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Robust Spread Spectrum Based Digital Video Watermarking Scheme in Frequency Domain

Nisha Chaudhary[1] **Savita Shivani**[2]
[1]B.Tech, M.Tech [2]B.Tech, M.Tech, Ph.D
[1,2]Department of Computer Engineering
[1,2]Suresh Gyan Vihar University, Jagatpura, Jaipur, Rajasthan

Abstract— There is an explosion of data exchange on the Internet and the extensive use of digital media. Consequently, digital data owners can quickly and massively transfer multimedia documents through the Internet. It has aroused intense interest in multimedia security and multimedia copyright protection, and this has become a critical issue in the modern digital era. The problem is severe in case of digital video as several copies of duplicate videos can be made on optical disks even with cheap commodity computers. This results in recording, editing and replication of multimedia contents, thereby providing revenue losses. Digital watermarking technique is the process of embedding noise-tolerant signal in the carrier signal. This dissertation focuses on the embedding of watermark bits into the video frames. A given video sample is spilt into frames for watermark embedding. A frame is first transformed into frequency domain using Discrete Fourier Transform. A watermark, modulated with PN sequence is transformed and added to the Fourier coefficients and then the inverse is obtained of modified Fourier Coefficients to get watermarked frame. This process is repeated to the entire length of video to get watermarked video. The video watermarking algorithm proposed is robust against the attacks of frame dropping, averaging and statistical analysis. Peak Signal to Noise Ratio (PSNR) is used as the quality metric for watermarking scheme. Mathematical techniques are presented and simulation are carried out using MATLAB.

Key words: Watermarking, DFT, FFT, Spread Spectrum, m sequences

I. INTRODUCTION

The rapid proliferation of multimedia over internet demands sophisticated technique for secure and efficient access to information. There is growing need to discourage unauthorized duplication and use of digital data. Watermarking refers to hiding a message signal into a host signal, without any perceptual distortion of the host signal [1]. As the word watermarking suggests, the mark itself is transparent or unnoticeable for the human perception system. Usually, the host signal is a digital media, like audio, video or images. Digital watermarking embedding refers to the method of inserting information into multimedia data, called original media or cover media e.g. text, audio, image or video. The embedded information or watermark can be a serial number or a random number sequence, ownership identifier, copyright message, control signal, transaction date, information about the creators of the work, bi-level or gray level image, text or other digital data format. As the Human Visual System (HVS) [2], is far from being perfect for images and video so it is possible to modify the pixel values without the watermark being visible. Provided that a certain HVS threshold is not exceeded, the modified (watermarked) image or video will be indistinguishable to the human eye compared with the original. After embedding watermark, the watermarked media are sent over Internet or some other transmission channel. Whenever the copyright of the digital media is under question, the embedded information is decoded to identify copyright owner. The decoding process can extract the watermark from the watermarked media (watermark extraction) or can detect the existence of watermark in marked content (watermark detection).

Watermarking video content important to avoid piracy and illegal manipulation. However, watermarking individual frames of video in spatial domain [3] in fragile and is subjected to various kinds of attacks. Also, with a little modification, the watermark gets destroyed and cannot be detected at the receiver end. Frequency domain watermarking is more robust as compared to spatial domain watermarking. Also, frequency domain watermarking using spread spectrum uses correlation based analysis at the time of watermark detection, which provides a way for blind watermarking. In this technique, the original unmarked video is not required at the receiver end and therefore, is useful in a broad category of applications. As the case with all watermarking systems, the perceptual fidelity of the marked content must be as low as possible. Also, the marking scheme should be robust enough to handle attacks and video editing to greatest possible extent. In this work, a tradeoff between PSNR and robustness is derived by embedding watermark in frames of the original video.

Intellectual property protection [4] is one of the greatest concerns of internet users today. Digital videos are considered a representative part of such properties so are considered important. There is a critical need of development of techniques that prevent malicious users from claiming ownership, motivating internet users to feel more safe to publish their work online. In this work an efficient and easily implemented technique for watermarking video files is presented. The proposed watermarking process embeds the watermark in the frequency domain, by altering the Fourier Coefficients [5] of a sub image of the original image. The embedded data can be extracted using a denoising process without the need of the original unmarked content. Thus, it provides a way of blind watermarking which is much more convenient and desirable as compared to non-blind watermarking.

Moreover, using Frequency domain for watermark embedding, one can achieve a much more robust watermark as compared to spatial domain watermarks. Also, with spread spectrum technique, the watermark energy is distributed uniformly over the host signal thereby providing much more imperceptibility as compared to spatial domain techniques.

II. RESEARCH APPROACH

This work proposes a technique of watermarking in the frequency domain. A given video is first divided into frames for watermark embedding. Each frame is then divided into RGB color planes for the purpose of watermark embedding. The color plane frame is then transformed using Discrete Fourier Transform to obtain the DFT coefficients. The watermarking bits to be embedded in the frame are first spreaded and modulated with a chosen PN sequence [6] and then added in the Fourier coefficients using the embedding algorithm. Each frame is separately watermarked with the content. The inverse Fourier Transform is then applied to get the watermarked color plane frame. All the three color planes are then tested to find out the minimum value of the PSNR. Finally, the one with the least value of the PSNR is selected and the other two color plane frames are kept unchanged. The watermarked frames are recombined to get back the watermarked video.

III. PROPOSED WORK

A. *Proposed Video Watermarking using PN sequences*

The current work focuses on video watermarking in frequency domain using Discrete Fourier Transform. A given video is segregated into the frames which are then separately processed. The embedding algorithm works as follows:

1) *Embedding Algorithm*

(1) Separate the given video into frames. The frame rate typically depends on the format of the video as well as video quality.
(2) Let the frame size be m *X* n. Each frame is then divided into red, green and blue planes for the purpose of watermark embedding.
(3) A binary watermark is modulated with a given PN sequence and embedded in magnitude of the Fourier Coefficients of the RGB planes one by one.
(4) The color plane is selected for watermark embedding which provides the highest value of PSNR.
(5) Inverse Fourier Transform is obtained for the plane to get back the watermarked plane.
(6) The planes are combined again to get back the watermarked frame.
(7) The process is repeated for all the frames of the video to get the watermarked video.

The process of watermark embedding is illustrated in the figure 3.1.

2) *Extraction Algorithm*

(1) Separate the given video into frames. Obtain the Red, Green and Blue planes of frame.
(2) Obtain the DFT of each of the color plane.
(3) Given a PN sequence, perform the correlation analysis with each of the plane, and corresponding de spreading. A value well above threshold gives the watermark bits.
(4) Repeat the process for all the frames to ensure the presence of watermark even in the case of frame dropping. As watermark is embedded in all the frames, the scheme provides a robust watermarking technique.

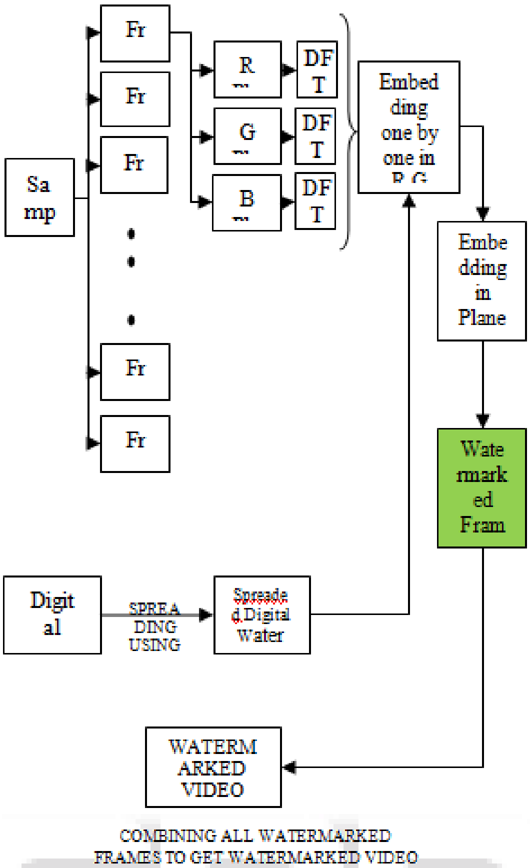

Fig. 3.1: Proposed Architecture of Embedding Process

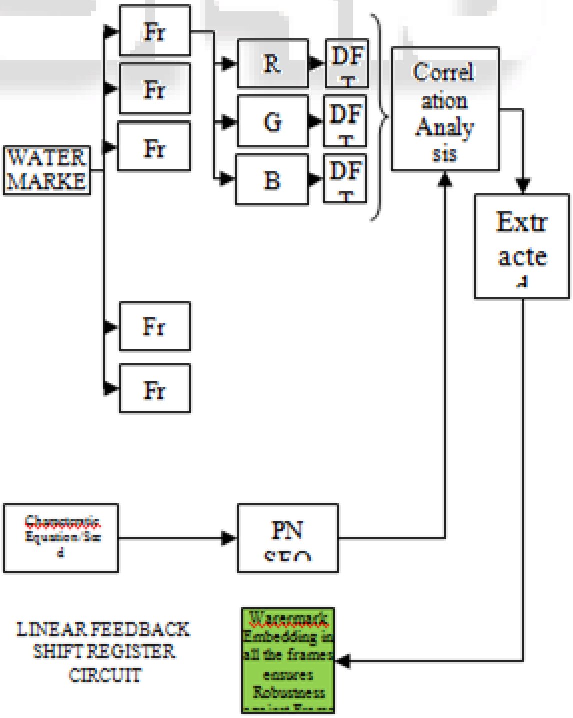

Fig. 3.2: Proposed Architecture of Extraction Process

B. *Watermark Embedding Scheme*

In this research, the watermarking scheme is carried out over 24 bit color videos. Consider an arbitrary frame of sample video to be watermarked, as shown in table 3.1.

Each frame is specifically an image and can be visualized in some format. Also, each pixel of the image is a 24 bit value comprising of 8 bits each of Red, Blue and Green color. Pixel value separation in RGB color planes is performed to embed the watermark.

Figure 3.3 is a sample video frame to be watermarked (frame number 191 in the frames displayed in chapter 4). Figure 3.2, 3.3 and 3.4 shows the Red, Green and Blue planes of the frame. The proposed method takes the Fourier Transform of each of these planes and embed the watermark modulated with PN sequence to each one of the R, G and B plane. PSNR value of each of these frames is computed and finally the one with highest value of PSNR (or least value of Mean Square Error) is selected. The rest two bit planes are kept intact. All the color planes are these merged to get the watermarked frame. All such frames are then combined to get the watermarked video.

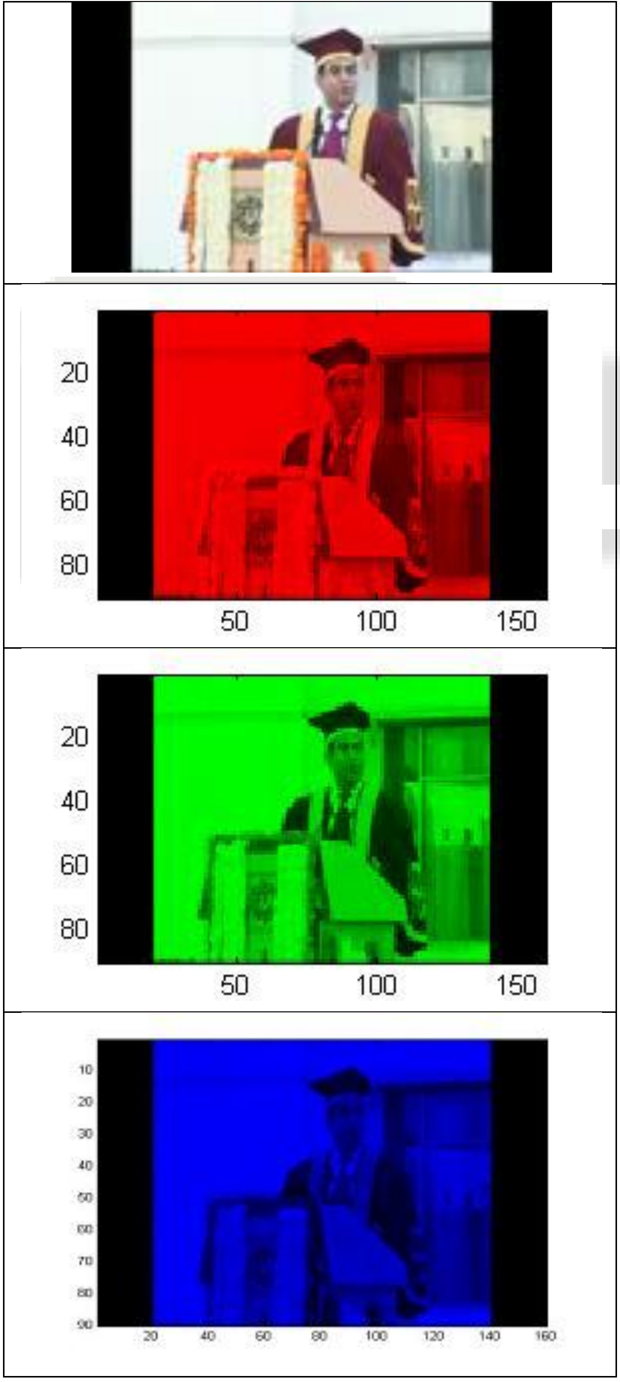

Fig 3.3 Original Color Frame and Decomposition into Red, Green and Blue color Planes

C. Watermark Detection

At the receiver end, the watermarked video is again partitioned into frames. Each frame is then further separated into Red, Green and Blue planes. The Fourier Coefficients of each of the color planes are computed and the presence of watermark is ensured by a correlation test with the same PN sequence. If the value of correlation between PN sequence and the extracted PN sequence is greater than a certain threshold, then one can ensure the presence of watermark in the given image plane. However, proper embedding of the modulated PN sequence in the Fourier coefficients is a tricky issue and can be done in several ways. The two dimensional Discrete Fourier Transform of a set of n numbers gives n complex number of the form a+ib, where a, b ϵ R, and i = √-1. In this dissertation, Binary phase only filter (BPOF) signature is used to embed watermark in the Fourier Coefficients.

D. Watermark Embedding in Fourier Coefficients

Consider an imaginary pixel matrix of dimension 8X8 as illustrated in figure 3.7.

11820331	6494913	10415645	12449088	12095072	8289687	1192490	9428863
12169468	6509693	7991089	5169284	4785451	12229114	1571845	2496992
9167064	3292591	14391728	1609133	659523	1655136	14452314	4201615
9041585	2030055	6468675	12742307	9000882	14376745	11324348	5311066
15459006	1376940	14296363	4963269	12989979	9841832	6723410	2274452
2209273	4487618	6910443	4115055	11229072	2794613	8091716	15981385
8949244	3091192	4421592	4159465	3213446	702114	8429983	12942187
13127260	4490681	11180514	6083491	4301314	14695071	16068162	494159

All the above values lie in the range [0,16777215] .The above table can be converted into binary values of length 24 bit in which the first 8 bits represent Red, the next 8 bits represents Green and the last 8 bits represents the Blue color. The corresponding RGB bit planes are as shown in figure 3.8, 3.9 and 3.10.

10110100	01100011	10011110	10111101	10111000	01111110	00010010	10001111
10111001	01100011	01111001	01001110	01001001	10111010	00010111	00100110
10001011	00110010	11011011	00011000	00001010	00011001	11011100	01000000
10001001	00011110	01100010	11000010	10001001	11011011	10101100	01010001
11101011	00010101	11011010	01001011	11000110	10010110	01100110	00100010
00100001	01000100	01101001	00111110	10101011	00101010	01111011	11110011
10001000	00101111	01000011	00111111	00110001	00001010	10000000	11000101
11001000	01000100	10101010	01011100	01000001	11100000	11110101	00000111

Red Plane

01011101	00011010	11101110	11110101	10001110	01111101	00110010	11011111
10110000	01010100	11101111	11100000	00000101	10011001	11111100	00011001
11100000	00111101	10011001	10001101	00010000	01000001	10000110	00011100
11110110	11111001	10110100	01101110	01010111	01011111	11001011	00001010
11100010	00000010	00100101	10111011	00110110	00101100	10010111	10110100
10110101	01111001	01110001	11001010	01010111	10100100	01111000	11011011

10001101	00101010	01110111	01110111	00001000	10110110	10100001	01111011
01001110	10000101	10011001	11010011	10100010	00111010	00101110	10001010

Green Plane

00101011	11000001	00011101	01000000	01100000	10010111	00101010	01111111
11111100	01111101	00110001	10000100	00101011	11111010	00000101	11100000
11011000	10101111	10110000	10101101	01000011	01100000	01011010	10001111
10110001	11100111	01000011	10100011	10110010	00101001	10111100	01011010
10111110	10101100	00101011	11000101	00011011	10101000	01010010	10010100
11111001	11000010	11101011	01101111	10010000	01110101	01000100	01001001
11111100	11111000	11011000	11101001	10000110	10100010	10011111	01101011
01011100	10111001	11100010	10100011	00000010	10011111	01000010	01001111

Blue Plane

The corresponding decimal values of each of the planes are:

180	99	158	189	184	126	18	143
185	99	121	78	73	186	23	38
139	50	219	24	10	25	220	64
137	30	98	194	137	219	172	81
235	21	218	75	198	150	102	34
33	68	105	62	171	42	123	243
136	47	67	63	49	10	128	197
200	68	170	92	65	224	245	7

Red Plane

93	26	238	245	142	125	50	223
176	84	239	224	5	153	252	25
224	61	153	141	16	65	134	28
246	249	180	110	87	95	203	10
226	2	37	187	54	44	151	180
181	121	113	202	87	164	120	219
141	42	119	119	8	182	161	123
78	133	153	211	162	58	46	138

Green Plane

43	193	29	64	96	151	42	127
252	125	49	132	43	250	5	224
216	175	176	173	67	96	90	143
177	231	67	163	178	41	188	90
190	172	43	197	27	168	82	148
249	194	235	111	144	117	68	73
252	248	216	233	134	162	159	107
92	185	226	163	2	159	66	79

Blue plane

The two dimensional FFT of the Blue plane can be obtained as shown in the figure given below:

1.4710 + 0.0000i	1.5230 + 0.0000i	1.0410 + 0.0000i	1.2360 + 0.0000i	0.6910 + 0.0000i	1.1440 + 0.0000i	0.7000 + 0.0000i	0.9910 + 0.0000i
-0.2050 - 0.0262i	-0.0603 + 0.0893i	-0.0331 + 0.2840i	-0.1182 + 0.0452i	-0.1269 + 0.0140i	0.1605 + 0.0554i	-0.1708 + 0.0273i	0.0780 - 0.1506i
-0.2350 - 0.2320i	-0.0580 + 0.0970i	-0.3200 + 0.0090i	-0.1450 + 0.0830i	-0.0780 - 0.0070i	0.0610 - 0.1670i	-0.1250 + 0.1810i	0.0250 - 0.1280i
-0.0890 - 0.0982i	0.1023 - 0.0567i	0.0051 + 0.2040i	-0.1478 - 0.0748i	0.2649 - 0.1200i	-0.1945 - 0.0766i	0.0908 - 0.1107i	-0.1200 - 0.0786i
-0.0690 + 0.0000i	0.0530 + 0.0000i	-0.1130 + 0.0000i	0.0980 + 0.0000i	-0.0430 + 0.0000i	0.0100 + 0.0000i	0.0460 + 0.0000i	0.0590 + 0.0000i
-0.0890 + 0.0982i	0.1023 + 0.0567i	0.0051 - 0.2040i	-0.1478 + 0.0748i	0.2649 + 0.1200i	-0.1945 + 0.0766i	0.0908 + 0.1107i	-0.1200 + 0.0786i
-0.2350 + 0.2320i	-0.0580 - 0.0970i	-0.3200 - 0.0090i	-0.1450 - 0.0830i	-0.0780 + 0.0070i	0.0610 + 0.1670i	-0.1250 - 0.1810i	0.0250 + 0.1280i
-0.2050 + 0.0262i	-0.0603 - 0.0893i	-0.0331 - 0.2840i	-0.1182 - 0.0452i	-0.1269 - 0.0140i	0.1605 - 0.0554i	-0.1708 - 0.0273i	0.0780 + 0.1506i

Table 3.1: Fft Coefficents For Blue Plane Of Jpg Image Of Frame

The magnitude of these Fourier coefficients are shown in figure 3.14 below:

1.471	1.523	1.041	1.236	0.691	1.144	0.7	0.991
0.206667462	0.107752401	0.285922385	0.12654754	0.127669926	0.169792255	0.172968003	0.16960059
0.33022568	0.113017698	0.320126537	0.167074834	0.078313473	0.177792013	0.21996818	0.130418557
0.132530148	0.116962302	0.20406374	0.165649872	0.290812672	0.209040211	0.143175172	0.1434502
0.069	0.053	0.113	0.098	0.043	0.01	0.046	0.059
0.132530148	0.116962302	0.20406374	0.165649872	0.290812672	0.209040211	0.143175172	0.1434502
0.33022568	0.113017698	0.320126537	0.167074834	0.078313473	0.177792013	0.21996818	0.130418557
0.206667462	0.107752401	0.285922385	0.12654754	0.127669926	0.169792255	0.172968003	0.16960059

Table 3.2: Magnitude Of Fourier Coefficients

The phase of the coefficients are shown in the table 3.15 given below:

0	0	0	0	0	0	0	0
0.00223062	-0.025852839	-0.150879829	-0.006674285	-0.001925504	0.006024449	-0.002789673	-0.033711042
0.01723219	-0.02919742	-0.000490874	-0.009990838	0.001566322	-0.047818362	-0.025277749	-0.08959948
0.019259834	-0.009673828	0.839099631	0.008833154	-0.007906526	0.006873744	-0.02128162	0.011432405
0	0	0	0	0	0	0	0
-0.019259834	0.009673828	-0.839099631	-0.008833154	0.007906526	-0.006873744	0.02128162	-0.011432405
-0.01723219	0.02919742	0.000490874	0.009990838	-0.001566322	0.047818362	0.025277749	0.08959948
-0.00223062	0.025852839	0.150879829	0.006674285	0.001925504	-0.006024449	0.002789673	0.033711042

Table 3.3: Phase of Fourier Coefficients

Using the modulus and the phase of the complex numbers, each of these can be written in the Euler form

$$a + ib = Ae^{i\theta} = A(cos\theta + i * sin\theta)$$

The Binary Phase Only Filter for the Fourier coefficients can be obtained by setting up the value 0 if tangent of angle of phase is equal to 0, -1 if it is negative and +1 if it is positive. Figure 3.5 shows the BPOF filter values.

0	0	0	0	0	0	0	0
1	-1	-1	-1	-1	1	-1	-1
1	-1	-1	-1	1	-1	-1	-1
1	-1	1	1	-1	1	-1	1

0	0	0	0	0	0	0	0
-1	1	-1	-1	1	-1	1	-1
-1	1	1	1	-1	1	1	1
-1	1	1	1	1	-1	1	1

Table 3.4: Magnitude Of Fourier Coefficients

E. PN sequence Generator

Consider the following circuit to generate a PN sequence:

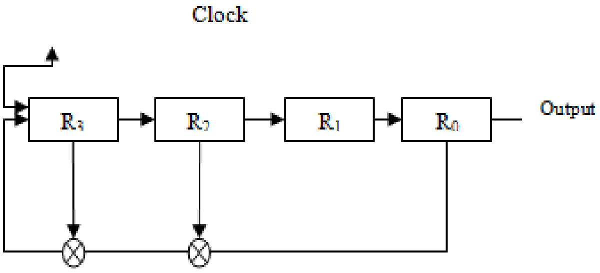

Fig. 3.4: LFSR Circuit for generation of PN sequence

R_1, R_2, R_3 and R_4 are the registers that hold 1 bit of information. The contents of the R_0 and R_2 are ex-ored and the result is again ex-ored with R_3 and the result is again fed to the R_3 register. The above circuit is an example of Linear Feedback Shift Register (LFSR) Circuit. Let the initial contents of the registers be (0,1,1,0), then the output can be generated in the following way.

Time	LFSR States	Output
0	0,1,1,0	-
1	1,1,0,1	0
2	1,0,1,0	1
3	0,1,0,0	1
4	1,0,0,0	0
5	0,0,0,1	1
6	0,0,1,1	0
7	**0,1,1,0**	**0**

Table 3.5: Linear Feedback Shift Register O/P For M Sequences

The last row is the same as the first one and therefore indicates that the same pattern would repeat thereafter. Thus, the period of the LFSR consisting of 3 registers is 2^3-1 = 7.

Denoting 0 with -1 to keep the values in polar format, the PN sequence obtained is -1,1,1,-1,1,-1,-1.

Consider the watermark to be bit sequence 101. Converting it into polar form, the watermark can be represented as 1 -1 1. The speeded sequence obtained to embed in the host signal is:

Watermark Bit	PN Sequence	Spread Sequence
1	-1	-1
	1	1
	1	1
	-1	-1
	1	1
	-1	-1
	-1	-1
-1	-1	1
	1	-1
	1	-1
	-1	1
	1	-1
	-1	1
	-1	1
1	-1	-1
	1	1
	1	1
	-1	-1
	1	1
	-1	-1
	-1	-1

Table 3.6: Embedding Of Bits Corresponding To Psnr Values

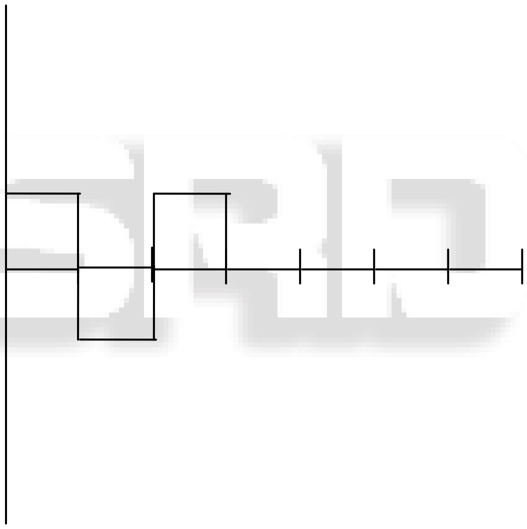

Fig. 3.5: The watermark to be embedded (represented as a signal). Horizontal axes shows the time and the vertical axes shows the amplitude.

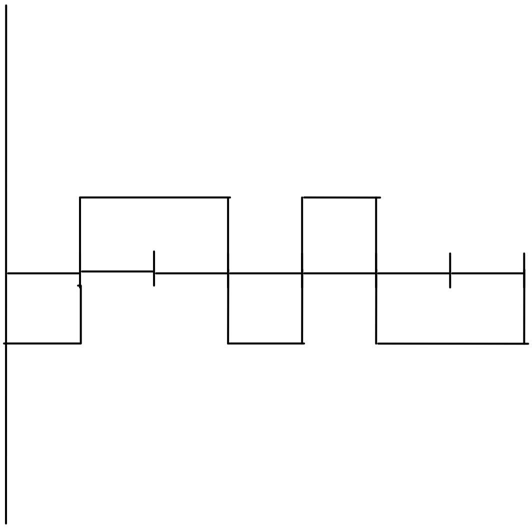

Fig. 3.6: The spreading corresponding to a one bit data. Horizontal axes shows the time and the vertical axes shows the amplitude.

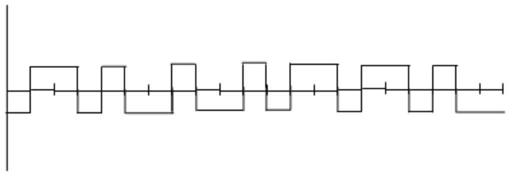

Fig 3.7 The spreading corresponding to a sequence 101. Horizontal axes shows the time and the vertical axes shows the amplitude.

Thus, the sequence to be embed is -1,1,1,-1,1,-1,-1,1,-1,-1,1,-1,1,1,-1,1,1,-1,1,-1,-1. These watermark bits are to be added in such a way so as to maintain the symmetry of the Fourier transform.

F. Proposed Algorithm for watermark embedding

The data to be embedded is used to modulate the magnitude of the Fourier coefficients in such a way so as to maintain the symmetry of the magnitudes. In the example shown above, the hypothetical frame consists of 64 pixels (8X8 matrix) and the watermark is to embedded in all the bits of the frame, such that the symmetry is preserved. In can be easily observed that the first row of the transform consists of all the real values, whereas the other seven values of each row are symmetrically separated. Thus, keeping the two rows, the first one and the middle, on can have a total of 48 pixels in which the values are to be modified. Also, as the symmetry is to be preserved, a total of 24 bits can be embedded in the magnitude of the coefficients. The spreaded code to be embed is to be appended with padding bits to make it 24 bits long.

Let α be the masking threshold value above which denotes a 1 and below which denotes a 0. This value is suitably chosen as per the magnitude of the Fourier coefficients. Consider the table for magnitude of Fourier coefficients repeated here for ready reference.

1.471	**1.523**	**1.041**	**1.236**	**0.691**	**1.144**	**0.7**	**0.991**
0.206667462	0.107752401	0.285922385	0.12654754	0.127669926	0.169792255	0.172968003	0.16960059
0.33022568	0.113017698	0.320126537	0.167074834	0.078313473	0.177792013	0.21996818	0.130418557
0.132530148	0.116962302	0.20406374	0.165649872	0.290812672	0.209040211	0.143175172	0.1434502
0.069	**0.053**	**0.113**	**0.098**	**0.043**	**0.01**	**0.046**	**0.059**
0.132530148	0.116962302	0.20406374	0.165649872	0.290812672	0.209040211	0.143175172	0.1434502
0.33022568	0.113017698	0.320126537	0.167074834	0.078313473	0.177792013	0.21996818	0.130418557
0.206667462	0.107752401	0.285922385	0.12654754	0.127669926	0.169792255	0.172968003	0.16960059

The two rows which are highlighted are to be kept intact and the embedding is performed in half of the remaining bits, as the other half is to be modified to maintain the symmetry of Fourier Transform.

Let α = .2, which indicates that a value equal to or below 0.2 denotes a -1 and a value above it denotes a +1. An integer multiple of a step size β is to be added (or subtracted) to (from) the magnitude to change it to denote the value it should represent.

Consider the data stream -1,1,1,-1,1, -1, -1, 1,-1,-1,1,-1,1,1,-1,1,1,-1,1,-1,-1,±1,±1,±1. The last three are padding bits which can either be +1 or -1.

One possible embedding with β= 0.1 is

1.471	**1.523**	**1.041**	**1.236**	**0.691**	**1.144**	**0.7**	**0.991**
0.106667462	0.207752401	0.285922385	0.12654754	0.227669926	0.169792255	0.172968003	0.26960059
0.13022568	0.113017698	0.320126537	0.167074834	0.278313473	0.277792013	0.11996818	0.230418557
0.232530148	0.116962302	0.20406374	0.165649872	0.190812672	0.209040211	0.143175172	0.1434502
0.069	**0.053**	**0.113**	**0.098**	**0.043**	**0.01**	**0.046**	**0.059**
0.232530148	0.116962302	0.20406374	0.165649872	0.190812672	0.209040211	0.143175172	0.1434502
0.13022568	0.113017698	0.320126537	0.167074834	0.278313473	0.277792013	0.11996818	0.230418557
0.106667462	0.207752401	0.285922385	0.12654754	0.227669926	0.169792255	0.172968003	0.26960059

Table 3.7: Embeding In Magnitude Values Of Fft Coefficients (Changed Values Are Shown In Red)

The Fourier coefficients can be constructed from these modified magnitudes and the original phase of the frame, using the Euler Formula.

1.471	1.523	1.041	1.236	0.691	1.144	0.7	0.991
-0.1058068331602219-0.0135226294087695i	-0.11626162963945+0.17217518286572i	-0.0331000000494138+0.28400000423974i	-0.118199999557336+0.045199999830724i	-0.226296940233946+0.0249657774883786i	0.160499999604685+0.0553999998635486i	-0.170800000176429+0.0273000000281998i	0.123990406324152-0.239396861441247i
-0.092673091815026-0.0914900310684512i	-0.058000000138993+0.0970000002324537i	-0.319999999518525+0.00899999998645852i	-0.145000000405504+0.08300000002321163i	-0.277199441638467-0.0248768729675547i	0.0953097525399101-0.260929978265i	-0.0681735991675316+0.0987153715945857i	0.0441690512392877-0.226145542345153i
-0.156154532083823-0.172296348883499i	0.10230000033329-0.0567000001847268i	0.00509999999894598+0.203999999957839i	-0.147800000252124-0.0748000001275973i	0.173810434475517-0.0787363236582182i	-0.194499999588112-0.0765999998377861i	0.0907999997280969-0.110699999668506i	-0.119999999650228-0.0785999997708992i
-0.069	0.053	-0.113	0.098	-0.043	0.01	0.046	0.059
-0.156154532083823+0.172296348883499i	0.10230000033329+0.0567000001847268i	0.00509999999894598-0.2039999999957839i	-0.147800000252124+0.0748000001275973i	0.173810434475517+0.0787363236582182i	-0.194499999588112+0.0765999998377861i	0.0907999997280969+0.110699999668506i	-0.119999999650228+0.0785999997708992i
-0.092673091815026+0.0914900310684512i	-0.058000000138993-0.0970000002324537i	-0.319999999518525-0.00899999998645852i	-0.145000000405504-0.0830000002321163i	-0.277199441638467+0.0248768729675547i	0.0953097525399101+0.260929978265i	-0.0681735991675316-0.0987153715945857i	0.0441690512392877+0.226145542345153i
-0.10580683331602	-0.11626162963	-0.033100000004	-0.1181999995	-0.22629694023	0.160499999604685-0.0553	-0.170800000176429-	0.123990406324152+0.239396861441

19+0.0135226294087695i	945-0.17217518286572i	94138-0.284000000423974i	57336-0.04519999983072 4i	3946-0.024965777488378 6i	999998635486i	0.0273000000281998i	247i

Table 3.8: Reconstruction Of Fourier Coefficients From Modified Magnitude And Phase Values

which on inverse Fourier Transform gives

86.5914	179.0096	29.0000	64.0000	100.4215	159.5774	56.2066	143.2899
257.1213	100.4501	48.9801	131.9652	36.7449	273.4859	25.5695	272.3826
158.7248	154.2812	176.0000	173.0000	124.3743	87.4226	75.7934	160.4070
193.5757	226.2233	66.9858	163.0000	165.7658	17.5094	167.4168	73.0462
217.5721	185.9904	43.0000	197.0000	24.8218	176.5774	96.2066	141.2947
173.6237	218.5499	235.0199	111.0348	159.1935	140.4791	88.5728	73.6901
238.1117	268.7188	216.0000	233.0000	176.2254	153.4226	144.7934	80.0085
145.6793	189.7767	226.0142	163.0000	5.2957	135.5256	45.4409	46.8810

Table 3.9: Reconstruction Of Pixel Values From Modified Fourier Coefficients

The original blue plane pixel values are shown in the table 3.10.

43	193	29	64	96	151	42	127
252	125	49	132	43	250	5	224
216	175	176	173	67	96	90	143
177	231	67	163	178	41	188	90
190	172	43	197	27	168	82	148
249	194	235	111	144	117	68	73
252	248	216	233	134	162	159	107
92	185	226	163	2	159	66	79

Table 3.10: Original Pixel Value Of The Blue Plane Of Image

The MSE fir the above hypothetical video frame is 620 giving PSNR value 20.20db.

The PSNR value for Suresh Gyan Vihar Universe convocation video (also provided in CD ROM enclosed) is computed in Chapter 4..

IV. CONCLUSION AND FUTIRE SCOPE

This dissertation proposes a technique of watermark embedding in video in frequency domain in which the video is segregated into frames. Each frame is then converted to image format and then separated into Red, Green and Blue Planes. The pixel matrix of each of the color planes is then subjected to two dimensional Fourier Transform. The text string to be used as watermark is first converted into ASCII code, and then modulated using PN sequence. The Fourier Coefficients are then converted into Euler Form by decomposing into magnitude and phase. This modulated string is then embedded into the magnitude of the Fourier Coefficients without affecting the phase.

To keep the fidelity of the watermark video as high as possible, the proposed technique embed the watermark in only one of the three planes, viz red, green and blue, which gives the highest value of PSNR. Later, at the time of detection, the extracted string is to be demodulated with the same PN sequence to get back the watermark, or the presence of watermark is ensured. It turns out that the PSNR value is a function of length of the watermark. PSNR values are inversely proportional to the length of the watermark message.

The proposed technique for video watermarking presents a robust technique against frame dropping attacks. As the different frames of the video, consists of watermark in any of red, green or blue planes, the watermark presence is unaltered against frame dropping. However, an additional computation cost is inculcated as the detector has to decompose the frame into RGB planes and each one is separately operated for the presence of watermark.

A. Future Scope

The proposed future work on the this technique of video watermarking embed the watermark selectively in the transitional frames of the video. Transitional frames are the frames in which the location of a sequence of frame changes. These are the frames in which some content of the new scene is superimposed on some content of the previous scene. However, in such a technique, there is a serious drawback of robustness of the embedded watermark. However, embedding selectively in the transitional frames and some intermediate frames will serve the purpose of robustness and at the same time, optimizing the fidelity of the watermarked video.

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