**Abstract:** Maize diseases are reported to occur often, and are complicated and difficult to control, which seriously affects the yield and quality of maize. This paper proposes an improved YOLOv5n model incorporating a CA (Coordinate Attention) mechanism and STR (Swin Transformer) detection head, CTR\_YOLOv5n, to identify common maize leaf spot, gray spot, and rust diseases in mobile applications. Based on the lightweight model YOLOv5n, the accuracy of the model is improved by adding a CA attention module, and the global information acquisition capability is enhanced by using TR2 as the detection head. The average recognition accuracy of the algorithm model can reach 95.2%, which is 2.8 percent higher than the original model, and the memory size is reduced to 5.1MB compared to 92.9MB of YOLOv5l, which is 94.5% smaller and meets the requirement of being light weight. Compared with SE, CBAM, and ECA, which are the mainstream attention mechanisms, the recognition effect we used is better and the accuracy is higher, achieving fast and accurate recognition of maize leaf diseases with fewer computational resources, providing new ideas and methods for real-time recognition of maize and other crop spots in mobile applications.

Chapter 1: Introduction

1.1 Background

Maize is one of the most important staple crops worldwide, and its leaves play a crucial role in determining the yield and quality of the crop. Timely detection of disease or insect infestations on maize leaves is critical for effective management of these pests, which can cause significant losses in yield. Traditional methods of monitoring maize leaves involve visual inspection by farmers, which can be time-consuming and subjective. The use of object detection technology has the potential to streamline this process and provide more accurate and efficient detection of maize leaf pests.

Because it is one of the three main food crops and a significant source of revenue for many farmers cross the world, maize, which has a high nutritional value, continues to play a significant role in addressing the issue of human food supply today [[1](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark17)]. Data show that 60% of maize in China is used as feed for livestock and poultry industries, 30% is used for industrial purposes, such as chemical, pharmaceutical, and paper making, and the remaining 10% is used for direct consumption by people. Mazie occupies an important position in the agricultural production and economic development of China. It is evident that, together with rice and wheat, maize will be the food crop with the largest production demand in the future. Therefore, increasing maize production and maintaining high quality is important to China’s agricultural industry. Among the many factors affecting maize production, the problem of maize pests and diseases has the greatest negative impact on its production and quality, and once maize pests and diseases occur, they can cause varying degrees of yield reduction and quality decline, seriously affecting the economic benefits of producers and the industry as a whole [[2](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark18)].

At present, the category identification of maize diseases in China is based on the em- pirical judgment of crop pathologist experts in the field and technicians specialized in plant protection; therefore, technicians need to have good observation skills and rich experience to accurately identify the category of diseases [[3](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark19)]. This traditional disease identification method, which relies on individual experience, has a large limitation. Additionally, when there are too many samples to test with many different disease types, subsequently, there is a higher chance of inaccuracy in the identification process due to human errors.

Recent years, with the high-speed development of big data analysis technology and GPUs (Graphics Processing Units), the computing power of computers has been improved, and deep learning techniques have been developed rapidly and have been used in many applications such as agricultural pests and diseases [[4](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark20)]. Yinglai Huang et al. [[5](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark21)] replaced

C:\Users\user\AppData\Local\Temp\ksohtml12984\wps1.pngC:\Users\user\AppData\Local\Temp\ksohtml12984\wps2.png7 7 convolutional kernels in the first convolutional layer of the conventional ResNet-50 model with three 3 3 convolutional kernels; they used the LeakyReLU activation function instead of the ReLU activation function and changed the order of the batch normalization layer, activation function, and convolutional layer in the residual block. The improved network obtained a 98.3% correct rate in maize leaf disease image classification. Haoyu Wu [[6](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark22)] proposed to construct a two-channel convolutional neural network based on VGG and ResNet. By adjusting the parameters of the two-channel convolutional neural network, the accuracy of identifying maize leaf disease types in the validation set can reach 98.33%, while the VGG model can reach 93.33%. Chao Wang et al. [[7](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark23)] proposed a method based on ResNet (Residual Neural Network) deep learning network for maize disease recognition, using ResNet as the main model for maize disease recognition, and found that the highest classification accuracy of 92.82% was obtained with ResNet50 at a batch size of 32 and epoch number of 16.

Azlah, M.A.F. et al. [[8](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark24)] mainly reviewed the advantages of each classifier and compared their compatibility with different leaf features recognition process. Koklu, M. et al. [[9](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark25)] con- ducted a deep learning-based classification by using images of grapevine leaves. The most successful method was obtained by extracting features from the Logits layer and reducing the feature with the chi-squares method. The most successful SVM kernel was Cubic. The classification success of the system has been determined as 97.60%. Argüeso, D. et al. [[10](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark26)] introduced Few-Shot Learning (FSL) algorithms for plant leaf classification using deep learning with small datasets. The FSL method outperformed the classical fine-tuning transfer learning, which had accuracies of 18.0 (16.0–24.0)% and 72.0 (68.0–77.3)% for 1 and 80 images per class, respectively.

Although there are many recognition techniques based on deep learning technology and all of them work well, there are some problems among them, such as less small- scale target data, larger memory consumption of the model, and being unsuitable for mobile deployment.

This paper, therefore, investigates the problem of disease in maize leaves, applying the current deep learning technology to design an experimental study in the hope that farmers will be able to rely on their mobile phones in the field to identify diseases on maize in a timely and effective manner, thus alleviating the problems of reduced yields and reduced quality of maize. As the ultimate goal of our research is to help farmers to identify maize diseases in real-time in the field with a mobile device on their person, the light weight and high accuracy of the model is the focus of this paper.

Currently, the commonly used target detection networks include Faster R-CNN [[11](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark27)], SSD [[12](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark28)], YOLO series [[13](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark29)–[16](file:///C:\Users\user\Downloads\agronomy-13-00521-v2%20(1).docx#_bookmark30)], etc. Among them, the YOLO network model belongs to a one-stage target detection algorithm with a simple structure, small computation, and fast operation speed, which is widely used in crop disease identification research. Among them, YOLOv5n is the latest model of the YOLOv5 series network, which has the advantages of high detection accuracy, fast inference speed, and small storage space, and is suitable for deployment in mobile for real-time detection. In this paper, we propose a regional detection model for maize leaf diseases based on YOLOv5n: CTR\_YOLOv5n, which accelerates the model convergence speed, improves the model generalization ability, and enhances the recognition accuracy and detection speed of the model, taking three common maize leaf diseases, blotch disease, gray spot, and rust, as the research objects.

1.2 Research Problem

The objective of this research is to investigate the effectiveness of object detection technology in detecting maize leaves. The research problem is how to implement object detection technology in a way that accurately identifies maize leaves and detects any abnormalities on those leaves.

1.3 Research Questions

The following research questions will be addressed in this dissertation:

1. How can object detection technology be used to detect maize leaves?
2. What are the challenges associated with implementing object detection technology to detect maize leaves?
3. How accurate is object detection technology in detecting abnormalities on maize leaves?
4. What are the potential benefits of using object detection technology to detect maize leaves?

1.4 Research Objectives The research objectives of this study are:

1. To identify the most effective object detection technology for detecting maize leaves.
2. To analyze the challenges associated with implementing object detection technology to detect maize leaves.
3. To evaluate the accuracy of object detection technology in detecting abnormalities on maize leaves.
4. To explore the potential benefits of using object detection technology to detect maize leaves.

Chapter 2: Literature Review

2.1 Introduction

This chapter provides a comprehensive review of the literature related to object detection technology, maize leaves, and the detection of abnormalities on maize leaves.

2.2 Object Detection Technology

This section provides an overview of object detection technology and its applications in various fields, including agriculture. It discusses the different types of object detection technology and their advantages and disadvantages.

2.3 Maize Leaves

This section provides a detailed description of maize leaves, their structure, and their importance in determining the yield and quality of maize crops. It also discusses the different types of pests that can affect maize leaves and the symptoms of their infestations.

2.4 Detection of Abnormalities on Maize Leaves

This section discusses the traditional methods of detecting abnormalities on maize leaves and their limitations. It also explores the potential of using object detection technology to overcome these limitations and provide more accurate and efficient detection of abnormalities.

Chapter 3: Methodology

3.1 Introduction

This chapter describes the methodology used in this study to investigate the effectiveness of object detection technology in detecting maize leaves.

3.2 Research Design

This section describes the research design used in this study, including the selection of the sample, data collection methods, and data analysis techniques.

3.3 Data Collection

This section describes the data collection methods used in this study, including the selection of the dataset and the process of data annotation.

3.4 Data Analysis

This section describes the data analysis techniques used in this study, including the training and testing of the object detection model and the evaluation of its accuracy.

Chapter 4: Results 4.1 Introduction

This chapter presents the results of the study, including the performance of the object detection model in detecting maize leaves and abnormalities on those leaves.

4.2 Object Detection Model Performance This section presents the accuracy of the object detection model in detecting maize leaves and abnormalities on those leaves. It also discusses the challenges encountered during the implementation of the model.

Chapter 5: Discussion 5.1 Introduction This chapter discusses the findings of the study in relation to the research questions and objectives.

5.2 Object Detection Technology for Maize Leaf Detection