

# Increasing the Capacity and PSNR in Blind Watermarking Resist Against Cropping Attacks

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**Abstract:** Watermarking has increased dramatically in recent years in the Internet and digital media. Watermarking is one of the powerful tools to protect copyright. Local image features have been widely used in watermarking techniques based on feature points. In various papers, the invariance feature has been used to obtain the robustness against attacks. The purpose of this research was based on local feature-based stability as the second-generation of watermarking due to invariance feature to achieve robustness against attacks. In the proposed algorithm, initially, the points were identified by the proposed function in the extraction and Harris and Surf algorithms. Then, an optimal selection process, formulated in the form of a Knapsack problem. That the Knapsack problem algorithm selects non-overlapping areas as they are more robust to embed watermark bits. The results are compared with each of the mentioned feature extraction algorithms and finally, we use the OPAP algorithm to increase the amount of PSNR. The evaluation of the results is based on most of the StirMark criterion.

**Keywords:** Watermarking, Feature Point, Histogram, Knapsack Problem, Geometric Attacks, OPAP Algorithm.

## 1 Introduction

TODAY, digital image watermarking is widely used to protect copyright and content authentication. Digital watermarking emerged as a tool for protecting the multimedia data from copyright infringement. The feature of digital watermarking is to allow for imperceptibly embedding watermark information in the original multimedia data [1]. One of the challenges in this field is the robustness of the presented algorithms against various attacks, especially geometric attacks [2]. The main requirements of a watermarking technique are robustness, capacity, imperceptibility and security [3].

In terms of watermarking, attack is defined by any processing that may harm uncovering of the hidden

secret information or communication of the information carried through watermark [4]. Most of the proposed methods are resistant to geometric attacks. Therefore, the purpose of this paper is to discuss resistance to geometric attacks. So far, most of the watermarking methods have been developed to improve sustainability [5]. Feature-based watermarking methods are introduced as the second generation of watermarking, which is categorized into three sub-categories: torque-based, histogram-based and feature point-based. The third sub-category (feature point-based) is used to form the local regions to store and extract watermarking. The features of an image are edges, corners, texture, and color. The features must have properties such as resistance to image transitions, rotation, and scale changes, as well as noise and local variations. They should also have invariance feature in such a way that the main information does not collide in attacks [6]. Boss *et al.* have applied Harris detector to extract feature points from an image [7]. Since the size of the pixels in an area of the feature will change when a watermark is inserted in the area, unoverlapped (non-shared) regions are prioritized for watermarking in order to avoid a sharp drop in the image quality [8]. A novel scheme Image watermarking based on invariant regions

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of scale-space representation, is proposed In [9].

The robust feature points, which can survive various signal processing and affine transformation, are extracted by using the Harris–Laplace detector. A local characteristic region construction method based on the scale-space representation of an image is considered for watermarking. At each region, the digital watermark is repeatedly embedded by modulating the magnitudes of discrete Fourier transform coefficients. In watermark extraction the digital watermark can be recovered by maximum membership criterion. And in [10], the corner response and the number of adjacent feature points are used remove overlapped feature regions.

However, the unoverlapped feature regions that have been selected for watermarking through these parameters cannot guarantee that the watermarking regions are well distributed in the whole image and the probability of a successful cropping attack rises because the selected regions do not always have the highest coverage. Has introduced a model based on the radial angle conversion, which is a region-based descriptor and resists to noise and rotation attack in [11]. One of the obvious features of this algorithm is its low computational cost obvious.

Local features show the image structure in many applications such as object identification, image retrieval, and calibration (grading) of the camera [12]. The feature area extracted by the detector cannot be used directly for digital watermarking for the following reasons:

1. The location and size of the extracted features are generally accessible to attackers.
2. The inclusion of watermarking in all regions also results in high image degradation and low strength because most features are overlapped [12].

Therefore, a high quality feature-based watermarking program should specify a set of nuoverlapped feature regions. Also, the repeatability of feature points represents the strength against geometric attacks. The location and size of the extracted features are generally accessible to attackers. The inclusion of watermarking in all regions also results in high image degradation and

low strength because most features are overlapped and they are not fixed. According to the mentioned reasons, we have a heuristic algorithm to select a set of the optimal nuoverlapped area for watermarking.

This set of area has the maximum distribution feature across the target image to resist cropping attack. In addition, the selection process is applied randomly to prevent the correct identification of the watermarked regions by the attackers. This is formulated as a multidimensional Knapsack problem and is solved through a method based on the genetic algorithm.

Table 1 shows a comparison between the available methods resistant to geometric attacks. As can be seen, the extraction from the histogram is blind and the reason for using it in the proposed scheme is the same issue. So we use this method to blind our scheme. Given the advantages of the histogram and the feature point methods in the proposed plan, we tried to present our proposed plan by integrating the two algorithms.

In the proposed method, we developed a new resilient method in feature-based image watermarking programs. An optimal selection process is also being formulated as a knapsack problem and solved using genetic algorithm-based discoveries. The experimental strength evaluation results show that our proposed method can effectively withstand various attacks, including geometric attacks. The results obtained are comparable to the reference [2], which is similar to our proposed scheme. This reference extracts only the corner points using the Harris algorithm without using non-overlapping points and places the watermark bits within these histogram regions of these regions.

However, our plan identifies the non-overlapping points completely intelligent by two extraction and Harris algorithms that first detect blob regions and corner points, which is determined by the knapsack algorithm and does not require user-defined settings. As was observed, with regard to the selection of non-overlapping points, better results were obtained in the crop (cutoff) attack than the reference, in which the proposed plan was better.

As far as paper [2] we were able to raise the watermarking capacity, the best results were obtained

**Table 1** Comparison of geometric attack resistant methods.

Method	Advantage	Disadvantage
Resist methods using fixed domain		
Frequency conversion method with constant range, such as DFT and etc.	Retrieval of the icons does not require the initial image and additional information	Complex computation of the retrieved cached image after the conversion has a low quality. Result values of relatively low resistance parameters
Histogram method	Simple retrieval of the original image does not require any particular data or parameter for extraction of the cached image	Relatively low resistance against processing attacks
The method of feature point resist to attacks		
Feature descriptor adoption method such as SIFT, extraction, and Laplacein Gaucin	Feature points are resist to rotation transfer and resize.	Watermarking Retrieval of a large volume of character descriptor data for adoption.

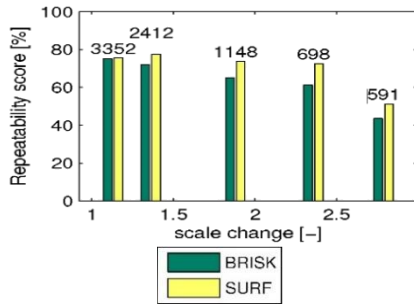


Fig. 1 SURF and BRISK repeatability diagrams [15].

by the Surf algorithm. With special regard to the extraction algorithm, it was anticipated that tests with this algorithm would have better outcomes against attacks, but the results outlined something else. Given the advantages of the histogram and the feature point methods in the proposed plan, we tried to present our proposed plan by integrating the two algorithms.

### 2 Sustainable Feature Extraction

SURF is a fast-moving feature points at rising speed of a detector and descriptor of rotation-resist feature and scale modification, which acts better than other extraction methods in the field of repeatability, distinctness, and resistance. Detectors and descriptors are obtained using the integral and convolutional images. In particular, the HASSIAN-based matrix is introduced for the detector and a distribution-based method (to achieve resistance and speed) is introduced for the descriptor [15].

Fig. 1 show the comparative values of repeatability for SURF and BRISK, in which SURF has shown the best performance in most. According to the reference charts, it is expected that the use of SURF-based feature points would have better resistance to attacks. As shown in Fig. 1, the SURF algorithm has a higher repeatability rate, meaning that this algorithm can detect more points after attack than the points detected before it.

Fig. 2 also compares the precision of the BRISK, SURF and SIFT algorithms after a 60-degree rotation attack on the test image. According to SURF documentation from the reference papers, the SURF algorithm is expected to provide better results to different attacks.

### 3 Genetic Algorithm and Expression of the Knapsack Problem

The Knapsack problem is used in combinatorial optimization. Suppose you have a set of objects, each of which has a certain weight and value. Assign a value to each object so that the weight of the selected objects is less than or equal to the predetermined value, and their value is maximized. The reason for naming this issue is tourist who has a backpack with a limited capacity and

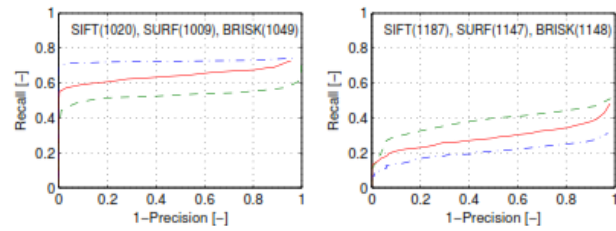


Fig. 2 Precision-recalling of SURF, SIFT, and BRISK [15].

must fill it with the most useful objects. This problem has been used extensively in optimization issues and might be the most useful one. One of the differences with other algorithms in this area, is the maximizing function and its bond. Therefore, this research is formulated as an optimally restricted problem through qualitative and overlapping conditions as follows:

1. Population initialization: The initial population is randomly plotted to maintain the diversity of chromosomes. Every person in the population should represent a practical solution without violations.
2. To better understand the topic, the following sentence was added: We generate the initial population of genetic algorithm. We define an X chromosome and a fitness value for each population member of the genetic algorithm.
3. Selection of Parents: this stage is the selection of people from the population to mate in order to produce new children.
4. Crossover and mutation: Generations are obtained after the selection of the parents of individuals through two crossover and mutation operators. Initially, a uniform crossover is applied to each parent in order to produce a child from the individual chromosome, which is determined by copying the corresponding bits in the parent two chromosomes. Each copied bit is selected with an equal probability from two-parent using a binary random number generator. If the random number is 1, then the bit is the first parent and otherwise the second parent is copied. Then the mutation operator is used for a short jump in the child's chromosome bits that changes them from 0 to 1 or vice versa. It should be noted that the generated child by crossover operators and mutation might not be feasible due to knapsack problem. Here a modifier is used to overcome this problem.
5. End: A duplicate process from step 2 to this step is performed to find the best solution [16].

### 4 The Proposed Algorithm

The purpose of this paper is to obtain non-overlapping circular regions suitable for watermarking. The selected circular regions should have the largest distribution of coverage on the image, so that the watermark on the

image is robust against the cropping attack. We turn the issue of selecting the appropriate circle regions into an optimization problem that has the following conditions:

1. The selected circular region should have the largest distribution of coverage on the image.
2. The selected circular region should not overlap.

The goal is to maximize the following:

$$\sum_{j=1}^{Nr} r_j s [j] \tag{1}$$

In which,  $Nr$  is the total extracted circular regions.  $s[j]$  is equal to 1 [15].

$$s_j = \begin{cases} 1, & \text{if the region } j \text{ is selected} \\ 0, & \text{otherwise} \end{cases} \tag{2}$$

If the  $j$ -th circular region is selected, it is equal to 1, otherwise, it is 0.  $R_j$  is the radius of the circle  $j$ .  $r_i$  is the weight vector of the Knapsack problem. Maximizing the above statement should be done with the following: This relation states that the two regions  $i$  and  $j$  ( $i \neq j$ ) should not overlap:

$$\sum_{j=1}^{Nr} p_{ij} s [i] s [j] < 0 \quad i = 1, 2, \dots, Nr \tag{3}$$

If the  $i$ -th and  $j$ th circular regions were overlapped and  $i \neq j$ ,  $p_{ij}$  is equal to 1, otherwise, it is 0.

In the proposed genetic algorithm, this problem is of a discrete value type and the chromosome type is binary. In addition, the vector of chromosomes and the cost function value were real values. The tournament method was used to select the parent members in the crossover operation, and the random operation was used in the mutation operation. The single point method is used to implement crossover operation and the binary mutation method is used to implement mutation operations.

### 5 Embedding Watermark

Embedding watermark putting bits we wish to be hidden in the image. In summary, the stage of watermark inclusion will be as follows:

1. Extracting feature points (HARRIS and SURF algorithms are applied separately to compare the evaluated parameters) and plotting circular regions.
2. The circle center of the point and circle radius are obtained from the relation  $r = \alpha \cdot \sigma$ . In which,  $\sigma$  is the feature scale and  $\alpha$  is a positive integer. A certain number of area should be selected among these circular regions using the genetic algorithm and the Knapsack problem so that the circular area was not overlapped and also have the maximum possible radius values.
3. Selecting non-overlapping regions to increase the resistance against attacks using the knapsack

problem, which is done by maximizing (4).

4. The cognitive weighing step to evaluate the capability of watermark inclusion to avoid excessive image destruction according to the noise visibility function (NVF).
5. Putting the watermark bit strings in the histogram of each local circle area (LCR).
6. In the final step, applying the OPAP algorithm to increase the PSNR rate.

These steps are performed separately for both HARRIS and SURF algorithms, so that we can compare the results and introduce the most robust and most efficient algorithm in different attacks.

### 5.1 Feature Region Selection

As stated, in addition to removing some overlapping regions, the selected feature regions should have the maximum distribution across the image so that they can resist the crop (cutting attacks) and use randomization for greater security. Therefore, the proposed method is formulated as an optimally restricted problem through qualitative and overlapping conditions as follows (In order to solve this combinatorial optimization problem, we transform it to a knapsack problem :

$$\text{maximize} \quad \sum_{j=1}^{N_R} \beta_j r_j s_j \tag{4}$$

$$\text{Subject to} \quad \sum_{j=1}^{N_R} q_j s_j \leq T_q \tag{5}$$

The variable  $q_j$  denotes the distortion of a watermarked region  $j$  compared with its original region, and  $T_q$  refers to the limitation of quality degradation of an image after being watermarked.

And

$$\text{maximize} \quad \sum_{j=1}^{N_R} \beta_i s_i s_j \leq 1, \quad i = 1, 2, \dots, N_R \tag{6}$$

In which,  $N_R$  is the extracted feature regions,  $r_j$  is the radius of the region  $j$ ,  $\{\beta_j\}$  is the key-dependent pseudo-numeric numbers with mean  $\mu$  and the variance  $\sigma_2$ , and  $s_j$  is defined as:

$$s_j = \begin{cases} 1, & \text{if the region } j \text{ is selected} \\ 0, & \text{otherwise} \end{cases} \tag{7}$$

Equation (2) means that only one region can be overlapped in each case. The  $p_{ij}$  value depends on the overlapping state of the two regions  $i$  and  $j$ .

In order to solve this compound optimization problem, we transform it into the Knapsack problem by expressing its constraint. Suitability assessment: Suitability is used to evaluate the likelihood of the best possible solution for a person. Each person in the current population has his\her own personal fitness to

show the degree of success as shown below:

$$\text{Fitness}(s) = \sum_{j=1}^{N_R} \beta_j r_j S [J] \tag{8}$$

In which,  $S[j]$  represents the  $j$ th bit in the chromosome of an individual. The fitness is in accordance with the objective function in (8), and the maximization of this fitness leads to the best solution to the selection of the feature region.

If two circle regions of  $i$  and  $j$  were selected and two circular regions were not the same, then there is an overlap.

The problem crossover is reduced by a finite amount of the maximization function. steps of fitness, crossover and mutation function as shown below.

### 5.2 Inserting the Watermark Bits in the Local Circle Region (LCR) Circular Histogram Chart

Using noise visibility function (NVF) to make a balance between imperceptibility and robustness leading to pre calculation in feature extraction feature region selection, and watermark insertion. With the noise visibility function, the watermarking strength is adjusted adaptively to preserve the perceptual quality of the image. The watermark can be detected with high accuracy after various possible distortions. According to the proposed algorithm, region normalizing is done in each selected circular feature region before placing the watermark bits to maintain the invariance of rotation and the degree of watermarking with a fixed length. Using this normalization, circular graded regions are rotated with a user-defined radius in a uniform direction based on the histogram gradient within the region [15].

Before watermarking inside any normalized region, the cognitive weighing process is performed to evaluate the ability to insert watermarking to avoid the high image destruction according to the noise observation function (NVF) [15]:

$$\text{NVF}(x) = \frac{1}{1 + \left(\frac{z}{\text{Var}_{\max}}\right) \text{Var}(x)} \tag{9}$$

In which,  $\text{Var}(x)$  shows the local variance in a window to the center of the pixel in the  $x$  coordinates; the  $\text{var}_{\max}$  is the maximum local variance in the normalized region, and  $z$  is the experimentally selected experiment to cover different images in the range of 50 to 100. Then, the watermarking bits must be embedded in the histogram of each local circle region (LCR).

### 5.3 The Method of Inserting the String of Watermarking Bits in the Local Circle Region (LCR) Histogram

Assume BIN1 and BIN2 are two consecutive stems in

the LCR (local circle region) histogram and the number of pixels in the BIN1 stem is equal to  $a$  and in BIN2 stem is equal to  $b$ . The law of inserting watermarking bits is as follows.

$$\begin{cases} \frac{a}{b} \geq T, & \text{if } w(i) = 1 \\ \frac{b}{a} \geq T, & \text{if } w(i) = 0 \end{cases} \tag{10}$$

In the above equation,  $T$  is a threshold value to control the number of pixels to be corrected.  $T$  is directly related to the imprinting of the image watermarking. According to the first equation, if the watermarking bit is  $w(i) = 1$  and  $a/b \geq T$  no operation is performed (in other words, the relation exists and does not need to change), but if  $w(i) = 1$  and  $a/b < T$ , we transfer the number of  $I_1 = (Tb - a)/(1 + T)$  pixels from the BIN2 stem to the BIN1 stem to establish the relation  $b_1/a_1 > T$ . According to the second equation, if the watermarking bit was  $w(i) = 0$  and  $b/a \geq T$  no operation is performed, but if  $w(i) = 0$  and  $b/a < T$ , we transfer the number of  $I_0 = (Ta - b)/(1 + T)$  from the BIN1 stem to the BIN2 stem to establish the relation  $a_1/b_1 \geq T$ .

Fig. 3 shows the Lena test image before and after applying the proposed algorithm. Also, the difference between the two images is also shown. As you can see, there is little difference between these two images, which shows that our plan has an acceptable visual clarity.

### 5.4 OPAP Algorithm

The optimal Pixel Adjustment Process (OPAP) is a spatial method that leads to relatively good results in increasing the PSNR of a stegoImage. The purpose of this algorithm is to reduce the error between coverImage and the stegoImage. This method examines the bit after the last watermarked bit per pixel. The proposed algorithm determines the best possible value for this bit to find the nearest number to the original pixel. The proposed algorithm is as follows:

Suppose  $P_i$ ,  $P_i'$ , and  $P_i''$  are respectively the  $i$ th pixels of the coverImage, stegoImage, and the image obtained from the OPAP algorithm (outputImage), respectively.



Fig. 3 Applying the proposed algorithm to the Lena's image; a) Lena's image before putting the watermark, b) Lena's image after putting the watermark, and c) Difference between the watermarked image and the original image.

$$P_i = \text{coverImage} \tag{11}$$

$$P_i' = \text{stegoImage} \tag{12}$$

$$P_i'' = \text{outputImage after OPAP} \tag{13}$$

The error caused by watermarking is shown with  $\delta_i$ :

$$\delta_i = P_i' - P_i \tag{14}$$

With direct substitution of the  $k$  bit of the message in  $k$ , we will have the least valuable bit of each pixel of the image:

$$-2^k < \delta_i < 2^k \tag{15}$$

$\delta_i$  value can be divided into three intervals:

$$\text{Interval 1: } 2^{k-1} \leq \delta_i \leq 2^k \tag{16}$$

$$\text{Interval 2: } -2^{k-1} \leq \delta_i < 2^{k-1} \tag{17}$$

$$\text{Interval 3: } -2^k < \delta_i < -2^{k-1} \tag{18}$$

According to these three intervals,  $P_i'$  values are converted to  $P_i''$  through OPAP method as to the following algorithm:

$$\text{Case 1 } (2^{k-1} \leq \delta_i \leq 2^k): \begin{cases} P_i'' = P_i' - 2^k, & \text{if } P_i' > 2^k \\ P_i'' = P_i', & \text{otherwise} \end{cases} \tag{19}$$

$$\text{Case 2 } (-2^{k-1} \leq \delta_i \leq 2^{k-1}): P_i'' = P_i' \tag{20}$$

$$\text{Case 3 } (-2^k < \delta_i < -2^{k-1}): \begin{cases} P_i'' = P_i' - 2^k, & \text{if } P_i' < 256 - 2^k \\ P_i'' = P_i' + 2^k, & \text{otherwise} \end{cases} \tag{21}$$

## 6 Watermark Extraction

Image extraction, extracting the bits embedded in the image. And since the watermark extraction is an essential watermark property, our proposed algorithm can be summarized as follows:

1. First we extract the feature points and circular regions.
2. For each feature point  $(x, y)$  we extract a local LCR (local circle region) region from the image. The center of the circle of point  $(x, y)$  and radius of the circle is obtained from the relation  $r = \alpha \cdot \sigma_n$ . In this respect,  $\sigma_n$  is the scale of the feature and  $\alpha$  is a positive integer.
3. Selecting non-overlapping regions by the backpack problem with the following condition.
4. Extracting watermark bits from the histogram.

Similarly, when placing watermark bits, feature regions are detected through the feature detector used in the watermark insertion process. We initially extract hidden information from the normalized region and obtain the image feature point. Using the genetic algorithm and the Knapsack problem, from among these circular regions, we must select a certain number of

regions so that the circular regions do not overlap and also have the maximum possible radius values.

We extract the watermarking bits from each of the LCR circular regions. If the extracted watermarking bits were equal to at least one circular region of the LCR with the same basic bitmaps or the same Wbits, the watermarking operation is performed correctly. Otherwise, if the watermark bits extracted from any of the LCR regions are not equal to the original watermark bits, we conclude that the image has not been watermarked.

Using extraction algorithms with broader coverage, we can extract more regions, thereby increasing watermarking capacity. Also, if the circle with the center  $(x_{c1}, y_{c1})$  and radius  $r_1$  and the circle with center  $(x_{c2}, y_{c2})$  and radius  $r_2$  are overlap, the following condition is held:

$$\sqrt{(x_{c1} - x_{c2})^2 + (y_{c1} - y_{c2})^2} < (r_1 + r_2) \tag{22}$$

If two circular area  $i$  and  $j$  are selected, that is,  $x(i) = 1$  and  $x(j) = 1$ , and also two circular regions are not equal  $j \neq i$  then they are overlapped, and one unit is added to sumt variable, which is the same implementation function for fitness:

To solve the Knapsack Problem, we reduce the problem's constraint to a finite amount from the maximization function.

### 6.1 The Method of Extracting the String of Watermarking Bits of the Local Circle Region (LCR) Histogram

Similarly, when placing watermark bits, feature Regions are detected through the feature detector used in the watermark insertion process. We divide the histogram into groups of two neighboring stems. Assuming that BIN1 and BIN2 are two consecutive stems in the histogram, a number of stem pins of BIN1 and  $b$  is the number of pins of the BIN2 stem.

Using the following equation, you can extract the watermark bits. By repeating this relationship for all successive neighboring stems on the histogram, we can get all of the watermark bits:

$$w(i) = \begin{cases} 1, & \text{if } \frac{a}{b} \geq 1 \\ 0, & \text{otherwise} \end{cases} \tag{23}$$

Thus, if  $a/b \geq T$ , then the value of the watermark bit is 1 and otherwise, if  $a/b < T$ , the bit value of the watermark is 0.

## 7 Peak-Signal-to-Noise Ratio (PSNR)

PSNR is used to measure watermarked mage quality, and it is desirable if the PSNR value is high. Generally, a value of 28 for a PSNR is a desirable number. The

related equation is as follows:

$$PSNR = 10 \log_{10} \left( \frac{MAX_I^2}{MSE} \right) \quad (24)$$

### 8 Results of Examinations and Review of Results

The present experimental research is a GA-based search with coding in MATLAB, which is tested on a personal computer with an Intel Core i3 1.90GHz processor and the runtime used to search for an optimal solution-close to about 105 seconds for all trial images in all experiments.

Experiments are performed on four well-known images of 512x512 from Aiplane, Baboon, Lena and Pepper. These images are converted to gray-level images for testing. Figs. 6 and 7 show these images (Scale and rotation means changing image size and rotation of the image in different degrees).

To review and evaluate the effectiveness of the proposed selection process, we initially assessed the proportion of replication capability between selected feature Regions in the overall image and attacked version for the tested images. In this assessment, we conducted attacks according to most of the StirMark criteria [17]. The applied attacks to the tested images were as follows:

1. Print-Scan attack;
2. Cropping attack that involves centralized cropping, ROI;
3. Cropping, and random cropping attack.

It should be noted that for a print-scan attack, images were printed with the Canon i-SENSYS LBP3010B printer and a resolution of 300 dpi. The printed images were scanned by the scanner Hp Scanjet G2710 and then cropped and changed to their original size using the Adobe Photoshop software.

Focused cropping attack(cutting the image) crops the area around the image and eliminates undesirable ROI cropping attacks. The random cropping attack saves a random-sized Region in the target image and eliminates the remainder of that image.

In Tables 4 and 5, a comparison is made between the PSNR values for the images tested by the proposed algorithm. The Extraction algorithm for each of the three tested images shows better results in our design.

Fig. 4 shows the images used in our test and The applied watermarking images are shown in Fig. 5. The

examined cover images for watermarking are two types of binary image and bit string. The watermarking images are used with 128x128, 64x64, and 16-bit bit string. Some of the images used in our tests are not used in other references. We have tried to use more images to further evaluate the proposed algorithm in future. In [2] feature extraction is used by the Harris algorithm and watermark bits are placed on the histogram of these regions. In our proposal, Harris feature extraction algorithm is used.

In addition, extraction algorithm is also used for increasing the watermark capacity and comparing the most robust algorithm in the proposed plan, and the most robust regions for putting the watermark bits by the Knapsack problem.To distinguish the feature regions, Harris and extraction operators have been used for comparison in our metode the results are compared with the two reference. From the results of the test cases in Tables 2 and 3, it can be deduced that the proposed algorithm obtains relatively better results using Harris feature points.

Therefore, the regions selected by this algorithm are more stable and more durable, and can withstand most of these attacks. And in [18] proposes a robust image watermarking scheme using visually significant feature points and image normalization,and the authors adopt a feature extraction method based on end-stopped wavelets to extract significant geometry preserving feature points.

As the results of the tables show, the proposed algorithm in ROI and Scaliing attacks is better. addition, the larger regions of the LCR are selected by SURF algorithm than the other one algorithms.

The ratio of watermarked points, which was successfully identified in Airplane, Baboon, Lena and Peppers’s image to the total number of watermarked points by the HARRIS and SURF against attacks shows in Tables 2 and 3.

It is also observed that this ratio is smaller than the extraction in the Harris algorithm. This shows that our algorithm has better results by the Harris algorithms. In The initial objective was to provide a plan based on the selection of watermark resist feature Regions in which the best regions were selected to put the watermark bits on the histogram of these regions.In fact, the results obtained show the performance of the proposed algorithm using two methods of detecting the feature points, relative to articles such as reference [2]. This

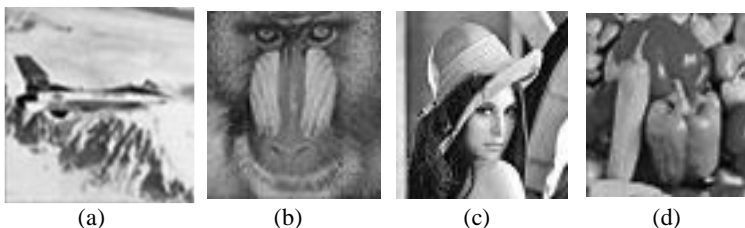


Fig. 4 Host images; a) Baboon, b) Pepper, c) Lena, and d) Airplane.

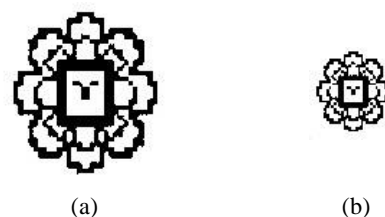


Fig. 5 Watermarking images; a) 128x128 and b) 64x64.

**Table 2** Comparison of two proposed algorithms for various attacks in the airplane and baboon.

Attack	Airplane				Baboon			
	Proposed method with SURF	Proposed method with HARRIS	[2]	[18]	Proposed method with SURF	Proposed methodwith HARRIS	[2]	[18]
crop10	21/36	15/30	5/14	-	25/41	11/36	10/17	-
crop25	20/36	12/30	-	-	27/41	9/36	-	-
crop50	10/36	8/30	-	-	20/41	6/36	-	-
GaussianFilter	20/36	13/30	6/14	-	22/41	12/36	8/17	-
Median3x3	18/36	8/30	10/14	-	19/41	5/36	11/17	-
Median5x5	7/36	5/30	-	-	20/41	3/36	-	-
Print-Scan	9/36	7/30	-	-	23/41	4/36	-	-
RandomBending	12/36	4/30	-	-	16/41	6/36	-	-
ROIcropping	7/36	4/30	-	-	13/41	6/36	-	-
Rotation5	12/36	4/30	6/14	-	20/41	10/36	8/17	-
Rotation15	14/36	10/30	-	-	20/41	10/36	-	-
Rotation30	9/36	5/30	4/14	-	24/41	3/36	14/17	-
Rotation45	7/36	4/30	-	-	24/41	3/36	-	-
Scaling.7	4/36	3/30	5/14	-	15/41	3/36	2/17	-
Scaling.9	18/36	4/30	5/14	-	14/41	2/36	2/17	-
Scaling1.1	11/36	6/30	-	-	23/41	3/36	-	-
Scaling1.5	12/36	2/30	8/14	-	22/41	3/36	11/17	-
SharpeningFilter	11/36	8/30	6/14	-	22/41	9/36	-	-
JPEG 30	15/36	11/30	12/17	-	22/41	9/36	14/17	-
JPEG50	17/36	13/30	-	-	22/41	10/36	-	-

**Table 3** Comparison of two proposed algorithms for various attacks on the lena and peppers.

Attack	Lena				Peppers			
	Proposed with SURF	Proposed method with HARRIS	[2]	[18]	Proposed with SURF	Proposed method with HARRIS	[2]	[18]
crop10	17/36	13/28	7/13	8/9	22/40	18/34	7/18	9/10
crop25	18/36	11/28	-	-	22/40	15/34	-	-
crop50	15/36	8/28	-	-	11/40	10/34	-	-
GaussianFilter	17/36	12/28	5/13	5/9	22/40	14/34	11/18	9/10
Median3x3	11/36	7/28	7/13	-	19/40	10/34	16/18	9/10
Median5x5	10/36	5/28	-	-	8/40	7/34	-	-
Print-Scan	8/36	7/28	-	-	10/40	2/34	-	-
RandomBending	11/36	3/28	-	-	8/40	5/34	-	-
ROIcropping	9/36	6/28	-	-	13/40	9/34	-	-
Rotation5	11/36	1/28	8/13	8/9	14/40	5/34	10/18	-
Rotation15	7/36	4/28	-	-	16/40	12/34	-	-
Rotation30	5/36	3/28	5/13	8/9	10/40	6/34	7/18	-
Rotation45	5/36	1/28	-	-	8/40	4/34	-	-
Scaling.7	3/36	1/28	7/13	-	5/40	3/34	6/18	-
Scaling.9	6/36	1/28	7/13	-	9/40	5/34	6/18	-
Scaling1.1	8/36	2/28	-	-	12/40	8/34	-	-
Scaling1.5	10/36	2/28	10/13	-	13/40	3/34	13/18	-
SharpeningFilter	7/36	6/28	-	-	12/40	10/34	-	-
JPEG 30	12/36	10/28	10/13	-	16/40	13/34	15/18	-
JPEG50	17/36	12/28	10/13	1	18/40	14/34	16/18	-

reference places the watermark bits on the histogram of the images evaluated using the HARRIS feature points.

In [2], only the corner spots are extracted by HARRIS algorithm, without using non-overlapping spots, and watermark bits are positioned within histogram area. This scheme intelligently identifies the non-overlapping spots by extraction and Harris algorithms, which detect both blob and corner regions. The most stable spots are extracted by the most robust property spots selection algorithms. The most resistant regions against attacks

are also determined using knapsack algorithm, without requiring user-defined settings. Given selecting non-overlapping spots, better results were obtained in the cut off attack than the similar article referenced in this paper.

Our plan, which has the same functionality as the proposed algorithm of this reference, has the advantage of optimizing the selection of the best area of the feature area to place the watermark bits. These regions are selected by the knapsack problem. We also evaluate



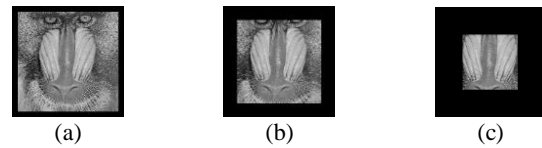
Harris and extraction for choosing the algorithms for selecting the region to select the best algorithm in similar designs. The selection of attacks is based on most of the StirMark criteria. It should be noted that this criterion has been evaluated in many papers, and in our tests all of these criteria were applied to the test images. However, few of these attacks were mentioned due to the lack of references to the proposed proposal, which uses feature points and histograms that examines all of these criteria. The purpose of this research at the first stage was to provide a plan based on the selection of regions of resilient property for marking, or watermarking that the best regions for placing watermark bits are selected by the knapsack problem and placed on the histogram of these regions. In these four comparisons on test images, it can be concluded that the algorithms, such as our proposed plan based on feature points, perform better in sustainability are due to the selection of lower SURF feature points and relatively large LCR regions selected by algorithms such as HARRIS. Figs. 6-15 show different attacks on one of the test images. Table 4 show PSNR values in the proposed method with the use of the OPAP algorithm. It is observed that the amount PSNR increases with the application of the OPAP algorithm.

**9 Conclusion**

In the proposed method, we developed a new resilient method in feature-based image watermarking programs. An optimal selection process is also being formulated as a Knapsack problem and solved using genetic algorithm-based discoveries. The experimental strength evaluation results show that our proposed method can effectively withstand various attacks, including geometric attacks. The results obtained are comparable to [2], which is similar to our proposed scheme.

This reference extracts only the corner points using the Harris algorithm without using non-overlapping points and places the watermark bits within these histogram regions of these regions. However, our plan identifies the non-overlapping points completely intelligent by two extraction and Harris algorithms that first detect Blob regions and corner points, which is determined by the Knapsack algorithm and does not require user-defined settings. As was observed, with regard to the selection of non-overlapping points, better results were obtained in the crop attack than the reference, in which the proposed plan was better. As far as paper [2], we were able to raise the watermarking capacity, the best results were obtained by the SURF algorithm. With special regard to the SURF algorithm, it was anticipated that tests with this algorithm would have better outcomes against attacks, but the results outlined something else. A number of researchers have introduces different methods in this regard. In this study, we have developed a new robust method in image watermarking programs based on property spots. An

optimum selection procedure is also presented, which is solved as a formulated knapsack problem, using discoveries based on genetic algorithm. The experimental results of strength evaluation show that our suggested method can efficiently resist against different attacks, namely geometric fluctuations. However, a challenge in the field of methods based on property spots is which algorithm gives the best results in our desired method. In this paper, we have made our effort to be a guide for those researchers who want to use property spots in their desired scheme, which is not done so far in the literature. We compare two common methods in this field.



**Fig. 6** Cropping attacks on the image; a) 10%, b) 25%, and c) 50%.



**Fig. 7** Applying Gaussian filter.

**Fig. 8** Applying median filter; a) median 3x3 and b) median 5x5.

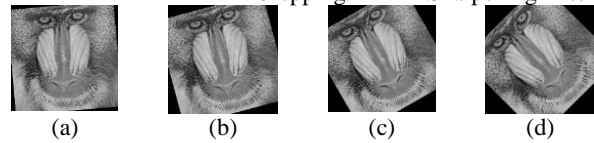


**Fig. 9** Print-scan.

**Fig. 10** ROI Cropping.



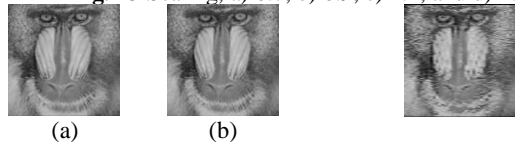
**Fig. 11** Sharpening Filter.



**Fig. 12** a) Rotation 5, b) Rotation 15, c) Rotation 30, and d) Rotation 45.



**Fig. 13** Scaling, a) 0.7, b) 0.9, c) 1.1, and d) 1.5.



**Fig. 14** Jpeg compression; a) 50 JPEG and b) 30 JPEG.

**Fig. 15** a) Random bending.

**Table 4** Peak of signal to noise rate (PSNR).

Image name	PSNR with feature point Harris algorithm [db].	PSNR with feature point algorithm [db].
Airplane	46.31	50.89
Baboon	47	52.56
Lena	48.31	55.56
Pepper	49	53.21

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