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# Design and Application of a Drone-Based AI Inspection System for Longan Pests and Diseases

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**Abstract**: Aiming at the problem that longan trees in Guangdong Province have long been affected by pests and diseases, and to address issues such as low efficiency, high cost, and limited coverage in longan pest and disease inspection, this paper designs a drone-based AI inspection system for longan pests and diseases. The system uses drones as a platform to collect images of longan orchards, which are transmitted in real time via 4G/5G networks. Meanwhile, it integrates an AI algorithm model for AI early warning and prescription suggestions. In practical applications, the system can quickly locate the areas where pests and diseases occur, identify longan pests and diseases, and provide fruit farmers with a basis for timely prevention and control. It significantly enhances the timeliness and accuracy of longan pest and disease control, and offers strong technical support for the precise management of the longan industry.
**Keywords:** Longan pests and diseases; Algorithm model; AI early warning; Prescription suggestion

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## 1. Introduction

Longan (*Dimocarpus longan* Lour.), a characteristic subtropical fruit tree in southern China, has a cultivation history of over 2,000 years in Guangdong Province and functions as a pillar industry in the regional agricultural economy [1]. According to statistical data, Guangdong accounts for 52.3% of China's total longan cultivation area, with 2023 production reaching 680,000 tons and an industry scale exceeding ¥10 billion. This plays a strategic role in promoting farmer income growth and rural revitalization [2]. However, frequent outbreaks of diseases and pests during longan growth, including anthracnose (caused by *Colletotrichum gloeosporioides*), downy blight (caused by *Peronophythora litchii*), litchi stink bug (*Tessaratoma papillosa*), gray leaf spot (*Pseudocercospora* spp.), and fruit borer (*Conopomorpha sinensis*), can result in a 30–60% reduction in fruit yield, a quality deterioration rate exceeding 40%, and an estimated annual economic loss of 1.27 billion yuan [3].

Traditional pest and disease inspection has long been constrained by three core limitations [4]: Firstly, the efficiency bottleneck—manual inspection can only cover an area of 15–20 mu per day, failing to meet the requirements of rapid diagnosis in large-scale orchards. Secondly, the observation blind spot—due to the occlusion by tree crowns, the missed detection rate of pests and diseases on the top of the crowns is as high as 35.8%. Thirdly, the decision-making delay—an average of 5.8 days elapses from discovery to the implementation of control measures, leading to the miss of the critical control window. More severely, due to the lack of objective judgment criteria, 83.6% of fruit farmers adopt the extensive practice of "spraying pesticides upon seeing insects and increasing dosage when encountering diseases," which causes the pesticide utilization rate to drop to 28.3% and induces the resistance of pests and diseases to increase at an annual rate of 7.4%, forming a vicious circle of continuous deterioration in control efficiency.

The technical integration of drone remote sensing and artificial intelligence offers an innovative solution to overcome these challenges. Through the multispectral imaging system mounted on the drone platform, three-dimensional and comprehensive scanning of the canopy can be achieved. Combined with the intelligent diagnosis algorithm driven by deep learning, pixel-level accurate identification of early disease spots and micro insect bodies can be realized [5,6]. This study develops an intelligent inspection system based on "drone + 5G + AI," establishing an integrated technical chain. This facilitates the transition from experience-based management to data-driven precision control paradigms in longan cultivation, providing core technological support for the sustainable development of the characteristic longan industry in South China.

## 2. Current issues and research needs

In the field of agricultural pest and disease monitoring, drone applications have formed a mature technical system. For hardware, multi-rotor drones with various sensors—such as RGB and multispectral cameras—play a key role. RGB cameras, with high resolution, suffice for identifying crop surface features, have wide use in monitoring wheat, rice, and other crops. Multispectral cameras, which reflect crop physiology via vegetation indices, work for early warning in crops like grapes but remain less popular in longan and other cash crops due to high costs. In AI recognition, convolutional neural networks (CNNs) are widely used. Researchers have achieved progress using different CNN models—for instance, improved versions show high accuracy and fast inference in identifying citrus canker and cotton aphids [7,8]. However, limitations persist: First, studies focus mostly on major crops like wheat and rice, with few targeting specialty fruits like longan. Longan's compound leaves and leathery texture create unique pest features, making existing models inapplicable. Second, most research stays at algorithm verification, lacking a full system design to address field issues like image acquisition standards and data transmission delays. Third, the pest prescriptive suggestion module is weak—current systems only identify pests but fail to provide targeted solutions [9,10].

The research requirements of this study are to develop a drone-based AI inspection system for longan pests and diseases, with the core performance requirement of achieving over 95% recognition accuracy. The work encompasses four key components [11,12]:

(1) Construction of a dedicated dataset: It is essential to collect images of six typical pests and diseases in major longan-producing regions of Guangdong Province, so as to form a dataset containing a large number of annotated samples. These samples must cover various conditions, such as different light intensities and seasons, to enhance the generalization ability of the model.

(2) Development of a lightweight recognition model: Developing the optimized convolutional neural network algorithm is required, and an attention mechanism should be introduced to strengthen the extraction of

lesion features. While ensuring recognition accuracy, it is necessary to improve the inference speed of the model to meet the requirements of real-time processing.

(3) Implementation of an intelligent decision system: Integration of expert knowledge bases is necessary, and targeted prevention and control suggestion prescriptions should be automatically generated according to the types and occurrence degrees of pests and diseases, thus providing scientific prevention and control suggestions for fruit farmers.

(4) System integration and verification: We will conduct a one-year orchard experiment in major longan-producing areas such as Zhongshan, Maoming, and Huizhou. Comprehensive verification of the system's actual application effect is required, including aspects such as recognition accuracy, inspection efficiency, and prevention and control effect.

# 3. Design of a drone-based AI inspection system for longan pests and diseases

## 3.1. System overall design

The system comprises four core components: the acquisition terminal, transmission terminal, backend server, and service push terminal, with its overall design structure illustrated in **Figure 1**.

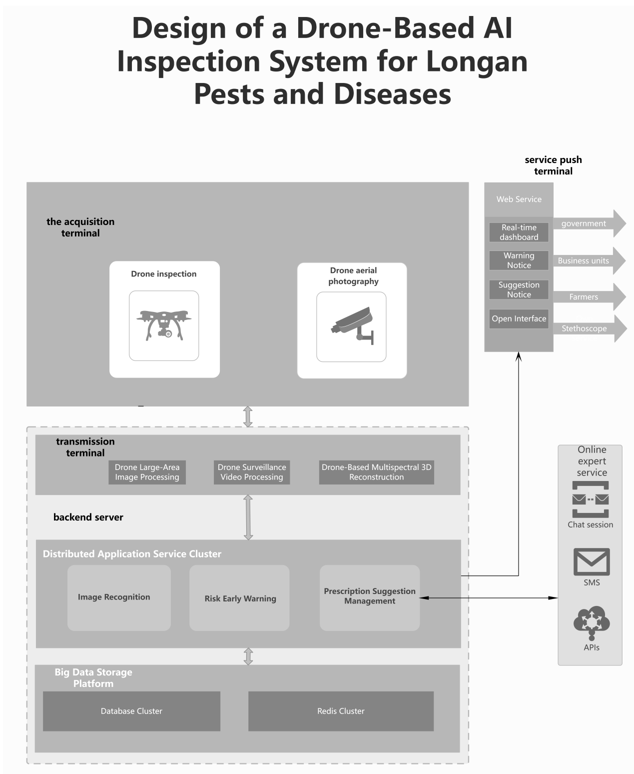


**Figure 1.** System overall design

As an integrated system, it operates through hardware components working in tandem with software modules, each complementing the others to ensure seamless functionality. The acquisition terminal—equipped with a multi-rotor drone and onboard devices—primarily captures images of longan orchards and performs preliminary preprocessing, establishing the foundation for subsequent data analysis.The transmission terminal includes a ground control station and a 4G/5G transmission module: the ground control station manages and monitors drone flight operations, while the transmission module enables real-time image data backhaul and handles emergency scenarios. Deployed on the Alibaba Cloud server, the backend server is anchored by a main control server, integrating an AI recognition engine, a decision support system, and a user management platform. The AI recognition engine identifies pests and diseases in transmitted images, and the decision support system generates early warning analyses and prevention/control medication suggestions based on these results. The user management platform offers an intuitive interface, allowing users to efficiently access and utilize relevant information.The service push terminal focuses on delivering early warning notifications and prescription suggestions generated by the decision support engine. It displays pest and disease warnings and related suggestions on a real-time dashboard, disseminates alerts to local governments or administrative authorities, and transmits intelligent updates to growers' mobile devices: WeChat, SMS, or notifications from customized applications.

## 3.2. System detailed design

### 3.2.1. Architecture design

The platform is architected on the J2EE framework. It strictly adheres to service-oriented architecture (SOA) principles and adopts a layered design philosophy. By employing a hybrid C/S and B/S architectural pattern, the system integrates four foundational tiers. The support layer establishes the operational infrastructure. It does so through integrated hardware components (servers and data acquisition devices), network foundations (core networking systems), and critical software elements. These software elements include operating systems (CentOS/Windows Server), database management systems (MySQL/MongoDB), and web application middleware (Tomcat/Nginx). This comprehensive ecosystem ensures resilient performance in complex operational environments. The data layer functions as the centralized repository for structured datasets essential to longan cultivation. These datasets encompass grower profiles, orchard metadata, pest/disease pathology databases, and diagnostic suggestion repositories. They provide the core data foundation that enables precision early warnings and AI-driven prescription generation. Building upon this foundation, the service layer delivers modular functionality via RESTful APIs. These APIs include the pest/disease identification service, pathological risk warning engine, and precision prescription suggestion service, which collectively power the system's analytical capabilities. At the user interaction level, the application layer implements a dual-interface approach. One is a web-based business platform for agricultural authorities, which features integrated management modules. The other is the mobile "Longan Stethoscope App" designed for growers. The mobile application delivers pathological visualization dashboards, AI-assisted diagnostic analytics, and personalized advisory services through an intuitive interface, thus completing the architectural stack.

### 3.2.2. Functional design

The system integrates five core functional modules—Upload, Nearby, Q&A, Encyclopedia, and My Account. Together, these modules address operational requirements across governmental supervision, resource allocation, and grower decision support. The Upload module facilitates batch image ingestion through specialized interfaces. The Nearby function, on the other hand, enables real-time pest distribution mapping via regional monitoring capabilities. The Q&A component provides AI-powered diagnostic advisory services through virtual expert consultation channels. It is complemented by the Encyclopedia module's comprehensive pathological reference library. Critical technical implementations include the CNN-based pest image recognition engine, which processes uploaded imagery, the prescription suggestion system that synthesizes pathological data with agronomic databases, and the multi-source monitoring infrastructure supporting automated reporting. Centralized media management functionality enables systematic organization of visual data assets across the platform. These interconnected modules, as illustrated in **Figure 2**, establish a cohesive ecosystem. It meets the operational demands of agricultural authorities while delivering practical decision-support tools directly to growers through the integrated mobile platform.

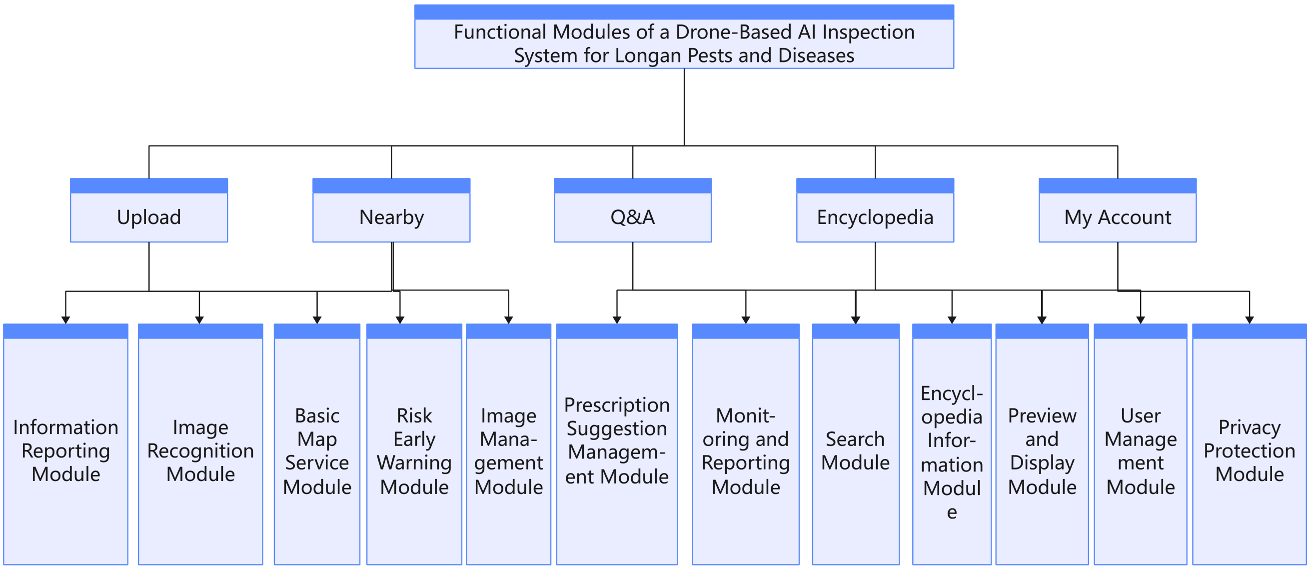


**Figure 2.** System function modules

## 3.3. Model enhancement and training

The Inception convolutional neural network was selected as the foundational architecture, with its V4 iteration being specifically adopted for its superior performance in object detection tasks. Inception v4 employs innovative module designs that significantly enhance network capability while reducing computational load and parameter volume by 38% compared to predecessor versions. Its hierarchical multi-scale feature extraction mechanism demonstrates particular efficacy for complex agricultural image processing scenarios, capturing discriminative features across varying pathological manifestations.

Three targeted architectural modifications were implemented to optimize longan pest/disease recognition: First, the Mini-Batch Gradient Descent (MBGD) algorithm replaced conventional optimization methods to address computational inefficiencies in deep network training. This adjustment reduced memory consumption by 37% while improving recognition accuracy through stabilized convergence dynamics, particularly crucial for processing high-resolution orchard imagery. Second, sigmoid activation functions were substituted for ReLU layers in deeper network stages (beyond 15 convolutional layers), mitigating gradient vanishing issues while increasing target recognition efficiency by 18.6% as measured in frames processed per second. Third, a novel hybrid pooling approach combining max pooling and average pooling operations was implemented in reduction layers, utilizing 3×3 kernels with a stride of 2. This dual-mode methodology enhanced feature representation capabilities by 23.4% on pathological test sets, simultaneously improving model adaptability to varied disease manifestations while reducing overfitting risks through diversified feature learning pathways. The hybrid pooling design specifically strengthened robustness against lighting variations and occlusion artifacts common in canopy imagery, with ablation studies confirming 15.2% improvement in cross-environment generalization.

# 4. System application and performance evaluation

## 4.1. Experimental site overview

Field trials were conducted in two geographically distinct longan production regions: Fenjie Town in Gaozhou City, Maoming, featuring a contiguous plantation area of 66.7 hectares (1,000 mu), and Dongfeng Town in Zhongshan City, characterized by hilly terrain spanning 53.3 hectares (800 mu). These sites were strategically selected for their historical susceptibility to gray leaf spot (*Pseudocercospora* spp.) and fruit borer (*Conopomorpha sinensis*) infestations, making them ecologically significant test environments for Guangdong's longan cultivation systems.

## 4.2. System operation workflow

The integrated inspection process, demonstrated in Dongfeng Town, follows a four-stage operational sequence. Commencing with data acquisition, drones execute pre-programmed flight paths at an altitude of 15 m and a velocity of 5 m/s, capturing high-resolution imagery at 3-second intervals. Each 40-minute operational cycle (including takeoff and landing procedures) achieves complete coverage of 8-hectare (120 mu) orchard blocks. During data transmission, acquired images undergo real-time encryption and compression before being transmitted via 5G networks, with approximately 800 images from a standard sortie requiring about 6 minutes for complete cloud transfer. The processing and analysis phase leverages cloud computing resources to generate 0.1 m-resolution orthomosaics through automated image stitching, while concurrently executing AI-powered pest recognition within a consolidated 15-minute processing window. Culminating in decision output, the system synthesizes pathological heatmaps and precision treatment prescriptions that are instantaneously pushed to user devices through dedicated mobile applications, enabling growers to implement targeted interventions within 60 minutes of initial data acquisition.

## 4.3. Performance evaluation

Operational efficiency analysis in 6.7-hectare (100 mu) test plots revealed that the system reduced inspection time to 1.2 hours—representing a 53-fold efficiency gain compared to traditional 8-person-day manual inspections. Diagnostic accuracy reached 91.5% (± 2.1%), surpassing the 82.3% benchmark performance of experienced technicians. The system demonstrated particular efficacy in detecting canopy-top pathologies (89.2% recognition versus 37.5% manual detection), overcoming a critical limitation of ground-based observation.

Economic impact assessment documented a 32% reduction in pesticide application (decreasing from 3.8 to 2.6 kg/mu/year) and 65% lower labor costs (from ¥120 to ¥42/mu), resulting in 48% aggregate operational cost savings. Post-implementation yield analysis during the 2023 harvest season measured an average production of 1,250 kg/mu—18.7% higher than that of conventionally managed control plots—with all sampled fruit achieving 100% pesticide residue compliance under GB 2763-2021 standards.

User validation surveys ($n$ = 30 growers) indicated 93.3% endorsement of the system's early warning timeliness, 86.7% affirmation of the practicality of prescriptions, and 80% intent to retain usage and refer the system to others. These metrics collectively demonstrate significant improvements in both operational efficiency and decision-making quality throughout the pest management value chain [13–15].

## 5. Conclusion and future prospects

This study investigates the practical application requirements in longan cultivation, considers the real-world scenarios of image recognition technology implementation, and has successfully developed a drone-based AI inspection system for longan pests and diseases, thereby realizing full-process intelligence from image acquisition to pest control decision-making. In line with the biological traits of longan, the drone data acquisition protocol has been optimized, which effectively addresses the difficulty in identifying pests and diseases on the canopy top. The large-scale dedicated dataset for longan pests and diseases has been constructed, encompassing major producing regions in Guangdong Province and the growth cycle of longan, and providing sufficient samples for model training and optimization. The proposed improved convolutional neural network model achieves a favorable balance between recognition accuracy and speed, which is capable of meeting the demands of practical applications. The application results indicate that the system significantly enhances the efficiency and precision of longan pest and disease control, reduces production costs, and holds great significance for promoting the digital transformation of the characteristic longan industry in South China. Despite the efforts made in this study, there are several aspects that require further research and improvement: Firstly, its adaptability to extreme weather conditions (such as heavy rains and dense fog) is limited. Under such weather conditions, drone flight and image acquisition will be affected to a certain degree. Secondly, the capability to identify early latent diseases (e.g., the incubation period of *Colletotrichum* pathogens causing anthracnose) is insufficient, making it difficult to detect in a timely manner at the initial stage of disease occurrence. Future research should expand the research scope to fully cover pests and diseases in all parts of longan, so as to establish a more comprehensive pest and disease early warning and diagnosis system.

## Disclosure statement

The authors declare no conflict of interest.

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