Overview of Research Status of Asphalt Pavement Diseases based on Image Recognition

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Abstract: In recent years, with the development of social transportation and economy, the continuous construction of urban roads, the total mileage of the road network in operation continues to increase, the task of road condition investigation is becoming more and more difficult, and the traditional work methods can no longer meet the current maintenance needs. It is necessary to study a more systematic and more intelligent road surface disease recognition technology. This paper introduces the research results of asphalt road surface disease image recognition and the domestic and international situation. The feature points are extracted through image digitization, and the classifier is used to classify the feature points for image processing. Finally Summarize the research on the image recognition of asphalt pavement diseases, and propose a new development trend.

Keywords: Pavement diseases; Image identification; Image digitization; Extract feature points

1. Introduction

My country is in the stage of rapid development of socialist modernization. During the "Twelfth Five-Year Plan" period, road maintenance will usher in a continuous peak cycle, and road disease identification is one of the foundations of maintenance. At this stage, the identification of typical road surface diseases is mainly through manual road recognition and video image collection. Manual road refers to the technicians on the ground to identify and record the disease; video image collection refers to the use of collection vehicles to implement video images on the road surface For collection, technicians use the video images collected indoors to identify diseases. With the vigorous development of highways, artificial road identification technology has a long period of time, low work efficiency, strong subjective awareness, and high maintenance costs. A series of defects, video image acquisition technology has become the trend.

This article comprehensively investigates the research results and application status of asphalt pavement disease recognition technology at home and abroad, introduces the content and steps of image recognition technology, and finally puts forward the prospects and prospects of asphalt pavement disease image recognition technology.

2. Research Status at Home and Abroad

2.1. Research status of image recognition technology abroad

In the 1980s, the Komatsu system in Japan used artificial light sources installed on both sides of the inspection vehicle for illumination. The data is captured by TV cameras, sensors, signal processors and image recording equipment; the data consists of high-density video recorders and general-purpose memory recorders. Parallel technology performs image processing in two process stages. The first stage is mainly image segmentation and feature extraction, which is executed by the parallel microprocessor. The second stage performs noise reduction, sub-image connection and restoration in parallel. However, the system cannot be commercialized in the end because the system cannot analyze the type of disease and can only work at night. It still requires many super microprocessors to perform two-stage image processing [1].

In the same period, the "Pavement Condition Assessment System (PCES)" developed by American Earth Corporation and the PAVUE system developed by the Swedish Infrastructure Services Corporation (IME) were road damage detection systems based on simulation technology. There is no way for the computer to directly process the analog quantity of the image data, and it is necessary to convert the collected image data to a digital quantity, which greatly reduces the efficiency of road damage information processing and limits the accuracy of damage recognition and measurement [2].

In the late 1990s, with the development of hardware technology and digital image processing technology, especially the development of CCD camera technology, the application research of CCD camera technology in

road damage detection has made some progress. The video signal of the CCD camera can be conveniently stored on the computer through the video capture card or image capture card for real-time display, storage and processing. With the rapid development of computer hardware, the cost of digital imaging systems based on CCD cameras has been greatly reduced. Therefore, CCD cameras and computer imaging technology have been widely used in the development of automatic detection systems for digital paving diseases under field conditions.

Up to this stage, the automatic detection technology of highway diseases in the United States, Germany, Australia and other countries has basically entered the practical application stage. Since 1969, Canadian Road Company has been conducting research on pavement data collection. So far, its customers have been distributed in more than 20 countries and regions around the world. Luwei has also developed an automatic pavement crack evaluation system. The core software package of the system, WiseCrax, has been widely used in more than a dozen countries and regions around the world. A company in Luwei alone has more than 200,000 kilometers of road images processed by WiseCrax each year. The WiseCrax system consists of three parts, namely real-time image acquisition, high-speed road surface disease analysis and quality control program [3].

ARAN is a modular data acquisition platform consisting of a specially modified chassis and various data acquisition subsystems. ARAN can measure and record up to 36 different indicators at the highest speed indicated by the speed limit sign. From flatness and rutting to a camera using a platform of 1380×1030 or more pixels, road condition imaging and road imaging of 1392×1040 pixels or more are performed. When ARAN is driving at high speed, a high-speed camera mounted on a telescopic boom can record continuous, non-overlapping and high-contrast 1.5mx 4m road images at various traffic speeds up to 80km/h (50mph). The imaging system can automatically select the appropriate part of the current image frame according to the driving speed, and the overlapping part will be discarded.

At the same time, because the system uses high-intensity synchronized flash, even in bright sunlight, it can eliminate shadows on trees, bridges, tunnels or other objects. This artificial lighting system will also highlight road surface disease information. In theory, even if there is no natural light ARAN can collect road images.

WiseCrax is an automatic pavement disease evaluation system developed by Luwei. It can automatically detect and analyze cracks within 1.0mm~1.5mm, and the crack detection rate of pavement can reach 90%~95%. Thanks to advanced image processing technology and efficient hardware acceleration, high accuracy and high speed of detection are guaranteed.

2.2. Research status of domestic image recognition technology

Since the middle and late 1990s, some domestic units have introduced a digital image acquisition system for pavement damage. The basic principle is to use a vehicle-mounted digital camera system to continuously collect road images at high speed, and then automatically process it indoors and manually pass the post-processing software. Pavement damage camera system greatly improves work efficiency and avoids the risk of highway damage investigation. With the rapid development of China's highway industry, it will become a widely used detection method. Due to high market demand and high prices of imported equipment, several research units in China have begun to explore localized car digital camera systems, and prototypes of road car cameras have been launched.

Beijing Xingtong Lianhua Technology Development Co., Ltd., with the support of the Ministry of Science and Technology Innovation Fund Project, has established a research team to develop road intelligent detection systems. Since the launch of the first generation of road intelligent detection system in June 2003, the system has undergone three updates. A large number of practical tests on tens of thousands of kilometers of expressways such as the Beijing Sixth Ring Road have proved that the system is fast, efficient and accurate, and the road and pavement maintenance and inspection systems have been improved.

In terms of system composition, the system can be divided into two parts: internal and external. On-site parts also include advanced sensors such as vehicle loading, image acquisition system (high-speed CCD + image acquisition card), laser sensor (LS), pool radar, GPS (Global Positioning System) receiver, odometer (Odometer), industrial computer, etc. Equipment composition. When the vehicle is traveling at normal speed, the system can use high-speed, high-precision image sensors and high-performance parallel image acquisition cards to preprocess and store road images. With the help of the global positioning system and the odometer, the road surface was destroyed and smooth. Including measurement data such as degree, rut, road condition and roadbed, and corresponding spatial location. The internal industry mainly includes subsystems such as data server, pavement damage detection software, pavement roughness analysis software and rut analysis software, road condition analysis software, radar roadbed analysis software, and highway maintenance comprehensive evaluation system. From data collection in the field to data analysis and evaluation in the field, the system constitutes a complete set of flow-type maintenance information acquisition schemes, which provides efficient and highly reliable theoretical basis for highway maintenance management.

In 2005, He Anzhi, Xu Youren and He Ning of Nanjing University of Science and Technology jointly developed the "3D Intelligent Inspection Vehicle for Road Surface Condition". The vehicle can scan any cracks and ruts on the road surface at a speed of 80-120 km/h and provide a road inspection report in time. The inspection vehicle has three technologies that surpass similar foreign products. Within one year after the product was launched, foreign similar products were forced to upgrade twice, and the price was reduced by half. The test vehicles have been tested in Beijing, Zhejiang, Henan, Tianjin and other cities. The detection system is also listed as the national standard for vehicle-mounted road surface detection system by the Ministry of Communications.

At present, domestic scholars have applied image recognition technology to various fields such as military, medical, agricultural, and transportation. However, the application of image recognition for asphalt pavement diseases is still very few. Guo Quanmin and Zhang Haixian used markers to connect The combination of domain and projection method successfully identified crack disease images, including lateral cracks, longitudinal cracks, and massive cracks. Among them, the mark connected domain method is used to distinguish linear cracks and massive cracks, and the projection method is used to subdivide whether linear cracks belong to lateral cracks or longitudinal cracks. The limitation of this method is obvious. Although cracks account for a large proportion of typical diseases of asphalt pavement, it can only distinguish the image of asphalt cracks, which is of little significance in practical application.

Tang Guifeng and others used the decision tree to calculate the number of pixel points of the diseased block, the length and width of the diseased block, the average gray value of the region, etc., and successfully identified the damage of the road surface. This recognition technology also has obvious limitations. It can only recognize whether the road surface disease image is damaged, but it cannot distinguish the specific disease, which is of little significance in practical application.

3. Image Recognition Technology

3.1. Overview

The use of computers for visual image recognition has been widely used in the field of vision and pattern recognition, and scholars and experts at home and abroad have also conducted in-depth research on it.

As early as the 1980s, image recognition technology had been produced. At that time, image recognition technology was based on human and text, and people judged the image content, nature, and text content, so as to obtain the judgment result. This is similar to the way of identifying typical diseases of artificial pavement at this stage, there are many drawbacks.

After the 1990s, computer intelligent image recognition without manual intervention has been greatly developed, and it can be divided into syntactic structure recognition and statistical recognition. With the deepening of research, color-based image recognition, texture-based image recognition, edge-based image recognition, computer neural network recognition, road image blur recognition, and SVM have emerged in recent years.

In general, image recognition technology is mainly divided into two major steps. The first step is to digitize the image and extract feature points; the second step is to classify the feature points using a classifier. And the extraction methods of feature points are various, and different methods have different effects on different types of image recognition.

Mateusz Kosikowski et al. extracted the feature points of the heat and color information shown in space and time in the image, but the cold color image of the asphalt pavement disease is not suitable for this method, and there is no prominent between the disease and the road surface. Differences in calorie information. ZhouBing et al. studied the extraction method based on image processing. According to the shape and color of the image, the symmetric Color-Spatial characteristics are used to describe the content of the image, but the color alone cannot express the image content very well. There is no obvious difference between the color and the disease. Wei Zheng used the method of image internal feature extraction to statistically analyze the geometric features of the image, and then combined with the contextual geometric information of the image to obtain the global features of the image. Due to the different features such as the length, shape and area of the road surface disease, If the above method is used for feature extraction, the recognition accuracy rate cannot meet the requirements.

In order to avoid monotonous recognition methods such as shape and color, a more flexible and robust recognition model needs to be built. Wang Bin et al. established a self-organizing image description model and proposed an algorithm SBRA for describing high-level semantic content of images. Although this method solves the defects of using color and shape recognition alone, for example, the location of pits and grooves on asphalt pavement, such pavement diseases do not have specific rules in spatial distribution. Obviously, this feature extraction algorithm is used in the identification of asphalt pavement diseases has great limitations.

Compared with the feature extraction algorithm, there are relatively few classifiers with better effects. Commonly used classifiers include neural networks and SVM. The neural network combined with other different algorithms has several new branches, such as wavelet neural network, BP neural network and so on. The BP neural network is proposed by Professor Han Liqun in my country. By backpropagating the error obtained by

comparing the final output with the expectation, the weights are continuously revised until the feedback error reaches an acceptable level. Compared with the general neural network, the accuracy of this method has been greatly improved, but in the case of continuous input of multiple dimensions, the network structure and training samples will continue to grow, and the function convergence rate will continue to decline.

In response to the above problems, Sun xiaoli proposed an improved nested wavelet neural network method for feature analysis, so that the wavelet base becomes the excitation function of the feature extraction layer, and the output value is the wavelet transform value of the signal at different scales and displacements , So that WNN can obtain scale and displacement information at the same time as wavelet transform, and achieve the best state through the training algorithm together with the network connection weights. This method overcomes the structural blindness of BP neural network and improves the recognition rate.

When a computer recognizes an image, it often hopes that the image will retain its features after it is rotated, scaled, and translated, but the computer does not have this capability at this stage. Therefore, finding the invariance of the image itself becomes the solution to this problem.

A matrix set obtained by calculating a digital image can usually describe the global characteristics of the digital image and can reflect various geometric characteristics of the image. Since a digital picture is usually regarded as a two-dimensional density distribution map, we can obtain the invariant moment function of the relationship between the spatial positions of the pixel values, and then obtain the shape information of the digital image from the invariant moment function. For example, the image orientation and image moment must be coordinated, and the shape information of the sent images can be used to construct the feature vector of the digital image, and has invariance.

Feature extraction is a key step in the image recognition process. The performance of feature point extraction directly affects the design and accuracy of subsequent classifiers, and even affects the feasibility of the entire recognition model.

If we regard the characteristics of a certain class of things as a set of feature points, the essence of image recognition is to compare the target image with the existing set, and use various algorithms to describe the image to effectively judge the similarity between the targets. This description is the extraction of image feature points, which are defined to describe the features of the image body, that is, a method of decomposing a digital image into a finite feature map.

Common feature point extraction methods are based on color, shape, texture and other methods. Due to the particularity of the pavement disease image, the features extracted from the image are required to have translation, rotation, and scaling invariant mathematical features, and the moment does not change to meet this requirement.

Moments are usually used in statistics to indicate the distribution of random quantities, and moments are usually used in mechanics to indicate the spatial distribution of matter. If the digital image of the disease is regarded as a two-dimensional density distribution function, the moment can be used to analyze the image, for example, the moment is used to represent the characteristics of the image, because the feature of the moment belongs to a kind of regional symptom. The invariant moment algorithm is an algorithm that can extract image features, and the mathematical features will not change due to translation, rotation, and scaling.

Invariant moment technology mainly solves two problems: The construction of invariant moments, how to construct invariant moments can extract image feature points from digital images with noise influence, imitation transformation, and environmental influence, and describe the image accurately. Calculation performance, that is, how to calculate the result of the matrix quickly and accurately while consuming as little time and resources as possible.

3.2. Image recognition technology

Mathematical Morphology is a new method applied in the field of image processing and pattern recognition. Morphology is a sub-discipline of biology. It is usually used to deal with the shape and structure of animals and plants. Mathematical morphology is a discipline based on strict mathematical theory. The language that describes mathematical morphology is set theory. The process of using mathematical morphology to analyze the geometric shape of an object is an approximation of the subject and the object. Use several basic concepts and operations of mathematical morphology, flexible combination and decomposition of structural elements, and use morphological transformation sequences for analysis.

In terms of pattern recognition, the method based on feature extraction has encountered great difficulties. How to express and extract functions, how many functions are needed, is very blind and inefficient. This technical process has gone through several stages from data collection, feature extraction to decision making, and the required operations make it difficult for the system to meet real-time requirements. The rise of artificial neural network image recognition has become a powerful tool to solve such problems. The basis of the neural network method is the neural network theory, which is usually used for road image restoration and type classification after crack detection. In practical applications, it is

usually combined with fuzzy set method or wavelet theory method.

Texture features are important features on the surface of natural or man-made objects. The stones used to make roads, asphalt and the spacing between stones and stones constitute the texture of the pavement. When the disease occurs, the texture will exhibit different characteristics. Therefore, some researchers use texture analysis methods for road disease detection. Used in combination with wavelet analysis. But this method is more suitable for analyzing whether there are diseases and disease areas, but it is not easy to do when it is necessary to segment out specific disease targets. And different road surfaces have different textures. Even in different sections of the same road, the texture of the road surface is very different.

Wavelet theory, as the analysis basis of multi-resolution theory in signal processing, is increasingly used in image processing, and its status is becoming more and more important. In image processing, wavelet transform is mainly used in image matching, registration, segmentation, noise reduction, reconstruction, enhancement, compression, morphological filtering and computer tomography. The denoising and compression of road surface disease images are usually carried out by wavelet transform in road image processing to perform enhancement and restoration.

Fuzzy information processing is to use fuzzy mathematics to process information with fuzzy uncertainty. Since many phenomena in the real world contain fuzzy information, fuzzy information processing technology has shown broad application prospects since its birth. Since the image itself contains fuzzy information, many scholars at home and abroad are committed to introducing fuzzy theory into image processing, and achieved good results. Fuzzy information processing technology is widely used in image enhancement, image segmentation and image recognition, and has also been widely used in image processing of road surface diseases.

4. Summary and Development Trend Analysis

4.1. Research status summary

With the rapid development of road construction in our country and the improvement of highway network system, the maintenance and management of highways is becoming more and more important. As an important part of highway maintenance management, highway pavement disease identification is also facing higher requirements. How to achieve accurate, non-destructive, rapid and comprehensive automatic detection of pavement diseases is its development direction.

The main function of image recognition technology is to distinguish the objects in the image based on the observed image, so as to make corresponding meaningful judgments. The specific implementation is to apply modern information processing technology and computer technology to human beings, and the cognitive process is simulated. Generally speaking, the image recognition system consists of three parts: image segmentation, image feature extraction and classifier recognition. The main function of image segmentation is to divide the image into multiple areas; image feature extraction is to perform corresponding feature extraction on images in multiple areas; and to classify the classifier recognition appropriately according to the results of image feature extraction. To some extent, image segmentation itself can be called the process of image recognition. All in all, with the continuous development of society, image recognition technology has also been greatly developed, and is also widely used in various fields, including medicine, aerospace, communications and other fields.

4.2. Research status summary

Image recognition technology can also be called image classification and belongs to the category of pattern recognition. In this technique, in the process of classifying images, it is often used to identify classic patterns. In recent years, the artificial neural network model and fuzzy pattern recognition classification developed by this technology have received more and more attention in image recognition. As far as the development trend of image recognition technology is concerned, the focus of future research on this technology should be as follows :

Compress the image. Image compression can be divided into two categories, namely lossless compression and lossy compression. Among them, lossless compression has certain limitations due to its compression ratio. Therefore, in the current research image recognition process, it cannot become a research hotspot. Many people focus on lossy compression during the research process, and lossy compression refers specifically to the loss of some information in the image after complex compression.

Three-dimensional image reconstruction. Due to the vigorous development of modern information technology, in the product design process, China gradually transitioned from traditional graphic design to three-dimensional space design. For example, in terms of maps, the previously used flat maps will be replaced by the three-dimensional electronic maps that exist today. In addition, 3D reconstruction technology also plays a very important role in archaeological research, which can promote the development of archaeology to a certain extent.

Virtual Reality. In the era of continuous development of computers, its calculation speed is now very fast, which also provides a certain possibility for virtual reality. In

this case, online virtual reality and video phones are also used in image recognition technology, which One development has also become a new trend.

In summary, in the process of continuous development of society, the development space of image recognition technology is also expanding, and its application prospects will be more extensive. In the process of acquiring and exchanging information, graphics are an indispensable part. After these situations, the application field of image recognition technology will become more and more extensive, and it will become one of the more common technologies in daily life. In particular, the application fields of image recognition technology mainly include the following aspects: biomedicine, aerospace technology, military and public security, communications and earthworks, culture and art, etc.

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