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Application of Super pixels Segmentation in Digital Image forgery Detection

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Abstract

In the era of technology, multimedia contents are exposed to manipulations which leads for unsecured information transmission and reception. One such form of multimedia information is Digital Image. An image may be easily tampered in such a way that it gets difficult to find the forgery through human vision. This leads to the forgery creation in content of image data. Integrity and authenticity of image must be evaluated. In context to this, an approach for forgery detection using Superpixels segmentation is proposed. Spectral clustering is applied for images to obtain the segmentation of images in the form of Superpixels. Mapping of High dimensional feature space pixel point with proper weight computation is performed first and then K-means and normalized cuts is optimized using this objective functions. The obtained Superpixel segments forms the block for extracting the features using SIFT. The features of Superpixel segments are matched with one another to obtain the tampered part of the image based on similarity. The results obtained with the proposed copy move forgery detection method shows better precision and recall rate under various conditions than the existing forgery detection methods.

Keywords: *Superpixel Segmentation, spectral clustering***,** *copy move forgery detection*

1. Introduction

In today's digital world, technology has been updated in such a way that there exists many easy possible ways towards the content modification of multimedia information. This easier way of manipulation has lead to the difficulty in accepting the Digital information as a proof of evidence. One such information content is Digital image. Image is also a form a message which can be used for communication between two entities. The authenticity and integrity is much necessary to have the image as a form of evidence or information transmission. Due to the availability of user friendly applications and technology for modification of images, providing the authenticity for image transmission is a challenging situation in present days. In this regard, image forgery detection method has to be implemented to provide authenticity of an image.

In Traditional methods algorithms are applied for forgery detection based on block and key point feature extraction for detecting forgery in images. Combination of block based and key point feature extraction methods were implemented to get improved results in forgery detection. The latest development in forgery detection algorithm provides the replacement of block based feature extraction with segmentation algorithm [4]. This helps in reducing computational complexity of forgery detection process as it combines the preprocessing step and formation of block for feature extraction. Image segmentation also plays an important role in various applications related to computer vision, reconstruction of images, object tracking and recovery of surface. Segmentation of image is obtained by tracing the intensity of pixels. Boundary and edge are the two basic requirements to form segments in image based on drastic changes in neighboring pixel intensity values.

Group of pixels which perceptually exhibits same meaning are grouped under single patch to form Superpixels[4]. These Superpixels forms segment in an image. Processing of Superpixel for the cases of similarity check, comparison or feature extraction in an image reduces computational complexity when compared to pixel to pixel based preprocessing of complete image. Thus the proposed method adopts Superpixels segmentation algorithm in place of block formation process of forgery detection to achieve reduced computational complexity. Feature extraction is applied for Superpixels and then the extracted features are matched to detect and locate forgery.

2. Literature Review

This section provides literature review of related works on forgery detection techniques and Superpixels segmentation.

Digital image forgery is broadly classified into two categories: Active and passive method [1]. Copy move forgery falls under the category of passive method.

In Copy move forged images, detection was based on either block based or keypoint feature extraction based detection method [2] and [3].

SIFT [4] and SURF [5] are commonly used in image and computer vision applications to extract the features in an image.

The author in this paper [6], has proposed a new approach of combined form of block based and keypoint feature extraction process to detect forgery in copy move forged image.

The implementation includes application of SLIC superpixels segmentation for forgery detection part of work. In this view literature review was carriedout to have latest efficient Superpixel segmentation algorithm.

In this paper [7], the authors propose a novel approach for visualizing the perceptual group . Global impressions are extracted in this case. This global impressions is used for segmenting the image based on graph partition method.

This approach helps in measuring the total dissimilarity between the different groups and similarity within the groups.

Simple Linear Iterative Clustering algorithm (SLIC) is efficient when computational complexity and memory is considered [8]. This algorithm also has limitaions due to several iterations for centroids and post processing step connectivity.

Linear Spectral Clustering (LSC) is presented in [9], which provides superpixels with both high boundary adherence and visual compactness. Unlike in traditional methods, LSC utilizes the kernel function and k-means for high dimensional feature space computation.

Thus the proposed work is implemented with the apllication of LSC on copy move forged images for forgery detection.

3. Implementation details

The proposed work is implemented on intel core i5 8^{th} gen PC using MATLAB. The methodology of implementation involves the following stages:

A: To initialize Superpixels count for the input image.

B: Apply Superpixels segmentation for the image.

C: Apply feature extraction algorithm

D: Superpixel block matching

E: Forgery region detection.

A: To initialize Superpixels count for the input image.

To obtain the number of superpixels of the input image DWT ‘Haar’ wavelet of 4 levels is used.

$$E_{\text{Low Frequency}} = \sum |CA4| \quad (1)$$

$$E_{\text{High Frequency}} = \sum \left(\sum |CDi| + \sum |CHi| + \sum |CVi| \right) \quad (2)$$

where E stands for Energy, CA4 is 4^{th} level approximation coefficients of DWT; CDi, CHi and CVi are ith detailed coefficients of DWT, i = 1, 2, …,4.

$$\text{Percentage}_{(LF)} = \frac{\text{ELF}}{\text{ELF}+\text{EHF}} \times 100 \quad (3)$$

$$S=\{\sqrt{0.02 \times M \times N}\} \quad \text{PLF}>50\% \quad (4)$$

$$S=\{\sqrt{0.01 \times M \times N}\} \quad \text{PLF}\leq 50\% \quad (5)$$

where $\text{Percentage}_{(LF)}$ refers to percentage of low frequency; S is the superpixels size initialized value; M x N is the size of the image.

B: Apply Superpixels segmentation for the image.

With the Superpixels seed value identified in the previous steps LSC algorithm is applied for the input image with the ratio of 0.075 to get segmented blocks. Figure1 (a) shows the input image and correspnding superixels of the input image is as shown in (b).

Figure1: (a) Input image (b)Superpixels Segments

LSC works based on kernel function which maps high dimensional feature space value for pixel of image. In place of eigen values and vectors calculation the algorithm computes appropriate weight function to obtain objective function of k-means cluster and for optimization computation for normalized cuts.

C: Apply feature extraction algorithm

Features from the images are extracted using this algorithm. Features in Block based techniques are pixels which are variant to geometrical transformations. So, Each superpixels of image which are used for extraction process to collect features must be invariant to transformations. Now a days, SURF [3] and SIFT [4] are commonly used feature extraction techniques in digital field. Figure 2 shows the SIFT features applied for segmented image based on superpixels method.

Figure 2: SIFT results for segmented image.

Features extracted using SURF and SIFT are invariant to geometrical transformations. In the proposed method both SIFT and SURF methods are applied for the superpixel segmented blocks of the image and evaluated.

D: Superpixel block matching

Block features can be represented as BF= (BF1, BF2.........BFn), where n is the total number of image blocks. Correlation coefficients (CC) of the image blocks are evaluated to obtain the number of matched feature points between the two blocks. For N blocks, N(N-1)/2 CC can be formed which are used to generate CC map. Feature points are mathed if the euclidean distance is having the value more than feature point matching threshold(TRp). The interpretation is that the feature point fa(xa, ya) is matched to the feature point fb(xb, yb) if the condition in (6) is satisfied.

$$d(fa ,fb) \times TRp \leq d(fa ,fi) \qquad (6)$$

where fa and fb are feature points; and d(fa,fb) is the euclidian distance between them; d(fa ,fi) is the euclidian distances between the keypoints fa and other keypoints in block pair. i indicates the ith feature point.

Elements present in the generated CC map are arranged in ascending order and are represented as CC_S = {CC1, CC2 ………… CCt}, where $t \leq N(N-1)/2$, which helps in finding TRb. After sorting the CC elements, first and second derivative of CC_S i.e. Δ (CC_S) and Δ2 (CC_S) and the mean value of the first derivative vector Δ(CC_ S)1 is calculated. To find TRb, select the minimum correlation coefficient value is selected among the larger value of second derivative compared with the mean value of the corresponding first derivative vector. i.e. Δ2 (CC S) > Δ(CC_ S)1. The selected CC value is defined as TRb.

With the calculated TRb, if the CC of the two block is larger than TRb, then the corresponding blocks are matched.

Suspected forgery regions are indicated using label for the feature match in the matching blocks.

E: Forgery region detection.

LSC method divides the input image into small superpixels. Based on the input image size, LSC calculates superpixel size S based on which the input image is segmented. S=20 is selected when image is of size approximately 3000×3000 and S=10 is selected when image is of size approximately 1500×1500

Figure 3 shows the forgery region detection and location. The suspected region and merged region is as shown in (a) and (b) respectively. The results obtained after the application of morphology is as shown in (c).

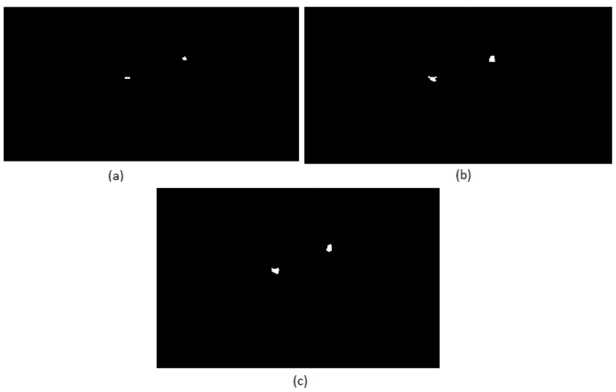

Figure 3 : Forgery region detection and location.
(a) Suspected region. (b) Merged region
(c) After Morphology

The gaps in merged regions are filled and forged region is is kept as it is with the help of Close morphological operation. This method uses structuring element as a circle. The radius depends on image size.

4. Results

Results obtained by experiments conducted on image dataset MICC-F220 are discussed in this secction. The dataset has 220 images, which consists of tampered and originals images each of 110 in count. The image size differs from 722×480 to 800×600 and tampered patch covers 1.2% of image. Images in MICC-F220 dataset are limited to rotation and scaling and doesn't contain source files. To overcome from these issues, benchmark database is used. This dataset contains total 96 images, in that 48 are original and 48 are tampered. The experimental results obtained for MICC-F220 [10] and benchmark data set [11] is as shown in table 1 and 2 respectively.

Precision and recall rate are used for performance evaluation. Precision is defined as the ratio of number of correctly identified forged images to totally identified forged images. Recall is also called as true positive rate which is defined as the ratio of number of correctly identified forged images to total forged images in database.

1. TP : True positive is number of correctly identified forged images.
2. FN : False Negative is number of wrong detection of forged images.
3. False Positive (FP): represents the number of wrong detection of original images.
4. True Negative (TN): represents the number of correctly detected original images.

Precision and Recall can be calculated using equations (7) and (8).

Precision = TP/(TP + FP) (7)

Recall = TP/(TP + FN) (8)

Apart from precision and recall, F1 measure is used to measure the forgery detection results which can be computed using equation (9).

F1 = 2x(precisionxrecall)/ (precesion+recall) --- (9)

By considering these parameters, accuracy of the methods can be evaluated using equation (10).

Accuracy = (TP+TN)/(TP+TN+FP+FN) --- (10)

Table 1: Comparison of detection methods using MICC-F220 dataset

Methods	Precision (%)	Recall (%)	F1 (%)	Accuracy (%)
SIFT irregular	100	93.75	96.77	96.87
SIFT regular	97.61	85.41	90.95	91.66
SURF irregular	97.05	68.75	80.48	83.33
SURF regular	96.96	66.66	79	82.29
Proposed method	98.69	95.23	96.92	96.92

Table 2: Comparison of detection methods using benchmark database

Methods	Precsion (%)	Recall (%)	F1 (%)	Accuracy (%)
SIFT irregular	81.4	73.33	77.15	74
SIFT regular	83.33	66.66	74.06	72
SURF irregular	75	20	31.75	48
SURF regular	80	13.33	22.85	46
Proposed method	82.15	76.55	79.25	75

5. Conclusions

With the advancement in technology, the multimedia contents are exposed for modification/manipulation which leads for unauthorised and unsecured transmission of information. In this paper, the proposed work aims in providing authenticity for image data. The method detects forgery in images which are tampered by using copy move forgery techniques. The method involves the application of Superpixel segmentation and SIFT feature extraction in image. Extracted features are matched between the superpixel segmentation to detect the suspecious region. The suspected region is obtained by applying morphlogical operation on merged region to locate the detected forgery in an image. Further work will be carried out for the datasets involving various challenging nature of image for forgery detection.

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