UNIVERSITY OF MINES AND TECHNOLOGY

TARKWA

FACULTY OF COMPUTING AND MATHEMATICAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

PROJECT REPORT ENTITLED

AN EFFECTIVE HYBRID PREDICTIVE MODEL FOR PEST DETECTION IN MULTIPLE CROPS IN GHANAIAN FARMS

BY

NYINI ELLEN ADWOA

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

PROJECT SUPERVISOR

....

DR IVY BOTCHWEY

TARKWA GHANA

MONTH, YEAR

CHAPTER 1

LITERATURE REVIEW

Overview

The review will begin by discussing the importance of pest detection in agriculture, and the challenges associated with traditional methods of pest monitoring. It will then provide an overview of existing predictive models for pest detection, including Remote Sensing Technology in Agriculture, Sensor Technology , Molecular Biology , machine learning algorithms. The review will also examine the factors that can influence the performance of predictive models for pest detection, such as the availability of data, the choice of features, and the selection of an appropriate modeling technique.

1.1 Pest Detection in Agriculture

Pest detection plays a crucial role in agriculture by helping to control crop pests and ensure crop security and quality. Traditional methods of pest identification have limitations such as being time-consuming and laborious, resulting in untimely and limited diagnosis. However, with the development of modern digital technology, image processing techniques have emerged as a new way for pest identification. These techniques involve preprocessing images, extracting features, and classifying them using machine learning algorithms, (Thenmozhi Kasinathan et al). Various studies have proposed improved network models and algorithms, such as the three-scale CNN with attention (TSCNNA) model and the YOLOv5 target detection algorithm, which have shown higher accuracy in pest detection compared to existing methods. These advancements in pest detection technology contribute to the success of integrated pest management efforts and enable timely and accurate pest control in the field, (Gousia Habib and Shaima Qureshi). Pests such as ants, rats and mice, as well as other food insects, can often carry diseases that can have a severely detrimental effect on society. Pest control helps manage and reduce this risk, meaning less product is wasted, consumers stay healthier, and the farmers' reputations remain intact, (mjbpestcontrol.co.uk).

1.1.1 Early Detection

Early detection of pests in agriculture is crucial for effective pest management and crop protection. Detecting pests at an early stage allows farmers to take prompt action to prevent the spread of infestations and minimize damage to their crops. Pest detection is multi-factor which includes the following activities:

(i) *Monitoring* : Regular monitoring of crops is essential for early pest detection. Farmers can use a variety of methods such as visual inspection, traps, pheromone lures, and sensors to monitor pest populations in their fields. Monitoring should be done at regular intervals to detect any signs of pest presence or damage. According to tracextech.com in August 2023, Agriculture places a high priority on crop monitoring since it enables early detection of pests and diseases, optimises resource use, and promotes sustainable practises. Monitoring supports farmers in making informed decisions, increasing productivity, and minimising environmental impact, which results in improved economic outcomes and long-term agricultural sustainability. Monitoring provides essential information about crop health, growth, and environmental conditions.

    Modern crop monitoring relies heavily on technology since it offers cutting-edge tools and methods for data gathering, analysis, and decision-making. Real-time monitoring of crop health, soil conditions, and weather patterns is now possible because of innovations like satellite imaging, drones, IoT sensors, and AI-powered analytics. With the help of this technology, farmers can practise precision agriculture, make the most use of their resources, and act quickly in case of emergencies, resulting in more output, lower expenses, and more environmentally friendly agricultural methods.

(ii) *Identification*: Once pests are detected, it is important to accurately identify the type of pest causing the damage. This can be done through visual inspection of the pests themselves, their feeding patterns, and the type of damage they cause to the crops. Proper identification is crucial for determining the most effective control measures to be taken. According to Timothy J. Gibb, pest identification is a step that is sometimes taken for granted. Nevertheless, accurate identification of the pest must always be confirmed. Although this process is one of the most basic elements of pest management, mistakes in identification are still common, especially when many pests are similar in appearance or behavior. Accurately identifying the pest and its damage, recognizing which life stages are present, and understanding the life history of the pest and how it interacts with people are all factors that help a pest manager anticipate damage and exploit the weak links in the pest's biology. Management efforts should never take place before the pest is properly identified.

(iii) *Prevention of spread*: Early detection of pests helps in implementation of preventive measures to contain the spread of infestations to other parts of the field or to neighboring crops. By containing pests early on, farmers can minimize the economic losses and environmental impact associated with widespread pest infestations.

1.1.2 Precision Agriculture

Precision agriculture, also known as precision farming or precision agriculture, is an innovative approach to farming that utilizes technology and data-driven strategies to optimize crop production while minimizing inputs and environmental impact. Precision agriculture involves the use of various technologies, such as GPS, sensors, drones, and data analytics, to collect and analyze information about soil conditions, crop health, and other factors that influence crop growth. Precision agriculture contains:

(i) *Site-specific management*: Precision agriculture enables farmers to manage their fields on a site-specific basis, taking into account variations in soil properties, topography, and crop growth within a field. By collecting data using sensors and other technologies, farmers can create detailed maps of their fields and tailor management practices to specific areas, optimizing resource use and crop performance.

(ii) *Data-driven decision-making*: Precision agriculture relies on data collection and analysis to make informed decisions about crop management. Farmers can use information gathered from sensors, drones, and other technologies to monitor soil moisture levels, nutrient content, pest populations, and crop health. This data allows farmers to adjust irrigation, fertilization, and pest control practices in real-time to maximize crop yields and quality.

(iii) *Increased efficiency*: Precision agriculture helps farmers improve the efficiency of their operations by reducing waste and optimizing resource use. By applying inputs, such as water, fertilizers, and pesticides, only where and when they are needed, farmers can minimize costs and environmental impact while maximizing crop productivity. This targeted approach to crop management can lead to higher yields and profitability for farmers.

(iv) *Remote monitoring*: Precision agriculture allows farmers to monitor their fields remotely using drones, satellites, and other technologies. This enables farmers to quickly identify issues such as pest infestations, nutrient deficiencies, or water stress, and take timely action to address them. Remote monitoring provides farmers with real-time information about their fields, helping them make proactive decisions to optimize crop production.

1.1.3 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is a holistic and sustainable approach to pest management that focuses on preventing and managing pest problems through a combination of biological, cultural, physical, and chemical control methods. IPM aims to minimize the use of synthetic pesticides and reduce environmental impact while effectively managing pest populations in agriculture. Here are some key points to consider about Integrated Pest Management:

(i) *Cultural controls*: Cultural practices play a key role in IPM by creating unfavorable conditions for pests and promoting natural pest control. Practices such as crop rotation, intercropping, mulching, and sanitation can help reduce pest pressure and enhance the resilience of crops to pest damage.

(ii) *Biological controls*:Biological control methods involve the use of natural enemies, such as predators, parasitoids, and pathogens, to manage pest populations. By promoting the presence of beneficial organisms in the agroecosystem, farmers can enhance biological control and reduce reliance on chemical pesticides.

(iii) *Controls*: While chemical control measures are used as a last resort in IPM, they are still an important tool for managing pest populations. Integrated Pest Management emphasizes the judicious and targeted use of pesticides, taking into account factors such as pest biology, timing of application, and environmental impact.

1.1.4 Crop Protection

Crop protection refers to the various practices and strategies employed by farmers to safeguard their crops from pests, diseases, weeds, and other environmental stressors that can reduce yield and quality. Effective crop protection measures are essential for ensuring a successful harvest and maintaining the health and productivity of agricultural crops. Here are some key points to consider about crop protection:

(i) *Pest management*: Pest management is a critical component of crop protection, as pests such as insects, mites, nematodes, and pathogens can cause significant damage to crops. Farmers use a combination of cultural, biological, and chemical control methods to manage pest populations and minimize crop losses. Integrated Pest Management (IPM) is a holistic approach to pest management that emphasizes prevention, monitoring, and the use of multiple control methods to effectively manage pests while minimizing environmental impact.

(ii) *Disease control*: Plant diseases, caused by fungi, bacteria, viruses, and other pathogens, can have devastating effects on crop yields and quality. Farmers implement disease control measures such as crop rotation, planting disease-resistant varieties, and applying fungicides to prevent and manage diseases. Timely detection and accurate diagnosis of plant diseases are crucial for effective disease control in agriculture.

(iii) *Weed management*: Weeds compete with crops for resources such as water, nutrients, and sunlight, and can reduce crop yields if left uncontrolled. Farmers use various weed management practices, including mechanical cultivation, mulching, cover cropping, and herbicide application, to suppress weed growth and protect crop productivity. Integrated weed management strategies combine multiple control methods to effectively manage weed populations and minimize weed-related losses.

1.2 Challenges Associated with Traditional Methods of Pest Monitoring

Traditional methods of pest monitoring, such as visual inspection and manual sampling, can be subjective, time-consuming, and may not always capture the full extent of pest populations in crops. These methods are often labor-intensive and require significant human resources, making them impractical for large-scale or remote agricultural operations. Additionally, traditional monitoring techniques may not provide real-time or continuous monitoring capabilities, leading to delays in detecting pest infestations and implementing control measures. As a result, there is a growing need for more efficient, accurate, and automated methods of pest detection in agriculture.The following are some challenges:

(i) *Inaccurate results*: Traditional methods of pest monitoring, such as visual inspection or trap placement, may not always provide accurate information on the presence and severity of pest infestations. 9

(ii) *Labor-intensive*: Traditional methods often require manual labor and time-consuming efforts to monitor pests, which can be costly and inefficient.

(iii) *Limited coverage*: Traditional methods may not cover a large enough area to effectively monitor pests, leading to gaps in surveillance and potential outbreaks.

(iv) *Subjectivity*: Human interpretation of pest monitoring data can be subjective and prone to error, leading to inconsistencies in monitoring and control efforts.

(v) *Lack of real-time data*: Traditional methods may not provide real-time data on pest populations, making it difficult to respond quickly to changing pest dynamics.

(vi) *Environmental impact*: Some traditional pest monitoring methods, such as chemical pesticides, can have harmful effects on the environment and non-target species.

(vii) *Resistance development*: Over-reliance on traditional pest monitoring methods can lead to the development of resistance in pest populations, making control efforts less effective over time.

1.3 Existing Approaches to Pest Detection in crops

Existing approaches to pest detection in crops encompass a range of technologies and methods that leverage advancements in fields such as remote sensing, sensor technology, machine learning, and molecular biology. These approaches aim to enhance the accuracy, efficiency, and timeliness of pest monitoring and management in agricultural settings.

1.3.1 Remote Sensing Technology in Agriculture

According to Katie Moran, Remote Sensing Analyst, Agriculture is a prominent example of an industry that benefits from remote technologies–particularly drones and high-resolution satellite imagery.

Some of the best-known uses of remote sensing in agriculture are to assess crop health by analyzing imagery for nutrient deficiencies, water stress, pests, and disease. While crop conditions can be apparent to the naked eye both on the ground and from the air, specialized remote sensors enable the collection of imagery that includes spectral bands beyond the range of visible colors (red, green, blue). Two such bands are near-infrared (NIR) and red-edge, which are invaluable for calculating vegetation indices to assess crop vigor. These bands and resulting indices can help identify plant stress before there are noticeable symptoms, allowing for early corrections and more efficient use of resources while also minimizing scouting and testing costs. This can be particularly helpful during drought years for monitoring crop water stress and efficiently irrigating, or flood years for managing fungal disease pressure from increased moisture.

There are numerous other remote sensing applications in agriculture. By collecting LiDAR or structure-from-motion (SfM) point clouds using drones, one can 3D model both ground and vegetation to create detailed terrain analyses and crop height/volume/biomass measurements for yield predictions. The very high pixel resolution offered by drone sensors also allows for weed mapping, as well as plant counts and germination tracking, so that germination failures can be replanted. Thanks to increasing advances in machine learning detection algorithms, remote sensing can even be used to predict when crops like broccoli are at the ideal harvest stage. Remote sensing is more accessible than ever with drones for time-sensitive and highly detailed imagery, in addition to increasingly affordable satellite imagery for extended monitoring of field conditions. With a changing climate and increased operating costs for farms, remote sensing can be a valuable tool for the early detection of stressed areas and production monitoring.

Here are some key aspects of remote sensing technology in relation to crops: Types of Remote Sensing Data:

(i) *Optical Remote Sensing*: This type of remote sensing captures images of the Earth's surface using visible and near-infrared light. It can provide valuable information on crop health, vegetation cover, and pest infestations.

(ii) *Hyperspectral Remote Sensing*: Hyperspectral sensors capture data in numerous narrow spectral bands, allowing for detailed analysis of crop characteristics, such as nutrient content, stress levels, and pest damage.

(iii) *Thermal Infrared Remote Sensing*: Thermal sensors detect the heat emitted by objects, including crops. This data can be used to assess crop water stress, monitor temperature variations, and detect pest infestations based on temperature differences.

(iv) *Radar Remote Sensing*: Radar sensors use microwave radiation to penetrate through clouds and vegetation, providing information on crop structure, soil moisture levels, and pest damage.

Applications of Remote Sensing in Crop Monitoring:

(i) *Crop Health Assessment*: Remote sensing data can be used to assess the overall health of crops by detecting changes in vegetation indices, such as NDVI (Normalized Difference Vegetation Index), which indicate stress or pest damage.

(ii) *Pest Detection*: Remote sensing technology can help identify pest infestations in crops by detecting changes in plant reflectance, chlorophyll content, and other physiological parameters affected by pests.

(iii) *Yield Prediction*: By analyzing remote sensing data, farmers and researchers can estimate crop yields based on factors such as plant biomass, canopy cover, and growth patterns.

(iv) *Irrigation Management*: Remote sensing can assist in optimizing irrigation practices by monitoring soil moisture levels, crop water stress, and evapotranspiration rates.

(v) *Precision Agriculture*: Remote sensing enables farmers to implement precision agriculture techniques, such as variable rate application of inputs, based on spatial variability detected through remote sensing data.

Benefits of Remote Sensing in Crop Monitoring:

(i) *Early Detection*: Remote sensing technology allows for early detection of crop stress, pest infestations, and diseases, enabling timely intervention and mitigation measures.

(ii) *Cost-Effective*: Remote sensing can provide large-scale crop monitoring at a relatively low cost compared to traditional ground-based methods, reducing the need for manual labor and resources.

(iii) *Data Integration*: Remote sensing data can be integrated with other sources, such as weather data, soil information, and crop models, to provide comprehensive insights into crop health and management practices.

(iv) *Sustainability*: By facilitating targeted pest management, optimized irrigation, and precision agriculture practices, remote sensing contributes to sustainable crop production and resource conservation.

***C*hallenges that affects Remote sensing Technology in Agricultural**.

According to research ,The soaring world population and climate change are recurring concerns in the agricultural sector. However, novel remote sensing (RS) technologies can certainly assist in the reduction of farming impact on the environment while offering efficient solutions for crop management to support agricultural sustainability.

Overall, remote sensing technology plays a crucial role in modern agriculture by providing valuable information for crop monitoring, pest detection, and decision-making processes. Its ability to capture detailed, timely, and spatially explicit data makes it a powerful tool for enhancing crop productivity, sustainability, and resilience in the face of pest challenges.

1.3.2 Sensor Technology in Agriculture

According to a paper published by SimonIoT, Sensors in agriculture are used to pick up measured information about the environment or plants, and that's transformed by the sensors to electrical signals that can be used to analyze the information.

Agriculture sensors are a way to gather information about crops, fields, equipment, and other key factors to be able to make informed decisions about agriculture. The sensors can be used for anything from measuring the pH level of the soil to the growth of the crops.

Overall, smart IoT sensors in agriculture are ultimately used to empower farmers and others in agriculture to make the best decisions about how to manage their crops and fields. Sensors provide them with real time data about their fields and crops, which can help them make better decisions on how to care for their crops and fields. For example, a sensor can help a farmer discover that the nutrients in the soil of a particular field are depleted. That farmer then knows it's time to switch farming techniques and to care for that field in particular.

Sensors can provide a wide range of information that can empower farmers to care for their crops and fields. By collecting a wide range of data from sensors, farmers can paint a complete picture of their farms, crops, and fields that helps them plan for the future accordingly. They know what fields need extra care, what ones are ready for crops, what crops grew well with the weather, and more. From there, they can plan for the future. Depending on the type, the sensor may be buried in the ground, where it will be read by probes that will convert the data into an electrical signal or reading that is comprehensible to humans.

***T*ypes Of Sensors are as follows:**

(i) *Optical sensors*: Optical sensors use light to measure data. These sensors can be installed and mounted on automobiles, satellites, drones, or robots that are able to be mobile enough to pick up data. The sensors cause the soil to reflect, which provides farmers with information about the soil and plant color. Optical sensors can help measure the moisture of soil, the organic matter content of soil, the content of clay, and more.

(ii) *Electrochemical sensors*: These sensors help in gathering chemical data of the soils by detecting specific ions in the soil. They provide information about the pH and soil nutrient levels. Typically, these sensors are mounted on special sleds. Soil samples are sent to a lab for analysis and the most accurate data collection. The goal of these sensors is to gather highly specific information about the soil to make informed decisions.

(iii) *Mechanical sensors*: These sensors are used to measure soil compression or mechanical opposition. The mechanical sensor is pushed through the soil. As it passes through the soil, it documents the holding forces that result from the cutting, smashing, and displacing of soil. Soil mechanical resistance is recorded in a unit of pressure and points out the ratio of the force necessary to go into the soil.

(iv) *Dielectric soil moisture sensors*: This sensor calculates the moisture levels in the soil with the assistance of a dielectric constant. This is an electrical property that substitutes depending on the moisture content in the soil. These sensors are primarily used to determine the moisture levels of the soil for optimal crop growth.

(v) *Location sensors*: These sensors are used to help manage weather conditions, and they're positioned at different places in a field to gather data about weather. The sensors use GPS location data to determine where certain phenomena are occurring.

(vi) *Air flow sensors*: These types of sensors measure soil air penetration. The expected result is the pressure needed to push a decided amount of air into the ground at a prescribed depth. These sensors can be fixed or mobile sensors to gather a variety of data.

***B*enefits of Using Agriculture Sensors**

These are some of the key benefits of using agricultural sensors today:

(i) *Helps maximize returns with minimum resources*: To combat high food demand, agricultural sensors can help farmers increase their yield while using the minimum amount of resources available, such as water, fertilizer, and seeds. This helps farmers conserve resources and still grow adequate food.

(ii) *Are simple and easy to install and use*: Sensors in agriculture can be simple to install and easy to use. They connect to a central location, which provides farmers with an easy way to gather information.

(iii) *Can be remotely controlled*: With IoT sensors, farmers can control sensors remotely. That provides them with the benefits of sensors without the complexities of having to manually manage each individual sensor.

(iv) *Provides information about pollution and climate change*: Agricultural sensors don't just need to provide information about soil and plants. They can be used to measure pollution and climate change data to create a more sustainable farm.

(v) *Empowers farmers to plan for the future*: Having data is important to making accurate predictions and making informed decisions. Smart agriculture sensors provide farmers with that data, so they can make informed decisions about their farms, crops, fields, and equipment, and so they can plan for the future.

***A* Challenge for Agriculture Sensors**.

The use of smart agriculture sensors is not without its difficulties. For optimal operation, smart farming and Internet of Things (IoT) equipment, including agricultural sensors, require constant internet access. In the agricultural sector, that can be problematic because a lot of farms and fields are extremely remote and don't have the infrastructure needed for constant connectivity.

Farmers in extremely remote places want ruggedized devices and an IoT partner who is prepared to put in the effort to deliver the greatest connectivity because of the problem of continuous connectivity.

All things considered, sensors in agriculture are an effective way to collect precise data on plants, fields, and machinery to enhance intelligent farming methods. The pH, moisture content, composition, compaction, weed identification, condition of farming equipment, and even the weather can all be understood with the use of sensors.

1.3.3 Molecular Biology in Agriculture

A paper published by Hernán Eduardo Laurentin Táriba says, Detailed knowledge of the processes involved in the central dogma of molecular biology has enabled the direct or indirect use of DNA in molecular characterization, in direct changes of genetic information (named genetic edition), and in the breeding of genetically modified organisms. The three activities have had a major impact on both research and production in agriculture. The characterization seeks to determine the identity of the individuals in the most reliable possible manner to make subsequent genetic diversity analyses, or to register or patent cultivars, or to make diagnoses of the presence of a certain pathogen or insect pest. These activities are usually done based on morphological traits, but these have the disadvantage of a high environmental influence and/or certain subjectivity in the determination. Molecular markers, especially DNA markers, and some isoenzymes overcome this disadvantage. Due to the high resolution they can have, DNA markers are becoming increasingly popular. The vast majority of them are based on the polymerase chain reaction (PCR), with their informative quality being dependent on whether they are co-dominant or dominant. When it is possible to relate an agronomically desirable characteristic with a band of some molecular marker, it is feasible to carry out molecular marker-assisted selection, which potentially has high efficiency. Genetically modified organisms are individuals in which DNA have been modified, either by insertion or deletion of some nucleotides (genetic editing) or by insertion of genes in an unnatural way since it is not through sexual reproduction. Therefore, it is possible to obtain individuals with genes from unrelated species to these via what is known as the recombinant

DNA technique. Bioethics and biosafety are concepts usually related to obtaining and using genetically modified organisms.

Benefits of Molecular Biology in Agriculture: With the development of molecular biology, some DNA-based technologies have showed great potentiality in promoting the efficiency of crop breeding program, protecting germplasm resources, improving the quality and outputs of agricultural products, and protecting the eco-environment etc., making their roles in modern agriculture more and more important. To better understand the application of DNA technologies in agriculture, and achieve the goals to promote their utilities in modern agriculture, this paper describes, in some different way, the applications of molecular markers, transgenic engineering and gene's information in agriculture. Some corresponding anticipations for their development prospects are also made.According to Jinggui Fang et al.

1.3.4 Machine Learning

The agricultural sector is witnessing a growing utilisation of machine learning (ML) across a range of applications, including yield prediction, crop classification, disease detection, pest monitoring, irrigation management, and soil analysis. ML algorithms can analyse large volumes of data generated from various sources such as remote sensing, weather stations, and soil sensors to provide insights and recommendations that can improve the efficiency and productivity of agricultural systems. The use of AI and deep learning techniques in agriculture has shown promising results in improving crop productivity, disease and pest detection, soil analysis, and irrigation management. According to R. Deepa,et al. Machine learning (ML) has emerged together with big data technologies and high-performance computing to create new opportunities to unravel, quantify, and understand data intensive processes in agricultural operational environments. Among other definitions, ML is defined as the scientific field that gives machines the ability to learn without being strictly programmed by Samuel A.L.

A clear overview of recent research in the area of crop pests and pathogens identification using techniques in Machine Learning Techniques like Random Forest (RF), Support Vector Machine (SVM), and Decision Tree (DT), Naive Bayes (NB), and also some Deep Learning methods like Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM), Deep convolutional neural network (DCNN), Deep Belief Network (DBN) was presented. The outlined strategy increases crop productivity while providing the highest level of crop protection. By offering the greatest amount of crop protection, the described strategy improves crop efficiency. This survey provides knowledge of some modern approaches for keeping an eye on agricultural fields for pest detection and contains a definition of plant pest detection to identify and categorise citrus plant pests, rice, and cotton as well as numerous ways of detecting them. These methods enable automatic monitoring of vast domains, therefore lowering human error and effort.By M. Chithambarathanu, M. K. Jeyakuma.

***C*rop pest classification.**

(i) *Maize pest classification*

In recent years, some researchers have used image processing and machine learning techniques to detect crop diseases . However, traditional machine vision methods are less robust in complex scenes, so it is difficult to meet the needs of complex scenes. With the excellent performance of deep learning at the ImageNet Large-Scale Visual Recognition Challenge (ILSVRC), deep learning has been rapidly developed. Among them, deep learning models represented by convolutional neural networks (CNN) have been successful in many fields, such as computer vision and natural language processing , and many deep learning architectures are gradually applied to agricultural crops pest identification, such as AlexNet , GoogleNet , VGGNet , ResNet, and Vision Transformer , which has been introduced from the field of natural language processing to the field of CV in recent years. Object detection of pests is one of the main tasks of plant pest detection, and the aim is to obtain accurate location and class information of pests, which can be well solved by CNN-based deep learning feature extractors and integrated models. Sabanci et al. proposed a convolutional recurrent hybrid network combining AlexNet and BiLSTM for the detection of pest-damaged wheat . Gambhir et al. developed a CNN-based interactive network robot to diagnose pests and diseases on crops . Sun et al. proposed a multi-scale feature fusion instance detection method based on SSD, which improved on SSD to detect maize leaf blight in complex backgrounds . Although all the above studies have suitable accuracy, they cannot meet the demand for real-time object detection. In computer vision, real-time object detection is a very important task. YOLO is a popular family of real-time object detection algorithms. The original YOLO object detector was first released in 2016 . This architecture is much faster than other object detectors and has become the latest technology for real-time computer vision applications. Currently, YOLO has been widely used in plant pest identification. For example, Roy et al. proposed an improved YOLOv4-based real-time object recognition system, Dense-YOLOv4, by integrating DenseNet into the backbone to optimize the transmission and reuse of features . Using the improved PANet to acquire location information and detect mango growth in complex scenes in orchards. Lawal et al. proposed YOLO-Tomato-A and YOLO-Tomato-B models based on YOLOv3 to detect tomatoes in complex environments and improved the performance of the models by adding labeling methods, dense architecture, spatial pyramid pooling, and the mish activation function to the YOLOv3 model . Li et al. proposed an architecture for plant pest and disease video detection based on a combination of deep learning and custom backbone networks . Experiments demonstrated that the customized DCNN network has outstanding detection sensitivity for rice stripe wilt and rice stem borer symptoms compared with YOLOv3 with VGG16, ResNet50, and ResNet101 as the backbone. Zhang et al. combined the pooling of spatial pyramids with YOLOv3 to achieve inverse by combining upsampling and convolution operations. Convolution can effectively detect small-sized plant pest samples in images, and the average recognition accuracy can reach 88.07With the YOLO family of object detection algorithms continuously updated, YOLOv7 was created in 2022 , which claimed that YOLOv7 is the fastest and most accurate real-time detector to date. There is less research on the application of YOLOv7 to plant pest detection, so we tried to apply YOLOv7 to plant pest detection while we further optimized its accuracy, speed, and computational load. On the other hand, although some researchers have explored DL-based detection and identification of pests, there are fewer studies on pest detection and identification for maize, an important agricultural crop. In this study, we propose the Maize-YOLO algorithm for maize pest detection. The proposed algorithm achieves a suitable balance between accuracy, computational effort, and detection speed to achieve fast and accurate detection of pests. The main contributions of this work are as follows: We inserted the CSPResNeXt module into the YOLOv7 network, replacing the original ELAN module, to improve accuracy while reducing model parameters and computational effort. We replaced the ELAN-W module in YOLOv7 with the VoVGSCSP module, which reduces the complexity of the model while maintaining the original accuracy and improving the speed of detection. We tested the detection of highly damaging pests on maize using Maize-YOLO on the IP102 dataset.

*L*imitations

1. *Appearance Variation:* Some types of pests have a large difference in appearance between the larval and adult stages, which can lead to poor recognition by the model.
2. *Dataset Limitations:* The study used the IP102 dataset, which may not reflect the full variety of pests in natural field environments.

These limitations highlight areas for future research and development to enhance the accuracy and applicability of the Maize-YOLO model for pest detection. The article also discusses the potential for combining Maize-YOLO with web interfaces, intelligent patrol robots, and smartphone applications for an easy-to-operate AI-based pest detection system.

CHAPTER 2

CONCLUSION AND RECOMMENDATION

2.1 Conclusion

2.2 Recommendations