Study on Intelligent Meteorological Service of Facility Agriculture Based on Cloud Edge

Le Zhangyan 1,a, Ren Wu 2, Shi Minghua 3, Geng Xueying*4,b, Wei Qucheng5

1 Langfang Meteorological Bureau of Hebei Province, Langfang, China
2 PipeChina North Pipeline Company Langfang, China
3 Langfang Meteorological Bureau of Hebei Province, Langfang, China
4 Langfang Meteorological Bureau of Hebei Province, Langfang, China
5 Langfang Meteorological Bureau of Hebei Province, Langfang, China

a110312086@qq.com, b* Corresponding author: gengxueying@126.com

Abstract. Facility agriculture is an important means of controlling agricultural production environment through engineering technology. However, its development cannot be separated from the influence of meteorological elements inside and outside the facilities. This study will improve the level of intelligent meteorological service in facility agriculture and promote rural revitalization. We investigated the current situation of intelligent meteorological service of facility agriculture in Hebei Province and the meteorological observation data in shed. We proposed an application model of cloud edge intelligent weather service based on the digitization, standardization and intelligence of facility agriculture. We independently designed low-cost intelligent nodes. They collect data automatically. The data can be transferred to the cloud for storage and analysis. The cloud displays data in real time. We can stereoscopic monitoring of the distribution points according to the actual situation of the facility greenhouses. These enable accurate data on greenhouse and crop management and planting management. We can model and analyze data at different scales in the cloud. These build the data cube. We can build platforms with different costs through cloud edge synergy. Its advantages are controllable cost and flexible customization. These ultimately achieve intelligent meteorological services for agriculture facilities. We have already carried out preliminary application of the strawberry shed and mochella shed in the Zhaofeng Agricultural Park in Langfang City. Farmers' economic benefits have increased significantly. The economic income per shed increases by $1,600. The results of this study were recognized by the farmers in Hebei province.

1. INTRODUCTION
Facility agriculture is an important part of modern agriculture. The level of digitalization, precision and intelligence has become one of the important indicators to measure the level of agricultural modernization in a region. They are also an important means of rural revitalization. General Secretary Xi Jinping delivered an important speech at the Central Rural Work Conference held on December 28, 2020. He called on the whole Party to shift its focus to comprehensively promoting rural revitalization. He made comprehensive arrangements to promote rural revitalization. He stressed the need to mobilize the whole Party and society to promote rural revitalization. The No. 1 central document proposed high-quality and efficient agricultural development for three consecutive years during the 2019-2021 period.
It proposed to strengthen the application of modern information technology such as big data, artificial intelligence and intelligent meteorology in the agricultural field. However, there are still some problems in facility agriculture production, such as low intelligent degree, low quality of facility crops and low utilization rate of climate resources. Cloud edge intelligent meteorological service of facility agriculture can further promote the high-quality and efficient development of facility agriculture. These can enhance the meteorological support ability of rural revitalization in our province.

By the end of 2019, the cultivated area of facility agriculture in China had reached 1.395 million hectares\[^1\]. More than 90% of the facilities are mainly solar greenhouses. The cultivated area of facility agriculture in Hebei Province is in the forefront of the country\[^2\]. However, the experience of growers still plays a dominant role in production management\[^3\] during the process of facility agriculture. Farmers lacked accurate quantification of various data indicators. The infrastructure was poor. Facility farmers were more concerned with planting techniques such as fertilization and Spray insecticide. Farmers didn't improve crop yield and quality by adjusting the microclimate conditions in the facilities. Agricultural technicians pay insufficient attention to environmental and meteorological conditions. Facility farmers mostly hanged simple temperature and humidity meter to master the greenhouse microclimate environment. But these had a poor ability to regulate the environment in the greenhouse.

Domestic and foreign scholars also had a lot of research on greenhouse regulation\[^4-7\]. Greenhouses with environmental control equipment were mostly controlled by manual buttons. These equipment were placed on a single station due to the high cost. These factors make the data acquired by traditional greenhouses less accurate. These conditions were an obstacle to increasing production and harvest in agriculture. Meteorological departments provide farmers with external weather forecast, wind, snowfall and other short-term approaching catastrophic weather in the facility agricultural meteorological services. Weather service personnel didn't fully understand the overall microclimate environment in the facility. They lacked of quantitative and accurate crop meteorological service indicators and effective means of accurate and intelligent meteorological service. Therefore, the study of cloud edge facility agricultural intelligent meteorological service is a favorable guarantee to promote the prosperity of rural economy. The research is also improving the ability of meteorology to serve facility agriculture.

In 2020, the Ministry of Agriculture and Rural Affairs clearly proposed to accelerate the integration of informatization and mechanization in the opinions on accelerating the development of mechanization of facility planting. They proposed to achieve automatic environmental regulation and monitoring of crop growth information at low cost. These facilities enhance the modern level of planting. These can realize information online perception and fine production control. These can form a "whole-process mechanization + integrated agricultural services" facility planting socialization service new mode and new business form. Our research can achieve facility cultivation intelligence through facility agriculture digitalization, standardization and intelligence. This study provides a strong support for the implementation of rural revitalization strategy and the modernization of agriculture and rural areas.

2. DATA AND METHOD

2.1. Data

2.1.1. Research data
From 2018 to 2020, we investigated the facilities in 11 cities and prefectures in Hebei Province. We got information on the types of facilities, the automated environmental controls in the shed, the current state of weather services, and so on.

2.1.2. Meteorological data
Meteorological observation will be carried out in Zhaoфeng Agricultural Park, Langfang City, Hebei Province in 2020-2021. We carried out self-designed comparative experiment of instrument observation. The comparison equipment were produced by HOBO in America and Beijing Yugen Company. Strawberries and morels were selected.
Strawberry observation items were selected for temperature, humidity and soil temperature and humidity, illumination and real-time photography. In the Morchella shed, observations include soil temperature, soil moisture, light and real-time photography. The purpose of these were to find out the distribution characteristics of meteorological conditions in the shed. We also observed outdoor meteorological data, crop growth (phenological period, fruit size, quality, etc.) observation data, crop light saturation point and compensation point data in the same period. We also summarized the meteorological data of growth service management during the whole growth period of strawberry and Morchella.

2.2. Method
We take artificial intelligence and deep learning as the core and industrial control as the starting point. Based on the kernel module, the edge intelligent computing analysis management system can carry out the adaptive regulation function of the growth and development environment of facility agriculture. We have built intelligent analysis service scenario of facility agriculture, including greenhouse microclimate/real scene automatic monitoring equipment (end), intelligent computing and analysis management system (side) of facility edge and remote cloud intelligent decision-making platform (cloud).

3. RESULTS AND ANALYSIS

3.1. Low cost intelligent node design
The smart node design includes a core computing module. This module installs the Linux operating system. It supports task scheduling, timing execution, programming, compilation and debugging. It can perform complex computation and analysis. On this basis, it can integrate monitoring sensor module group, control device module group, networking communication module group and storage power module group and other extended module group. The integrated monitoring module group is mainly positioned to realize monitoring observation and data acquisition of environmental elements, including air temperature and humidity, light intensity, soil monitoring, image acquisition and other elements monitoring module. The control device module group is mainly positioned to provide linkage control function for the equipment in the greenhouse, including heating and ventilation module, shading and filling module, insect repelling and spraying module, irrigation module, monitoring and display module, etc. Networking communication module group is mainly aimed at network data transmission, including Lora, 4G-LTE, WIFI, NB-IoT and other networking transmission protocol modules. Storage power module is mainly aimed at providing edge storage and power supply functions, including solar power module, lithium battery and other power modules and local TF card, mobile disk and cloud storage modules (Figure 1).

![Figure 1 Intelligent Node Design](image-url)
3.2. Stereo monitoring, cloud edge and end collaboration

In order to accurately obtain the spatial distribution characteristics of greenhouses, crops and environmental elements, we designed a set of intelligent node three-dimensional layout and control scheme. The three-dimensional distribution of the scheme is based on the size of the greenhouse, horizontal and vertical direction of the distribution of points. The distribution range is customized according to the actual situation of the greenhouse. Nodes should be placed inside and outside the boundary of the greenhouse. The location of the automation equipment in the shed should be considered comprehensively.

The greenhouse is divided into an accurate three-dimensional grid in the three-dimensional space. Each node can obtain the element data of its point location (Figure 2). In order to obtain the overall statistics and analysis results of the whole greenhouse more quickly and accurately, the cloud edge and end linkage should also be carried out.

![Figure 2 Stereo monitoring of distribution points](image)

We have built a set of comprehensive data statistical analysis display platform based on the cloud edge. The sensor-side data acquired by each edge node is stored on the platform through the edge end and the cloud. This ensures the high availability of the platform and avoids the unavailability of the platform due to a single point of failure. Multiple intelligent nodes can be statistically analyzed in the cloud for time, space and elements. The real-time changes of greenhouses, crops and elements can be displayed in the cloud. According to the early warning threshold, it further responds and provides the basis and feedback for the equipment linkage. Finally, based on the data collected continuously on the platform, we constructed the data cube of crops, greenhouses and planting management in space, time and monitoring elements. The data cube is analyzed by winding up, drilling down, slicing and rotating. This can lay a digital foundation for accurate service and modeling analysis in the future.

3.3. Equipment linkage and modeling analysis

The control module of the intelligent node supports the integration of common industrial controllers, infrared remote control, wireless remote control and other modules, and supports a variety of control instruction transmission protocols. With the cooperation of the network transmission module of the intelligent node, cloud remote patrolling and centralized monitoring of all the control devices in the greenhouse can be realized. The trigger threshold of the control device was obtained after modeling and analyzing the environmental elements of greenhouses and crops. It can also realize the intelligent linkage of environmental elements warning. For example, when the cloud detects that the temperature in the grid represented by 60% of the nodes in the greenhouse exceeds the threshold warning, the greenhouse ventilation device will be automatically started and the shading device will be adjusted. When the temperature drops to the set threshold value range, the device automatically stops. In addition, based on data from greenhouses and crops, we can do an online projection of specific meteorological disasters to assess the damage. Therefore, we can formulate a joint plan for meteorological disaster emergency management to minimize the loss.
Through accurate modeling and analysis of the whole life cycle of greenhouses, crops and planting management, we can provide more targeted standardized management suggestions and solutions according to local conditions (Figure3). For example, we modeled the three-dimensional layout and observation of greenhouses on the basis of digitization. We analyzed the defects existing in different directions of the greenhouse and put forward accurate solutions. We can establish a greenhouse standard suitable for local production to facilitate large-scale promotion. We digitally model the entire life cycle of crops. We analyzed the growth characteristics and morphological characteristics of crops in each stage. The standard model of crop growth was constructed to lay the foundation for improving crop yield. In terms of planting, different management and water and fertilizer use patterns are digitally modeled. By analyzing the benefits and costs of different methods, we construct a standardized planting system to control labor costs. We can also carry out detailed modeling and analysis of water, fertilizer and drug management in different critical stages of crops. In this way, the standard scheme of linkage and management can be established and the theoretical foundation of intelligent management can be laid.

3.4. Accurate and intelligent meteorological services
We provide cost and demand solutions tailored to farmers at different stages of development. First of all, according to each greenhouse and planting crops to design a set of accurate three-dimensional monitoring layout scheme. Each intelligent node can choose different sensors and control modules according to the different point locations. Each intelligent node has a unique QR code. The field patrol personnel can scan the QR code through the mobile terminal to obtain the real-time data query page of the node. We can build a data display and control platform based on the whole greenhouse or agricultural park level. According to the user facility agriculture development stage, we can provide WeChat small program, APP, WEB site and large screen comprehensive display control and other options of different costs of the platform. Through this platform, real-time weather element data and grid forecast data can be pushed regularly for farmers in this region. Major meteorological early warning notices can be timely pushed. Furthermore, combined with expert knowledge, we provide predictive and preventive maintenance advice to growers. On the basis of modeling analysis, real-time notification of adverse environment, fault and alarm and recovery notification can be configured on the platform. Through the control module of the intelligent node, the automatic linkage scheme configuration of the control device is realized. When the alarm is triggered, it provides farmers with real-time information access to major events and choice of intelligent processing scheme Settings. At the same time, the platform also supports the establishment of user, business, technical and expert support groups to form an innovation group serving agriculture. By sharing real-time status data of greenhouse crops through the platform, experts can diagnose online. Maintainers can also debug it remotely. We can provide a variety of areas for planting users close to the service.
The research results were popularised and applied in Zhaofeng Agricultural Park of Langfang City in Hebei Province from December 2020 to May 2021. The experimental crops were strawberry and mochella. According to the different requirements of strawberry and mochella for meteorological conditions, intelligent nodes for observation of different meteorological elements were designed. Technicians can view the real-time data and historical data of all nodes in the shed through the enterprise WeChat. The camera node can record the growth of crops in real time and display them in the form of photos. Leaf area and fruit size were calculated by image recognition technology. Technicians can also spot diseased plants in time. Users can receive real-time outdoor weather forecast through the enterprise WeChat. Users can receive automatic warning of unsuitable meteorological conditions in different growth stages in time. Through the accumulation of multi-source data, we developed a precise planting service plan for strawberries and morels.

4. Conclusion and discussion

4.1. Conclusion
From 2018 to 2020, the research team visited Hebei Province to investigate the development status of facility agriculture and meteorological services. The development of the research on the intelligent meteorological service of facility agriculture at the edge of cloud can improve the ability of meteorology to serve the intelligent agricultural service. The existing problems in the development of facility agriculture were the low level of modernization and the insufficient level of meteorological intelligence. Therefore, it was necessary to improve the ability of meteorology to serve the wisdom of facility agriculture. The development of the research on intelligent meteorological service of facility agriculture based on cloud edge can improve the level of agricultural modernization and the meteorological support ability of rural revitalization.

Low-cost intelligent edge nodes are independently designed according to different crops for data acquisition. Three-dimensional monitoring and distribution are carried out according to the actual situation of the facility greenhouses to obtain accurate data of greenhouses, crops and planting management. The data collected by the edge nodes are transmitted to the cloud through the network nodes for storage and analysis. The data are presented in real time through the cloud. Data were modeled and analyzed at different scales in the cloud. Data cubes were constructed. Through cloud edge end collaboration, the platform with different costs is built. They can provide farmers with controllable cost, flexible and customized precision services. At the same time, equipment linkage can be supported through the cloud. Ultimately intelligent meteorological service of facility agriculture can be realized.

4.2. Discussion
The agricultural intelligent meteorological service system based on cloud edge is still in the experimental stage. First of all, the precision of intelligent nodes and the design of the shell need to continue to explore and improve in the future work. Secondly, although the equipment linkage scheme had been completed, the complete automatic linkage has not been realized due to the power supply problem in the shed. At present, we realized the automatic warning. Finally, there are few accumulated data. Further research on crop modeling is needed in the future.

REFERENCE
[1] Luo F, Xu H.B, Zuo Z.Y, etal.(2020) Present situation, shortage and countermeasure of facility agriculture in China. Jiangsu Agricultural Sciences, 10:57-62.
[2] Wei R.J, Wang X, Le Z.Y. (2018) Microclimate of solar greenhouse in North China and its efficient utilization. Meteorological press, Beijing, 1-45.
[3] Wei R.J, Wang X, Di Z.G. (2016) Present situation and improvement measures of solar greenhouse in HeBei Province. China Vegetables, (6):6-9
[4] Balliu A, Sallaku G. (2016) An overview of current situation and trends in Albanian vegetables protected cultivation sector. Acta Horticulturae, 1142:449-454.
[5] Li Yang. (2019) Intelligent Measurement and control System of Tomato Growth Environment in Greenhouse Based on Internet of Things. Shandong Agricultural University.

[6] Sun Y, Yang W Q, Zhu D. Environmental Perception Internet of Things Intelligent, Network Technology Research and Application. Advanced Materials Research, 2014.

[7] Wen S.C, Zhi Y.Z, Li Z.Y. (2015) Service Platform for Sunlight Greenhouse Group Internet of Things Based on Cloud Computing[J]. Computer Engineering.