ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

ICITCSA 2017

Pioneer College of Arts and Science, Coimbatore

Vol. 6, Special Issue 1, January 2017

# Mathematical Approach for Fourier-Finite Mellin Transform using Adjoint Operators for Secure Medical Image Steganography based on QR-Codes

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**Abstract**: In the current scenario, medical records are most sensitive information and require an uncompromising security during both storage and transmission. In most of the hospitals these information are stored separately and referred to the consultant separately. Due to this separate storage and transmission there is a possibility of unauthorized access of data which already exists. In order to protect these data, we proposed a new steganography technique based on Fourier- Finite Mellin Transform using Adjoint Operators.

**Keywords**: Transmission, Steganography, Fourier- Finite Mellin Transform, Adjoint Operators.

## I. INTRODUCTION

Steganography is the process of hiding information in plain sight. This technique is in different fields such as medical, military and industrial applications. Hiding large information in natural images are still complex problems in digital era. Electronic health records are originally generated and maintained based on the approaches such as confidentiality and integrity. Confidentiality states that unauthorized parties should not be granted to access medical images during transmission. Similarly, integrity implies that images should not be modified in any way. The above approaches are used to protect the medical records. The organization of this paper is as follows: section 2 describes the related work, section 3 gives the details of proposed methodology and section 4 explains the testing and performance analysis for the proposed work, finally section 5 discussions about results and section 6 concludes the work

## II. RELATED WORK

Z.Xiang et al.,[1] has proposed integer wavelet transformation scheme for extracting the information from the stego-image. R.O.EI Safy et al [2] has proposed that IWT is a non-linear transformation having a structure of lifting scheme and as its rate distortion performance is similar to DWT, it ensures perfect reconstruction. In order to improve the efficiency, Akkamahadevi D.H et al[3] proposed IWT based on LSB substitution method. Mamta juneja at el[4] proposed a robust image Steganography. B.Shiva kumar et al[5] predict the performance comparision of robust Steganography based on LSB with multiple transformation techniques. Shanjun zhang et al[6] has proposed a novel water marking method to embede QR codes in digital images.

## III.PROPOSED METHODOLOGY

### 3.1 QR Codes

The Quick Response is a two-dimensional bar code that is in the form of matrix which has developed by Denso wave and release in 1994. It can be encode in many type of characters such as numeric, alphanumeric, alphabetic, symbols and control codes. Approximate maximum capacity, 7,089 characters can be coded in one symbol and maximum version is 4.0. Some of its features are high capacity and error correction. Error correction helps to restore when symbol is dirty or damaged.

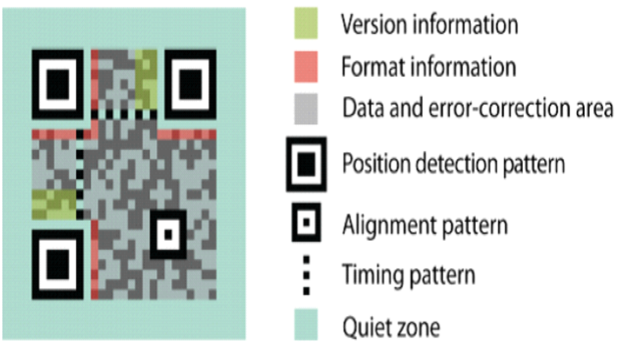


**Fig. 1 QR-Code**

### 3.2 Fourier- Finite Mellin Transform using Adjoint Operators

Fourier- Finite Mellin transform in the distributional sense by defining the definition of distributional generalized Fourier-Finite Mellin Transform which as follows the adjoint differential operator $f \rightarrow x^2 D_{xx} f$ is a continuous linear mapping from the dual space $FM^*_{f,b,c,a}$ into itself, corresponding operator transform formula is

$$FM_f \{ x^2 D_{x,x} f(t,x) \} = {}_P FM_{f2} \{ f(t,x) \}$$

Consider

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

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**ICITCSA 2017**

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**Vol. 6, Special Issue 1, January 2017**

$$FM_f\left\{x^2 D_{XX}\, f(t,x)\right\} = \langle x^2 D_{xx}\, f(t,x), e^{-ist}\left(\frac{a^{2p}}{x^{p+1}} - x^{p-1}\right)\rangle\,[$$

$$= \langle f(t,x), -D_{xx} e^{-ist} x^2 \left(\frac{a^{2p}}{x^{p+1}} - x^{p-1}\right)\rangle$$

$$= \langle f(t,x), -D_{xx} e^{-ist}\left(a^{2p} x^{-p} - x^{p}\right)\rangle$$

$$\langle f(t,x), -xD_x e^{-ist}\left(a^{2p}(-p)x^{-p-1} - px^{p-1}\right)\rangle$$

$$= p\langle f(t,x), -xD_x e^{-ist}\left(a^{2p} x^{-p-1} + x^{p-1}\right)\rangle$$

$$= p\langle f(t,x), -xD_x e^{-ist}\left(a^{2p} x^{-p} + x^{p}\right)\rangle$$

$$= p\langle f(t,x), -xD_x e^{-ist}\left(a^{2p} x^{-p} + x^{p}\right)\rangle$$

$$= p\langle f(t,x),\ e^{-ist}\left(a^{2p}(-p)x^{-p-1} + px^{p-1}\right)\rangle$$

$$= -p^2 \langle f(t,x), e^{-ist}\left(\frac{a^{2p}}{x^{p+1}} - x^{p-1}\right)\rangle$$

$$= -p^2\, FM_{f1}\left\{f(t,x)\right\},$$

Where FM $_{f2}$ is second type of Fourier- Finite Mellin Transform.

$$FM_f\left\{x^2 D_{xx}\, f(t,x)\right\} = -p^2 FM_{f1}\left\{f(t,x)\right\}$$

In our proposed, we followed embedding process and extracting process.

### 3.3 Proposed Steganography encoding process

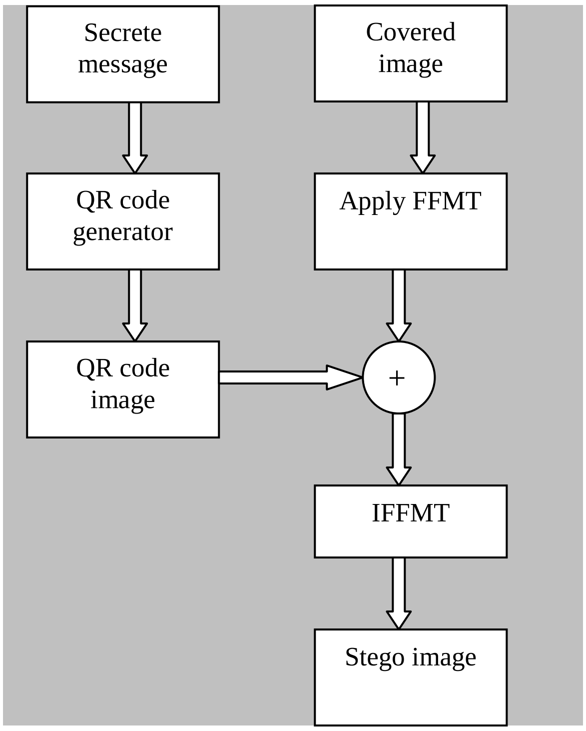


**Fig.2 Encoding Model**

During this process first read one cover image and secrete image. Apply the FFTM on the cover image and secrete image to get a FFTM cover image. Then apply fusion process on both cover and QR secrete image to get composite image and get stego image. The schematic diagrams are represented in the figure-2.

It is a reverse process of encoding proposed approach. In this process, first read one cover image and stego image. Apply the subtract stego image coefficients with cover image components and reconstructed the image. FFTM on the cover image and stego image are converted into secret image. The schematic diagram are represented in the figure-3.

**Embedding Algorithm**

Step-1: Read the rectangular shape cover image
Step-2: Generate a QR code with a secret image.
Step-3: Apply FFMT on both cover and QR Code image
Step-4: Embed the QR code image into cover image.
Step-5: Reconstruction of cover image to apply IFFMT.
Step-6: finally get a stego image

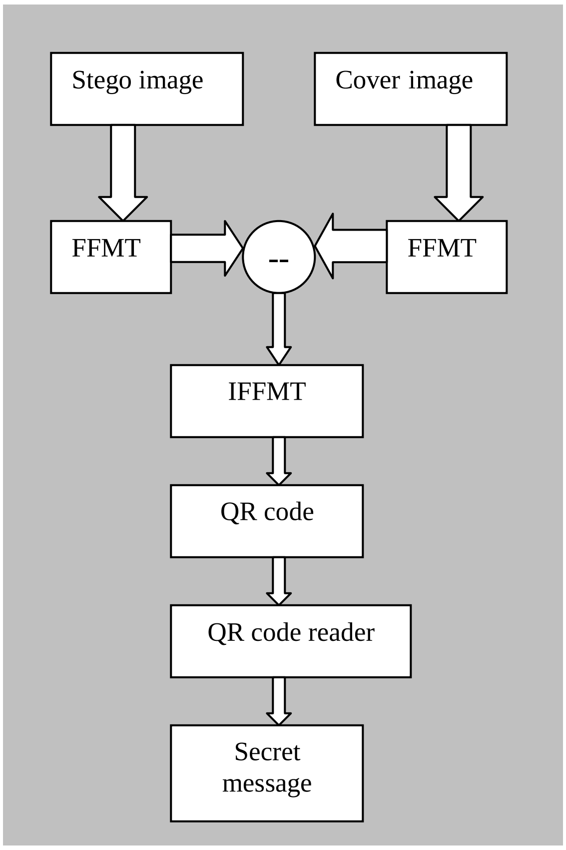


**Fig-3 Decoding Model**

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

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Vol. 6, Special Issue 1, January 2017

**Decoding Algorithm**

Step-1: Read the stego image and original image
Step-2: Apply FFMT on both cover and stego image
Step-3: subtract stego image into FFMT Component and get the QR Code image..
Step-4: finally get a extracted secret message from the QR Code image

## IV. TESTING AND PERFORMANCE ANALYSIS

To evaluate the performance of this proposed approach, we implemented MATLAB 2010 version 7.10. In our experiment we tested 100 images are taken and analyzed. In order to evaluate the proposed method the following metrics are used such as Peak Signal to Noise Ratio(PSNR), Mean Squared Error(MSE), Normalized Cross Correlation (NCC), Average Difference (AD), Structural Content ( SC), Maximum Difference (MD), Normalized Absolute Error (NAE) Quality measures are observed.

**Peak Signal to Noise Ratio:** PSNR is the ratio of maximum power of the signal and the power of unnecessary distorting noise. The signal is the original image and the noise is the error in reconstruction. The general formula is represented below equation

$$\text{PSNR} = 10\log_{10}\left[\frac{MxN}{RMSE}\right]$$

**Mean Squared Error**: MSE measures the average of the square "error" between the images. The error is the amount by which the estimator differs from the quantity to be estimated. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate. The formula for mean square is given as

$$\text{MSE} = \left[\frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\left[\hat{f}(i,j) - f(i,j)\right]^2\right]^{1/2}$$

Where M*N is the size of the image, (i, j) and f (i, j) are the matrix element of the fused and the original image at (i, j) pixel.

**Normalized Cross Correlation**: NCC in which the brightness of the image and template can vary due to tighting and exposure conditions, the images can be first normalized. This is typically done at every step by subtracting the mean and dividing by the standard deviation. That is the cross correlation of the template, t(x, y) with sub image f(x, y) is

$$NCC = \frac{1}{n}\sum_{x,y}\frac{\left(f(x,y) - \bar{f}\right)\left(t(x,y) - \bar{t}\right)}{\sigma_f \sigma_t}$$

Where n is the number of pixels in t(x, y) and f(x, y), is the average of f and is standard deviation of f. In functional analysis terms, can be thoughts of as the dot product of two normalized vectors, that is if

F (x, y) = t (x, y) – and T (x, y) = t (x, y) -

Then the above sum is equal to F and T is real matrices of Normalized Cross Correlation.

**Average Difference**: The average number of a set is the total of those numbers divided by the number of items in that set and the average brightness of a region is defined as the sample mean of the pixel brightness within that region. The difference in visual properties that makes an object distinguishable from other objects. The formula for average difference is given as

$$D = \sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k} - x'_{j,k}) / \; M\;N$$

**Maximum Difference**: As expected the metrics that are responsive to distortions are also almost always responsive to the image set. Conversely, the metrics that do not respond to variation of the image set are also not very discriminating with respect to distortion types. The fact that the metrics are sensitive, as would be expected, to both the image content and distortion artifacts does not eclipse their potential as quality metrics.

$$MD = MAX\left(\left|X_j k - x'_j k\right|\right)$$

**Normalize Absolute Error:** Normalization is the process of isolating statistical error in repeated measured data. Absolute error is the uncertainty in a measurement, which is expressed using the relevant units. Also, absolute error may be used to express the inaccuracy in a measurement. Normalized absolute error formula is given as.

$$D = \sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k} - x'_{j,k}) / \; M\;N$$

**Structural Content:** SC is also correlation based measure and measures the similarity between two images. Structural Content (SC) is given by the equation

$$SC = \frac{\sum_{j=1}^{m}\sum_{k=1}^{n}(x_j, k)^2}{\sum_{j=1}^{m}\sum_{k=1}^{n}(x'_j, k)^2}$$

## V. RESULTS AND DISCUSSION

The image quality factors MSE, PSNR, NCC, AD, MD, NAE and SC are observed. From this observation, our

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ISSN (Print) 2319-5940

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Vol. 6, Special Issue 1, January 2017

proposed approach better when compared to traditional methods. The experimental results are shown in table 1. the value of of the normalized cross correlation lies between -1 to 1. if the two images are same, then the value is assigned to 1. if two images are different to each other then the NCC is assigned to -1 and it will be zero if images are completely uncorrelated. The best quality of the stego image formed by the other image quality metrics followed in the ranges. PSNR is observed it ranges from 45 to 48. Mean squared Error is observed it ranges from 2 to 3. AD is observed and it ranges from - 0.1 to 0.5. Structural content is observed ranges from 1 to 2. MD is ranges from 5.0 to 6.0. Normalized Absolute Error is observed from 0.01 to 1.

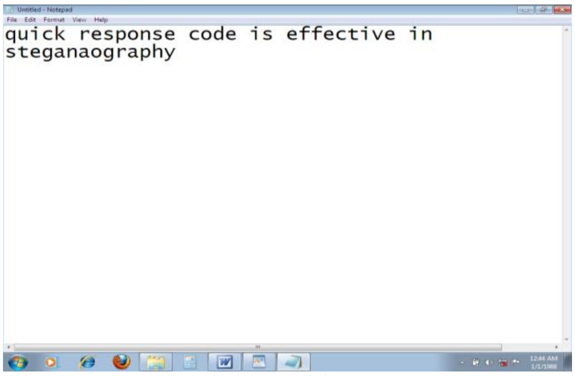


Fig-4 Secrete image

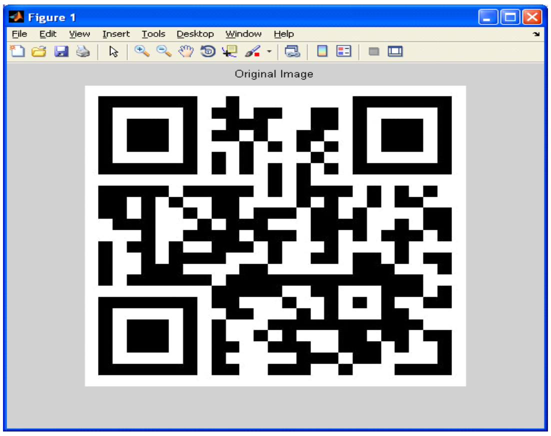


Fig- 5 Secrete image Quick Response Code

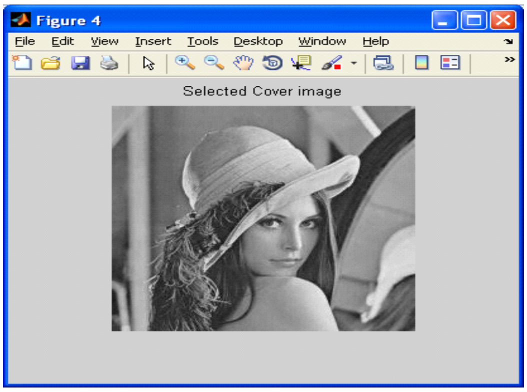


Fig-6 Original Image

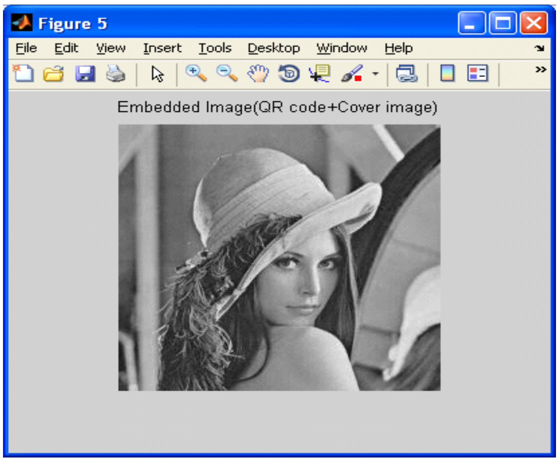


Fig-7 Stego image

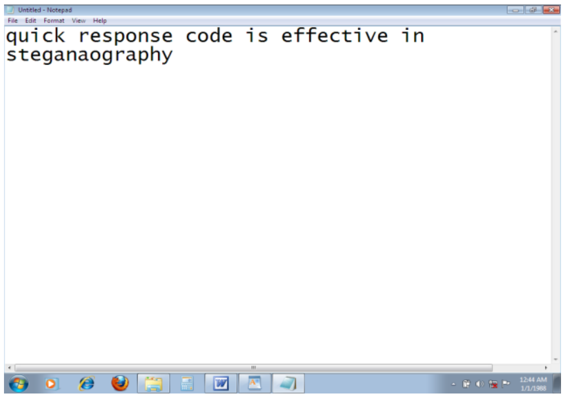


Fig-8 Recovered Image

TABLE I. PERFORMANCE ANALYSIS

| Image/ Quality measures | Img 1 | Img 2 | Img 3 | Img 4 | Img 5 |
|---|---|---|---|---|---|
| PSNR | 48.64 | 49.21 | 49.78 | 50.24 | 52.4 |
| MSE | 2.4 | 2.1 | 2.6 | 2.4 | 2.8 |
| NCC | 0.98 | 0.96 | 0.98 | 0.97 | 0.95 |
| AD | 0.2 | 0.4 | 0.3 | 0.5 | 0.3 |
| SC | 1.5 | 1.32 | 1.4 | 1.7 | 1.9 |
| MD | 5.23 | 5.18 | 5.27 | 5.5 | 5.78 |
| NAE | 0.70 | 0.55 | 0.28 | 0.76 | 0.56 |

(PSNR- Peak Signal to Noise Ratio), MSE (Mean Squared Error), NCC (Normalized Cross correlation), AD (Average Difference), SC (Structured Content), Maximum Difference (MD), Normalized Absolute Error (NAE)

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**Vol. 6, Special Issue 1, January 2017**

## VI. CONCLUSION

In this paper, we have proposed a new Steganography scheme based on QR code with FFMT decomposition technique. In our proposed algorithm, the hidden information was extracted with high capacity and robustness with acceptable visual quality.

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## BIOGRAPHY

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ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering

ICITCSA 2017

Pioneer College of Arts and Science, Coimbatore

Vol. 6, Special Issue 1, January 2017

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