Review of Robust Video Watermarking Methods for Copyright Protection Application

Azizah Abdul Manan†, Ali Boroujerdizade, Seyed Mojtaba Mousavi*1
1Advanced Informatics School (AIS), Menara Razak, Universiti Teknologi Malaysia (UTM), Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, MALAYSIA,
*1mosavi@fkegraduate.utm.my

Abstract— In the digital world, due to the ease of creating, publishing and tampering of works, copyright protection became a major issue. This issue is much significant in movie industry which cause millions of dollars losses. With new technologies, almost everybody is able to produce, edit and share videos. Thanks to the Internet the sharing of works also, become a breeze. Hence, there should be a mechanism to prove the ownership and make sure of the integrity. Watermarking is one of the effective ways to help copyright protection. The aim of this work is exploring through the current watermarking solutions for copyright protection of digital video. For this purpose, foundations of video watermarking are explained firstly. Then a review on robust video watermarking methods for copyright protection application is proposed.

Index Term—video watermarking; copyright protection; ownership identification

I. INTRODUCTION

According to the current information explosion rate, one of the major issues that producers are facing is ownership identification and proofing it, in other word copyright [1, 2]. In addition, digital media, which becomes the main mean of information sharing, makes the issue even worse. The reason is the original work can be copied, modified or exchanged over peer-to-peer networks. The main copyright consideration is copying the movies throughout the internet. Nevertheless, watermarking which is an information hiding method is hired to address this issue [3, 4].

Watermarking is able to help about ownership identification and approval, in addition to copy control and modify prevention. As soon as the second step of watermarking is applied to a medium, it becomes a carrier. The three steps are generating, embedding, and retrieving the watermark [4, 5]. In the digital world, there are many different types of carriers such as text, image, audio, video etc. [6]; even human DNA can be used as carrier [7].

Watermarking is a compound of data payload, fidelity and robustness. The trade-off between these three factors is very important. Data payload means the amount of information (the number of bits). Fidelity describes the watermarking only allowed to change the carrier imperceptibly. The ability of watermark to remain unchanged against attack is called robustness [8, 9].

One of the very first usages of the digital watermarking is copyright protection. Embedding watermark makes it possible to identify the owner of a digital work. In case of the illegal copy, the legal owner can use the watermark as a proof of ownership in the court. However, it is possible a malicious user finds and remove the watermark [10].

By adding a second watermark to a file, both owner and invader can claim and prove the ownership. Nevertheless, having the original video or time stamping can resolve some of these problems. If the watermarking scheme is a reversible one, the invader can reproduce the original file to defeat the watermark. The situation, in which both the owner and the invaders have the original and the watermarked version of the file, is called deadlock [8]. Therefore, copyright irreversible algorithms are hired and in some cases they are supported by a trusted third party [11]. This work presents a review on robust video watermarking methods, which are proposed for copyright protection application.

The rest of this work is organized as follows: In Section II an overall outline on the watermarking is given. Then, foundations of video watermarking such as terminologies, characteristics, applications, models, techniques and challenges are explained in Section III. In addition, all kinds of attacks against video watermarking are listed in this section. A review on robust video watermarking methods for copyright application is proposed in Section IV. Conclusion of the study is given in Section V.

II. WATERMARKING OVERVIEW

The multimedia technology and the way of using it have been grown and changed significantly during the past decade. Therefore, legal distribution of these materials in a secure way becomes a necessity. Digital works in image, audio and video format are becoming the best way of transmitting the content, especially using the internet as the carrying platform. While the unauthorized copying and republishing is growing fast, the need for a protection mechanism seems irresistible. Thus, copyright protection for digital material is a trending field of research [12]. To provide the security for digital content, watermarking becomes an attractive solution among researchers and industry [13].

Steganography is the art and science of covered writing in the way that only the sender and authorized receiver are able to read the message. Both watermarking and steganography are relying on imperfections of human senses. The eyes and ears are incapacitated to detect minor differences. Therefore, a little change cannot be felt in video, image, audio, or any other carrier by human eyes. The arrangement of digital watermarking is to provide some prohibition methods against illegitimate duplication or abuse of digital contents [14].

The technique that volunteers a tool to safeguard the digital content from unlawful repetition and manipulation is digital watermarking. The watermarking refers to the process of producing and embedding of some data into the digital media such as image or video. Some application, like copyright protection or access control, requires the ability to reverse the watermarking process in order to detect and recovering the embedded data.
A digital watermark is that portion of unnoticeable data, which is in the digital file. This digital file, which is used in the watermarking process, is known as cover or carrier. Watermarking process has three phases:

- Generating the watermark
- Embedding the watermark into the carrier
- Retrieving the watermark

Generating the watermark is a very important step. Depends on the application of watermarking, an appropriate watermark should be used. For instance, in terms of owner identification only a unique watermark can relate the carrier or intellectual property to its owner. As it is a key step of identifying the best way is outsourcing the generation to a trusted third party who generates and store the watermark. The embedding step is hiring an algorithm, which hides the watermark into the carrier. Retrieving step is to reverse the embedding and extracting the watermark, which can be done using an algorithm based on the one that used in embedding. The retrieved watermark can be verified by comparing with the trusted third party’s stored copy.

III. VIDEO WATERMARKING

Based on the different available digital file types and application of the watermarking, the digital watermarking can be categorized. The category is most likely into image, audio and video watermarking. Although the video watermarking is usually based on image watermarking techniques, their methods and applications are very dissimilar.

Protecting the video from illegal duplication and detecting the tampering by hiring a techinc to embed watermark into the video’s sequence of frames is the definition of the video watermarking while embedding watermark into the each frame can be similar to image watermarking [8].

In watermarking field, the video is very interesting. First, because the availability is significantly higher and then almost all formats have enough redundant information that can be altered without ruining the frames. It is possible to present video in both spatial domain [15] and transform (frequency) domain [16]. To simplify, the spatial domain deal with pixels and in transform domain video is segmented based on frequency bands. In order to transform a video to its frequency representation there are several methods such as Discrete Cosine Transform (DCT) [17], Discrete Wavelet Transform (DWT) [18], or Discrete Fourier Transform (DFT) [19], which all of them are reversible [20].

Even though the security of data is addressed by cryptography, It seems watermarking has become the main mean of copyright protection. The fundamental but naïve idea is since it is invisible and remains after common processing; therefore, it can be considered as secure. Although this idea is abandoned, however it is perceived that there is a significant possibility to utilize watermarking to achieve copyright protection. To clarify watermarking provide a communication channel while cryptography can provide a secure layer on top of it. Therefore, watermark security can be defined as “the inability by unauthorized users to have access to the raw watermarking channel” [21].

A. Video Watermarking Terminologies

Some specified terms are commonly used in watermarking area. These terms are described in Table I [22, 23].

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Video</td>
<td>Video is a collection of still images in the sequential order, which is equally time spaced. Might come with or without audio.</td>
</tr>
<tr>
<td>Payload</td>
<td>It calculates how big a file should be, to be enough to hide the whole watermark in it.</td>
</tr>
<tr>
<td>Perceptibility</td>
<td>The imperceptible watermark method is when the difference between the original digital file and the watermarked one is cannot be sensed by HVS.</td>
</tr>
<tr>
<td>Robustness</td>
<td>The watermark ability to survive and remain recoverable after an attack. Based on the application a watermarking method could be robust, semi-fragile or fragile.</td>
</tr>
<tr>
<td>Security</td>
<td>It is ability to keep the watermark from unauthorized access. In watermarking terminology, an attack is any process that may impair detection of the watermark or communication of the information conveyed by the watermark.</td>
</tr>
</tbody>
</table>

B. Characteristics of Digital Video Watermarking

Video watermarking has the same characteristics as an image one. Nevertheless, there are some characteristics which is delicately belongs to the video methods of watermarking. According to [22] and [24], a video watermarking method should have features that mentioned in Table II in order to recognized as an effective one.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indifferently</td>
<td>It talks about the invisibility of the watermark. Based on the application might be different.</td>
</tr>
<tr>
<td>Robustness</td>
<td>It talks about the tediousness of the watermark against intentional or unintentional attempt of removal.</td>
</tr>
<tr>
<td>Universality</td>
<td>It talks about a unique algorithm, which is applicable for all kinds of digital media (image, audio and video) as well as hardware.</td>
</tr>
<tr>
<td>Unambiguous</td>
<td>It talks about the retrieving the watermark without any error in order to recognizing the owner of the file accurately.</td>
</tr>
<tr>
<td>High real time</td>
<td>Video signal has three dimensions so the amount of data is much more than the image. The real time embedding and retrieving needs more time.</td>
</tr>
<tr>
<td>Random detection</td>
<td>The watermark can be in any part of the video independent of the video playback order</td>
</tr>
<tr>
<td>Combination of the video CODEC</td>
<td>The real-time requirements can be fulfilled if only the watermarking happens in coding and decoding level.</td>
</tr>
<tr>
<td>Blind detection</td>
<td>The non-blind technics requires the original file in order to retrieve the watermark. However, since the video files are usually huge keeping and using the original files are inconvenient.</td>
</tr>
</tbody>
</table>

The robustness of the watermark should survive the attacks mentioned in Table III [22]. In other words, a robust watermark remains retrievable even after one or some of these processes.
C. Video Watermarking Applications

Although same techniques are hired in watermarking, but the purpose of it is different. The different purposes of applying a watermark on a file are described in Table IV.

<table>
<thead>
<tr>
<th>Video Watermarking Applications</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copy Control</td>
<td>Avoid illegal doubling</td>
</tr>
<tr>
<td>Broadcast monitoring</td>
<td>Identify where, when and how the video is broadcast or used</td>
</tr>
<tr>
<td>Fingerprinting</td>
<td>Trace back illegal usages</td>
</tr>
<tr>
<td>Authentication</td>
<td>Detect if the video is tampered or not</td>
</tr>
<tr>
<td>Enhanced video coding protection</td>
<td>Add additional information e.g. error correction</td>
</tr>
<tr>
<td></td>
<td>Identifying and proving the ownership</td>
</tr>
</tbody>
</table>

D. Video Watermarking Models

There are three categories of solution in video watermarking [24]:
- Non-compressed domain
- Codec level
- Compressed domain

In the first solution, the watermark is embedded directly into the raw video, and then the video is encoded. The most important advantage of this solution is the ability to use image-watermarking methods over video. The disadvantage of using this method is, it increases the bit rate and it might be lost in encoding and compensation procedure. The second solution is to combine the watermarking embedding and detection modules into the encoder that may be the only effective way to perform a real-time watermarking. In addition, it does not change the bit rate. The third solution is compressing the video and then embedding the watermark into the compressed file. The advantages of this method are maintaining the quality and lower computational complexity.

E. Video Watermarking Techniques

There are lots of watermarking algorithms in video watermarking arena. Even many image-watermarking algorithms are adopted to be used over video. Technically, it is possible to extend any image watermarking technique for watermark video. However, the reality is that the video watermarking has its specific challenges that the image watermarking is incapable of addressing them. For instance, there is a significant built-in redundant data between frames, distributed between dynamic and static part of a sequence of frames like swapping, averaging, lossy compressions, digital-analog conversion and statistical analysis. According to the [22, 25-27], video watermarking schemes are categorised into; Spatial domain, Frequency domain [28-30] and MPEG based watermarking schemes. An overview of such a categorization is shown in Fig. 1. Different methods of information hiding are also explained in Wayner book [31].

F. Video Watermarking Challenges

There are three main challenges that should be addressed in video watermarking beside those that are common among other media. First, all those non-hostile video processes that alters the video signal. Second and most critical one is collusion. Third is watermarking in real-time [8].

1) Watermarking Attacks: In almost all applications, both carrier and watermark are processed in order to create the watermarked file. These processes could be digital to analog, analog to digital, lossy or lossless compression, etc. However, the watermark could be damaged or removed intentionally or unintentionally by such processes. Other types of process are applied directly to the impeding watermark transition. These processes, which impede the watermark in watermarking terminology is called the attack and the watermark that is recovered in this way is called attacked data. In terms of attacks, the robustness is the most important side of watermarking. Clearly, the definition of robustness is the ability of remaining unbroken after attacks. The measurement of robustness is done by criteria like channel capacity, the probability of bit error or miss probability. It is difficult to analyse the watermarking algorithm theoretically by considering different attacks. Hence, benchmarking becomes the tool to measure the performance. A framework, which combines potential attacks and provides a method to weight the findings, is a benchmark. Despite early attacks, new ones are improved using watermarking knowledge [32].

2) Attacks Classification: In this part, different possible watermarking attacks are expressed and categorized.

   a) Active attacks: The invader intentionally attempts to eliminate the watermark. Active attack is still an unsolved problem in fingerprinting, copy control and copyright protection [33].

   b) Passive attacks: The attacker only attempts to determine whether a mark is present or not. This becomes an issue in case of covert communication [33].

   c) Collusion attacks: It is almost same as active attack but with a different method. To remove the watermark several copies of the watermarked data are engaged. This is a serious problem in fingerprinting while it can be a problem in any...
application. The success of the attack is directly related to the number of copies [33].

Robustness is the main consideration in previous video watermarking works while there is a very little work on malicious attacks. The security issue is defined as preventing unauthorized access by unauthorized users to the watermarking channel [21]. One of the security issues, which can be also used as the evaluation, is collusion attack. This attack is pointed out for still images firstly. Two different types of this attack is described as follow [8].

In collusion type-I, different watermarks are embedded into different copies of the same data (Fig. 2). The collusion only has to make a linear combination of the different watermarked data, e.g. the average, to produce un-watermarked data [17].

![Fig. 2. Collusion attack of type-I][2]

In Collusion type-II, the same watermark is embedded into different copies of different data (Fig. 3). A good estimation of the watermark gives permission to obtain un-watermarked data with a simple subtraction with the watermarked one [17].

![Fig. 3. Collusion attack of type-2][2]

d) Inter-video collusion: Collusion is studying the watermarking channel to find watermark characteristics and using this information to extract or damage the watermark. In practice, a linear or nonlinear operator can be hired to merge several watermarked documents to extract the un-watermarked part [34]. For instance, if a malicious user collects some copies of a movie, which each of them have different watermarks, it is possible for him to average the frames and recover an un-watermarked version of the movie. There is one countermeasure suggested by [35]. Their design distributes the watermark in a way that collecting some few copies out of all watermarked files is useless to recover or remove the watermark. This attack is possible when the attacker manages to collect some videos, which all have same watermark. By combining frames and files the watermark signal and its location can be estimated [8].

e) Intra-video collusion: Despite the inter-video attack which is originally an image watermarking issue, intra-video collusion is video specific [8, 36]. The intra - video attack works with only one video. However, since the most common method is frame-by-frame watermarking. Each frame can be considered as one watermarked content and using all frames for collusion [36].

f) Forgery attacks: Instead of removing the watermark, the hacker embeds a new genuine watermark to cover the changes, which happened to the fragile original watermark. With this, the hacker makes a corrupted watermark valid again. This attack is mostly against the data authentication [23].

g) Simple attacks: It is also known as waveform attacks or noise attacks. The hacker attempts to destroy the watermark by manipulating the digital file without any effort to detect the watermark. Such an attack can be performed by adding noise, cropping, gamma correction, filtering, compression, etc. [37].

h) Detection-disabling attacks: It is also known as synchronization attacks. The hacker changes the digital file somehow that it becomes impossible or infeasible for the detector algorithm to detect and recover the watermark. Geometric distortion is the most likely way to do so. It is any kind of geometric transformation like pixel cluster, insertion or removal the pixels, rotation, shifting, zooming, etc. [23]

i) Ambiguity attacks: It is also known as deadlock attacks, inversion attacks, fake watermark attacks, or fake-original attacks. The hacker confuses the detector by producing fake data, either the original or watermarked one. For instance by adding several watermarks it becomes impossible to detect which watermark is correct or which one is the first one [23].

j) Removal attacks: The hacker attempts to eliminate the watermark completely to recover the original data. This can be done by analyzing the watermarked data and estimating the watermark. Hence, the watermark can be separated from the original data. This way of attack has nothing to do with the security of the algorithm itself. The detection and recovery are becoming very impossible. This can happen through quantization, denoising, demodulation and collusion attacks. Nevertheless, the complete removal is usually very difficult while all these methods of attack can damage the watermark significantly [38].

k) Cryptographic attacks: The hacker tries to break the security part of the algorithm in order to remove or replace the watermark. Brute force attack and oracle attack are examples of this type. Brute force search for the embedded data and oracle is recovering the original data using an available detector. Nevertheless, these attacks are very difficult in practice because of their high computational complexity [38].

l) Protocol attacks: In this attack, the hacker uses the reversibility of the algorithm and recovers the watermark. Using the recovered watermark the hacker claims for the ownership. Hence, the copyright cannot be protected any more. Therefore, the watermarking method for copyright protection should be one-way function [38]. Copy attack is another type of protocol attack. The goal is to estimate and copy the watermark and embed it into other data, which is called target data [39].

m) Geometric attacks: Despite of removal attack, geometric attack distorts the synchronization. Since the detector should be perfectly synchronized to detect and recover the watermark, any imperceptions leads to unsuccessful detection. A resynchronization process also might be so complex to be practical [38, 40].

n) Estimation-based attacks: The hacker attempts to predict the watermark or the original data signal using statistics of the watermarked data. The estimation can be obtained through some stochastic criteria like minimum mean square
error, maximum posteriori probability or maximum likelihood [38].

IV. REVIEW ON ROBUST VIDEO WATERMARKING METHODS FOR COPYRIGHT APPLICATION

Tu et al. [41] proposed a novel watermarking method based on Block Truncation Coding (BTC). Despite other methods, this scheme only alters the watermark to extract a key. It is also possible to register more than one watermark in a single host. The aim is owner identification and the steps are explained in Fig. 4.

Fig. 4. BTC-based watermarking scheme [41]

Pei et al. [42] worked on watermarking in motion vector regions. In other words, the copyright information is embedded inside the motion vector regions of video frames with H.264 format.

Rajab et al. [43] focused on a digital video watermarking method to prevent the illegal manipulation and distribution of video content. The proposed method in this paper is a robust, effective and imperceptible watermarking method. The method effectiveness is conveyed by asset of using DWT and SVD, which are two powerful mathematical transforms. In addition, the robustness against different attacks such as rotation, salt & pepper noise, JPEG compression, Gaussian noise, frame averaging and frame dropping is measured.

Mohammeh et al. [44] worked on the estimation of motion. For this purpose, the motion areas in different frames are detected. Specific bands in wavelet domain are chosen for embedding the data by motion estimation approach. The candidate bands in this work are HL and LH bands where the motion in these areas has the lowest impact on the quality of extracting watermark after different type of attacks on the watermarked video. Fig. 5 visualize this work.

Bhatnagar et al. [45] worked on authentication and copyright protection. The proposed scheme is a semi-blind reference watermarking approach based on DWT and SVD transforms. In place of using randomly generated Gaussian noise type watermark, a grayscale logo image is used as a watermark. Fig. 6 demonstrates the method in detail.

Chen et al. [46] proposed a method to fulfil copyright protection purpose. In the first step, the video frames are divided into small shots. Then according to the similarity of shots, they need to be classified with a clustering algorithm. Finally, the watermark is transformed into the wavelet domain by using DWT, and according to the level of its coefficients, the wavelet coefficients are embedded in suitable shots. During the extraction process, to extract the embedded wavelet coefficient, it is also required to divide a video into shots and extract the frame from each shot. The final extraction step is collocating all parameters by using inverse DWT (IDWT). In this scheme, most portion of watermark could be extracted even when only partial video shots are available. The mentioned steps are shown in Fig. 7.

Fig. 5. Robust video watermarking for copyright protection [44]

Fig. 6. Semi-blind reference watermarking [45]

Fig. 7. Shot based video watermarking [46]

Fung et al. [16] presented a new algorithm to insert the watermark in videos. Unlike the regular approaches that insert the watermark into the video frames, this method inserts data into the side view. In this method, the watermark is embedded by changing the video frames references. Then, DWT-SVD transforms are applied to embed a grayscale
image on the luminance (Y) of YUV converted video. The watermarking steps are illustrated in Fig. 8.

The watermarking method proposed by [47] is for copyright and integrity protection. In this work, SVD features of an image matrix and the characteristics of multi-resolution of DWT are used. Hence, a new SVD based digital watermarking scheme is suggested. The singular values of low-frequency band of the watermark image are embedded into the corresponding singular value coefficients of the original image.

The proposed method in [48] used both special and wavelet domains to improve the robustness against the copyright attacks. Two blind methods in the wavelet and spatial domain are used for video watermarking and the results are compared to each other. In both methods, a combination of quantization and spread-spectrum based approaches is utilized. Furthermore, Hamming error correction code is applied to preserve the watermark against singular bit errors. In proposed spatial domain technique, the watermark data is inserted in a luminance block. As well, in the transform technique, the same information is inserted into the selected wavelet coefficients of the middle wavelet sub-band (Fig. 9 and Fig. 10).

The method presented in [49] is a mixture of multiband (M-band) wavelet, genetic algorithms (GA) and fuzzy logic algorithms. First, M-band decomposition of the original image is obtained by using wavelet transform. Then the GA algorithm is utilized to find threshold values for the selection of host coefficients as well as respective embedding strengths. In the extraction part, in order to increase the watermark decoding performance, multiple stage detection through cancelation of multiple bit interference (MBI) effect is used, which is implemented by fuzzy logic algorithm.

Kamkar et al. [17] proposed a DCT based robust video watermarking scheme for copyright application. This technique is robust against the collusion and rotation attacks. In order to enhance the robustness against the collusion attack, the embedded blocks of successive video frames are changed. For this purpose, a Pseudo Random Number (PRN) generator and a permutation vector are used. In addition, using rotation invariance property of the Complex Zernike Moments makes this method robust against the rotation attack. For embedding the watermark bits, the square blocks that are placed on the middle position of every luminance channel are used. The scheme also shows good robustness against conventional video attacks including a Rayleigh fading wireless channel. In Table V, different robust video watermarking methods for copyright protection application are compared. In this comparison, the issues and the solutions are explained.

V. CONCLUSION

Creating, modifying and distributing information has become very easy and routine in the digital era. Since with digital materials, almost everyone can modify and redistribute any work. The major problem that this rate of information creation and distribution cause is copyright.

It is vastly accepted that the watermarking is one of the effective ways for copyright protection. In copyright protection, robustness is the main concern. The aim of watermarking for copyright protection is to have a mark on the digital file to identify the owner of it. In this application, any change on the watermark is intolerable. In video watermarking, the quality is very important. The quality of the video should remain as the original one and the watermark must be invisible. Since the watermarking is a good way to address copyright protection.

In this work, a review on robust video watermarking methods for copyright application is proposed. First, an overview about the watermarking is given and the importance of video watermarking for copyright protection is described. Then, different aspects of video watermarking are explained such as video watermarking terminologies, characteristics, applications, models, techniques, and challenges. Finally, a review on robust video watermarking methods for copyright protection application is given. The comparison table of the explained method is also illustrated in this part.

ACKNOWLEDGMENT

The authors would like to acknowledge Universiti Teknologi Malaysia (UTM) for providing facilities and
Table V: COMPARISON OF DIFFERENT ROBUST VIDEO WATERMARKING SCHEMES FOR COPYRIGHT PROTECTION APPLICATION

<table>
<thead>
<tr>
<th>Reference</th>
<th>Year</th>
<th>Issue</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>[41]</td>
<td>2004</td>
<td>Copyright and ownership identification. Robustness against common image processing attacks.</td>
<td>Novel watermarking scheme based on BTC.</td>
</tr>
<tr>
<td>[43]</td>
<td>2008</td>
<td>Prevent illegal distribution of digital video. Robustness against rotation, JPEG compression, salt and pepper noise, Gaussian noise, frame averaging and frame dropping.</td>
<td>DWT and SVD</td>
</tr>
<tr>
<td>[44]</td>
<td>2009</td>
<td>Copyright protection and robustness against lossy compression, frame dropping and averaging.</td>
<td>Using motion estimation approach for embedding watermark into the specific bands of wavelet domain.</td>
</tr>
<tr>
<td>[46]</td>
<td>2010</td>
<td>Recording copyright information (robust against MPEG coding, color noise, shot dropping and frame averaging).</td>
<td>Insert the wavelet coefficients in appropriate shots according to the level of its coefficients.</td>
</tr>
<tr>
<td>[47]</td>
<td>2011</td>
<td>Copyright video watermarking. Robustness against noise addition, frame attack and MPEG compression.</td>
<td>The grayscale watermark is embedded into side view of the video instead of frames.</td>
</tr>
<tr>
<td>[47]</td>
<td>2015</td>
<td>Robustness against conventional video attacks, rotation attack and collusion attacks.</td>
<td>Using DCT and Zernike Moments transforms. The extraction method is blind.</td>
</tr>
</tbody>
</table>

resources to get this work done. Also many thanks to Ministry of Higher Education (MOHE) for funding and supporting this research and providing excellent research environment in which this work was conducted and the scientific research targets fully accomplished (Grant no. R.K130000.7838.4F643).

REFERENCES


