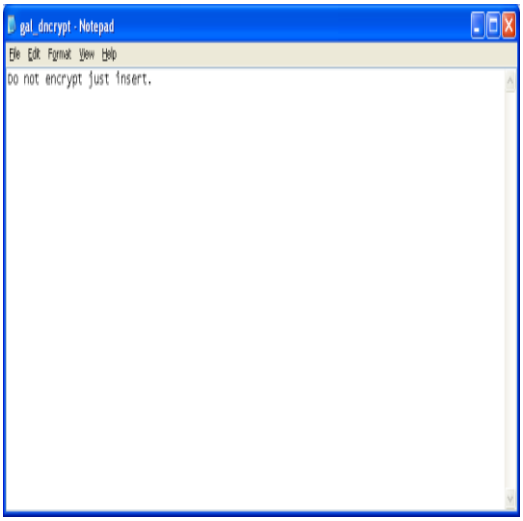

Fig. 1. Text File containing text to be encrypted

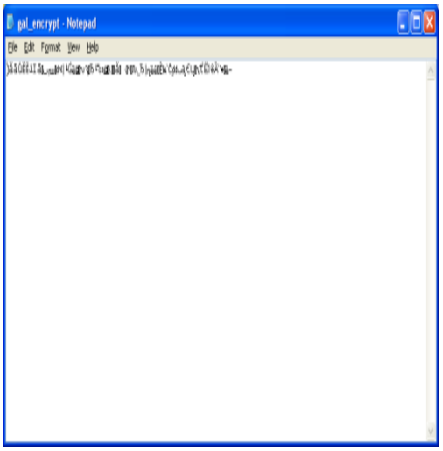

Fig. 2. Encrypted Text to be watermarked

IV. Proposed Decryption Algorithm

Decryption algorithm is used decrypt the encrypted file. The following algorithm is used-

Step1: Choose Fuzzy matrix key for decryption coming from encryption algorithm

Step2: Find the Compliment-Max-Product Matrix and break the file into same four parts with appropriate values of fraction.

Step3: Retrieve the original file

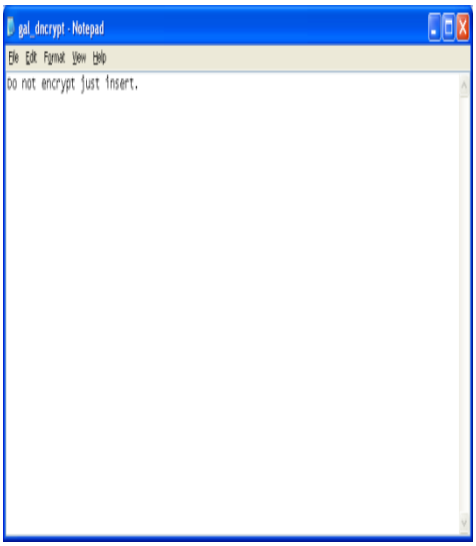

Fig. 3. Decrypted Watermarking File

V. EMBEDDING THE WATERMARK

There are various methods of watermarking. Watermark is visible or invisible. Sometimes invisible watermark is cipher text in order to make watermark more robust and not easily identifiable. When encrypted text or file is embedded in the image the watermark is undetectable. The image is divided into parts one region of interest (ROI) and another is non-region of Interest (i.e. background). Watermarking in the ROI is done where authentication of image is connected.

As we watermark in the ROI then it cannot be easily tampered or deleted. In medical images watermarking is done in non-ROI as to preserve the image accuracy. Here, we will use Fuzzy logic to watermark the image.

The image is having five parts according to ROI

a) *High Priority(HP)*-is the main area
b) *Medium Priority(MP)*- next important
c) *Low Priority(LP)*-least important
d) *Background(BG)*- background of picture
e) Outside (OS)- may be padding zone

All images may not have all five parts. Some may be divided as HP, BG & OS and so on. It depends on image in how many parts it can be divided. OS is padding i.e. the part of file where picture definition is not stored. This is the non-visible region of image.The Fuzzification is converting crisp set to fuzzy set with a membership function. Here, we have Crisp Set A consisting the four image zone. The Fuzzy Set A consists of elements with membership function μ. Here, we want to embed watermark at ROI of image. We take A={HP,MP,LP, BG}. In case of medical image we take B={ BG, OS} as crisp set and then fuzzfication is done.

$A=\{x_1, x_2, x_3, x_4\}$

$\mu_A(x_1)=0.44/$ HP $\mu_A(x_2)=0.42/$ MP

$\mu_A(x_3)=0.14/$ LP $\mu_A(x_4)=0.14/$ BG

The watermark is divided into four fuzzy set elements x_1,x_2 ,x_3 and x_4. It is stored in the regions HP,MP ,LP and BG respectively. Fig 4 shows watermarked image with fuzzified encrypted text file. When we want to retrieve the watermark we need to defuzzify and collect the four parts of watermark then its combined to one file. Then, this file is decrypted using decryption algortihm as given above.Different images have different membership functions for embedding like some images have logic like (0.25/x1, 0.25/x2, 0.25/x3, 0.25/ x4). The x1 is starting of embedding, x2, x3 and x4 are end of ROI of image. In order to make a robust watermarking it should be resistant to noise attack, geometric filter attack and compression attack. Embedding is resistant to all of three above said method.

Steps to be followed for watermarking-

Step1: Deciding the region for embedding using fuzzy membership function.

Step2: Divide encrypted watermark into four files.

Step3 : Convert the Digital Image into Byte Code.

Step4: Convert the Encrypted Watermark files to Byte Code.

Step5: Insert the Byte code of Watermark into Image file using Fuzzy rule.

Step6: Convert the Byte Code to desired Image File Format.

VI. RETRIEVING THE WATERMARK FROM DIGITAL IMAGE

Retrieving the watermark is done by extracting watermark from Digital Image and decrypting the file and obtained the watermark. Steps to be followed are as follows-

Step1: Convert the Watermarked file into Byte Code.

Step2: Extract the Byte Code of Watermark using defuzzification.

Step3: Convert the Byte Code file to text/file.

Step4: Decrypt the text/file using Decryption algorithm.

VII. CONCLUSION

The digital images are watermarked with encrypted files in order to have invisible watermark. The watermark is encrypted and decrypted to see whether image is authentic or it is tried to tamper. The watermark is robust against geometric filter attack, scaling attack, compression attack and noise attack. The drawback of the method is, it uses fraction values for encryption like you encrypt by 0.2. Now for decryption 0.1, 0.2 and 0.3 values can work out. This is loop hole of fractions as values are nearby. So, appropriate programming is required so that decryption cannot be done with other than expected value or key. The proposed method of watermarking depends upon the type of image on which watermark is used. The medical images, images of natural calamity and weather forecasting, company logo, Software logo and etc have different requirements for authenticity and copyright protection. In medical images and weather forecasting ROI is most important so watermark should be out of ROI. In company logo or Software logo tampering or deletion of watermark is an issue so watermark is to be embedded in ROI.

VIII. FUTURE SCOPE OF WORK

The future scope of work is on invisible watermark, fuzzy rules creation and embedding the watermark so that difference in quality of image of original and watermarked image is minimal.

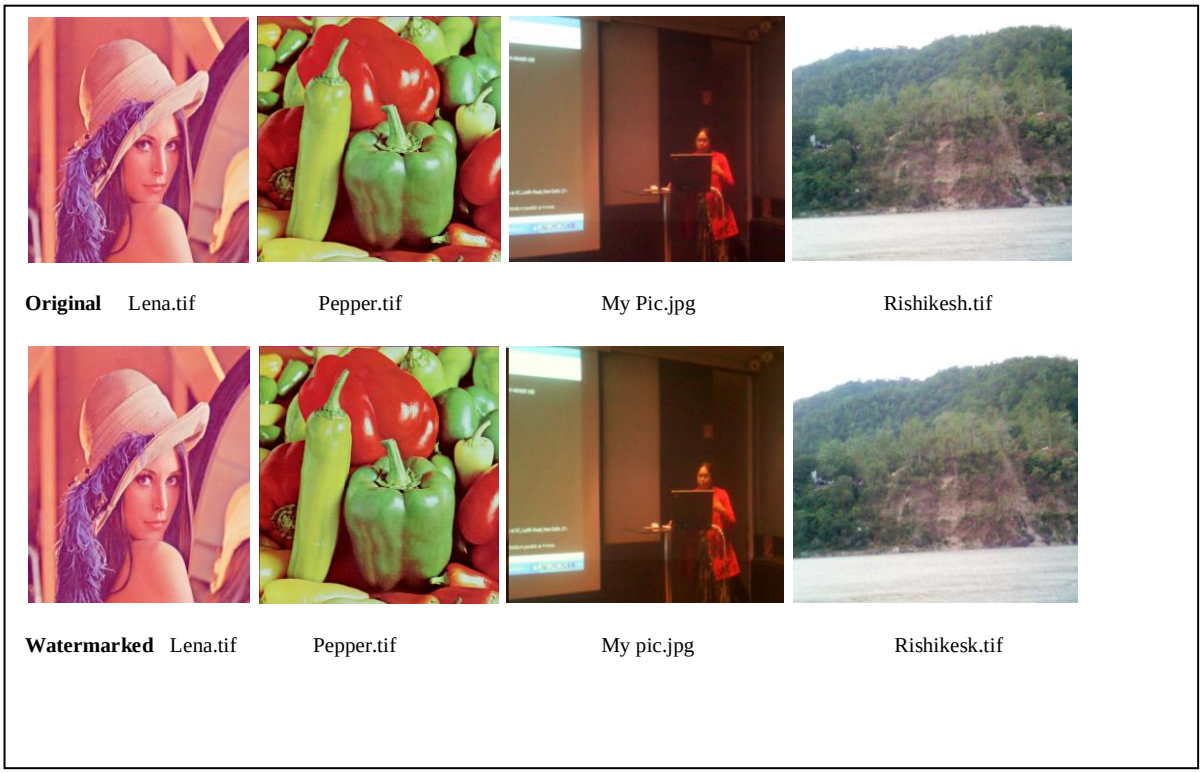

Fig. 4. Original and Watermarked Images

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