Application of Artificial Intelligence in Material Testing

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Abstract. Under the development of artificial intelligence technology, the technical level of machine learning and machine vision has been significantly improved. For testing, machine vision can input the characteristics of the inspected object into the computer, while machine learning ability enables the computer to better analyze the characteristics of the inspected object and make the testing conclusion. Compared with traditional testing methods, this process has the characteristics of high accuracy and high speed, and its excellent performance can be used in all aspects of material testing.

Key words: machine learning, machine vision, Material Testing.

1. Introduction

In the traditional testing field, inspectors test and issue reports by manual methods such as eyes, hands and feet, which would produce certain human errors on the one hand, and it is difficult to improve the efficiency on the other hand. Compared with foreign countries, the development history of domestic testing and testing business is relatively short, and the research in the field is still mainly qualitative research, lacking quantitative research and empirical analysis, which urgently needs scientific demonstration and suggestions [1].

On July 8th, 2017, the State Council issued the "New Generation Artificial Intelligence Development Plan", which officially raised artificial intelligence to the height of the national development plan. The government work report repeatedly mentioned artificial intelligence, and proposed to cultivate and expand new industries and develop new kinetic energy through artificial intelligence. Artificial intelligence includes machine vision, machine learning and other fields.

Recently, machine vision can gradually replace manual testing. The working principle of machine vision is that the computer inputs external information (such as color, shape, position, etc.) by acquisition equipment to achieve the effect similar to human eye observation. It is an important branch of computer science, involving image processing, pattern recognition, signal processing, opto-mechatronics and other fields. With the rapid development of technology in the field, the overall technical level of machine vision has reached a new level.

With the introduction of the method, the problem of testing accuracy can be solved quantitatively, and the testing efficiency can be greatly improved. A large amount of testing data is generated, that is, testing big data. Testing big data has the characteristics of general big data, that is, massive, complex and rapidly changing, and is an important resource to promote the development of testing industry. According to Reference [2], data has become the same raw material as minerals and chemical elements, which can promote the strategic emerging development in the field of testing in the future. The utilization of data resources will not follow the development path of science and technology, that is, from data to knowledge to ability, but according to the direct way from data to value. The typical case of mining value in the field of big data is the well-known case of Google earning huge revenue through advertising [3]. It is a topic that the executors of the testing industry on how to empower the testing big data and make it produce greater benefits.

Machine vision trained by machine learning can maximize the role of mining and testing big data, and its application in this field is becoming more and more extensive.

2. Algorithmic level of machine learning

The purpose of machine learning is to establish an expert system through machine learning. In the process of testing, the machine imitates experts to judge the target [4].

In general machine vision testing, image processing tools such as gray difference and image enhancement are used to solve the problems of background light and testing angle deviation of the tested object, and image noise reduction is carried out. According to the method mentioned in reference [5], the input layer can be established, and the vision machine can be trained by the convolutionalal neural network (CNN) recognition algorithm based on machine learning, Relu activation function and RMSProp algorithm of adaptive learning rate optimization, so as to achieve the target effect.

With the development of technology, a faster testing method named YOLO (You only look once) [6] appears, which directly divides the original picture into small squares that do not coincide with each other, and generates the feature map of corresponding scale by convolutional. Compared with CNN, YOLO algorithm no longer calculates the window sliding according to a certain step size, that is, it only calculates CNN once. Through the operations of input layer, convolutional layer, sampling layer, connection layer and output layer, it can speed up the testing speed on the premise of ensuring the testing accuracy, and even realize the functions of on-demand testing and real-time video testing.

3. Materials external testing

The materials external testing is the best scene using machine vision, such as the testing of road surface cracks, material surface defects and textiles.

Traditionally, the testing of road cracks and other impacts on driving safety is mainly based on human subjective judgment. The error of this judgment is random and uncontrollable, and inspectors need to spend a lot of time reading pictures frame by frame, so the testing efficiency is not high. Through the mode of machine vision and the algorithm of machine learning, only the acquisition device is loaded on the high-speed vehicle, and the collected images are input into the computer in real time, which can effectively reduce the testing error and improve the testing efficiency. According to machine learning, accurate quantitative data can be obtained for the geometric characteristics of roadside cracks, including crack direction, structure, length, width, area, etc. Based on the above data, the degree of pavement damage can be evaluated. Comparing the training set of machine learning with test set, it can be found that the testing accuracy of the training set is over 93%, and complex cracks can be distinguished, and the testing efficiency is obviously improved. Harbin Guochang Intelligent Transportation Technology Co., Ltd. and Harbin Institute of Technology jointly developed the road surface testing vehicle "Harbin Institute of Technology Guochang" [7], which has collected high-quality road surface pictures at a certain driving speed and carried out the testing work simultaneously.

Reference [8] showed that for crack defect testing of a transparent plastic product, the defect was coupled with its own stripes and uneven transmittance, which improved the testing complexity. The accuracy of the traditional method is 65.8%, and the single sheet takes 942 milliseconds. The depth machine learning vision system using original image-convolutional layer-feature image-candidate box of automatic recognition and location-classifier can achieve an accuracy rate of 85.0% and take 101 milliseconds. The accuracy rate has increased by 29% and the speed has increased by more than 9 times. The improvement of testing accuracy is due to the fact that the size of the input original image is not limited in the calculation process, so that the picture information can be completely preserved; The efficiency improvement is due to the weight sharing operation, which simplifies the training process.

Testing of textiles, including component testing and colony testing [9]. In the component testing, the cotton and hemp of the product can be quickly distinguished according to the fiber cross-sectional shape by taking photos and identifying, and then the cotton content in the blended product can be judged; With the same idea, the cashmere content in cashmere sweater can also be judged; In colony

counting, similar to the examples in medical testing, machine vision testing with machine learning ability can identify the number of colonies in textiles, and provide a basis for the factory quality testing of labor protection products such as masks.

4. Materials internal testing

For materials internal testing, it is necessary to replace the traditional machine vision tools with machine vision tools with perspective function, such as industrial CT. Testing object, such as grain of solid rocket motor.

For solid rocket grain, conventional testing methods include radiographic flaw testing, ultrasonic flaw testing, industrial CT flaw testing, etc., which have different application scope, testing level and cost. For defects with grain adhesion gap less than 0.2 mm, the above methods are difficult to be tested by human eyes, and the testing efficiency is low [10].

Through machine vision based on machine learning to interpret data, the accurate measurement of material defect testing can be realized, and the measured length and area parameters can be accurately given. The principle is to train the machine vision algorithm by marking a large number of existing testing images, and solidify the interpretation process to form machine vision testing with machine learning ability. This kind of testing can distinguish the defective areas more accurately. Although further learning or manual discrimination is needed to judge the formation of the absent areas-sticking or rich glue, the testing time is 20% of the traditional testing, which can significantly improve the testing efficiency.

5. Food testing

For some types of food testing, the conventional machine vision tools can no longer meet the requirements, but the identification means for the tested items has changed into the identification of biological and physical and chemical indicators of food. Usually, the electronic nose based on modern bionic technology is used to analyze the odor, so as to achieve the purposes of freshness judgment and quality classification [11].

Traditional electronic nose testing can achieve ideal recognition degree for linear problems, but for nonlinear problems and multi-dimensional problems, there will be some deviations. This difficulty can be effectively solved by machine learning. As shown in Reference [12], the electronic nose is used to test the freshness and quality of food. Salmon samples at different refrigeration temperatures (0℃, 4℃ and 6℃) are divided into test set and training set, and the odor fingerprint change results are obtained by electronic nose. The results show that, test set and training set trained by machine learning model. The total prediction accuracy is 70.97% and 95.00%, respectively, and the prediction accuracy for specific sensitive temperature (0℃) is 57.14% and 89.3%, which fully shows that the machine learning technology can significantly improve the identification of salmon freshness and improve the testing accuracy in biological testing, especially in biological testing with certain complex factors.

6. Special equipment testing

For the special equipment testing, the focus is mainly on the protection of inspectors from the working environment, harmful substances and potential safety hazards. In the process of testing, "Internet of Things Application Programming Interface" can be applied, and RIFD can be used to mark various special equipment [13], so as to realize automatic application, and robots can replace human beings to test special equipment.

7. Conclusion

By using machine vision and machine learning in artificial intelligence, it can provide a new development direction for testing, improve the accuracy and efficiency, and serve the modern testing.

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