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Study Analysis to New Trend for 3D Video Watermark

Análisis del estudio a la nueva tendencia para la marca de agua de video 3D

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ABSTRACT/ In recent years, the transmission of 3D (Three Dimension) multimedia elements, especially 3D video became very easy because of the quick development of 3D multimedia systems. As well as, the danger of copyright breaking for 3D videos has also raised. "Video piracy" is the fundamental threat that comprises the 3D video contents. 2D and 3D video watermarking applied in many areas such as protect the copyright of media owner, broadcast surveillance, controlling on copying video, and ensure authentication of the video. Unfortunately, until recently, 3D video watermark does not take more attention. In this paper, the techniques that are used to conserve 3D video data from any illicit access are presented. The categories of 3D video watermark techniques are explained also. Analysis study about 3D video watermark is introduced through survey some existing watermark schemes, and showing the differences between these, in term of security goals, watermark embedding algorithms that make their system more robust to various type of attacks that are briefly mentioned. Furthermore the paper presents more common quality measurements utilized.
Keywords: Multimedia, 3D video, Watermark, stereoscopic video, Multiview video, DIBR.
RESUMEN/ En los últimos años, la transmisión de elementos multimedia 3D (Three Dimension), especialmente el video 3D, se hizo muy fácil debido al rápido desarrollo de los sistemas multimedia 3D. Además, también ha aumentado el peligro de que se rompan los derechos de autor de los videos en 3D. La "piratería de video" es la amenaza fundamental que comprende los contenidos de video en 3D. La filigrana de video 2D y 3D aplicada en muchas áreas, como proteger los derechos de autor del propietario de los medios, transmitir la vigilancia, controlar la copia de video y garantizar la autenticación del video. Desafortunadamente, hasta hace poco, la marca de agua de video 3D no llama más la atención. En este documento, se presentan las técnicas que se utilizan para conservar los datos de video 3D de cualquier acceso ilícito. También se explican las categorías de técnicas de marca de agua de video 3D. El estudio de análisis sobre la filigrana de video en 3D se introduce a través de la encuesta de algunos esquemas de filigrana existentes, y muestra las diferencias entre estos, en términos de objetivos de seguridad, algoritmos de incrustación de filigrana que hacen que su sistema sea más robusto para varios tipos de ataques que se mencionan brevemente. Además, el documento presenta mediciones de calidad más comunes utilizadas.
Palabras clave: Multimedia, video 3D, marca de agua, video estereoscópico, video Multiview, DIBR.

1. Introduction

In the recent years, the transmission of 3D (Three Dimension) multimedia elements, especially 3D video became very easy because the quick evolution of the 3D multimedia systems. Consequently, the risk of breaking copyright of 3D videos has been increased. The most form of threat is "video piracy". Where it means the illegal action that aims for gaining copyrighted video without the permission of the authentic owner, and copying it and then redistributing it, or selling it with new illegal copyrights. Therefore, it is necessary for protecting the copyrights of 3D videos [1] [2] [3] [4]. Digital Rights Management, steganography, cryptography, and watermarking are protection techniques utilized to keep video data from any illegal

access[5]. This paper focuses on watermarking techniques due to its importance.
Watermarking: It is a particular form of data hiding systems that aims to ensure data authentication and copyright preservation. Therefore, it is consider one of the efficient DRM (digital right management) tool methods. Watermarking is embedding secret code (e.g. Logo, image, text, etc.), visibly or in invisibly in one of the multimedia elements whether text, audio, 2D-3D image or video. Watermark code refer to media creator, owner, or authenticated user. The quality of the transmitted watermarked data must be perceived after adding the watermark. Without any restriction, a marked content can be further distributed/consumed by any user. Any legitimate/illegitimate usage can be specified at any moment by detecting the mark. If the user doesn't need to restrict the media copy/distribution/consumption, he/she can use the watermarking techniques, where it provides mechanisms for tracking the source of the content illegitimate usage [5, 6] [7] [3]. There are no paper surveys all aspects of 3D video watermark in term of their classification, embedding domain, and related works schemes. In this paper, we are trying to overcome this problem by presenting the classification of the 3D video watermarking and showing the embedding /extracting domains.
As known 3D video represented by different format for example stereoscopic, depth-based, and multiview video format [8]. The watermarking schemes for each format is explained in this research. The main goal of this research is also to survey the existing watermarking techniques that are proposed for protecting 3D video and showing their strong and weak points. The geometry based watermark not consider in this paper. Different types of attacks with the quality metrics that are implemented to measure the quality of 3D video contents after an attack are briefly discussed in this paper. Where there is very few research collects the all types of attacks that are tested on the watermarked 3D video, with available measurements that shows the robust of the proposed schemes, in contrast to all presented researches, this paper doing this process. Finally, some comparisons between the proposed protecting algorithms are introduced. The presented paper has section 2 shows the classification of 3D video watermark depending on the 3D video format. Section 3 for presenting the related work schemes. Section 4 listed the various types of 3D video attack with quality measurements. Section 5 gives several comparisons among related work results in term of how it tolerates the attack. Some concluding remarks are given in the final section 6 with some future works.

2. 3D Video Watermark

As watermark techniques used for protecting traditional image and video, the copyrights protection problem of the 3D video is ensured by 3D watermarking technique that embeds the watermark into 3D content. [9] [4]. The applications of 3D watermarking not only restricted by copyright protection, but extended to other areas like broadcast surveillance, controlling on copying video, and ensure authentication of the video [7]. 3D watermarking can be grouped into three classes based on where the watermark secret codes are embedded and extracted [9] [10] [5]:

3D_Embedding/3D_Extracting: This type of watermarking embed and extract a watermark in/from 3D model (geometry and texture) in the scene. The major objective of 3D/3D watermark is to ensure the protection of 3D models in computer graphics application [9] [5] [10].

3D_Embedding/2D _Extracting: The second one uses 3D representation (geometry or texture) for embedding and extracts the watermark from a 2D representation (image or video). Projection process used to acquire 2D data from 3D representation. Computer animation, computer gaming, and virtual realities are the applications of this type of watermarking [9] [10] [5].

2D_Embedding /2D_Extracting: This type aims to protect the 3D scene that based on the 2D images, where embedding and extraction operations are done directly on these images or videos. The benefits of 2D/2D watermarking are decreasing the amount of 3D content that further distributed and utilized illegally. The main application of this type of watermarking is ensuring the copyrights of multiview video content, where the ensuring the ownership of the original views and virtual views that are generated from it must be proven [9] [5, 10]. Some of 3D video watermarking schemes are the same watermarking schemes applied in the video, stereo image, or 3D mesh. [11]. As we know 3D video is represented as stereo based video, depth based video, and multiview video

[5]. Watermarking each of these types is presented as follow:

A. *Stereoscopic Video Watermarking*

Stereoscopic video is the simplest format composed of 2 left and right view, these views can be captured via two similar cameras placed at different positions in order to capture the same scene. Two capture devices similar to human eyes in their act, this makes the viewer watch the scene in the high-quality immersive environment [8]. Disparity map is one of the methods that used to represent this video format, it generated from the left and right views [12] [5]. Applying the watermarking algorithm on two paired views independently may effects on the quality of 3D perception by generating different visual distortions [11]. The stereoscopic video watermarking schemes can be classified into view based and disparity-based, as explained in Figure. 1. [5, 11]

- *View-based Watermarking:* To protect stereoscopic format both or one view is protected. Classical 2D watermarking techniques can be employed directly on the stereo data [11]. In the view-based watermarking some schemes embed the watermark on the right view. Then the watermarked right view together with the left view used to estimate the disparity map that is finally transmitted with the left view to the other side of communication. The receiver uses the disparity-matching algorithm to reconstruct watermarked right view of helping of the disparity map with the left view. After that, by applying the decoding algorithm the user extracts watermark from the recovered right image [5] .
- *Disparity-based Watermarking:* This approach allows to embed the watermark in the disparity map after computing it from the two views. Both the left view and the watermarked disparity map are transmitted to the receiver that reconstructed the watermark from the right view.

The problems associated with the above methods is its capability for securing the pair views of a stereo image, but not protecting the one views. [5]

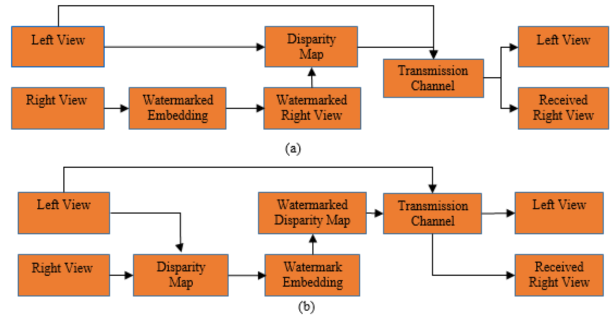

Figure 1. Stereoscopic video watermarking (a) based on view (b) based on disparity map

B. *Depth based Watermarking*

Image plus depth format is effective 3D representation. Over communication channel, both the depth and the classical color image (center image) are transmitted. DIBR process performed to generate the virtual left and right images. [13] [12]. The more significant issue in this scheme is protecting the center, the left and right views from unauthorized delivery [1]. The overall protection system is depicted in Figure. 2. In fact, the DIBR process imposes additional noise [13]

Many reasons makes traditional watermarking schemes specified for 2D and stereo video not suitable for DIBR system likes: *first*, DIBR process makes watermarked center image pixels partially transfer to various distances horizontally. *Second*, after the watermark embedding, the corresponding depth images may be manipulate. [12, 14]. From literature, the watermark is embedded either in original view or in the rendered view. [2]

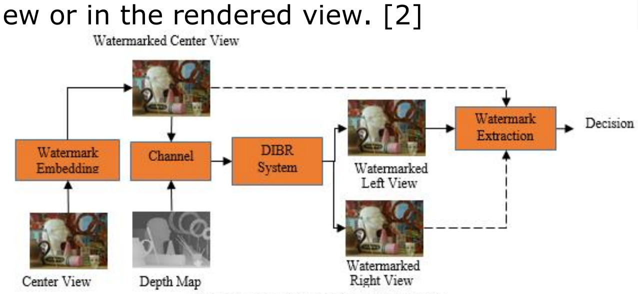

Figure 2. Depth based watermark scheme

Figure 2. Depth based watermark scheme

C. *Multiview plus depth Watermarking*

In this approach, more than 2 views are captured by setting up many synchronized cameras. A watermarking approach has been proposed to conserve copyright of this type of media, by inserting the watermark to video views frame-by-frame [11]. Multiview Video plus Depth" (MVD) is set of 2D video views plus a depth image that generated by rendering operation [1]. Independently or simultaneously, 2D video and depth images can be protected [15] There are several challenges of MVD such as: The view synthesis process using depth itself may break the watermark, in this case, it's called (synthesis attack) [2]. In case of synthesis new frame from the watermarked frame, the watermark may not be detectable if similar frames have the different watermarks. Another challenge is collecting of watermark components in the synthesized view if different watermarks are embedded in unlike views of the same scene. Major characteristic challenge of MVD is to extract the embedded code from a virtual views, created for an arbitrary view selected by the user [9]

3. Related Works

The existing watermark schemes can be divided into three main classes, 2D video-based watermark, depth map-based watermark, and zero-watermark schemes. In order, to provide robustness and imperceptibility watermark, the 2D video-based watermark techniques uses the characteristics of 2D video. After embedding, the extraction of the watermark from the synthesized 2D videos is hardly processing, due to the DIBR process that destroys the synchronism of watermark embedding and extracting. However, there are many drawbacks of 2D video-based watermark schemes such as these methods imposed some irreversible distortions to the video content, not considering depth-map components of 3D videos, and finally these schemes embed watermarks into the 3D videos before the video distribution. In contrast, depth map-based watermark schemes solves the problem of 3D video contents distortion, where it restricts the manipulation of depth maps data under a specific threshold. However, there are also several problems of these schemes like, it has the insufficient robustness against some signal processing or geometrical attacks. Copyright of 2D video and depth-map not protected independently, because they insert watermarks into the depth maps only. Finally, they also inserts the watermarks into the 3D videos before the video distribution. To address the problems with 2D video-based and depth map-based watermark schemes, the recent watermarking scheme used 2D video with the depth for protecting the copyrights. Some related watermarking researches are presented in this paper based on where their authors embedded the watermark for copyright protections as follow:

Color and Depth based Embedding

Lee, Lee, & Lee (2011) [16] proposed scheme takes the advantages of apparent characteristics, motion on z-axis and pixels of stereoscopic video to be unobserved by rendering, from depth information. Color video frames are used for the embedding/extracting process, by using additive spread spectrum algorithm, and normalized cross-correlation used for watermark extraction.

Dhaou, Jabra, & Zagrouba, (2018) [1] propose a new approach of 3D anaglyph video watermarking. The system consist of two main steps. The first one involves decomposing the original 3D anaglyph video into different GOP (Group of Pictures). After that, each GOP has broken into three classes of images: reference, blue, and red images. In order to increase system robustness, various embedding algorithms are applied to each type of image. Where the when apply the watermark approach on blue channel, only this channel is modified. The watermark on red channel follow the same this, except the reference channel need to modify red, blue, and depth channels. After that, and to gain anaglyph 3D images, all marked channel with their original channels are combined together. Finally to obtain marked anaglyph 3D video, all marked GOP are collected. The robustness of this scheme come from apply Discrete Wavelet Transform (DWT) for embedding a watermark, that able to extract a signature form more than one image, even other images are attached.

El-Shafai, El-Rabaie, El-Halawany, & El-Samie (2018) [3], implements different hybrid watermarking schemes in order to protect 3D video data. The first scheme is the Singular Value Decomposition (SVD) based on homomorphic-transform combined with Discrete Wavelet Transform (DWT) domain. While another watermarking scheme is the Discrete Stationary Wavelet Transform (DSWT) combined with Discrete Cosine Transform (DCT) domain. So, the proposed hybrid consists of three different phases. In the first phase DWT is used for transforming the two depth watermark. Then, the fusion process is implemented, and after that the fused depth watermark frame are reconstructed by employing Inverse DWT (IDWT). Second phase includes using proposed 2D chaotic Baker map technique to encrypt the resultant fused depth watermark frame. Then, the embedding process is done by embedding the encrypted fused depth watermark frame to the 3D- High

Efficiency Video Coding (HEVC) color frames. For watermark extraction process, the three phases are implemented in reverse order. Another proposed watermarking technique is introduced by the authors named SVD based on homomorphic transform watermarking in the DWT domain, where the encrypted fused depth watermark frames are inserted into the color frames at the chosen wavelet transform coefficients by employing the SVD algorithm. By choosing most suitable regions inside the color frames and employing homomorphic transform on it, the performance of the watermarking process can be improved.

Liu et al, (2017) [15] proposed watermarking technique for protecting of 3D video, which used zero-watermark scheme with similarity-based retrieval (RZW-SR3D). The proposed system consists of two stages, first, the features of 2D video and depth map components are taken away, second stage involves generating master shares and ownership shares depending on extracted features and their relevant watermark information. Whenever a new video is queried, two phases also executed, first one is the similarity-based retrieval in which the features of queried video and its depth-map components are extracted and compared with the features that are stored early. The master shares of the 2D video and depth map data are created when any match occurs. Finally, the copyright ownership of the illegal 3D video is specified by stacking the produced master shares with the ownership shares acquired according to the retrieval results.

Color based Embedding

Garcia & Dugelay (2003) [17] embeds the watermark in 3D video object texture map instead of its geometrical data. In this scheme, all synthesized images from a 3D object are protected. After the embedding, the watermarked object published either for further utilize or representations in virtual scenes. In order to ensure that the represented object is protected, the scheme enables the user to reconstruct the watermarked texture and by finally read out the embedded watermark from the texture of an image.

Franco-Contreras, Baudry, & Doër (2011) [18][29][30], suggests an idea that transforms the spatial input views onto another domain called invariant domain, in order to perform the embedding process. Authors offered using any conventional watermarking algorithm such as Spread Spectrum (SS) or Quantization Index Modulation (QIM) watermarking, and then the watermarked vector return to original domain. At the receiver side, the watermark detector is responsible for estimating presence or absence a watermark, and to read out watermark code if needed. There is no necessity for accessing to the original views and/or the parameters of the used camera in order to recover watermark[31][32].

Y.-H. Lin and J.-L. Wu, [10] authors in this paper suggested blind watermarking scheme for protecting 3D images contents that are created by DIBR technique. The proposed system is blind system meaning that, there is not necessary to provide depth image for watermark extraction.

Waleed, Jun, Hameed, Hatem, & Majeed (2013) [19][33], offers a digital watermarking technique depends on the analysis RGB color of anaglyph 3D video. In her scheme, authors used the color video, specifically the blue channel for embedding the watermark, they performs DWT and inverse DWT in order to gain the watermarked blue channel. Then the watermarked channel is joint with other channels (red and green) to produce the 3D watermarked frame. After that, all 3D watermarked frames are unified to create the final watermarked 3D video. In this watermarking technique, the authors used the identical watermarks for all frames.

Salih, Abid, & Hasan (2015) [4], suggest using a blind and imperceptible watermark technique for protecting 3D video, where in this scheme watermark code inserted into the blue channel using DWT algorithm. To identify the best location (frame), a scene change detection technique is used.

Rana & Sur, (2015) [2] The aim of their work is to protect multiview video plus depth (MVD) by securing original as well as synthesized views. The input to author's scheme is left and right view, these views are rendered by DIBR to generates center view that is used for watermark embedding, choosing synthesize view for embedding makes the scheme invariant to synthesis process. In order to obtain the watermarked version of the left and right views, the watermarked view is inverse rendered. Furthermore, Dual-Tree Discreet Wavelets Transform (DT-DWT) watermark embedding process used.

Al Barodi, Wu, & van Schyndel, (2017) [20] employs two embedding algorithms first, the

Dual-tree complex wavelets transform (DT-CWT) second, Haar discrete wavelet transform (Haar DWT). Authors embeds watermark into stereoscopic three-dimensional (3D) video. The results of analysis two methods show that the CWT is more efficient than the DWT.

W.-H. Kim, Hou, Jang, & Lee (2018) [21], proposes robust watermarking methods makes the system robust against synthesis attack and geometric distortions. Authors suggest using a template-based DIBR watermarking method. The proposed method takes the properties of DIBR that allow to the pixel to only move horizontally, and don't allow to destroy the smaller block. In order to utilize these properties, Discrete Cosine Transform (DCT) and curvelet domains are used as embedding algorithm. Authors notice that if the adding the message watermarks without using templates makes the protection system more susceptible to geometric attacks.

Depth based Embedding

Rana, Gaj, & Sur (2016) [7], proposed a watermarking technique that embeds the watermarking to depth sequences, the main feature of this scheme is that: if the watermark is embedded in original views or synthesis views, the system still able to extract the watermark. Motion compensated temporal filtering (MCTF) is applied over the video frames to find connected pixels for inserting the watermark that makes the scheme tolerant to attack resulted from video compression. To identify less sensitive regions to the human visual system, a foreground object must be detected. Suitable coefficient must be selected carefully for the embedding process. Scale Invariant Feature Transform (SIFT) can be utilized.

4. 3D Video Attacks and Quality Measurements

A. Attack

From the surveyed papers, we can collect the types of Attacks that try to destroy the watermarking system as follow:

- Noise: Additive Gaussian noise (due to Analog/Digital and Digital/Analog conversions). Noise Visibility Function (NVF). Additive White Gaussian Noise (AWGN), Gaussian filtering, Averaging filter, Gaussian low pass filter, salt and pepper noise, blurring attacks, Poisson, and Speckle noise.[18]
- Histogram equalization and Intensity adjustment, Gamma Correction, Contrast Enhancement.[4]
- Geometry attack: scaling, rotation, cropping, translation, resizing, shearing, sharpening, partial illumination changes, and projective transformations.[1]
- Frame operations (Median filtering, deleting some frames, frame swapping, frame insert, frame dropping, Frame suppression, and changing the frame orders).
- Compression (JPEG compression, JPEG2000 compression, 3D-HEVC compression attack, MPEG compression, lossy MPEG-4 compression). [22]
- Combination attacks: for example rotation combined with noise attack, filtering together with geometric attacks, frame suppression combined with geometric attacks, white Gaussian noise, frame dropping attack spatial resolution downscaling mix with and geometric attack. Changing of view, collusion attack and synthesis view attack, watermark payload.[1, 20]

B. Measurements

The perceptual attributes of 3D video like (overall image quality, sharpness, naturalness, and depth perception) differ from those in traditional 2D video. These attributes make using 2D quality metrics in measuring 3D video quality may be not accurate [23]. For measuring the perceptual qualities of 3D video the following measurements used for that purpose:

- Subjective quality measurements that depends on statistical assessment by human viewers. There are several methods used for subjective quality assessment such as single stimulation continuous quality scale (SSCQS), Double Stimulus Impairment Scale(DSIS), Normalized Correlation value (NC), structural content (SC), and Finally Multi-Scale Structural Similarity (MSSSIM) [7]. The NC measure the robustness against Gaussian low pass filtering attack, the system considers more robustness when the values for NC of the reconstructed watermark are equal to 1 [1]. The NCC measures the reconstruction of the watermarked frame against the original. How the watermarked image data is closely to the original in terms of the average signal power is measured by SC [20]. After watermark embedding, visual degradation may be occurs, to measure this degradation MSSSIM is used [7].

- Objective quality measurements such as the Peak Signal Noise Ratio (PSNR), Mean Square Error (MSE) [11] [24], and Structural Similarity (SSIM), Mean Average Difference (MAD). Whenever the PSNR value is High, the quality of watermarked videos is high also and the changes after the watermark embedding process is less noticeable. Unfortunately, PSNR not provide any information about depth perception.
- There are a number of quality models combine subjective with objective measures such as Video Quality Metric (VQM), Moving Picture Quality Metric (MPQM). VQM is used to measure the perceptual effects that are impairing the video (e.g. blurring, global noise, jerky/unnatural motion, block, and color distortion) [25].
- Precision and recall measurements are used when copied videos are modified by different individuals [26].

5. Results

As summarized from all above works, we can introduce comparison between the proposed algorithms in hence strong points and how it tolerates different types of attack. Table 1 explains this comparison.

Table 1: Results of Related Works

Ref.	Advantages and Disadvantages
[1]	High invisibility Robustness against rotation, scaling and cropping, (salt & pepper, Poisson & Speckle, Gaussian, Average filter, and blurring) noises. Also robust against compression (MPEG-4 codec). Robust against Deleting and changing some frame orders, histogram equalization and Intensity adjustment**,** some combination of attacks. Robust against blue or red channel attack.
[3]	Both the Hybrid watermarking techniques given high value in term of PSNR and NC. DWT + Homomorphic + SVD technique robust to the rotation attack, the Gaussian noise, blurring attacks, JPEG compression, resizing and crop attacks. Consumed acceptable CPU processing times. Improved the channel bandwidth by keeping the transmission bit rate.
[15]	RZW-SR3D could avoid content distortion. RZW-SR3D fulfill considerable robustness against different global, geometrical and temporal attacks
[17]	Due to the difference between dependent and the independent view in successive frames, this scheme may face from spatial and temporal de-synchronization error. The object motion is not considered in this scheme.
[18]	Watermarked content has correlation scores greater than unwatermarked content, even it decreases from the reference to the real cameras. Robust against low pass filtering, additive white Gaussian noise (AWGN), and lossy MPEG4 compression.
[10]	Good performance against the JPEG compression and noise adding attacks Low bit error rate against the DIBR attack. lower PSNR value, with high blindly scores for the 3D views The energy of inserted watermark is very large. Against geometric distortion, the scheme given not good results. The scheme didn't take into account the pre-processing/ configuration of depth image.
[19]	High degree of imperceptibility. Robustness against the following noise attack: salt and pepper, Gaussian and histogram equalization, Gamma correction, low pass filter, and Intensity Adjustment, The system is strong against JPEG compression. The extracted watermark after cropping attack has degraded insignificantly but it's still readable and understandable.

	The result showed that the scheme not robust against Poisson noise, speckle noise, frame suppression, and Frame swap, also MPEG compression. The scheme is not tested against a combined attack
[4]	Robust against noisy attacks (Gaussian low pass filtering attack). It strong against (Gamma, Correction, Intensity Adjustments, histogram equalization, cropping) attacks. It able reconstruct the watermark after lossy JPEG compression attack High imperceptibility watermark system The scheme not strong against Speckle noise, Poisson noise, Frame swaps, and Frame suppression MPEG compression. The system not experimented against combined attack
[2]	The proposed scheme given somewhat similar results against the Lee's scheme [16] in term of PSNR, SSIM, VIFp. But, it not give good results against Rana's scheme [27]. Offered better results than [16] and [27] schemes in term of collusion attack. when extracting the watermark from original embedded views, It given bit inferior results than, [27] Good performance than [16] scheme in hence synthesis view attack
[20]	DT-CWT is best in term of NCC, SC, and PSNR than the QIM-NTSS technique and DWT watermarking. Robust against some combinations attacks. Three levels of watermark payload tested to reach acceptable imperceptible watermarking strength.
[21]	Increased imperceptibility Reduced the insertion energy compared with the 2D-DCT Robust against additive noise, a JPEG attack, and give good performance on the rotation, translation and shearing attacks. Strong against combination attack like Rotation with translation and scaling with. It's weak against rotation and scaling attack, so compared with the other combination attack the scheme give higher the error. This method don't robust against 3D video coding such as HEVC.
[7]	PSNR-HVS and MSSSIM values are better than the watermarking technique that is proposed by [28], that based on Quantization Index Modulation (QIM) Robustness with the 3D-HEVC compression, view synthesis attack, and temporal scalability attack (says frame dropping).

6. Conclusion and Future Works

The transmission of 3D multimedia elements, especially 3D video became so easy, this is because the growth of the 3D multimedia technology. With this evolution, the danger of copyright violation for 3D videos has also been increased. The nature of digital media makes the copy and redistribute the media contents very easily. When multimedia data created, there is a considerable challenge to copyright owners and multimedia producers to conserve their data from the loss during transmission. Therefore, it is necessary to develop 3D video protection techniques from any unauthorized access, modification, and masquerading. Examples of these techniques are digital rights management, steganography, cryptography, and watermarking.

Watermarking is a particular form of data hiding systems that aims to ensure authentication of the data and copyright preservation. The domains of embedding and extracting watermarks are different, these domains are explained in this paper. Also the proposed watermarking techniques divided into 3 groups ones used color channel for embedding, others used depth channel, and the last group used both (color and depth) channels for protection. All these works are presented in this paper with some important results. The summarization 3D video attacks and quality measurement tools are shown in shortcut manner. In the future works, the researchers can improve the color/depth based watermarking techniques because there is little research in that domain and they can test different attacks to measure their system robustness.

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