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Application of Intelligence Information Fusion Technology in Agriculture Monitoring and Early-warning Research

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Abstract—**This paper introduces a dynamic feedback crop simulation system used to simulate and forecast the growth of crops. It was known that a precise and effective crop simulation was beneficial for the investigating of crops' growth and production forecast. The real-time monitoring data applied for this simulation system was derived from Agriculture monitoring and early-warning research space (AMERS) which was established by Agriculture Information Institute of Chinese Academy of Agricultural Sciences. A more accurate and valid simulation system is proposed in this paper, by improving the system of agriculture model with the collected data. The corrected model is able to predict the crop's growth and yields more accurately. During the lifecycle of the whole crops the model is corrected and predicted continuously until the simulated data is highly consistent with the real data. The collected data can be used as the input of the simulation, and the corrected model for real-time feedback. A growth index which was calculated by the monitoring data used to measure the growth of crops was proposed. This growth index will responded to the crops simulation model for system amendment. The result of late growth and yield forecasting will be updated by the revised model. Two applications of this system were briefly introduced.**

Keywords-crops simulation; dynamic feedback; agriculture monitoring and early-warning space

I. INTRODUCTION

In recent years, with the development of information technology and popularization of computer technology, intelligent agricultural system has been paid more and more attentions. The crops simulation is an important field of intelligent agricultural which provided more intuitive, comprehensible and accurate agriculture technologies, and it is also an interdisciplinary study involving agriculture, economics, environmental science, computer science and artificial intelligence. Intelligent agriculture simulation system is important branches of modem agriculture which will help researchers complete the agriculture experiment, the real-time crops' growth and the yield prediction, with the advantage of low cost and efficient. As an important means of formulation of agricultural policy, ensure the food safety and maintain social stability, the forecast of gain yield plays a significant role in sustainable development.

Various crops' modeling methods were provided by scholars such as fractal, L-systems [1], stochastic process [2], artificial intelligent, etc. The first crops growth model ELCROS was presented by de Wit in the 1960' [3]. Crop Environment Resource Synthesis (CERES) model was a typical growth model of the American which paid attention to the systematicness and practicability [4]. Agricultural Production Systems Simulator (APSIM) is a crops integration platform developed by Austrian scientists which includes wheat model, corn model, cotton model, rape model, etc. PS123 model used for the evaluating of soil productivity which developed by Driessen P.M. *et al*. in Netherlands [5]. Zhu C.R. built a maize simulation with response growth model and morphological structure model which based on the system parameters [6]. These crops models with the ability of simulate the growth and yield formation of the crops, but lack the function of dynamic real-time self-correcting [7].

II. AGRICULTURE MONITORING AND EARLY-WARNING RESEARCH SPACE (AMERS)

Agriculture monitoring and early-warning research space (AMERS) is a multifunctional agriculture information terminal which collected the holographic market information of agro-products, sensors data (such as temperature sensor, humidity sensor, optical sensor, biosensor and so on) and monitoring images during the growth of crops. In Fig. 1 shows the system framework of AMERS. The AMERS has provided fundamental support for data collection and subsequently intelligent analysis and early warning via fast response and continuous work. This study has changed the situation that in the past we could not get access to the data, hardly find the underlying reasons, and uneasy to propose suggestions on agri-price fluctuations. [8]

The modern information technology such as sensor technology, intelligent recognition technology, mobile collection technology will applied to the production, circulate and consumption of agriculture. All stages of agriculture environmental information, growth information and market information were collected, apperceived, and monitored by automatic and intelligent means. The mass data among the agriculture production circulate and consumption provided strong support to the agriculture big data process by data exchange technology, cloud data management and

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virtualization technology. A big data computing platform was built which combined with Google's MapReduce programming model.

In the paper, the real-time sensors data and monitoring images of AMERS were used for the dynamic crops simulation system by the data fusion technology. As it is shown in Fig. 2, real-time data was transmitted to the application terminal of AMERS.

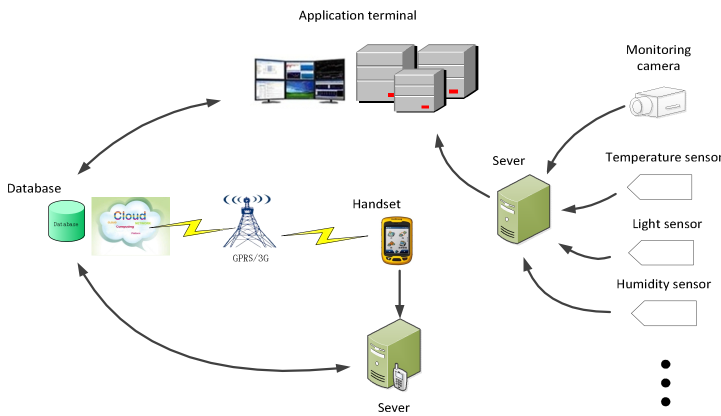

Figure 1. System framework of AMERS.

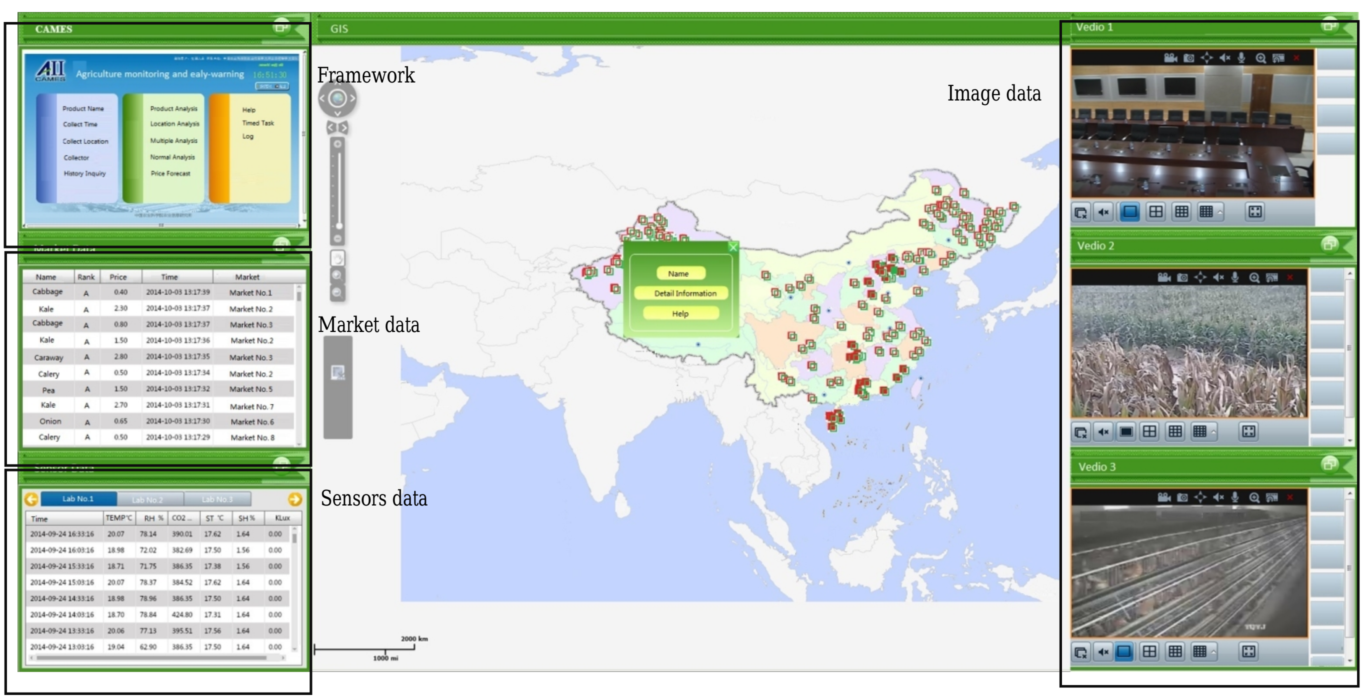

Figure 2. Application terminal of AMERS.

III. SIMULATION SYSTEM

In general, the crops' growth simulation consisted of the following parts: growth period, morphological development, photosynthesis and respiration, the uptake and partition of nutrient, the relation between crops and water and the effect of meteorology [9]. The crops' growth model is the core of the simulation system [10] which will be calculated by the algorithm of model and depending on the inputs of crops' information data. It also will take into consideration various factors, such as meteorological condition, edaphic condition, material inputs and so on. The nutrient uptake and partition model of crops were built by absorption kinetics of nitrogen, phosphorus and potassium in soil.

There are two methods, first, the yield prediction based on the growth model which according to the mechanism of crop growth by computing the growth environment, agriculture inputs and agriculture business circumstance. Second, the yield prediction based on the crop monitoring which achieved by image processing technology, pattern recognition technology. Actually, both of the two methods have their own limitations. The first method is excessively idealization which considered all the growth of crop will coordinate the uniform pattern. This method can't adjustment the model after the parameters have installed. And the other one, judge the growth and production just by the representation of crop, which ignore the relationship between the growth mechanization and growth.

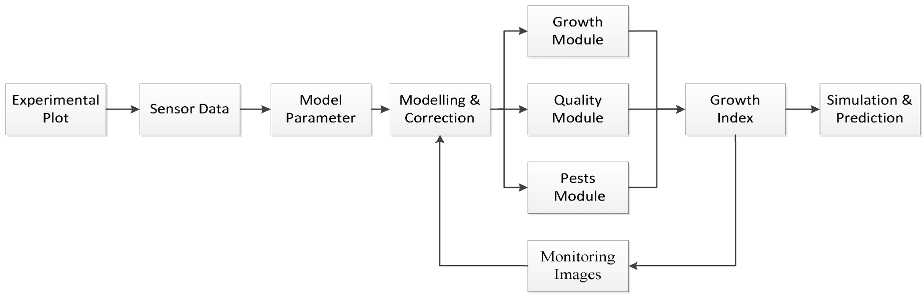

Figure 3. Flow chart of the simulation system.

In Fig. 3, it is the flow chart of the simulation system which will took several steps as follows. Step 1, require sensors data from the experimental plot. Step 2, use the sensors data as input of the simulation system parameters. Step 3, modeling the crops simulation with these parameters and establish the reasonable system design. Step 4, divide the system into separate parts or modules, such as growth module, quality module, pests module and so on. Step 5, credit the growth index with above modules. Step 6, compare the growth index with the crops growth which will recognize by the intelligent agriculture monitoring system, and sent the feedback to the simulation system for the model reconstruction.

A. Growth Index

A growth index was presented in this paper which is a growth state of crops formed by a series of observation functions. The growth index calculated by the crops growth state which collected by various sensors with information fusion technology. This crops growth state was composed of various growth parameters that will direct or indirect measured by sensors.

$$I = I_p \cdot I_m \cdot I_{mete} \cdot I_n / I_{pest} \tag{1}$$

Where, I is growth index, Ip is spectrum index, Im is morphology index, Imete is meteorological index, In is nutrient index, and Ipest is pest index. Spectrum index, morphology index and pest index were produced by different digital image recognition algorithms by monitoring images. Meteorological index was integrated by light sensor, temperature sensor and humidity sensor. Nutrient index was acquired by chemical sensor for measuring nitrogen, phosphorus and potassium content in the crops.

B. Application

- Application for the intelligent agricultural management

By studying the relationship between material inputs and crops yield with this system, a more effective production model was built. And use the optimal theory and algorithm to maximize production benefit of crops. [11]

It is convenient to build a Bayes experiment model with this simulation system. Though the intelligent control system various material inputs will be quantified invested into the production.

- Application for the yield forecast

Another important application of the system is to prediction the late-stage growth and yield dynamically, by the real-time input parameters. The crop simulation system will read the data from the data base for computing. The growth index will be calculated by the simulation system which include leaf area, plant height, dry matter weight, NDVI (normalized differential vegetation index) and chlorophyll content. The model of the corps simulation will constantly be revised in order to enhance the predictive accuracy of the model unceasingly by the growth index which will observed and calculated with the simulation system. [12] As it is shown in Fig. 4, it is the diagram of agriculture sensors layout. The whole cropland was divided into small pieces, and the sensors were placed in the different points. All of the small pieces of the cropland were signed by the coordinate system which is show in Fig. 4. The value of point P is calculated by data difference method with all the consecutive sensor points.

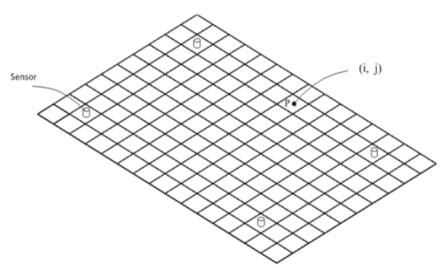

Figure 4. Diagram of agriculture sensors layout.

As it is shown in Fig. 5, it is the flow chart of the application for the intelligent agricultural management. First, all of the information which included nitrogenous fertilizer, phosphate fertilizer, potassic fertilizer and water were collected by kinds of sensors. Second, all of the collected information was input into the crops model, meanwhile it contains other inputs, such as solar duration, the level of carbon dioxide. Third, the growth index will be calculated by the crops model. Finally, with the growth index the yield will be forecasted. [13]

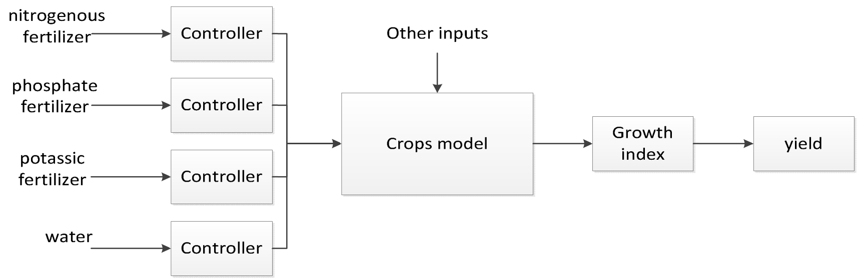

Figure 5. Application for the intelligent agricultural management.

IV. CONCLUSIONS

It is revealed that higher grain yield can be best explained by adoption of advanced technologies, followed by material inputs, environment, climate and policy. A crops simulation system helps to study the intricacies of the dependences between these factors and grain yield. In this paper, two typical applications of the intelligence information fusion technology in agriculture monitoring and early-warning research were introduced. These two applications show the multidisciplinary combined with traditional agriculture and modern information technology.

Further researches will be focused on how to improve the facticity and real-timely of the simulation. The CAMES make the agricultural research use the advantage of information system fully, and the researchers will finish their work more conveniently and efficiently in this iconoclastic model. The strong alignment of the information technology and agricultural technology represent the development direction of the future agricultural technology. In our subsequent research, we are also interested in applying the simulation system to facilitate the monitoring and early-warning of agricultural production and markets.

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