ISBN 978-93-84422-71-4
Proceedings of 2016International Conference on Image Processing, Production and Computer Science (ICIPCS'2016)
London (UK), March 26-27, 2016 pp. 23-29

Copy Move Forgery Detection Using Gabor Filter and ORB

Gul Muzaffer[1], Ozge Makul[1], Beste Ustubioglu[1] and Guzin Ulutas[1]

[1]Departmant of Computer Engineering Karadeniz Technical University Trabzon, Turkey

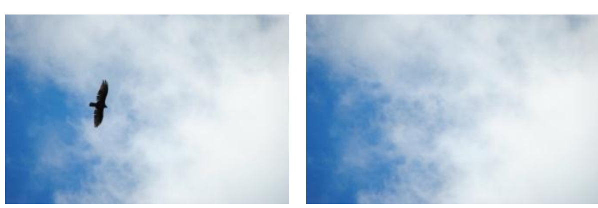
Abstract: *Digital images are easy to forge by using copy move techniques via availability of powerful image processing and editing software. Nowadays researchers study on detection of forgery techniques which are divided into block based and keypoint based methods in literature. This paper presents a keypoint based copy move forgery detection approach which extracts the keypoint from smooth regions. Gabor filter is used for image texture retrieval and histogram equation is applied to textured image as preprocessing. After that ORB is used to extract the keypoints from image. Forged regions are detected by matching the keypoints. Proposed approach is tested on attacked images (Gaussian blurring and jpeg compression).Obtained results show that our proposed method is robust to these attacks.*

Keywords: *keypoint based, copy move forgery, scaled orb, Gabor filter*

1. Introduction

Digital image can be used as significant evidence of a crime so digital image provide assistance for making decision about criminal event. Nowadays digital image forgery become pervasive by using easy access of powerful image editing software tools like Photoshop, 3D Max, GIMP etc. So it has become increasingly difficult to rely on originality of image and it has become a challenging problem. Due to this problem, researchers suggest techniques to examine the originality of digital images.

Copy move forgery is one of the most popular image forgery techniques because it can be made easily with using freely available image editing tools. The purpose of copy-move image forgery is to cover evident details or to duplicate some region of an image. A part of an image is copied and pasted into another region in the same image. It is very hard to detect forgery with naked eyes, thus forgery detection method should detect the replicated regions, even though they are slightly dissimilar to originals. Original image and its copy move forgery image given in Fig. 1 (a) and (b) respectively.



(a) (b)

Fig. 1. a)Original Image b)Forged Image

In the literature copy move forgery detection methods can be divided into two groups: Block based and Keypoint based methods. Fridrich et al.s study as detection of the copy move forgery is the first interference in the literature [1]. Their method is block based and not robust to against scaling, translation and rotation. After this study, Popescu et al. used PCA to extract feature vectors from the blocks [2]. Their work reduced the dimension of feature vector utilizing the characteristic of PCA. The method is more robust to additive noise. But their method has also a insufficiency because it is not robust to rotation attack. Bayram et al. suggested using Fourier-Mellin Transform (FMT) to create the feature vectors [3].Because of overcome the rate complexity problem in block based method, keypoint based methods were proposed.

Huang proposed the algorithm based on SIFT (Scale Invariant Feature Transform) [4], and after that, Amerini et al improved the SIFT approach in which hierarchical clustering is added on the SIFT keypoints [5]. SURF (Speed up Robust Features) is another keypoint descriptor which is widely used by researchers to detect copy move forgery. Xu Bo et al. [6], proposed a fast method to detect copy move forgery based on the SURF. The standard version of SURF is faster than SIFT. In 2015 Zhu et al proposed a new method for copy move forgery detection based on scaled ORB [7] which is faster than SIFT and SURF. Their method can resist the geometric transformation, such as scaling and rotation, and post-processing, such as blur, noise, and JPEG compression but cannot detect forgery by smooth surfaces because it uses FAST corner detection at keypoint extraction step. To overcome this problem we apply the texture retrieval from image before feature extraction.

Our study based on Gabor Filter and ORB. As the first step the method extracts texture information from the forged image, to use keypoint extraction methods on it. Because of the smooth regions of images also have a texture and in our approach reveals the structure of these regions by using the Gabor Filter. By this way ORB can extract the keypoints from the textural information of the image. After obtain the ORB features, they are matched between every two different key points using the hamming distance; finally, remove the false matched key points using the RANSAC algorithm and then detect the resulting copy-move regions. According to experiments, the method gives higher detection ratios in smooth surfaces, than ORB based works in the literature [7] and also our method is robust to post-processing operations like Gaussian blurring and jpeg compression.

The rest of the paper is organized as follows. Section 2 gives proposed work with an introduction to Gabor Filter and ORB shortly. The experimental results and conclusions are given in Section 3 and Section 4 respectively.

2. Proposed Method

In this study, there are three basic steps; i) Extraction of the texture information from forged image with Gabor Filter and then histogram equalization. ii) Detection of the ORB keypoints and descriptors from the textured image.iii) Matching the keypoints to detect forged regions with Hamming distance. iv) Removing false match with RANSAC [8].

2.1. Gabor Filter

Gabor filter [9] which is a linear filter has been widely used for texture analysis, image retrieval in image processing. It is defined as a Gaussian function modulated by complex sinusoidal signal as follows:

$$g(x,y) = \left(\frac{1}{2\pi\sigma_x\sigma_y}\right).e^{\left[-\frac{1}{2}\left(\frac{x'^2}{\sigma_{x^2}}+\frac{y'^2}{\sigma_{y^2}}\right)\right]}.e^{(2\pi jWx)} \tag{1}$$

$$\begin{aligned} where\ x' &= \ xsin\theta + ycos\theta \\ \boldsymbol{y' = -xcos\theta + ysin\theta} \end{aligned} \tag{2}$$

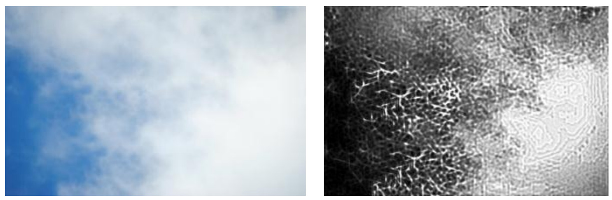
σ_x and σ_y are Gaussian function's standard deviations of Gaussian function along x and y axies, W is central freguency of sinusoidal signal and θ is orientation angle.

Gabor representation of smooth image is obtained by convolving the image with Gabor filter as follows:

$$G_{f,\theta}(x,y) = I(x,y) * g_{f,\theta}(x,y) \tag{3}$$

where $*$ is convolution operator, f spatial frequencies, $I(x, y)$ intensity value of gray scale smooth image at (x, y) coordinate. This formula's mean is to apply an image varying wavelength and orientation. In this paper, Gabor filter is desinged with 8 orientation angles and the result of applying Gabor filter to image is as shown in Fig 2.

The filtered forged image may have a low contrast texture. Because of this, the extracting key points step from forged image may fail. In this paper, histogram equalization [10] is used to make improve contrast of the forged image. By applying histogram equalization to the forged image, texture information such as edge regions, intensity variation is made explicit to improve extracting keypoints performance. The result of histogram equalization of filtered forged image is shown in Fig 2.



(a) (b)

Fig. 2. (a) Smooth forged image (b) Gabor filter and Histogram equalization result

2.2. Feature Extraction from Textured Image with ORB

In this study features were extracted from the textured image using Oriented Fast and Rotated Brief(ORB) proposed by Rublee et al. in 2011 [11].For copy move forgery detection ORB is used by Zhu et al in 2014 [7].ORB involves the following stages: extract the orientated FAST key points and get their descriptors with the rBRIEF(Rotation-Aware Brief).

2.3. Extract the Oriented FAST Keypoints

Keypoints are extracted by using the simple and rapid algorithm, FAST (Features from Accelerated Segment Test) [12].

The FAST method focuses on every pixel and the Bresenham cyclo-region. According to [12], the accuracy and computational complexity would be balance when radius is 3.At first number of pixels in Bresenham cyclo-region that are less or greater than the central point (x,y) is controlled. Then, if the number is higher than the threshold the centric point (x,y) is FAST-9 (which represents the threshold is 9) points that is pointed out as a vector fast(i)=[x_i, y_i, oc_i, in_i].

The (p+q)th invariant moment $m_{p,q}$ of key point 'O' is given in (4) . For an appropriate calculation, the neighborhood N(x,y) is at the first quadrant of Cartesian coordinates, and 'O' is origin.

$$m_{p,q} = \sum_{x,y} x^p y^q I(x, y) \tag{4}$$

and with using these moments the centroid can be find as in (5)

$$C = \left(\frac{m_{10}}{m_{00}}, \frac{m_{01}}{m_{00}}\right) \tag{5}$$

The orientation of the key point is the angle of $\overrightarrow{OC}$, which is formulated as (6) with arctangent function.

$$\theta = atan\left(\frac{m_{01}}{m_{10}}\right) \tag{6}$$

To improve the rotation invariance of this measure we make sure that moments are computed with x and y remaining within a circular region of radius T. We also choose T is 15 to be the patch size, so that x and y run from [-15, 15].

2.4. Build the Rotation-Aware Brief (rBrief) Feature

The rBRIEF(Rotation-Aware BRIEF) feature can be obtain with the orientation of key point via a binary test τ is defined as (7), where p(x) is the gray pixel value of point x and y satisfies the Gaussian distribution in the neighborhood of x.

$$\tau(p: x, y) = \begin{cases} 1, & p(x) < p(y) \\ 0, & p(\&x) \geq p(y) \end{cases} \tag{7}$$

The feature BRIEF is represented as a vector of n binary tests: (We choose the vector length n=256)

$$f_n(p) = \sum_{1 \leq i \leq n} 2^{i-1} \tau(p: x_i, y_i) \tag{8}$$

To allow the BRIEF features to be invariant to rotation, an efficient method is to steer BRIEF according to the orientation oFAST keypoints. For any feature set of n binary tests at x_i and y_i, define matrix $P = \begin{bmatrix} x_1 \ldots\ldots & x_n \\ y_1 \ldots\ldots & y_n \end{bmatrix}$.Using the orientation θ_i and rotation matrix$R = \begin{bmatrix} cos\theta_i & -sin\theta_i \\ sin\theta_i & cos\theta_i \end{bmatrix}$. $P_\theta = R_\theta$. P is obtained. So the ORB descriptor of oFAST keypoint become as (9);

$$ORB(i) = f_n(p) | \; (x_i, y_i) \in \mathrm{P}_\theta \tag{9}$$

3. Experimental Results

The detailed analysis and the effectiveness of the proposed method is given in this section. The forgery database is created by images from Google image search and Comofod small database [13].The images forged with using an open source image editing software, GIMP.

For a *N*×*M* test image, forgery detection capability of the proposed method is tested with a metric called by Detection Ratio (DR) given in (10). *DR* is the ratio of matched keypoints inside the doctored regions .F is the total number of pixels, that reside on those regions andK_F. To provide independence from image size, these metric multiply with *NxM/100*. The higher *DR* is the better accuracy in detecting image forgery.

$$DR = \left(\frac{K_F}{|F|}\right) \frac{NxM}{100} \tag{10}$$

To evaluate the proposed method, the images tampered with smooth regions as a simple copy move forgery and then post processing operations, Gaussian blurring and jpeg compression, is applied on them and results are given as following experiments.

Firstly we experiment the proposed method as in Fig. 3 without any attack. The original image is given in Fig. 3(a) and it is covered by another smooth region from the same image to create the forged image given in Fig. 3(b). Fig. 3(c) shows that ORB [7] does not detect any keypoints on the forged regions because the region is covered by smooth region and ORB fails detection of keypoints in smooth regions. However, the proposed method finds 7941 keypoints on the forged image and true matching is 296 as can be seen in Fig. 3(d). The proposed method determines the forged region with more matched keypoints.

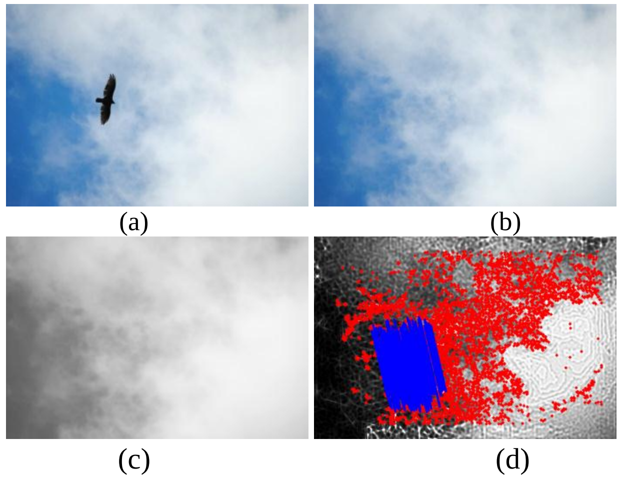


Fig.3. (a) Original image (b) Forged image

(c) The result of ORB method (Total keypoint: 0 True matched keypoints: 0) (d) The result of proposed method (Total keypoint: 7941 True matched keypoints: 594)

Blurring operation is used in the second experiment to blur the forged image. The plane at topmost is covered with as given in Fig. 4(b) to create forged image, Fig 5(b). The forged image is blurred by a Gaussian filter with parameters. Proposed method extract 4418 keypoints and ORB detect 360. As in shown Fig. 4(c), 44 true matching is obtained with our proposed method. Fig. 4(d) shows ORB do not find any true matched keypoint and also it has false matching.

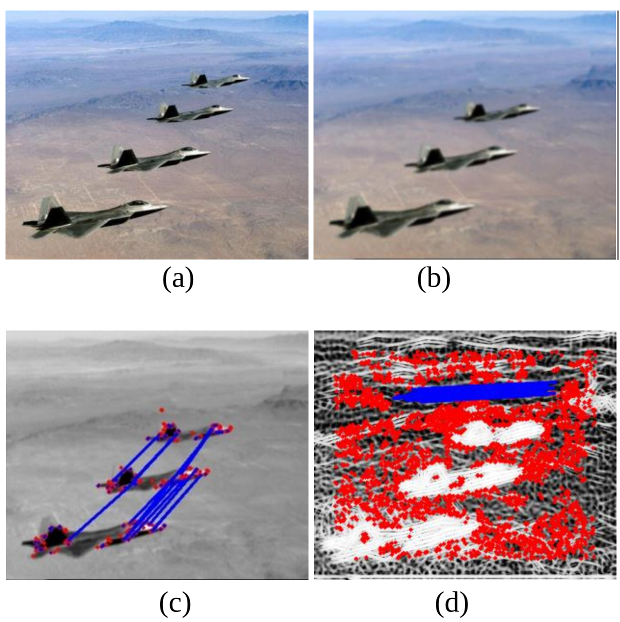


Fig.5.(a) Original image (b) Forged image and attacked on Gaussian Blurring

(c) The result of ORB method (Total keypoint: 360 True matched keypoints: 0)
(d) The result of proposed method (Total keypoint: 4418 True matched keypoints: 44)

40 test images, from created database, are blurred using the following parameters: *5x5*, *7x7* and *9x9* kernels. Figure 6 gives the average detection ratios of the methods. The results are also compared with ORB as can be seen in Fig 6. The proposed method has higher *DR* compared to ORB.

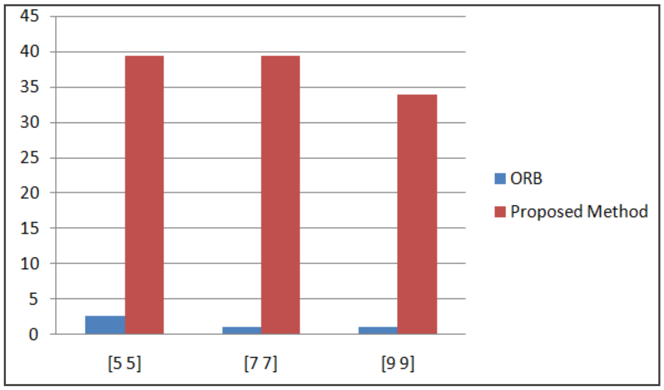


Fig. 6.Comparison test results for Gaussian Blurring

Our last experiment is for images attacked on JPEG compression. In Fig. 7(b) the image forged with grass and being attacked from JPEG compression with quality factors QF=90.As shown in Fig. 7(c) ORB has no true matching on forged region. In Fig. 7(d) 24 true matching are obtained with our proposed method.

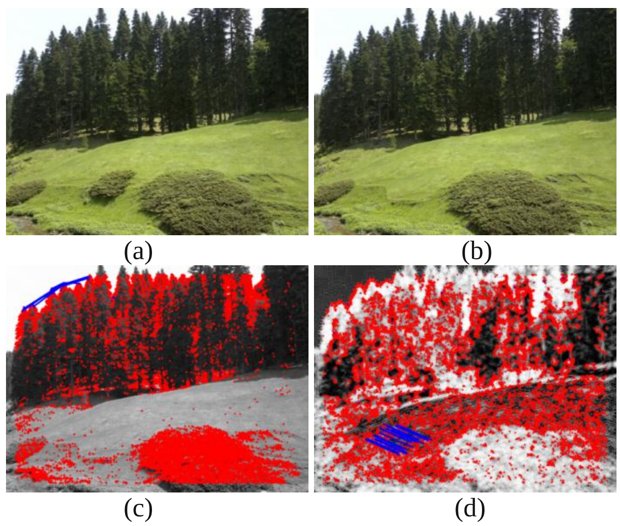


Fig. 7.(a) Original image (b) Forged image and attacked on JPEG compression
(c) The result of ORB method (True matched keypoints: 0)
(d) The result of proposed method(True matched keypoints: 24)

We also experiment JPEG compression for 40 tampered images again from our created database were with different quality factors QF=70, 80 and 90. Fig. 8 indicates that the proposed method has higher average DR compared to ORB for jpeg compression.

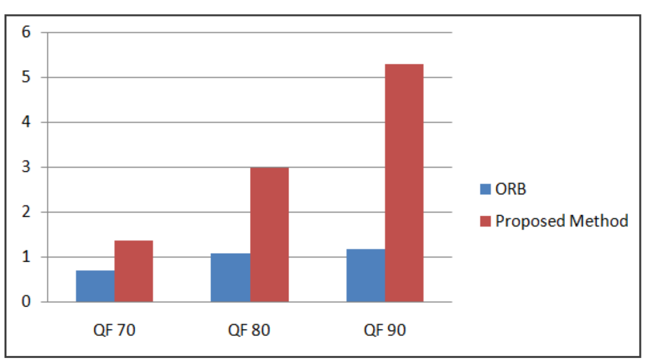


Fig 8. Comparison test results for JPEG compression

4. Conclusions

In this study a novel keypoint-based copy move forgery detection method is proposed. As a keypoint based technique ORB cannot detect forgery on the smooth regions because it uses FAST corners. The image texture retrieval with Gabor filter from smooth regions is achieved. Then ORB is used as feature extraction method. Thus, ORB keypoint extraction algorithms are applicable on the structural information and extract keypoints from the structural information of the smooth regions. Thus, one of the most important disadvantages of the ORB is eliminated by the proposed method.

5. References

[1] J. Fridrich, “Detection of copy -move forgery in digital images” Digital Forensic Research Workshop, Cleveland, OH, pp. 19-23, 2003 .

[2] A. C. Popescu H. Farid “Exposing digital forgeries b detecting duplicated image regions” Tech. Rep. TR2004 -515, Department of Computer Science, Dartmouth College, 2004.

[3] S. Bayram, H. Sencar, N. Memon, “An efficient and robust method for detecting copy-move forgery ” IEEE International Conference on Acoustics, Speech and Signal Processing, 2009

http://dx.doi.org/10.1109/icassp.2009.4959768

[4] H. Huang W. Guo and Y. Zhang “Detection of Copy -Move Forger in Digital Images Using SIF Algorithm ” in Proceedings of IEEE Pacific-Asia Workshop on Computational Intelligence and Industrial Application, Vol. 2, pp. 272-276, 2008.

[5] Amerini I, Ballan L, Caldelli R et al, “A SIFT-based forensic method for copy–move attack detection and transformation recovery”. IEEE Trans Inf Forensic Secur 6:1099–1110. doi:10.1109/TIFS.2011.2129512,2011.

http://dx.doi.org/10.1109/TIFS.2011.2129512

[6] Xu Bo, “Image Copy-Forgery Detection Based On SURF”, IEEE Multimedia Information Networking and Security (MINES), 2010 International Conference , Nanjing, Jiangsu, Nov 4-6, 2010.

http://dx.doi.org/10.1109/mines.2010.189

[7] Zhu Ye, Shen Xuanjing and Chen Haipeng, “Copy-Move Forgery Detection Based on Scaled ORB”, Proceedings of Multimedia Tools and Applications, vol. 75, no. 9, 2015.

[8] Fischler MA, Bolles RC “Random sample consensus: a paradigm for model fitting with applications toimage analysis and automated cartography.” Commun ACM 24:pp 381–395 , 1981.

http://dx.doi.org/10.1145/358669.358692

[9] J. G. Daugman, “Two-DimensionalSpectral Analysis of Cortical Receptive Field Profile”, Vision Research, Vol. 20, pp. 847-856,1980.

[10] R. C. Gonzalez and R. E. Woods, “Digital Image Processing”, Third Edition, 2008.

[11] Rublee E, Rabaud V, Konolige, “ORB: an efficient alternative to SIFT or SURF”,ICCV: pp. 2564–2571,2011

[12] Rosten E, Drummond T, “Fusing points and lines for high performance tracking.”,ICCV: pp. 1508–1515, 2005.

http://dx.doi.org/10.1109/iccv.2005.104

[13] Dijana Tralic, Ivan Zupancic, Sonja Grgic and Mislav Grgic, “CoMoFoD - New Database for Copy-Move Forgery Detection,” in 55 International Symposium ELMAR, 2013.