A Parking Space Recognition Method Based on Digital Image Technology

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Abstract

In recent years, the number of cars in the city has been increasing, leading to an increasingly prominent issue of urban parking space. Consequently, the automatic identification method for parking spaces has emerged as a crucial research direction. This paper presents a design and implementation scheme for recognizing the status of parking spaces in urban areas based on digital image processing and other technologies. In this paper, the real-time pictures of multiple parking Spaces are collected to identify the parking space, so as to determine the use of the parking space. The experimental results demonstrate the feasibility and effectiveness of the proposed method, which holds practical significance in addressing parking space detection problems through digital image processing.

Keywords: OpenCV, parking spot detection, convolutional neural network, intelligent transportation

1. Introduction

In recent years, with the popularity of family cars, urban road traffic and urban parking space management problems become increasingly prominent.

In the new intelligent parking management system, the method of identification of parking space status is also improved with the progress of technology. At first, all kinds of sensors are used to recognize and judge the status of parking Spaces, but these methods have disadvantages: ultrasonic recognition method makes the error of the sensor larger because there are multiple echoes. The method of infrared identification of parking space status is affected by the change of ambient light source and heat source, resulting in high misjudgment rate. Geomagnetic detection is extremely inconvenient to install.

In response to the above problems, experts in related fields began to look for new solutions. A new research hotspot has been formed. According to the research findings, it has certain advantages to use digital image technology for real-time monitoring of parking lots and to analyze and judge the use of parking Spaces within the scope of video surveillance through image algorithms. Therefore, this paper studies the parking space recognition method based on digital image technology.

This paper is divided into four parts. The first part is the background. The second part is an introduction to the development environment, briefly introducing Python, OpenCV and CNN. The third part introduces the system process, including pre-processing, parking space division, CNN model construction and parking space detection. The fourth part summarizes the main content of this paper.

2. Introduction to development environment

2.1. Introduction to Python

Python was designed in the early 1990s by Guido van Rosum of the National Center for Mathematical and Computer Science Research in the Netherlands as a replacement for a language called ABC. Python provides efficient high-level data structures, as well as easy and effective object-oriented programming. Python's syntax and dynamic typing, as well as the nature of the interpreted language, make it a programming language for scripting and rapid application development on most platforms, as versions are updated and new features of the language are added, it is gradually used for independent, large-scale project development [1]. Python is one of the most popular programming languages for beginners, and the Python interpreter is easy to extend with new functions and data types in C, C++, or other languages that can be called through C. Python can also be used as an extension language in customizable software. Python's rich standard library provides source code or machine code for every major system platform.

2.2. *Introduction to OpenCV*

OpenCV is an open-source library for machine vision and machine learning, based on Apache2.0. It boasts excellent compatibility and can be deployed across multiple operating systems including Linux, Windows, Android, and Mac OS. Comprising both C and C++ languages as a whole, it also provides interfaces for Python, Ruby, MATLAB, and other programming languages to facilitate development work in various language preferences. OpenCV incorporates a vast array of general algorithms in the fields of image processing

and computer vision. Its functionalities encompass object recognition, face recognition, action recognition, motion tracking among others. As such, it stands as a pivotal software library within the realm of image processing and machine vision [2], [3].

2.3. *Introduction to CNN*

The human visual system is processed hierarchically in the visual cortex of the brain, and the working process of the brain's processing of visual information is a continuous iterative and abstract process. Starting with the original image of pupil intake, some cells in the cerebral cortex find the edge and direction of the object. Then, the brain determines the general shape of the object in front of the eyes and abstracts. Then the big brain further determines the class of the object. Finally, through the analysis of the information, the conclusion is drawn. CNN network, full name Convolutional neural network, is a deep learning model inspired by the human visual nervous system. It can be divided into convolution layer, pooling layer and fully connected layer. Convolution layer is used to extract local features in image. Pooling layer is used to greatly reduce the magnitude of parameters. The fully connected layer is used to output the result. Convolutional neural network (CNN) is a classic algorithm of deep learning, which is widely used in computer vision, natural language processing and other fields, and can better process data information with stable effects such as pixels and audio and video without additional feature engineering requirements.

3. Methodology

The system design process can be roughly divided into pre-processing, parking space division, CNN model construction and training, parking space recognition and other stages. In the pre-processing stage, the information will be processed and only the effective information will be retained. Parking Spaces are extracted and stored as samples in the stage of parking space division. In the model training stage, the two-classification model will be trained to recognize whether there is a car in the parking space. Finally, the images are monitored in real time and the gaps are marked.

3.1. pretreatment

Due to the influence of various natural factors, the difference between the target object in the picture and the backscene image is not high, the available information is weak, and the parking space can not be recognized directly. Therefore, a variety of processing of the original image is required. For example, removing noise and enhancing image detail to distinguish the target object from the background image.

In order to facilitate post-processing, background filtering should first be carried out to filter out irrelevant background information in the image and facilitate subsequent recognition. The method is to define the mask, set the maximum and minimum thresholds, and convert information outside the threshold interval into zero value information.

The second step is binary processing, which converts the image into grayscale. This is because the grayscale image only retains the brightness information and omits a lot of irrelevant information, which effectively reduces the amount of calculation in the later stage.

The third step is Canny edge detection, which is divided into four steps: Gaussian filtering, calculating gradient value and gradient direction, filtering non-maximum value, double threshold detection method. It can effectively determine real and potential edges, and can better detect most of the required boundaries [4].

The original image is shown in Fig. 1. and the pre-processed image is shown in Fig. 2.

Fig. 1 Original image

Fig. 2 Pretreatment result

3.2. Parking space division

Through observation, it can be found that the parking lot is composed of different straight lines, which can be further divided by detecting these straight lines. The method is to use Hough transform, a feature detection algorithm widely used in computer vision, to find out some features in graphics. Hough transform obtains more accurate results by giving the type of shapes to be identified, and then determining the shape of the object through voting mechanism in the parameter space, and filtering out objects with too large or too small intervals. Some cracks or other line segments in the image may be mistaken for parking space lines, and the parking space lines are basically vertical or horizontal. The irregular line segments can be further eliminated by calculating the slope of the line segments to improve the accuracy.

3.3. CNN network training

After the parking space image is obtained, it is divided into training set and test set according to the proportion of 70% and 30%, and then divided into occupied set and non-occupied set according to whether or not the vehicle occupies the parking space, which is used for subsequent model training.

This model training uses VGG16 network, VGGNet is a neural network jointly developed by Oxford University and Google DeepMind in 2014, which is composed of 13 convolutional layers +3 fully connected layers. The convolutional layer is the core of the convolutional neural network. The essence of the convolutional process is based on a small moment matrix, that is, the convolutional kernel. The pixel matrix of each layer of the image is continuously scanned by step size, and the scanned value is multiplied by the number of the convolution check position, and then added and summed. Convolution kernel is equivalent to a filter, used to extract image features, convolution kernel generally has 3*3 and 5*5 sizes, usually used is 3*3 size, training effect is better. The fully connected layer refers to the connection between each node of the N-1 layer and the n layer, that is, the activation function input of the node of the n layer is the weight of all the nodes of the N-1 layer, which is used to synthesize the features extracted from the previous side. It plays the role of "classifier" in the whole convolutional neural network.

Due to the small size of the data set, in order to get a better model, the third step is to carry out data enhancement operations. Data enhancement can be divided into online enhancement and offline enhancement according to the use method. Offline enhancement is suitable for small data sets and can effectively increase their size. The multiplier of enhancement depends on the number of images converted, such as rotating all images to double the data set. There are two types of commonly used data enhancement, supervised and unsupervised. The commonly used one is supervised data enhancement, which is based on the existing data set and expands the existing data by analyzing the completeness of the data and adopting certain rules. Supervised data enhancement can be subdivided into single sample data enhancement and multi-sample data enhancement. In practice, single sample data enhancement is more used.

Finally, the data of the training set is imported into the model for training. The accuracy of the test set obtained after the completion of all programs is 91.4%, and the accuracy rate is consistent with the prediction period. Later, VCC16 can be changed to ResNet50 to further improve the accuracy, but the training speed of ResNet50 is slower than that of VCC16, so from the perspective of efficiency, VCC16 is finally chosen.

The results of parking space detection are shown in Fig. 3.

Fig. 3 Parking test results

4. Conclusion

The program will process and detect the picture in real time, and the vacant parking Spaces in the picture are marked green, and the occupied parking Spaces are not marked. Some areas in some pictures are incorrectly marked, such as the guiding line area of the parking lot is marked as empty parking space, which can be further improved by modifying the CNN model. The detection and statistics of the remaining areas are basically in line with expectations, and the processing and detection of parking space information is realized.

Through OpenCV and convolutional neural network, real-time monitoring of parking space occupancy is realized, which can be applied to urban parking lots for convenient management. In addition, the system can be further optimized to increase speed and adapt to more complex scenarios, thus providing more efficient and timely data for parking lot management.

References

1. Haitao Huang, Python 3 Ice-Breaking Artificial Intelligence from Entry to Actual Combat (in Chinese).
2. Yaling Zhou, Traffic flow detection system based on OpenCV. Beijing: Beijing University of Posts and Telecommunications, 2015.
3. Minglu Zhang, He Xiaodong, Research on Traffic flow statistics Algorithm based on OpenCV. Computer Knowledge and Technology, 2016,12 (19) : 169-170.
4. Mingrui Zhao, Research on parking status detection method based on machine vision. Shenyang: Shenyang Jianzhu University, 2021.

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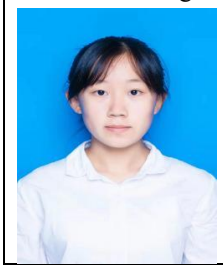

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