Research and Analysis about System of Digital Agriculture Based on Network Platform

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Abstract: Digital Agriculture is a Intelligent computer management and application system that includes many high new technologies, such as infomationization, digitization, network, automation and so on. On the basis of analyzing the main researching content and meaning of "Digital Agriculture", this paper designs the system construction of "Digital Agriculture" based on Internet, and discusses the function and structure of main core modules of Digital Agriculture system in detail. Finally, this paper also analyzes the developing trend about "Digital Agriculture".

Keywords: Digital Agriculture; Agricultural infomationization; Network technology

Preface

The former American vice-president Gore put forward the concept of digital earth in the speech addressed in California Science Center on January 31, 1998. From that time, the concept of "digital earth" has aroused great concern and become one of the newest researching hotspots of science and technology field in the world. It has remarkably accelerated the development of Digitalization in different fields. Digital agriculture is one of the most important researching parts of digital earth and is the extending of "information superhighway", "digital earth" and "knowledge economy" in the field of agriculture. It is a comprehensive technology system of agricultural production and management combined technology of Digital Earth with technology of modern agriculture, and is the only way of agriculture modernization, integration, and automation. The research and application of digital agriculture can not only promote agriculture technology revolution, but also bring about the further developing trend of agriculture in the informational society.

1. Introduction of "Digital Agriculture"

In the new century, agriculture will turn into water-saving agriculture, mechanical and intelligent agriculture, and high-quality, high-yield, pollution-free agriculture. Digital agriculture is a necessary and effective approach to realize all of these purposes, and is the core of agricultural informatization. Digital Agriculture is also called informational agriculture or intelligent agriculture, which refers to the utilization of Digital Earth technology, including multi-resolution remote sensing, telemetering, GPS and GIS, computer etc. It also involves all the high-new-tech systems which are unified with the agricultural production activity and the production management, such as farmland information fast collecting, farmland cultivation, land management, agricultural chemicals utilization, contamination control, agricultural engineering equipments and their industrialization technology and so on. Namely, it's a comprehensive agricultural production management technical system which integrates Digital Earth technology and the modern agricultural technology.

From 1990's, Digital Agriculture has been put into practice systematically for about more than ten years. Now, the research of Digital Agriculture has reached a higher level in the developed countries. The using of these high-techs has gotten to a practicable level at many developed countries. They have generally realized to collect, manage, product and transmit all kinds of information of agriculture supported by GIS, RS, GPS , DSS and computer network etc..For example, the United States has created information managing system of crop strains throughout the nation, and the information of more than 600 000 sample plants has managed by computers. The Plant Protection Bureau of French Ministry of Agriculture has built nation-wide computer networks to survey and forecast diseases, insects and chemical remains of different kinds of crops. The Japanese Province of Agriculture, Forestry and Aquatic Products has built data bank system of many crop strains, such as rice, soybeans and wheat, etc. The Research Academy of New Zealand Agriculture and Husbandry provide all sorts of information services, the so-called "farm system"[1]。

China is a great agricultural country with large population, limited soil resources and traditional manual farming mode, so the central government has been attaching great importance to the development of agriculture and put forward a new agricultural technology revolution -- the transformation from traditional agriculture to modern agriculture and from extensive farming to intensive farming. From 1998, China put forward the concept of "Digital China", and this bring about the further development of digital agriculture, which can promote agriculture technology revolution[2]. Now, in China, many provinces have built different kinds of Digital Agriculture system, such as Expert system of wheat, crop simulation modeling, Pesticide Ranking System, web-based seedling production Management system and so on.

2 Research Contents of Digital Agriculture

Digital agriculture is a new agricultural technology which combines with the agricultural technology, the modern computer technology, the network communication, the spatial information technology, and will become agricultural development new pattern in the 21st century[3].The essence of Digital agriculture is to realize the digitization of process in every aspect of agriculture (including crop production, animal husbandry, aquatic products industry, forestry)by using information technology. It includes digital informationization of agricultural factors (biological, environmental, technical and social), agricultural production process, and agricultural managements (agricultural administration, agricultural production management, agricultural science and technology management and agricultural enterprise management, etc.). In other words, each agricultural field and process must be expressed by the binary numeral (0, 1) and digital model in the digital agriculture system, So Digital agriculture, exception for production of crop, also includes precision gardening, precision foster, precision processing, precision running and management even includes forestry, herd, foster, processing, production, supply and sale. It is an agriculture technology system with the whole procedure of the whole agriculture will be characterized by digital, network, and intelligent, using technology of remote sensing, telemetry, tele-control, and computer. It will realize auto-collecting of information, effective job, intelligent management of agriculture production, and make every square meter have optimized using. It will constitutes an information agriculture technology system included monitor and estimation of crop, land, and soil, dynamic analyses and diagnose forecast of crop growth, and factors of environment, it also includes intelligent management and decision of agriculture production[4]。

3. System Architecture of Digital Agriculture

Digital agriculture involves various aspects of agricultural production, the main contents of it includes the construction of database, Metadata standard, monitoring system, forecasting and decision-making system, and information-releasing system etc. and roughly falls into four levels: information basis level, functional modules level, integral application level and integral web portal level, which integrate with each other (Fig.1).
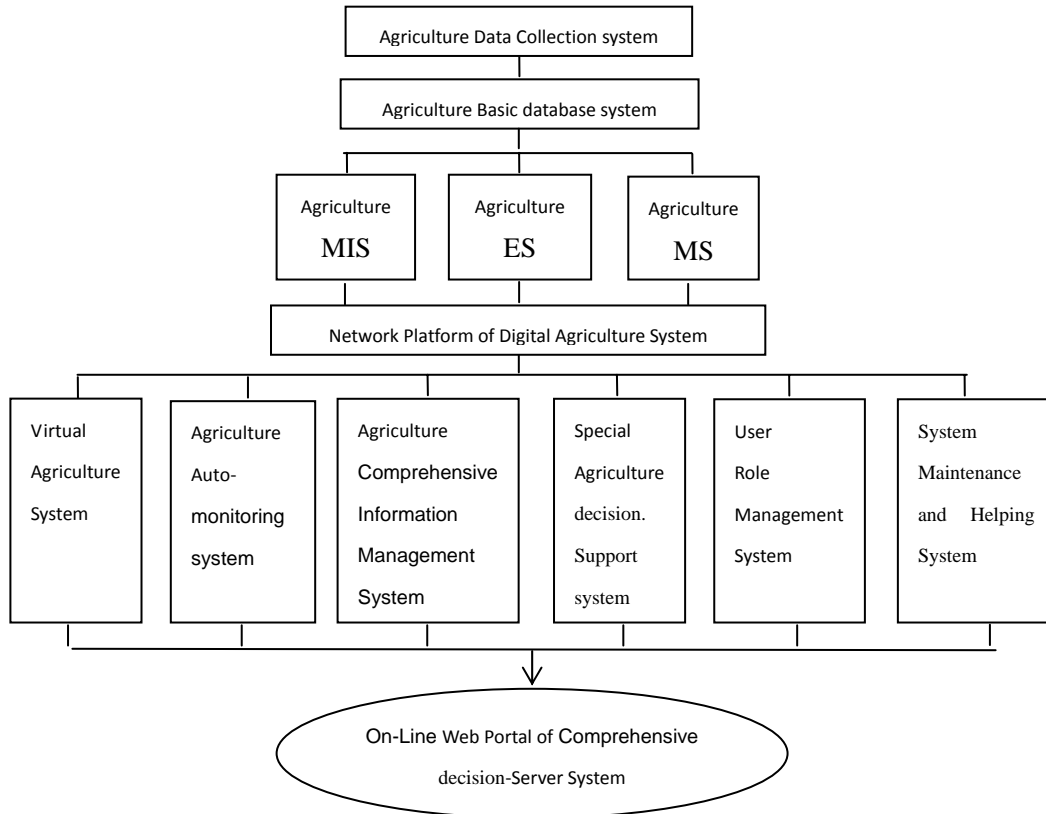

Fig. 1. System Frame Architecture of Digital Agriculture

4. Structural Designing of Digital Agriculture System

4.1 Information Basis Level

The environment of farmland is a very complicated ecology system, and involves many different kinds of factors, such as soil, fertilizer, moisture, shine, temperature, atmosphere, and so on. All of these data have the features of enormous, dynamic, regional, and sequential. In addition, the collection and expression of agricultural data includes not only directly related factors, but also recessively indirectly related factors. So the information basis level which take charge of data collection, processing, and analysis is an important and complicated basis level of Digital Agriculture System.

This level includes public information basis, attribute information basis and spatial data basis facilities. The public information basis includes laws, rules, regulations and technology standards. The attribute information basis takes charge of the management of non-spatial attribute data. The spatial data basis is a consistent, integral geo-spatial data and service system, including spatial data structure of digital agriculture, coordinated management of spatial data, renewing and distribution system, exchange standard of spatial data and metadata, etc.(Fig.2).

public information DB
Attribute information DB
Spatial information DB

information Center

Data Analysis System GIS

Internet

Communication Interface — Area1

Information acquisition

Sensor | Weather station | RS | GPS

Communication Interface — Area n

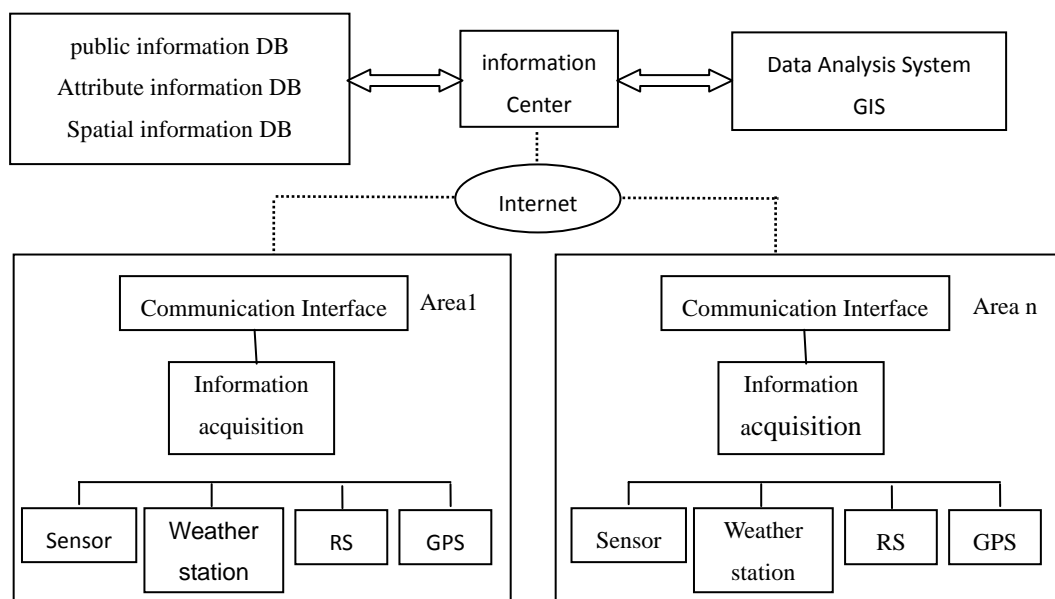Information acquisition

Sensor | Weather station | RS | GPS

Fig. 2. Information Basis Level

In this level, the acquisition of data is the core of this level, how to achieve field data rapidly and effectively and how to transmit the data in low cost and high reliability is an important research topic. The peculiar of agricultural production environment and agricultural production process makes the special feature of the farmland data acquisition: dispersed collection points, long average collection period, low speed, small amount of data, bad conditions of field and so on[5]. All of these factors increase the degree of difficulty of data acquisition. In recent years, the mainly using method and technology of data acquisition includes manual measurement, statistics and analysis of experiment data and modern automatically collection. In these methods, modern automatically collection has the features of higher precision, faster speed, wider range and more data, and has gradually become the main method of data collection. It mainly involves RS (Remote Sense), GIS (Geography Information System), GPS (Global Position System) and network technology and so on.

4.2 Functional Modules Level

Functional Modules Level mainly takes charge of management, update, Search and Analysis of agricultural basis information database (non-spatial data and spatial, static and dynamic), expert knowledge database and agricultural model database system. It includes Agriculture MIS (Management Information System), Agriculture ES (Expert System) and Agriculture MS (Model System) (Fig.3).

Information Basis Level

Agriculture MIS | Agriculture ES | Agriculture MS

Spatial MIS | Non-Spatial MIS | Knowledge maintainin | Expert consult | 3D Crop Model | 3D Environment Model
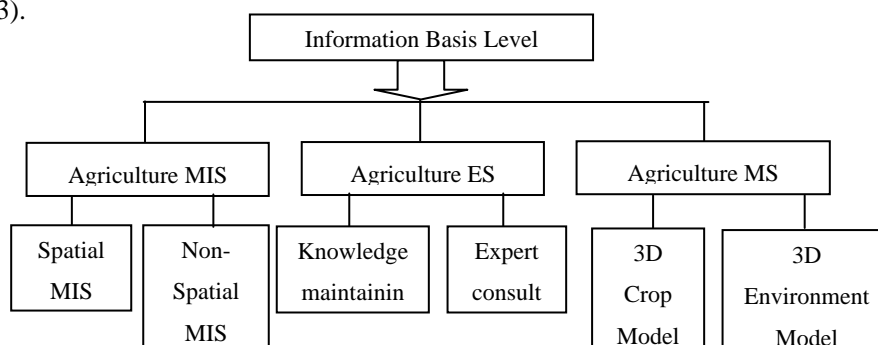
Fig. 3. Functional Modules Level

The function of agriculture MIS involves the management, update, search, statistic and output of agriculture basic attribute information (such as product, biology, Science and Technology, economy data etc.), and spatial geography information (such as environment resource, agricultural condition, agriculture produce data etc.), it also includes the function of comprehensive management, search, analysis and output of attribute data and spatial data.

Agriculture ES mainly involves the creation of knowledge database, advisory of expert, search and output of knowledge and so on. Knowledge database mainly stores and manages special agriculture expert knowledge, these knowledge include basic fact (test specimen) of agriculture, theory knowledge from book, knowledge of common sense, and concluding knowledge from agriculture expert. The quantity and quality of knowledge is the key factor of ES and would affect the precision of solution about user's problem.

Agriculture MS is used to store and manage different kinds of agricultural models, such as agricultural spatial analysis models, crop simulation models, comprehensive evaluation models, statistics and analysis models and so on. It is the theory basis of digital agriculture and important guarantee of process management, intelligent decision and scientific plan of agriculture production

4.3 Integral Application Level

The integral application level is based on the network platform and takes charge of system integration of different special modules of digital system. It mainly includes agriculture comprehensive MIS, virtual agriculture system, Agriculture DSS (Decision Support System), Agriculture Automatic Monitor System and so on.

4.3.1 Virtual agriculture system

The virtual agriculture is one of the greatest key subsystems of digital agriculture. The rationale of virtual agriculture is the truth that the relationship between crops and environment is computable [6]. The virtual agriculture system takes networks and computers as a platform to simulate and reappear the studied objects of each link in the agriculture and achieve the aims of interaction and visualization of studied objects and environments. In a broad sense, virtual agriculture includes: virtual crops (Fig.4), virtual animals, virtual agricultural machinery manufacture, virtual farm and so on [7].
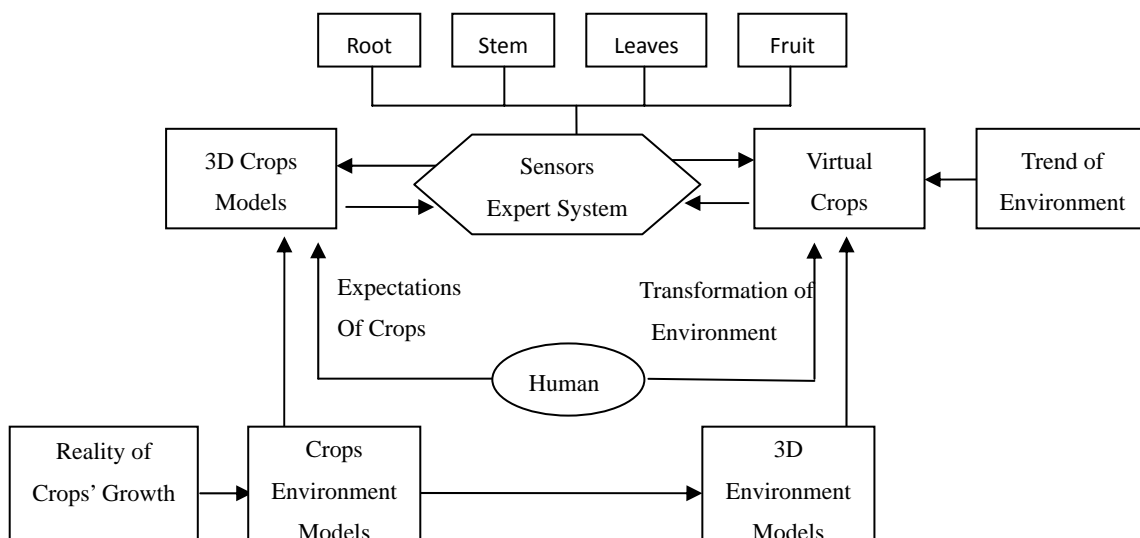

Fig. 4. Architecture of Virtual Crops System

4.3.2 Agricultural DSS

Agricultural DSS (Decision Support System) means the using of DSS in the field of agriculture. DSS can be considered as a computer based system which allows the user to solve semi-structural processes by using comprehensive datasets and analytical models, according to El-Najdawi and Stylianou[8]. Agriculture DSS is built on the basis of agriculture information system, crop simulation system and agriculture expert system, and can be used in any fields of agriculture. Today, the research of agriculture DSS has developed from single field decision (such as DSS for Pest Management, cotton efficient fertilization DSS) to integrative DSS, from single user system to multi-user B/S system. Through Internet, it makes the expert knowledge can be gotten at any time and any place by any person (Fig. 5).
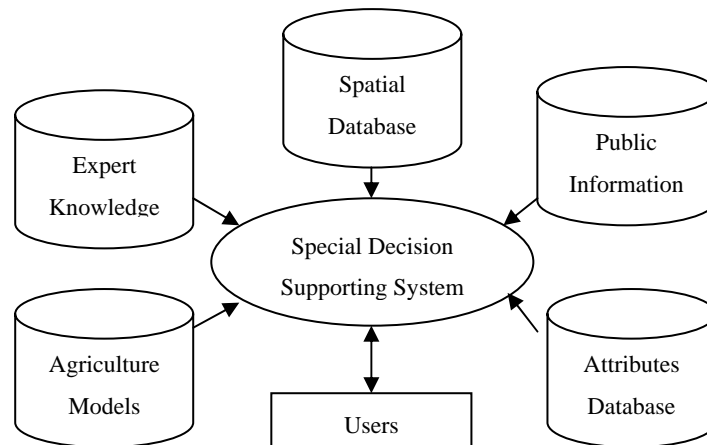

Fig. 5. Agriculture Decision Supporting System

4.3.3 Remote Auto-Monitoring System of Agriculture

Remote Auto-Monitoring System of Agriculture realizes the communications between the computer and remote data collectors with the network (such as GSM). The entire system is composed of data management center and remote monitor terminal (Fig.6).
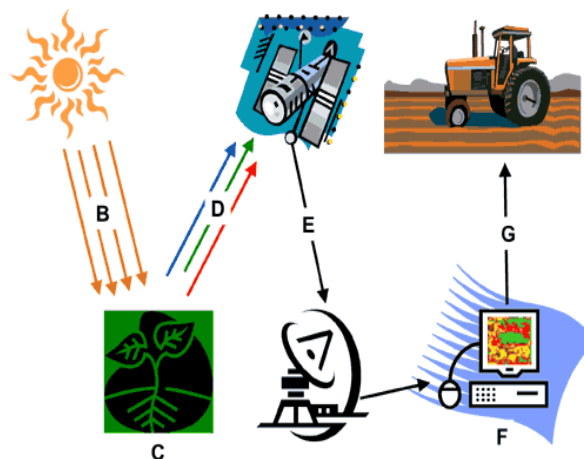

Fig. 6. Remote Monitoring System of Agriculture

The function of the data management center is to control the network module to send and receive messages and to display, store and print the data which received from the remote terminal. The function of remote monitor terminal is to control the network module to send and receive the

messages, deal with the collected data and send them back to data management center. The system is based on B/S mode; users can browse the data and set the parameters with the browser.

4.4 Comprehensive Integral Web Portal Level

The Internet is the important technological platform which ensures remote data collection, remote management, remote monitor and conduct of agricultural production. By using portal website, digital agriculture system can integrate data collection; data analysis; process simulation and decision support together and create a integrative flow of information. Users can have different operation and get different result according to their requirement with the browser (Fig.7).
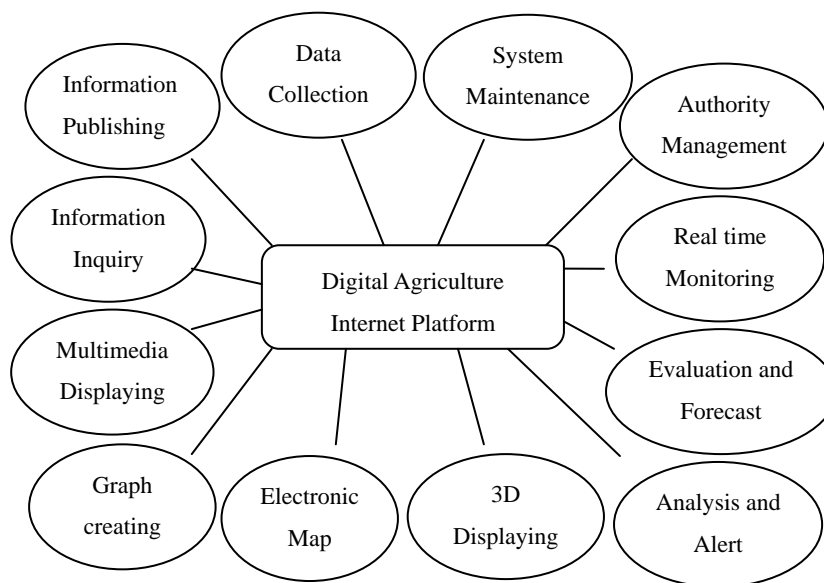

Fig. 7. Internet Server Platform of Digital Agriculture

Summary

Digital agriculture is based on modern theory of agriculture, with using the technology of digital Earth, to realize intelligence of procedure of agriculture, to promote production and maintain the develop ability of agriculture. The research of digital agriculture not only is the support technology and the strategic target which the development modern agriculture chooses inevitably, also is a challenging practice process. How to implement the digital agriculture, different areas in our country still be at the exploration stage, in the recent ten years, rationale and application related to the technical system of digital agriculture has become active domain of high & new technology research in the main developed country. It can predict that the application and the fast development of digital agriculture in China will become an important content of agricultural development in the 21st century. By the multi-disciplinary fusion and coordination, digital agriculture will effectively adjust the rural industrial structure, enhance the agricultural benefit, increase the farmer's income, improve the countryside ecological environment, and realize the sustainable development of agriculture and rural economy.

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