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Review on Local Binary Patterns Variants as Texture Descriptors for Copy-Move Forgery Detection

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***Abstract*— Past decades had seen the concerned by researchers in authenticating the originality of an image as the result of advancement in computer technology. Many methods have been developed to detect image forgeries such as copy-move, splicing, resampling and et cetera. The most common type of image forgery is copy-move where the copied region is pasted on the same image. The existence of high similarity in colour and textures of both copied and pasted images caused the detection of the tampered region to be very difficult. Additionally, the existence of post-processing methods makes it more challenging. In this paper, Local Binary Pattern (LBP) variants as texture descriptors for copy-move forgery detection have been reviewed. These methods are discussed in terms of introduction and methodology in copy-move forgery detection. These methods are also compared in the discussion section. Finally, their strengths and weaknesses are summarised, and some future research directions were pointed out.**

***Keywords*— LBP variants; feature extraction; digital image forgery; copy-move**

I. Introduction

Advancement in information technology has allowed the transmission of digital images from one place to another place very easily. Compared to word, image can explain any situation in much better form as it enables us to understand vividly. Nowadays, images had been the convenient way to express and transmit information in the field of medical imaging [1], law enforcement and forensic investigation. However, the availability of various powerful computer applications such as Adobe Photoshop, GNU Image Manipulation Program (GIMP) and Paint.NET, cause the authenticity of an image to be questioned as forgery over an image can be performed easily and frequently but very difficult to identify. In order to understand the process of image forgery, it is necessary to pay attention to the type of manipulation that can be done by the image editing tools in changing the features of an image. The process of forgery will likely leave an artifact [2] or unnatural correlation [3] that can be analysed to reveal the kind of manipulation done by forgers.

In the field of image forgery, there are several types of tampering that had been investigated. Fig. 1 until 5 shows the appearance of the image after being forged by copy-move, splicing, retouching, morphing, and resampling, respectively. The details of the forgery are provided in Table 1.

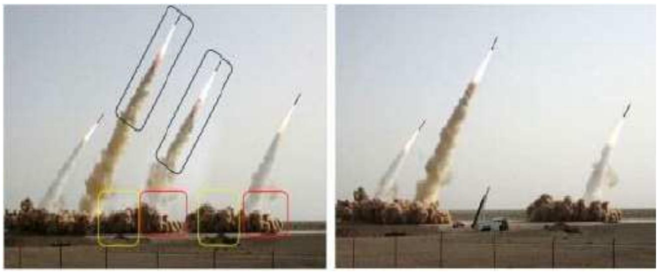

Fig. 1 An example of copy-move forgery

Fig. 2 An example of splicing

Fig. 3 An example of image retouching

Fig. 4 An example of image morphing

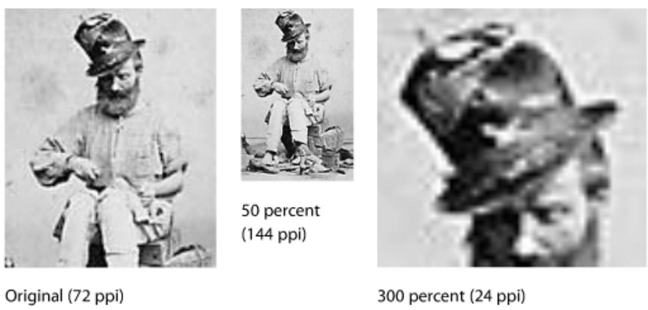

Fig. 5 An example of image resampling

However, copy-move forgery is the most dominant form of digital image tampering where some objects are being cloned in the same image [4]-[8]. Christlein *et al.* [9] supported the statement by stating that within this field, copy-move forgery detection (CMFD) is probably the most actively investigated subtopic. CMFD is known to have a high level of difficulty since the copied region has almost similar characteristics in terms of texture, noise, and colour with the host image. Besides, [10] stated that to make matter worst, the copied region is pasted on multiple locations (one-to-many) or several copied regions are pasted on multiple locations of the same image (many-to-many).

Furthermore, most of the tampered images do not solely involved plain copy-move but also being tampered by post-processing attacks such as photometric manipulations and geometric transformations which make it more challenging [11]-[12]. JPEG compression, Gaussian additive noise, blurring, brightness adjustment, colour reduction, and colour contrast are the examples of photometric manipulations while rotation and scaling are the examples of geometric transformations.

Additionally, forgers make the process of validating the authenticity of an image become more difficult by combining the attacks [13] such as rotation with Gaussian noise, rotation with blurring, scaling with JPEG compression and much more. Fig. 6 shows the type of manipulation exists in copy-move forgery.

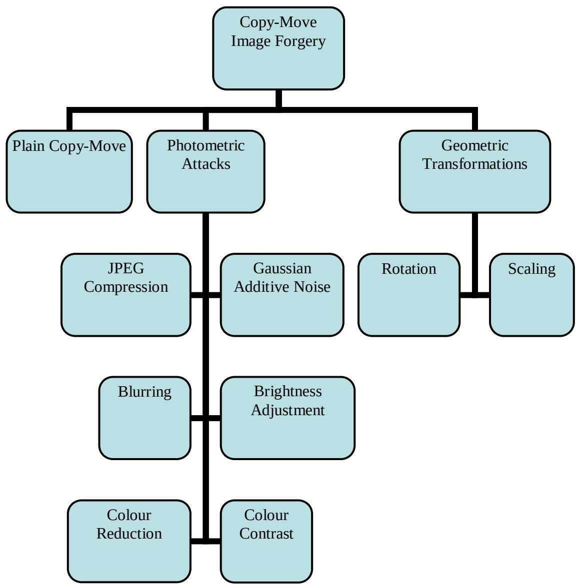

Fig. 6 Type of manipulations in copy-move forgery

These combined attacks normally change the image texture, thus, requiring great effort to detect the forgery. Image texture may provide information about the physical properties of objects, such as smoothness or roughness, or differences in surface reflectance, such as colour [14],[15]. Although the texture is easy to identify, it is difficult to define. As a result, many texture descriptors had been introduced. Since the 1960s, texture analysis has been a topic of intensive research, and over the years, a wide variety of techniques for discriminating textures have been proposed. In recent years, some very discriminative and computationally efficient local texture descriptors have been developed. The robustness of performance offered by these new descriptors has led to significant progress in applying texture-based methods to a large variety of computer vision problem. Among all existing local texture descriptors, LBP operator is one of the best local texture descriptors for copy-move forgery detection [10].

On the basis of the comprehensive literature review, the widely used local texture descriptors for copy-move forgery detection method had not yet been reported. This review discusses the development, comparison of the methods in terms of the advantages and disadvantages, as well as future challenges. The contribution of this study will help researchers in the field of copy-move forgery detection to choose a robust descriptor that can withstand against combined attacks involving geometric transformations and photometric attacks.

TABLE I
TYPES OF DIGITAL IMAGE FORGERY

Types	**Details**
Copy-Move	Copy-move forgery is one type of image tampering that involves the process of copying and pasting a part of the image on another part within the same image. Basically, this forgery aims to conceal unwanted parts of the image either by adding or hiding certain part.
Splicing	Splicing is a form of tampering by creating a composite image from two different source images with the aim to alter its content. The creation of the forged image is called as spliced or single composite image.
Retouching	Retouching is a technique that does not show obvious manipulations after changing the features. This method is highly used for commercials by the professional image editors especially for magazine covers by changing the background, adjusting contrast, and others to make the appearance more attractive.
Morphing	Image morphing is a technique that is used for the metamorphosis of one image to another. The result of the morphed image will look similar to both of the source image and the target image. It is also known as a process of generating the intermediate images from the source image to the destination image.
Resampling	Resampling is the result of the image that undergoes geometric transformations to create a high-quality forged image. Rotation, scaling, stretching, skewing, and flipping are among geometric transformations that involved in image resampling.

II. MATERIAL AND METHOD

Feature extraction method is very important in detecting forgery. Feature extraction aims to compute the specific representation of the data that can highlight relevant information [1]. Besides, it is a useful tool for removing irrelevant or redundant information and reducing feature dimensionality [16]. LBP variants are methods under the group of binary descriptors for extracting image features by describing the spatial structure of the gray image texture. With the rapid growth of real-time applications, binary descriptors which aim primarily at fast runtime and compact storage have become increasingly well-known [17].

Zheng *et al.* [18] developed rotation invariance method that used texture features based on Local Binary Pattern (LBP) [19]-[22], where the features are directly extracted from each overlapping block. The proposed method has low computational time even though it does not convert colour images to grayscale. Additionally, it is not only invariant to the rotation but also robust to noise and blurring attacks. Another rotation invariance method has been proposed by [22] where they used LBP operator to describe the image texture from grayscale images. However, these images are contaminated with noise, lossy JPEG compression, and several other post-processing attacks that can cause high false positives. Thus, a Gaussian low-pass filter is used in pre-processing to improve image quality by removing noise contained therein where filtering by more than twice can increase the detection performances [23]. The properties of LBP is capable of reducing the computational complexity problem [24]. The matching process is done by calculating the Euclidean distances for each block of the image. Although this method is invariant to rotation and flipping, it cannot detect forgeries that involve rotation at different angles.

AlSawadi *et al.* [25] introduced a method using LBP and neighbourhood clustering, which does not consider the gray-level images as conversion process may cause a loss in some weak but important traces of forgery. Instead, the input image is decomposed into three colour components to utilise multiple information presents in the different colour component. The method calculates the LBP histograms for blocks from each component as the features. This method is not only able to reduce the false positives but also robust to rotation and scaling. However, the performance decreases when handling the combination of rotation and scaling attacks.

Tralic *et al.* [26] present a new approach for CMFD where cellular automata (CA) is used. CA is used to calculate the feature vectors for each overlapping block because it can properly describe the texture of blocks by learning a set of rules for those blocks. Those rules appropriately describe the intensity of changes in every block and are used as features for detection of duplicated areas in the image. A reduced description based on a proper binary representation using LBP is proposed to solve the issues with a large number of pixel intensities in grayscale images that result in a combinatorial explosion in the number of possible rules and an even larger number of possible subsets of rules. The proposed method shows a very accurate detection in most cases that involve plain copy-move forgery and forgery with photometric attacks. Coping with the addition of noise and JPEG compression is possible when pre-processing is applied. This method performed pre-processing using an averaging filter prior to the detection process. However, there are some cases when detection is not satisfactory, such as the presence of areas with many pixels of similar values that result in many blocks being falsely detected. Aside from that, the detection of geometrical transformation such as scaling and rotation of the copied region is beyond the scope of the proposed method.

Muhammad *et al.* [27] introduced the usage of steerable pyramid transform (SPT) and LBP for image forgery detection. The feature vector for this method comes from the LBP histograms of each SPT subbands. The motivation of using translation and rotation invariant SPT in the proposed method is because of the function of SPT as a multi-resolution technique. Though another multi-resolution technique, DWT [28] is used before in image forgery detection, there is no orientation filtering involved in DWT. Support Vector Machine (SVM) is applied to classify images into forged or authentic. The method is robust for copy-move and splicing forgery with and without geometric transformations. However, this method is not developed for handling images tampered with post-processing methods.

Dixit *et al.* [29] introduced a new hybrid approach based on Discrete Wavelet Transform with LBP to resolve problems of finding a forged section of varying size and located at different locations on the image. The proposed method gave a high accuracy for plain copy-move forgery detection and low complexity of block pairs matching as lexicographical sorting had been used. However, it does not develop to detect image tampered with post-processing attacks.

Liao *et al.* [30] developed Dominant Local Binary Patterns (DLBP) to extract image features for texture classification. The proposed features are robust to image rotation, less sensitive to histogram equalisation and noise. It comprises of two sets of features which are DLBP in a texture image and the supplementary features extracted by using the circularly symmetric Gabor filter responses. The DLBP method makes use of the most frequently occurred patterns to capture descriptive textural information, while the Gabor-based features aim at supplying additional global textural information to the DLBP features.

Guo *et al.* [31] developed a completed modelling of the LBP operator for texture classification by developing an associated completed LBP (CLBP) scheme. The proposed method combined the original LBP with the measures of local intensity difference and central pixel-gray-level. This method is invariant to the rotation as it inherits the ability of original LBP. However, it is very sensitive to noise [32]-[36] as the centre pixel gray-level is still used as the threshold directly [37].

Davarzani *et al.* [38] proposed a CMFD method using Multi-resolution Local Binary Patterns (MLBP), which considered the gray-level images. The Wiener filter is used to improve the detection performance. MLBP is applied to every block after filtering to extract the features. Both lexicographical sorting and KD tree is used for time reduction and accuracy enhancement in the matching phase. Finally, the parameters of geometric transformations are determined, and the removal of the possible false matches is attained. The proposed method not only detects duplicated regions but also determines the geometric transformations applied to the tampered regions. Although this method is invariant to common post-processing operations including rotation, scaling, JPEG compression, Gaussian blurring, and Additive White Gaussian Noise (AWGN), it cannot detect duplicated regions with arbitrary rotation angles, low performance with a scaling factor above and below 1.1, and still time consuming for forgery detection in high-resolution images.

Previous work had been revised by [37] where the parameters for most common attacks and degree of rotations were included. The authors proposed a novel approach for detection of copy-move forgery using Completed Robust Local Binary Pattern (CRLBP). Compared to original LBP, the value of each centre pixel for CRLBP is replaced by its average local gray-level [34]. The proposed method consists of filtering the tampered images using a hybrid filter of the adaptive mean filter and adaptive wiener filter before being divided into overlapping blocks to remove the noises, blurring, and also reduces the effect of JPEG compression simultaneously from the image. As a result, the quality of image had been enhanced while preserving its details for efficient and precise detection. The CRLBP method is invariant to rotation [39], [40] and most common post-processing methods such as JPEG compression, noise, and blurring with accuracy up to 96%. In addition, a new technique was introduced to solve the false match problem which caused by flat region. Unfortunately, the proposed method is still time-consuming for forgery detection, especially in the high-resolution images.

III. Result and Discussion

The reason behind the usage of LBP variants for feature extraction is because of the good properties of the methods in extracting texture, which remains similar in the copied and pasted area even some post-processing is applied after forgery. Therefore, the texture pattern can be a good indicator of forgery detection. Table 2 and 3 show the main function of LBP variants against possible attack(s) and the strength and weakness of LBP variants in copy-move forgery detection, respectively.

IV. Conclusions

In this review, several commonly used LBP variants for copy-move forgery detection are reviewed. Table 2 shows the advantages and disadvantages of each method discussed in this review. As the awareness of image forgery detection increases over the years, many methods have been developed to detect copy-move forgery with plain copy-move and post-processing attacks. LBP variants discussed here are based on texture which remains similar in the copied and pasted region even after some post-processing attack is applied. Therefore, the texture pattern can be a good indicator of forgery detection.

However, there are some issues and challenges remain in copy-move forgery detection. One of the issues is the high computational complexity, and this, in turn, results in a lexicographical sorting which is needed to reduce the time complexity. Another issue would be multiple attacks due to many manipulations possible to be done by forgers. Most of the existing approaches are limited to handle plain copy-move and single attack only. Although multiple attacks had been concerned by researchers nowadays, yet, only a few methods have been developed to solve them. Therefore, there is a need to develop methods that are efficient to deal with these challenges.

TABLE II

MAIN FUNCTION OF LBP VARIANTS AGAINST POSSIBLE ATTACK(S) IN COPY-MOVE FORGERY DETECTION

Reference	Method	Main Function	Possible Attack(s)
[18]	LBP	Used for identifying spatial image texture	-Rotation -Noise -Blurring
[22]	LBP and Gaussian filter	Calculating residual map to estimate the correlation pattern	-Rotation -Flipping
[25]	LBP and neighbourhood clustering	Texture pattern is a good indicator of forgery detection where the copy-moved blocks have similar LBP histograms while neighbourhood clustering technique is applied to remove isolated block candidates	-Rotation -Scaling
[26]	LBP and CA	Extracting feature vectors from overlapping blocks and use CA to learn a set of rules	-Noise -JPEG compression
[27]	LBP and SPT	SPT yields a number of multi-scale and multi-oriented subbands. Then, LBP histograms describe the texture in each SPT subband	-Rotation -Translation
[29]	Hybrid of LBP and DWT	LBP is calculated for blocks to generate descriptors to match similar blocks while DWT is applied over image for decomposition of image which reduces the computational cost	-Rotation -Scaling -Blurring -Noise addition -Flipping and bending
[30]	DLBP	Makes use of the most frequently occurred patterns to capture descriptive textural information	-Rotation -Noise
[31]	CLBP	Defining three operators, CLBP_C, CLBP_S, and CLBP_M to extract the image local gray level, the sign, and magnitude features of local difference, respectively	-Rotation
[37]	CRLBP	Extracting features for the purpose of copy-move forgery detection by substituting the central value of 3*3 pixels with average local gray level	-Rotation -Additive noise -Blurring -JPEG compression
[33]	MLBP	Combining the information provided by multiple LBP operators for feature extraction process	-Rotation -Scaling -JPEG compression -Blurring -Noise

TABLE III

STRENGTH AND WEAKNESS OF LBP VARIANTS

Reference	Method	Strength	Weakness
[18]	LBP	-Low computational time -Rotation invariance -Robust to noise and blurring attacks	-Not scale invariance -Handle single attack only
[22]	LBP and Gaussian filter	-Low computational time -Rotation invariance -Flipping invariance	-Limited to certain angle of rotation -Not scale invariance -Handle single attack only
[25]	LBP and neighbourhood clustering	-Reduce false positive -Efficient for handling single attacks	-Low performance for multiple attacks
[26]	LBP and CA	-Robust for plain copy-move	-Low performance for large similar areas -Unable to handle geometric transformations
[27]	LBP and SPT	-Rotation and translation invariance -Robust for handling plain copy-move and geometric transformations	-Unable to handle photometric attacks
[29]	Hybrid of LBP and DWT	-Robust for plain copy-move -Low computational complexity -Low false positive	-Unable to handle post-processing attacks
[30]	DLBP	-Rotation invariance	-Unable to handle scaling attack -Unable to handle multiple attacks
[31]	CLBP	-Rotation invariance	-Sensitive to noise -Unable to handle scaling attack
[38]	CRLBP	-Low false positives -Rotation invariance	-High computational time for high-resolution images
[38]	MLBP	-Low computational time -Robust to plain copy-move and geometric transformations	-Limited to certain angle of rotation -Limited to certain range of scale -High computational time for high-resolution images

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