Intelligent Agricultural Production System based on Climate, Crop, and Field Information

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OUTLINE

1. Issues in Agriculture
2. Intelligent Agricultural Production System
3. Strategies
01

Issues in Agriculture
World Population Growth

- **World population growth**
  
  (source: writings.basiliochen.com)

- **Increased demand for food production**
  
  (source: www.economist.com)
Food Safety

- Pesticide residue in foods

**CHEMICALS IN YOUR SHOPPING**

Foods most likely to have pesticide residues:

- Oranges: 97.98%
- Flour: 96.83%
- Pears: 96.52%
- Pineapple: 93.33%
- Grapes: 91.33%
- Apples: 90.63%
- Dried Grapes: 80.95%
- Raspberries: 76.47%
- Bread: 73.61%
- Carrots: 72.97%
- Peppers: 70.27%

(source: www.dailymail.co.uk)

**SUPERMARKETS ARE NOW URGENTLY RECALLING SALADS AND SANDWICHES CONTAINING EGG**

(source: www.grimsbytelegraph.co.uk)
Demand for Organic Food

Organic agricultural land

Climate Change

- Yield loss due to climate change

Global warming

Yield Loss Due to Drought Stress

Yield: Bushels per Acre

- Wet spring, early frost -16%
- Blight -18%
- Drought -17%
- Drought -26%
- Drought -29%
- Flood
- Unusual Climate Events
### 2016 Global food security index

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(source: A report from the EIU)

### Food self-sufficiency in Korea

- **Food self-sufficiency**: except feed for livestock
- **Grain self-sufficiency**: including feed for livestock
Challenges in Agriculture

- Need of increasing food production (quantity)
- Increased demand for safe food or environment-friendly agriculture (quality)
- Demand for business model for highly economic return in agriculture
- Required high global competitiveness in agriculture
- Improvement of life quality of persons working in agriculture

Innovation of agricultural production system using digital transformation technology

*Digital transformation (4th industrial revolution): highly connected and highly intelligent society based on technology of ICT/IoT, robot/UAV, artificial intelligence, big data, 3D printer etc.*
02

Intelligent Agricultural Production System
Intelligent Agricultural Production System

(source: Farm Forward by John Ddere, www.youtube.com)
Intelligent Agricultural Production System

(source: Trimble Connected Farm, www.youtube.com)
Intelligent Agricultural Production System

“An intelligent agricultural production system can maximize the efficiency of the system by unsupervised learning with minimum interception of human”

- **Input**: labor, chemicals (fertilizer, pesticide, etc.)
  - water (irrigation), energy, environmental control, etc.

- **Output**: Quantity and quality of agricultural product

(Intelligent agricultural production system)

Decision making system (experience -> Big data, Artificial intelligence, etc.)

Actuating system (human -> agricultural machinery -> Robot, UAV, etc.)

Monitoring system (human sense -> soil, crop sensors)

*UAV sensing platform*

Weather information
Precision Agriculture

“Site-specific variable technology based on farm field and crop conditions”

Optimum input:

Right time,
Right amount,
Right place
Monitoring System

- Satellite
  - Large covered area (FOV)
  - Low sensitivity

- UAV
  - Small covered area (FOV)
  - High sensitivity

- Mobile robot

- Biosensor
Monitoring System

Sensor platforms
Monitoring System

Sensors

- SICK LMS-291
- Mini MCA Tetracam
- Sony DSC-V1
- Micro-Hyperspec VNIR
- Tetracam-ADC
- FLIR Thermovision A40M
Genomics and Phenomics

- **Genomics**
  - High throughput analysis of genes and their immediate products, to study the structure and function of genes and genomes

- **Phenomics**
  - High throughput analysis of plant growth and physiology, to reveal the role of each gene in the function of the whole plant

Genomics + Phenomics = Functional Genomics

Innovation, Gene discovery
Monitoring System

- **Phenomics**

  Phenomics uses imaging techniques to allow researchers to study the inner workings of leaves, roots or whole plants.

  - Visible imaging – color, morphology
  - Infrared & Near-infrared imaging
  - Fluorescence imaging
  - Magnetic resonance imaging
Visible imaging

1. Plant color classification
   - Plant health
   - Stress
   - Nutrients
   - Senescence

2. Plant morphology
   - Stem, leaves
   - nodes, length of leaves

Plant growth
Near infrared (NIR) imaging

Measuring water distribution and dynamics

wheat dried down at elevated temperature

0h
4h
8h
16h
Monitoring System

- Infrared (IR) imaging

Quantify temperature differences
(e. g. within leaves and between plants)
“Diagnosis of crop stress, disease, nutrient deficiency in an early stage”

**Molecular level**
- Micro/nano biosensing technology
- High sensitivity and small FOV
- Possible to diagnose in an early stage
- Direct sensing for crop monitoring

**Canopy level**
- Spectroscopic, imaging technology
- Low sensitivity and large FOV,
- Not easy to diagnose in an early stage
- Indirect sensing for crop monitoring
Monitoring System

**Biosensor for early diagnosis**
Monitoring System

Sensing for virtual farming

- Digitization
- Feature extraction
- Geometric modeling

Breed variety heredity
Topology
Shape feature
Distribution
Agricultural technologies

Visual canopy model
Crop model & Expert system
Statistic distribution analysis
Monitoring System

- Monitoring rice plant in the whole life cycle using UAV

**Plowing**
- Surface elevation variation
- Uniformity of plowing depth

**Transplanting**
- Planting density (missing plant rate)
- Space between plants
- Coordinate each plant

**Disease/Pest management**
- Monitoring disease and nutrient deficiency

**Harvesting**
- Yield measurement at each plant
- Yield variation

Maximize yield and quality with minimum input
Monitoring System

- Plowing stage: uniform surface elevation
Monitoring System

Transplanting stage: planting density
Monitoring System

- Growing stage: crop growth information based on spectroscopic and morphological analyses

<table>
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<th>Date of image acquisition</th>
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<th>NIR image</th>
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Harvesting stage: yield monitoring of each plant

\[
y = 1.073x - 0.2227 \\
R^2 = 0.9308
\]

Predicted number of grain

\[
y = 0.7055x + 28.32 \\
R^2 = 0.8421
\]

Ground truth of number of grain

Predicted grain area (mm\(^2\))

Ground Truth of grain area (mm\(^2\))
Decision Making System

- Collecting data of weather, soil, crop in various conditions
- Big data based optimum model for input of agricultural materials
- Calibration of the model in various environments

(www.airinov.fr)
Integrated farming system of Monsanto

Integrated Farming Systems™ Would Combine Advanced Seed Genetics, On-farm Agronomic Practices, Software and Hardware Innovations to Drive Yield

**DATABASE BACKBONE**
Expansive seed-by-environment testing makes on-farm prescriptions available for certified seed dealer sales and service.

**VARIABLE-RATE FERTILITY**
Variable rate N, P, & K “Apps” aligned with yield management zones.

**PRECISION SEEDING**
Planter systems enabling scripts for variable rate seeding with optimal row spacing of hybrids in a field by yield management zones.

**FERTILITY & DISEASE MANAGEMENT**
“Apps” for in-season custom application of supplemental rates of nitrogen and fungicides.

**BREEDING**
Significant increases in data points collected per year to increase annual rate genetic gain.

**YIELD MONITOR**
Advances in Yield Monitoring to deliver higher resolution data.

(test.monsanto.com)
Actuating System

- Application of robots: variable-rate actuation
Actuating System

- Aerial manipulator for collection and inspection of crops

- Cooperative control of multi-UAVs for transportation of products
Actuating System

- UAV–based tracking of small insect
- Haptic teleoperation of aerial manipulator
- Cooperation between UAV and autonomous tractor
Strategies and Conclusions
Strategies

- Fully automated agricultural production in the whole life cycle
Strategies

- Cooperation between automation-related industry and agriculture for the development of core technology
- Adoption of new technology from related advanced industry

(Google's self-driving car) (Autonomous tractor)
Strategies

- Innovative idea based core technology, creative engineers/researchers
Innovation of Agricultural Production System !!!

Thank You !!!

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