Watermarked medical image transmission over 4G LTE system

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ABSTRACT

In the present world Telemedicine is an application, which is used to transfer medical images over the network in a secure manner all over the world. Here highly secured watermarking technique is used for Medical Image enhancing security and maintaining authentication of medical data and transfer the watermarked image over the LTE system then recover the image in Medical format (Specially DICOM format). The Region of interest (ROI) and the Region of Non-interest (RONI) of medical images are separated. Only RONI is used for watermarking embedding. This technique will use the 'correlation factor' equals to 1. The correlation factor for various attacks like noise addition, filtering, rotation, and compression ranges from 0.90 to 0.95. Probably The PSNR with weighting factor 0.02 is up to 48.53 dBs. The presented scheme is non-blind. It is very challenging to design an efficient wireless communication system, because of many factors, affecting the performance of a typical wireless communication system. Single Carrier Frequency Division Multiple Access (SC-FDMA) & Orthogonal Division Multiple Access (OFDMA) are a serious part of future mobile communication standards like Long Term Evolution (LTE). Here, in this proposal, the transmission process of a medical image over the LTE system is discussed.

1.Introduction

1.1 Background and Motivation

Telemedicine combines Medical data Systems with Information Technology that has the use of computers to receive, store, and distribute medical information over long distances. Telemedicine is often divided into several medical-related technologies using computers for healthcare like teleradiology, telepathy, telecare, telesurgery, teleneurology, etc. In the number of medical applications, medical images require special safety and confidentiality, because critical judgment is completed on the knowledge provided by medical images. Critically ill or injured patients are often treated locally by effective and secured communication between remote hospitals and distant specialists. Exchange of medical images between hospitals located in several geographical locations may be a common practice now each day as shown in fig 1. Hence, the healthcare industry asserts secure, robust, and more information hiding techniques promising strict secured authentication and communication through the internet or mobile phones. Digital image watermarking provides copyright protection to digital image by hiding appropriate information in the original image to declare rightful ownership. Four essential factors are commonly wont to determine the quality of the watermarking scheme. They are

a)robustness,
b)imperceptibility,
c)capacity and
d)blindness.

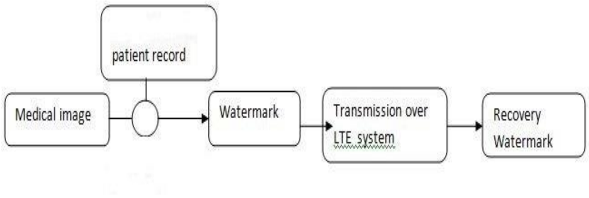

Fig1: Transmission of medical images from physician of remote hospital to specialist through LTE System .

1.2 Statement of the problem

1. Remote consultation
2. Present system used OFDMA but Upcoming system will be used SC-FDMA for uplink and OFDMA for downlink
3. In OFDMA , PAPR is very high as result amplification efficiency is low
4. In SC-FDMA , PAPR is very low.

1.3 Research objectives

In the present world mobile phone are available to every person . But telemedicine service is not available in mobile communication system .Our goal is to watermark a medical image and securely transmission the medical image over LTE system . For this reason we watermarked a medical image for authentication and enhancing security and then transmit this image over LTE system. For separating ROI and RONI we use Sutherland Hodgeman and subdivision algorithm. In this process we easily clipped polygonal RONI part and watermarked in this segment . For transmitting a medical image over long term evolution 4G (LTE) wireless system, we have to transmit a medical image through SC-FDMA and reconstructing it using OFDMA. Analyze how can get a better image after transmission. We will show how PSNR gives better in respect to SNR and also analyze with different sub-carrier mappings. And finally we will differ how the existing technology is backward then the new LTE advance, which use SCFDMA in uplink and OFDMA in downlink. To evaluate PAPR we use SC-FDMA and OFDMA.

2. Basic wireless Communication system

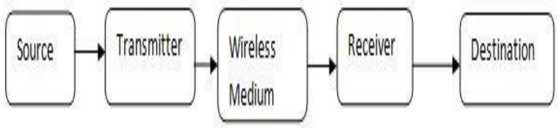

Fig2: Basic wireless of communication System

Wireless communication is the transition of data or power between two or more points that are not connected by an electrical conductor. The most common wireless technologies use radio. With radio waves distances are often short, like a couple of meters for television or as far as thousands or may be many kilometers for deep-space radio communications. It contains various types of fixed, mobile, and portable applications, including two-way radios, cellular telephones, and wireless networking. Other forms of applications of radio wireless technology admit GPS units, garage door openers, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones.

Somewhat less common ways of acquiring wireless communications admit the utilization of other electromagnetic wireless technologies, like light, magnetic, or electric fields or the utilization of sound. LTE, LTE-Advanced, Wi-Fi and Bluetooth are common modern wireless technologies utilized in the 2000s. Wireless operations allow services, like long-range communications, that are impossible or impractical to implement with the use of wires. The term is usually utilized in the telecommunications industry to ask telecommunications systems. Which use some form of energy (e.g. radio waves) to transfer information without the use of wires. Information is transferred during this manner over both short and long distances.

3. Research Methodology

3(a):Watermarking

3.a.1: Region of Interest (ROI) & Region of non-interest (RONI) segmentation:

It is vital to separate of ROI and RONI in a medical image. For segmentation of ROI and RONI we use Sutherland Hodgeman algorithm which can select the RONI for embedded watermarking .

Sutherland Hodgeman algorithm:

It are often used those issue

Edges of polygon got to be tested against clipping rectangle.

#May got to add new edges, Edges discarded or divided.

Multiple polygons may result from one polygon .

– Clip single polygon using single infinite clip edge

– Repeat 4 times

• Note the generality:

– 2D convex n-gons can clip arbitrary n-gons

– 3D convex polyhedra can clip arbitrary polyhedral

Input:

– v1, v2, … vn the vertices defining the polygon

– Single infinite clip edge w/ inside/outside info

• Output:

– v'1, v'2, … v'm, vertices of the clipped polygon

• Do that 4 or more times

• Traverse vertices (edges)

• Add vertices one-at-a-time to output polygon

– Use inside/outside info

– Edge intersections

Can be done incrementally

• If first point inside add. If outside, don't add

• Move around polygon from v1 to vn and back to v1

• Check vi,vi+1 wrt the clip edge

• Need vi,vi+1's inside/outside status

• Add vertex one at a time. There are 4 cases

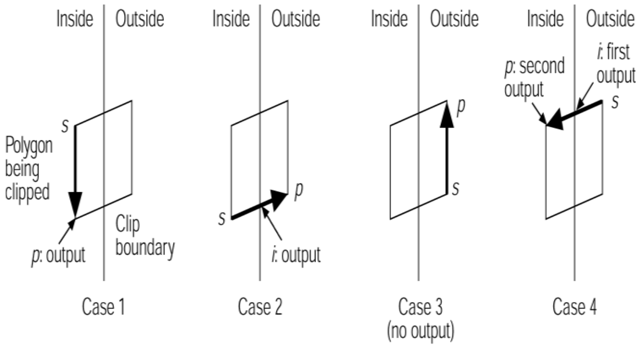

Fig 3.a.1: separation procedure

For each polygon P P' = P

– for each clipping edge (there are 4) {

• Clip polygon P' to clipping edge

– for each edge in polygon P'

» Check clipping cases (there are 4)

» Case 1 : Output vi+1

» Case 2 : Output intersection point

» Case 3 : No output

» Case 4 : Output intersection point & vi+1}

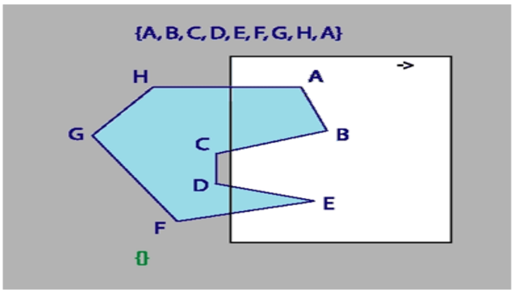

Fig 3.a.2(1): Apply Sutherland Hodgeman Algorithm

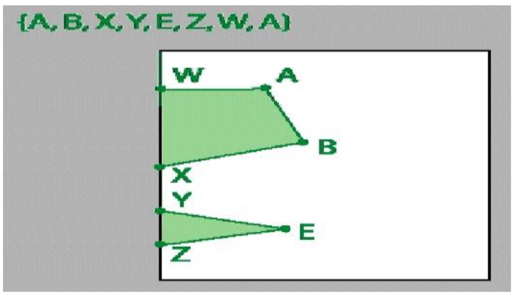

fig 3.a.2(2) : Final Result

Subdivision Algorithm: Subdivision algorithm is a recursive procedure based on two step strategy that first decides which projected polygons overlap a given area A on the screen and therefore potentially visible in that area. Second in each area these polygons are further tested to work out which one are going to be visible within this area and will therefore be displayed. If visibility cannot be made usually rectangular window is further subdivided until a visibility decision can be made, until area is a single pixel.

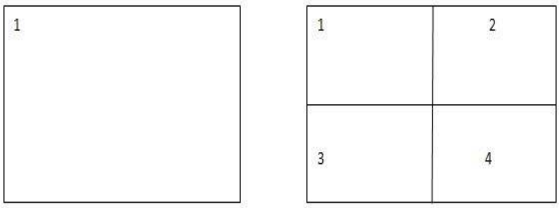

Fig 3.a.3: Subdivision Algorithm

3.a.2: DCT & DWT based digital watermarking

DISCRETE COSINE TRANSFORM :

With the character of discrete Fourier transform(DFT), discrete cosine transform(DCT) turn over the image edge to make the image transformed into the form of even function. It's one of the most common linear transformations in digital signal process technology. Two dimensional discrete cosine transform(2D-DCT) is defined as

$$F(jk) = a(j)a(k) \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} \left(f(mn) \cos\left[\frac{(2m+1)j\pi}{2N}\right] \cos\left[\frac{(2n+1)k\pi}{2N}\right] \right) \text{------------} (1)$$

The corresponding inverse transformation(Whether 2DIDCT) is defined as

$$f(mn) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} a(j)a(k)F(jk) \left(\cos\left[\frac{(2m+1)j\pi}{2N}\right] \cos\left[\frac{(2n+1)k\pi}{2N}\right] \right) \text{------------} (2)$$

The 2D-DCT can not only concentrate the most information of original image into the littlest low- frequency coefficient, but also it can cause the image blocking effect being the littlest, which can realize the great compromise between the knowledge centralizing and therefore the computing complication. So it obtains the wide spreading application within the compression coding.

DISCRETE WAVELET TRANSFORM

Wavelet transform could also be a time-domain localized analysis method with the window's size fixed and form convertible. There is quite a blast differentiated rate in high frequency a neighborhood of signals DWT transformed. Also, there's quite a good frequency differentiated rate in its low-frequency part. It can distill the information from the signal effectively. Discrete wavelet transform (DWT) basic idea in the image process is to multi-differentiated decompose the image into an independent frequency district and the sub-image of the varied spatial domain [5][6]. Then transform the coefficient of sub-image. DWT has been transformed after the primary image and it's decomposed into 4 frequency districts (LL, LH, HL, HH). If the knowledge of the low-frequency district is DWT transformed, the sub-level frequency district information is going to be obtained. A two-dimensional image after three-times DWT decomposed can be shown as Fig.3.a.4. Where L represents a low-pass filter, H represents a high-pass filter. An original image is often decomposed of frequency districts of HL1, LH1, HH1. The sub-level frequency district information of LL2, HL2, LH2, and HH2 has been decomposed from the low-frequency district information. By doing this the first image is often decomposed for n level wavelet transformation.

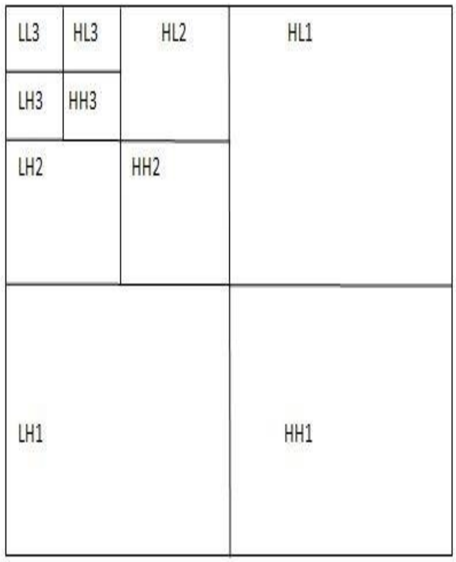

Fig 3.a.4: Sketch Map of Image DWT Decomposed

The information of the low-frequency district is an image close to the original image. Most signal information of the original image is in this frequency district. The original image of the level detail, the upright detail, and the diagonal detail represents the frequency districts of LH, HL, and HH respectively. Human eyes are sensitive to the change of smooth district of the image, but not sensitive to the tiny change of edge, profile, and streak by the character of HVS. Therefore, it's hard to sensible that the big extent coefficient of the high-frequency band of the image DWT transformed into by putting the watermarking signal. Then it can carry more watermarking signals and has a good concealing effect.

Watermark Embedding

The way of watermark embedding is shown in Fig 3.a.5 . It contains some steps as follow:

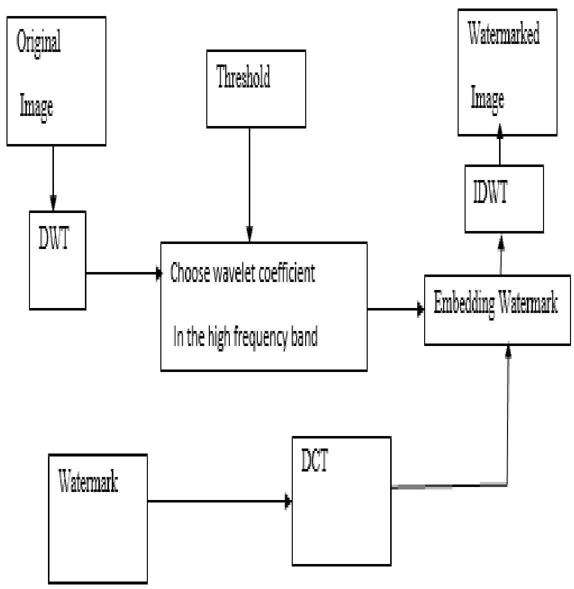

Fig 3.a.5: Sketch Map of Watermark Embedding

Step A: For progressing the robustness of the watermark algorithm and thus the privacy of the watermarking image, transform the watermark, that's to make the image DCT transformed and a disordered image is going to be acquired.

Step B: DWT transform: Putrefy the host image X by L-levels using two-dimensional DWT. Then an approaching sub-image(low waveband information) and 3L detail sub-images(high-frequency band information) are acquired. the way to choose the DWT levels L has trusted the sizes of the primary image and thus the watermarking signal. the upper DWT level is, the upper the concealing effect of embedding watermark is.

Step C: Choose the streak blocks: The high waveband information of the DWT image is plotted into 2 * 2 image sub-blocks Bk. Then count entropy and square values of each image sub-block Bk. The image sub-block with a small value of entropy should be smooth block, which with big value should be streak block or edge block. and therefore the square value of the streak block is small, the one of edge block is bigger. By choosing the proper threshold of entropy and therefore the square, the streak blocks wanted Uk (k = 1,2…… ， P×Q) are going to be obtained.

Step D: Embedding the watermark: Amend the wavelet coefficient values Ck of the chosen streak blocks Bk to finish the watermark embedding. and therefore the embedding formula is as follow:

Ck′ = Ck + a × vk ,k = 1， 2……., P×Q-----------------------(3)

Where Ck illustrates the previous wavelet coefficient value of streak sub-block Uk , Vk represents the No.k component weight of one-dimensional digital watermarking sequence V, ′Ck represents the new wavelet coefficient value of streak sub-block k U , represents the embedding depth for digital watermarking.

Step E: Inversing transform: After embedding the watermarking signal, unite the knowledge of the lowest waveband and thus the mended high waveband. Then the wavelet transform of the image is inversed by the L-level, and thus the watermarked image is obtained.

3(b) MEDICAL IMAGE TRANSMISSION OVER LTE SYSTEM

3.b.1: INTRODUCTION

LTE stands for future Evolution and it had been started as a project in 2004 by telecommunication body referred to as the Third Generation Partnership Project (3GPP). SAE (System Architecture Evolution) is the analogous evolution of the GPRS/3G packet core network evolution. The term LTE is usually used to represent both LTE and SAE.

LTE evolved from an earlier 3GPP system acquainted as the Universal Mobile Telecommunication System (UMTS) which successively evolved from the worldwide System for Mobile Communications (GSM). Even related specifications were formally referred to as the evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN). The primary version of LTE was documented in Release 8 of the 3GPP specifications.

On the way towards fourth-generation Mobile TV, MMOG (Multimedia Online Gaming), streaming contents are fast increments in mobile data observance and root of the latest applications which have motivated the 3GPP to figure LTE.

The main goal of LTE is to supply a high rate, low latency, and packet optimized radio-access technology supporting flexible bandwidth deployments. Same time its specification has been designed to support packet-switched traffic with seamless mobility and great quality of service.

LTE Evolution:

Year	Event
Mar 2000	Release 99 - UMTS/WCDMA
Mar 2002	Rel 5 - HSDPA
Mar 2005	Rel6 - HSDPA
Nov 2004	Work started on LTE specification
Year 2007	Rel 7 - DL MIMO, IMS (IP Multimedia Subsystem)
Jan 2008	Spec finalized and approved with Release 8
Year 2010	Targeted first deployment

Table 3.b.1: LTE Evolution

3.b.2: Long Term Evolution (LTE)

LTE, the successor technology not only of UMTS but also of CDMA 2000, is essential because it brings up to 50 times implement rate and far better spooky proficiency to cellular networks. It introduced to urge higher data rates, 300Mbps peak downlink, and 75 Mbps peak uplink. during a 20MHz carrier, data rates beyond 300Mbps are often achieved under excellent signal conditions.LTE is a perfect technology to support high data rates for services like voice IP (VOIP), streaming multimedia, videoconferencing, or maybe a high-speed cellular modem.

LTE wont to both Time Division Duplex (TDD) and Frequency Division Duplex (FDD) mode. In FDD uplink and downlink transmission used different frequencies, while in TDD both uplink and downlink use an equivalent carrier and are separated in time. It supports flexible carrier bandwidths, from 1.4 MHz up to twenty MHz also as both FDD and TDD. it's designed with a scalable carrier bandwidth from 1.4 MHz up to twenty MHz in which bandwidth is employed depends on the waveband and therefore the amount of spectrum available with a network operator.

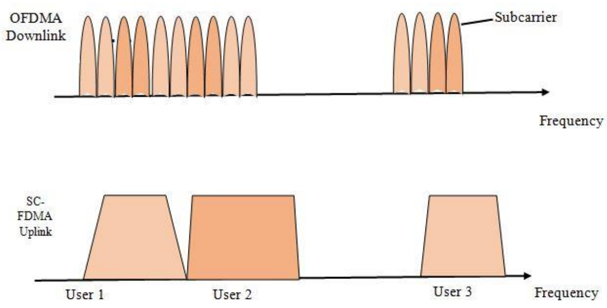

Figure 3.b.1: LTE uplink and downlink waveform

All LTE devices need to support (MIMO) Multiple Input Multiple Output transmissions, which permit the bottom station to transmit several data streams over an equivalent carrier simultaneously. All interfacer between network nodes in LTE are now IP based, along the backhaul connection to the radio base stations. This is an excellent simplification compared to earlier technologies that were initially supported E1/T1, ATM, and frame boosters, with most of them being narrowband and expensive.

Quality of Service (QoS) mechanism has been standardized on all interfaces to make sure that the need for voice involves a continuing delay and bandwidth, can still be met when capacity limits are reached. Works with GSM/EDGE/UMTS systems utilizing attending 2G and 3G spectrum and new spectrum. Supports hand-over and roaming to existing mobile networks.

Advantages of LTE:

• High throughput: High data rates can be acquired in both downlink as well as uplink. This causes high throughput.

• Low latency: Time constituent to connect to the network is in range of a few hundred milliseconds and power-saving states can now be rapted and departed very quickly.

• FDD and TDD in the same platform: Frequency Division Duplex (FDD) and Time Division Duplex (FDD), both schemes can be used on the same platform.

• Superior end-user experience: Optimized signaling for connection organization and other air interface and mobility regulation process have further promoted the user experience. Shortened latency (to 10 ms) for better user experience.

• Seamless Connection: LTE will also support a seamless connection to existing networks such as GSM, CDMA, and WCDMA.

• Plug and play: The user does not have to manually install drivers for the device. Instead, the system automatically recognizes the device, loads new drivers for the hardware if needed, and begins to work with the newly connected device.

• Simple architecture: On account of Simple architecture low operating expenditure (OPEX).

Basic parameters of the LTE:

Parameters	Description
Frequency range	UMTS FDD bands and TDD bands
Duplexing	FDD, TDD, half-duplex FDD
Channel coding	Turbo code
Mobility	350 km/h
Channel Bandwidth (MHz)	1.4 3 5 10 15 20
Transmission Bandwidth Configuration NRB : (1 resource block = 180kHz in 1ms TTI)	6 15 25 50 75 100
Modulation Schemes	UL: QPSK, 16QAM, 64QAM(optional)
	DL: QPSK, 16QAM, 64QAM
Multiple Access Schemes	UL: SC-FDMA (Single Carrier Frequency Division Multiple Access) supports 50Mbps+ (20MHz spectrum)
	DL: OFDM (Orthogonal Frequency Division Multiple Access) supports 100Mbps+ (20MHz spectrum)
Multi-Antenna Technology	UL: Multi-user collaborative MIMO
	DL: TxAA, spatial multiplexing, CDD ,max 4x4 array
Peak data rate in LTE	UL: 75Mbps(20MHz bandwidth)
	DL: 150Mbps(UE Category 4, 2x2 MIMO, 20MHz bandwidth)
	DL: 300Mbps(UE category 5, 4x4 MIMO, 20MHz bandwidth)
MIMO (Multiple Input Multiple Output)	UL: 1 x 2, 1 x 4
	DL: 2 x 2, 4 x 2, 4 x 4
Coverage	5 - 100km with slight degradation after 30km
QoS	E2E QOS allowing prioritization of different class of service
Latency	End-user latency < 10mS

Table 4.2: LTE Parameters

3.b.3: OFDMA

The OFDMA system is a multiuser version of the OFDM system, and all that were previously mentioned about the OFDM system also hold for the OFDMA system. Each user in an OFDMA system is usually given certain subcarriers during a certain time to communicate. Usually, subcarriers are allocated in contiguous groups for simplicity and to reduce the overhead of indicating which subcarriers have been allocated to each user. One of the major problems with an OFDMA system is to synchronize the uplink transmissions, because every user has to transmit his frame so that he avoids interfering with the other users. The OFDMA system for mobile communications was first proposed in based on multicarrier FDMA, where each user is assigned a set of randomly selected subcarriers. Figure 3.b.2 shows the block diagram of the OFDMA system.

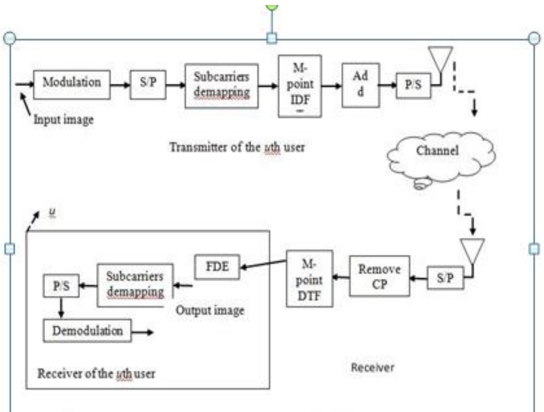

Figure 3.b.2: Transmitter and receiver structures of the OFDMA system over a frequency-selective channel.

3.b.4: SCFDMA:

The block diagram of the DFT-SC-FDMA system is shown in Figure 3.b.3. One base station and U uplink users are assumed. There are totally M subcarriers and each user is assigned a subset of subcarriers for the uplink transmission. For simplicity, we assume that each user has the same number of subcarriers, N. As shown in Figure 3.b.3 , the DFT-SC-FDMA system has much in common with the OFDMA system except for the additional DFT and IDFT blocks at the transmitter and receiver, respectively. For this reason, the DFT-SC-FDMA system is sometimes referred to as the DFT-spread or DFT precoded OFDMA system. The transmitter of the DFT-SC-FDMA system uses different subcarriers to transmit information data, as in the OFDMA system. However, the DFT-SC-FDMA system transmits the subcarriers sequentially, rather than in parallel. This approach has the advantage of enabling a low PAPR, which is important to increase cell coverage and to prolong the battery lifetime of mobile terminals. At the transmitter side, the encoded data is transformed into a multilevel sequence of complex numbers in one of several possible modulation formats. The resulting modulated symbols are grouped

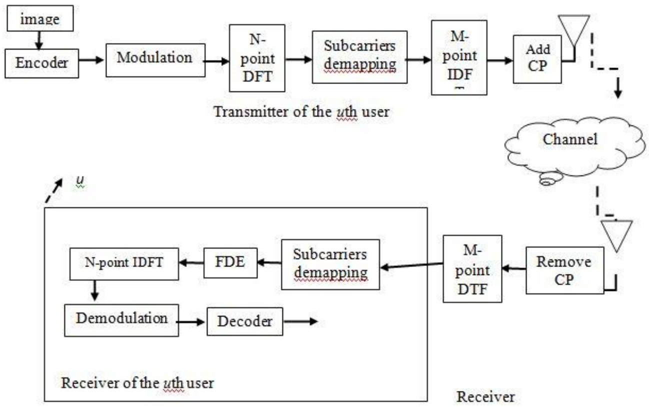

Figure 3.b.3: Structure of the DFT-SC-FDMA system over a frequency-selective channel.

into blocks, each containing N symbols and the DFT is performed. The signal after the DFT can be expressed as follows:

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-\frac{j2\pi}{N} nk}$$

where

N is the input block size {x(n):n=0,…, N−1} illustrates the modulated data symbols

The outputs are then mapped to M (M>N) orthogonal subcarriers followed by the M-point IDFT to convert to a time-domain complex signal sequence. M= QN is the output block size. Q is the maximum

number of users that can transmit, simultaneously. Notice that the remaining (M− N) subcarriers may be used by the other users communicating in the cell, thus a promising multiuser access is achieved. The turning signal after the IDFT can be given as follows:

$$\bar{x}(m) = \frac{1}{M}\sum_{l=0}^{M-1}\bar{X}(l)e^{\frac{j2\pi}{M}ml}$$

where {X –(l): l=0, …, M−1} represents the frequency-domain samples after the subcarriers mapping scheme. Before transmission through the wireless channel, a CP is appended in front of each block to provide a guard time preventing IBI in the multipath channel. At the receiver side, the CP is removed from the received signal and the signal is then transformed into the frequency domain via an M-point DFT. After that, the subcarriers demapping and the FDE processes are performed. Finally, the equalized signal is transformed back into the time domain via an N-point IDFT, followed by the demodulation and decoding processes. After removing the CP, the received signal can be written as follows:

$$r = \sum_{u=1}^{U} H_C^u \bar{x}^u + n$$

Where,

$\vec{x}$ Uis an M×1 vector representing the block of the transmitted symbols of the uth user nis the M×1 vector of zero-mean complex additive white Gaussian noise (AWGN) with variance σ_n^2

$H_C^U$is an M× M circulant matrix describing the multipath channel between the uth user and the base station

Some properties of the DFT-SC-FDMA system are listed as follows [9]:

For perfect synchronization, as in the OFDMA system, the DFT-SC-FDMA system can achieve MAI-free transmission by allocating different subcarriers to different users.

The DFT-SC-FDMA system guarantees orthogonality among users over a multipath channel provided that the length of the CP is longer than the channel impulse response.

The DFT-SC-FDMA system has lower PAPR than the OFDMA system, thereby providing better coverage and longer terminal talk time.

The simple single-tap equalizer can be used in the frequency domain for channel equalization, with the zero-forcing (ZF) or MMSE criterion. The computational complexity of the equalizer is independent of the length of the channel impulse response.

The DFT-SC-FDMA system is more robust to spectral nulls.

However, the DFT-SC-FDMA system has some disadvantages as follows:

It has a higher complexity than the OFDMA system. At the transmitter side, it requires an additional DFT process with a dynamic DFT size relying on the number of allocated subcarriers. At the receiver side, it requires an additional IDFT process.

Noise enhancement at the linear receiver occurs. The IDFT block spreads the noise contribution to the faded subcarriers, and it is enhanced by the equalizer over the whole bandwidth.

Due to the similarity between the DFT-SC-FDMA system and the OFDMA system, the DFT-SC-FDMA system is also sensitive to CFOs, the in-phase/quadrature-phase (I/Q) imbalance, and the phase noise.

3.b.5: Subcarrier Mapping

DFT output of the info symbols is mapped to a subset of subcarriers, a process called

subcarrier mapping. The subcarrier mapping assigns DFT output complex values because the

amplitudes of some of the selected subcarriers. Subcarrier mapping can be classified into

two types: localized mapping and distributed mapping. In localized mapping, the DFT

outputs are mapped to a subset of consecutive sub-carriers thereby confining them to only a

fraction of the system bandwidth. In distributed mapping, the DFT outputs of the input file

are assigned to subcarriers over the whole bandwidth non-continuously, leading to zero

amplitude for the remaining subcarriers. A special case of distributed SC-FDMA is called

interleaved SC-FDMA, where the occupied subcarriers are equally spaced over the whole

bandwidth. Figure 3.b.4 is a general picture of localized and distributed mapping.

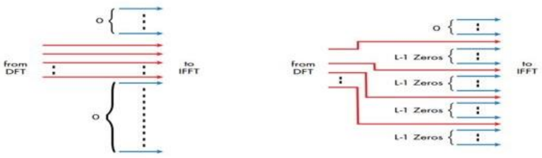

Fig3.b.4 : Localized mapping vs. Distributed mapping

An example of subcarrier mapping is shown in Figure 3.b.5. This example assumes three users
sharing 12 subcarriers. Each user features a block of 4 data symbols to transmit at a time.
The DFT output of the info block has four complex frequency domain samples, which are
mapped over 12 subcarriers using different mapping schemes.

SC-FDMA inherently offers frequency diversity gain over the quality OFDM, as all
information data is covered multiple subcarriers by the DFT mapper. However, the
distributed SC-FDMA is more robust with reference to frequency selective fading and offers
additional frequency diversity gain, since the knowledge is spread across the whole system
bandwidth. Localized SC-FDMA in combination with channel-dependent scheduling can
potentially offer multi-user plurality in frequency chosen channel conditions.

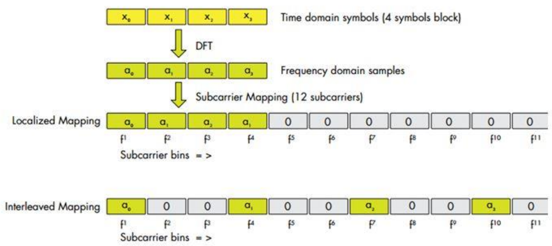

Fig 3.b.5: Subcarrier mapping example

3.b.6: OFDM to SCFDMA

The main difference between OFDM and SC-FDMA transmitter is that the DFT mapper. The transmitter groups the modulation symbols into a block of N symbols after
mapping data bits into modulation symbols,. An N-point DFT transforms these symbols in the time domain into
the frequency domain. The frequency-domain samples are then mapped to a subset of M subcarriers where M is usually greater than N. Similar to OFDM, an M-point IFFT is employed to
generate the time-domain samples of these subcarriers, which is followed by a cyclic prefix,
parallel to serial converter, DAC and RF subsystems.

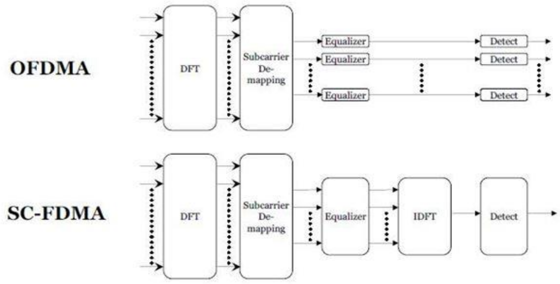

Fig 3.b.6: OFDMA vs SCFDMA

3(c): Dewatermarking

3.c.1: Watermark Distilling

The way of watermark distilling is shown in Fig.3.c.1 . It contains some steps as follow:

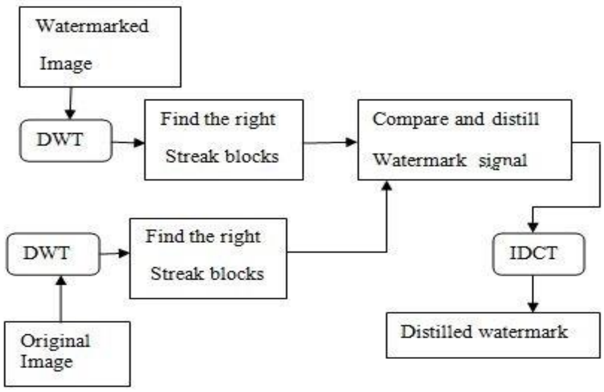

Fig 3.c.1: Sketch Map of Watermark Distilling

Step A: DWT transform: Transform the first image and therefore the watermarked image by L-levels using DWT. And the information on rock bottom waveband and therefore the high-frequency band are obtained.
Step B: confirm the streak blocks: The high-frequency band information, both of DWT image of the first and therefore the watermarked one, is plotted into 2 ∗2image sub-blocks. The streak block U, which is obtained from the high-frequency band of the original image after being DWT transformed, can be as an index by using its position. Through the index, the streak block U′,

resembling to the sub-block of the high-frequency band of the DWT resolved watermarked image is acquired.

Step C: Distilling the watermarking signal V ′: Calculate the entropies H (U¬k)and H(Uk′) which are respectively corresponding to the streak block Uk and Uk′. And the result of H(Uk)- H(Uk′) is easily obtained. When this value is bigger than a certain threshold value, it’s thought that there is watermarking component weight information in the streak block Uk′of watermarked image. Then it’s signed as 1, else 0.

Step D: Inversing transformation of watermark: Then the discrete cosine transform of the disordered watermarking image is inversed, and therefore the watermark image is obtained.

3.c.2 THE ANALYSIS OF ROBUSTNESS AND CONCEALING

Generally speaking, the evaluation of a watermarking algorithm contains two parts: robustness and concealing. The comparability of the distilled watermark with the original watermark is quantitatively analyzed by using Normalized Cross-Correlation.

The concealing of the watermark is quantitatively analyzed by using Peak Signal to Noise(PSNR). This Peak Signal to Noise(PSNR) is defined as.

PSNR= $10\log 10 \frac{A^2}{\frac{1}{N*M}\sum_{i=1}^{N}\sum_{j=1}^{M}[f(i,j)-f'(i,j)]^2}$

Its unit is db. And the bigger the PSNR value is, the better the watermark conceals .

4.Expected output of the research

Fig 4.1: breast cancer Before watermarked

Fig 4.2: breast cancer After Watermarked

F=0.06

PSNR=42.48

Correlation (ρ)=1

5. Conclusion & Future work

This paper presented a medical image watermarking model whereby medical image data is used to determine the most appropriate watermark method and capacity for each region on a medical image. The model was invented to preserve the visual integrity of medical images, which must not be compromised by watermarking. It was shown that although numerous medical image watermarking methods exist, the degradation of the whole image rather than of individual subsections is generally considered. ROI based techniques do not consider the degradation of all regions, only of non-ROI regions. ROI regions generally remain unwatermarked and therefore unprotected.

The model presented in this paper considers the most appropriate watermark method and capacity for each 8x8 block in a medical image. It was shown that using the structural comparison metric, less perceptual damage is caused to areas of high standard deviation than low standard deviations. Therefore, regions of high standard deviation on medical images can be watermarked with more robust methods and at higher capacities than regions with lower standard deviations. Higher standard deviation regions also fall into the same standard deviation category before and after watermarking, because they remain unaffected by the payload information that is embedded within them.

One area on that was neglected by the watermarking model presented here is the black background, which generally has a very small standard deviation. In addition to watermarking high standard deviation areas on medical images, background regions can also be watermarked to increase the payload capacity of the images. This can be regarded as a special case of ROI.

Some future options that can be explored for the medical image watermarking model are:

- alternative region definitions, other than 8x8 blocks
- more sophisticated region characterizations, tailored to medical images (for example, segmentation into different tissue types)
- other perceptual similarities, or error, metrics (for example, ones that take luminance and contrast into account)

This type of system is appropriate for medical images because the amount of perceptual degradation caused by watermarking is limited. At the same time, medical image data is protected by watermarking, which enhances the security of the data.

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