Application of Intelligent Traceability Management System in Agriculture—Take Aodong Fruit and Vegetable Planting Cooperative as an Example

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Abstract. At present, strengthening the construction of agricultural product quality and safety traceability system and vigorously developing digital and intelligent agriculture have become the focus of future agricultural development. This project concentrates on the development of Golden Pear planting and processing industry chain in Aodong Village, Shigezhuang Town, Wuqing district, Tianjin. It combines Internet of Things, QR code traceability technology with cloud big data to develop an intelligent management system for Yongbei Golden Pear industry chain. The intelligent platform management makes fine traceability management from production to consumption possible, so as to further enhance the characteristic brand of cooperative agricultural products, create cooperative agricultural products sales channels and new image, and improve quality and efficiency of agriculture.

1. Introduction
In recent years, agricultural development and agricultural product safety have been the focus of China. As consumers pay more attention to product quality and production process, especially Internet technology has provided new ways and means for rural industrial development and agricultural product safety, it has become the cornerstone of food safety traceability management system to apply information technology to food processing and agricultural automatic production management. For this reason, Aodong Fruit and Vegetable Planting Cooperative in Tianjin, supported by municipality and SASAC, is established. In 2015, the economic development plan “One Village, One Policy” in Aodong Village was approved by the municipal party committee. 400 mu land was transferred, among which 350 mu was used for planting Golden Pear and 50 mu for developing facility agriculture, involving more than 80% of farmers in the village. This project, based on the development of Aodong Fruit and Vegetable Planting Cooperative, adopts Internet of Things technology, QR code technology, big data processing technology and cloud server to develop a cloud intelligence management system combing agricultural products planting, processing, sales, logistics, and traceability. It is expected to enter the picking period in November, with an annual output of 250,000 kg and an annual sales of 1 million yuan in 2018. The effective implementation of this project will make a positive contribution to promoting the integration of rural scientific and technological information resources and development of “smart agriculture”, and improving the ability to serve rural scientific and technological information.

2. Application of GPS and QR Code Technology
On the one hand, traceability e-commerce platform for Yongbei Golden Pear should be established to ensure that each tree has its own QR code. Detailed information of product planting, processing and...
transporting can be obtained with mobile phones. As shown in (figure 1 and figure 2), through GPS positioning and QR code identification technology, each tree seedling and each planting plot are positioned and numbered, and field operations such as planting, irrigation, fertilization, weed control, pollination, fruit thinning, bagging, pest control, picking, detection are automatically recorded by mobile phones instead of human. With the help of digital records such as pictures and videos, every field operation can be reviewed. On the other hand, the brand Yongbei should be fully used to improve the quality and added value of fruits. If the market promotion of “Yongbei Golden Pear” is done well in advance, the sales price can be increased, resulting in greater economic benefits and opening up a market for the sharp increase in output in the following years. The popularization and application of QR code technology to other agricultural products will contribute to promoting the integration of rural scientific and technological information resources, promoting the development of “smart agriculture” and improving the ability to serve rural scientific and technological information. Eventually it will lay a foundation for the implementation of information traceability management in the planting process.

Figure 1. One Tree One Code E-commerce Platform.

Figure 2. QR Code of Relevant Production Management Process of Golden Pear.

3. Automatic Detection Sensor Interface of Field Environment Information

The intelligent traceability management system for Golden Pear combines automatic monitoring sensor interfaces such as field environment information, carriage environment of transportation vehicles, GPS, real-time video monitoring with mobile phone. Therefore, traditional production records relying on manual operation will be replaced by the intelligent traceability management system developed by the project, which can reduce the difficulty for farmers to introduce traceability
management data [1]. As shown in (figure 3), individual systems have independent operation modules thanks to the automatic monitoring sensor of field environment information, transportation parameter of GPS and time sensor interface, real-time video monitoring interface, etc. On the other hand, they are integrated with the cloud data server system according to the cross-system interface required for intelligent traceability management of agricultural products. These data are processed automatically to complete relevant big data analysis, which combines with field operation information interface to integrate the intelligent traceability management interface system of Golden Pear.

![Diagram](figure3.png)

**Figure 3.** Research and Technology Roadmap of “Smart Cloud Service Platform for Yongbei Golden Pear Industry Chain”.

### 3.1. Analysis of Intelligent Traceability Management Data and Cooperative Production Verification Process

Through in-depth interviews and field research with cooperative farmers, relevant first-hand and second-hand data are collected. The interaction between farmers’ field operations and the system is planned by work process analysis and converted into standardized processes, which serves as the basis for application system analysis and design.

### 3.2. Building Mobile Phone Data Input System Module for Field Operation

IDEFO module analysis technology is used as a system description tool to produce a Function Model of the system to represent the control conditions of input and output and required mechanisms of each module of the system, so as to conduct process analysis. Next, an intelligent traceability management mode is constructed by using UML as shown in (figure 4). Taking the prevention and control of plant diseases and insect pests by farmers as an example, firstly, farmers scan the QR code with mobile phones and data is transmitted to the server. Then farmers enter the system and continue to scan the QR code for pest control, and the server sends out QR codes to confirm whether pest control procedures are executed. When farmers confirm the result, the mobile phone screen will then display the choice of using the medicine. Farmers can confirm the medicine from the mobile phone screen, and at the same time, they can take photos of the medicine immediately, upload the photos to the server for archival reference, and finally the server will send the screen of confirming the medicine back to the mobile phone to complete the whole process [2].
3.3. Integration of Automatic Detection Sensor Interface of Field Environment Information

According to the planting environment parameters such as air temperature and humidity, carbon dioxide concentration, soil water content, sunshine luminosity, etc., real-time automatic monitoring is carried out by the Internet of Things sensor. There are already modules that can operate independently in the market. However, according to the requirements of intelligent traceability management of agricultural products, the system integration with cloud data server as shown in Figure 2 needs to be further defined and developed [3]. In this study, the information exchange mode between the system interface of the field environment information automatic monitoring server (lower server) and the Yongbei Golden Pear industry smart cloud server (upper server) is expected to use Http-Post mode and reply whether the information is received or not to confirm if the information exchange is complete as shown in (figure 5).

Take air temperature as an example, the XML exchange format can be defined as:

```xml
<TempDataCode></TempDataCode>
<XMLID></XMLID>
<ChangeStatus></ChangeStatus>
<FieldID></FieldID>
<LocationID></LocationID>
<FarmerID></FarmerID>
<Num></Num>
<Unit></Unit>
```
When data is exchanged between the servers of both parties, they must reply to the exchange result to confirm whether it is successful. Code specification for information exchange result: 0-success, 1-XML format error, 2-XMLID value duplicate.

Exception handling of information exchange. If the exchange result is incorrect due to the short expected settlement time, both parties shall resend it after unit time, which shall be determined after both parties reach an agreement. If it is impossible to solve the problem for a long time, in order to make production smooth, the storage system must provide an information inquiry interface when information cannot be exchanged normally to assist users to login the production automation management system.

3.4. Application System Development
It uses Microsoft.Net technology platform and the second generation of N-Tier based on object-oriented program and XML, and integrates the systems and applications of Web services to design and develop a smart cloud management system for Yongbei Golden Pear industry chain see (figure 6).

Figure 6. Scanning QR Code with Mobile Phone to Obtain Product Information.

3.5. System Introduction and Innovation Diffusion
The steps for establishing relevant industrial chain include:

First, on-site early testing. According to the steps of the operation process and the relevant QR code labels, key users are requested to conduct field tests in advance to confirm the mobile network transmission function and the convenience of operation, so as to provide reference for system modification and introduction of training [4].

Second, user education and training. It should provide users with education and training based on the introduction of the system. The main preparations include: preparation of documents and mobile devices, plenary explanation meeting, and operation training.

Third, seminar on experience exchange. When the system is implemented after two or three weeks, all users are invited to share their experience about the implementation process. On the one hand, suggestions for system improvement are provided. On the other hand, appropriate peer pressure is brought about, so as to enhance users’ introduction motivation and reduce the influence of a few human factors on system introduction.
4. Integration and Analysis of Big Data in Production and Marketing of Golden Pear and Its Industrial Impact

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used.

4.1. The Application of Neural Network Algorithm

In the first year of this study, an intelligent traceability management system of Golden Pear was established to complete the automatic monitoring and data collection of environmental parameters of agricultural land production, as well as the collection of customer data on the e-commerce platform, thus becoming a big data source for later long-term growth and customer information [6]. However, in addition to the data correlation analysis between actual output and relevant information, intelligent algorithm is needed to establish the prediction model of agricultural production capacity and potential customer groups. This research will combine neural network algorithm with relevant big data analysis to establish the prediction model of production capacity and potential customer groups. Among all kinds of neural network modes, back-propagation network (BPN) has been widely used in various fields in recent years. Characterized by high storage capacity, generality, fault tolerance, quick recall, etc., it is suitable for identification of dynamic systems [7].

The mathematical model of the neural network system is shown in (figure 7), wherein the relationship between the output $y_i$ of node $i$ and the input $x_j$ of node $j$ is shown in equation (1).

![Figure 7. Neural Network System Model.](image)

$$y_i = f_i \left( \text{net}_i \right) = f_i \left( \sum_{j=1}^{n} w_{ij} x_j - \theta_i \right)$$

(1)

$W_{ij}$ is the connection weight between nodes $i$ and $j$. At the same time, it is also the bias of node $i$. $f_i$ is the transfer function. The back-propagation network applied in this project is the most common network architecture among the multi-layer feedforward neural networks and belongs to the supervised learning network as shown in (figure 8). Its hidden layer neurons adopt smooth and differentiable transfer functions and define an error function which is transmitted forward to the output of the network and compared with the expected value, and then the error is reversely propagated by the steepest descent method to minimizing the error. The error of BPN is defined as:

$$E_p = \frac{1}{2} \sum_{i=1}^{N} \left( t_i^p - O_i^p \right)^2$$

(2)

$t_i^p$ and $O_i^p$ are the nodes of $i$th. For the expected output and actual output of pth training mode, the adjustment of weight is based on gradient-descent to minimize the error.
\[ \Delta w_{ij} = -\eta \frac{\partial E_p}{\partial w_{ij}} \]  

\( \eta = \text{learning rate} \)

Figure 8. BPN Neural Network System.

With the application of neural network algorithm, the field environment information is automatically monitored by the Internet of Things sensor in real time. Then intelligent algorithm is used to analyze the correlation between crop growth and environmental parameters, so as to establish a production capacity prediction model and provide market sales reference serving as a reliable basis for production and sales planning [8]. The production capacity prediction model can effectively predict the production process and quantity of agricultural products in the current season. The gap between production and marketing will be reduced effectively with the analysis of e-commerce order and the big data of customer group to adjust production and marketing plan, and set potential customers for customized marketing.

4.2. Influence Scope of Industrial Application
In addition to the application of agricultural products shown in (figure 9), the industrial correlation diagram of the research and development results, the system can also be applied to animal husbandry, aquaculture, food processing industry, etc. while the overall system application includes businesses related to telecommunication and mobile phone system development. The research can affect the development of related industries.

Figure 9. Industrial Correlation Chart of Research and Development Results.
4.3. Service Benefits of Derivative Industries

(1) Intelligent service of industrial chain traceability management: cumbersome traceability management record work will be done by mobile phone and Internet of Things technology. The complexity of traceability management record work will be greatly reduced with the introduction of information technology, which can be popularized and applied to animal husbandry, aquaculture, food processing and other related industries with strict requirements on safety traceability. With the application of this intelligent traceability management construction method and system, innovative service and business operation modes will be introduced.

(2) Production and marketing management of large-scale organic agricultural production farms or enterprises: The domestic production and marketing mode of organic agricultural products is moving towards large-scale and contractual production. In addition to self-established farm production, enterprises can also provide diversified products and production capacity for many contracted small farmers. The intelligent management system and platform developed by this project can be applied to the collaborative management of production and marketing of large enterprises to improve their management efficiency of production and marketing.

(3) Production and marketing management of small-scale agricultural products: The future agricultural development is characterized by distinctive agricultural products in various regions. For example, Aodong Fruit and Vegetable Planting Cooperative in Tianjin has set up a special cooperative area with local farmers and other producers and processors to integrate the planting, processing and marketing of relevant distinctive agricultural products. The intelligent management system platform of this study is suitable for the marketing of characteristic agricultural products.

5. Conclusion

Intelligent traceability management system, a new growth pole of China’s rural economy, will receive more and more attention in the future. This paper mainly analyzes the application of intelligent traceability management platform of Yongbei Golden Pear in Aodong village. It finds out that the platform increases consumers’ confidence in the safety of agricultural products with transparent information and promotes farmers to plant high-quality agricultural products. What’s more, it introduces new technologies and new formats into agriculture, and has far-reaching significance for Tianjin’s agricultural production transformation towards “refinement, organic and high added value”.

6. Acknowledgment

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