Copy-Move Forgery Detection Based on Scaled ORB and K-means++

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***Abstract*—Copy-move is a common practice of digital image tempering. Due to the availability of low cost software, the forging rate of image is increasing. That is why, image security authentication is playing a critical role in our society. So copy move forgery detection (CMFD) is enabled to detect the forged portion of an image. In this method, we proposed Scaled ORB and k-means++ algorithm for detecting the forged region. The pyramid scale space is identified first which is essential in the next step. Feature is an important property for detecting a region. So the ORB descriptor plays an important role in this method. From each scale space, extracting FAST key points and the ORB features. With respect to the original image, the coordinates of the orientated FAST key points are reverted. Now k-means++ algorithm is applied on ORB descriptors. The clustered features are matched every two different key points using hamming distance. Then the forged key points are detected. Based on those key points, two circles are drawn on the forged region and original region. If the forged region becomes rotational invariant, moment is needed to be calculated. In this method, geometric transformation (scaling and rotation) is feasible. This paper shows a method to detect the forged region efficiently for images which are modified by rotation and smoothing condition. The proposed method reduces the running time compared to the previous work.**

Keywords— Scale space, ORB feature, k-means++, geometric transformation, FAST key points.

I. INTRODUCTION

The world has become technologically advanced. So it is easy to forge images with the help of many low cost softwares. So authentication of an image is not ensured. Images can be forged in many ways. Copy move forgery is one of them. In this method an image is forged by copy and paste of one or multiple parts of the image. One can add an extra part to the image hiding its real part. So authentication of that image becomes vulnerable. Nobody can recognize those forged images by visual look. Sometimes criminals get passed freely with the help of forged images and victims do not get their justice. Moreover, judges can not identify the incident properly because of forged images. Many newspapers publish fake news. So many times normal people fail to identify whether the images are right or not. So it can be said that public security becomes at stake due to forged images. To restrict forgery, many methods have been proposed. With the help of those methods an forgery can be identified easily. Thus image authenticity increases and people get justice. With the advent of forgery detection, criminals think twice before committing a crime.

Copying a part of an image and pasting it on the same image is termed as forged image. Detecting the forged region is a passive forgery detection. For detecting and localizing the image many method have been introduced. The methods are divided into two categories-Block-based methods[1] and key points-based methods[2]. In block-based methods, overleaping or non-overleaping blocks of equal size are required for extracting the features from each of the block. Then comparing those blocks, the forged region is easily detected. If specific block pair is matched, it is named as 'copy-move' because of having similar features. But in key-points based methods, key point detectors and features are used to identified the key points. And extracted those key points from a region are used to feature matchng. But dis-advantages of these key point is false matching. RANSAC[3] is an eliminating algorithm to remove the false matching. Key point based technique takes less execution time over block-based method. In key-points based method, for feature extraction and matching the region around the key points are to be considered. But the entire image blocks are considerd for matching in block-based technique.

II. RELATED WORK

To identify accurate features, a lot of researches have been published for detecting copy-moved regions. Many block-based and key-point based methods have been introduced to detect forged regions by identifying appropriate features which are scale invariant, translation and rotation. Numerous methods such as SIFT, ORB and BRISK are relatively new and very efficient to extract the feature. On the contrary, these methods require low computational cost compared to block-based method. Fridrich et al. [5] proposed a method where DCT has been used to extract the features on the overleaping blocks. And it is known as block-based method. Here few datasets were used on their experiment. It was the first work on forgery image. In block-based method, if the forged region is scalable, it will not capable of detecting the tempered region. Popescu et al. [6] proposed a method based on PCA for feature extraction. Approximately 100 images of size 512x512 have been used as their dataset. This method can't be responsive in the geometric transformation i.e. after rotation and scaling of a sample, it can not be detected as forged. Li et al. [7] mentioned a method based on DWT and SVD also known as block-based method. This method works only when the sample is being highly compressed or edge processed. Huang et al. [9] and I. Amerini et al. [21] used SIFT feature extraction method and it was a key point based extraction method. Noisy and blurred sample can not be detected as a forged image. Zhu et al. [16] proposed a method based on Scaled ORB where ORB features help to detect the forged region of a digital image. The dataset was collected from the Columbia University natural images library. But time complexity is not good as it compares all extracted descriptor. Descriptors being sent to clustering, our proposed method performs better. So it is needed to compare only clustered center to detect the forged region. Jian Li et al. [20] used SIFT based approach where the running time for detecting the forged region is high and also its false positive rate is high. Kakar et al. [21] can not detect the multiple duplicate regions as forged image.

III. PROPOSED WORK

The research is conducted with Scale ORB and k-means++. ORB is a key-point based feature extraction technique. Extracting the feature of an image is a critical step. Finding the suitable matches after k-means++ clustering within the image and marked as a copy-moved region. The block diagram of the proposed method is demonstrated in figure 3. Those steps are explained elaborately.

A. *RGB to gray conversion*

The input image may be any kind of format. The equation to convert a RGB to gray scale is given below.

$$I = 0.299\,R + 0.587\,G + 0.114\,B \tag{1}$$

Here, the intensity of an image is denoted by I and the red green and blue channel of a color image is denoted by R, G and B respectively.

B. *Identify the pyramid scale space*

To identify pyramid scaled space, Gaussian pyramid is used which was proposed by David Lowe [17]. With octaves and intervals, the pyramid scale space is constructed. Octaves mean an image which gained after resizing by the specific interval.

With the help of Gaussian smoothing, same octaves are built in intervals. Where $L_{oc,\,in}(x,\,y,\,\sigma_{oc,\,in})$ is the pyramid scale space at 'oc' octave and 'in' interval, $G(x, y, \sigma)$ is Gaussian function, σ is the smoothing factor of Gaussian function. $L_{1,1}(x, y, \sigma_{1,1})$ denote the gray image of the main image I(x, y).Last pyramid scale space $L_{oc,in}$ is achieved by down sampling of the last octave by a factor 2.

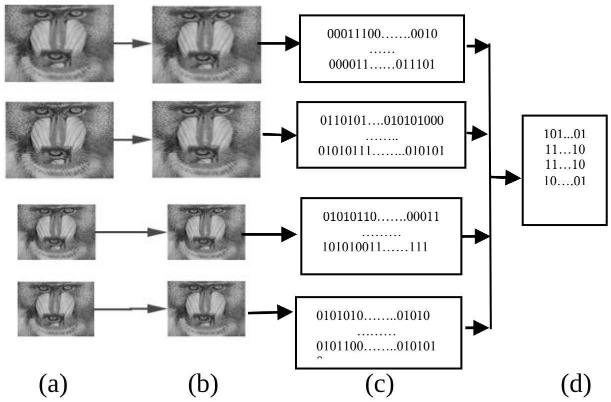


Fig. 1: (a) Pyramid scale space (oc=2, in=2), (b) oFAST key points of each space, (c) ORB descriptors of each space (d) scale ORB.

$$L_{oc,in}(x, y, \sigma_{oc,in}) = G(x, y, \sigma_{oc,in}) * L_{oc,in-1}(x, y, \sigma_{oc,in-1})$$

$$G(x, y, \sigma) = 1/\,2\pi\sigma^2 e^{-(x^2+y^2)/2\sigma^2} \tag{2}$$

C. *Extract scaled ORB feature*

Actually ORB feature is not a scaling-invariant descriptor but in the field of image processing scale-invariant descriptor is important. For making the feature descriptor scaling-invariant, key points assign the pyramid scale information.

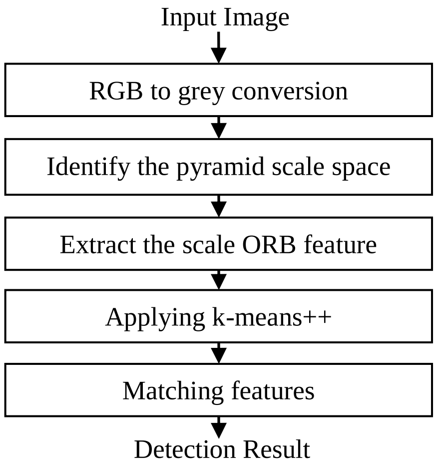


Fig. 2: Block diagram of the proposed method.

(a) *Extract the FAST keypoints*

For extracting key points, we use a rapid algorithm known as FAST [18,19]. It concentrates on the Bresenham cyclo-region and each pixel. Getting the accurate value we take the radius equal to 3. Firstly, check the pixel's number in the Bresenham cyclo-region than the centric point(x, y). If the number of pixels is larger than the threshold value, the centric point(x, y) is known as FAST-9 points. So it can be denoted as $fast(i)=[x, y, oc_i, in_i]$.

(b) Orientation Compute

The general equation of central moment define as follow

$$m_{p,q} = \sum_{x,y} x^p y^q I(x,y) \quad (3)$$

Then, the centroid 'C' is determined by

$$C = (\frac{m_{10}}{m_{00}}, \frac{m_{01}}{m_{00}}) \quad (4)$$

The orientation θ of the key point 'O' is determined by

$$\theta = a\tan(\frac{m_{01}}{m_{10}}) \quad (5)$$

Where m_{10} is called row moment.

m_{01} is called column moment.

Now, equation becomes ofast(i)=[x, y, θ_i, oc_i, in_i].

(c) Build the rBRIEF feature

A binary test τ of rBRIEF feature defined by

$$\tau(P:x,y) = \begin{cases} 1, \mathrm{p(x)} < \mathrm{p(y)} \\ 0, \mathrm{p(x)} \geq \mathrm{p(y)} \end{cases} \quad (6)$$

P(x) is the gray of point x and y satisfies the Gaussian distribution. BRIEF feature is defined as a vector of n (n=256) binary tests:

$$f_n(p) = \sum_{1 \leq i \leq n} 2^{i-1} \tau(P:x,y) \quad (7)$$

A feature set of n binary tests at x and y define matrix $P = \begin{pmatrix} x_1 \cdots & \cdots x_n \\ y_1 \cdots & \cdots y_n \end{pmatrix}$ Using the operation Theta θ_i and the corresponding rotation matrix $R_\theta = \begin{pmatrix} \cos\theta_i & -\sin\theta_i \\ \sin\theta_i & \cos\theta_i \end{pmatrix}$ steered matrix $P_{\theta_i} = R\theta_i P$ will be constructed. Now ORB descriptor of oFAST point becomes

$$ORB(i) = f_n(p) \mid (x_i, y_i) \in P_\theta \quad (8)$$

D. *Applying K-means++*

D. Arthur and S. Vassilvitski proposed a clustering algorithm [17] known as k-means++. This is the extended version of k-means. Here the cluster center is chosen wisely. So the required number of iterations is less than k-means. In k-means++, the initial center is chosen randomly like k-means. K-means++ algorithm is then applied on the ORB descriptors.

The distance between dataset X and its closest cluster center is represented as D(x). Now the algorithm follows these steps.

1. A cluster center c_1 is chosen randomly from the dataset X like k-means.
2. Then all the possible distances are calculated from the chosen center and denoted as D(x).
3. New cluster center c_i is chosen based on the distance D(x). The long distance cluster center is selected compared to all D(x) and this is known as weighted probability $D(x)^2 / \sum_{x \in X} D(x)^2$.
4. The steps 2 and 3 are repeated until the k centers are found.
5. All the processes are computed like the standard k-means algorithm.

Though the steps 2 and 3 take more time to select a perfect center, the step 5 converges very quickly which is the advantage of k-means++ over k-means clustering algorithm.

E. *Matching Features*

The feature matching process computes using double loop i.e complexity N*N. Using double loop from 1-k the matching be checked, where K is the number of cluster of the ORB descriptor.

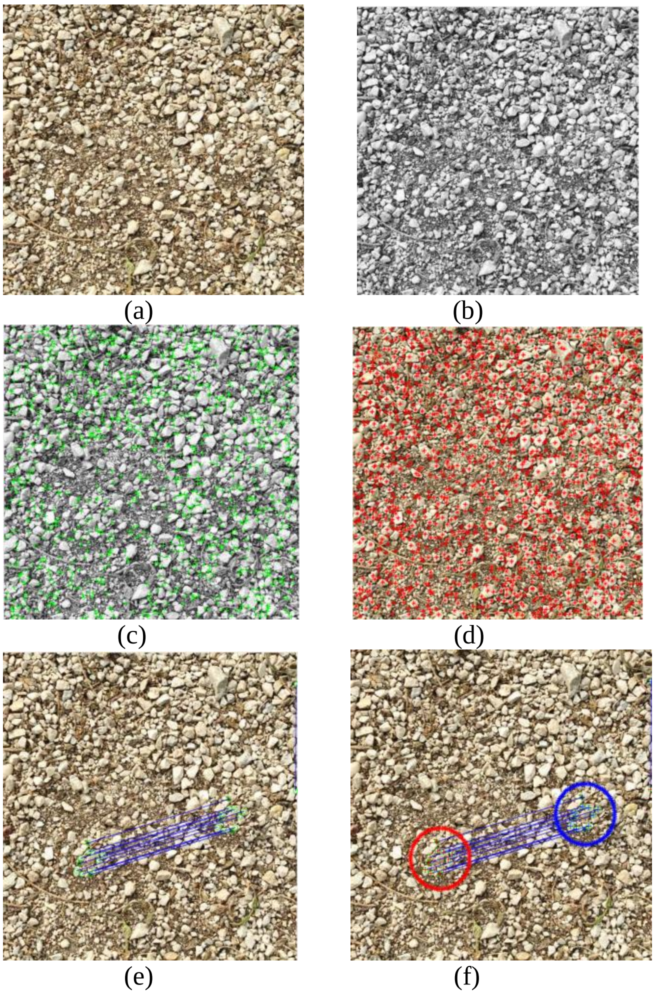


Fig. 3: (a) Input image (b) Gray image (c) Extract FAST key points (d) ORB features (e) Matching features (f) Detected result.

IV. EXPERIMENT

A. Experiment Setup

ORB algorithm was firstly implemented by Zhu et al. [16] to find out the ORB descriptors. The experimental environment follows the windows 10 operating system and the Matlab R2018b. Dataset is collected from MICC-F220 and CoMoFoD (small)[22] for this project. We also created 30 dataset for checking our proposed method.

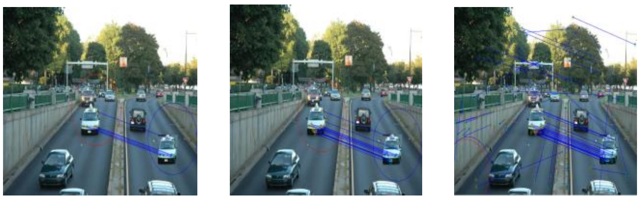
B. Experiment results and analysis

The proposed method is evaluated using the dataset of MICC-220 and CoMoFoD (small) [22]. Dataset in different size like 1000*700 or 700*1000 which are divided into three groups. Some non-compressed dataset with only translation of copied region, some are only non-compressed and some are simple scenes. In 2013, the CoMoFod (small) [22] database was publicized where the size of the dataset was 512*512 in PNG format. Different categories of images are stored in this dataset like translation (40 images), rotation and scaling (40 images).

The original image is shown in figure 4(a) from the dataset of MICC-F220. The tempered form of the original image is shown in figure 4(b). The temper detection of the images is shown in figure 5 on the basis of different threshold value. When the low threshold value is applied, less number of key points is extracted. If the forged region is small, the possibility of extracting the key points decreases. As a result, it becomes difficult to detect the forged region. When the threshold value is high, it extracts large number of key points and the possibility to detect the false match increases.

(a) Original image (b) Tempered image

Fig. 4: Tempered image with its original image.



(a) T=0.4 (b) T=0.5 (c) T=0.8

Fig. 5: Detection result of tampered image

TABLE I. MATCHING RESULTS WITH DIFFERENT THRESHOLD VALUE

Threshold value	0.1	0.3	0.4	0.5	0.6	0.8
Number of matches	12	24	26	30	36	146
Number of false matches	0	0	0	2	9	too many

We performed some common post processing methods on MICC-F220 dataset of temper images for making our method robust and sensitive. Most of the images are from different papers and internet. The optimal threshold value is taken T=0.5. When the threshold value is low, less number of key points is extracted. But when the threshold value is high, large number of key points is extracted where the probability of false matching increases figure 10(c). So the threshold value is kept at optimal level to detect the forged region efficiently. To measure the performance of the proposed method a confusion matrices is used. We used the dataset of MICC-F220 which consists of 50 images. The dataset has both forged and original images. We performed our test and result as follows: 40 forged images are detected as forged, 5 forged images are detected as original image, 2 original images are detected as forged image, and 3 original images are detected as original images.

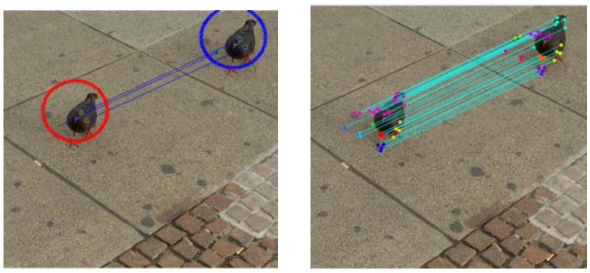
TABLE II. CONFUSION MATRICS

Number of images	TP	FP	TN	FP	Accuracy
50	40	5	2	3	86%

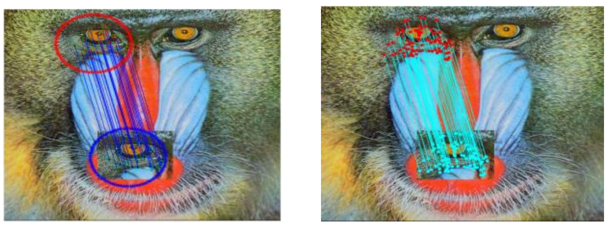
TABLE III. THE MATCHED KEY POINTS AND RUNNING TIME

Methods	The number of key matched points(Total)	Running time Sec (Total)	False match (Total)
SIFT[19]	3589	73.3386	246
Proposed Method	1553	13.2594	104

Above table shows the calculation of 15 forged images from the dataset of MICC-F220.



(a) (b)



(c) (d)

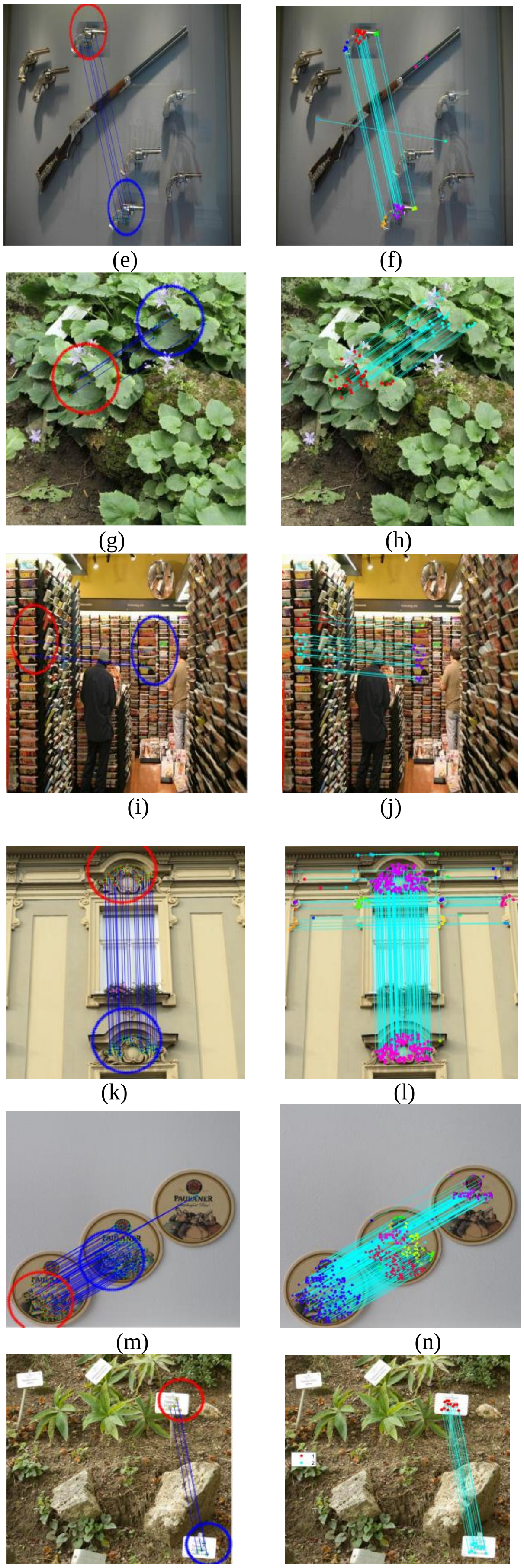


Fig. 11: Result of Scaled ORB and k-means++ and SIFT[19] respectively

sTABLE IV. THRESHOLD VALUE SETTING BASED ON FORGED REGION DETECTION

Threshold	Detection of forged region	Non forged region detected as forged
0.1	Fair	No
0.3	Fair	No
0.5	Good	No
0.8	Bad	Yes

TABLE V. THE PERFORMANCE RATE FOR DIFFERENT METHODS

Modifications	Different methods		
	G.Lynch[23]	*Y.Huang[8]*	Proposed method
Without modification	97%	99.9%	99.9%
Rotation	0%	Only less than 5 deg.	99.5%
JPEG compression	30%	80%	68%

V. Conclusion

In this paper, we proposed a key point based method where key points are extracted by ORB algorithm which is better than SIFT and SURF. This method not only detects the forged region but also the region which changes after geometric transformation like scaling, rotation and transformation. The advantage of the proposed method is the rapid detection of tempered regions. The time complexity of the proposed method is better than many existing methods. Our proposed method have the ability to detect the copy-move region and copy-rotate-move region also. The false positive rate is negligible and true positive rate is higher than the compared method. Our method is faster compared to the block-based methods. In future, the proposed method can be extended to detect the digital image as forged after applying many post processing which are not used in this method on the pasted region.

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