A pest sexual attraction monitoring system based on IoT and image processing

ZHAO Qing\textsuperscript{1,2,3,a}, ZANG Hecang\textsuperscript{1,2,3,b}, ZHANG Jie\textsuperscript{1,2,3,c}, WANG Meng\textsuperscript{1,2,3,d}, ZHENG Guoqing\textsuperscript{1,2,3,e}, LI Guoqiang\textsuperscript{1,2,3,f*}

\textsuperscript{1}Institute of Agricultural Economics and Information, Henan Academy of Agricultural Sciences, Zhengzhou China;
\textsuperscript{2}Henan Technology Innovation Strategic Alliance for Intelligence Agriculture Industry, Zhengzhou China;
\textsuperscript{3} Henan Engineering and Technology Research Center for Intelligent Agriculture, Zhengzhou 450002, Henan China

\textsuperscript{a}sunflower.701@163.com, \textsuperscript{b}109242204@qq.com, \textsuperscript{c}36658920@qq.com, \textsuperscript{d}403186333@qq.com, \textsuperscript{e}236368091@qq.com, 
\textsuperscript{*}Corresponding author: fmoonlgq1984@163.com

Abstract. In order to improve the efficiency and timeliness of pest field sexual attraction monitoring and then improve the efficiency of crop pest forecasting, in this study, we improved the traditional method of sexual inducement by designing a remote insect trap image collection device with image collection, remote communication and other Internet of Things technologies. An image processing and counting method based on OpenCV cascade classifiers was constructed with remote sexual attraction images. A pest situation database was established, and a pest monitoring and early warning system was constructed. The application of the system is convenient for plant protection technicians to collect and query the pest monitoring data, as well as the release of the pest early warning information, and it does realize the informatization of crop pest monitoring and early warning.

1. Introduction
In agricultural and forestry production, massive losses are caused by pests every year, so plant protection is significant. Therefore, the integration and experimental demonstration of pest-related agricultural Internet of Things monitoring and early warning technologies can timely sense the occurrence of pests, make accurate early warnings, and improve the efficiency of pest control [1-2]. At present, the survey and collection of the monitoring and early warning information of major crop pests in our country mainly rely on the manual survey method combined with the observation of the insect situation forecasting lamp and the trapping of sexual attractants. Light trapping and reporting require regular sampling and bringing back indoor classification statistics, which has poor timeliness. The number of light attracted insects is large, so the workload is enormous. There are many types of attracting insects, and staff must have a wealth of professional insect classification knowledge, which still very difficult to distinguish. There are still great technical difficulties in image recognition with many types of non-target insects and near-source species of certain types of insects [3-6].

Sex pheromone is used to trap insects in the field. The method is simple and widely used. The technology of sex pheromone is mature and reliable. However, it needs the forecasters to take samples
regularly and bring them back to the laboratory for artificial analysis and statistics, which consumes a lot of workforce and time. The measured results have inevitable delays [7].

In this study, against the problem such as targeted trapping and reporting timeliness, low degree of electronization of pest survey data, a special insect remote trapping and reporting device was developed to improve the original method. Then a monitoring and early warning system for crop pest trapping collection was constructed. Based on the server, the system collects pest information through the remote sexual attraction and forecast device. The administrator user logs in to the system to maintain the pest situation and other related information, then makes statistics on the overall occurrence of pests, which is comprehensively displayed through the web home page. The monitoring point users query the occurrence of local pests through the login system and release the pest warning information to the designated groups by SMS.

2. Hardware design for remote sexual attraction monitoring device

The remote sexual attraction monitoring device involved in the collecting and monitoring system mainly includes five parts: power source, power controller, miniature camera, insect trap, and 4G router. (1) The power source is connected with the camera and router through the power controller to realize the power supply. (2) The power controller is a KG316T DC12V time-controlled switch, which can be set according to actual needs to control the power supply time of the camera and router. (3) DV-IP903P 1.3-megapixel micro webcam is selected as the micro camera, which is compact and suitable for installation in the trap box and can set the FTP file path for uploading images. (4) The trap is composed of an insect sex trap core and armyworm board, which is used to trap and kill the monitored target insects. (5) A 4G router is a SIM card industrial router, which is used for wireless communication of image data to upload to the server.

The power supply is composed of solar panels, storage batteries, and charge controllers. The solar panel receives sunlight to generate current, which is transformed by the charge controller to charge the battery. The solar panel is placed on the top of the pole, the lower side is the trapping box, and the other side is the waterproof box for the integrated installation of the equipment. The top of the trap box is a rainproof cover, in which a micro camera is installed. The camera faces the armyworm board and the lure core on the lower platform; Battery, power controller, 4G router, etc., are installed in the waterproof box on the other side (Figure 1).

![Fig.1 Schematic structure for remote sexual attraction forecaster](image-url)
3. System Design

3.1. System Architecture Design

From the technical framework, the pest sexual attraction monitoring system is mainly divided into three levels. The first is the data collection layer, which uses remote sexual attraction monitoring devices to collect image data. The second is the data transmission layer, which transmits data through a 4G network or a WLAN network; The third is to process the insect information and use it on the web (Figure.2). The system is composed of a server, a backstage database, and a user's Web terminal, which adopts B / S architecture. The user Web terminal completes the access to the warning release database and the pest information database through the link to the server, then realizes the application of pest data management, monitoring, and early warning on the web terminal.

![Fig.2 System hierarchical architecture](image)

3.2. System Function Design

The system roles are designed for monitoring point users and administrator users. The two roles log on to the system's web and display different interfaces, and the corresponding functional modules are designed respectively. The user interface of the monitoring point includes three functional modules, user information maintenance, pest information management, and monitoring and early warning. The pest information management includes two sub-modules: additional recording and query of pest information. The monitoring and early warning include three sub-modules, early warning threshold setting, address book management, monitoring, and early warning information pushing. The administrator's user interface consists of 4 functional modules: system management, pest information management, pest information query, and basic pest information. The system management includes three sub-modules: user information management, site information maintenance, and FTP directory management. Pest information management includes two sub-modules: supplementary input information management and sexual attraction image management. The basic pest information includes three sub-modules: insect name and insect state information, crop and pest relationship.
4. key technologies

4.1. Hardware Integration
The sexual attraction device is mainly based on the timing camera function of the remote video monitoring system. It integrates 4G wireless transmission technology to realize the timing collection and return of image data. Through the background integration of the mobile phone SMS (short messaging service) cloud service function, the monitoring point users can release early warning information to the designated personnel.

4.2. Image Processing Method
The image processing function of C#-OpenCV function library was used to preprocess the sexual attraction image, and the steps are as for Figure 3.

![Image preprocessing steps and corresponding functions](image)

Fig.3 Image preprocessing steps and corresponding functions

Based on the tree structure of AdaBoost cascade classification of OpenCV, the SVM recognition model is established, and the train cascade program of OpenCV is used for classifier training to realize image counting. (1) The positive and negative samples of insect sex attractant image (taking corn borer as an example) were prepared, and Haar features were extracted and trained by AdaBoost; (2) The trained classifier is used to detect the corn borer, and the detected samples are saved in the database; (3) AdaBoost is used to extract HOG features from the detected samples, an SVM classifier is used to train them to get the recognition classifier, which is used to classify the first layer of detected samples; (4) In order to further reduce the false detection rate, the samples which are identified as corn borer in the second layer are processed with the double threshold to remove the background and extract the conventional features. The flow chart is shown in Figure 4.
5. System implementation

5.1. System development environment
This system is based on Visual Studio 2017 integrated development environment and the development language C#, Asp.net; Windows 7 operating system or above. Microsoft Visual Studio 2015 is used as the development tool, and the B/S mode is adopted. The background server adopts the Windows Server 2008 operating system and SQL Server 2008 database system.

The system can get the image data returned by remote device by setting FTP folder and return path in the background. The user of the monitoring point enters data and processed data into the background server.

5.2. Function realization
Users of the monitoring point enter the site interface through user name and password, and it is displayed as three modules: personal center, pest information, monitoring, and early warning. Through the pest information module, users can filter, view, and download the pest information data from this monitoring point, provide the information-adding interface, which is convenient for users to supplement and improve the pest information. In the monitoring and early warning module, users can set the threshold of the target pests to manage the early warning information and set the information push address book with working the list of the planting households and other relevant personnel and their mobile phone number. When the occurrence of the target pest reaches the warning threshold, the monitoring point user selects the person to be sent in the message push interface, writes and pushes the warning information.

The administrator user enters the management interface through the user name and password, and it is displayed as four modules: system management, pest information management, statistical report, and basic pest information. In the insect information management module, the administrator can manage the recorded database, including location, time, crops, pest name and state, quantity information, etc., can
manage the image from the sexual attraction devices, input the statistics to the database after the images processing by background recognition program (Figure 5).

6. Discussion and Conclusion
Based on insect sex pheromone and IoT technology, the construction of the pest monitoring system will improve the informatization and timeliness of pest sexual attraction detection [8]. Presently infrared technology has been used to count the pest in attraction. The monitoring of *Spodoptera litura* on vegetables in Hubei and Anhui has been realized, which the peak period of occurrence is the same as conventional sexual attraction monitoring. However, there was a certain error between the statistical value of the insect population and the actual trapping result [9-10].

In this study, the IoT-tech has been applied to improve the traditional working model of pest sexual attraction forecasting by enhancement for timeliness and usefulness. Under the integration of image processing in the system, it will further the efficiency of data processing [11-12]. Meanwhile, the images are saved as original data, which is convenient for manual verification to ensure accuracy. The system of this study is suitable for grass-roots agri-technicians to accurately grasp the real-time dynamics of farmland pests and issue an early warning, which is conducive to timely do a favourable job in pest prevention measures and promote the healthy development of plant protection work.

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