Simulation and Analysis of Digital Video Watermarking Using MPEG-2

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***Abstract*— Quantization Index Modulation (QIM) is an important method for embedding digital watermark signal with information. This technique achieves very efficient tradeoffs among watermark embedding rate, the amount of embedding induced distortion to the host signal and the robustness to intentional or unintentional attacks. Most of the schemes of video watermarking have been proposed on uncompressed video. This paper introduces a compressed video watermarking procedure to reduce computations. In a video frame the luminance component is an important factor where much change can not be made as it can disturb the original data. The MPGE-2 video compression technique is based on a macroblock structure, motion compression and conditional replenishment of macroblocks. To achieve high compression motion compensation employed with P-frames, the Discrete Cosine Transformation (DCT) always exists in video stream for high robustness. In this work the QIM technique used for embedding is the DC component of chrome DCT of P-frames. The robustness of the proposed method has been studied through simulation.**

KEYWORDS- ***Bit Error Rate (BER), Discrete Cosine Transformation (DCT), MPEG-2, Normalized Cross-Correlation Function (NC), Quantization Index Modulation (QIM).***

I. INTRODUCTION

In the digitized word with the increase of the uses of extensive data communication the problem of security, authentication of the multimedia data also increases. It is required to prevent unauthorized duplication and use of digital data. To achieve this digital watermarking is most important way for security and authenticated access to information. A watermark could be a binary stream, a logo, or the features of multimedia content. It can be done in raw video streams or in different stages of the compression process. In compression process host data can be the coded bit streams, DC coefficients stream, MPEG-2 Video Watermarking using QIM or the residual coefficient streams of luminance and chrominance signals. In this paper the chrominance blocks of non-intra macro-blocks are used for embedding the watermark. Generally one out of the three frames (I, P or B) mainly we use the I-frames as the life of I-frames is crucial for the video signal and P, B-frames are highly compressed by motion compensation thus having less capacity. Also, motion estimation in P-frames provides good temporal information about the video. Authentication of P frames does not depend on the authentication results of previous reference frames. If I-frames are tampered, the pixel values of future frames will also alter as they are encoded based on these tampered reference frames. One class of embedding methods that achieves optimal rate, distortion and robustness trade-offs is called QIM which is used here.

II. CLASSIFICATION OF WATERMARKING TECHNIQUES

Researchers have investigated many video watermarking techniques that are robust and invisible. Most of them operate on uncompressed video or embeds watermark directly into the compressed video. These schemes can be distinguished in terms of their domain, capacity, real-time performance, the degree to which all three axes are incorporated, and their resistance to particular types of attacks. The 3 main types of scheme are:

A. The Spatial Domain Watermarks:

In this the watermark is applied to the pixel or coordinate domain, no transforms are applied to the host signal during watermark embedding. The watermark is derived from the message data via spread spectrum modulation.

B. The Frequency Domain Watermarks:

Generally DCT, FFT and wavelet transform are used as the methods of data transformation. The main strength offered by transform domain techniques is that they can take advantage of special properties of alternate domains to address the limitations of pixel-based methods or to support additional features. For instance, designing a watermarking scheme in the DCT domain leads to better implementation compatibility with popular video coding algorithms such as MPEG. These are relatively more robust than the spatial domain watermarking schemes, particularly in lossy compression, noise addition, pixel removal, rescaling, rotation and shearing.

C. The MPEG Coding Structures:

Video watermarking techniques that use MPEG-1,-2 and -4 coding structures as primitive components are primarily motivated with the goal of integrating watermarking and compression to reduce overall real-time video processing complexity. Compression in block-based schemes like MPEG-2 is achieved by using forward and bi-directional motion prediction to remove temporal redundancy and statistical methods to remove spatial redundancy. The major drawback of these schemes is that they can be highly susceptible to re-compression with different parameters, as well as conversion to formats other than MPEG. The principle of MPEG-2 video compression is motion compensated hybrid coding, wherein I-frames are split into blocks of 8*8 pixels which are compressed using DCT quantization, ziz-zag scanning, run-level coding, and entropy coding as shown in Fig. 1.

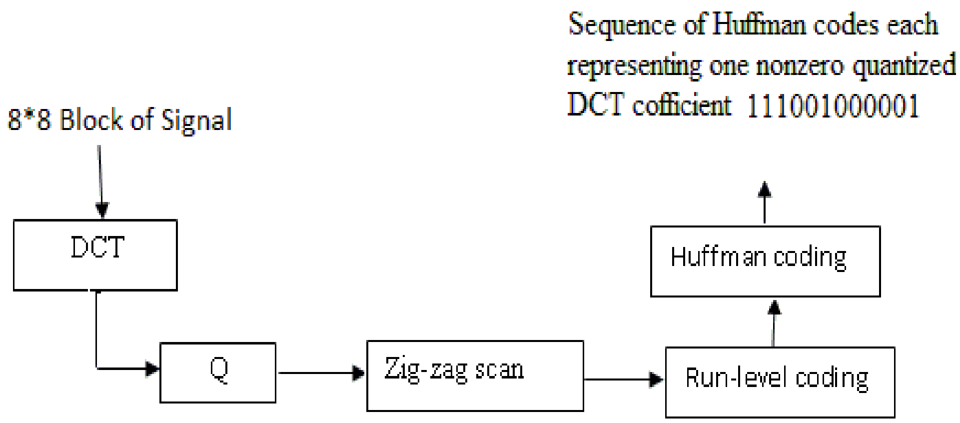

Figure1. DCT Encoding on one 8*8 Signal Block

The P and B frames are motion compensated and the residual prediction error signal frames are split into blocks of 8*8 which are compressed in the same way as blocks from the I-frames. Instead of adding the watermark signal in the pixel domain, the algorithm extract for each encoded 8*8 block of the video, the corresponding block from the watermark signal. Then transform the watermark block using the DCT and add the two blocks in the transform domain. In fig. 1, on the left hand side, the information of MPEG-2 bitstream is split into header and side information, motion vectors (for motion compensation) and DCT encoded signal blocks. Only the later part of the bitstream is altered whereas motion vectors and header information remain untouched and are copied to the watermarked MPEG-2 bitstream. The DCT encoded signal blocks are represented by a sequence of a Huffman codes. Each incoming Huffman code is decoded by variable length decoder (VLC) and inversely quantized (Q^{-1}). After inverse quantization, we have DCT coefficients of the current signal block.

III. WATERMARK EMBEDDING USING QIM

The QIM achieves very efficient tradeoffs among watermark embedding rate, the amount of embedding-induced distortion, and the robustness to intentional/unintentional attacks. It permits to embed one bit b of the message into one feature of the host signal. It uses two quantizers, Q_0 and Q_1. When the bit to embed is a 0, the used quantizer is Q_0 and when the bit to embed is a 1, the used quantizer is Q_1. Any quantizer Q is defined by a step Δ that defines Nc quantization cells equally spaced by $1/\Delta$. Quantizing a value x_n with Q(x), consists of substituting the value of x_n with the nearest quantization cell value. The watermark detector quantizes the received signal r by the union of two quantizers Q_0, Q_1. The detector determines the index of the quantizer containing there construction point closest to the received signal. This index corresponds to the received watermark information $\hat{b}$. The QIM header information and motion data are kept unchanged and simply added to the output bit-stream without any change. DCT data is computed by performing Huffman decoding and inverse quantization. Video bit-stream is first passed syntactically and data related to header information, motion, texture are separated out in separate buffers. Let us presume a block of 8*8 samples originating from the frame of sequence for I- frame or from a prediction error signal for P- frame, respectively. The block is transformed with the DCT and then quantized. QIM technique permits to embed one bit b $\in$ {0;1} of the message into one DC coefficient. Consider the case when the sample with index i of the DC coefficient, is denoted by fi. Quantizing a value fi with Q(f), consists of substituting the value of fi with the nearest quantization cell value fi'. Altered DCT coefficients are then zig-zag scanned and run level encoded with VLC codeword. Modified codeword then added to the bit-streams to produce the new MPEG-2 video stream with embedded authentication information.

IV. WATERMARKING EXTRACTION

The watermark is decoded from the extracted bitstream as shown in Fig.2. The extracted bitstream is passed through the variable length decoder (VLD) and then given to zigzag de-sequencer. The position of DC coefficients is identified and accordingly watermark bits are generated from the quantization table. Parameter required for watermark extraction is only step size used in the quantization process. This is required for the generation of quantization table at the receiver.

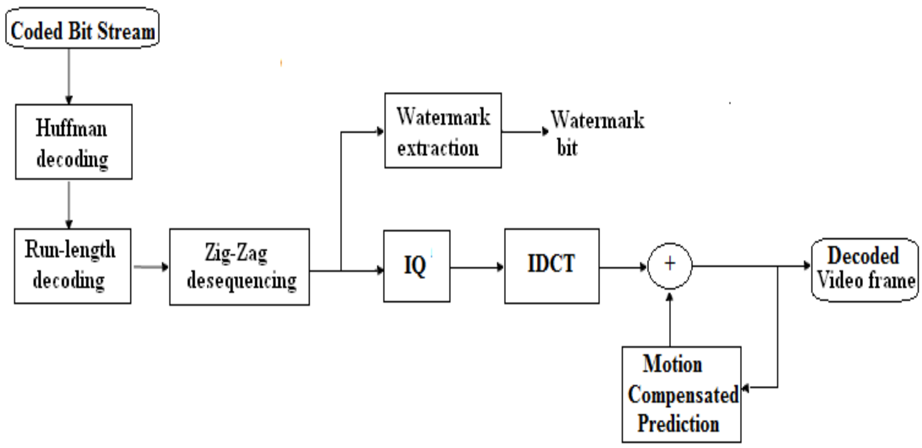

Figure.2 Watermark Extraction from MPEG-2 Decoded Bit-stream

For extraction the watermark detector quantizes the received signal f(i)'' by the union of two quantizers {Q0;Q1} and gets $f_0(i)$ and $f_1(i)$ respectively. The detector determines index of the quantizer containing reconstruction point which has minimum Euclidean distance to the received signal. This index corresponds to the received watermark information $\hat{b}$. In the case when encoder embeds one bit in each sample of the host signal, the detection can be described as:

$$\hat{b}_i = \arg_{b \in \{0,1\}} \min(f(i)'' - f_b(i))^2 \quad \text{.......................................(1)}$$

V. SIMULATION AND RESULTS

For an effective watermarking the two fundamental requirements need to be satisfied i.e. transparency and robustness. The transparency represents the invisibility of the watermark embedded in the signal data without degrading the perceptual quality, and the robustness which means the watermark should not be removable by attacks, including signal processing, compression, re-sampling, frame dropping, frame averaging, cropping, etc. It is a very important requirement for digital watermarking in any application. Here for evaluation of the algorithm we have introduced the term BER and NC. The BER is evaluated as;

$$BER = \frac{1}{M}\sum_{i=0}^{M-1} l \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where, l represents the erroneous bits, evaluated as, l = 1 if, $\tilde{w}_i \neq w_i$

= 0 if, $\tilde{w}_i = w_i$ ……………………………………(3)

The normalized correlation between the extracted watermark & embedded watermark is given as

$$NC = \frac{\sum_{i=0}^{N-1} w(i)\tilde{w}(i)}{\sum_{i=0}^{N-1} (\tilde{w}(i))^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Here, w(i) is original watermark and $\tilde{w}$(i) is the extracted watermark. The PSNR is defined as

PSNR=10 log (2552 /MSE) ……………………………………. (5)

where MSE is calculated as:

$$MSE = \frac{1}{MN}\sum_{i=0}^{N}\sum_{j=0}^{M}(V_{orig}(i,j) - V_{wat}(i,j))^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Where, Vorig(i;j) are coefficients of original video & Vwat(i;j) coefficients of watermarked video.

The Simulation of the work has been carried out using MATLAB Version 7.9. The video sequence used is Miss America having size of each frame as 320*240. The original and watermarked frame from each video appears to be identical as shown in Fig. 3.

(a) Original Frame

(b) Watermarked Frame

Figure.3 Figure showing original and watermarked frame.

The MATLAB results obtained for PSNR, NC, BER of the watermarked video are shown in Fig. 4, and again the results PSNR, NC, BER Vs Quantization Level when watermark is embedded in P- frame are shown in Fig. 5, 6 & 7 respectively

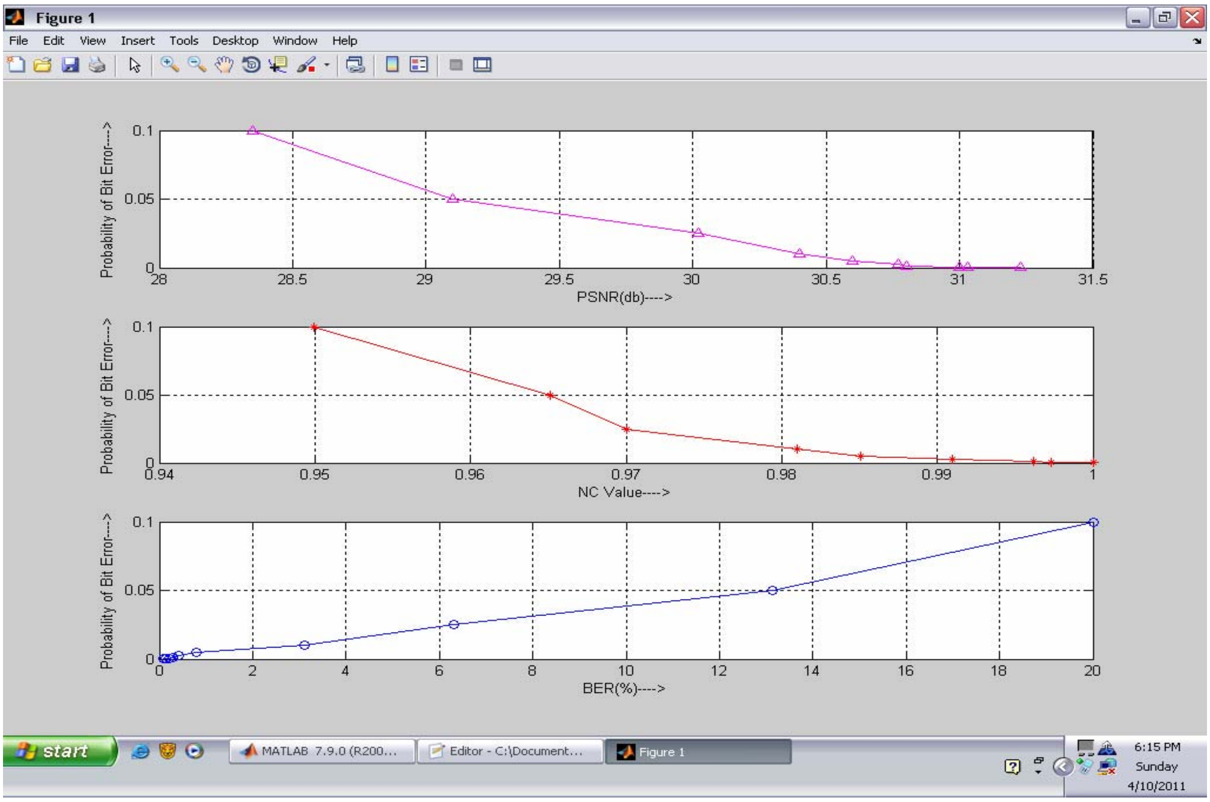

Figure 4. Graph of PSNR, NC and BER of received signal Vs Probability of error.

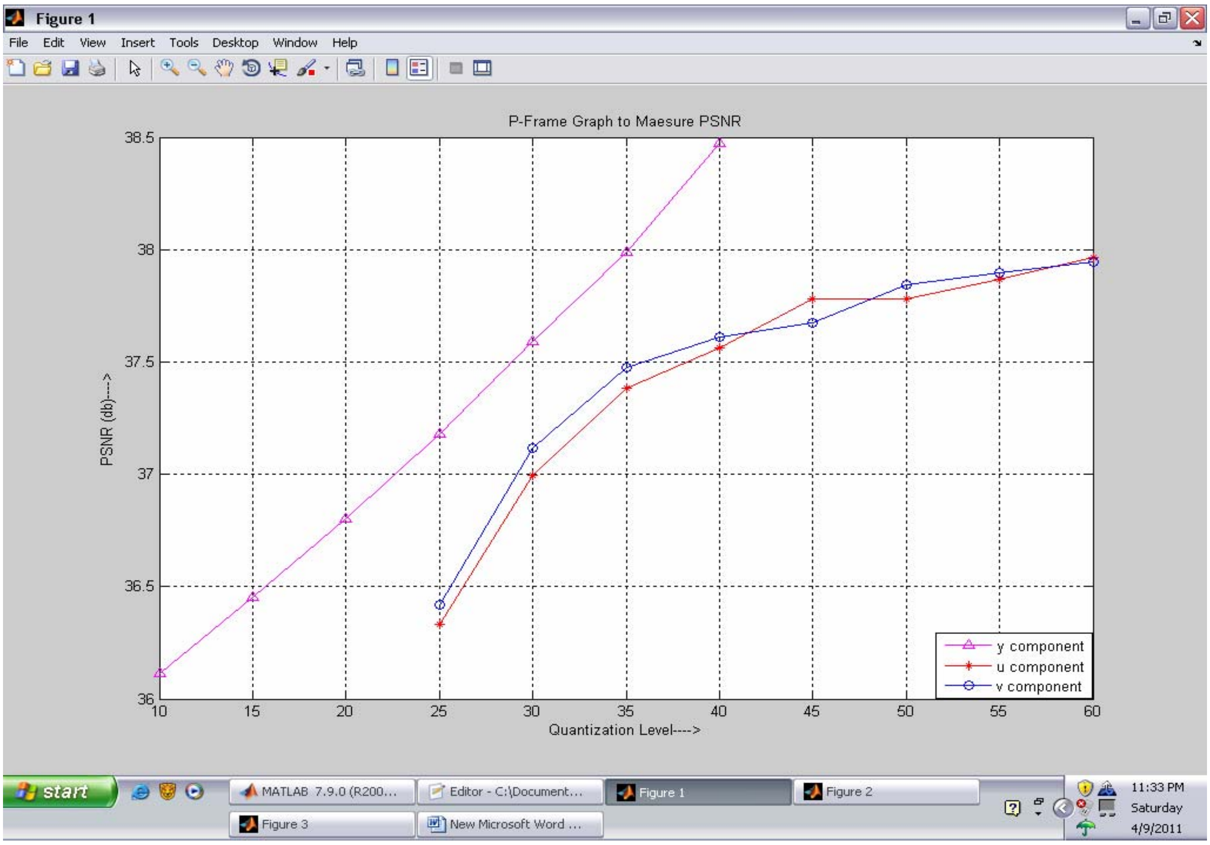

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Figure 5. Graph showing PSNR of watermark with different levels for QIM

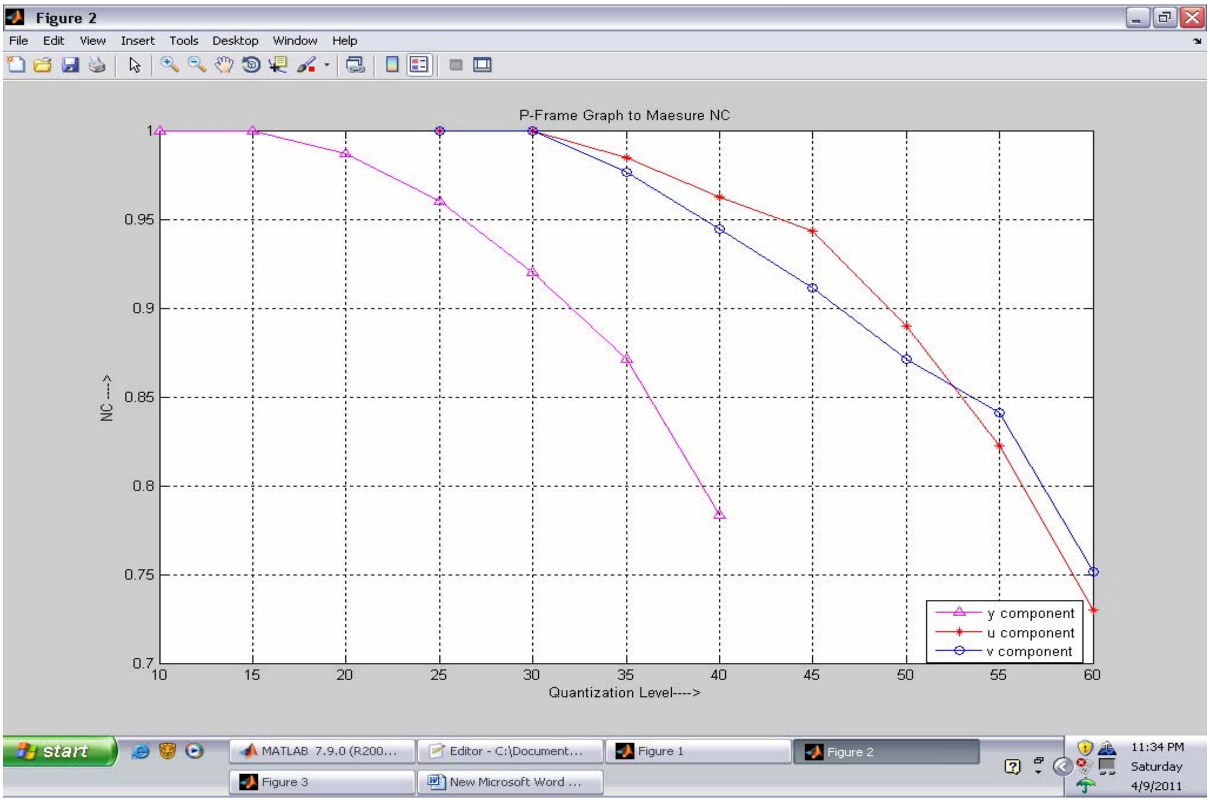

Figure 6. Graph showing NC of watermark with different levels of QIM

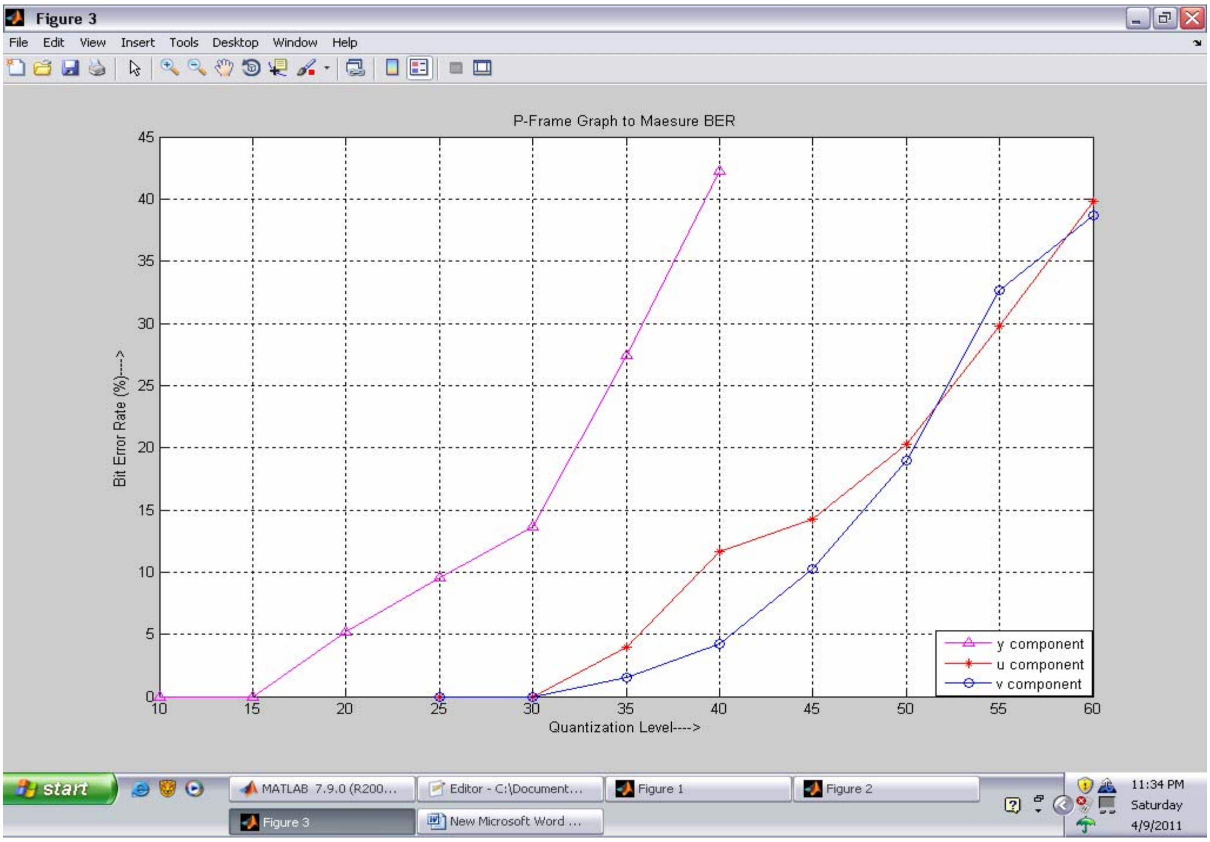

Figure 7. Graph Showing BER of Watermark with different levels of QIM

VI. CONCLUSION AND FUTURE SCOPE

In the present work the system embeds a watermark into the quantized DCT coefficient during the MPEG-2 video encoding process. One watermark bit is embedded into the DC coefficient in each 8*8 DCT coefficient block of P- frames and (320*240), thousands of watermark bits can be embedded in just one P-frame. The step size of QIM is adjusted according to the size of direct coefficients to improve digital watermark detection rate and visual effect. This achieves the optimal trade off between watermark payload and distortion to video quality due to the embedded watermark bits. The PSNR of y, u and v components increase with the increasing level of quantization. However the BER decreases with increasing levels. Since data of P- frame is sensitive (due to less redundancy) the small step size increases the watermark BER and decreases the NC. In binary symmetric channel PSNR and NC decreases with increased probability of error. This watermarking process does not alter the motion vector information or any of the critical side information. In addition the watermark extraction process can be achieved without knowledge of the original watermark. This QIM based video watermarking concept can also be used in compressed domain and the robustness can be checked by applying different attacks like frame dropping, frame averaging, cropping etc. Furthermore it can be used for compressed video bit stream too.

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