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Image Processing Technology Based on Machine Learning

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***Abstract*—Machine learning is a relatively new field. With the deepening of people's research in this field, the application of machine learning is increasingly extensive. On the other hand, with the advancement of science and technology, graphics have been the an indispensable medium of information transmission, and image processing technology is also booming. However, the traditional image processing technology, more or less has some defects, this paper introduces machine learning into image processing, and studies the image processing technology based on machine learning. This paper summarizes the current popular image processing technology, compares various image technology in detail, and explains the limitations of each image processing method. In addition, on the basis of image processing, this paper introduces machine learning algorithm, applies convolution neural network to feature extraction of image processing, and carries out simulation test. In the test, we select voc2007 dataset for image segmentation, Imagenet dataset for target detection, cifar100 dataset for image classification, and ROC curve for performance evaluation. The results show that the algorithm based on deep learning can achieve high accuracy in image segmentation, classification and target detection. The accuracy of image segmentation is 0.984, the accuracy of image classification is 0.987, and the accuracy of target detection is 0.986. Thus, image processing based on machine learning has great advantages.**

***Index Terms*—Machine learning, Image Processing, Convolution Neural Network, Feature Extraction**

I. INTRODUCTION

For image extraction useful information has become vital, and image processing technology has become vital. Image processing technology has been widely used in various fields, including video surveillance, automatic vehicle driving, industrial defect detection, agriculture, transportation, medicine, military and other fields [1]. Following the growth of science and technology, machine training techniques have rapidly returned to the forefront of people's minds. Machine learning technology provides convenience for many aspects of modern society.

Digital picture processing is now widely used. Due to the significance of picture handling skills, there has been a great advancement in image processing technology. Z. Zhu et al. [2] suggested a new multimodal approach to image merging based on image factorization and thin presentation, which can effectively fuse images. L. Mauryaa et al. [3-4] proposed a social spider optimized image fusion method, which can increase contrast while maintaining brightness while fusing images.K. Li et al. [5] used multi-peak feature fusion for map labeling, which can effectively improve labeling accuracy. Montesinos et al. [6] use Bayesian network to classify images, and the classification accuracy can be more than 90%. Singh et al. [7] used genetic algorithm to train genetic function network and then used the trained model for satellite video categorization, which solved the problem of inaccurate satellite image categorization. Maa et al. [8] analyzed an object-based supervised land cover image classification algorithm. Liu et al. [9] used polyscale depth functions to classify scenes from satellite images at high resolution, and the simulation accuracy was significantly improved. D. Meraa et al. [10] used feature selection methods to detect image targets, which can achieve real-time detection and a high detection rate.

This paper summarizes the image processing technology, compares various image technology in detail, and explains the limitations of each image processing method. In addition, this paper introduces machine learning algorithm in image processing technology, and applies convolution neural network to feature extraction in image processing, so as to effectively improve the accuracy of image segmentation, image classification and target detection, which proves the superiority of image processing technology based on machine learning.

II. MACHINE LEARNING AND IMAGE PROCESSING

A. *Image processing*

(1)Image Enhancement

Image enhancement technology adjusts various attributes of the image to make the image clearer, such as adjusting the brightness, contrast, saturation, and hue of the image to increase its clarity and reduce noise. The method of image enhancement is to add some information or transform data to the original image by certain means, selectively highlight the features of interest in the image or suppress some unwanted features in the image, so that the image matches the visual response characteristics. Sometimes the acquired image is dark, low contrast and noisy. Among them, image enhancement can be divided into two categories: frequency domain method and space domain method. The former regards the image as a two-dimensional signal and performs signal enhancement based on the two-dimensional Fourier transform. The representative algorithms in the latter spatial domain method include local averaging method and median filtering method. At this time, the image needs to be enhanced. Histogram equalization is an important image enhancement technology that can be used for the entire image or the extracted parts of the image. Both genetic algorithm and particle swarm algorithm have the limitation of falling into local minimum. There is also a direct transformation of the image to achieve the effect of image enhancement, such as: Laplacian transformation of the image using Laplacian operator, Log transformation and gamma transformation of the image, etc. Table 1

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selects several image enhancement algorithms for comparison. And digital image processing has rapidly developed into an independent subject with strong vitality in more than 40 years. Image enhancement technology has gradually involved all aspects of human life and social production, and it plays a role in the fields of aerospace, biomedicine, industrial production, and public security.

TABLE 1
SEVERAL IMAGE ENHANCEMENT ALGORITHMS

Author	work	Algorithm
Y.C. Chang [11]	Contrast and brightness enhancement	Histogram transplantation
S. Suresh and S. Lal [12]	Contrast and brightness enhancement	Modified differential evolution

In recent years, the combination of various optimisation techniques has also been of great interest. One method is the combination of a socket search (CS) with a particle cluster optimization algorithm. The cuckoo search is a global search algorithm based on population. Combining with the particle cluster algorithm and the genetic algorithm, has better results than the separate particle algorithm and the genetic algorithm in the best solution approach[13].

Next, we select several of the most common and simple image enhancement algorithms for detailed description.

1) Image enhancement based on histogram equalization

The main principle of the tool for histogram equalization based image enhancement algorithm is to redistribute the pixel values of the image. Its general application scenario is to increase the local contrast of the image. The image applied by the algorithm needs to have similar contrast between the local images of the interested part. For example, histogram equalization can be used to make the contrast of the over exposed and underexposed images more prominent, And the image with obvious difference between foreground and background. Among them, the image enhancement algorithm still has certain defects. Some images have high peaks and the contrast will not be naturally enhanced after processing; and the grayscale of the transformed image is reduced, and some details are reduced.

The calculation process of histogram equalization algorithm is as follows:

The first step, equalization process: histogram equalization ensures that the original size relationship remains unchanged in the process of image pixel mapping, that is, the brighter area is still brighter, the darker area is still darker, but the contrast is increased, and the brightness cannot be reversed; the value range of pixel mapping function is between 0 and 255. The cumulative distribution function is a single growth function, and the range is 0 to 1.

The second step is to realize the cumulative distribution function

Comparing the probability distribution function with the cumulative distribution function, the two-dimensional image of the former is uneven, and the latter is monotonically increasing. In the process of histogram equalization, the calculation formula of mapping method is as follows:

$$s_k = \sum_{j=0}^{k} \frac{n_j}{n} \quad K = 1,2,3,..L-1 \qquad (1)$$

2) Image enhancement based on Laplacian operator

The image strengthening algorithm based on the Laplace operator uses the Laplace operator for image strengthening. The major thought is to degrade the image by using the second differential of the image. In the image field, the differentiation is sharpening, and the integral is blurring. The use of second-order differentiation to degenerate the image is the use of neighboring pixels to improve contrast. There is also a Laplacian function in OpenCV, because OpenCV performs Laplace transform on an image. The image is a grayscale image, so it is equivalent to extracting more edge information of the image. The Laplace transform of digital images generally uses a 3×3 convolution kernel to convolve the image, and then an enhanced image can be obtained. Among them, the main medium for human transmission of information is language and image. According to statistics, visual information accounts for 80% of the various information received by humans, so image information is a very important information transmission medium and method. The convolution kernel is self-defined according to experimental needs. The convolution kernel used in this article is shown in Figure 1.

0	−1	0
−1	5	−1
0	−1	0

Figure 1. Laplacian convolution kernel

3)Image enhancement based on gamma transformation

Gamma transform mainly rectifies pictures having high or weak grayscale values to strengthen the comparison and achieve the effect of image correction. The calculation formula is as follows:

$$s = Cr^{\gamma} \; r\epsilon[0,1] \qquad (2)$$

Where C is a constant, γ is the gamma coefficient, and S is the pixel value after transformation. Choose different γ to get different gamma curves as shown in Figure 2.

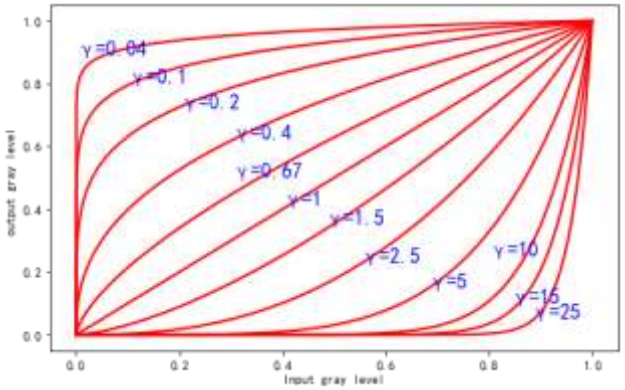

Figure 2. Gamma curve

From Figure 2, we can see some rules. $\gamma = 1$ is the dividing line. When $\gamma < 1$, the small gray value of the image has a strong expansion effect. The smaller the value, the stronger the effect. In addition, when the value of $\gamma > 1$, the expansion effect of large gray value of the image will also be enhanced, and the larger the value, the stronger the effect. In this way, we can change the value of gamma to achieve the purpose of enhancing low gray.

(2)Feature Extraction

Image features contain the basic information of the

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image, including geometric features, shape features, texture features, etc. image features are very important in the process of image analysis and processing. According to the previous research experience, the number of extracted image features is not the more the better. The more image features, on the contrary, will increase the time of feature extraction in the process of recognition and detection, thus reducing the efficiency of detection. Among them, there are many factors that affect the clarity of image quality. The uneven outdoor illumination will cause the image gray to be too concentrated; the image obtained by the camera undergoes digital/analog conversion, and noise pollution occurs during line transmission. The image quality will inevitably decrease. In the lighter case, the image is accompanied by noise and it is difficult to see the details of the image; the more severe case, the image is blurred, and even the outline of the object is difficult to see clearly. The features of images should have the following properties:

1) Scale invariance;

2) Rotation invariance;

3) It has strong anti noise ability and stable robustness to illumination;

4) At the same time, it has lower feature dimension.

Table 2 is a comparison of some feature extraction.

TABLE 2
FEATURE EXTRACTION ALGORITHM

Algorithm	Feature extraction	limitation
Multi-image saliency analysis	Extract ROI	Unwanted background information appears
Unified capability feature extraction	Rotation and scale-invariant local features	Different matching results for different data
Digital surface model	Pixel and feature level extraction of urban scenes	Multi-feature classification is difficult
Reversible jump Markov chain Monte Carlo sampler	Extract features such as rivers, channels and roads	Too sensitive to experimental settings

These are artificially designed features. With the popularity of deep learning, the most popular feature extraction method is feature extraction based on CNN. Now we will explain the feature extraction of hog and LBP.

1)HOG features

The HOG characteristic is a local feature and the HOG characteristic is obtained from computing and counting the grade histogram of the image. The HOG feature has image geometry and optical invariance characteristics because it operates on a partial image. The procedure of HOG function selection is as below:

In the first step, the image is converted into a gray image, and the conversion formula is as follows:

$$\mathrm{Gary} = 0.3\mathrm{R} + 0.59\mathrm{G} + 0.11\mathrm{B} \tag{3}$$

In the second step, gamma correction is used to normalize the color information of the image to eliminate the color interference. The calculation formula is as follows:

$$\mathrm{I}_2(\mathrm{x},\mathrm{y}) = \mathrm{I}_1(\mathrm{x},\mathrm{y})^{\mathrm{Gamma}} \tag{4}$$

Where $\mathrm{I}_1(\mathrm{x},\mathrm{y})$ is the value before correction, $\mathrm{I}_2(\mathrm{x},\mathrm{y})$ is the value after correction, and Gamma is the correction coefficient.

Then use the results of formulas (5) and (6) to calculate the amplitude and phase. The calculation formula is as follows:

$$\alpha(x,y) = tan^{-1}\left(\frac{G_y(x,y)}{G_x(x,y)}\right) \tag{5}$$

Where $\mathrm{H}(\mathrm{x},\mathrm{y})$ is the value at (x, y), and $\mathrm{G}(\mathrm{x},\mathrm{y})$ and $\alpha(\mathrm{x},\mathrm{y})$ are amplitude and phase respectively.

In the fourth step, the image is divided into image blocks, and then the image blocks are divided into cell units. The shape of cell unit can be set by itself. For example, the size of image block is divided into 16 × 16, and then each image block is divided into four 8 × 8 cell units;

The fifth step is to count the gradient histogram of each cell to form the feature descriptor of each cell; suppose that the histogram is divided into 9 bin from 0 to 360 degrees to count the gradient information of 8 × 8 pixels to form a 9-dimensional feature vector.

In the sixth step, four cells are formed into an image block, and the hog feature descriptors of all cells in an image block are put together to get the hog feature descriptor of the image block.

2)LBP features

The LBP feature is a local feature of an image. Its core idea is to use the pixel value of the center pixel of the image block as the threshold, and then compare the surrounding pixel values with the threshold. If the value exceeds the limit, it shall be recorded as 1, otherwise recorded as 0. Classify these 1 and 0 to create a binary number to represent the text information of the image. If the image block size is 3×3, an eight-bit binary number is generated. Taking a 3×3 image block as an example, the LBP extraction process is shown in Figure 3. Calculated as follows:

$$LBP = \sum_{p=0}^{7} 2^p f(g_p - g_c) \tag{6}$$

Among them, $\mathrm{g_c}$ and $\mathrm{g_p}$ are the pixel value of the central pixel and the pixel value of the p-th domain pixel respectively. f(x) is a step function, and its expression is as follows:

$$f(x)\begin{cases}1 & x \geq 0\\ 0 & x < 0\end{cases} \tag{7}$$

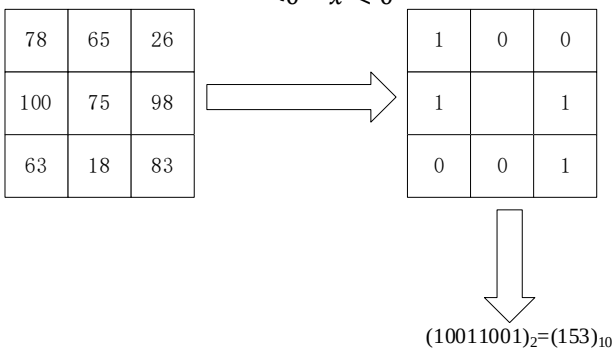

Figure 3. LBP feature extraction

3) SIFT features

Sift is a scale invariant feature inspection method. To achieve scale invariance, Sift constructs an image scale space, which is constant to the scaling, rotation and radiation shift of the image.

Firstly, the image scale space is generated, that is, the original image is sampled according to different frequencies to obtain multiple zoomed images; then, the local extremum points in the scale space are detected, which may include edge response points and some points with low contrast, which need to be excluded to leave the local extremum points which can reflect the image features

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more accurately, The histogram gradient direction of the region centered on the extreme point is counted, and the maximum direction is taken as the main direction to generate the feature descriptor. The calculation method of feature descriptor is to take 16×16 window around the feature and use Gaussian weighting to draw histogram of gradient direction in 8 directions on 4×4 image block, and count the accumulated value of each gradient direction to form a seed point. The gradient histogram of each seed point contains 8 values, a total of 128 values, which are combined into a 128 dimensional SIFT feature vector.

The matching of feature points is calculated by nearest neighbor algorithm, that is, the Euclidean distance between feature description vectors is calculated, and the point with the smallest distance is selected for matching.

(3) Image segmentation

Fragmentation is the classification of image cells into different categories, so that there are some relevant parts in each category. This is very important when you are trying to identify some important areas in an image, such as forest cover, pedestrians and vehicles. With the introduction of post-European, researchers extend the combination of these algorithms to the segmentation field.

Table 3 shows the comparative analysis results of some image segmentation.

TABLE 3
COMPARISON OF IMAGE SEGMENTATION ALGORITHMS

Image segmentation	Advantage
Cuckoo search, McCulloch method	High computational efficiency and good convergence
Markov Random Field Algorithm	Use fewer features to achieve higher accuracy
Deep Convolutional Neural Network	Efficient boundary extraction improves classification
Zhenghang Firefly Algorithm	Multi-level subdivision and less calculation time

The methods used include quantification, clustering and the possibility of finding the minimum number of clusters. In DCCN algorithm, limit detection is first added to a fragmented encoder to create a new model. It's a combination of a collective network and a coder, but the main disadvantage of this model is that it's a very large model, which merits attention for researchers. using this model. And the export limit is very vague.

(4) Image target detection

The target detection method could be classified into two sections: target placement and target identification. The position of the target and the target category are precisely in the known image. Under normal circumstances, the target in the image is uncertain, length, width, height, angle, etc. is random or there is a situation where the target is not uniform, but includes multiple categories, which bring recognition and the target position of the day. A certain degree of complexity.

(5) Image filtering

Filtering is a common method to eliminate interference in image preprocessing. It can not only suppress the image noise, but also ensure that the edge information of the target in the image is not destroyed. There are many methods for image filtering, including Gaussian filtering, mean filtering and other linear filtering, as well as median filtering and bilateral filtering in nonlinear filtering.

1) Gaussian filtering

Gaussian filtering is mainly used to eliminate Gaussian noise. Its filtering process is to weighted average the gray value of the image, that is, a two-dimensional scale factor of the Gaussian kernel convolutes with the pixels in the image to remove the noise.

2) Median filtering

Median filter is a classical nonlinear filtering method, which is very effective to eliminate salt and pepper noise, and has a special role in the phase analysis of optical measurement fringe image. The implementation process is as follows: the first step is to take the odd number of sampling points from a given sampling window in the image. The second step is to assign the middle data to the current pixel according to the sorted values.

3) Edge filtering

This method combines the compromise of geometric space proximity and pixel difference. Based on Gaussian filtering, bilateral filtering has an extra Gaussian variance. Therefore, pixels far away from the edge will not have much impact on the edge pixels.

B. Machine Learning

(1) Machine learning

What is machine learning? Machine learning is a multidisciplinary cross-specialty, covering knowledge of probability theory, statistics, approximate theory and complex algorithm knowledge. Use computer as a tool and devote to real and real-time simulation of human learning methods, and divide existing content into knowledge structure to effectively improve learning efficiency. We know that human beings will have a variety of experiences in the process of growth and life, and we will regularly summarize these past history or experience, and draw certain "rules of law". Sometimes we will label the results of these "rule rules", such as successful, failed, correct, wrong and so on. In this way, when we are faced with some new things that need to be judged and speculated, we will naturally search for and use some of the "rules" we summarize to guide our future life and work. Machine learning simulates the "learning" mode of human beings. It establishes a set of "models" by training the existing data, so as to predict the new input data. Among them, the common algorithms of machine learning include decision tree algorithm, naive Bayes algorithm, support vector machine algorithm, random forest algorithm and artificial neural network algorithm. And machine learning has a wide range of applications. Whether in the military or civilian fields, there are opportunities for machine learning algorithms, including data analysis and mining, pattern recognition, and bioinformatics.

(2) Convolution neural network

The research on convolutional neural networks can be traced back to the neocognitron model proposed by Japanese scholar Kunihiko Fukushima. Convolutional neural network is a widely used machine learning model, which is mainly used for classification and prediction. The structure of convolutional neural network includes input layer, hidden layer and output layer. Because of its multi-layer network structure, it can be used to approximate some more complex functions. The traditional image processing technology is relatively seriously affected by the environment. The convolution neural network has strong robustness, which greatly improves the recognition

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accuracy. The connections between convolutional layers in a convolutional neural network are called sparse connections. That is, compared with the full connection in the feedforward neural network, the neurons in the convolutional layer are only connected to a part of its adjacent layer, not all neurons. As a representative algorithm of deep learning, convolutional neural network has the ability to characterize learning, that is, it can extract high-order features from input information.

1) Characteristics and structure of convolution neural network

Its unique characteristics are determined by its structure. Its main characteristic is that the weights of the connected two layers of neurons are not completely connected. And in many neural network layers, the weights that connect the two layers of neural networks are not completely connected, and the connection weights of neurons in the same layer under the same filter are the same. These features reduce the number of weights and complexity of the network model.

2) The characteristics of convolution neural network

Convolutional neural networks are built on top of traditional neural networks by increasing the depth of each layer and signal processing. Its basic signal conduction is the same as the traditional neural network, which processes the leading signal through the neuron structure. The main network layer can be divided into two types: convolution layer and pooling layer.

Each layer of CNN can have some activation function to accept the product sum of input and weight, except for input layer. With the help of activation function, CNN selects the features extracted from the network by nonlinear mapping to avoid the problem of insufficient expression ability of linear operation.

(3) Feature extraction based on CNN

In this paper, CNN is applied to feature extraction of image processing. Therefore, the feature extracted by CNN has translation invariability. Using CNN to extract features is divided into the following steps:

1)Convolution layer: Use the convolution kernel to convolve the input image to obtain the result after convolution, and then pass it to the excitation layer. The convolution operation process is shown in Figure 4.

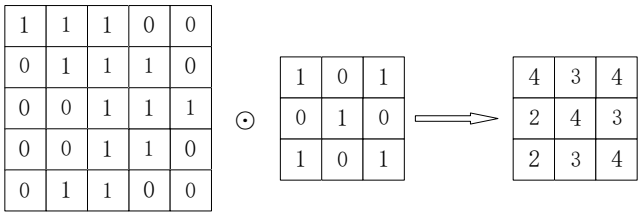

Figure 4. Convolution operation process

2)Excitation layer:Use the activation function to perform a nonlinear mapping on the output of the convolution layer. The activation function is shown below.

$$f(x) = \max(0, x) \tag{8}$$

3)Pooling layer: Reduce the dimensionality of the output of the excitation. Since the input passes through the convolutional layer, if the convolution kernel is relatively small,while maintaining the image depth while reducing the dimensionality, the pooling layer generally uses maximum pooling, and the calculation process is shown in Figure 5.

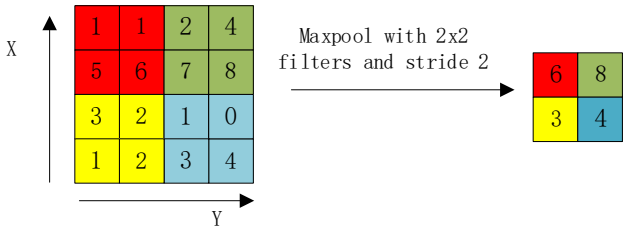

Figure 5. Maximum pooling process

The pooling process is also moved on the input graph with a window. The difference between the three pooling methods lies in the value calculation in the window. The maximum pooling is the maximum value; the average pooling is the average value of the sub sampling fast elements; and the random pooling is the random value according to its probability. Pooling is also a kind of special convolution kernel, but the difference is that pooling acts on non coincident regions in the image.

4) Fully connected layer: Re-fitting features to reduce the loss of feature information, turning the feature map output by the pooling layer into a one-dimensional feature vector, this one-dimensional feature vector is the feature that can be used for subsequent processing.

III. Performance Evaluation Method and Analysis

A. *Performance Evaluation Method*

We know that quality evaluation is very subjective. Many parameters must be used for quality evaluation. Moreover, there is opposition to it being exceptional. Quality evaluation should be compared with existing technologies to highlight the superiority of the algorithm in this Article. The calculation parameters selected in this document include FSIM, SSIM, the Accuracy and Withdrawal Rate.

(1) FSIM

The FSIM refers to the similarity of characteristics between the input image and the final image, which is calculated as follows:

$$FSIM = \frac{\sum_{x \epsilon X} S_L(x) PC_m(x)}{\sum_{x \epsilon X} PC_m(x)} \tag{9}$$

(2) SSIM

The SSIM entry specifies the format of the sequence between the last image and the sequence. The calculation formula is as follows:

$$\mathrm{SSIM} = \frac{2\mu_x \mu_y + C_1}{{\mu_x}^2 + {\mu_y}^2 + C_1} \tag{10}$$

(3) Accuracy

Exactly, it's an attempt to underestimate the overall impact of his work. The calculation formula is as follows:

$$precision = \frac{\sum_{i=1}^{N} GT_i BW_i}{\sum_{i=1}^{N} BW_i} \tag{11}$$

Where $\mathrm{BW_i}$ is the binary image of the i-th pixel, $\mathrm{GT_i} = 1$ means that the i-th pixel belongs to the region of interest, and $\mathrm{GT_i} = 0$ means that the i-th pixel e does not exist in the ROI.

(4) Recall rate

The Recall rate is the reason for the correct comments correctly provided for in the overall comments. The calculation type shall be as follows:

$$\mathrm{recall} = \frac{\sum_{i=1}^{N} \mathrm{GT_i BW_i}}{\sum_{i=1}^{N} \mathrm{GT_i}} \tag{12}$$

This metric includes both false positives and false

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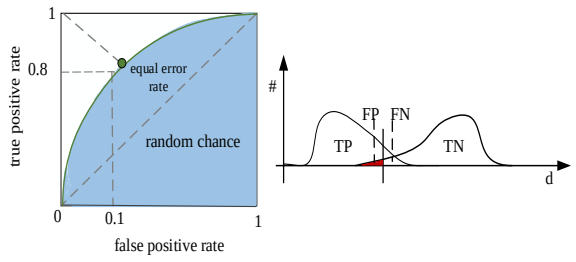
negatives, taking false negatives into account.

B. Performance Evaluation Analysis

ROC curve, also known as receiver operating characteristic curve, is also a performance evaluation standard. This curve is the effect under all possible classification thresholds. This curve is used to draw TP and FP when different classification thresholds are used. Lowering the classification threshold will result in more samples being classified as positive, thereby increasing the number of false positive and true examples.

The ROC curve is shown in Figure 6. Figure 6(a) in the figure shows that under ideal conditions.



(a) (b)

Figure 6. ROC curve

In this paper, the image segmentation, image classification and target detection algorithms based on deep learning are implemented on the public data and the above. The performance of each algorithm is quantitatively analyzed, and the performance simulation results are given. Image segmentation uses the VOC2007 data set, target detection uses the imagenet data set, and image classification uses the CIFAR100 data set.

From Figures 7, 8 and 9, we can see that, and Figure 9, that the image segmentation, classification and target detection based on deep learning algorithm can achieve high accuracy. Among them, the image segmentation accuracy reaches 0.984, the image classification accuracy is 0.987, and the target detection accuracy rate is 0.986.

IV. CONCLUSION

With the development of science and technology, machine learning technology has rapidly returned to people's vision. Machine learning technology provides convenience for many aspects of modern society. The automatic target tracking research in the field of image processing, go game and unmanned driving are all involved in the important technical field of machine learning. For this reason, the accuracy of machine learning image processing is improved based on the image processing accuracy of machine learning.

In this paper, the current popular image processing technology is summarized, and various image technology are compared in detail, and the limitations of each image processing method are explained. Then machine learning is introduced into image processing technology. In the feature extraction of image processing, convolution neural network is used to extract image features. The voc2007 data set, Imagenet data set and cifar100 data set are selected for image segmentation, target detection and image classification simulation tests, and their performance is evaluated by ROC curve.

The results show that the image processing technology based on machine learning can effectively improve the accuracy of image segmentation, classification and target detection. Artificial intelligence will continue to be a hot topic in the future decades, and as the most important research field of artificial intelligence, machine learning, evolutionary algorithm will also be greatly brilliant. We believe that the application of machine learning in image processing technology is more and more extensive, and the research results of this paper will also provide some reference value for this.

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