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Robust Digital Video Watermarking With Different Distortions: A Survey

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ABSTRACT: With the growth of the technology the needs to enhance the security paradigms are also increasing day by day. Since the data travels over the internet as it is considered as the fastest means of communication now a days the chances of data tampering and losing the confidentiality of data is also increasing. The concept of watermarking was developed to retain the confidentiality and copyright of the original data. But when the watermarked data either it is a video or image transferred over the transmission media it gets distorted. The distortion can occur in terms of the geometry of the image or videos. Hence this leads to the several issues while detecting the watermark from the distorted digital data. Various kinds of distortions can take place such as barrel distortion, rational distortion etc. The corresponding distortion models are also discussed in this study. As this study provides an overview of the whole concept of the detecting the robust watermarking from the videos.

KEYWORDS: Video watermarking, distortion, barrel distortion model, rational distortion model, divisional distortion model.

I. INTRODUCTION

Video is an electronic medium for the recording, duplicating and broadcasting of moving. Video innovation was initially created for cathode ray tube (CRT) TV frameworks, however a few new advances for feature show gadgets have following been designed[1]. Charles Ginsburg drove an exploration group building up one of the first reasonable feature recording devices called video tape recorders (VTR) [2]. In 1951 the first feature recording device caught live pictures from TV cams by changing over the cam's electrical motivations and sparing the data onto attractive feature tape [3].After the innovation of the DVD in 1997 and Blu-beam Disk in 2006, offers of tape and recording hardware plunged. Later advances in PC innovation permitted PCs to catch, store, alter and transmit feature cuts [4].Video can be joined or dynamic. Intertwining was developed as an approach to diminish flash in right on time mechanical and CRT feature shows without expanding the quantity of complete edges every second, which would have yielded picture subtle element to stay inside the restrictions of a slender transfer speed [5]. The flat sweep lines of every complete edge are dealt with as though numbered successively, and caught as two fields: an odd field (upper field) comprising of the odd-numbered lines and an even field (lower field) comprising of the even-numbered lines [6].

Digital video or advanced feature is a sort of computerized recording framework that works by utilizing a computerized instead of a simple feature signal [7]. Advanced feature embodies a progression of orthogonal bitmap computerized pictures showed in fast progression at a steady rate [8]. In the connection of feature these pictures are called edges. We measure the rate at which frames are shown in frames per second (FPS).Since each frame is an orthogonal bitmap advanced picture it includes a raster of pixels[8]. In the event that it has a width of W pixels and a tallness of H pixels we say that the frame size is WxH. A watermark is data about root, proprietorship, duplicate control and so forth. This data is inserted in media content with taking care intangibly and robustness [9]. The watermark is implanted and extricated according to necessity. Video watermarking is not the same as picture watermarking, in light of the fact that extra information are accessible here that permits data to be all the more needlessly and dependably installed [8] [9].

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The figure below portrays the concept of video watermarking in a flow. The process of video watermarking comprises of following modules:

1. **Original Video:** Original video refers to the sequence of frames which results to the video. This is the input video selected by the end user which will further use for embedding the watermark behind it [7].
2. **Watermark:** Watermark refers to the data which is going to embed behind the cover image, video etc. The watermark can be text, image etc.
3. **Watermark mechanism:** When the watermark and the cover imageare entered by the user then the next step is to select a method which will imply to embed the watermark behind the cover data. There are various techniques available to embed the watermark.
4. **Watermarked videos:** After embedding the watermark, a video will be generated which will be comprised of watermark. The watermark can be of two types i.e. visible and invisible.

After getting the watermarked video then the watermarked video will be send to the other end. While the watermarked video is travelling over the transmission media, then at that time the video can get distorted due to the addition of some noisy data. The distortion and its various types are discussed in the next section. This study is conducted in order to analyze that whether it is possible to detect the watermark from a distorted video or not, alongwith its various types of distortion models are also discussed in a brief.

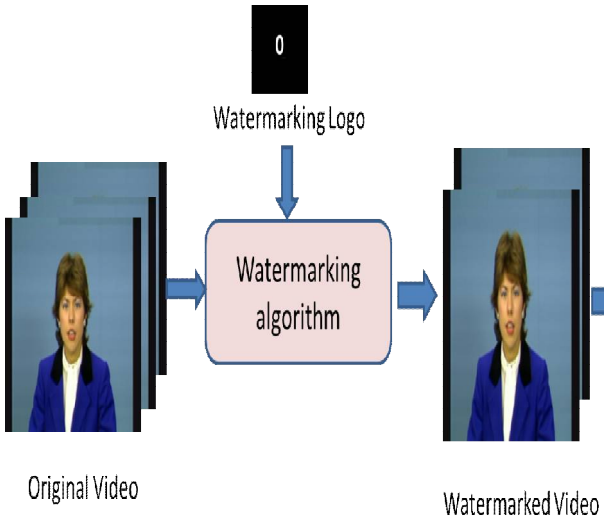

Fig.1 Video watermark technique [5]

There are multiple algorithms for embedding the watermark. For any embedding the watermark we require an original video in which we embed the digital information. After embedding watermark it passes to the channel. There are multiple distortion effects the video's watermark. This distortion also effects the watermark information which is embedded. In this paper, we show the originalframes, which are created from the video and also show the effect of distortions on the original frames.

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Fig. 2Original frame

II. TYPES OF DISTORTIONS

Distortion is a term which fit into the optic insufficiency also known as anomalies that lead to the degradation in the quality of the final video or image [11]. On the other hand, it is defined that the distortion doesn't affect the quality of the digital data, but it ruins the geometry of the frames to a portion. Distortion can be classified as follows:

1. Radial Distortion
   1.1 Barrel Distortion
   1.2 Pincushion Distortion
2. Rational Distortion

1. RADIAL DISTORTION

Radial distortion is a type of distortion which momentous manipulations in the geometry of the image or frames [12]. Radial distortion is a lack in straight line transmission. The impact of radial distortion is that straight lines are twisted as general bends and center points are moved in the spiral heading from their right position. Together with a spatial change, the amendment of radial distortion is the majorstep in the picture amendment or ortho correction [13]. Particularly when working with non-metric computerized cameras, the outspread twisting achieves noteworthy qualities and an adjustment of this mutilation ought to be the initial phase in picture handling [14].The radial distortion is further categorized in two terms i.e.

a) Pincushion Distortion
b) Barrel Distortion

Barrel distortion is atype of radial distortion where the focus point moves from its focal point to the center of the image [15]. It is also known as negative displacement.It ismostly occurs in case of wide angle lenses.
The pincushion is a kind of positive displacement in terms of radial distortion [16]. In this the optical points are moved further from the center of attractions as shown in figure2 (b). It is generally found in case of narrow angle lenses.

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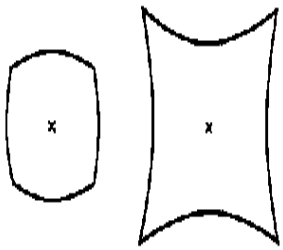

(a)(b)

Fig. 3Frames effected with (a) Barrel distortion and (b) Pincushion distortion [24].

It is generally not clearly rotationally symmetrical, but rather for a calculation of thedisfigurement it is thought to be symmetrical [14]. In the case, the picture ought to be utilized for the estimation of division, Symmetrical distortion of focal points ought to be rotationally balanced (or if nothing else about rotationally symmetrical to the adjacent points). In the event that it is not, the amendment for symmetrical bending can bring about theerror in the position of a few focal points [15]. Because of the assumption of its rotational symmetry, spiral bending over a picture can be exhibited as a general distortion depicting trust between an outspread division from the picture focus and spiral twisting [16]. Since a basic twisting capacity is generally not known and can't be gained by systematic means, the polynomial estimation of radial distortion capacity is utilized.

BARREL DISTORTION

Nonetheless, the pictures of genuine cameras experience the ill effects of pretty much focal point expression, which is a nonlinear and for the most part radial distortion. The most pervasive type of this impact is the barrel and the pincushion mutilation [18]. The first is because of the way that numerous wide focal points have higher amplification in the picture focus than at the bounds. This causes the picture edges to contract around the middle and frame a state of a barrel.
The figure below represents the original grid of the frame of the video and the frame that is affected by the barrel distortion. Hence, from the image it can be observed that the geometry of the frame is modulated instead of the frame itself.

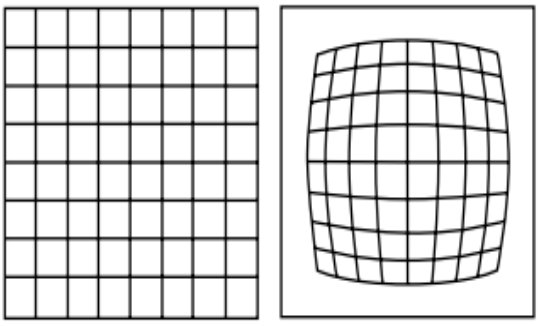

Fig. 4The original grid and the effect of barrel (center)[18]

III. DISTORTION MODEL

Distortion model refers to the mathematical model specifically meant for explaining the particular distortion in the model. It comprises of the various mathematical equation which can be applied onto the actual image or the frame in order to check the visualized effect of the distortion on the image [19]. For example, let’s consider an image or frame

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whose actual size is 250 and after distortion it is shrunk to 180, then in this case the distortion model will be applied to see the effects. There are following types of distortion model are available:

1. Barrel distortion Model.
2. The Division Model.
3. Rational distortion Model.

1. BARREL DISTORTION MODEL

Theexaggeration of the focal point reduced with the lengthwise distance which leads to the movement of the focal points radially towards the center of the frame [19]. This effect is known as barrel distortion. The image shown in figure4 depicts the frame of the image which is defected by the barrel distortion.

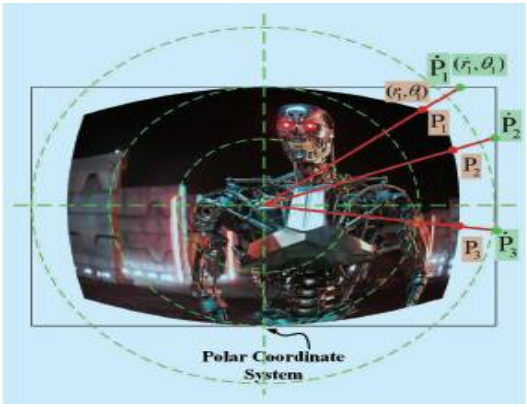

Fig. 5A warped image with barrel distortion[1]

The barrel distortion model was given by the Taylor expansion as shown in equation below:

$$\dot{r} = r(1 + k_1 r^2 + k_2 r^4 + \cdots + k_i r^{2i} + \cdots) \quad \ldots (1)$$

Here in equation (1),
$\dot{r}$: depicts the distance from center of distortion in the undistorted image.
r: stands for the distance from the center of the distortion in a distorted image.
$k_1$is a coefficient used for expressing the value of radial distortion.
The following equation (2) defines the polynomial equation with two coefficients used for the barrel distortion in the case of wide angle lenses. In this equation k_1 refers to the variable which monitors the nature of the distortion that occurs in the image or frame. In case if the first order approximation solution is not able to obtain then it will be attuned.

$$\dot{r} = r(1 + k_1 r^2 + k_2 r^4) \quad \ldots (2)$$

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Fig. 6Frame affected by the Barrel distortion

2. THE DIVISION MODEL

The divisional distortion model holds opposite views as compare to the other distortion models. Genuine focal point distortions are commonly extremely intricate, and frameworks which negotiateconsciously with nonlinear distortion utilize high-arrange models or query tables to align their cameras [21]. For PC vision, in any case, and especially to match, exactnesses of the sequence of a pixel are all that are requisite.As a consequence, it becomes normal to extend the distortion function as a Taylor series by keeping the first nonlinear terms even as shown in the equation (3).

$$x = (1 + \lambda\|p\|^2)p \quad \ldots (3)$$

Various models have been developed, but there not all of them were quite efficient, but there was a model which can be considered for evaluating the effect of the distortion of the image. The following equation (4) defines the mathematical formulation corresponding to the division model:

$$p = \frac{1}{(1 + \lambda\|x\|^2)}x \ldots (4)$$

The point that is difficult to keep in mind is that the equation (4) is not an estimation of the equation (3). Both of the equations are the form of true estimations corresponding to the camera's distortion function.

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Fig.7 Frame affected by the Division distortion

3. RATIONAL DISTORTION MODEL

The rational distortion model comprises of following mathematical formulations:

$$f(r,k) = {}^{1}/_{1 + k_1 + r} \quad \ldots (5)$$

$$f(r,k) = 1/1 + k_1 + r^2 \quad \ldots (6)$$

$$f(r,k) = (1 + k_1 r)/(1 + k_2 r^2) \quad \ldots (7)$$

$$f(r,k) = 1/(1 + k_1 r + k_2 r^2) \quad \ldots (8)$$

$$f(r,k) = (1 + k_1 r)/(1 + k_2 r + k_3 r^2) \quad \ldots (9)$$

$$f(r,k) = (1 + k_1 r^2)/(1 + k_2 r + k_3 r^2) \quad \ldots (10)$$

In the above equations (5),(6),(7),(8) and (9) and (10) the mathematical models are radially symmetrical around the focus point of the distortion and it is defined by the radius r. These mathematical models are continuous in nature and $r_d = 0 \; iff \; r = 0$.The estimation of x_d refers to an odd function of x. These are the specific criteria to elect the candidate for a rational distortion function. Now, we show the effect of rational distortion on the original frame where we had embedded the watermark. We only show the rational 9 and 10 older model.

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Fig. 8Frame affected by the Rational distortion(order 9)

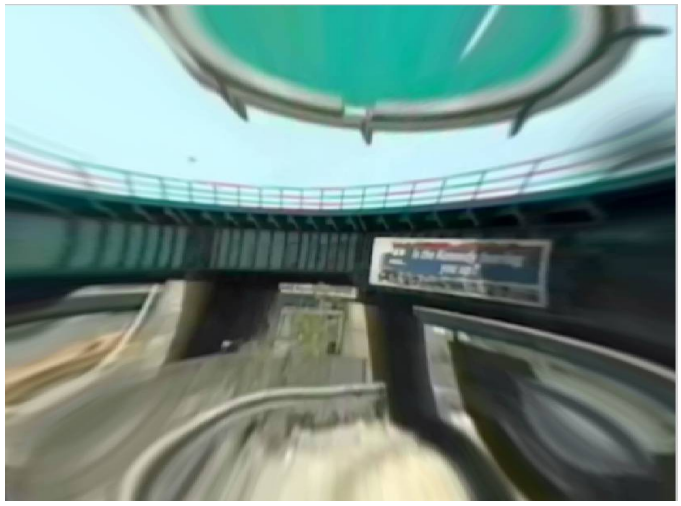

Fig. 9 Frame affected by the Rational distortion(order 10)

We are seeing that when we increases with the rational model the distortion will also increase and there are more difficult to acquire the watermark information.

IV. RELATED WORK

This section represents the traditional work that has been done in the field of detecting the watermark from the distorted video.

Huawei Tian[1] in 2016 proposed a mechanism which was implied to detect the robust watermarking in the mobile videos in contrast to barrel distortion for head mounted display i.e. HMD. An estimation mechanism for barrel distortion was given in this work to detect the watermark from the pre-wrapped image in head mounted display. After this the similar warp was imposed to the implanted watermark mask with the anticipated parameters of barrel

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distortion. Hence the implementation of this proves that the detection of watermark is possible in case of both images i.e. pre-warped and original respectively.

Changet al [2],in 2010 derived a study which focuses on the concept of lens distortion that occurs in the document picture which is taken by the hand held camera.Consequently, in order to sort out this the new approach was dragged which was comprised of arithmetical morphology based lens correction algorithm. The process of the proposal was begun with the implementation of an adaptive thresholding algorithm which divides the image into several portions and then applied the morphological algorithm to use the clustered based attached modules into text lines. After this the second order polynomial algorithm was used to fix the focus point of the text line and created the object function to the lens deformation. To solve the deformation of the image the curved warped line was converted to the straight site of line.

M. Gadermayr et al [3] in 2013 bring the focus of the research work to the concept of analyzing the impact of various distortions in case of medical images. Endoscopic images were considered as the field of interest in order to detect the celiac diseases automatically. To accomplish the objective of the study, various distortion methods were compared and then those distortion techniques were applied to the images of endoscopies which were later classified accordingly. Various interpolation mechanisms were also analyzed under this study since it was observed that the interpolation also leaves some impact to the images. Along with this, various feature extraction methods were also analyzed in order to prove the advantages of applying the distortion correction algorithms. And finally, after implementing the proposal, it was concluded or observed that it is not feasible to analyze the efficacy of the distortion correction mechanism in contrast to medical images in order to detect the disease automatically because the advantage ofthe distortion alteration mechanism totally relies upon the method that is chosen for the feature extraction for classification of the diseases.
Andrew W Fitzgibbon et al [4] in 2001 depicts that how linear approximations of the base matrix with respect to double view point i.e. $m\ and\ y$ can be improved to add radial lens distortion. This was accomplished by shifting towards the other lens model which had comparable powers along with standardized coordinates instead of standard distortion model. And in order to depict the basic matrix approximation a new estimated model was proposed in this study, which was compared with bundle adjusted calibration grid data. From the results of this study it was observed that the proposed estimator model was quite efficient in the sense of speed.

V. CONCLUSION

In conclusion section it can be concluded that the vast research work has been done in the field of detecting the robust watermark from videos, images etc. This study provides an overview of the various concepts such as video watermarking, types of distortions that can occur in the videos and various distortion models that can be applied to analyze the visual effect of the distortion.
Further enhancements can be done in the field of water mark detection by using barrel distortion, rational distortion and divisional distortion model.

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