

# A Robust Watermarking Method for an Authentication of Video Surveillance Applications

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**Abstract:** *The problem of authenticating the video content is the major role of any automated video surveillance systems (AVS). This research work delivers an approach to authenticate the surveillance video which can be used by attorneys to prove their clients using Digital Watermarking. The digital watermark gives an assurance that the provided video surveillance frame is not tampered. In this paper, we proposed a robust video watermarking approach for an authentication of video surveillance applications. The digital watermark is embedded into the Discrete Wavelet domain of the identified key frames using holoentropy. Here, the pixel map will be optimally generated for the watermarking and the image embedding using the proposed classifier using Moth – flame - Rider optimization based Neural Network (MF-ROA-based NN) will generate the optimal map prediction based on the fitness measure, such as wavelet coefficient, energy, entropy, loop coefficient, and standard deviation, respectively. This optimal map is used for both embedding and extraction. The experimental results prove that the proposed systems can authenticate the surveillance video frames against various attacks when compared to the existing systems.*

**Keywords:** *Automated Video Surveillance Systems (AVS), Digital Watermarking, Discrete Wavelet Domain, holoentropy, optimal map*

## I.INTRODUCTION

Video surveillance systems play a major role in forensic evidence in court. The video files of digital surveillance systems need to be authenticable. Thus a technique like watermarking is applied for tamper detection purposes. The watermark must not have any effect on visual information and or compromise the video evidence in any way. High imperceptible watermarks can meet these requirements [1]. Video tamper detection is a major challenge for today's researchers in the field of multimedia security [1]. Tamper-resistant watermarks are designed for copyright protection to declare the ownership. The tamper resistant watermark must be robust in nature so that it is impossible or difficult to remove watermark without visibly damaging the watermarked media. While fragile watermarks designed to detect the tampering of the watermarked media as these are very sensitive to modifications. The tampering will modify or destroy the watermark. Fragile watermark provides basis for the tamper detection as well as tamper localization [2]. Most tampered media have part of the medium altered using objects in the medium itself.

Parts of a medium can be altered geometrically to change their appearance. The commonly used by forgers include cropping, rotation and scaling [2]. An alteration using scaling changes the size of objects, often creating an illusion. Rotational modification, on the other hand, changes the angle of alignment of an object in the medium [1]. The continuous growth of Internet Technologies has made the communication and circulation of digital multimedia contents very easy. However, this leads to an increase in illegal operations such as duplication, modification, forgery, and copyright infringement. Therefore, the copyright protection, content authentication, and ownership identification have become critical requirements of the multimedia content security [3]. Watermarking is the process of embedding data into a multimedia element such as image, audio or video. This embedded data can later be extracted from, or detected in, the multimedia element for different purposes such as copyright protection, access control, and broadcast monitoring [4]. A basic watermarking system has three major requirements, such as transparency, robustness and blind detection [5]. The watermark is concealed as additional information to the original video which may degrade the visual quality of watermarked video content. Hence, maintaining the perpetual transparency of video content after watermark concealing is vital [5]. Introducing watermarks in digital videos can be useful to safeguard copyright. The watermark can be inserted either in uncompressed (raw) video or compressed video. Video signals are often stored and transmitted in a compressed format. Application of uncompressed watermarking techniques for compressed video sequences, however, needs complete decoding and re-encoding of the video for watermark embedding or detection [6]. Although digital video watermarking, which is the process of hiding digital information in a host video signal, is a solution to this problem, there are some important issues, such as imperceptibility, blind detection, security and robustness to attacks that need to be considered during the design of the watermarking algorithm [7]. Despite video watermarking in the compressed domain, which may cause error propagation due to embedding, watermarking in the uncompressed domain is easier. In this case, the designer does not care about the video bit-rate [8]. Although video watermarking has many properties, the main three ones are imperceptibility, robustness and payload or capacity. All three are closely related to each other: for example, when robustness increases, imperceptibility decreases, and vice-versa [1].

**Manuscript published on 30 December 2019.**

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A robust video watermarking scheme must maintain the integrity of watermark transparency plus robustness to pirate attacks [5]. Video watermarking algorithms can be divided into three groups including pixel domain, transformed domain, and compressed domain based on the place in which the embedding is directly applied. Pixel domain algorithms directly embed the watermark into video frame pixels. The main advantage of these algorithms is that they have low computational complexity and as a consequence can be implemented easily. However, they are less robust against attacks; in this regard, statistical and geometrical techniques are utilized to improve the robustness [8].

The above study motivates us to develop a robust watermarking scheme which authenticates the surveillance video frames. The proposed system identifies the key frames using holoentropy, then identifies the optimal map using the Moth flame – rider – based Neural Network classifier. Such optimal map is used for both embedding and extraction which makes the system robust against various attacks.

The rest of the paper is organized as follows: section 2 elaborates related works, section 3 describes proposed methodology, section 4 demonstrates the experimental results and finally conclusions were drawn in section 5.

### II. RELATED WORKS

Digital watermarking method was developed to enhance the effectiveness of the compression ratio. However, it was not secure against geometric attacks. In [2], Bi-directional Extreme Learning Machine (B-ELM) was developed to makes the embedding and extraction process quite fast. However, the performance was not effective. In [3], Bi-orthogonal

Wavelet Transform was introduced to enhance the efficiency and security in the surveillance system, but this system was not robust. Zero-watermarking scheme was developed in [4] to exhibits strong robustness against various video attacks. Conjugate Symmetric Sequency-Complex Hadamard Transform (CS-SCHT) was modelled in [5] to resists various attacks like RS, BD and HEVC compression. However, the computational cost is high. Multi-BAM-FUZ was developed to enhance the embedding capacity of the scheme [6]. Novel video watermarking approach was developed to identify the malicious consumers from the video services [7]. The robust video watermarking technique was introduced to detect the video surveillance accurately even very fine cutand- paste blocks. It focuses on video watermarking, particularly with respect to the Audio Video Interleaved (AVI) form of video file format. However, it offered a high degree of imperceptibility and efficient tamper detection. It requires a large quantity of sequences to be processed, which makes computational efficiency an additional constraint on video watermarking for surveillance systems. It proved to be equally efficient in detecting tampering and in their overall robustness, but not in terms of their imperceptibility. It was able to embed confidential and integrity information into hosts effectively and also improved the efficiency of detecting tampering [8].

This section elaborates the work related to the authentication of video.

| Authors                                | Methods   | Pros  | Cons   |
|--|---|---|--|
| Asikuzzaman M <i>et al.</i> [7]        | Digital watermarking method                                       | It was robust and effective against H.264/AVC compression, additive noise, baseline distance adjustment, and both 2D and 3D camcording.                 | It was not secure against geometric attacks.   |
| Rajpal A <i>et al.</i> [3]             | Bi-directional Extreme Learning Machine (B-ELM)                   | It makes the embedding and extraction process quite fast. It was robust against the preprocessing interferences, like cropping, filtering, and scaling. | However, the performance was not effective.  |
| Sake A. and Tirumala R [4]             | Bi-orthogonal Wavelet Transform                                   | It improved the imperceptibility, efficiency and security in watermarking.  | However, it was not robust.  |
| Liu X <i>et al.</i> [9]                | Zero-watermarking scheme  | It does not cause any distortion to the synthesized 3D videos, exhibits strong robustness against various video attacks.                                | It failed to enhance the robustness of the content-based features against geometrical attacks such as rotation and cropping. |
| Meenakshi K <i>et al.</i> [5]          | Conjugate Symmetric Sequency-Complex Hadamard Transform (CS-SCHT) | This scheme is resilient to various attacks like RS, BD and HEVC compression.   | However, the computational cost is high.   |
| Loganathan A. and Kaliyaperumal G [10] | Multi-BAM-FUZ   | The embedding capacity of this scheme is far better than the existing algorithms.   | However, it was not suitable for fast motion videos.   |
| Mareen H <i>et al.</i> [11]            | Novel video watermarking approach                                 | It effectively identifies the malicious consumers of video services.  | The detection rate was very less.  |
| Arab F <i>et al.</i> [1]               | Robust video watermarking technique                               | It attained better detection capabilities and better imperceptibility   | It failed to accurately detect the fine cutand- paste blocks.  |

#### 1.1. Contributions:

The issues on the above study motivate us towards the following contributions:

- Develop an effective watermarking scheme in the video surveillance system to enhance the performance of the watermarking mechanism.
- Develop a novel watermarking concepts this helps to inquire the features of the embedding characteristics.

### III. PROPOSED METHODOLOGY

The primary intention of this research work is to design and develop a new method for video watermarking. This work performs the video watermarking framework by involving four phases, as (i) Key frame identification, (ii) pixel map generation, (iii) embedding phase, and (iv) extraction phase, respectively. Initially, the input video is collected from the video surveillance system and will be fed to the latent frame identification phase, where the key frames will be effectively identified using the concept of holoentropy. The selected latent frames will be allowed to the pixel map generation module. Here, the pixel map will be optimally generated for the watermarking and the image embedding using the proposed classifier. The proposed Moth-flame-riding optimization algorithm-based Neural network (MF-ROA-based NN) classifier will be the integration of the

standard RideNN [14] and moth-flame optimization (MFA) [15] such that the proposed classifier will generate the optimal map prediction based on the fitness measure, such as wavelet coefficient, energy, entropy, loop coefficient, and standard deviation, respectively.

Then, the generated optimal pixel map will be forwarded to the embedding phase, where the watermark image will be embedded in the video. In the embedding phase, the video watermarking will be carried out using the Haar wavelet-based embedding. Moreover, the extraction process will be carried out using the inverse Haar wavelet-based embedding. In the extraction phase, key will be used to extract the embedded watermark image in the video by applying the inverse Haar wavelet-based embedding and it is tested for robustness. Figure 1 shows the architecture of the proposed video watermarking approach for surveillance video applications.

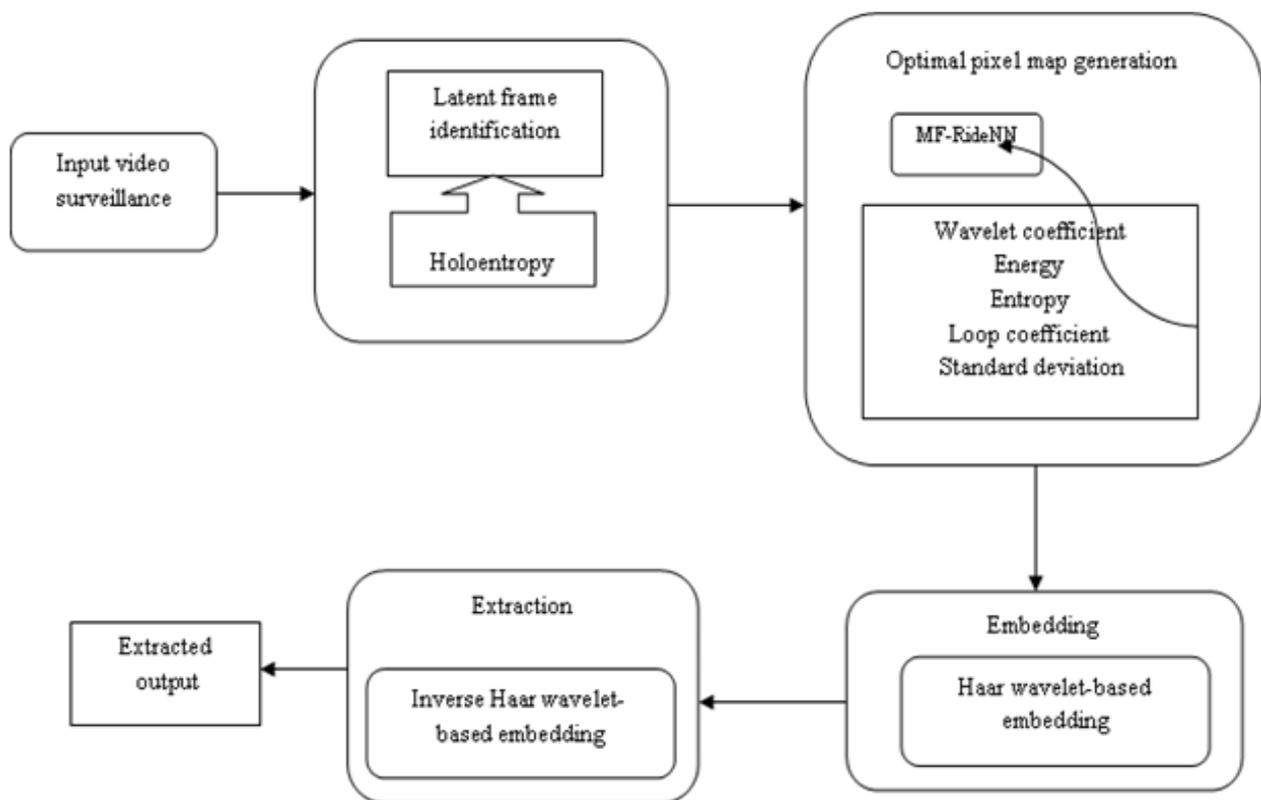


Fig. 1. Architecture of the proposed MFA-Ride- based NN approach for Video Surveillance

### IV. EXPERIMENTAL RESULTS

The simulation experiments were carried out in this section to test the efficiency of the proposed system. This approach is tested with large data set of popular surveillance videos and CAVIAR dataset [16] as shown in Fig. Due to page constraint, we have shown few surveillance video samples namely ‘suzie’ ‘abcnews’, ‘blanchardtownhouse’, ‘oldstreet’, ‘sporecctvfootage’, ‘taximeter’, ‘wnycnews’, ‘womaninstreet’ and ‘caviar’ and watermark image as ‘lena’ as shown in Fig.2



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Fig. 2.A sample cover video frames

Moreover, the watermarks chosen to verify the robustness of the proposed system are the benchmark test images such as *lena*, as given in Fig.3



Fig. 3 A sample watermark images

The Fig. 4 shows the watermarked video frames *blanchardtownhouse\_wand* and the extracted watermark *lena1*



Fig. 4 Watermarked Video frames and extracted watermarks

## 4.1 Performance Metric

The performance of the proposed method in terms of imperceptibility and robustness were evaluated using the performance metrics, namely Peak Signal to Noise Ratio (PSNR), and Normalized correlation coefficient respectively.

## 4.2 Attacks:

To investigate the performance of the proposed video watermarking system, we voluntarily introduced some attacks on each watermarked videos such as, Frame Noising introduces various noises on the watermarked video such as, gaussian noise of variance 0.05, Salt and pepper noise with density 0.05. Frame cropping is an attack

performed by an illegitimate users by cropping the significant portion of the video frames at the rate of 50%. Frame Insertion is an attack involves inserting the frames randomly at various locations in the rate of 50%. Frame Dropping is an attack dealt with dropping the frames randomly at the rate of 50%. Frame Swapping involves swapping of frames randomly at the rate of 50%, Frame Rotate, Frame Rate conversion attack dealt with changing the number of frames shown per second. The various frame rates used for testing purposes are varying in the range 50fps. Temporal redundancy is evaluated by embedding the watermark weight matrix on the test videos with temporal redundancy of  $r=6$  frames and MPEG Compression. The proposed scheme shows high resistance to all the mentioned attacks with good and acceptable quality factor (see Fig. 5)

| Type of attack                              | Watermarked frame   | Extracted Watermark   | Type of attack                               | Watermarked frame   | Extracted Watermark   |
|---|---|---|--|---|---|
| Gaussian noise (variance = 0.05)            | <br>PSNR = 51.51   | <br>NCC = 0.99   | Salt and pepper noise (density = 0.05)       | <br>PSNR = 49.99   | <br>NCC = 0.98   |
| Frame Cropping(20%)                         | <br>PSNR = 49.89   | <br>NCC = 0.97   | Frame Insertion (Rate = 50%)                 | <br>PSNR = 51.88   | <br>NCC= 0.99    |
| Frame Dropping (Rate = 50%)                 | <br>PSNR = 51.01   | <br>NCC = 0.99   | Frame Swapping (Rate = 50%)                  | <br>PSNR = 50.62   | <br>NCC = 0.99   |
| Frame Rotation (30°)                        | <br>PSNR = 46.74  | <br>NCC = 0.91  | Frame Rate conversion (20fps)                | <br>PSNR = 49.99  | <br>NCC = 0.95  |
| Frame Resizing (Upscaling to W=429 H = 240) | <br>PSNR = 51.67 | <br>NCC = 0.99 | Frame Resizing (Downscaling to W=114 H = 64) | <br>PSNR = 48.77 | <br>NCC = 0.94 |
| Temporal redundancy R=6 frames              | <br>PSNR = 49.56 | <br>NCC = 0.97 | MPEG Compression                             | <br>PSNR = 50.12 | <br>NCC = 0.99 |

Fig. 5 Watermarked Video Frames (Attacked *blanchardtownhouse*) and Corresponding Extracted watermark (*lena*)

### 4.3 Comparative Study

The proposed video watermarking scheme for video surveillance applications was tested and compared with the relevant watermarking systems Arab et.al. (Video watermarking for tamper detection of surveillance

systems). From Table 1, we infer that the proposed system is more robust when compared to the related system for all kinds of attacks.

Table. 1 Comparison of Proposed Approach with Existing System [1]

| Attacks                      | Existing System [1] |                   |        | Proposed Approach |                   |        |
|------------------------------|---------------------|-------------------|--------|-------------------|-------------------|--------|
|                              | Tamper Detect       | Watermark Extract | NCC    | Tamper Detect     | Watermark Extract | NCC    |
| Gaussian Noise               | NA                  | NA                | NA     | Yes               | Yes               | 0.9999 |
| Salt and Pepper Noise        | Yes                 | Yes               | 0.9995 | Yes               | Yes               | 0.9876 |
| Frame Cropping               | Yes                 | Yes               | NA     | Yes               | Yes               | 0.9789 |
| Frame Insertion              | Yes                 | Yes               | 0.8885 | Yes               | Yes               | 0.9999 |
| Frame Dropping               | Yes                 | Yes               | 0.905  | Yes               | Yes               | 0.9987 |
| Frame Swapping               | Yes                 | Yes               | 0.999  | Yes               | Yes               | 0.9995 |
| Frame Rotation               | Yes                 | Yes               | 0.9786 | Yes               | Yes               | 0.9123 |
| Frame Rate Conversion        | NA                  | NA                | NA     | Yes               | Yes               | 0.9564 |
| Frame Resizing (Upscaling)   | NA                  | NA                | NA     | Yes               | Yes               | 0.9964 |
| Frame Resizing (Downscaling) | NA                  | NA                | NA     | Yes               | Yes               | 0.9493 |
| Temporal Redundancy          | NA                  | NA                | NA     | Yes               | Yes               | 0.9756 |
| MPEG Compression             | NA                  | NA                | NA     | Yes               | Yes               | 0.9912 |

V.CONCLUSIONS

In this research work, we have designed a new robust Moth – Flame – Rider based Neural Network (MF – ROA – based NN) technique to identify the optimal map for both embedding and extraction in the wavelet domain. The proposed technique is suitable for authenticate the surveillance video frames which can be used for law evidence. The proposed approach satisfies the imperceptibility, robustness and security in all kinds of attacks when compared to the existing system.

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