

Digital Agriculture--One of Application Domain of Digital Earth

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ABSTRACT this paper describes the concepts and contents of digital agriculture, it's current status and trend. The information technology, spatial technology, and micro-electronics technology make a revolution to traditional agriculture. The operations of cultivating , reaping, fertilizer, management have the characters of automatization, intelligence, optimization. We mainly describe the agriculture intelligence device, and then give several aspects of building digital agriculture.

KEYWORDS Digital agriculture Digital Earth Remote sensing Agriculture device

1. Introduction

Digital Agriculture, also called Precision Agriculture, the same name as Information Agriculture, Intelligence Agriculture, Farming by Inch, or Cyberfarm, is an advanced technological system related to middle or small scale of farmland, combined directly with activity of agriculture production and administration. It applies the technology of Digital Earth, included multi-resolution remote sensing (NOAA-AVHRR, one meter resolution of satellite remote sensing), Telemetry(temperature of atmosphere, humidity of soil etc.), GPS, GIS, and computer network. Simplified say, Digital Agriculture is a composite technology system of agriculture production and management combined technology of Digital Earth with technology of modern agriculture. Satellite and computer will make an revolution of farm business. Digital Agriculture is the only way of agriculture modernization, integration, and developability.

Al Gore, vice president of American, in his speech: " The Digital Earth : Understanding our planet in the 21th Century" said: " Farmers are already beginning to use satellite and Global Positioning System for early detection of diseases and pests, and to target the application of pesticides, fertilizer and water to those parts of their that need it the most. This is known as precision farming, or ' farming by inch' ".

Digital Architecture, or Precision 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.

Digital Agriculture started from 1955 in America. It is different from "agriculture gardening" in 50-60's in Japan, "ecology agriculture" and "green agriculture" coined by advanced country in 60-70's, and "agriculture factory" in Israel. It is based on

cultivation of big farmland, using advanced technology as background. It is an agriculture technology system with the characteristics of integration and information. It means that whole procedure of the cultivation, semination, irrigation, fertilizer, farmland management, protection of forestry, estimate of product, store, and administration will be characterized by digital, network, and intelligence, using technology of remote sensing, telemetry, tele-control, and computer. It will realizes information driver, effective business, intelligence management, reasonable job for agriculture product, to promote agriculture production, make every square meter have optimized using. It will constitutes an information agriculture technology system included monitor and estimation of crop, land , and soil, current or dynamics analyses of crop growth, and factors of environment, diagnose forecast, cultivation step, management planning and decision support.

With the development and application of micro-electronics, agriculture device have been integrated with machine and electronics, controlled by intelligence, which can automatically collect and process agriculture information. In addition, biological engineering, crop cultivatiob, forecast of pest, modeling and simulating of crop cultivating, and using of virtual reality in agriculture production, all of these promote the development of intelligence agriculture device, technology of automatical monitor, and optimized decision support system. Those also promote agriculture production, and form a base of "Digital Agriculture" or "Precision Agriculture".

National Research Council of America has a special term to research strategy of advanced agriculture technology. After discussion through academy, they issued the report:" Precision Agriculture in the 21st Century----Geospatial and Information Technologies in Crop Management"

which show the potential of improving crop production and management and economic efficiency with the technology of geospatial information, and illuminate the current research status of precision agriculture and development opportunity of agriculture by the technology of geospatial information. Now in advanced country, digital agriculture includes the automatic agriculture operation and the technology of agriculture production and management using remote sensing, GPS, GIS, DCS, DSS, network, and biology engineering.

2. Remote Sensing

Remote sensing is used as method of information collect and dynamic monitor in digital agriculture. Weather satellite can provide weather status every day, and radar of survey rain can forecast rainfall. High resolution land satellite and sea satellite can provide immediately information and forecast for agriculture, forestry, herd, foster of near seashore, and prawn of ocean. 1 to 3 meter pan band remote sensing, 3 to 5 meter multi-band remote sensing, and 6 to 30 kilometer width scan remote sensing will be prevailed and can collect information for agriculture conveniently.

Geophysics Environment Research Co. (GER) issued "GER Earth Research Observation System, GEROS" planning, and launched small satellites to monitor the process of agriculture, provided services for agriculture information. These satellites have 6 bands, 10-meter resolution, can repeatedly collect agriculture information in period of 3 to 4 days. This planning provide information about cultivation, status of crop growth, fertilizer, irrigation, and pest to farmer through wide area network, so farmer can immediately takes step. The TASC/WSI Corp. in Boston has more attention for digital agriculture, which provides image of remote sensing to farmer using aerial multi-spectrum system through CD-ROM or network. The fee is 20 cent every acre. Resource 21 is a corporation to provide services for digital agriculture which plan to launch 4 agriculture multi-spectrum remote sensing satellites with 10- meter resolution which can provide symptom map of cultivation status. The symptom map combined with GIS can figure out diagnosis map. Then using decision support system we can make action planning map, and farmers using these planning maps and GIS, GPS to take step. International conference of remote sensing "Conference on Geospatial Information in Agriculture and Forestry", makes digital agriculture as it's core content.

3. Intelligence Device

Experiences and experiments show the diversity of average production in meters unit in farmland can arrives to 70—100%. The main reason is difference of attribute of soil, inorganic fertilizer (N,P, K), organic fertilizer, topography, water, cultivation and management in the farmland unit. Not only the production differs in same year, but the production of same field unit differs in different years.

The technology of digital agriculture is composed of technology of geospatial information and modern agriculture. The united reaper with GPS automatically make the map of crop production (typical spatial resolution is 15 square meters), the map of topography, and parameters of soil in field. Using data resource, simulation model of crop growth, model of invest and output, crop management knowledge base, and decision support system, and with participation of decision-maker, a crop management prescription map can be made. This prescription map can direct investment and management of farmland.

With the development of GPS and the DGPS positioning system, a component of intelligence agriculture device has been developed. The DGPS has 12 channels, automatically provide 3D dynamic positioning data, and has the common interface to device of intelligence agriculture monitor. The precision of difference processed DGPS can arrives to centimeters. DGPS can be used in information collection and operation of soil, status of crop, pest etc. Through GPS and other electronic sensors in united reaper, the production information and other information of every farmland unit, such as humidity and granularity of grist, can be recorded, then the map of production of every farmland can be made through computer. Tractor and united reaper is now equipped with electronics device, the agriculture also is running through computer. Geographic Information System (GIS) is used to store, analysis, process, and represent of geospatial data and attribute data which apply to land management, the analysis of component, thickness, inorganic fertilizer and organic fertilizer of soil, and the analysis of weather, rainfall, tiptop temperature, lowest temperature, and the speed of wind of recent years. Using agriculture GIS, building geospatial data base, we can use geospatial processing to learn the growth of crop, the potential of pest, gain the necessary information for decision making, and build aided decision support system for cultivation of crop, direct to operate and control agriculture product.

Intelligence agriculture device is already as

commodity. Britain, America, and Canada have made united grist reaper with DGPS positioning and automatical measure of production. Tractor and seeder equipped with GPS and computer appeared in the market of America from 1998. These devices can automatically adjust the amount of seed, fertilizer, or pesticide according to the result automatically detected from recently 3 years, included production etc., through the analysis of computer and then send the instruct to device to operate, such as depth, amount of culture, amount and type of pesticide.

When the united reaper works in farmland, it records the average production of very farmland unit, and store the data in intelligence card. Then we can read the card into PC, using GIS to process the vector map and cluster, and the distributing map of production of farmland can be made and will be used to instruct operation. The Massey Ferguson in Britain can provide this kind of machine, which has a LED screen in seat cabin using various graphic interface, to monitor components of machine and display the distributing map of production. According to America Case II in 1996, 19% of over 300 hectares farm uses GPS, and will be 90% in 2000 year. A manufacture declares their 30% new machines have been equipped with sensor used to detect production, the error of this sensor is within 3%. Several countries of Euramerican begin to develop sensor for computation of production in united reaper for corn, beet, potato, sugarcane, and cotton. International publication "Computer and Electronics in Agriculture" will issue special to introduce the research result. If the intelligence agriculture machine under control of prescription map equipped with DGPS, it can automatically select type of seed. The seeder will automatically adjust amount of seed of cultivated wheat. The machine which can automatically carry fertilizer and scatter pesticide are all commercial.

The devices which can automatically collect information about farmland is a difficult term currently. It needs to develop new sensor relate to moisture of soil, fertilizer (N,P,K), weed, pest, status of crop seedling. Many of these are affected by weather, changing in spatial and time. Collecting real-time information proved to be difficult, and a mass of collecting information from farmland and it's processing take much time and money. Several items already became stressed research object in this domain. The technologies include TDR measure of moisture of soil, multi-spectrum recognizing between weed and crop seedling, vision image processing, ionic selected field effect transistor and shoot flow which measures content of nitrogen in soil. Many of those will be commercial.

The research and practice of Precision Agriculture have already been about 20 years. In middle of 70's, micro-electronics develop fleetly, which make agriculture machine moved to integration of machine and electronic. High-powered, high-speed, wide-breadth agriculture device is designed which widely using new material, new crafts, and technology of micro-electronic control. The design of agriculture device stresses security, comfortable, detectable and controlling of status of job. The agriculture device without electronic control is already unfashionable. In later of 80's, with the advance of electronic and information, the monitor system of agriculture device moved to intelligence, from unit based control to distributed control, from job of alone machine to integration of DSS. The using of electronics and information technology in agriculture device indicated the milestone of agriculture mechanization. Through electronic, agriculture device possesses the attribute of intelligence which communicate easily. These promote the constitution of modern agriculture device based on knowledge and information. Electronics used in agriculture device have five domains:

- Promote technology ability of machine's job: monitor of process, control, diagnose, communication.
- Environment friendly cultivation: saving material and energy, reduce pollution of soil, water, plant and animal.
- Precision operation of process: to collect information of process in time, accurately implement control command.
- Ameliorate environment of worker: friendly interface, convenience of operation, security, comfortable;
- Support management decision: communication, schedule, optimized system object.

New generation of agriculture device and the information based product management decision is the importance condition of precision agriculture. Although the main precision agriculture devices, such as the reaper with the ability of mapping production, the seeder, fertilizer and pesticide device which operated by prescription map, have already been commercial in advanced country, there is necessary to expand the application domain of agriculture machine.

Digital agriculture or precision agriculture requires agriculture operation to be automatization and intelligence. That means the precision on time, spatial, quality(seed, fertilizer, pesticide) and quantity(amount of seed, fertilizer, pesticide,

cultivate depth, times ,amount of irrigated water, production), forecast and predict, (weather, crop, pest, and production).

4. Building of Digital Agriculture

The several aspects of digital agriculture include:

(1) fundament database building (digitalization)

- fundament geographic data: includes 1:5000---1:10000 digital terrain data, nature water system , artifact irrigate system, road, village, agriculture machine station, storehouse, land use, and land cover data.
- Land and soil data: includes depth, component , fertilizer of soil in unit of 100 square meters , the type and the amount of fertilizer used every year,
- Weather data: average temperature every week past years, rainfall, wind direction , wind speed, hail, tiptop temperature, lowest temperature, and other factors of agriculture weather.
- Document of agriculture pest and diseases past years, and prevention step.
- Types of crop cultivated past years(five years), method of management, and the record of production.
- Agriculture management step and estimation step past years(five years), include irrigation, cultivation.

(2) monitor system building (remote sensing, telemetry, and network)

- Technology of remote sensing satellite, includes multi-resolution, from NOAA which provide 1 kilometer to aerial and other remote sensing, to monitor land, soil, crop cultivation and crop growth termly, frequency of monitor is defined by capital condition.
- To monitor moisture and temperature of soil using sensor, the gained data transferred by network, ,

(3) predict and forecast system building (intelligence)

- weather disaster forecast : using data of NOAA, to forecast of local weather station by contrasting and to analyses these data
- Monitor diseases and pest disaster: to analyses crop diseases and pest disaster past years, and contrasting the current practice pest and sickness, combined the weather trend and other environment condition to forecast.

- Forecast crop production: using type of crop, growth of crop, the production and management resent three years to forecast production.

(4) tele-control system building (network, intelligence)

- agriculture machine tele-control system: with the help of GIS and GPS, the agriculture machine tele-control system which specially used for the service of agriculture cultivation will runs according to the procedure coded in advance to accomplish activities of agriculture, including cultivation, fertilizer, reap, parch, and store.
- Agriculture automatically irrigating and tele-control pesticide spraying system: irrigation system of farmland is automatization and intelligence. According to different needs of moisture of soil and growth of crop in different period, to irrigate automatically.

(5) control and command system building (network, intelligence)

- agriculture assistant decision: using the result of analysis of land, soil, weather, to make a choice of breed, fertilizer, and pesticide which don't pollute the soil.
- Agriculture control system: based on the scheme of assist decision system, the agriculture technician makes decision finally with the assistant of automatic control system, to accomplish procedures of agriculture operation.

Digital agriculture is based on modern theory of agriculture, using the technology of digital Earth, to realize intelligence of procedure of agriculture, to promote production and maintain the developability of agriculture.

Actually current precision agriculture technology is farmland-oriented crop production precision farming which based on the idea of agriculture industry system. It is managed subtly with information and knowledge. But this idea should expend to the whole procedure of cultivate, foster, process, pre-production , middle-production, and post-production. Recently decade, automatic gardening, forecast model of animal foster, automatic control of environment, maintaining fresh of production, and value-added production, all of these adopt the result of advanced information technology, such as real-time detection of biology information, machine vision, model control, pattern recognising.