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Overview of Traffic Sign Detection and Recognition Methods Based on Image Processing

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Abstract

At present, artificial intelligence has been applied in a large number of driverless vehicles. Driverless vehicles have gradually entered the eyes of the public and been accepted by the majority of the public. As a result, the important guarantee of their driving safety has gradually attracted the attention of the public. Road traffic signs as an important representation of road traffic information, traffic signs is mainly contains the driveway speed tip warning prompt lane, lane direction indicator, such as road traffic information, traffic sign recognition system (TSRS) as an important part of intelligent transportation system (ITS), can effectively identify the traffic signs accurately can improve the driving safety. In our work, mainly summarized the research achievements over the years, the scholars and learn from the traditional image processing and depth direction were analyzed, and the challenge for traffic sign detection and recognition and evaluation standard must be summarized, how to make use of the characteristics of traffic signs and effective model to improve enhance the traffic sign detection and recognition system extensibility and robustness, main research direction in the future yes.

Keywords

Detection and identification of traffic signs; Driverless; Image processing; Deep learning.

1. Introduction

With the gradual improvement of living standards and the rapid development of science and technology, people's demand for intelligent transportation systems is becoming stronger and stronger. After the performance of computers has also made a qualitative leap, people use computers to simulate humans to process large amounts of complex data. Unmanned driving technology and intelligent driving assistance systems are processing mechanisms that simulate the human visual system to complete some operations such as image classification, target detection, and target recognition. At present, many image processing technologies have been used in unmanned driving technology and intelligent driving assistance to detect pedestrians, front and rear vehicle distances, road lines, etc. However, the recognition and detection of road traffic signs is not particularly large, and road traffic signs are the most intuitive road traffic information reminder that has been passed down. Different countries have their own set of mature road traffic sign systems. Therefore, research in recent years The staff has carried out a series of in-depth research from theoretical methods, software and hardware. The following focuses on these aspects of research.

Fig 1: Part of traffic signs

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2. Development Status

The automatic recognition of traffic signs attracted people's attention in the 20th century. In 1987, Akatsuka, a researcher from Japan, used some traditional image processing algorithms and pattern recognition technology and applied them to car driving technology to develop a road traffic sign recognition system, which has huge reality and milestone significance [1].

In 2011, the German Neural Network Computing Laboratory established a road traffic sign standard database[2], which played a huge role in the recognition and detection of road traffic signs. Subsequent localities began to establish their own standard databases to identify road traffic signs. The combination with deep learning neural network has made a good foundation.

In 2013, China's self-developed self-driving cars were tested from Beijing to Tianjin. The maturity of driverless technology reflects that China's technology involved in the road traffic system is also becoming more and more perfect.

In recent years, the rise of deep learning and machine learning has made greater progress in the detection and recognition of traffic signs. Hasegawa et al. [3] proposed a highly accurate object detection and recognition method using deep learning. The scale change of traffic sign detection is robust. Kong et al. [4] proposed a light traffic sign recognition (TSR) algorithm based on cascaded CNN. Compared with the YOLO network, this algorithm reduces the computational complexity by about 55% and reduces the CPU reasoning time by about 32%. In the detection network, mAP remains at the same level, and the final result is increased by about 4% by identifying the network. Qian et al. [5] used a region-based convolutional neural network to identify and detect the three categories of data set images of prohibitions, warnings, and instructions in domestic road traffic signs in China. Zhu et al. [6] designed an end-to-end convolutional neural network to complete detection and classification of traffic sign recognition and detection algorithms. In order to solve these problems from the perspective of lack of symmetry, Qi et al. [7] proposed the idea of applying the concept of balanced data and deformable localization area to the target recognition network. The research is based on the improvement of Libra R-CNN.

In terms of application, the ultimate goal of traffic sign detection is to be widely used in actual intelligent vehicle navigation systems. Today, many technologically advanced countries have made great achievements in this area, and many technologies have been put into use.

3. Traffic sign Detection

3.1. Traditional Image processing Methods

3.1.1. Color-based Traffic Sign Detection Method

A traffic sign detection method based on color features usually includes three steps: extracting specific color points from an image; connecting the extracted color points into regions; filtering regional features and outputting an ROI containing traffic signs. The main advantage of this type of method is that it is not easily affected by the shooting angle and distance, and the processing speed is fast. The disadvantage is that the color information is easily affected by the light, and the adaptability to different light intensities is limited.

In response to this problem, the current main solution is to convert the space to other color spaces. The most commonly used is the RGB feature space. Varan et al. are based on the RGB color space to extract the red points in the image. The extraction rule is to use 1.5 times the red component greater than the sum of the green component and the blue component as the red point [8]; Janssen et al. used normalized RGB components and set a threshold to detect red points [9]. Liu et al. set a variety of thresholds to detect red points for different light intensities [10], Rahmad et al. [11] proposed a method for image segmentation based on normalized RGB, which was extracted by the previous process. Spot to detect traffic signs, the recognition rate and recall rate of normalized RGB method in traffic sign recognition are 98.7% and 95.1%, respectively.

In addition, there are HSV space and HSI space, and the computational complexity is lower, so it is used by some other algorithms. In addition to the above-mentioned color spaces, it also includes LAB space, YCbCr space, LUV space, etc., but in practice, these spaces are not widely used. Gomez et al. [12] used different color spaces for comparison under experimental conditions and found that the normalized RGB color space and the HSV color space obtained similar results, and were better than other color spaces. Zhang et al. [13] proposed a color probability model based on YCbCr space and an improved color enhancement method based on MSER to detect candidate regions.

3.1.2. Shape feature extraction

When the traffic sign and the background color are the same or similar, the detection process will have different degrees of misdetection and missed detection. However, the traffic signs often have strong shape characteristics in the design process. For example, most of the domestic traffic signs are round Shape, triangle and rectangle. Therefore, it is also an important method to use the shape of traffic signs to recognize traffic signs.

In terms of shape features, commonly used methods include Hough transform to detect specific shapes [14], geometric models based on image gradient orientation information [15], etc. Barbes [16, 17] expands the application field on this basis, and mirrors the symmetry algorithm It is applied to the detection of triangles and squares, but the detection accuracy is not as high as that of circles, and there is a gap in real-time performance. Later, Belaroussi [18] improved the application of the Hough algorithm to the triangles, and the real-time performance was improved. In recent years, Rangarajan et al. proposed an optimal corner detection method [19], which detects the corners by convolving the designed mask with the image, which has good robustness. Some scholars have proposed methods based on curvature [20]. In addition, some scholars have proposed a detection method based on texture features and MSER algorithm [21]. The latter has the characteristics of good stability, affine invariance, and efficient and fast calculation. Since detection based on color and shape is extremely time-consuming, some people propose to use a radially symmetric detector, but it is very sensitive to noise. In order to solve the above problems, detection methods based on sliding windows [22] have been proposed, but due to the real-time requirements of traffic sign detection and recognition, these methods have not been applied.

3.2. Detection Of Traffic Signs Based On Deep Learning Methods

Traditional algorithms are not ideal in terms of prediction accuracy and speed. As deep learning algorithms shine in the field of computer vision and gradually become the mainstream, traditional algorithms are gradually dimming.

Most of the methods used in current image processing are deep learning, or neural networks. The neural network builds a layer-by-layer network through many neurons, and activates the layer to make the model have a strong nonlinear fitting ability. Neural network is essentially a combination of matrix multiplication and non-linearity. It uses many filtering kernels to filter the features that are most useful to the results and suppress the features that are not useful to the results for learning and classification.

The most commonly used training models are still VGG, RESNet, and Inception. Designers usually apply the original model directly to train the data once, and then select the better model for fine-tuning and model reduction. Because the model must be high in accuracy and fast at the same time. The commonly used method of model reduction is to reduce the number of convolution sums and reduce the number of modules of resnet. Commonly used detection models are still FRCNN, Mask-RCNN, YOLO, SSD and other network models. On the one hand, the accuracy is indeed high, and on the other hand, the speed can now be optimized to achieve

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real-time. For example, in recent years, Tabernik et al. [23] used the ResNet-50 to improve and data augment Mask R-CNN through the convolutional neural network method to solve the entire process of detection through automatic end-to-end learning. Rajendran et al. [24] proposed a traffic sign recognition system based on a YOLOv3 detector and a customized CNN classifier. The average accuracy was found to be 92.2%. It can reach an average frame processing rate of about 10 frames per second (fps). Novak et al. [25] proposed a YOLO-based application software, that is, the YOLO v3 algorithm is used for real-time positioning and object detection of traffic participants, and an additional CNN used to classify more specific subcategories (traffic signs). This model The recognition rate is as high as 99.2%.

4. Recognition Of Traffic Signs Based On Deep Learning Methods

The recognition of traffic signs is mainly to recognize the target features obtained through recognition algorithms. Recognition algorithms mainly include neural network algorithms, support vector machine algorithms, genetic algorithms, template matching, nearest neighbor classifiers, tree classifiers and Adaboost classifiers [26].

With the widespread application of deep learning, scholars from various countries have also added deep learning to the recognition of traffic signs. The most common methods are CNN, neural network, SVM. The representative SVM maximizes the classification interval to obtain the support vector of the classification plane. It performs well on the specified feature data set and has a high recognition rate. Although the BP neural network has shorter running time than SVM, its recognition rate is relatively low. Convolutional neural network has shorter running time than SVM and BP neural network, and the recognition rate is higher, so convolutional neural network has better superiority. Literature [27] proposed a traffic sign recognition method based on ROI and convolutional neural network. Compared with the methods of SVM and traditional CNN, the recognition rate and recognition speed are significantly improved. Literature [28] proposed an improved TrafficNet network, and initialized it with the initialization parameters on the original GoogleNet, and trained on the GTSRB data set, with a recognition rate of 99.80%. Literature [29] proposed the detection and recognition of traffic signs based on saliency and convolutional neural networks, and compared three methods combining AlexNet network, LeNet network, HOG and SVM. The image is the longest time-consuming of the three algorithms. In the recognition process, AlexNet takes a little longer than LeNet, but the gap is not very big. In general, the AlexNet network model has a higher accuracy in the recognition of traffic signs, and is more suitable for the recognition of traffic signs.

The accuracy of recognition has a lot to do with the depth of the neural network. Generally, the deep network can achieve higher accuracy than the shallow layer. Therefore, the literature [30] made improvements on the traditional LeNet-5, by increasing its number of layers to improve the recognition effect, and applied it to the recognition of real traffic signs. It has been verified that these improvements have achieved good results. The improved LeNet-5 model of Zhang et al. [13] is used to improve the speed and accuracy of recognition. Compared with other algorithms, this algorithm has the characteristics of short classification time, high classification accuracy, and strong generalization ability. Yasmina et al. [31] used an improved LeNet-5 network to extract a deep representation of traffic signs to perform recognition. It consists of a convolutional neural network, which is modified by connecting the output of all convolutional layers to a multilayer perceptron, achieving a verification accuracy of 97.1%.

Literature [32] introduces a new feature learning method using group sparse coding. Its coding strategy is better than the existing coding method with an accuracy rate of 99.46%. Kamal et al. [33] introduced a new network SegU-Net, which is formed by merging the latest segmented architectures SegNet and U-Net to detect traffic signs in video sequences. Its accuracy and recall rate are respectively 96.72% and 93.65%. Sun et al. [34] proposed a traffic sign detection and recognition method based on image processing, and combined with a convolutional neural network to classify traffic signs, mainly for circular traffic signs. By using image preprocessing, traffic signal detection, recognition and classification, used in TensorFlow to implement CNN, this method can effectively detect and recognize traffic signs. The test results show that the accuracy of this method is 98.2%.

5. Two or more Evaluation Criteria For Traffic Sign Detection

In order to compare the performance of different methods, a common benchmark needs to be established to measure the performance of each method. Due to the lack of recognized data sets and performance indicators, there is no unified benchmark for the related lane line detection literature. Evaluation metrics include mAP, FPS, memory footprint, FLOP, number of arguments, and so on. Traffic signs are mainly divided into four categories: Mandatory, Prohibitory, Danger, and Other.

The German Traffic Sign Detection Dataset (GTSDB) contained 900 images and a total of 1206 Traffic signs, among which 600 training images contained 846 Traffic signs and 300 test images contained 360 Traffic signs. The scholars from Universidad DE Sevilla in Spain comprehensively evaluated the existing mainstream target detection algorithms for traffic sign detection, which has an important reference value for researchers and developers. The scholar evaluated the current state-to-art algorithm of target detection, including Faster R-CNN, R-FCN, SSD, YOLO V2, and combined them with various extraction networks, including Resnet V1 50, Resnet V1 101, Inception V2, Inception Resnet V2, Mobilenet V1, Darknet-19. The network is fine-tuned on the GTSDB training set of traffic sign database, and then evaluated on the test set of the data set, and good comparison results are obtained.

The Belgian Traffic Sign Dataset(BTSD) Dataset was proposed as a benchmark for tasks such as Traffic Sign classification, detection, tracking, etc. There are more than 10,000 images in the BTSD data set, of which more than 8,000 contain labeling information, and the pixels of the images are 1628 × 1232, including 62 categories of traffic signs. Huang et al. [35] studied the use of this data set in the classification of traffic signs and achieved good results.

Tsinghua -Tencent 100K Dataset(TT100K) was proposed in the research of Tsinghua University Zhe Zhu et al., 100,000 pictures were selected from the road street view pictures of 10 regions in 5 different cities in China, with 2048 × 2048 high pixel, which contains 10000 traffic signs, and various forms of annotations were used, such as rectangle, polygon, oval, etc. Using Zhe Zhu et al's improved Overfeat-CNN model, it can achieve 91% recall rate and 88% accuracy rate on TT100K.

However, due to the different number of images, image acquisition conditions and image acquisition locations in the data set, the types and corresponding Numbers of traffic signs contained in the images are also diverse, and the labeling of traffic signs is not consistent, which makes it difficult to form a unified public data set. We need a large data set that can be identified steadily in challenging scenarios. On the basis of the large data set, the test protocol and performance indexes of traffic sign detection are unified to provide benchmarks for different methods. This is also the future direction to develop.

6. Challenges Faced By Automatic Traffic Sign Detection And Recognition

1) The generalization ability of the model: In practical applications, the test image may come from a different data distribution during training. The data that has never appeared before may be different from the training data in terms of perspective, size scale, scene configuration, and camera attributes. This difference in data distribution will cause a significant drop in the accuracy of various deep network models.

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2) Small-scale and ultra-large-scale data processing problems: Although deep learning has achieved great success in various tasks by using a large amount of labeled data, the existing technology is usually used in small data because only few labeled instances are available. The other extreme is how to use super-large-scale data to effectively improve the performance of the recognition algorithm. For critical applications like autonomous driving, the cost of errors in image recognition is very high.

3) Other objective impact issues: issues such as shooting angle, weather, obstructions, etc. will have a greater impact on the detection results of traffic signs.

7. Concluding remarks

Although there are many challenges and problems in the detection and recognition system of traffic signs, with the continuous advancement of technology, we firmly believe that the detection and recognition of traffic signs will have better applications. In general, the detection and recognition of traffic signs The system has broad development prospects. We are eagerly looking forward to the upcoming progress and looking forward to these new technologies to change our lives in profound and magical ways.

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