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# Watermarks Technique in MPEG-1Video by B-spline

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**Abstract**

As the computers are more and more integrated via the network, the distribution of digital media is becoming faster, easier, and requiring less effort to make exact copies. One of the major impediments is the lack of effective intellectual property protection of digital media to discourage unauthorized copying and distribution.

This paper aims to produce random and dynamic watermarking technique to provide copyright protection for digital media (video) by embedding a digital image for video sequences compressed according to the MPEG-1 video coding standard.

Digital image is used to be embedded in one of the most widespread video coding standard (MPEG-1), by implementing third degree B-spline curve equation on I-frames macroblocks data to interpolate data and provide according to the comparing condition effective points that represent the selected location where watermark image will be embedded.

Using B-spline curve fitting equation will show distribution of watermark location through secondary intra-frame of MPEG-1 standard by drawing curves depending on watermarked points as control points.

Test measurements will be used to prove robustness of the proposed technique against watermark attacks and control point for curve drawing illustrating how watermark image is distributed among a number of video samples.

**Keywords:** MPEG-1 , B-spline ,Impg, I-frame, watermarking.

## تقنية العلامة المائية في فيديو MPEG-1 باستخدامB-Spline

**الخلاصة**

كلما زاد التوحد بين الحاسبات من خلال الانترنت ، فإن توزيع الوسائط الرقمية اصبح اسرع، اسهل ويتطلب جهداً اقل لعمل نسخ مشابهة منه.وإن احدى العقبات الرئيسية هي النقص الفعال في حماية الملكية الفكرية للوسائط الرقمية والذي يشجع على التوزيع والاستنساخ غير المرخص به.

يهدف هذا البحث الى تقديم خوارزمية اضافةعلامة مائية عشوائية وديناميكية لتوفير الحماية لحقوق الملكية للوسائط الرقمية (الفيديو) بتضمين صورة رقمية في متواليات مضغوطة من الفيديو وفقاً لنموذج الفيديو المرمز MPEG-1. تستخدم الصور الرقمية لتُضمن في احد اكثر انواع نماذج الفيديو المرمزة(MPEG-1) بتطبيق معادلة المنحني من الدرجة الثالثة من نوع (B-spline) على بيانات macroblocks للاطار الداخلي ( I-frame) لاقحام البيانات وتقديم نقاط فعالة وفقاً لشرط مقارنة والتي تمثل المواقع المختارة التي سيتم تضمين الصورة الرقمية كعلامة مائية فيها.استخدام معادلات المنحنى (B-spline) لتظهر كيفية توزيع مواقع العلامة

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المائية خلال الاطار الداخلي الثانوي (secondary I-frame) لنموذج MPEG-1 عن طريق رسم منحنيات بالاعتماد على مواقع العلامة المائية كنقاط سيطرة. مقاييس الاختبار ستستخدم لاثبات قوة النظام المقترح ضد الهجوم على العلامة لمائية ونقاط السيطرة في رسم المنحنى ستوضح كيف تم توزيع الصورة الرقمية بالنسبة لعدد من عينات الفيديو.

## Introduction

Also referred to as simply *watermarking*, a pattern of bits is inserted into a digital image, audio or video file that identifies the file's copyright information (author, rights, etc.). The name comes from the faintly visible watermarks imprinted on stationery that identify the manufacturer of the stationery. The purpose of digital watermarks is to provide copyright protection for intellectual property that's in digital format. [Vol 00]

An effective watermarking procedure should satisfy or consider the following requirements:

1. ***Imperceptibility:*** The hidden information must not impair the original content for regular use, [Mat 08].
2. ***Robustness:*** The watermark should be impossible to remove even if the algorithmic principle of the watermarking method is public. [Job 03]
   In particular, the watermark should be robust to:
   - ***Common digital processing***
   - **Subterfuge** ***attacks (collusion and forgery)***
   - ***Geometric distortions.***

   In order for a watermark to be robust, it must be embedded into perceptually significant regions of the media despite the risk of eventual fidelity distortion. The reason is quite simple: if the watermark were embedded in perceptually insignificant regions, it would be possible to remove it without severe quality degradation of the cover content.
   Further, perceptually significant regions should be chosen with respect to sensitivity of human visual system which is tuned to certain spatial frequencies and to particular spatial characteristics such as edge features.[Zlo 07]
3. ***Unambigueity:*** The retrieved watermark should uniquely identify the copyright owner of the content, or in case of fingerprinting applications, the authorized recipient of the content.
4. ***Capacity:*** Capacity is the issue allowing embedding of the maximum number of distinguishable watermarks. The significant components of an image have a perceptual capacity that allows watermark insertion without perceptual degradation. In other words, any attempt to remove or destroy embedded watermarks will influence the significant components of an image and thus lead to fidelity degradation. [Job03].
5. **PublicWatermarking**
   Authentication without using original sources is necessary for two reasons:
   - Searching for the original image in large digital libraries is time consuming
   - Application of "Web-crawling" detection.

   Source-based and destination based approaches are two major watermarking schemesThe source-based approach focuses on ownership authentication/ identification.

A unique watermark is detected or extracted to determine the owner of data. It is desirable to confirm ownership by retrievingthe watermark without the original image. On the other hand, the destination-based method can be used to trace the end user when illegal use such as reselling occurs. Under these circumstances, the existence of original images is allowed, [Hsu 98].

6. **Resolving Rightful Ownership deadlock**

Awatermarkshould unambiguously certify the true occupant. It is in fact very important and is usually ignored in most watermarking schemes. [Gua 01]

**Related Work**

Several techniques have been reported in the literature aiming at watermarking in the compressed domain, some of previous algorithms were simply treating video as a sequence of still image and applying the traditional image watermarking were not efficient and might even expose the host media to some new type of attacks.

That was largely due to availability of a huge number of marked images. The redundant watermarking information in many similar video frames presents a potential hole for malicious pirates.

Previous research as like [Men 98], used digital visible or invisible watermarks for protecting or verifying the original image or video ownership. A novel compressed domain approach is proposed to embed visible watermarks in MPEG-I and MPEG-2 video streams. The algorithms

operate on the DCT coefficients which are obtained with minimal parsing of input video. The embedded watermarks adapt to the local video features such as brightness and complexity to achieve consistent perceptual visibility. The embedded watermarks are robust against attempts of removal since clear artifacts remain after the possible attacks.

[Hua 00] work on both watermark structure and embedding strategy affect robustness of image watermarks, where watermarks should be embedded in discrete cosine transform (DCT) domain in order for the invisible image watermarks to be robust, though many papers in the literature agree that watermarks should be embedded in perceptually significant components, DC components are explicitly excluded from watermark embedding.

**Compressed Digital Video Types**

Video compression is an enabling technology for a wide variety of applications, including video delivery over the internet, advanced television broadcasting, and video storage. [Shi 00]

All video compressors share common characteristics. The following terms describe the step-by-step process of compressing video, [Woo 05]:

- frame difference
- motion estimation
- discrete cosine transformation
- entropy coding

Most practical video compression techniques are based on lossy compression, in which greater compression is achieved with the penalty that the decoded signal is not identical to the original. The goal of a video compression algorithm is to achieve efficient compression whilst minimizing the distortion introduced by the compression process.

Video compression algorithms operate by removing redundancy in the *temporal*, *spatial* and/or *frequency* domains. By removing different types of redundancy (spatial, frequency and/or temporal) it is possible to compress the data significantly at the expense of a certain amount of information loss (distortion). Further compression can be achieved by encoding the processed data using an entropy coding scheme such as Huffman coding or Arithmetic coding.

In order to encourage interworking, competition and increased choice, it has been necessary to define standard methods of compression encoding and decoding to allow products from different manufacturers to communicate effectively. This has led to the development of a number of key International Standards for image and video compression, including the JPEG(Joint Photographic Experts Group), MPEG(Motion Picture Experts Group) and H.26× series of standards, [Ric 03].

Both ITU-T (International Telecommunications Union-Telecommunications Standardization) and ISO (International Standardization Organization) have defined different standards for video coding and also defined common standards for both organizations which are (H.264/ MPEG-4 AVC). These standards are summarized in Figure (1) and their evolution is shown in [Gua 01].

**Mp Mpeg-1 Compressed Video File**

The ISO/IEC 11172 specification that defines the audio, video and multiplexing standards collectively and colloquially referred to as the MPEG-1 is used in this proposed system as the media file to be protected. In MPEG-1 video file, three types of pictures are considered: Intraframe (I-frame), forward-predicted frame (P-frame),and bidirectional frame(B-frame), which are described as follows. Since video is a sequence of still images, it is possible to compress a video signal using techniques similar to JPEG. Such methods of compression are called intra-frame coding techniques, where each frame of video is individually and independently compressed.

Intra-frame coding exploits the spatial redundancy that exists between adjacent pixels of a frame. A frame is first divided into 8 X 8 blocks of pixels, and the 2-D DCT(Discrete Cosine Transform) is then applied independently of each block. This operation results in an 8 X 8 block of DCT coefficients in which most of the energy in the original block is typically concentrated on a few low-frequency coefficients.

A quantizer is applied to each DCT coefficient that sets many of the coefficients to zero. This quantization is responsible for lossy nature of the compression algorithm. Compression is achieved by storing only the coefficients that survive the quantization operation and by entropy coding their location information and amplitudes.

Temporal redundancy results from a high degree of correlation between adjacent frames. In computing the frame-to-frame difference, a block based motion compensation approach is adopted for P-frame. A block of pixels (target block) in the frame to

be encoded is matched with a set of blocks of the same size in the previous frame (reference frame).
The block in the reference frame that best matches the target block is used as the prediction for the latter.
This best-matching block is associated with a motion vector that describes the displacement between it and the target block. The motion vector is also encoded along with the prediction error. The prediction error is encoded using the DCT-based intra-frame encoding technique.
In bidirectional prediction, some of the video frames are encoded using two reference frames, one in the past and one in the future. A block in those frames can be predicted by another block from the past reference frame (forward prediction), or from the future reference frame (backward prediction), or by average of the two blocks (interpolation). Frames that are bidirectionally predicted are never themselves used as reference frames.
A video sequence is divided into a series of GOPS (Group of Pictures), where each GOP contains an I-frame followed by an arrangement of P-frames and B-frames. Figure (2) shows an example of a GOP structure.

**B-Spline Polynomials Curve**

The term *B-spline* was coined by Isaac Jacob Schoenberg and is short for basis spline. In the mathematical subfield of numerical analysis, a **B-spline** is a spline function that has minimal support with respect to a given degree, smoothness, and domain partition. A fundamental theorem states that every spline function of a given degree, smoothness, and domain partition, can be represented as a linear combination of B-splines of that same degree and smoothness, and over that same partition. In the computer science subfields of computer-aided design and computer graphics, the term **B-spline** frequently refers to a spline curve parameterized by spline functions that are expressed as linear combinations of B-splines (in the mathematical sense above). Although Bezier curves and surfaces are well suited to many shape modeling problems, complex geometric constructions are required to guarantee continuity when piecing curve together,[Fau 79].

$$D_{New}=(1-u)^3/6D_{i-1}+(3u^3-6u^2+4)/6D_i +(-3u^3+3u^2+3u+1)/6D_{i+1}+u^3/6D_{i+2} \quad \ldots(1)$$

$$_{New}=(1-u)^3/6V_{i-1}+(3u^3-6u^2+4)/ +(-3u^3+3u^2+3u+1)/6V_{i+1}+u^3/6V_{i+2} \quad \ldots(2)$$

Where :

u = parameter that x and y are related to each other through their dependence on it.

x= DNew , y= VNew

(X,Y) represent the values of the new

The use of spline functions avoids this by using mathematical constrains to allow only those curves that process the required continuity of joints.
The B-spline function generates a curve section, which has continuous slopes so that they fit together smoothly as shown in Figure (3).
A B-spline of order k=3 consisting of n-k+2 segments is defined by a linear combination of basis functions C1 using n+1 control points V1

$$C_1(u) = b_{-1}(u)v_{i-1} + b_0(u)v_i + b_1(u)v_{i+1} + b_2(u)v_{i+2} \quad \ldots 3$$

where the basis functions are defined by

$$b_{-1}(u) = {}^{1}/_{6}\left(-u^3 + 3u^2 - 3u + 2\right) \quad \ldots4$$

$$b_0(u) = {}^{1}/_{6}\left(3u^3 - 6u^2 + 4\right) \quad \ldots5$$

$$b_1(u) = {}^{1}/_{6}\left(-3u^3 + 3u^2 + 3u + 1\right) \quad \ldots6$$

$$b_2(u) = {}^{1}/_{6}\, u^3 \quad \ldots7$$

A B-spline curve exhibits local control a control point is connected to four segments (in the case of cubic and moving) a control point can influence only these segments. In Figure (4) the effect of changing control points P1 is shown. This pulls the segments of curve in the appropriate direction and also affects, to a lesser extent, parts of the curve and thus demonstrates the important locality of B-spline.[Abd 06]

- ***Properties of B-Splines***
  1. composed of multiple connected polynomial curves
  2. each segment is affected by $k$ control points
3. each control point affects $k$ segments, max.
4. inside convex hull.
5. local modification.
6. symmetric.

Precisely, lower degree curves can be used and still maintain a large number of control points. Changing position of a control point will not globally change the hape of the whole curve s (local modification property). Since B-spline curves satisfy the strong convex hull property, they have a finer shape control. Moreover, there are other techniques for designing and editing the shape of a curve such as changing knots. However, B-spline curves are still polynomial curves and polynomial curves cannot represent many useful simple curves such as circles and ellipses. Thus, a generalization of B-spline, NURBS, is required.

**Embed Image in MPEG-1 Video File**

Figure (5) shows the proposed technique, In this technique effective points where Watermark will be embedded are found by applying polynomial 3'rd degree B-spline equation to secondary I-frame data.

Normalization from image processing point of view is used twice in the proposed technique:

1- To normalize macroblock data between 1, 255.

2- After dividing all average values by amaximum value, these values are normalized to return data between 0-

Determining effective points depends on comparing the original value with the average one.

Using B-spline interpolation, normalization in embedding will increase complexity of watermark data points which will make it difficult to attack, complexity achieved because of randomization of effective points that have been generated depending on B-spline equation. Figure (6) shows how to choose I-frame effective points where *digital image watermark* is embedded.

The Proposed algorithm for the effective points determination works as follows:

***Step 1:*** Normalization

```
for(i=0;i<LenDat;i++)
 D[i]=(float)(Data[i]/255.0);
```

***Step 2:*** Apply third degree equations below to interpolate new values of Data_new

- for(i=1;i<LenDat-2;i++)
- for(u=0 ;u=1 ; u= 0.01)

$$D_{New}=(1-u)^3/6D_{i-1}+(3u^3-6u^2+4)/6D_i+(-3u^3+3u^2+3u+1)/6D_{i+1}+u^3/6D_{i+2}$$

$$V_{New}=(1-u)^3/6V_{i-1}+(3u^3-6u^2+4)/6V_i+(-3u^3+3u^2+3u+1)/6V_{i+1}+u^3/6V_{i+2}$$

***Step 3***:Find Sum 0f 100 values-100 values came from a change in u value 0-1 where u=0.01 - from above equation to any value and calculate average of an these values :

- for(i=1;i<LenDat-2;i++)
- for(j=0;j<100;j++)
  $DAll[i] += D_{New}[i][j];$
- AvD[i] = DAll[i]/100

**Step 4**: Find Maximum value of average value

**Step 5**: Divide All Average values / maximum value.

**Step 7:** Transform new value between (0 – 1).

**Step 8:** If (Original point > Average ) then embed DWM image in LSB of original point .

Repeat steps from (1-7)

After selecting where to embed digital watermark image principle of X-OR will be used to add digital watermark image to video file then curve fitting for the watermarked locations will be drawn.

**Digital Watermark Extraction**

In any watermarking system it is important to extract watermark from the video file, so in the proposed system illustrated in Figure (7) to extract a watermark image, the following steps will be done:

1- Parse watermarked video file to extract secondary I-frame.
2- Using the algorithm shown in figure (6) find effective points in the extracted secondary I-frame to determine where watermark data were embedded.
3- Extract watermark image according to the following algorithm where

Input: Watermarked secondary I-frame macroblock

Output: Watermark Image size (112 * 64), Mpeg-1 video standards

Process:

Count= Array of 112 * 64 , k=0

***Step 1***: for I=1 to LenDat-2

***Step2****:* A= D_new((which chosen from effected point algorithm))

***Step 3***: For each A

- Take reminder of LSB in A by divide it /2
- If Reminder=1 then count [k]=1, k=k+1
- If k>=8 then k =0, coun=count +1
  - else Count[k] = 0

***Step 4****:* transform sequential bits in count to bytes.

***Step 5****:* Divide byte to 112*64

***Step 6:*** Construct BMP watermark image.

***Step 7****:* Display watermark image.

**Results**

The watermark robustness depends directly on the embedding strength, which in turn influences the visual degradation of the video. Most distortion measures used in visual information processing belong to the group of difference distortion measures. These measures are all based on the difference between the original, undestroyed and the modified, destroyed video. The different distortion measure values after being implemented on the sampled watermarked video are shown in Table (1). Figure (8) shows how distribution of watermark image in I-frame differs from one sample to another.

**Conclusions**

The proposed technique is to embed a digital image as a watermark into intra-frame of Mpeg-1 video coding standards, the following conclusions can be driven.

1. When MPEG-1 video coding standard is parsed four types of frames can be detected (I,B and P) frames , where Intra-frame(I-frame)can be divided into two types (main I-frame and secondary I-frame) , main I-frame contains information about all video frames therefore any changes in its data will affect display of video. For this reason digital watermark image has been embedded in data of secondary I-frame.
2. Spline interpolation is applied through implementing polynomial B-spline curve fitting to normalized secondary I-frame macroblocks data in order to find effective point where watermark image is embedded. This will provide a random and dynamic technique since watermark location will differ from one video sample to another depending on secondary intra-frame data .
3. For the video samples that are taken to test proposed technique, each sample will show different curve fitting drawing which proves that watermark distribution through video samples will be restricted only to I-frame data.
4. The proposed watermark technique has the characteristics of invisibility because there is no obvious difference between original and watermarked video sample.
   Using Different Distortion Measures shows that whenever the size of video sample increases MSE and SNR decreases. This means increasing video size will provide huge host data and watermark will not affect video file data.
5. Tests on the proposed watermarking technique proved that it is robust because
   a. It is independent on host data and each video watermarked sample is processed according to its own data.
   **c.** Resist distortion while being sent through internet or Compressed using compression programs.
   **d.** Proposed watermark system resists forgey attack when the same watermark image is used to watermark already watermarked video sample because watermark image

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**Table (1) The Different Distortion Measures on watermarked video**

| | Video sample | Size | Duration (sec) | MSE | NMSE | Variance | Standard Deviation | SNR |
|---|---|---|---|---|---|---|---|---|
| 1 | Tennis | 873 | 0.04 | 4.25777340 | 24.56641769 | 7009.81540661 | 83.72463989 | 0.04070598 |
| 2 | Bus | 876 Kb | 0.04 | 4.23302698 | 26.03943634 | 6898.26223609 | 83.05577850 | 0.03840329 |
| 3 | Flower | 878 Kb | 00.04 | 7.50706053 | 14.04962540 | 7120.28624715 | 84.38179016 | 0.07117628 |
| 4 | Allosaurus Small | 1.00 Mb | 00.06 | 0.00345414 | 5809414.00000000 | 5858.63509735 | 76.54171753 | 0.00000017 |
| 5 | Earth | 1.06 Mb | 0.06 | 0.00330687 | 6057666.00000000 | 5749.03822081 | 75.82241058 | 0.00000017 |
| 6 | D14 | 5.16 Mb | 00.29 | 0.84172338 | 167.95230103 | 5766.29159761 | 75.93610382 | 0.00595407 |
| 7 | Lion | 6.30 Mb | 1.17 | 0.28737795 | 383.30468750 | 5702.11359161 | 75.51234436 | 0.00260889 |
| 8 | Romeu E Julieta | 28.2 Mb | 02.50 | 0.10571834 | 1295.08410645 | 5768.41085260 | 75.95005798 | 0.00077215 |

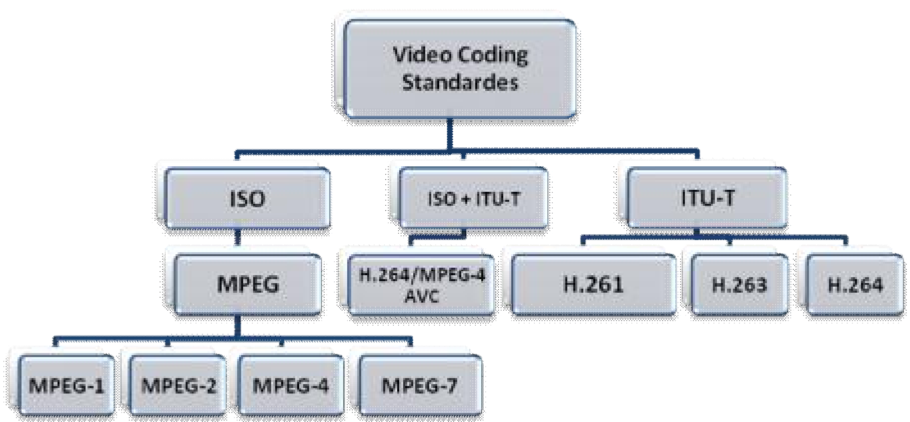



**Figure (1) Video Coding Standards**

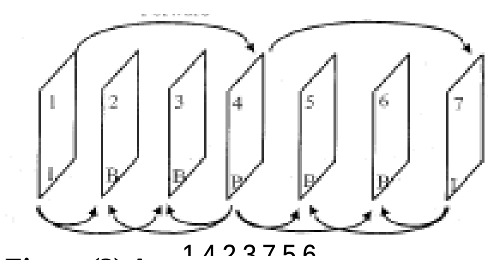



**Figure (2) An example of group of pictures**

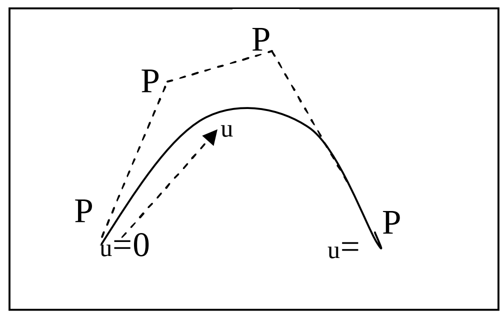



**Figure (3) B-spline Curve segments**

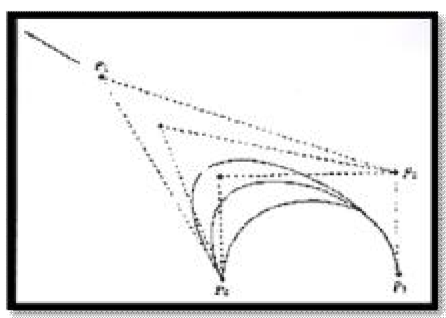


**Figure (4) The effect of changing the position of control point P1**

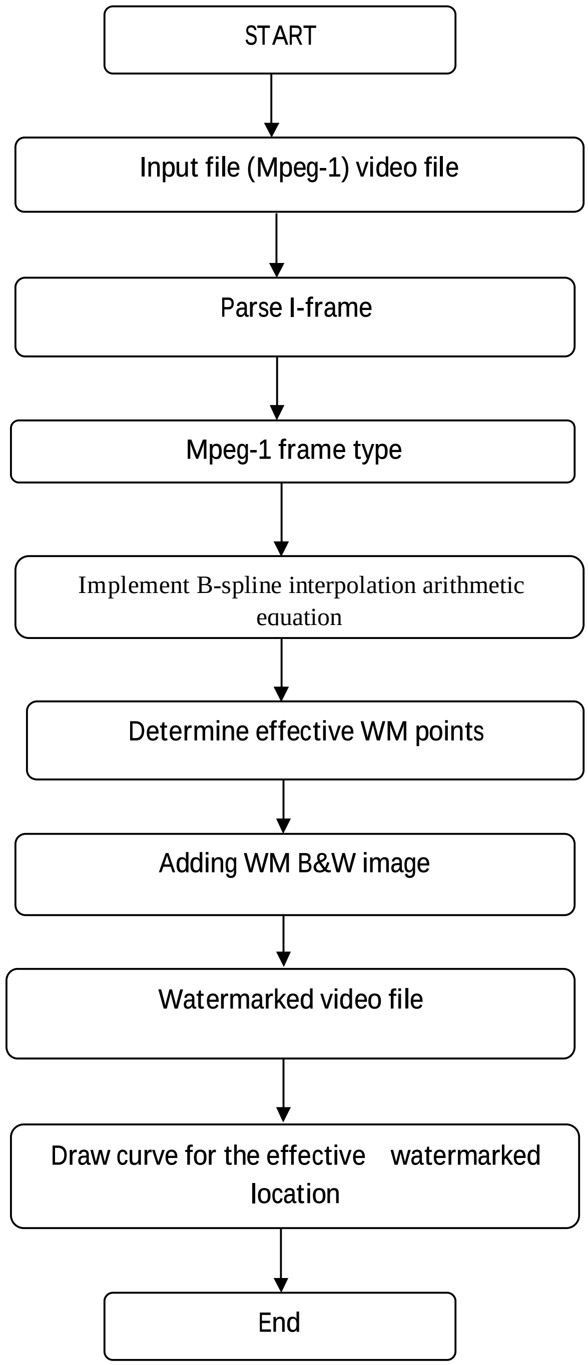



**Figure (5) General overview for the proposed system**

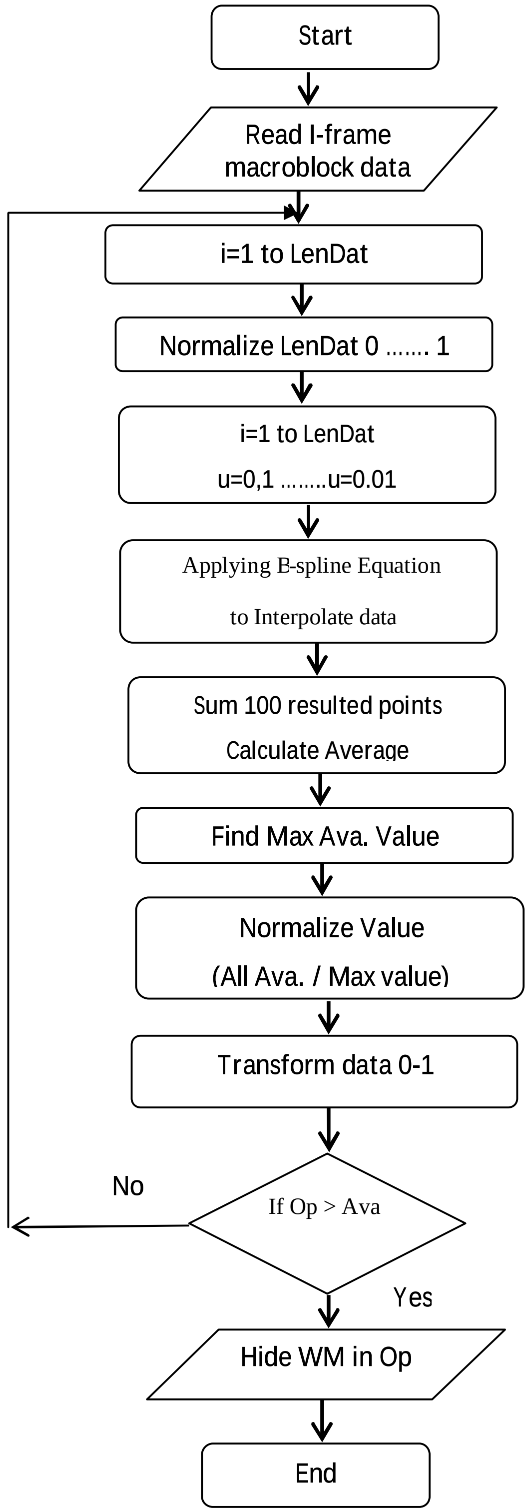



**Figure (6) General Overview for Effective points determination flowchart**

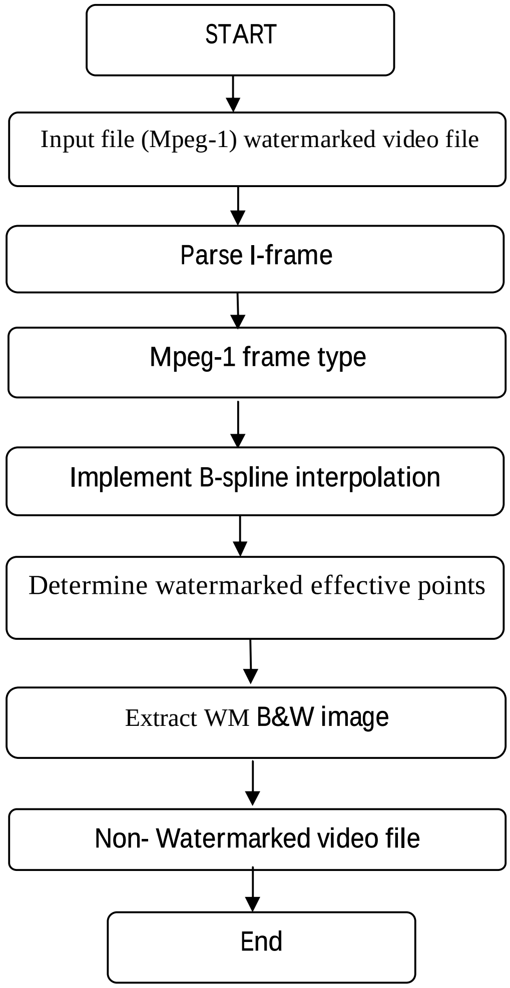
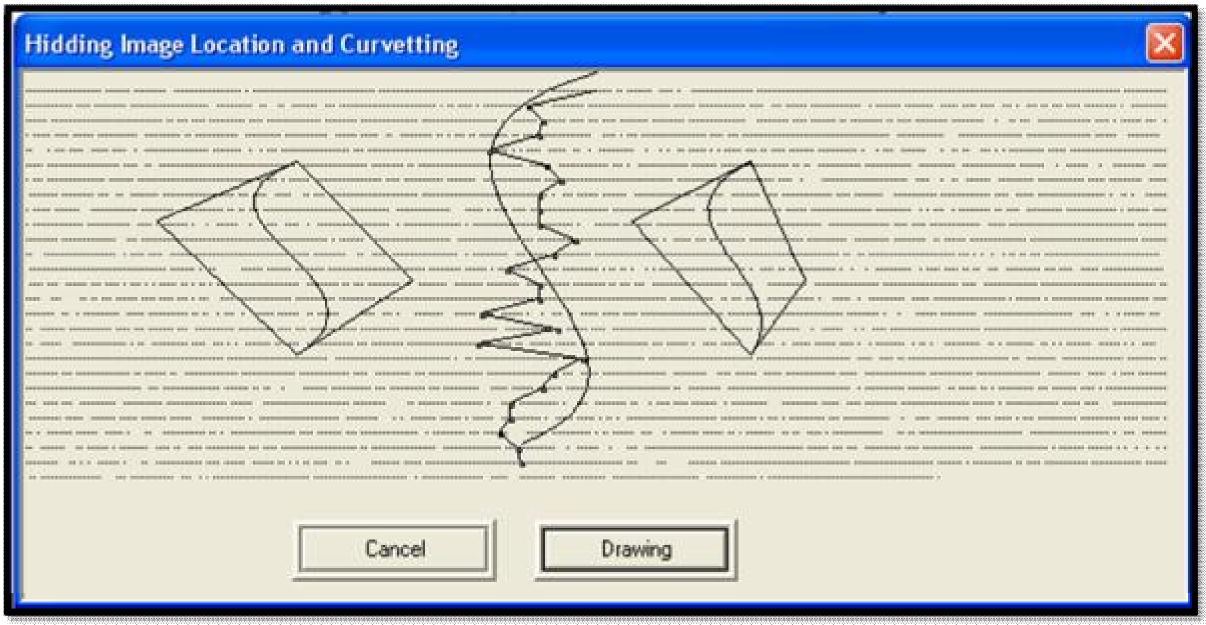
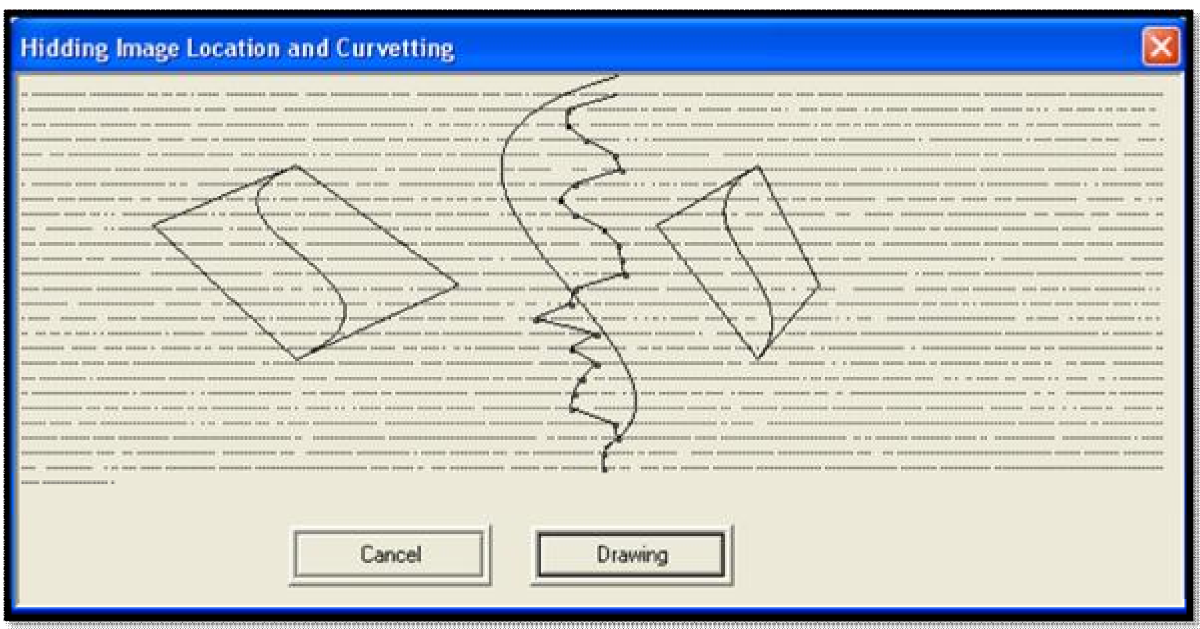


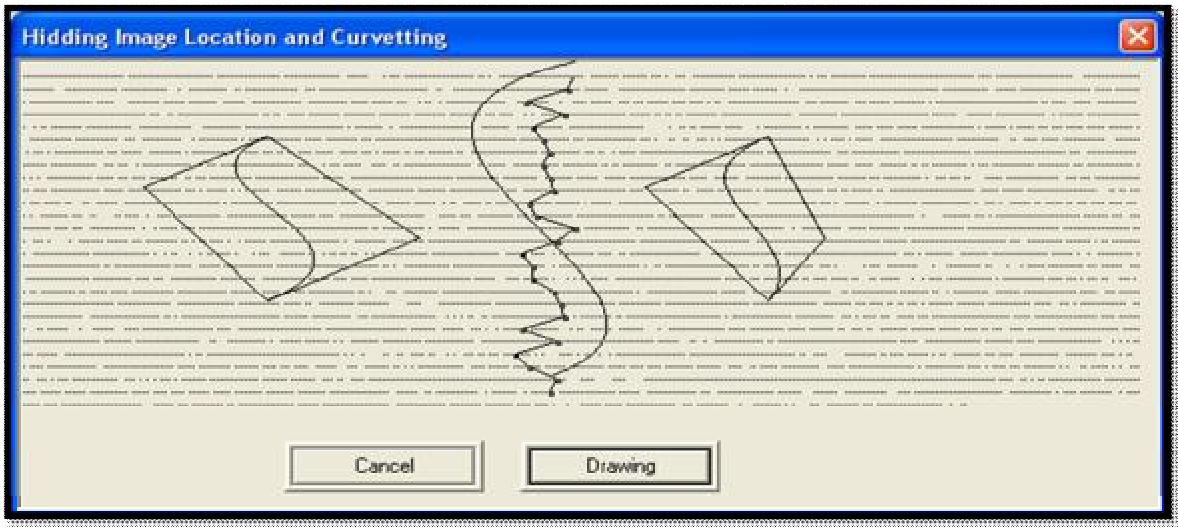

**Figure (7) the proposed algorithm to extract digital image watermark**



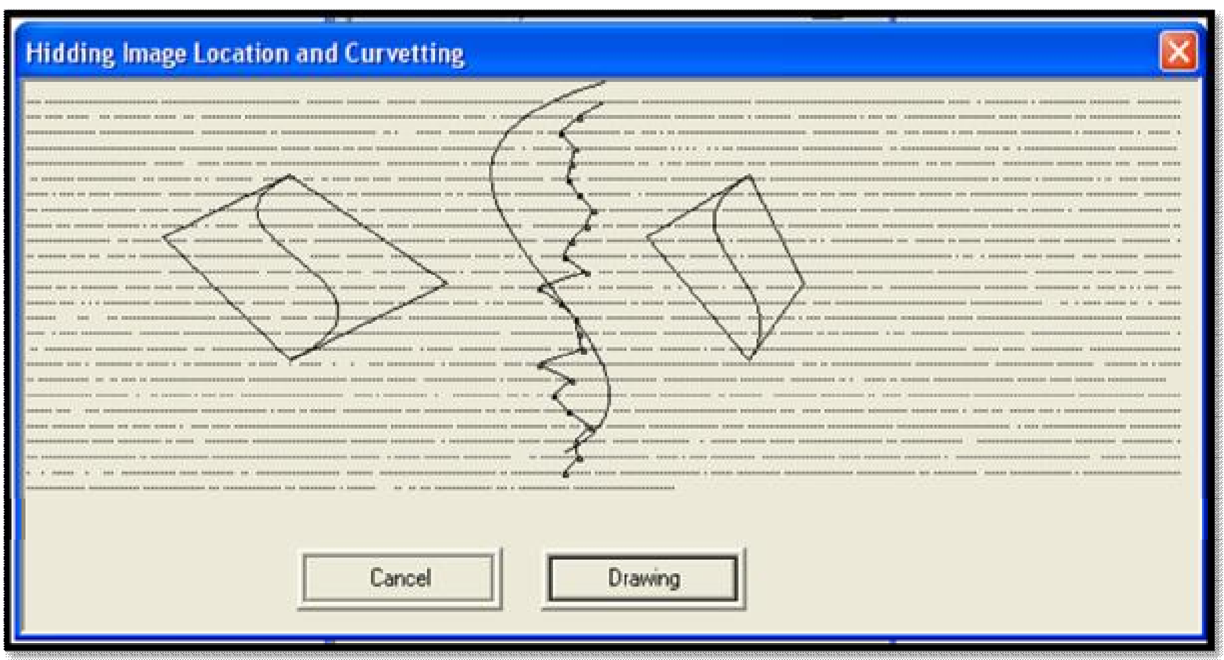

**a- MPEG-1 (Talksmall) video sample , size=760 KB, Duration=0.08**




**b- MPEG-1 (AllosaurusSmall) video sample , size=1.00MB, Duration=0.06**




c- MPEG-1 (Gonewithwind) video sample, size=6.74MB, Duration=0.40 sec




d- MPEG-1 (Lion) video sample , size=12.7MB, Duration=1.17 sec

**Figure (8) Distribution of watermark image in different sample**