Digital Media Image Recognition Method Based on Improved Fuzzy C-means Clustering Analysis

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Abstract. Digital media plays a more and more important role in people's life. In recent years, as an important part of digital media, image is widely used. It has become a hot spot in image information processing to determine the similarity between images by calculating the perceptual hash. This paper mainly studies the intelligent traceability of digital image based on improved fuzzy c-means clustering analysis. This method can improve the information truth degree identification of data image, which can assist the development of data image information detection and recognition system based on improved fuzzy c-means clustering analysis. Firstly, this paper analyzes the value of image recognition technology in streaming media environment. For the current streaming media image recognition technology, the main application areas and demand state are described. Then, from the perspective of technology, several main technologies in this field are discussed, and the digital image technology of improving fuzzy c-means clustering analysis is analyzed and constructed. Experimental results show that the method can improve the efficiency and accuracy of digital media image recognition. This method has a certain reference value to promote the development of digital image analysis technology.

Keywords: Digital Media, Image Information Processing, Improved Fuzzy C-means Clustering Analysis, Intelligent Traceability

1. Introduction
In modern life, digital cameras are almost everywhere, and a large number of digital images produced by them appear in society and all walks of life [1]. With regard to the research in the field of digital image, the demand of digital image forensics technology is growing [2-3]. For example, forensic scholars have been focusing on the research of specific image sources for a long time.

With the rapid development of electronic imaging technology and modern network construction, in daily life, people can easily and quickly share their own or others' digital images with others through the Internet [4]. At the same time, the technology of using computer to process, edit and modify digital images is becoming more and more mature, and the utilization rate of this technology is also getting higher and higher [5]. There are many editing and processing tools for digital images, but when these processed digital images are used in official media, court evidence and scientific research, they will cause a series of information security problems and affect the harmonious development of society [6-7].
Multimedia transmission technology in life has been very mature, people's lives have been everywhere digital images, but in the increasing progress of scientific and technological products, its negative impact with the improvement of people's high-quality modern life is also growing. In the digital age, no matter what industry or any enterprise you work in, no matter what profession you major in or what role you play in your life, it is not difficult to make a fake digital image. Various technologies and products used to promote the progress of human society may also be used by lawless elements, endangering public security and even national interests.

2. Related theory of digital image source recognition

2.1. Pattern noise extraction and correlation detection

A certain type of digital camera generates a certain number of digital images. For these digital images A, the de-noising algorithm is used to get the de-noising digital image B. Then the difference between A and B is calculated to get the noise residual of these digital images. The maximum likelihood estimation or average algorithm is used to calculate the noise of the digital camera model [8]. The formula (1) for extracting mode noise is as follows [9-12]:

\[ I = g^\gamma [(1 + R) A + \Omega] + \Theta_q \]  

Where I is the digital image; g is the color channel after gain; \( \gamma \) is the gamma factor, R is the multiplicative coefficient mode noise; A is the digital image scene; \( \Omega \) is the random noise; \( \Theta_q \) is the quantization noise during JPEG compression.

Because it is difficult to solve the R pair, it is simplified according to the second-order Taylor formula:

\[ I = g^\gamma [(1 + R) A + \Omega] + \Theta_q \]

\[ = (gA)^\gamma \left( 1 + R + \frac{\Omega}{A} \right)^\gamma + \Theta_q \]

\[ = (gA)^\gamma \left( 1 + \gamma R + \gamma \frac{\Omega}{A} \right) + \Theta_q \]

\[ = I_0 + I_0 R + \Theta \]

In equation (2), R and R are combined, R represents \( \gamma R \), \( I_0 = (gA)^\gamma \) represents the non noise part of digital image, \( I_0 \) represents the influence of mode noise R on \( I_0 \), and \( \Theta \) represents the set of digital image noise.

Pattern noise is the high-frequency part of digital image. The noise residual w of each digital image I is obtained and denoised by F. the common denoising methods include wavelet transform, block matching 3-D (BM3D) filtering algorithm, principal component analysis (PCA), etc. The noise residual expression (3) is as follows:

\[ W = I - F(I) \]  

The maximum likelihood estimation formula (4) and average formula (5) for solving digital image residuals are as follows:

\[ R = \frac{\sum_{i=1}^{M} W_i I_i}{\sum_{i=1}^{M} I_i^2} \]  

\[ R = \frac{1}{M} \sum_{i=1}^{M} W_i \]  

Where m is the number of digital images acquired by a camera model; I = 1,2,..., M, R are the
camera mode noise.

2.2. Source detection enhancement technology

Enhancement technology is one of the ways to improve the performance of image source detection. Another way to improve the performance of image source detection is to use the camera reference template with high accuracy. Hu et al. Proposed a new source camera recognition method based on the mode noise of large component imaging sensor. The pixels used for correlation detection are the points with large pixel values in the camera reference template extracted from the original image, which are generally called large component. Other pixels are ignored in the correlation detection. Kang Xiangui et al. Arranged the pixel values of the extracted camera reference template from large to small by sorting, and only retained the top 5% of the largest part of the template and its position information to form the enhanced camera reference template. In the process of correlation detection, for the noise extracted from the test image, firstly, the enhanced camera reference template is used to save the pixel value of the corresponding position, and other positions are cleared, that is, the enhanced image mode noise. When the object of image source detection is a large component of pattern noise, the performance of image source detection can be improved and the computational complexity of correlation detection can be reduced. Because of the limitation of the filter, the previous work is to complete the image source detection based on mode noise in a single color channel.

CFA interpolation is widely used in digital cameras. Only half of the pixels in G color channel are recorded by sensors, and only a quarter of the original values in R channel and B channel are recorded. Then the rest of the pixels are calculated by interpolation algorithm. Korus et al. Proposed a multi-scale fusion method, which combines multiple candidate change probability maps into a single, more reliable decision map. Candidate regions are obtained by sliding windows of various sizes, so they can be expanded by introducing modulation threshold drift and content related neighborhood interaction to take advantage of the advantages of small-scale and large-scale analysis, so as to improve the positioning performance, have better shape representation and more easily detect the regions with changed pattern noise. Aiming at the problems of digital camera source detection based on pattern noise, an improved pattern noise extraction algorithm is proposed. The main idea is that based on Lukas algorithm, firstly, Wallis pre filtering is used to suppress low-frequency noise and enhance pattern noise; secondly, Sobel edge detection operator is used to effectively eliminate the complex edge texture area of the image; finally, correlation detection is carried out between the pattern noise and the reference pattern noise template. An empirical mode decomposition (EMD) method based on integrated noise reconstruction is proposed in this paper. The intrinsic noise components in the original signal are used to improve the mode confusion, and the intrinsic noise components are used to cancel each other. In this method, the key noise estimation technology adopts hard like threshold processing method, and the correlation between coefficients is ignored.

3. Parameter optimization and extended training method in unknown model checking

3.1. Parameter optimization method in unknown model checking

Most of the image source identification techniques are unable to recognize the unknown model samples due to the lack of training data of the unknown camera model. In order to solve this problem, this section proposes a parameter optimization method of k-nearest neighbor algorithm to detect unknown model samples from unlabeled training set.

For the problem of parameter K selection in k-nearest neighbor algorithm, set Q contains known model samples and unknown model samples, and set P is known model. In short, all unknown model samples in set Q are regarded as one kind of samples, and it is convenient to calculate the optimal parameter K by using ark in set Q. Two measures are defined as follows:

1) Accurate rate of unknown model (ARU) refers to the ratio of the number of unknown model images correctly detected to the total number of unknown model images. The calculation formula is as follows (6). Where a is the number of correctly detected unknown model images; A is the total number
of unknown model images.

\[ ARU = \frac{a}{A} \quad (6) \]

2) The accurate rate of known model (Ark) refers to the ratio of the number of known model images correctly detected to the total number of known model images. The calculation formula is as follows (7). Where, B is the number of known model images correctly detected; B is the total number of known model images.

\[ ARK = \frac{b}{B} \quad (7) \]

3.2. Outward bound
At present, support vector machine (SVM) has been widely used in model classification technology as a classification and recognition method with strong generalization ability, especially when it is based on multi classification task. The main idea of nonlinear SVM is to map the samples into a feature space, so that the original hypersurface model corresponds to the hyperplane model in the feature space. This method makes the sample linearly separable in the high-dimensional feature space, and its topology is shown in Figure 1.

![Figure 1 Topological graph of nonlinear support vector machine](image)

The commonly used kernel functions are: (1) polynomial kernel function; (2) linear kernel function; (3) RBF kernel function; (4) logistic regression function (also known as sigmoid). In this chapter, we use BRF kernel function and introduce it as follows:

The characteristic of RBF is that the dimension of the high-dimensional feature space it represents has no upper limit, that is to say, after any sample is mapped from the low dimensional space to the high-dimensional feature space, it can be separated linearly. The performance of support vector machine based on radial basis kernel function mainly comes from penalty factor \( c \) and kernel function parameter \( \sigma \). The penalty factor mainly affects the error ratio and classification interval of the feature space, while the kernel function parameter mainly affects the distribution of samples mapped to the high-dimensional feature space. The smaller the parameter \( \sigma \) is, the smaller the classification of the sample will be, and the easier it will lead to over fitting; the larger the parameter \( \sigma \) is, the coarser the classification of the sample will be, and the sample cannot be classified.

4. Camera model recognition method based on ensemble learning with small samples

4.1. Integrated learning

Ensemble learning method: multiple base learning machines are obtained from the sample training set by training base classifiers, and these individual learners are integrated by some combination method. In ensemble learning, if the learning algorithms of base classifiers are all trained for a certain class of models, ensemble learning is called "homogeneous" and is essentially a binary classification method. "Heterogeneous" ensemble learning includes different types of individual learners for multi
classification tasks.

Boosting is an iterative algorithm that transforms weak learners into strong ones step by step. After many iterations, it will evolve into a strong classifier with good classification effect. In training, it is easy to get a weak learner. The literature introduces its strong theoretical basis and characteristics. Figure 2 introduces the process and steps of boosting algorithm: (1) give a weight to each training sample; (2) train a base classifier, and use this classifier to test the training set, and calculate the weight of the training set to be improved from the samples with wrong classification. (3) A base classifier is retrained with the training set after adjusting the weight; (4) the last classifier with the best performance is obtained by iterating in this way.

![Figure 2 Boosting algorithm flow chart](image)

Based on the supervised learning method, every base classifier generated by boosting algorithm after the first base classifier is trained according to the error rate of the previous sample. Therefore, the algorithm can effectively reduce the error rate of the learning system. With the increase of the number of iterative training, the accuracy of the learning system in the training set continues to improve. The random sampling of features can reduce the correlation between the base classifiers, so as to solve the influence of the increase of the square error in this process.

The training set of boosting algorithm remains unchanged in each round of training, and each sample of the training set adjusts the weight according to the last learning effect, and continues to train the new base learner. Although this method can significantly improve the performance of base classifiers, due to the over fitting phenomenon caused by noise, each base classifier can only be generated in order, and the training efficiency is poor.

4.2. Analysis of experimental results

Figure 3 shows the classification accuracy of eight sets of images by five methods. There are two kinds of camera model images in image set A, and the accuracy of the five methods is over 90%. Bagging method with CART as the base learning algorithm has the highest accuracy, followed by BS method. There are three kinds of camera model images in image sets B and C, among which the accuracy of SVM and BS algorithms is the highest in image sets b and c respectively, and Adaboost method does not perform well in image sets B and C. There are four camera model images in image sets D, E and F. SVM method and Bagging method are slightly higher than BS method in image sets D and E, respectively. BS has the best performance in image sets F, which shows that the
classification performance of BS is stable in image sets containing four camera models. There are six camera model images in image sets G and H, and the accuracy of the five methods is about 80%. BS method is slightly higher than SVM method and Bagging method in image sets G and H respectively.

Figure 3 Arg_rate histogram of five methods on eight image data sets

5. Conclusion
Digital image is now known as an important way to save information, due to image editing software and high-speed network transmission, resulting in a large number of image tampering and loss of image authenticity. Digital image source identification technology greatly ensures the originality and reliability of the image. There is an unknown model in the training samples. A method of parameter optimization and extended training is proposed to solve this problem. In the research of digital image source identification technology, most methods use a large number of known model samples to train the classifier, so as to improve the performance of the classifier. The lack of sample information of unknown models leads to poor performance of most existing methods. Aiming at the problem of unknown model in data set, a method of parameter optimization and extended training is proposed.

At present, as an important branch of blind forensics technology, digital image source identification technology has great research value in judicial expertise, criminal investigation and other aspects, but most of the research results are obtained under limited conditions, and many of the research results are from various research institutions or laboratories. If we want to solve the urgent problems in practice, we also need to strengthen academic cooperation and exchange, and continue to innovate on the original research results, so as to vigorously promote the progress of technology and realize the practical significance of technology research for the society.

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