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Application and Prospect of Image Recognition in Intelligent Agriculture

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Abstract: Image recognition has been successfully applied in automatic driving and face recognition, and its application in agriculture can greatly promote the process of intelligent agriculture. This article firstly expounds the basic concepts of the intelligent agriculture and image recognition, and enumerates the part of the development of intelligent agriculture in China and abroad. Then, the image recognition in land classification and protection, accurate identification of animals as well as pest and disease detection are analyzed. It is concluded that the source of image data is relatively single, and it is difficult to deal with the identification problem of multi-agent and multi-variable quickly and accurately, as well as the hardware performance is defective. Finally, the prospect of the application of image recognition in intelligent agriculture is proposed, which can be used as a reference for future research in related fields.

Keywords: Intelligent agriculture, Image recognition, Deep learning.

1. Introduction

Agriculture is closely related to human beings. It is the foundation of economic development and an important guarantee of social stability. After entering the 21st century, the world population is still growing in the range that can be expected. Even if the growth rate is slower than that of the last century, the world population is still growing in a very large number due to its huge base, and the output of food needs to increase accordingly to meet the demand for food in the future. However, as more and more developing countries gradually realize industrialization and urbanization, it is inevitable that the proportion of agricultural labor force in the total labor force will decrease. At the same time, affected by the world situation and natural conditions, ensuring food production is still a serious problem in the future.

With the development of information technology gradually accelerated, the application of cutting-edge technology, such as artificial intelligence, big data, intelligent robot in the field of industry and service industry gradually became widely mature and reliable, thus the technology application in the field of intelligent agriculture is feasible, and image recognition is one of the most concern, promising and cutting-edge technology in the field of artificial intelligence. It has attracted extensive attention from scholars in professional fields in China and abroad. This paper introduces the background of intelligent agriculture and the concept of image recognition, studies the application cases of image recognition in agriculture, summarizes the application and future prospects of image recognition in intelligent agriculture, and provides reference for the future application direction of image recognition in intelligent agriculture.

2. The Concept and Development of Smart Agriculture and Image Recognition

2.1. The concept of intelligent agriculture

Up to now, intelligent agriculture has not been clearly defined in the academic community. Intelligent agriculture is usually described as the combination of modern high-tech and traditional agricultural planting to achieve intelligent, automated and specialized management and overcome the disadvantages of low efficiency, low quality and long-time consuming of traditional agriculture. In the late 1970s, the European and American developed countries applied expert system to agriculture for the first time. The concept of precision agriculture first emerged in the US in the 1980s. In 1997, academicians of the American Academy of Sciences and the American Academy of Engineering jointly put forward the concept of "digital agriculture", which is considered to be the predecessor of intelligent agriculture. Since entering the 21st century, the development of 3S-technology has further promoted the development of intelligent agriculture in various countries. In China, the concept of "smart agriculture" was formally proposed in 2014.

2.2. The development of intelligent agriculture in China and abroad

The United States has not only powerful science, technology and industry, but also highly mechanized, specialized and regionalized agriculture which cannot be ignored. The agricultural production in the United States is mainly based on small family farms with a high degree of intensification. In 2020, the U.S. Department of Agriculture announced a five-year plan, the USDA Science Blueprint - Scientific Directions 2020-2025, which proposed to focus on developing sensors for detecting crop pests and diseases. In October of the same year, the US State Department issued the National Strategy for Key and Emerging Technologies, in

which agricultural technology, artificial intelligence and other key technologies were mentioned.

In China, after the concept of "smart agriculture" was formally proposed in 2014, "smart agriculture" appeared frequently in the No.1 Central Document[1]. In 2021, the full text of the 14th Five-Year Plan of The People's Republic of China for National Economic and Social Development and the Outline of the Vision for 2035 was released, which pointed out the need to utilize "smart agriculture" to achieve "agricultural modernization." In February 2022, The State Council of China issued the 14th Five-year Plan for Promoting Agricultural and Rural Modernization, which mentioned strengthening the support of agricultural science and technology and equipment and further promoting innovation in agricultural science and technology.

2.3. The concept of image recognition

Image recognition is one of the applications of deep learning, utilizing the computer to complete the image collection, pre-processing, feature analysis and other operations, and then compare with the content of the standard database, so as to complete the recognition of different objects.

2.4. The development of image recognition

In the 1950s, the research on two-dimensional image recognition has begun. In the 1960s, as Roberts published the first professional paper in CV field, the research on image recognition of three-dimensional objects began to unfold. In 1966, an M.I.T. professor, Seymour Papert, drafted a report called "The Summer Vision Project", marking the emergence of image recognition as a new scientific field. In 1979, The Neocognitron model proposed by Kunihiko Fukushima, a Japanese scholar, was regarded as the prototype of convolutional neural network (CNN). In the 1980s, British neuroscientist and psychologist David C. Marr published his book "Vision", which greatly promoted the development of image recognition, and some of the concepts and algorithms in it are still widely used today. In 1995, Yann Lecun constructed Lenet-5, which was the first commercial use of convolutional neural networks. In 2012, AlexNet's outstanding performance promoted the extensive research and exploration of convolutional neural networks. In 2014, Goodfellow invented generative adversarial network (GAN), which is an important research achievement in the field of image recognition and computer vision. In 2022, the combination of CNN, GAN and Transformers will provide more efficient and excellent algorithms for image recognition applications in various fields.

3. Application of Image Recognition in Intelligent Agriculture

The salient features of intelligent agriculture include regionalization, specialization and mechanization, namely to find the right cultivated land, planting suitable crops on the selected land and then efficiently and accurately determine the species of the plant diseases and insect pests as well as their locations, degree and scope, so as to assess the severity of the diseases and insect pests. Then take measures to eliminate pests and diseases (such as smart pesticide spraying) and increase yields. The following is a review of image recognition in land classification and protection, accurate identification of animals as well as pest and disease detection and other aspects.

3.1. Land classification and protection

Arable land is an essential land resource in agriculture, but for the same crop, not all arable land is suitable for its cultivation. Therefore, in intelligent agriculture, it is very important to determine the type of arable land. In the past, it was almost impossible to complete land classification through traditional satellite image analysis, because its recognition accuracy was too low. However, with the application of convolutional neural network in agriculture, the above problems have been broken through, and the new classification method has been verified.

Jinglun Li proposes a Convolutional Neural Network (CNN) model named Dual Path Attention Network (DPA-NET)[2]. By comparing different module combinations and ablation experiments of different models, it is found that the recognition results are optimized compared with previous models under the condition that the computational amount is almost unchanged. At the same time, based on the above DPA-NET model, Jinglun Li designed a remote sensing image recognition system for multiple land types, which can quickly obtain thematic maps of remote sensing images without manual work, facilitating researchers' in-depth exploration of land classification.

Tian Tian et al. took GF-1 PMS panchromatic multi-spectral fusion image as data source, and completed the fine classification of crops in areas with complex planting structures based on three deep learning models, namely U-NET, PSPNet and DeepLabv3+, overcoming the problem of low accuracy in crop classification by traditional statistical classification or image recognition methods[3]. It provides an important reference for accurately obtaining the information of crop type, area and spatial distribution in the region with scattered plots, complex crop species and scattered distribution.

Based on image recognition in terms of land use of the related literature summary, it is found that after optimization, the image recognition algorithm efficiency and accuracy are higher than that of the traditional ones, which indicates the image recognition technology can be in the field of land classification and protection and play a more important role. But at the same time, in order to make the role of image recognition wider, it is also necessary to establish a universal database.

3.2. Accurate identification of animals

Animal husbandry and aquaculture are important components of agriculture. In the past, few algorithms could accurately identify animals, and most of them could not realize real-time recognition. But with the introduction of neural network into image recognition, not only the accuracy is greatly improved, but also real-time monitoring recognition can be realized.

Qi Li proposed an expanding-deformable Convolutional Networks (E-DCN-Cascade RCNN) algorithm for cattle object detection[4]. Compared with former algorithms Cascade RCNN, RetinaNet and Faster RCNN, the AP value of detection accuracy increased by 4.2%, 6.4% and 10.3% respectively. At the same time, Qi Li also proposed a lightweight method for cattle detection model based on DC-

SMKD. After the algorithm restored the detection accuracy, the model's name is DC-SMKD-YOLOv5s, and its AP was improved to 92.99%. Compared with the traditional SSD target detection algorithm, the model size was smaller by 80M, and the AP was 1.34% higher. It suggested that the detection accuracy and detection speed of this model are higher.

Qi Wang proposed an algorithm for density estimation of shrimp seedlings based on multi-scale and dual-channel fusion[5]. In this algorithm, ResNet101 was used as the feature extraction module of the whole network, and the features of the head of shrimp seedlings were learned under the unfavorable conditions of background noise and unequal distribution of shrimp seedlings. MAE and MSE were used as indexes, which can learn the multi-scale characteristics of shrimp seedlings. If the target detection algorithm can be added to the density estimation counting, the accuracy of the algorithm can be greatly improved.

After summarizing the literature of image recognition in animal accurate recognition, it is found that the detection accuracy and detection speed of the image recognition algorithm proposed in recent years are higher than the traditional algorithm, which indicates that the application of image recognition technology in animal husbandry in intelligent agriculture is feasible. But at the same time, image recognition also has disadvantages to be overcome in the field of accurate animal recognition, such as large network model and simultaneous recognition of multiple organisms.

3.3. Pest and disease detection

How to prevent pests and diseases is a very important problem in agriculture. In previous traditional agriculture, farmers were more accustomed to identifying diseases and pests with naked eyes, which was not only laborious, but also not accurate. However, the appearance of image recognition technology can greatly reduce the above shortcomings, making intelligent agriculture closer to human beings.

Yuliang Gao et al. proposed an image recognition algorithm for rice diseases and insect pests integrating grouped attention mechanism[6]. After introducing shuffle attention (SA) into the Inception-ResNetV1 convolutional module, compared with the traditional model ResNet50 and Inception-ResNetV1, the number of model parameters decreased by 62.7% and 32.5%, and the accuracy increased by 1.8% and 1.21%, respectively, overcoming the shortcomings of the traditional algorithm of insufficient attention proportion and low accuracy.

Huijie Xu et al. proposed an improved detection model of corn leaf diseases and insect pests -- Yolov3-corn[7]. The average detection accuracy (mAP) and recall rate of the recognition model reached 93.31% and 93.08%, which were 4.03% and 9.78% higher than the previous YOLOv3 model respectively. It overcomes the problems of poor robustness and real-time performance of traditional recognition models.

The related literatures of image recognition in pest and disease detection in recent years are summarized. Although some crops pests can be detected and analyzed through image recognition, there are still a large number of crop pest detection algorithms or systems need to be improved or developed. Moreover, because of the wide variety of pests and diseases, often occurring at several times and affected by geographical and crop types, it is important to establish a database that is applicable and large in size.

4. Discussion and Outlook

After sorting out the above literature, image recognition technology is widely applied in intelligent agriculture, but there are some problems that need to be solved in the future.

The accuracy and rapidity of image recognition need a lot of training, so as to verify the feasibility and reliability of the design model, and a lot of training needs to rely on a large number of databases. Due to the relatively late start of agricultural intelligence in China, there is a lack of universal and universal data sets for many fields. The data sets used in studies are usually self-made by laboratories, and there are relatively few sources of experimental image data. There is a slight lack of authority and integrity.

At present, the accuracy and speed of image recognition technology are relatively high in the recognition of single objects, but the performance of image recognition technology is not satisfactory in the face of multi-subject and multi-variable recognition problems, and in the future of intelligent agriculture, multi-subject and multi-variable recognition problems could not be ignored and must be broken through.

Image recognition usually requires the cooperation of hardware and software to maximize its efficiency, especially the speed of its operation requires chips with high computing capacity. However, the fact that the performance of chips in this field is relatively weak in China, which is an important factor restricting China's development of image recognition technology in intelligent agriculture.

Some algorithmic network models occupy a large amount of storage space, which can improve the accuracy of image recognition to a certain extent, but also relatively weaken the portability of the model, increase the difficulty of maintenance, and increase the landing cost of products.

In view of the current research situation, the following aspects should be further studied:

The establishment of a database of high quality, high standard and high data volume can not only accelerate the speed of image recognition, but also make contributions to the future study of multi-agent and multi-variable recognition problems, which has a fundamental impact on the application of image recognition in intelligent agriculture.

The research on high-performance chips in related aspects should continue to be carried out. At the same time, the image recognition algorithm should be optimized and the network model should be lightweight under the premise of not affecting the accuracy and efficiency of recognition, so as to accelerate the deployment of image recognition in the field of intelligent agriculture.

5. Conclusion

This paper sorted out and introduced the relevant literature of image recognition in smart agriculture in recent years, and elaborated the application of image recognition in land use and protection, accurate identification of animals and detection of diseases and pests, in the summary of their advantages, but also analyzing their shortcomings. Nowadays, with the advent of scientific and technological progress in the era of artificial intelligence, coupled with national policies to support intelligent agriculture, the application of image

recognition in intelligent agriculture will be paid more and more attention by researchers, and the existing problems will gradually make breakthroughs. It is believed that in the future, image recognition technology will play a higher and higher role in intelligent agriculture, and more and more image recognition technology will be applied to agriculture, so as to realize the real intelligent agriculture.

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