Integration and application of key technologies in precision agriculture

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Content

1. Overview of precision agriculture
2. The supporting techniques of precision agriculture
3. Research status of key technology of precision agriculture
4. Integration and application of precision agriculture key technology
1 Overview of precision agriculture

Background

The world's grain output was about 2532 million tons in 2014.

China's grain output was about 607 million tons in 2014.
1 Overview of precision agriculture

Background
1 Overview of precision agriculture

Background

Problems in agriculture:

Energy consumption is high,
environmental pollution is serious,
market competition is fierce

To realize the harmony between human and nature

Sustainable agriculture
1 Overview of precision agriculture

Background

Goal:
Sustainable agriculture

Technology:
Precision agriculture
1 Overview of precision agriculture

Background

Spatial and temporal variability of cropland
1 Overview of precision agriculture

Background

spatial distribution of phosphate fertilizer content in a Farmland
1 Overview of precision agriculture

Background

Spatial and temporal variability of cropland

Fig. 11 Soil chemical property map in 2000
1 Overview of precision agriculture

Background

Spraying (Farming) Uniformly
1 Overview of precision agriculture

Basic Conception

traditional farming $\rightarrow$ Uniform operation, ignoring variation

New farming $\rightarrow$ Field management based on variation
Basic idea on farming: intensive and meticulous farming

A traditional Chinese painting on farming and harvesting

the Southern Song Dynasty (1127-1279)
1 Overview of precision agriculture

Basic idea on farming:

intensive and meticulous farming
Precision agriculture (PA), also known as precision farming (PF), is a broad term commonly used to describe particular farm management concepts, sometimes referred to as site specific crop management (SSCM). The term first came into popular use with the introduction of GPS (global positioning satellites) and GNSS (global navigation satellite systems) as well as other methods of remote sensing which allowed farm operators to create precision maps of their fields that provide detailed information on their exact location while in-field. Advancements in technology have enabled the practice of precision agriculture to expand, providing even greater advantages for farmers and agricultural operations, including yield monitoring and crop scouting.
1 Overview of precision agriculture

Terms:

Prescription farming
Site specific crop management (SSCM)
Precision farming
Precision agriculture
1 Overview of precision agriculture

Process of PA
1 Overview of precision agriculture

Step 1:

grasp farmland variation Correctly

- Soil
- field operations
- plant information

information acquisition technique and Sensors

- Crop yield information
- weather information
- material used for agriculture
1 Overview of precision agriculture

Step 2:
Modeling of agricultural production processes

Farming Prescription
Aim: optimum benefits

- Soil
- field operations
- plant information
- Crop yield information
- weather information
- material used for agriculture
Step 2:
Realization – variable rate farming

Aim: optimum benefits

- Precision Feertilization
- Precision Seeding
- Precision Irrigation
- Precision Weeding
- Precision Deinsectization
- Precision Harvest
1 Overview of precision agriculture

- Economic requirements
- Legal requirements
- Environmental requirements
- Reduced inputs

- Soil and crop characteristics
- Difference in soil and crop characteristics
- The key to implementing precision agriculture
- The impact of difference on output
- Adequate information and appropriate technology management

- Precision agriculture
- Appropriate inputs
  - Timely inputs
  - Suitable inputs
  - Properly targeted inputs

- Increased output
  - Social benefits
  - Ecological benefits
  - Economic benefits
Overview of precision agriculture

1. Economic Push
2. Legislation
3. Environmental Pull
4. Reduced Inputs
5. Improved Control
6. Precision Farming
7. Management Information System
8. Geographical Information System
9. Decision Support System
10. Crop Models & Field History
11. Increased Efficiency
12. Less Waste
13. Improved Gross Margin
14. Less Environmental Impact
1 Overview of precision agriculture

Benefits of Precision Agriculture

- Increase productivity and net profit
- Better decision making ability
- Improve soil productivity
- Improve water quality
- Improve wildlife habitat
- Sustains natural resources for future generations.
1 Overview of precision agriculture

Typical Precision Crop Production

Data Transporting

Analysis & Planning

Data Transporting

Field operations and Data Collection
1 Overview of precision agriculture

Information Acquisition:

- Soil fertility
- Moisture content
- Soil texture
- Topography
- Pest population
- pH
Soil Information

**Fast changers:**
- nitrate level
- moisture content
- pest population

**Slow changers:**
- topography
- texture
- pH
1 Overview of precision agriculture

Information Acquisition: Yield Map

- Find the yield map
- Why the difference in the maps?
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Information Acquisition: Yield Map

raw data
grid map

Smoothing map
contour map

2017/10/30
1 Overview of precision agriculture

Other Maps

Example: Mapping Insect Migration

Army worm count: 8-5-98
Army worm count: 8-7-98
Within field migration
1 Overview of precision agriculture

Making a prescription map

(a) Precision fertilizer prescription maps

(b) formula for calculating the amount of fertilizer applied

\[ F_a = \frac{F_d}{j} = \frac{(F_{op} - F_p - F_s)}{j} \]

- \( F_a \): fertilizing amount
- \( j \): fertilizer utilization factor
- \( F_{op} \): replenished amount of fertilizer
- \( F_{op} \): amount of required fertilizer
- \( F_s \): Soil fertility potential
- \( F_p \): absorbed fertilizer by plants
Overview of precision agriculture

Making a prescription map

crop modeling
1 Overview of precision agriculture

Making a prescription map   crop modeling

- Rainfall, irrigation
- Potential transpiration
- Absorption vitality of root system
- Actual transpiration
- WUE
- Biomass
- Soil nutrient
- Soil moisture
- m_{shoot}
- m_{root}
- Leaf area
- Stem biomass
- Root biomass
- Canopy/root
-茎生物量
- 叶面积
- 叶面积
1 精细农业概述

Making a prescription map  crop modeling
Making a prescription map  crop modeling

06:00
1 精细农业概述

Making a prescription map  crop modeling

photolepsy of individual organs
1 Overview of precision agriculture

Making a prescription map  crop modeling


Dynamic growth of individual maize based on functional-structural GREENLAB model
1  Overview of precision agriculture

Making a prescription map  crop modeling
1 Overview of precision agriculture integration and application
1 Overview of precision agriculture integration and application

Precision Farming applied to Tea in Tanzania

- Fields
  - Highly structured (tea bushes grown in blocks)
- Yield mapping
  - Plucked by hand, recorded weight, block and quality
- Fertilizer application
  - Applied by hand based on treatment maps
- Technology
  - Low support
- Special considerations
  - Irrigation, logistics of production (keeping the factory full)
1 Overview of precision agriculture

Precision Farming applied to sugar cane in Australia, Brazil and Mauritius

- Fields
  - Highly structured small blocks
- Yield mapping
  - Hand cutting moving to mechanical harvesters
- Fertilizer application
  - By hand, using maps, increasingly mechanized
- Technology
  - Medium support
- Special considerations
  - Reducing the cost of production, Mechanization, De-rocking, no burning after 2006 in Brazil.
Coconut trees

- **Fields**
  - Well established groves (each tree numbered)
- **Yield mapping**
  - Record harvest from each tree
- **Fertilizer**
  - Applied by hand, according to treatment maps
- **Technology**
  - Low support
- **Special considerations**
  - Labour shortages
  - Operator safety (15m trees!)
1 Overview of precision agriculture

- Picked by hand
- Weighed by block
- Quality graded on farm
1 Overview of precision agriculture

integration and application
expand PA to other area

**Variable management based on spatial and temporal variation**

- Precision Forestry
- Precision Agrotechny
- Precision Livestock and poultry breeding
- Precision Horticulture
2. Supporting Technologies of PA

GNSS: Global Navigation Satellite System
GIS: Geographic Information System
RS: Remote Sensing
2. Supporting Technologies of PA

GNSS:

GPS: Global Positioning System. The United States

GLONASS: GLObal NAvigation Satellite System. The formerly Soviet, and now Russian

BeiDou-2: (or BDS, formerly known as COMPASS), second generation Beidou Navigation Satellite System. China.

Galileo: Galileo positioning system. The European Union and European Space Agency

RNSS (Regional navigation satellite systems):

NAVIC (NAVigation with Indian Constellation): developed by Indian Space Research Organisation (ISRO). throughout India and within a region extending approximately 1,500 km around it.

QZSS: Quasi-Zenith Satellite System, is a proposed three-satellite regional time transfer system and enhancement for GPS covering Japan.
GPS consists of three major segments. These are the space segment (SS), a control segment (CS), and a user segment (US).
2. Supporting Technologies of PA

space segment (SS)

SS is composed of the 24 orbiting GPS satellites in GPS parlance, six orbital planes with four satellites each. The orbital period is about one-half a day, so that the satellites pass over the same locations or almost the same locations every day. The orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on the Earth’s surface.
2. Supporting Technologies of PA

The control segment (CS)

CS is composed of:

A master control station (MCS), an alternate master control station, four dedicated ground antennas, and six dedicated monitor stations.

It provides the operational capability that supports GPS users and keeps the GPS system operational and performing within specification.

Ground monitor station used from 1984 to 2007, on display at the Air Force Space & Missile Museum at Cape Canaveral in Brevard County, Florida, United States
2. Supporting Technologies of PA

The user segment (US)

US is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial and scientific users of the Standard Positioning Service.

GPS receivers are in general composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock (often a crystal oscillator). They may also include a display for providing location and speed information to the user.
2. Supporting Technologies of PA

GPS RECEIVERS
Beidou and Compass
2. Supporting Technologies of PA

BDS

Schematic diagram of BDS
2. Supporting Technologies of PA

GNSS single-point positioning

Correction signal
2. Supporting Technologies of PA

DGNSS: Differential GNSS System
2. Supporting Technologies of PA

- **GNSS**
  - Global Satellite Navigation System

- **SBAS**
  - Satellite Augmentation System

- **DGNSS**
  - Direct GNSS

- **OmniStar, StarFire, TerraStar**

- **RTK**
  - Real-time Kinematic

- **PPP**
  - Precise Point Positioning

- **CORS**
  - Continuous Operational Reference System

Coverage:
- 10 m
- 1 m
- 10 cm
- 1 cm

- 10 km
- 100 km
- 1,000 km
- 10,000 km

SBAS: Satellite Augmentation System
GNSS: Key technology of PA

GNSS: key technology of Precision Agriculture (PA)

- Agri-GNSS CORS CORS for Agriculture
- Data Management System: LBS for Agriculture

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Performance</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm level (horizontal)</td>
<td>±2.5 cm</td>
<td>Auto-steering</td>
</tr>
<tr>
<td>cm level (vertical)</td>
<td>±3 cm</td>
<td>Land levelling, deep tillage, ......</td>
</tr>
<tr>
<td>dm level</td>
<td>±1 dm</td>
<td>Information collecting ......</td>
</tr>
<tr>
<td>m level</td>
<td></td>
<td>Fleet management ......</td>
</tr>
</tbody>
</table>
GNSS Application in Precision Agriculture

- GNSS is the basis of precision agriculture, and is the core support of precision operations and fine management.

- GSA: 500,000 Auto-steer GNSS terminals were used, most of them used in US, Canada, and Australia.

GNSS Application in Precision Agriculture

Use of Precision Technology in US

<table>
<thead>
<tr>
<th>Service</th>
<th>2015</th>
<th>2013</th>
</tr>
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<tbody>
<tr>
<td>GPS Guidance w/ Auto...</td>
<td>61%</td>
<td>83%</td>
</tr>
<tr>
<td>GPS Guidance w/ Manual...</td>
<td>63%</td>
<td>82%</td>
</tr>
<tr>
<td>Precision Services Offered</td>
<td>66%</td>
<td>82%</td>
</tr>
<tr>
<td>GPS-Enabled Sprayer Control</td>
<td>53%</td>
<td>74%</td>
</tr>
<tr>
<td>Satellite/Aerial Imagery for...</td>
<td>39%</td>
<td>51%</td>
</tr>
<tr>
<td>GPS for Logistics</td>
<td>21%</td>
<td>37%</td>
</tr>
<tr>
<td>Soil Electrical Conductivity...</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>Telemetry</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Chlorophyll/Greenness Sensors</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Other Vehicle-Mounted Soil...</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>

Bruce Erickson, David A. Widmar. 2015 Precision Agricultural Services Dealership Survey Results.
2015 Types of GPS Correction Used in US

- Utilize WAAS: 69.9%
- Personal RTK base station (fixed or portable): 11.7%
- Purchase satellite correction (i.e., OmniSTARXP or HP, StarFire 2): 27.2%
- Purchase correction for RTK array/cluster (i.e., Deere, Trimble): 25.7%
- Purchase RTN (Real Time Network) connection: 5.3%

Bruce Erickson, David A. Widmar. 2015 Precision Agricultural Services Dealership Survey Results.
2. Supporting Technologies of PA

DGNSS Applications

Agricultural machinery automatic navigation
Auto guidance system made in US

Ag Junction

John Deere

AgLeader

Headsight

Trimble

CASE IH

DigiFarm

Topcon

壁虎

Raven

Novariant

Ag Junction

John Deere

AgLeader

Headsight

Trimble

CASE IH

DigiFarm

Topcon

壁虎

Raven

Novariant
Yield Monitoring, Variable Rate Application

AgLeader Cotton Yield Monitor

John Deere crop input control system

AutoSwath

Shoarer et al, 1999
2. Supporting Technologies of PA

DGNSS Applications

Obtaining its boundary by driving with a GNSS receiver around a farmland

topography of a farmland
2. Supporting Technologies of PA

DGNSS Applications

- Grain flow sensor
- Humidity sensor
- GPS receiver
- Computer

Components of yield measure system for combine harvester

2017/10/30
2. Supporting Technologies of PA

DGNSS Applications

Vehicle navigation equipment, AgLeader Co.

Easy and affordable, the EZ-Guide® Plus lightbar guidance system from Trimble, represents a breakthrough in simple vehicle guidance.

Accurate GPS position output (via NMEA) for yield monitors, planters, variable rate controllers, and field computers

Bright LED lights and clear display to keep you driving on line in dust, fog, or even in the dark

Integrated GPS with the standard EZ-Guide Plus lightbar or your choice of higher performance receivers—we have the accuracy and corrections that best suit your operation

Simple displays, including overhead and perspective view show you where you need to be

Choose from multiple guidance patterns and between plan and 3D perspective views to see where you are and what you’ve been doing
BDS Application in Precision Agriculture in China

- BDS for marine fisheries: universal application
- GNSS for area measure: widely used
- Auto-steer guidance for tractor: increase quickly
- GNSS for operation monitoring: increase quickly
- GBAS for agriculture: used in some areas
- Other areas: being explored

中国北斗精准农业应用：
- 海洋渔业：基本普及
- 面积测量：广泛使用
- 自动驾驶：增长迅速
- 作业监管：增强迅速
- 地基增强：部分应用
- 其他应用：正在探索
China's mainland coastline measures approximately 18,000 km, with a total maritime area of 4.73 million sq km, with a total fishing boat of 1.2 million, about 310,000 marine fishing vessels and 8 million people engaged in fishing.

The Beidou navigation satellite system will help establish a security system to protect fishermen.

BDS mainly provides instant alarms and unique short messaging services.

- guide vessel to destination
- report emergencies to fishery departments
- weather forecasting service

The government pays for most of the cost of the client terminals. More than 50,000 fishing vessels in China had been equipped with BDS terminals.
The owner of farm machinery usually provides social service for the farmers without machinery. The driver should calculate the operation area for each field.

The harvester installs a navigation terminal similar to the taxi meter.

GNSS for area measure 面积测量应用
## History of Tractor Auto Guidance 自动驾驶发展

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>Mechanic &amp; Electronic</td>
<td>Requirement</td>
</tr>
<tr>
<td>1990</td>
<td>Mechatronics &amp; hydraulics integration</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>GPS (L1)</td>
<td>Demonstration of assisted steering (US)</td>
</tr>
<tr>
<td>2010</td>
<td>GPS (L1+L2)+INS</td>
<td>Popularization of auto guidance (US) Import and demonstration (China)</td>
</tr>
<tr>
<td>2013</td>
<td>BDS terminal (China)</td>
<td>Subsidy for BDS terminal (China)</td>
</tr>
<tr>
<td>2016</td>
<td>BDS terminal (China)</td>
<td>Popularization of auto guidance (US) Regional popularization of auto guidance (China) Half of GNSS terminal made in China (China)</td>
</tr>
</tbody>
</table>

### Diagram:
- **2010**: BDS terminal (China) subsidy and popularization in the US.
- **2013**: BDS terminal subsidy in China.
- **2016**: BDS terminal subsidy and regional popularization in China.

### Notes:
- BDS: BeiDou Navigation Satellite System.
- L1, L2: GPS satellite signals.
Auto guidance system made in China 中国自动驾驶

- 盛恒天宝
- 北京合众思壮
- 北京农林科学院
- 沈阳自动化所
- 山东北斗华宸
- 南京天辰礼达
- 上海华测
- 上海司南
- 广州中海达
- 华南农业大学
- 北京合众思壮
- 山东北斗华宸
- 南京天辰礼达
- 上海华测
- 上海司南
Auto guidance system made in China

The amount of tractor automatic driving system in China

Regional distribution of tractor automatic driving market in China

数据、图片来源：赵延平，我国北斗农机自动化应用现状，“金桥产业技术创新会议”第十三次会议，2016.3
Function of Auto Guidance  自动驾驶作用

- Improve operation quality
- 提高作业质量
- Increase yields
- 增加作物产量
- Improve work efficiency
- 提高工作效率
- Extend operation time
- 延长作业时间
- Increase the area of land
- 提高土地利用率

- Reduce skill requirements
- 减少技能要求
- Reduce labor load
- 减少雇工成本
- Reduce harvesting loss
- 减少产量损失
- Reduce fertilizer & chemical application
- 减少化肥农药施用
GNSS for operation monitoring 作业监管应用

- Farm machinery service organization 农机合作社
  - Fields
  - Personnel
  - Tractors
  - implements
  - …..
The operating supervision system includes: vehicle terminal, server, platform and monitoring terminal.
The working area is calculated according to the picking head, fan and positioning terminal.
Smartphone based precise monitoring

Give the tractor, driver and agricultural machinery QR codes, the driver scan the QR code before working, will be helpful on operation management.

<table>
<thead>
<tr>
<th>3G/4G status</th>
<th>GNSS status</th>
<th>Working status</th>
<th>Illustrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>normal</td>
<td>normal</td>
<td>Data transferred to server in real-time</td>
</tr>
<tr>
<td>abnormal</td>
<td>normal</td>
<td>normal</td>
<td>Data transferred to server when GPRS/3G/4G connected</td>
</tr>
<tr>
<td>normal</td>
<td>abnormal</td>
<td>abnormal</td>
<td>Not working</td>
</tr>
<tr>
<td>abnormal</td>
<td>abnormal</td>
<td>abnormal</td>
<td>Not working</td>
</tr>
</tbody>
</table>

Data transferred to server in real-time

Operation statistics

Normal/abnormal

Start/pause/continue

Stop
GNSS for operation monitoring: deep scarification
Remote sensing (RS)

RS is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation. In current usage, the term "remote sensing" generally refers to the use of satellite- or aircraft-based sensor technologies to detect and classify objects on Earth. It may be split into "active" remote sensing (i.e., when a signal is emitted by a satellite or aircraft and its reflection by the object is detected by the sensor) and "passive" remote sensing (i.e., when the reflection of sunlight is detected by the sensor). Examples of passive remote sensors include film photography, infrared, charge-coupled devices, and radiometers.
气象卫星北京地区城市热岛监测图
2006年07月21日13:53（北京时）
2. Supporting Technologies of PA

The main spectral response characteristics of green plants
2. Supporting Technologies of PA

The main spectral response characteristics of green plants

\[
RVI = \frac{R_{ir}}{R_r}
\]

\[
NDVI = \frac{R_{ir}}{R_{ir} + R_r}
\]
2. Supporting Technologies of PA

The main spectral response characteristics of green plants
2. Supporting Technologies of PA

remote sensing platform
2. Supporting Technologies of PA

in-situ remote sensing
2. Supporting Technologies of PA

in-situ remote sensing
2. Supporting Technologies of PA

in-situ remote sensing

Spectral characterization of different leaf area index

<table>
<thead>
<tr>
<th>LAI</th>
<th>Reflectance</th>
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<tbody>
<tr>
<td>2.49</td>
<td>1.88</td>
</tr>
<tr>
<td>1.43</td>
<td>1.18</td>
</tr>
<tr>
<td>0.85</td>
<td>0.54</td>
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</tbody>
</table>

soil
2. Supporting Technologies of PA

in-situ remote sensing

Spectral characterization of water content in leaves

<table>
<thead>
<tr>
<th></th>
<th>W1_76.6</th>
<th>W2_78.2</th>
<th>W3_79.4</th>
<th>W4_79.9</th>
<th>W5_79.4</th>
<th>W6_80.3</th>
</tr>
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<tbody>
<tr>
<td>7</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>叶片含水量 (%)</td>
<td>80.3</td>
<td>79.5</td>
<td>79.9</td>
<td>79.4</td>
<td>78.2</td>
<td>76.7</td>
</tr>
<tr>
<td>叶面面积指数</td>
<td>1.1994</td>
<td>1.124</td>
<td>0.944</td>
<td>0.956</td>
<td>0.884</td>
<td>1.146</td>
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</tbody>
</table>
2. Supporting Technologies of PA

in-situ remote sensing

The spectral characterization of aphids in wheat

- Healthy leaf
- Groups of insects
- Intensive blade

Reflection Rate vs. Wavelength
2. Supporting Technologies of PA

in-situ remote sensing

wheat rust and its spectral characterization
2. Supporting Technologies of PA

aerial remote sensing
2. Supporting Technologies of PA

aerial remote sensing
2. Supporting Technologies of PA

System overview

- Computer
- GPS antenna
- RTK-GPS
- INS and GDS
- Adjustable pan-head
- Laser range finder
- Multi-spectral imaging sensor
Inversion of physical parameters using spectral data

canopy water content (%)  \hspace{1cm} \text{Chlorophyll AB concentration in canopy (mg/g)}
2. Supporting Technologies of PA

aerial remote sensing

Inversion of physical parameters using spectral data

Canopy total nitrogen content (%)

Canopy soluble sugar content (%)
New application: To Combine remote sensing with agronomy. The ecological and physiological significance of physicochemical parameter image processing and analysis.

2. Supporting Technologies of PA

aerial remote sensing

The region where wheat is strong

The region where wheat is weak

全氮含量 (R)
可溶性糖 (G)
叶绿素a+b (B)
Inversion of wheat canopy stratification parameters based on reconstructed reflectance spectra
3 advances in key technologies of PA

Research progress of sensing and detection technology

Research progress of intelligent equipment technology

Research progress of wireless sensor network technology
3 advances in key technologies of PA

Sensor of soil moisture

- Pivot
- Blade
- Sensing cone
- Force sensor
- Force lever
3 advances in key technologies of PA

Sensor of soil electrical conductivity

Constant current source

Voltage meter

Soil surface

\[ A_1 \quad V_1 \quad V_2 \quad A_2 \]
3 advances in key technologies of PA

Sensor of soil EC

\[ y = 689.6x^{-0.814} \]

\[ R^2 = 0.994 \]

Output voltage (V) vs. soil electrical conductivity (μS/cm) for different parameters:
- \( a = 5, b = 10 \)
- \( a = 5, b = 15 \)
- \( a = 5, b = 20 \)
- \( a = 10, b = 20 \)
- \( a = 15, b = 30 \)
3 advances in key technologies of PA

Sensor of soil EC
Automatic acquisition of soil EC information

Soil EC is an inherent property to measure soil conduction current capacity. The results show that the sand has low EC, the surface soil has medium EC and clay has high EC.

Attribute of soil EC:
1. water retention capacity / water leakage
2. cation exchange capacity (CEC)
3. depth of clay layer (texture)
4. capacity organic compounds
5. salinity
6. pH
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Automatic acquisition of soil EC information

Figure 1 - Shallow (0 – 0.3 m) and deep-reading (0 – 0.9 m) soil EC maps, and soil clay and sand content maps.
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Sensor of soil nutrient content

λ₁, λ₂, λ₃, ..., λₙ

Light source

Transducer

Optical fiber

Sensor unit

Instrument

Adjustment

Signal processing

Signal processing

Data collection

Data processing

Modeling

Display

Calibration

Validation

Signal processing

TN

TN (%)

Real measured value (%)
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Sensor of soil nutrient content

![Diagram of sensor](image)

- **Probes**
  - Length: 30 cm
  - Internal: 7 mm glass fiber

- Glass fiber divided into two parts: diameter of 5 mm
- Thickness: 5 mm metal plate limits the probe's entry into the soil

- Light-emitting diode and lens, about 0.5 m in length
- Outer diameter: 36 mm
- Display and button
- Handle
- Control circuit

- **Hand grip**
- **Control circuit box**
- **Support pole**

Probe (length: 30 cm, internal 7 mm glass fiber)

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Sensor of yield monitor

Yield Monitor Interface Unit (YMIU) (inside rhs service door)

Flow Sensor

Moisture Sensor (elevator mount)

DGPS Receiver & Antennae

Display

Header Height Potentiometer

Ground Speed Sensor

Elevator Speed Sensor

Sensor of yield monitor

<table>
<thead>
<tr>
<th>F1:Northwst</th>
<th>L2:VAR1</th>
<th>Wheat</th>
<th>02/11 11:11 AM</th>
<th>DG</th>
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<tbody>
<tr>
<td></td>
<td>INSTANT</td>
<td>AVG</td>
<td>CARD</td>
<td>OK</td>
</tr>
<tr>
<td>Yield (BU/AC):</td>
<td>65.5</td>
<td>67.8</td>
<td></td>
<td></td>
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<tr>
<td>Moisture (%) :</td>
<td>12.0</td>
<td>12.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area Count</td>
<td>(Manual)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HARV1</td>
<td>HARV2</td>
<td>HARV3</td>
<td>CHANGE</td>
</tr>
<tr>
<td></td>
<td>LIGHT</td>
<td>LIGHT</td>
<td>LIGHT</td>
<td>MAIN</td>
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</table>

HARV1 HARV2 HARV3 CHANGE LIGHT MAIN

Area Count

0% Cutting Width 100% BOUND TILE

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Sensor of yield monitor

- Bed
- Strain gauge
- Sensitive rod
- Impact board

Diagram showing the sensor of yield monitor with labeled parts:
- Elevator
- One-way light barrier
- Probe
- Source
- Clean grain conveyor
- Detector
A combine with a AFS system
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Sensor of yield monitor

图5.1 划分为六个等级的产量图
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On-demand fertilization (Precision fertilization)

Double barrel variable rate fertilizer applicator
camera
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Crops absorb nutrients from the soil
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Crops absorb nutrients from the soil
3 advances in key technologies of PA

Crops absorb nutrients from the soil
3 advances in key technologies of PA

Fertilization to supplement soil nutrients
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Crop nutrient inconsistency
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...and adjusts the amount of fertilizer.
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Hence all plants develop optimal.
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On-demand fertilization (Precision fertilization)

Measurement → Calculation of N fertilizer demand → N application
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On-demand fertilization (Precision fertilization)
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Precision weeding
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Precision weeding

1. LEDs emit light on the ground
2. The detector reads the reflected light
3. Onboard electronics activate the valve cartridge if a plant is detected
4. The WeedSeeker Sensor sprays only weeds not bare ground!

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<< Back to previous page
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Precision weeding
Application of WSN in Agriculture

Environmental Monitoring on Croplands

Sensor Node:
- Sensor
- Soil moisture
- Soil temperature
- Power supply
- Solar panel
- Wireless communication
- ZigBee

Sink Node:
- Data aggregating
- Long-distance delivering

Base Station:
- Data receiving
- Data logging
- Analyzing

Soil moisture sensor

Soil temperature sensor
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Internet of Things

Sensor, Sensor Network

Processing, computing, decision

Application layer

Access and Transmission

Network layer

Sensing Layer
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Application of WSN in Soil Sensing
3 advances in key technologies of PA

Application of WSN in Soil Sensing
### 3. Advances in Key Technologies of PA

**Application of WSN in Soil Sensing**

<table>
<thead>
<tr>
<th>序号</th>
<th>监测项目</th>
<th>监测点</th>
<th>时间</th>
<th>监测值</th>
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<td>9</td>
<td>2011-9-18 2:39:27</td>
<td>21.61</td>
<td>偏高</td>
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<td>19.41</td>
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<td>2011-9-18 0:15:14</td>
<td>20.36</td>
<td>偏高</td>
<td>正常</td>
</tr>
</tbody>
</table>
It mainly uses solar energy so that it can reduce energy consumption.

It consists of three parts, thermal insulation walls, movable thermal insulation covers made by cotton, straw, and so on, and fixed cover.
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Wireless sensor network in greenhouse
Application of WSN in Solar Greenhouse

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KNOWNLEDGE INSERTS ON APPLICATION

INTERNET

MACQU-H50

Greece

China

INTERNET

CLOUD

FEEDING THE WORLD

IoT

CAU

MOTS GEOM

KOM-MIR-HOS

LEVEL2

SOLAR GREENHOUSE STATION

TRANSFORM SOILLESS

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Application of WSN in Solar Greenhouse
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3 advances in key technologies of PA

Laser Leveling System

- Laser transmitter
- Laser receiver
- Reference plane
- Controller
- Tractor
- Scraper
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Laser Leveling System

Control

Laser Receiver

Hydraulic control system

Laser Transmitter

Paddy-fields

Dry-fields
THANK YOU!