Development of ANTS for plant factory and measurement of $\text{CO}_2$ concentration

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Issues of the science, earth and society

Life innovation
- Medical Treatment
- Care
- Human extension
- Aging society
- Computational biology
- Brain science
- Life/Mental phenomenon

Green innovation
- Environmental change
- Natural disaster
- Epidemic infection
- Material recycling
- Low carbon
- Biodiversity
- Plant factory
- Environmental measurement control

Dependability
- Safety and security
- Artificial object
- Maintenance
- Urban infrastructure
- Accident disaster
- Economic phenomena
- Crime
- Terrorism
- Information security
- System failure
Tohoku Earthquake and Tsunami
11 March 2011
Merits of the plant factory

• Fukushima Daiichi nuclear disaster, soil pollution issue.
• Decrease the population of the agriculture.

The plant factory is influenced by neither the weather nor soil, but can harvest agricultural products stably.
Sunlight-type plant factory
Fully artificial light-type plant factory
Present situation of the environment measurement and control system for the plant factory
Technical issues of the conventional system

1. Sequence control, analog measurement including a lot of noise
2. Complex system, complex wiring, asynchronously control
3. Too expensive, adapted large plant factory and not adapted to Japanese plant factory
4. Closed hardware/software, unnormalized standard, unfamiliar
5. Fixed point observation, difficult to understand dynamics, to observe from remote place and to construct database of each green house

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vicious cycle
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Requirement definition of integrated environment measurement and control system

1. Digitalization, chipping, downsizing
2. Networked system
3. Low cost, adaptive to large/small scale
4. Open source, open hardware
5. Active sensing, Telexistence, robot control

ANTS (Active-sensing Networks and Telexistence System)
Concept of ANTS (Active-sensing Networks and Tele-existence System) (1/2)

- Active-sensing Networks
Concept of ANTS (Active-sensing Networks and Tele-existence System) (2/2)

• Tele-existence
The circuit diagram of ANTS
ANTS and sensors

- CO\textsubscript{2} sensor
- Pyranometer
- Temperature and relative humidity sensor
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Active sensing robot

A sensor is moved perpendicularly.
(degree of freedom 1)

A growth chamber
ANTS in a growth chamber

A growth chamber

ANTs

Temperature and Relative humidity sensor

CO₂ sensor

pyranometer
Intensity of solar radiation of the day of summer

- Intensity of solar radiation is almost zero from 18:00 to 06:00.
The dark respiration

$\text{CO}_2$ concentration increased 106.6[ppm/h]
Photosynthesis by sunlight (1)

CO$_2$ decreases by photosynthesis 212[ppm/h]
Photosynthesis by high-pressure sodium lamp(1)
Photosynthesis by high-pressure sodium lamp (2)

$\text{CO}_2$ decreases by photosynthesis 185 [ppm/h]
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Summary

• We were able to produce a growth chamber and ANTS.

• As type artificial light and solar type, we experimented in the photosynthesis of the tomato by using ANTS.

<table>
<thead>
<tr>
<th>light source</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>sunlight</td>
<td>212[ppm/h]</td>
</tr>
<tr>
<td>a high-pressure sodium lamp</td>
<td>185[ppm/h]</td>
</tr>
</tbody>
</table>
Future plan

• Future subjects are to CO2 control the photosynthesis of the active-sensing by using ANTS with various plants in the chamber.

• Actual measurement in the plant factory
Thank you for your attention!
Proposal of integrated measurement and control system for plant factory (by Dr. KOZAI, Chiba Univ.)

Option measuring instrument
- Liquid thermometer
- Actinometer
- CO2 concentration
- Flowmeter
- CO2 container
- flowmeter
- Heat pump
- wattmeter etc.

Option apparatus
- Ventilation window
- motor
- CO2 container
- Solenoid valve
- Heat pump
- Ventilation fan etc.

Air outflow
- SD/USB Memory
- Micro Computer
- Clock
- Digital I/O
- DC Supply

LCD
- Time, Temperature, humidity, VPD

Temperature, humidity, 2 sets

Small fan

Filter

Air inflow

Requirement specification size: 15x5x10cm
ANTS cost: 100,000 yen
= 36000 Taiwan dollar

Sensor: IC digital chip

2013/3/15 Toyokix Kozai
Telexistence robotics unit

Master side

Slave side
Vision and arm unit of ANTS stereo, microscope camera and sensor arm

3DOF sensor arm with x500 microscope

2DOF stereo camera

Motion control computer

Stomata and surface of a leaf observation using network