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Estimate the Position of Pirate in Theatre

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Abstract: Many pirated digital movies by camcorder capture are found on the Internet or on the street market before their official release. During piracy of cinema footage, composite geometric distortions commonly occur due to the angle of the camcorder relative to the screen. There are various research has been done to utilize the geometric distortions that will be occur during piracy in theatre to estimate the position of pirate in theatre via watermarking scheme followed by LACF (local auto correlation function). This paper present the notion of Watermarking and the features required to design a watermarked video for piracy deterrence. We review several methods, and introduce frequently used key techniques. The aim of this paper is to focus on the watermarking technique that is good for piracy deterrence. The majority of the reviewed methods based on watermarking emphasize on the notion of secure spread spectrum way of watermarking followed by LACF for estimating the position of pirate.

Keyword: Digital cinema, local autocorrelation function, video watermarking, audio watermarking, local auto-correlation function (LACF).

I. INTRODUCTION

This Camcorder piracy in theatres is movie theft by pirate who brings a camcorder into a theatre and record a movie from the screen. Recently, camcorder piracy has become a serious problem due to technical advances in camcorders. The Motion Picture Association claims that the annual loss caused by pirated movies is 6.1 billion dollars and that over 90% of the pirated movies of new release titles are illegal recordings made by camcorder piracy. As a deterrent against the camcorder piracy in theatres, several watermarking techniques have been proposed. The main idea of these techniques is to embed a secret message into the movie, and the message indicates where and when the movie was shown. If movies are pirated and the illegal recordings are made available via the Internet or some other route, then the secret message can be extracted to determine where and when the illegal recordings were made. This sort of technique is very effective since it can help to specify the theatre and ShowTime the illegal recordings were made for a further surveillance. However, the earlier techniques cannot identify the pirate, who made the illegal recordings. A process for the purpose of identifying the pirate as follows: 1) the pirate illegally records watermarked movies and distribute the illegal recordings to the Internet or in the street market. 2) A conventional watermarking system such as finds the illegal recordings on the Internet and analyses the embedded message to determine the theatre and the Showtime at which the illegal recordings were made. 3) The position estimation system estimates the position in the theatre where the pirate was, precisely enough for specifying the seat. 4) A person identification system identifies the pirate by making correspondence between the seat and the person who was on the seat. A ticketing system or a video surveillance system may be used as the person identification system.

II. Proposed System

Video watermarking scheme

a) Watermark Embedding

This section describes the watermark embedding process in the host video, which is designed in such a way that satisfy the requirements for digital cinema. The watermark pattern is generated and then inserted into the video frames based on spread spectrum way with considering HVS (human visual system). In this scheme, the watermark pattern is used in two ways: one is to carry payload data and extract it robustly; the other is to find illegally cam cording position. In order to accomplish both roles, the watermark pattern should have periodicity for LACF to calculate geometric distortions. The periodicity is obtained by tiling the basic pattern. M and N denote the width and the height of the host video and m and n denote the number of repetitions in horizontal and vertical direction, respectively. The 2-D basic pattern is then modulated to contain the bit payload (e.g., serial number of the theatre, time stamp, etc.). The modulated Basic pattern w is repeated m × n times to get the periodicity. After a periodic watermark pattern of size M × N has been Obtained, the pattern is embedded in an additive spread-spectrum way with perceptual scaling.

b) Watermark Detection

It is done in two step: 1) find geometric distortions using the LACF on the estimated watermark pattern and 2) recover the watermark from the distortions and extract the embedded message.

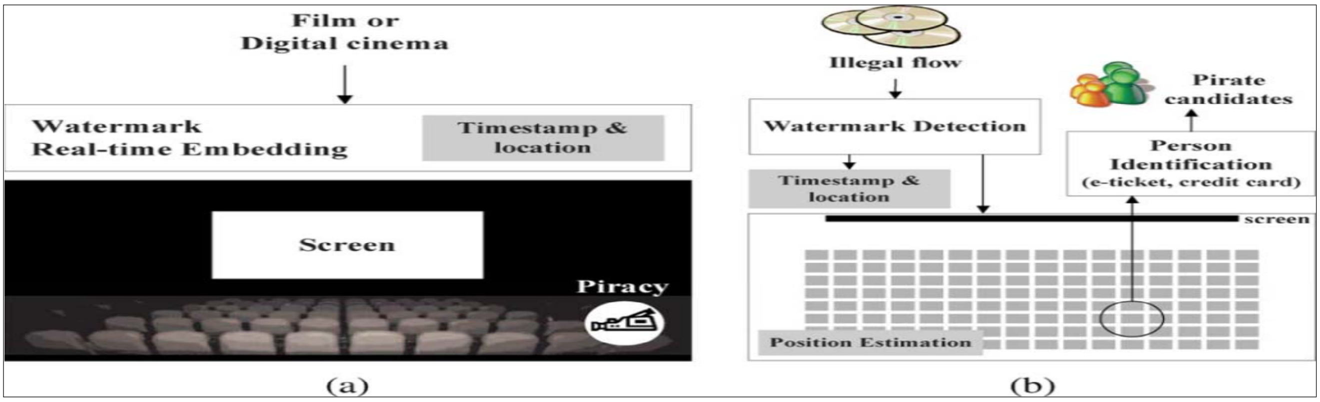

Fig. 1. Scenario for pirate identification. (a) Illegal capturing of the watermarked movie in the theater. (b) Position estimation through watermark detection.

1. Estimating Geometric Distortion

Due to the fact that a blind detector is used, the embedded watermark is estimated by employing Wiener filtering as a denoising filter. Subtracting the denoised frame from the captured frame, for obtaining an approximate version of the embedded watermark pattern. Both estimating geometric distortion and extracting watermark are proceeded using this extracted pattern. The shapes of captured cinematic footages in the rectangular frames are generally quadrangle. The distances and the angles of the scenes are not preserved and parallel lines do not project to parallel lines unless they are parallel to the image plane. A rectangle is transformed into a quadrangle by perspective projection. Let x=(x, y, 1) T be the homogeneous vector that represents a point in the original frame and x' =(x,y,1)T be the homogeneous vector that represents a point in the geometrically distorted frame. Local auto-correlation function (LACF) was employed for estimating projective transform. It computed the autocorrelation function of two local areas of the image that are parallel to each other instead of computing auto-correlation of the whole image. The estimation model which uses two parallel areas for LACF can estimate projective transforms with only one vanishing point. Since the camcorder capture raises projections with more than one vanishing point which converts a rectangle to a quadrangle, we employ the estimation model which considers simultaneously LACF results of both two vertical local areas and two horizontal areas. Now by using LACF H can be calculated and once H is calculated further step can be processed using H.

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2. ***Watermark Extraction and Position*** **Estimation of Pirate**

The watermark pattern is recovered from the geometric distortion using the inverse matrix H-1. Due to the fact that the matrix H is a non-singular matrix by the definition of projective transformation, the inverse of H is always obtained.

III. AUDIO WATERMARKING SCHEME

Embedding audio watermark signals into movie soundtracks is very typical. In fact, most of the watermarking methods that have been used for movies are video watermarking methods. This difficulty comes from the nature of the movie soundtracks. They are composed of several types of audio such as music, sound effects, voice, and silent portions. In the voice and silent portions, which seems to dominate large portions of a soundtrack, the watermark embedders cannot embed a strong watermark signal without degrading the acoustic quality. This is the sparseness of movie soundtracks problem. However, this problem can be overcome by maximum-likelihood analysis using the entire recorded signal, and achieve precise recording position estimation by watermarking the multiple-channel soundtrack. Now describe how the position estimation system works. Each of the channels of the soundtrack named as a *host signal* (HS). The watermark signal for each HS is generated using spread spectrum (SS) technique with different SS codes. The watermark embedder generates a watermark signal for each HS and ads the watermark signal to the HS to generate a *watermarked host signal* (WHS). Each WHS is emitted into the air from a separate loudspeaker. If the movie is recorded with a camcorder, the monaural *recorded signal* (RS) of the audio will be a mixture of all of the WHSs. In the RS, the signal from each loudspeaker is delayed in proportion to the distance from that loudspeaker to the microphone of the camcorder. The concept is to utilize these delays for the position estimation. Therefore, the detection strength of each watermark signal will have a peak at a particular time dependent on the delay times. Taking this into account, the stochastic model of the detection strength has been constructed.

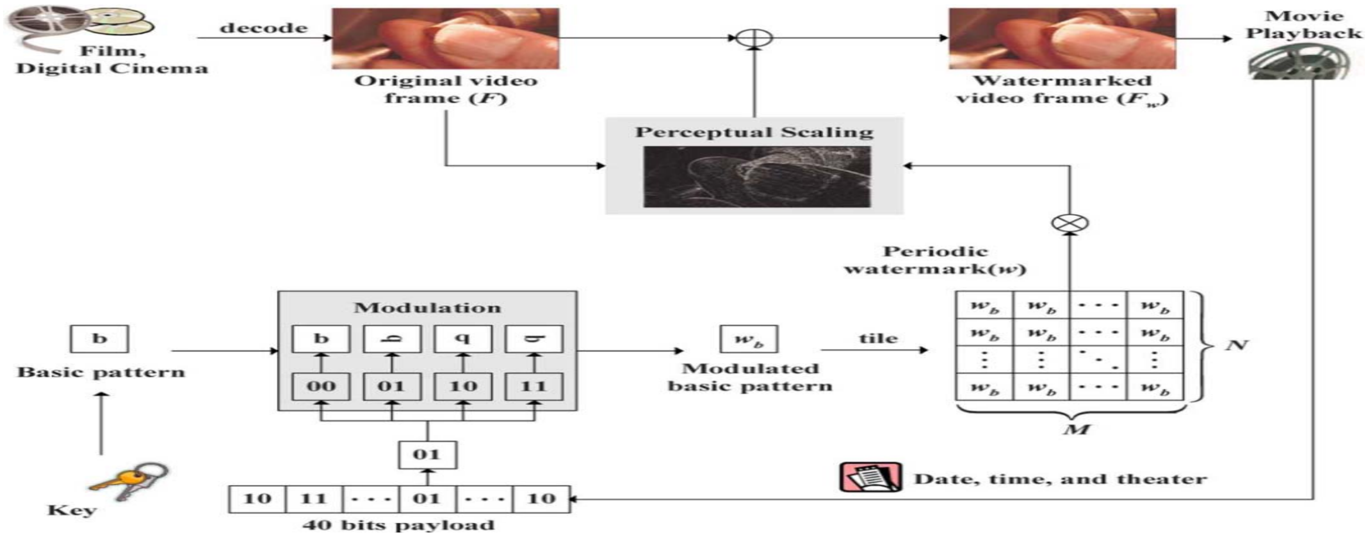

Fig. 3.1. Watermark embedding procedure.

The system calculates the probability of obtaining the detection strengths based on the model and finds an optimal recording position from the probability using maximum-likelihood analysis.

The main concept of this technique are listed as follows.

Digital watermarking of multiple channel audio signals can be used for finding recording positions down to specifying a specific seat in a large auditorium. This is a brand-new application of the digital watermarking technique.

Recording position estimation method that is usable even for sparse movie soundtracks. The problem of unreliable watermark signals in the silent portions of the movie soundtracks is addressed by a one-step approach utilizing the detection strength model and the entire RS.

The subjective listening tests assessing the acoustic quality of the watermarked multichannel movie soundtracks. As far as, this is the first efforts to assess the acoustic quality of audio watermarking in an environment with more than two speakers.

IV. Conclusion

Given that many pirated copies of digital cinema are captured by the camcorder, we proposed a video watermarking scheme to protect digital cinema against camcorder capture. First, our scheme provides robust watermark detection against camcorder capture to extract information about when and where the piracy occurred. Second, the position of the pirate in addition to the time and location information is estimated by our PEM. It limits the number of piracy suspects in the theatre and helps to find out the pirate by matching persons to the databases stored in the electronic ticket offices or in payment system. We showed that our proposed scheme is robust against composite geometric distortions that commonly occur due to the angle of the camcorder relative to the screen. In our experiment, the PEM could estimate the position of the camcorder with an MAE of (33.84, 9.53, 50.38) cm. It is proved that these results of our PEM can be applied in real theatres.

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