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Enhancing Precision Agriculture Using Big Data Analytics

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Abstract： Agricultural data has the characteristics oflarge amount of data, various types and complicated structure. With the emergence of technologies such as cloud computing, Internet of Things and big data, the development of precision agriculture has become a new trend in agricultural information technology. This paper proposes a big data application framework for precision agriculture. The designed model consists of data acquisition, data integration and data analytics. Using bigdata analytics, precision agriculture is able to be implanted to guide refined agricultural production.
Keywords—Precision Agriculture; Big Data; Decision Support

I. INTRODUCTION

With the development of information technology, cloud computing and Internet of Things, Mobile Internet and othertechnologies, we have entered the era of big data. The development of big data technology has undoubtedly promoted the transformation of information technology. Thistechnology not only plays an important role in the fields of e-commerce, medical care, sales, finance, etc., but also plays animportant role in agriculture. Agriculture is a traditionalindustry, and a primary industry. Agriculture is the foundation of human survival and development. In the past 50 years, the development of information technology has promoted the transformation of agriculture from traditional todigital and intelligent (Janssen et al., 2017). The emergence of big data technology is to promote researchers to establish a large number of computational models to assess and improve the efficiency of agricultural production.

As early as the 1990s, PA was put forward as high- efficiency and sustainable agriculture (Shibusawa, 1998). With the development and popularization of Internet of Things technology, the cost of sensors is declining and moreand more sensors are being used in agricultural production (Goap A., et al., 2018). The accumulation of agricultural datais from traditional handwritten records or manual digital records to automatic acquisition of data from sensors. The data obtained in this way is more accurate and highly targeted, and the data accumulation has begun to explode. Therefore, the connotation of precision agriculture also extends to all aspects of natural resources and production, such as planting, breeding, ecological environment, meteorology, water conservancy, natural disasters, etc., which are characterized by regionalization, diversification, diversity and complexity. In this case, using big data technology to conduct a comprehensive analysis of agriculture, from soil testing, irrigation, fertilization, to real- time monitoring and harvesting of crops, new precision agriculture technologies are covering all aspects of agricultural production operations and management, big data driven precision agriculture is become the future of agricultural development (Janssen et al., 2017). In 2015, the US made over US$4.6 billion investment in agriculture technology, mainly on software and digital agriculture — a combination of data and algorithms that provides specific recommendations at the sub-field level (L. Burwood-Taylor,2015).

However, agriculture involves a wide range of crops. Therefore, access to and analysis of agricultural-related data is also facing a series of challenges. First, the industry is lacking regulation of access to agricultural data. The second is the lack of unified management and integration methods for data storage, cleaning, and pre-processing. Third, the model for data analysis cannot adapt to the diversity needs throughout cropping (Tan, L. 2016). Therefore, based on thetheory and technology of agricultural big data application architecture, the production and management of precision agriculture is the focus of future research.

In this paper we propose a big data analytics framework for precision agriculture, and discuss the elements for developing a decision support system.

II. A PRECISION AGRICULTURE FRAMEWORK

Precision agriculture is a modern agricultural concept highly based on spatial information, sensor network, statistics, and quantitative implementation of informationsupported operations in crops (Kendall et al., 2017). In precision agriculture, decision support system (DSS) are built to optimizing production procedures. Since 1970s, the introduction of weather forecast, satellite images, aerial images, communication technologies, variable rate fertilizer application, and crop health indicators characterized the first phase of precision agricultural revolution. The second wave aggregates the machine data for even more precise planting, topographical mapping, and soil data. With the advance of big data, precision agriculture will be the most transformative and disruptive advance, not only on the farm, but across the entire agriculture and food value chain.

Through big data analytics technology, insight into the insights in massive data, providing intelligence and creating value. In the agricultural field, big data promotes all relevant factors of agricultural production to be deeply aggregated. Through cross-industry and inter-disciplinary data analysis and mining, the development of optimized decision support systems promotes the development of agriculture towards "precision" and "wisdom". According to the top-level designprinciples, we decompose the relevant elements of precision agriculture and propose a big data analysis framework for precision agriculture.

As is shown in figure 1, our big data analytics frameworkfor precision agriculture is composed of four tier, including data sources, data integration, decision module, and user-endapplications.

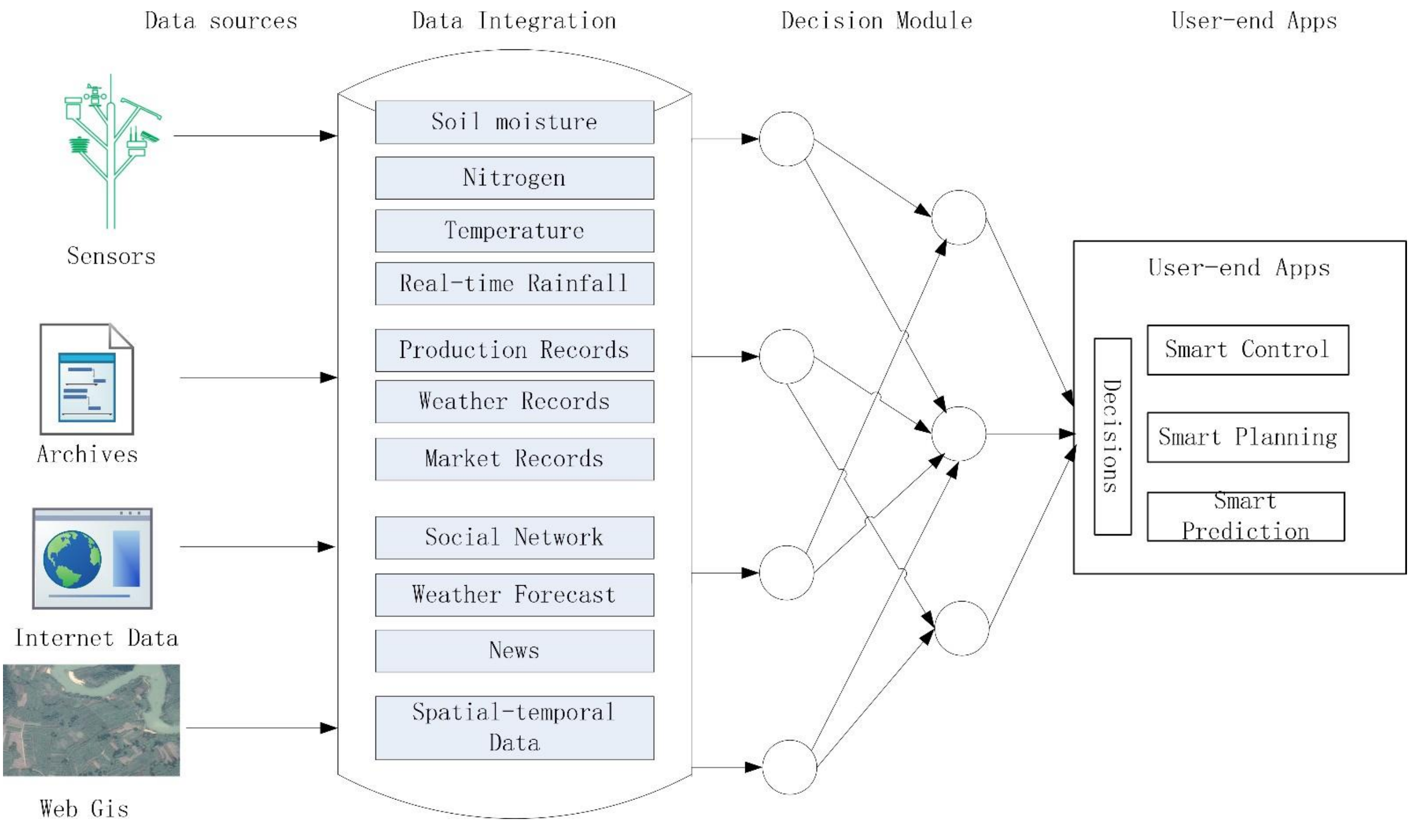

Fig.1. Big data analytics framework for Precision Agriculture

III. DATA SOURCES

There are many types of big data resources that provide data support for precision agriculture, including IOT sensor information, historical records of agricultural production over the years, extensive information from the Internet, and spatial-temporal data related to geographic information.

A. Sensor Network Data

Internet of Things technology links physical objects in thereal world to the Internet. Sensors and wireless communication networks through the Internet of Things playan extremely important role in the data collection phase. Collecting data from sensors is the primary way to automated agricultural information acquisition. To make the acquired data clear and definite, as well as organized, it is necessary topredefine the acquisition activity. Table 1 shows the specification for partial field sensor data, including data type, unit of measurement, sampling frequency, and so on.

The temperature sensor, humidity sensor, rainfall sensor, soil pH sensor, etc. are deployed to obtain the real-time statusof natural resources such as land resources, water resources and atmospheric resources, and the data records are stored asa key basis for real-time control (Mohanraj, Ashokumar, & Naren, 2016). On the other hand, the long-term accumulationof data resources will also play a supporting role in future agricultural production decisions. The data collected by the sensor section is the most important part of agricultural big data and is the main target of data mining analysis.

Acquisition data from sensors could be high in velocity and volume. To control the quality of sensor data, we have developed data acquisition specifications in terms of data type, data unit, and sample rate. Table 1 illustrates some typical sensor data specifications. Rainfall is collected 10 times per hour, measured in millimeters and stored as float. Other sensor data might be measured in Celsius, Hour, or Percent. Following this rule table, automate data from sensors would be easily processed in later procedures.

TABLE 1. DATA SAMPLE RULES

Data Acquisition	Data type	Unit	Sample Rate
Rainfall	Float	mm	10samples/hour
Water Evaporation	Float	mm	10samples/hour
Air Temperature	Float	℃	10samples/hour
Sunlight Time	Float	Hour	10samples/hour
Sunlight Intense	Float	w/m2	10samples/hour
Soil moisture	Float	%	10samples/hour
Soil PH	Float	N/A	10samples/hour

B. Historical Data

Historical data objectively describes relevant information in agricultural production activities. Historical data is a collection of records collected in time series, including process records of agricultural production, statistical data, climate information, cross-cutting agricultural-related data, and some unfinished historical data and books.

Internet information includes video, audio, pictures, text on social networks, and information on policy information, market information, agricultural technology information, and global agricultural product production layout published by agricultural related websites. There are many ways to collect economic data on agricultural products, such as the "crawler" technology of websites, and obtain information from relevantagricultural websites.

C. Spatial Data

Precision agriculture is inseparable from the technical support of GIS (Geographical Information System). GIS integrates GPS, remote sensing and other data, and uses map as a platform to express various natural and socio-economic information in an intuitive and visual way. It is a powerful tool for the accurate management of spatial information database for crops. Field information is expressed and processed by GIS system, which is an important part of precision agriculture implementation.

IV. DATA INTEGRATION

A. Data Normalization

In the era of big data, standards first have become the consensus of data applications in all walks of life. With standards, data can be shared to support the development of big data processing platform applications. (luo zhiqing, et al., 2018) studied the relevant standards and norms of agricultural data, including information standards for species and related pests and diseases, varieties of primary (original) agriculturalproduct commodity names and their connotations and extensions, agricultural industrial service name specifications and Connotation, extension, agricultural industry information classification norms, weights and measures name specifications, rural basic information standards, data exchange formats and protocol standards. Take crop cultivation as an example, the crop information table lists land conditions, planting date, planting specifications, watering, fertilization and other information. Like Table 1 shows, the nomenclature crops are able to eliminate the diversity of naming. The format, naming, measurement rules,etc. are output as unique version. In this way, one object withvarious values from diverse source systems could be unified,paving a foundation for establishing accurate prediction model of crops.

TABLE 2. CROP INFORMATION

Attributes	Description/Norm
Crop Name	Latin name of the crop
Crop Details	Description of the crop
Icon	An icon to be shown in Apps
Field	The field where plant grow on
Soil Type	Type of the suitable soil
Sowing Date	Best period to sow
Sowing Depth	How deep to sow(in CM)
Row Spacing	Distance between rows(in CM)
Plant Spacing	Distance between plants(in CM)
Pest Control	Common types of pests
Fertilizing	Fertilizer needed

B. Data Integration

Due to the extensiveness and heterogeneity of agricultural data, the processing, organization and aggregation of data is an indispensable step in the analysis of big data. Data integration is the integration of interconnected, distributed, heterogeneous data sources that enable users to access these data sources in a transparent manner. Big data processing is anew technology generated for a large amount of dynamic streaming data and unstructured data (Zhan, Yuanzhu, et al., 2018). Dynamic streaming data and unstructured data are thefocus of today's big data collection, storage, and analysis, relying only on static and structural. The data is difficult to support the powerful functions of big data, and the scalabilityof traditional relational databases is difficult to meet the needs of big data storage.

ETL tools can be used to integrate and integrate heterogeneous data and assist in the construction of data warehouses to form thematic databases for various industries.Take data out of a variety of storage methods, carry out the necessary transformation and organization, and form data marts for application analysis. (Bansal, S. K. 2014) Designed an Extract-Transform-Load (ETL) framework to integrate and publish data from multiple sources as open linked data. This concept is proposed in data reference technology, but isequally applicable to big data processing techniques.

C. Decision Support Model

The core of precision agriculture big data system is decision logic. In a traditional decision support system, the decision logic is coded for a specific application. However, agricultural production is complex and uncertain, and traditional methods are difficult to cope with agricultural dataanalysis. In recent years, researchers have begun to use artificial neural networks, machine learning and other technologies in precision agriculture. The agricultural production process faces a series of processes that require decision support (Kamilaris, Kartakoullis, & Prenafeta- Boldu, 2017). It summarizes the techniques and tools used for agricultural big data analysis, pointing out that precision agriculture decision-making needs should be related to machine learning, image processing., cloud platform, GIS, remote sensing, modeling and simulation technologies.

Establishing a decision model for crop production processes requires consideration of crop production diversity.In order to solve the problem of poor adaptability of decisionmodels, we propose an open precision agriculture decision support model. Based on the principle of openness, we introduce reconfigurable modules for user intervention at different stages of the data chain to extend the generalizationcapabilities of decision support systems.

In the example of fertilization decision shown in Figure 2, in the data integration module, we form the Data Marts needed for decision making by extracting relevant data such as crop varieties, weather, and soil. In the core part, users choose the fertilization plan among many decision models toachieve decision support and control. The model libraryconsists of a number of evaluation and prediction models, which are built based on various factors combined with knowledge and expert experience in fertilizer science, soil science, and plant nutrition science.

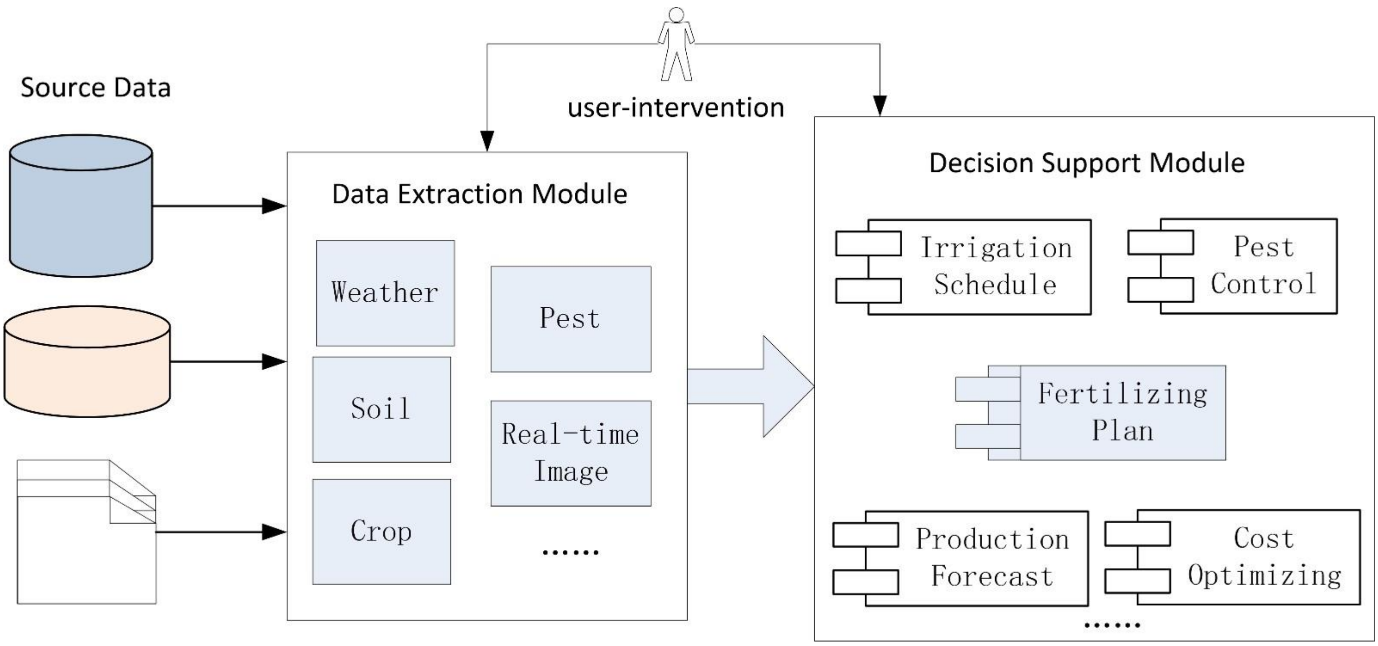

Fig. 2. Decision support model architecture

V. MODEL APPLICATION

We are studying the implementation of the banana precision water-fertilizer program in southern China throughbig data approach, although the plan is still in its infancy. Bymonitoring the nutrient content and weather conditions in thesoil, as well as the growth pattern of the crop, combined withthe statistical records of the planting history in that area, information on pests and diseases, the crop fertilizer demandplan was designed and carried out. Through the use of neuralnetwork algorithm to establish a crop growth model, farmland is able to optimize the timing and formula of irrigation and fertilization, and guide the scientific and precise fertilization in the whole process of banana production.

VI. CONCLUSION & RECOMMENDATIONS

Precision agriculture is an emerging field of big data technology applications. Driven by cloud computing and Internet of Things technologies, the relevant factors of the whole process of precision agricultural production are increasingly collectable and measurable, which provides conditions for applying data analysis and decision support for agricultural production processes using big data technology. Based on the data sources involved in precision agriculture, this paper proposes an application framework for applying big data to precision agriculture, and analyses the various components and workflows of this framework. The framework classifies and summarizes the sources of precisionagricultural big data, and pre-processes and extracts according to the actual needs of actual users to form a data mart that can be used for decision support analysis. In the data analysis phase, the user selects the decision model accordingto different application requirements to achieve the purpose of decision support.

The ultimate goal of building agricultural big data is to provide more accurate agricultural services, technologies and methods in data collection, analysis, and release, to meet the specialization and individualized needs of agricultural production and research, and to research in agricultural big data in the future. The process needs to paymore attention to the problems at the implementation level.

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