Digital Video Watermarking Using Principal Component Analysis

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***Abstract*—with the rapid development of network and digital technology, security of digital contents is a serious problem. Digital watermarking can provide an effective security protection to digital contents. A digital watermark is embedded in an electronics document to provide multimedia copyright protection and authentication purposes. In this paper we start from some basic knowledge about digital watermarking. Then we go deeply with algorithm. We discuss digital video watermarking scheme based on Principal Component Analysis. Lastly we discuss applications of watermarking. A video file is a continuous collection of static images, and each image is composed of three color channels. Algorithms used over here allow us to embed a watermark in the three color channels RGB of an input video file. The main advantage of this method is that the same or multi-watermark can be embedded into the three color channels(R,G,B) of the image that helps to increase the robustness of the watermark. Furthermore, using PCA transform allows choosing the suitable significant components into which to embed the watermark**

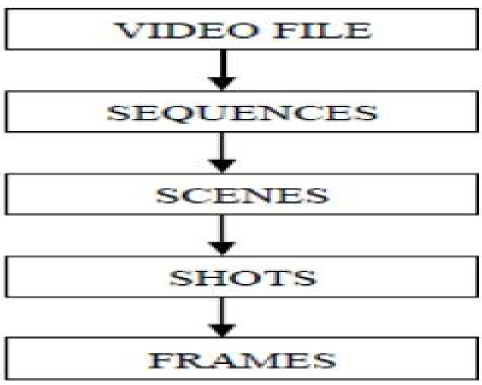
**Keywords— security of digital contents, Multimedia protection,
Video watermarking, PCA, Color channels (RGB).**

I. Introduction

Video Watermarking is an embedded image or pattern in video. In day today life Image Watermarking is often used. It is helpful as security features of banknotes, passports, postage stamps and other very important documents. Similarly, digital watermarking is some embedding information in a digital signal. It is used to verify the digital signal's authenticity or the identity of its owners. Common medium on digital watermarking is audio, picture, or video. Several different digital watermarks can be embedded in one signal at the same time, and if the signal is copied, then the information on it will also be copied and carried in the copy. Now days, technology is developing more and more fast, it is playing an important role in people's life and work. Due to the the rapid development of network and digital technology, we largely use the Internet and digital signal to transmit information. Digital watermarking is used for a wide range of applications, such as: copyright protection, authenticity identification. Digital watermarking is not a novel technology, there are some traditional algorithms and

applications, but with the emergence of new digital signal, application and attack, applications, such as: copyright protection, authenticity identification.

Digital watermarking is not a novel technology, there are some traditional algorithms and applications, but with the emergence of new digital signal, application and attack, corresponding digital watermarking will appear. Video file is a continuous collection of static images, and each image is composed of three color channels. This method allows to embed a watermark in the three color channels RGB of an input video file. In this method video unit is decomposed to frames [7] [8]. Frames are considered as three color images(R, G, B). An invisible watermark is embedded, into the three different RGB channels of the video frame. PCA transform is used to embed the watermark in each color channel of each frame. Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. The important advantage of this method is that the same or multi-watermark can be embedded into the three color channels of the image. It helps to increase the robustness of the watermark. Furthermore, using



PCA transform allows choosing the suitable significant components into which to embed the watermark.

Manuscript received April, 2014.

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Fig 1: video representation from video to frame.

Video: video is an unstructured data stream. It consists of a sequence of video shots. Scenes: In any particular scene, semantically related shots are merged together. Shots: shots can be defined as video units produced by one camera, and the shots boundary detection is made using the key frames. Shot boundary detection is important in reconstruction phase. It is important with respect to the trade-off between the accuracy and the speed in the reconstruction phase. Frames: one frame is one complete scanned image from a series of video images; frame is a static image. The video [Fig.1] stream is decomposed to sequences, then to scenes then to shots and then each frame extracted in each shot; then the watermark is embedded in each frame for robustness reasons [1].

II. Principal Component Analysis

Principal component analysis (PCA) is a mathematical procedure which includes a classical statistical method. This linear transform has been widely used in data analysis and compression. Principal component analysis is the statistical representation of random variables. It converts large number of variables into few meaningful variables.

Suppose we have a random vector population **x**, where many of the existing efforts have been based on to the shot based video analysis. In this work focus is on the frame-based video analysis.

$$X = (x1, x2, \ldots xn)^T \ldots\ldots\ldots\ldots\ldots(1)$$

and the mean of that population is denoted by

$$\mu_x = E\{X\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$$C_X = E\ \{(X - \mu_x)\ (X - \mu_x)^T\} \ldots(3)$$

The components of Cx are denoted by Cij. It represents the covariances between the random variable components xi and xj. The component cii denotes the variance of the component xi. The spread of the component values around its mean value is indicated by the variance of a component. When the two components i.e. xi and xj of the data are uncorrelated then their covariance is zero (cij=cji=0). The covariance matrix is always symmetric. Using a sample of vectors x1,x2-----xm, one can calculate the sample mean and the sample covariance matrix as the estimates of the mean and the covariance matrix.

Covariance matrix is a symmetric matrix. Using this matrix we can calculate an orthogonal. basis by finding its eigen values and eigenvectors. The eigenvectors ei and the corresponding eigenvalues λi are the solutions of the equation

$$C_x ei = \lambda iei,\ i=1,2,\ldots.n \ldots\ldots\ldots\ldots(4)$$

For simplicity we assume that the are distinct. These values can be found, for example, by finding the solutions of the characteristic equation

$$[C_x - \lambda I] = 0 \ldots\ldots\ldots\ldots\ldots(5)$$

Where the I is the identity matrix. Matrix I is of the same order as that of Cx and the |.| denotes the determinant of the matrix. If the data vector consists of *n* components, then the characteristic equation becomes of order *n*.

III. Encoding process

In encoding process there are six steps[1].

First step: An input video is splitted into audio stream and video stream using video stream splitter [Fig.2] and the video stream is decomposed to frames [Fig1]. Each frame is considered as a colour image separately.

Second step: using the proposed technique, first we have to separate the frame F(N, N) to three separate RGB color channels: Red, Green and Blue to embed a watermark into a given original color frame of size F(N, N),. Then we can obtain, respectively, the three sub-frames: FR (N;N), FG(N;N) and FB (N;N).[Fig 3]

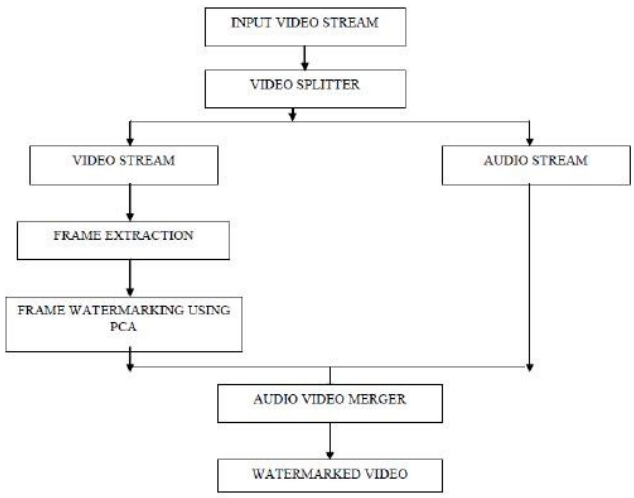

Fig 2: Video Watermarking Process

Third step: in this step PCA transform is applied to each of the three sub-frames. Now each of the three color-banded frames FR , FG and FB is separately subdivided into four sub-frames[fig.3]. After applying PCA transform we can get PCA basis function for each of the sub-frames respectively: [Φ]R, [Φ]G, and [Φ]B. The principal components of each of FR, FG and FB are computed. Then we have the three PCA coefficients: YR, YG, YB.

$$(Yi)w = Y_i + \propto (Yi)Wi\ldots\ldots(6)$$

where α is a strength parameter. Then we obtain ywR, ywG, ywB.

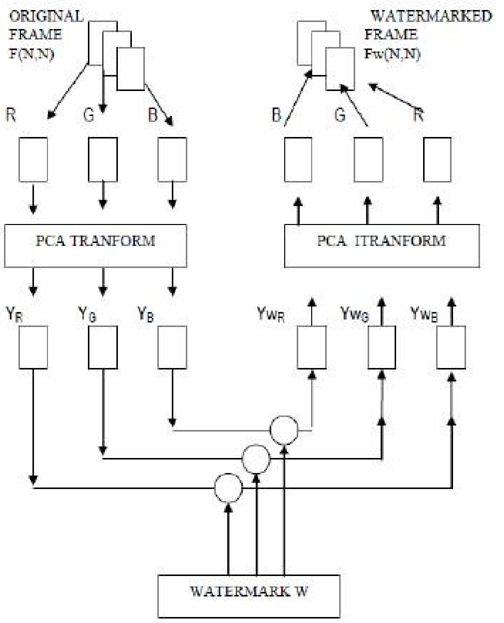

Fig.3 watermarking encoding using PCA)

Fourth step: to insert a watermark, select the perceptually significant components of each the three coefficients. Here we are using a pseudo-random sequence of length M as a watermark. The values of w is a random real number with a normal distribution, W = w1;w2:::wM. Then we embedded the watermark into the predefined components of each PCA sub-block uncorrelated coefficients. The embedded coefficients were modified, for each sub-frame, by the following equation:

Fifth step: using inverse PCA process, the three RGB watermarked colour channels are separately recovered.

$$Fw(\emptyset^T) \quad ^{-1}Y_w = \emptyset Y_w\ldots\ldots.(7)$$

we can retrieve the watermarked frame Fw(N;N) by superposing the three resulting color channels FwR, FwG and FwB.

Sixth step: We proceed to video reconstruction, by retrieving first the video shots and the scenes from the watermarked frame, and by using the Video/ audio merger tool we reproduce the watermarked video file.

IV. DECODING PROCESS

A watermark is detected through the process shown in fig. 4.

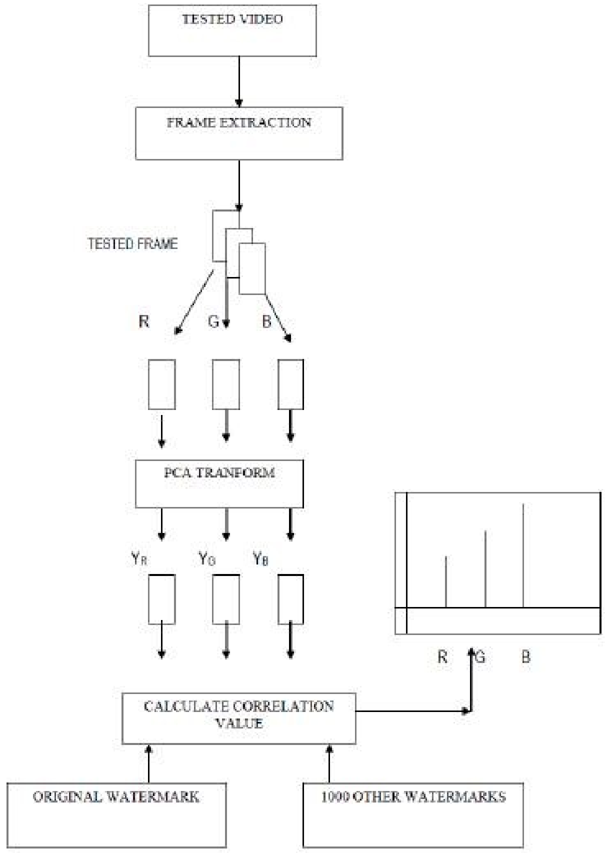

Fig 4: Watermark detection process

This process is useful for recognition of the authenticity of the embedded watermark. The tested video stream is passed to frames extraction process [Fig.1]. We applied the correlation based detection for each frame. Three extracted watermarks are compared to other 1000 watermarks. In consequence we get the PCA coefficient for each.

VI. APPLICATIONS

Application of watermarking in traditional area (Ownership and copyrights): It is essential to communicate our copyright ownership and usage rights no matter we are global media corporations or freelance photographers. Digital content is travelling faster and further than ever before since the combination of access and new tools. Digital is now a primary means of communication and expression. We can embed watermarks which contain imperceptible digital data that can include ownership information, contact details, usage rights and anything we choose. For people who are looking for an efficient way to monitor, manage and monetize their digital assets, digital watermarking is an effective way and is widely used today. Digital watermarking can ensure our ownership and contact information are attached to our content, and can add automated licensing to increase revenues, automated remind us when there is an unauthorized use. Protection for audio and video content: In global entertainment industry, piracy of music, film and video is a multi-billion dollar big problem. Digital watermarking can help limit the unauthorized copy and redistribute, it can provide an added layer of security to the content protection. Digital watermarking can communicate copyright ownership and rights of usage, protect content against common threats of piracy like camcorder recording, Peer to Peer sharing, copying, format conversion and other forms of re-processing. We can enjoy our entertainment experience without any difference even if the content has embedded watermarks.

Forensics applications:

Forensic watermark applications increases a content owner's ability of detection and responce to misuse of its assets. Forensic watermarking is used to collect evidence for criminal proceedings and to enforce contractual usage agreements between a content owner and the people or companies with which it shares its content. A forensic application embeds the identity of a recipient into an asset copy at the time it is produced or transmitted. Sophisticated forensic applications embed situational metadata such as transmission time, received format, and recipient IP address. Some watermark applications embed a distinct forensic watermark at each stage of content distribution, enabling pinpoint accuracy.

When a leak is discovered or suspected, the forensic watermark retrieved from the leaked copy identifies the intended recipient and provides evidence — in the form of situational metadata — that the copy was delivered to its intended destination. The evidence can be used to trigger contractual provisions or as legal evidence in a criminal action.

VII. COMPUTER SIMULATIONE

We have performed simulation using proposed technique and found satisfactory results. For a video of 141 frames we apply above mention method.

For an example, we use frame number 40. For this particular frame mean square error is 1.2323e-005and PSNR in db is 113.3467. After applying the proposed watermarking method using PCA to the video stream, the obtained watermarked and reconstructed video shows that there is no noticeable difference between the original video and watermarked video, which confirm the invisibility requirement in our watermarking method.

VIII. CONCLUSION

With a high degree of energy concentration, PCA is suitable for data hiding. By slightly altering the most significant data block in the transform domain, an invisible watermark can be inserted into the frame. More aspects of the attack-resistant capability are currently under investigation. The idea of embedding the watermark in the three color channel is to improve robustness by inserting in each color channel of each frame. PCA based watermarking scheme allows to select the appropriate PCA coefficients for embedding and in fact it is always possible to watermark a color video file without affecting its perceptual quality.

Digital watermarking has a widely application, including copyright protection, content protection, locating content online, and so on. In conclusion, digital watermarking gives authentication, identification, and integrity to digital signal, and helps the owners can use their digital assets under protection.

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