A Novel Region Duplication Detection Algorithm based on Hybrid Approach

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Abstract

The digital images from various sources are ubiquitous due to easy availability of high bandwidth Internet. Digital images are easy to tamper with good or bad intentions. Non-availability of pre-embedded information in digital images makes the tampering detection process more difficult in case of digital forensics. Thus, passive image tampering is difficult to detect. There are various algorithms available for detecting image tampering. However, these algorithms have some drawbacks, due to which all types of tampering cannot be detected. In this paper researchers intend to present the types of image tampering and its detection techniques with example based approach. This paper also illustrates insights into the various existing algorithms and tries to find out efficient algorithm out of them.

Keywords- Image Tampering, Image Splicing, Image Cloning, Image Retouching

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1. Introduction

The first incidence is occurred in decade of 1840 according to the image tampering history. The first forged image has been produced by Hippolyta Bayard. His famous tampered picture is committing suicide. There is hardly difference between Digital Image Tampering and Conventional Image Tampering. The only difference in the digital images and conventional images is black films and photographs. Nowadays, anyone can swimmingly produce fake or forged image with the help of image editing applications like GIMP, Adobe Photoshop, Picasa, lightroom etc.

1.1 Objectives

The alteration in digital image is the main aim of image tampering. This image tampering may be done to hide the information in an image or purposely to send some private or confidential signals from sender to

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The objective of this paper is to build a system, which will detect all the types of tampering in an image.

1.2 Applications

Image tamper detection techniques can be applied in following areas to detect tampering:
1. Surveillance System
2. Medical Imaging
3. Journalism
4. Criminal Investigation
5. Social Networking sites threats
6. Intelligence Services

The leftover section of the paper is structured as: Literature review is discussed in Section II. Section III presents Results and Evaluation parameters values of different author’s implemented algorithms. Section IV addresses the Analysis of exiting techniques. Section V concludes with future scope.

2. Literature Overview

2.1 Image Tamper Detection

Image tamper detection is a part of Digital Forensic, which has an objective of revitalization with analysis in tampered images [1]. Classification of image tampering is shown in Fig. 1. There are two approaches for image tampering which are Active and Passive.

In active Image Tampering, an image is having pre-embedded information, such as fingerprint or watermark. Original image knowledge is required to detect tampering in this type of techniques [2].

In passive image tampering, pre-embedded information of an image is not required [3]. Knowledge of an Original image is also not required in this type of tamper detection technique [4]. Using Passive tamper detection techniques, the tampering can be detected for major images from magazines, newspapers, posters, various websites etc [5].

There are three categories of passive image tampering, which are image retouching, image cloning and image splicing. If an image is tampered using Blurring, Scaling and Rotation, then it is an example of an
image retouching. An image retouching is also done using Pixel temperature change and object colour modifications. Fig. 2 shows the pattern of this type of tampering.

![Image Retouching](image-retouching.png)

In an image cloning technique, the duplication is done in an image using one or more pieces of the same image [6]. Hence, it is also called as region duplication. Fig.3 shows the pattern of this type of tampering and its detection.

![Image Cloning](image-cloning.png)

In the third type of tampering technique i.e. image splicing, one or more pieces from different images are combined together. Fig. 4 shows pattern of this type of tampering.

![Image Splicing](image-splicing.png)

Image tamper detection, in passive techniques, is not an easy job as compared to the active techniques. It is because in passive techniques pre-embedding information is not present [7]. So, the focus of this study is on passive image tamper detection.

2.2 The Processing Pipeline for Detection of Passive Image Tampering

The process of passive image tamper detection includes various steps like, essential pre-processing
techniques for an image, Feature can be extracted from an image, matching of feature vectors, filtering as per the requirement and post-processing [8]. There is a general processing pipeline to detect tampering in an image which is shown in Fig.5.

![Fig.5. Process of Image Tamper Detection](image)

Pre-processing technique on an image includes colour to gray scale translation, image resizing, conversion to binary format, Skeletonisation, Morphological Operation, and separation of plane [9][10].

Feature extraction is known as dimensional reduction, which is classified into block based and key point based [8]. The focus is on high entropy points of an image in key-point approach. The various algorithms are applied on those high entropy points to find out feature vectors [11]. Similarly, the image splits into blocks of specified size like 8*8 or 16*16 and then feature extraction algorithms are applied [12]. Feature vectors of an image can be obtained using various algorithms which are discussed in later section.

The next step is the matching of feature vectors. For matching process, there are various techniques like kd-tree algorithm, Lexicographic sorting etc. Thus, these matching pairs are of tampered part of an image.

False matches can be minimized using filtering. False tampering is detected using intensities of neighbouring pixels. Matched pairs are conserved using final step post-processing. The processing pipeline for detection of an image tampering is shown in Fig.5.

Major important algorithms are reviewed as follows:

**Scale Invariant Feature Transform (SIFT)**

Features of digital images are extracted using SIFT algorithm. The extracted features are then compared with each other to trace the duplicate region [13]. The drawback of this method is high dimensionality of the SIFT descriptors. There is scope for improvement in the existing technique.

**Speed Up Robust Features (SURF)**

From digital images, features are extracted using SURF algorithm and then using adjacent neighbouring; the matching of vectors is done. SURF features are invariant to scale and rotation. It is also detects tampering if there are noise, blurring and jpeg compression present.

**Zernike**

ZERNIKE moments are superior in all the terms with respect to insensitivity to image noise, information content etc [14]. These moments are rotation invariant [15]. Affine transformation is still weak in this method.

**Hue Moments**

These moments are rotation invariant. To identify various typed characters, Hue’s moments are used in a pattern recognition research. The computation of Hue moment from normalized and centralized moments having degree three are shown in nth Hue invariant moment:

\[
I_1 = \eta_{20} + \eta_{02} 
\]

\[
I_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2 
\]
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\[ I_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \]  
\[ I_4 = (\eta_{30} + \eta_{12})^2 + (3\eta_{21} + \eta_{03})^2 \]  
\[ I_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})(3(\eta_{21} + \eta_{03})^3 + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})(3(\eta_{30} + \eta_{12})^3 - (\eta_{21} + \eta_{03})^2) \]  
\[ I_6 = (\eta_{20} - \eta_{02}) [(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2(42) + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})] \]  

To distinguish mirror image, a skew invariant is used as follows:

\[ I_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2 + (3\eta_{30} - \eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \]

In this paper, a hybrid or mixed proposition, based on key-point and blocks, is presented with experimental results. This approach elevates the drawbacks of traditional approaches. The memory requirement is higher for algorithms, which are based on key-points than based on blocks. The false positive detection in image tampering is occurred due to JPEG compression in block-based approach [16]. Amount of high-dissimilarity and identity resemblance of non-copied regions are more challenging tasks in key-point based algorithms, whereas block based approach is efficient to detect the same. In general, the key-point based algorithms give best results for an image, which is rough in nature; whereas block based algorithms give best results for an image, which is smooth in nature. These are benefits and drawbacks of traditional approaches of image tamper detection. Hence, the presented approach elevates the drawbacks of traditional approaches. In the presented hybrid approach, global features are extracted using Hue Moments and local features are extracted using SIFT algorithm [17] [18].

3. Results and Evaluation Parameters

There are various descriptors explained in literature above. For this experiment MICCF220 database is used. For this experiment, a novel combined approach based on key-points (SIFT) and blocks (Hue Moments) are used. The results of various scenarios are shown in the following figures which are Fig. 6, Fig. 7 and Fig. 8:

![Fig.6. Result of hybrid (key-point based with block based) approach](https://ssrn.com/abstract=3425340)
In above experimental results, top row contains original image, tampered image and images divided into overlapping blocks sequentially and bottom left window shows extracted key-points, bottom middle window shows combined features of key-point and block based approach and bottom right window shows detected tampered region of image.

The evaluation parameters for above experimental result are Recall, Precision, F1 Score and Accuracy.

4. Comparative Analysis

Precision can be calculated as the possibility that detected tampering is of true tampering. Recall can be
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\[
\text{Precision (P)} = \frac{(\text{True Positive (TP)})}{(\text{True Positive (TP)}) + \text{False Positive (FP)}}
\]

\[
\text{Recall (R)} = \frac{(\text{True Positive (TP)})}{(\text{True Positive (TP)}) + \text{False Negative (FN)}}
\]

\[
\text{Accuracy} = \frac{(\text{True Positive (TP)} + \text{True Negative (TN)})}{(\text{True Positive (TP)} + \text{False Negative (FN)} + \text{True Negative (TN)} + \text{False Positive (FP)})}
\]

\[
F1 \text{ score} = \frac{2\times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}
\]

The comparative analysis of these results is mentioned in table 1.

| Method     | Precision | Recall | Accuracy | F1 Score |
|------------|-----------|--------|----------|----------|
| Hue [2]    | 67.61     | 74.89  | 70.14    | 80.67    |
| SIFT [2]   | 88.37     | 79.17  | 67.18    | 90.53    |
| Hybrid Approach | 97.68     | 96.04  | 92.48    | 96.85    |

The comparison is shown using graphical presentation in fig.9. The hybrid system, which is the combination of SIFT and Hue Moments, gives the highest values for all analytical parameters in regards to detect tampering.

![Fig.9. Comparative Analytical graph of SIFT, Hue and Hybrid Approach](image)

5. Conclusion

This study concludes that; the hybrid approach elevates the drawbacks of traditional algorithms by combining feature vectors of SIFT and Hue Moments algorithms. As results show hybrid approach in image tamper detection are the most efficient in all analytical parameters that are Recall, Precision, F1 Score and Accuracy. As it has almost 95% significance level, it is the most appropriate method for different genres of images such as flat surface, rough surface, multiple tampering in one image, rotated and scaled tampered image. This paper definitely helps other researchers and the domain experts to select image tamper detection techniques and hybrid approach over other techniques and approaches to get efficient results.

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6. Future Scope

In existing literature, there is no single system present, which can detect the tampering in an image with all three categories of passive approach. If such kind of system will be developed in future, then that will be helpful for social cause.

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