Selection of Feature Regions set for Digital Image using Optimization Algorithm

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Abstract - Image transformation techniques are used for extraction of local features which are used in many applications such as object recognition, database retrieval, and motion tracking. The effectiveness of a digital image is identified by the robustness of image candidate regions. This paper aims to obtain most robust and minimal region set which preserves image quality. It first performs a simulated attacking procedure on non overlapped region set to evaluate the robustness of every candidate feature region. According to the evaluation results, it adopts a track-with-pruning procedure to search a minimal primary feature set which can resist the most predefined attacks. In order to enhance its resistance to undefined attacks under the constraint of preserving image quality, the primary feature set is then extended by adding into some auxiliary feature regions. This work is formulated as a multidimensional knapsack problem and would be solved by Optimization Algorithms such as Genetic Algorithm as well as Particle Swarm Optimization and Simulated Annealing based approach. The experimental result uses some benchmark images. Comparing results of different optimization techniques on primary feature region set, the proposed method determines the best choice of optimization techniques for selecting most robust and minimal region set under the constraint of preserving image quality.

Keywords: Corner response, Feature, optimization, robust, simulated attack

1. Introduction

With the development of internet, manipulation of data becomes easier. Application uses digital data includes electronic advertising, real-time video and audio delivery, digital repositories and libraries, and Web publishing etc. This ease of access to digital data brings with itself the problem of copyright protection. It has been recognized that current copyright laws are not enough for dealing with digital data. This has led to an interest towards developing new copy prevention and protection mechanisms. Thus, one effort that has been attracting increasing interest is based on robust regions set using such robust regions one could keep their information secure.

Thus, this process of gaining robust regions set includes two important things. First one is avoiding repeated selection of robust regions to resist similar attacks since the magnitude of pixels in a region will be modified, thus it could be better to select nonoverlapping regions to avoid a major degradation of image quality. For selection of non-overlapping regions here corner as a feature has been used [6]. And the second is selecting the most robust and smallest feature regions set. Neither corner response nor the number of its neighboring feature points nevertheless can guarantee the selection of nonoverlapping regions with the maximum robustness to various attacks; It likely helpful to find out the most robust regions if there is prior knowledge of each region’s attack resistance capability. Accordingly, it processes with the plan of a feature region selection method based on the idea of simulated attacking and optimization techniques. The experimental result uses some benchmark images [11].

2. Existing systems

In existing method two issues are identified based on feature-based schemes: 1. Avoiding repeated selection of robust regions for watermarking to resist similar attacks, and 2. the difficulty of selecting the most robust and smallest feature region set to be watermarked. For the first issue, since the magnitude of pixels in a region will be modified when a watermark is inserted into this region, it is preferred to select nonoverlapping regions for watermarking to avoid a major degradation of image quality. Neither corner response nor the number of its neighbouring feature points, however, can guarantee the selection of nonoverlapping regions with the maximum robustness to various attacks, because higher corner response and a large number of its neighbouring feature points do not always imply higher robustness of itself. Moreover, a feature region may have different degrees of robustness against different attacks [6]-[7]. These phenomena result in the second issue. It would be helpful to find out the most robust regions if there is prior knowledge of each region’s attack resistance capability.
Because this set may fail to resist some non predefined attacks, we need to add some auxiliary regions selected from those residual feature regions to enhance the robustness of watermarked image against undefined attacks under preserving its visual quality. Since the characteristics of undefined attacks are of wide variety and are difficult to model, we therefore adopt a multi-criteria optimization strategy [15], [16] for the selection of auxiliary feature regions.

3. Literature Survey

The effectiveness of a digital image is indicated by the robustness of regions against various attacks. Attacks which attempt to destroy or invalidate watermarks can be classified into two types, noise-like signal processing and geometric distortions. The methods to resist geometric distortions can be classified into the transform-based, pilot-based and feature-based schemes. Here in existing method two issues are identified based on feature-based schemes: 1. Avoiding repeated selection of robust regions to resist similar attacks, and 2. the difficulty of selecting the most robust and smallest feature region set to be watermarked.

For the first issue, since the magnitude of pixels in a region will be modified when a watermark is inserted into this region, it is preferred to select nonoverlapping regions for digital image to avoid a major degradation of image quality. Neither corner response nor the number of its neighboring feature points, however, can guarantee the selection of nonoverlapping regions with the maximum robustness to various attacks, because higher corner response and a large number of its neighboring feature points do not always imply higher robustness of itself. Moreover, a feature region may have different degrees of robustness against different attacks [4], [8]. These phenomena result in the second issue. It would be helpful to find out the most robust regions if there is prior knowledge of each region’s attack resistance capability. Because this set may fail to resist some non predefined attacks, we need to add some auxiliary regions selected from those residual feature regions to enhance the robustness of digital image against undefined attacks under preserving its visual quality. Since the characteristics of undefined attacks are of wide variety and are difficult to model, we therefore adopt a multi-criteria optimization strategy for the selection of auxiliary feature regions.

3.1. Feature Based Digital Image

Most features of an image can be preserved after it suffers a distortion such as scaling, rotation, or illumination changes. Therefore, several feature-based methods have been developed by exploiting the robustness of feature regions against various attacks.

After feature region detection, selecting an optimal set of nonoverlapping regions for digital image is necessary. Normally, feature selection according to a single criterion like corner response or the number of neighboring feature points inside a region cannot guarantee maximum robustness against various attacks. Here, we use the three overlapping cases, A, B, and C in Fig. 1, obtained by the Harris–Laplacian detector to illustrate this phenomenon.

The resistances of each region after being attacked are shown in Table 1 [1]. Every region’s corner response is also shown in that table. In case B, region B3 has the highest corner response and better robustness, so the corner response seems to be a good criterion of feature region selection. Unfortunately, this observation is not satisfied in case A, because region A1 is the most robust one among the overlapping regions but its corner response is the smallest. This is not an unusual case in an image. Furthermore, in case C, both regions C2 and C3 have good robustness but can resist different kinds of attacks. The C2 region is able to resist most attacks except the filter based distortion. In contrast, only JPEG based attacks cannot be resisted by C3. The selection would be easier if both A and C region series are involved since by this way all the predefined attacks can be resisted when A1 and C3 are selected. On the other hand, the set, A1 and C2, is not a good choice because they are not complementary in resisting various predefined attacks and thus cannot resist Gaussian Filter and Median 3X3 attacks. As a result, a region set would be better in robustness when its regions can be complementary in attack resistance as many as possible. Accordingly, we can conclude that it is hard to accurately identify the robustness of all regions by a single criterion like the corner response. In practice, the aggregate attack resistance capability of all selected nonoverlapping regions is more convincing, and it could be regarded as the overall robustness of a digital image.
Table 1: Feature Survival after attacks on selected regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Feature/Corner Response</th>
<th>JPEG 50</th>
<th>JPEG 60</th>
<th>Rotation 15 Stamps</th>
<th>Rotation 30 Stamps</th>
<th>Median 3x3 Filter</th>
<th>Gaussian Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region A</td>
<td>2113</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>Region B</td>
<td>78346</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>Region C</td>
<td>389067</td>
<td>X X X</td>
<td>X X X</td>
<td>X X X</td>
<td>X X X</td>
<td>X X X</td>
<td>X X X</td>
</tr>
<tr>
<td>Region D</td>
<td>49722</td>
<td>0 X 0</td>
<td>0 X 0</td>
<td>0 X 0</td>
<td>0 X 0</td>
<td>0 X 0</td>
<td>0 X 0</td>
</tr>
<tr>
<td>Region E</td>
<td>225338</td>
<td>0 x 0</td>
<td>0 x 0</td>
<td>0 x 0</td>
<td>0 x 0</td>
<td>0 x 0</td>
<td>0 x 0</td>
</tr>
<tr>
<td>Region F</td>
<td>320690</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>Region G</td>
<td>19942</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>Region H</td>
<td>357984</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>Region I</td>
<td>423883</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
<td>0 0 0</td>
</tr>
</tbody>
</table>

Feature detectors perform specific transformations on digital images to extract their local features, ranging from a point to an object, and have been adopted in many applications such as object recognition, database retrieval, and motion tracking. As per the observations of previous studies, feature detectors are robust to attacks if they can be re-detected in the attacked image. The re-detected region is examined for the consistency (bit error) between itself and the original feature region. Using $d_{r,a}$ to indicate whether the region can resist the predefined attack or not, it is defined as:

$$d_{r,a} = \begin{cases} 1, & \text{BER}(W, W_r) \leq T \\ 0, & \text{otherwise} \end{cases}$$

Where BER $(I, I_a)$ denotes the bit error between original image $I$ and image $I_a$ after different attacks on it. $T$ is a predefined bit error threshold.

In the final phase, the most robust and smallest set of nonoverlapping feature regions is selected according to the result of attack resistance analysis. This work is formulated as follows:

$$R^*_p = \arg \max_{R_p} \left\{ \sum_{i=1}^{N_a} \delta_{r_i}^{r_p} \min \tilde{r}_p; \right\}$$

$$\forall r_i, r_j \in R_p, \ k \neq j \rightarrow r_i \cap r_j = \emptyset$$

Where $R_p$ is the set of selected feature regions in which any two regions $r_i$ and $r_j$ are not overlapped, and the value of $\delta_{r_i}^{r_p}$ is determined by otherwise:

$$\delta_{r_i}^{r_p} = \begin{cases} 1, & 3r \in R_p, dr, ai = 0 \\ 0, & \text{otherwise} \end{cases}$$

$R^*_p$ is the $R_p$ satisfying with the maximum value of $\sum_{i=1}^{N_a} \delta_{r_i}^{r_p}$. A track-with-pruning algorithm is proposed to carry out the work of this phase are defined in appendix B.

C. Extended stage after simulated attacking

By the previous stage, an optimal feature region set is chosen to resist the predefined attacks. Because this set may fail to resist some non predefined attacks, we need to add some auxiliary regions selected from those residual feature regions to enhance the robustness of image against undefined attacks under preserving its visual quality. Since the characteristics of undefined attacks are of wide variety and are difficult to model, we therefore adopt a multi-criteria optimization strategy for the selection of auxiliary feature regions. First, the assumption that the feature regions which survive more types of predefined attacks are more likely to resist undefined attacks is applied. The symbol $g_{r,a}$ is defined to indicate the overall resistance degree of the region against all predefined attacks, and it is determined by:

$$g_{r,a} = (d_{r_1,a_1} + d_{r_1,a_2} + \ldots \ldots + d_{r_N,a_N}) = \sum_{i=1}^{N_a} d_{r_i,a_i} + 1$$

Where $d_{r,a} \in \{0,1\}$ indicates if the region can resist the $i$th predefined attack and $N_a$ is the total number of predefined attacks. The resistance of a region against a predefined attack is regarded as a possible characteristic of the region. The symbol $g_{r,a}$ is the summary representation of $N_a$ characteristics of a region. We also refer to two generic characteristics of feature regions, the corner response and the integration scale, since we cannot exclude the possibility that there are undefined attacks with the characteristics never occurred in the predefined attacks.

The parameter which denotes the limitation of quality degradation of an image after attacks considered as peak signal-to-noise ratio (PSNR) value between a cover image and after attacks on cover image. The optimization problem formulated as MDKP that is a knapsack problem with a collection of different constraints or one multidimensional constraint.

A GA-based heuristic search procedure is adopted to solve this MDKP for determining the best choice of auxiliary feature regions.

The existing method consumes too much computation time in measuring the robustness of feature regions due to the simulated attacking. And similarly to get most as well as smallest region set existing method has been used genetic algorithm which requires some computations.

4. System Architecture

The following figure “Fig 2” shows us system architecture. These works have been split in two
operational stages as Primary feature set searching stage and feature set extension stage respectively.

![Block diagram for regions set selection Method](image)

4.1. Primary feature set searching stage

This process obtains the robust regions after applying simulated attacking on digital image. This includes

- **Digital Image**: To find out robust region the input for the system is a digital Image. This image is applied to detect corner feature by which regions could obtained.

- **Corner Detector**: To obtained regions of an image, corner feature will be useful. Thus by using corner detectors such as Harris-Laplacian and Harris – Affine, corner are detected. This is shown in fig 1.

- **Non Overlapping Region Set**: Main issue is avoiding repeated selection of robust regions to resist similar attacks, since the magnitude of pixels in a region will be modified when attacks occurs on region, it is preferred to select nonoverlapping regions for digital image to avoid a major degradation of image quality.

- **Perform Simulated attacking**

The difficulty is selecting the most robust and smallest feature region set for digital image. Neither corner response nor the number of its neighboring feature points, however, can guarantee the selection of nonoverlapping regions with the maximum robustness to various attacks, because higher corner response and a large number of its neighboring feature points do not always imply higher robustness of itself. Moreover, a feature region may have different degrees of robustness against different attacks. It would be helpful to find out the most robust regions if there is prior knowledge of each region’s attack resistance capability.

Because this set may fail to resist some non predefined attacks, we need to add some auxiliary regions selected from those residual feature regions to enhance the robustness of image against undefined attacks under preserving its visual quality. Since the characteristics of undefined attacks are of wide variety and are difficult to model, we therefore adopt a multi-criteria optimization strategy for the selection of auxiliary feature regions.

4.2. Feature Set Extension Stage

By the previous stage, an optimal feature region set is chosen for digital image to resist the predefined attacks. Because this set may fail to resist some non predefined attacks, we need to add some auxiliary regions selected from those residual feature regions to enhance the robustness of digital image against undefined attacks under preserving its visual quality. Since the characteristics of undefined attacks are of wide variety and are difficult to model, we therefore adopt a multi-criteria optimization strategy for the selection of auxiliary feature regions. A GA-based, Particle Swarm Optimization and Simulated Annealing search procedure is adopted to solve this MDKP for determining the best choice of optimization techniques for selecting most robust and minimal region set under the constraint of preserving image quality.

- **i) GA (Genetic Algorithm)**

Genetic algorithms are based on the concepts from population genetics and evolution theory [13], [14]. The algorithm is constructed to optimize fitness of a population of elements through crossover (recombination) and mutation (perturbation) operations on their genes. Selection replicates the most successful solutions found in a population at a rate proportional to their relative quality. Recombination decomposes two distinct solutions and then randomly mixes their parts to form novel solutions. Mutation randomly perturbs a candidate solution.

- **ii) Particle Swarm Optimization (PSO)**

It is motivated by social behavior of organisms such as bird flocking and fish schooling. In the PSO algorithm, the potential solutions called particles are flown in the problem hyperspace. Change of position of a particle is called velocity. The particle changes their position with time. During flight, particle’s velocity is stochastically accelerated toward its previous best position and toward a neighborhood best solution. POS has been successfully applied to solve various optimization problems, artificial neural network training, fuzzy system control, and others [12].

- **iii) Simulated Annealing**
It is based on an analog of cooling the material in a heat bath – a process known as annealing [17]. A solid material is heated in a heat bath until it melts, then cooling it down slowly until it crystallizes into a solid state (low-energy state). The atoms in the material have high energies at high temperatures and more freedom to arrange them. As the temperature is reduced, the atom energies decrease. The structural properties of the solid depend on the rate of cooling. From the point of view of search methods for optimization problems, simulated annealing is a stochastic local search method. It always accepts a selected better-cost local solution and it may also accept a worse-cost local solution with a probability which is gradually decreased in the course of algorithm’s execution.

5. Detailed Design

5.1. Mathematical Model

i) Dataset: It includes set of various features, Corner detectors, various attacks on feature region set, Set of non-overlapping regions, Set of Resistible region, Set of Primary Feature region Set and finally smallest resistible region set which preserves image quality after known and unknown attacks

ii) Activities:

Activity1: Feature detection of an image
Activity2: Selection of primary feature region Set
Activity 3: Apply optimization

5.2. Algorithm

i) General Algorithm

Step 1: Read digital image
Step 2: Find feature as corner for regions of an image
Step 3: Find out corner response of regions
Step 4: According to corner response select non overlapping regions set
Step 5: Apply simulated attacking procedure
    If survives against attacks
        Add to primary set
    Otherwise
        Add to pruned set
Step 6: To select regions against non predefined attacks for robustness
    Apply optimization algorithms on primary regions set which is obtained from Step 5.as
    - genetic Algorithm.
    - Particle Swarm Optimization
    - simulated annealing
Step 7: For better performance against various kinds of attacks compare results obtained from step 6.
Step 8: Finally obtains most minimal and robust features

ii) A track with pruning Algorithm

Input: All feature regions detected by the feature detector, \( R_0 \).
Output: Primary feature region Set, \( R_p^* \)

Where, \( R_p^* \) is a Primary feature region set produced by applying simulated attacking on digital image.

Step 1: Initialize associated parameters and set the size of inspected feature region sets as NULL.
Step 2: Check if the termination condition is satisfied.
Step 3: while it cannot resist more attacks
    The candidate Set is included in the pruned set by adding more feature regions.
Step 4: Otherwise
    Update the primary feature region set with a candidate feature region set if the latter can resist more attacks than the former.
Step 5: Stop.

iii) Genetic Algorithm

Generate initial population

do
    Calculate the fitness of each member
    // simulate another generation
    do
        Select parents from current population
        Perform crossover add offspring to the new population
        while new population is not full
        Merge new population into the current population
    Mutate current population
while not converged

6. Expected Results

In this, for attack three well-known 256 X 256 images, Lena, Baboon, and Pepper, are used as an input. All schemes adopt Harris–Laplacian detector to extract feature regions. For each test image, the detector extracts 100 feature regions according to their corner response.
TABLE 2: Results for regions for Lena (LA) image against attacks

<table>
<thead>
<tr>
<th>Methods</th>
<th>Image</th>
<th>JPEG</th>
<th>Sharpening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harris Laplacian Corner Detector</td>
<td>LE</td>
<td>3/15</td>
<td>1/15</td>
</tr>
<tr>
<td>Simulated attacking with GA optimization Algorithm</td>
<td>LE</td>
<td>7/14</td>
<td>5/14</td>
</tr>
</tbody>
</table>

7. Conclusion

This system is suitable for applications where ever robustness of a digital image is required for prevention and protection of digital contents against various kinds of attacks. Similarly it preserves improved image quality. It uses integration scale, corner response and attack's resistance capability as performance parameters. Comparing the results of different optimization techniques on primary feature region set- The proposed method determines the best choice of optimization techniques for selecting most robust and minimal region set under the constraint of preserving image quality.

It uses Simulated annealing and Particle Swarm Optimization algorithms which would improve the robustness of feature regions set than the Genetic Algorithm,

IX. REFERENCES


[6] Riccardo Poli, William B. Langdon and Nicholas F. McPhee “A Field Guide to Genetic Programming” University of Essex – UK rpoli@essex.ac.uk
