

Comprehensive Data Collection by Sensor Network and Optical Sensor for Agricultural Big Data

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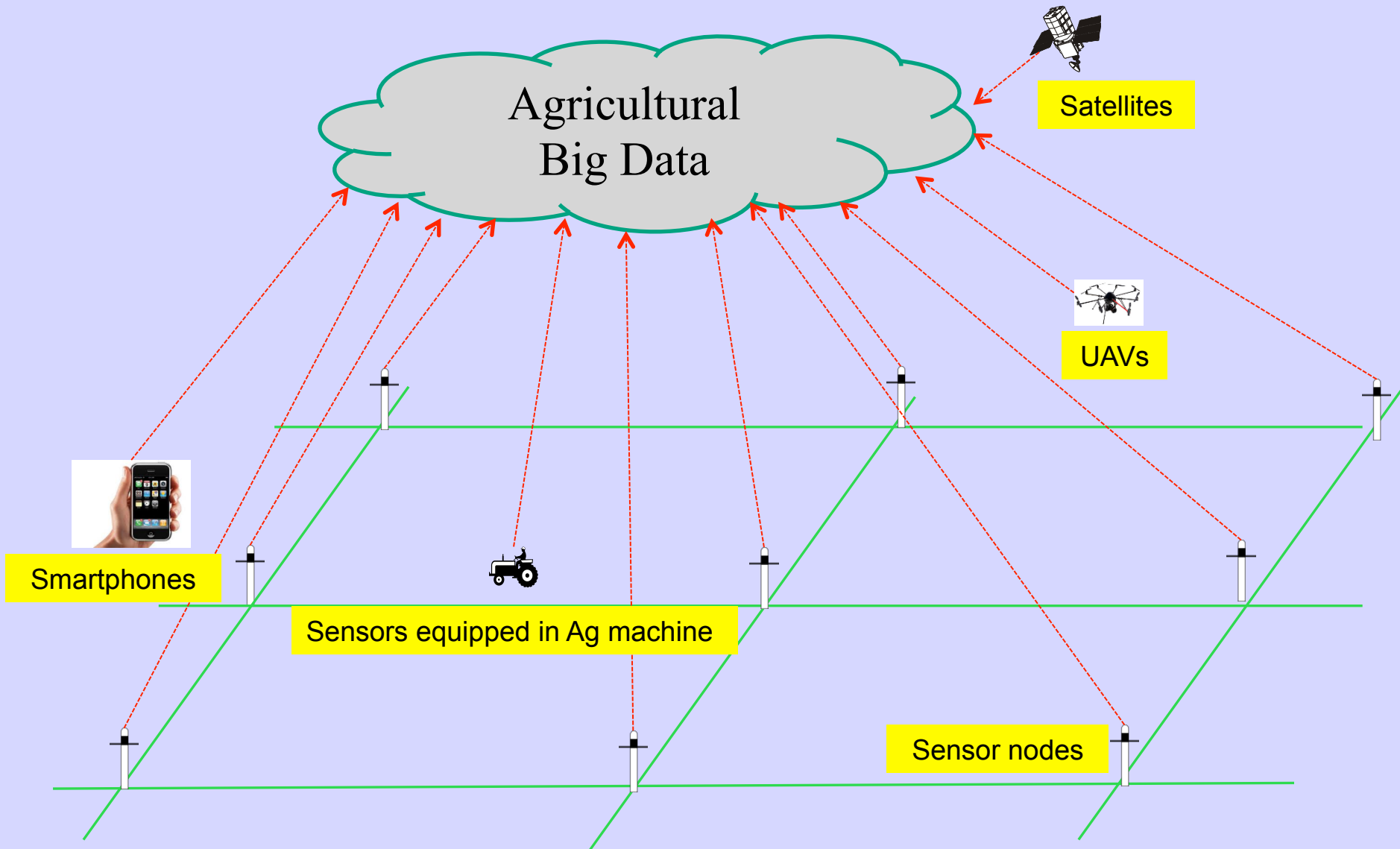
** *University of Tsukuba*

Big Data: Indispensable for Smart AG & Phenomics

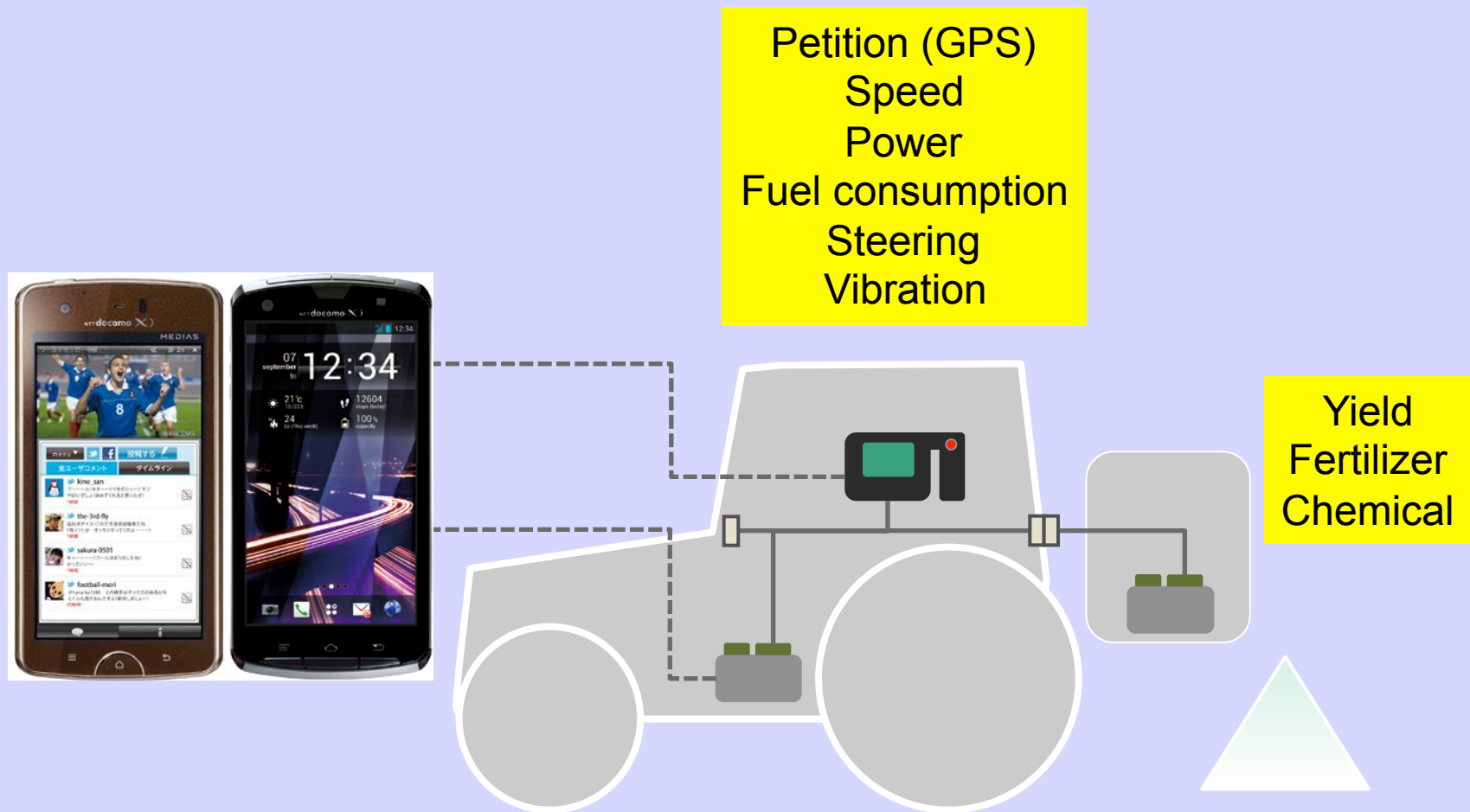
- Environmental condition
- Image of UAV and satellite
- Yield distribution
- Farmer's state and machine's state
- VRA (Variable Rate Application) for fertilizer
- Plant growth rate and photosynthesis rate
- Stress tolerance
- Insect pest distribution
- Individual's genome

Comprehensive Field Data Collection

Big Data by CLOP (CLOUD Open Platform/Practice)



M2M & IoT in Agricultural Machine



M2M & IoT in UAV

Green, Blue, Red and/or Infra-Red



An image taken by the UAV



Barriers in Sustainable Sensor Network for Smart AG & Field Phenotyping

Wired Parts Were Weak Points in Field Sensing.

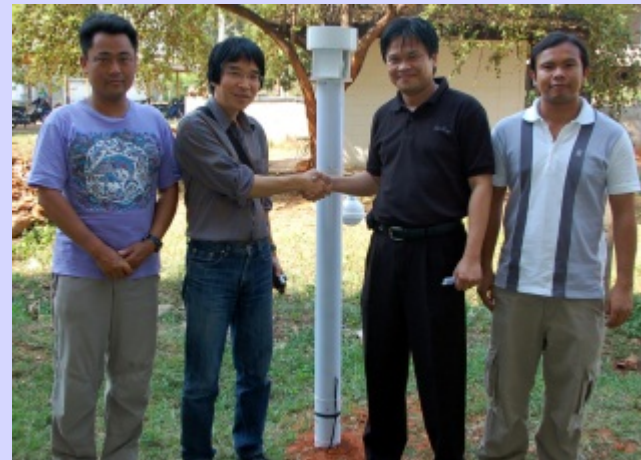


Erosion of synthetic rubber



Water leak

Conventional Field Servers Are Too Difficult to Make for Most Researchers and Students.



Open-FS: Simplified and Open-source FS

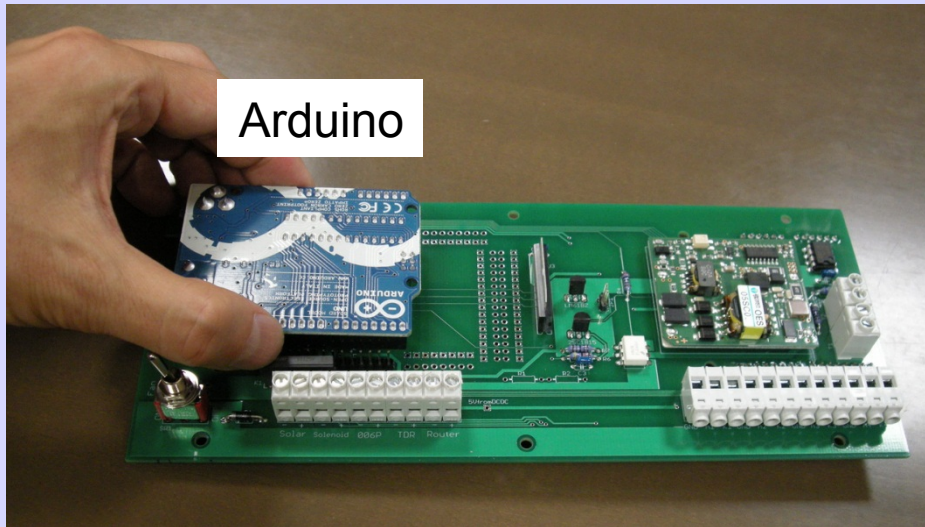


-  **nfa4324a** @nfa4324a 14分
Battery 6.5 [V], Board-T 17.6 [deg-C], S-Moist 92029 [Hz], Soil-T 14.2 [deg-C], Top-FD 43, Bottom-FD 9
開<
-  **nfa4324a** @nfa4324a 1時間
Battery 6.5 [V], Board-T 17.1 [deg-C], S-Moist 92029 [Hz], Soil-T 14.2 [deg-C], Top-FD 43, Bottom-FD 4
開<
-  **nfa4324a** @nfa4324a 3時間
Battery 6.5 [V], Board-T 19.1 [deg-C], S-Moist 92398 [Hz], Soil-T 14.2 [deg-C], Top-FD 73, Bottom-FD 19
開<
-  **nfa4324a** @nfa4324a 4時間
Battery 6.3 [V], Board-T 21.5 [deg-C], S-Moist 92691 [Hz], Soil-T 14.7 [deg-C], Top-FD 63, Bottom-FD 14
開<
-  **nfa4324a** @nfa4324a 4時間
Battery 6.3 [V], Board-T 22.0 [deg-C], S-Moist 134870 [Hz], Soil-T 15.6 [deg-C], Top-FD 0, Bottom-FD 9
開<

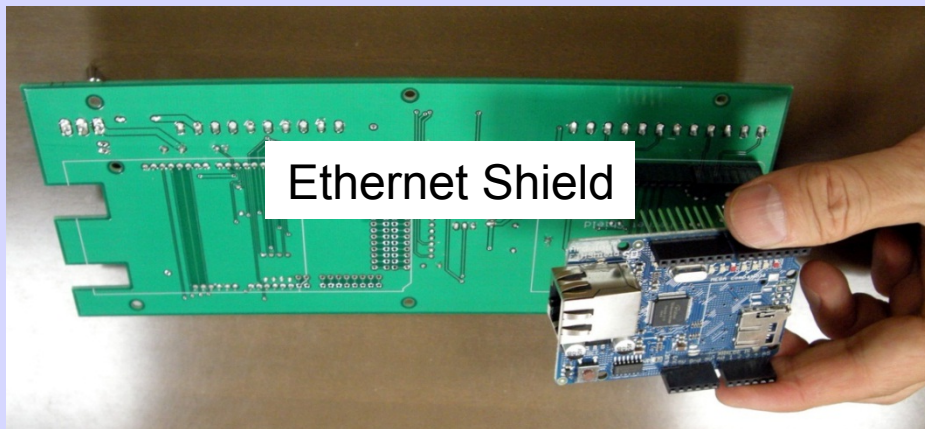
Tweeting data beside plants

How to Make Open-FS

1



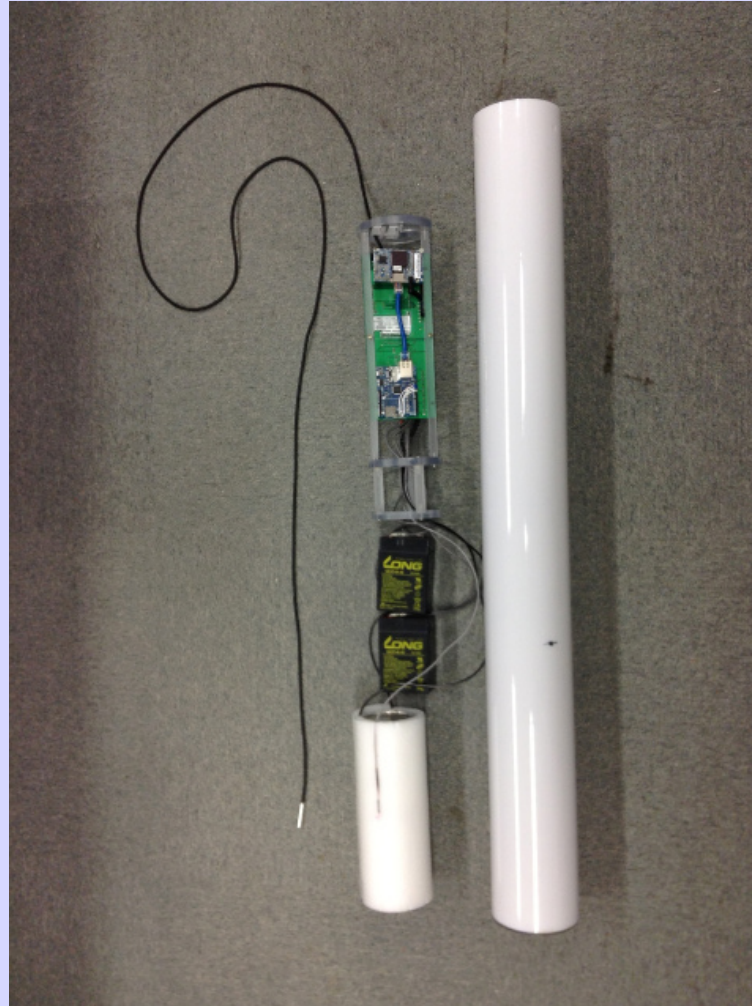
2



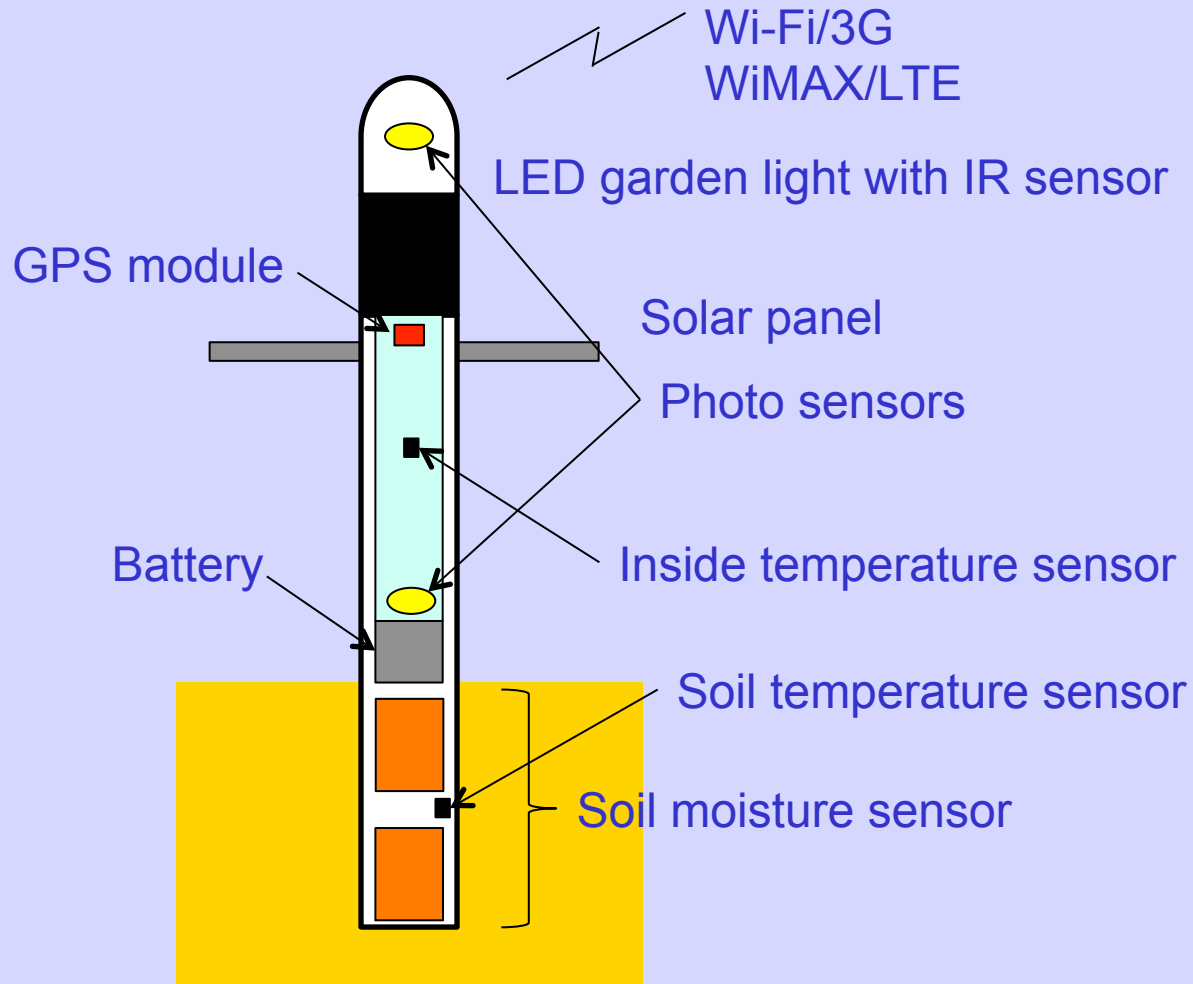
3



Inside Components And A Case of Open-FS



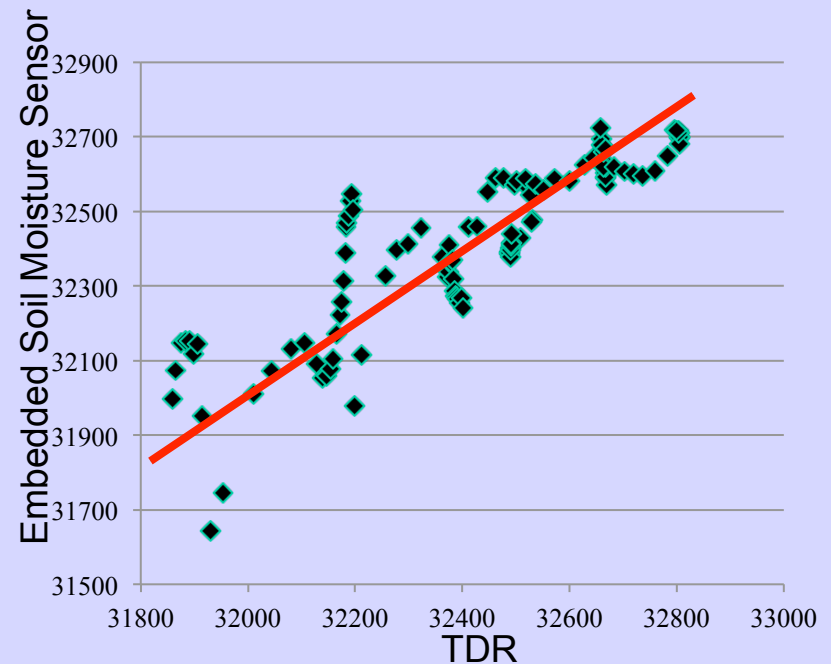
Open-FS (Open Field Server) IS Gradually Simplified And Upgraded For Field Phenotyping.



Low-cost Soil Moisture Sensor Using Two Cans

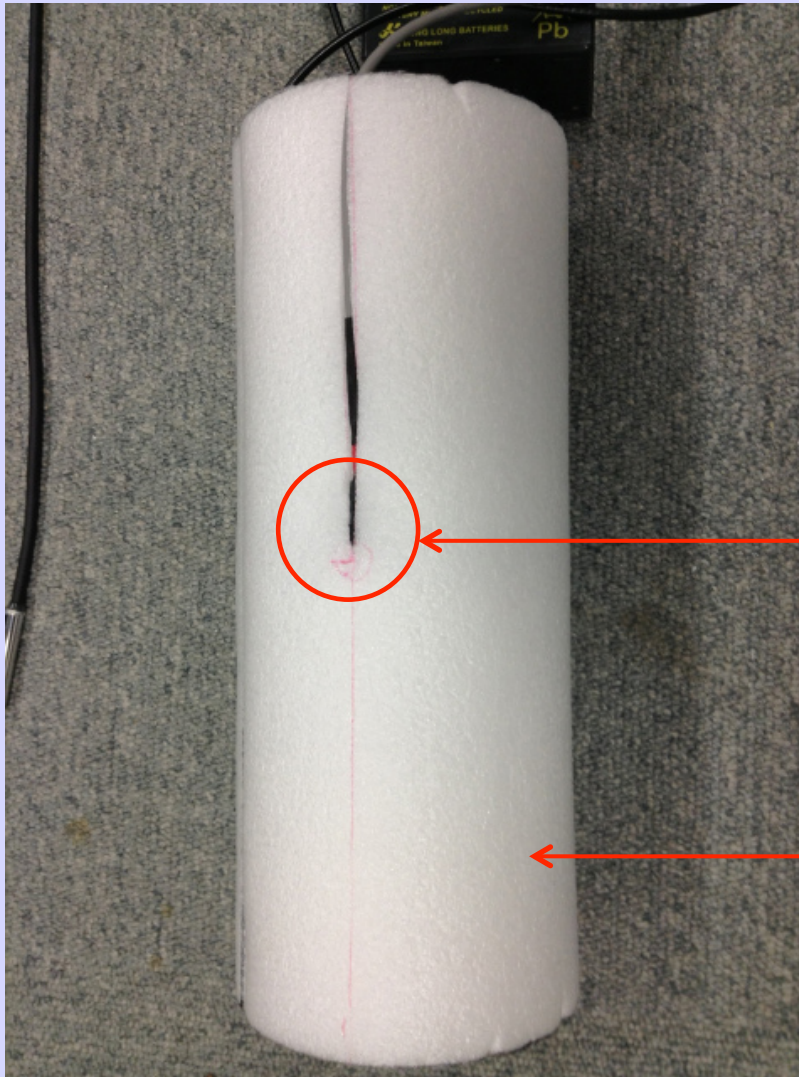


Soil moisture sensor by using cans



Relationship between a conventional soil moisture sensor (TDR) and the low-cost soil moisture sensor.

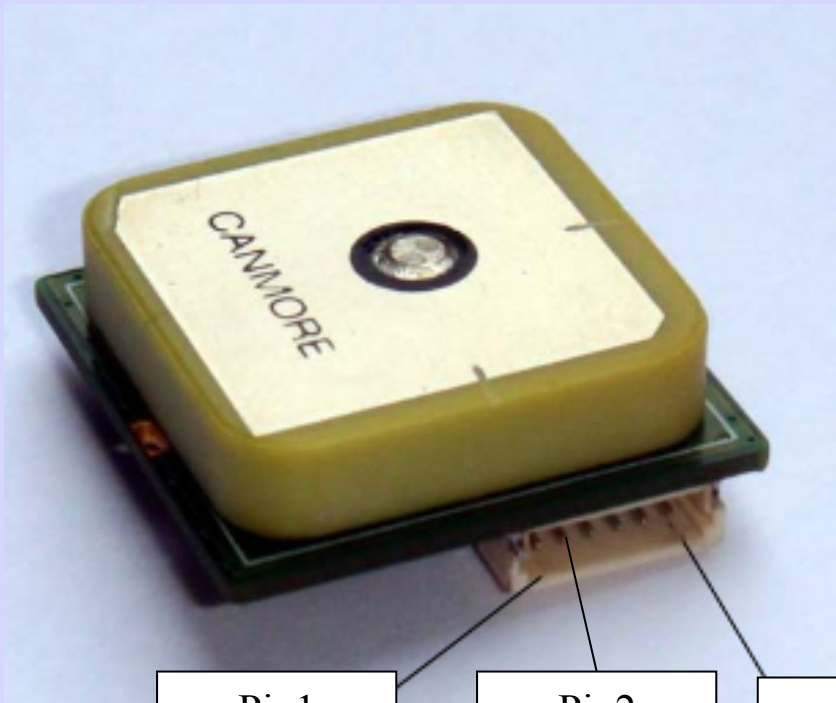
Soil Temperature Sensor



Soil temperature sensor
It measuring soil temperature through the Open-FS case (plastic pipe).

Thermal Insulator
The temperature sensor is isolated from other parts by the thermal insulator.

GPS Module for Location Data and Synchronized Operation of Sensor Nodes



Pin1
(GND)

Pin2
(Power)

Pin6
(Serial data out)

GT-723F:
about 30USD. It takes
10seconds to get location
data after switch-on.

Only the three pins must be connected to Open-FS (Arduino) through the mother board.

Tweeting Geolocation Data Using ThingSpeak

(<https://www.thingspeak.com/>)

ThingSpeak
HOME CHANNELS APPS FEATURES

Community Documentation Sign In Sign Up

create your Internet of Things application with **ThingSpeak** [an open application platform designed to enable meaningful connections between things and people]

Dynamic Light Levels

Light

Time

You left your lights on 2 minutes ago.

Light level was 89% in your room.

features

- Open Source API
- Real-time data collection
- Data processing
- Data visualizations
- Location-awareness
- Status context

applications

- Sensor monitoring
- Energy monitoring
- Connecting devices and systems
- Geo location tracking
- Interfacing with social networks
- RFID transactions

get started

If you are ready to get started, [Sign Up](#) for a free user account.

connect



ThingSpeak
HOME CHANNELS APPS FEATURES

Apps

ThingTweet

ThingHTTP

TweetControl

React



ThingSpeak
HOME CHANNELS APPS PLUGINS DEVICES

Apps » ThingTweet

Link Twitter Account

Twitter Account	Action	API Key	Action
sensorbot0014	Unlink Account	[REDACTED]	Regenerate API Key



ThingSpeak
HOME CHANNELS APPS FEATURES

Community Documentation Sign In Sign Up

Secure Sign In

Please sign in to access your account.

User ID: sensorbot0014

Password: [REDACTED]

Remember my User ID

[Forgot your password?](#)


[Sign In](#)

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Tweeting location Information by Geolocator API

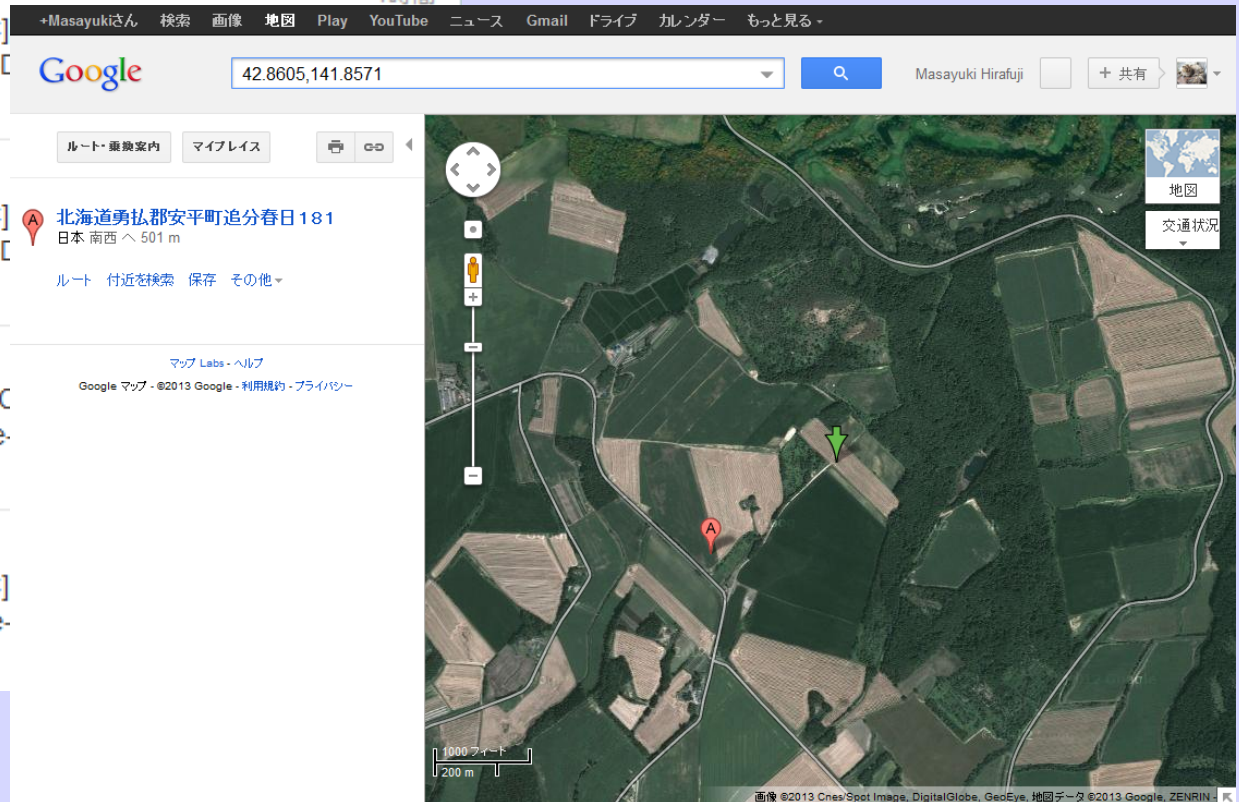
 **open-fs** @openfsgps 17分
Battery 6.0 [V], Board-T 2.0 [deg-C], S-Moist 189706 [Hz],
Top-FD 0, Middle-Up-FD 2, Middle-Down-FD 0, Bottom-FD 0
📍 厚真町 (勇払郡), 北海道 から

 **open-fs** @openfsgps 1時間
Battery 6.1 [V], Board-T 4.0 [deg-C]
Top-FD 0, Middle-Up-FD 3, Middle-Down-FD 0, Bottom-FD 0
📍 厚真町 (勇払郡), 北海道 から

 **open-fs** @openfsgps
Battery 6.1 [V], Board-T 8.0 [deg-C]
Top-FD 0, Middle-Up-FD 7, Middle-Down-FD 0, Bottom-FD 0
📍 厚真町 (勇払郡), 北海道 から

 **open-fs** @openfsgps
Battery 6.2 [V], Board-T 14.0 [deg-C]
Top-FD 0, Middle-Up-FD 18, Middle-Down-FD 0, Bottom-FD 0
📍 厚真町 (勇払郡), 北海道 から

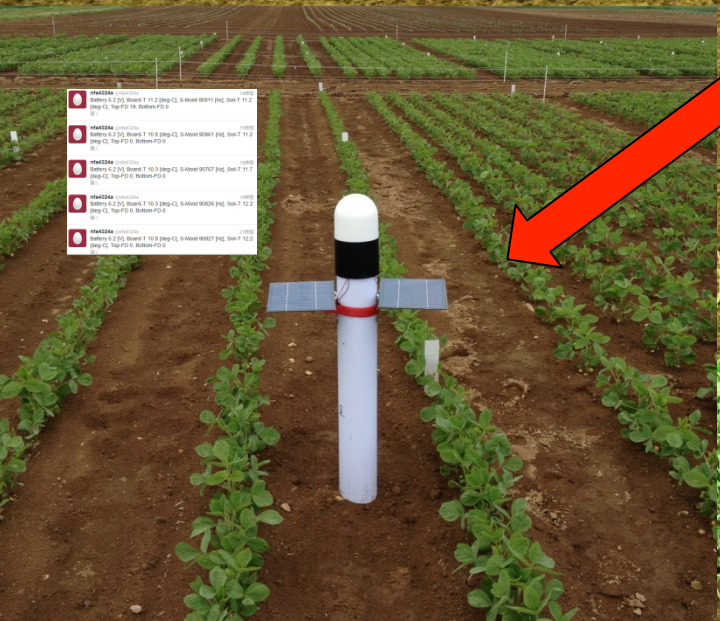
 **open-fs** @openfsgps
Battery 6.1 [V], Board-T 9.0 [deg-C]
Top-FD 0, Middle-Up-FD 11, Middle-Down-FD 0, Bottom-FD 0
📍 厚真町 (勇払郡), 北海道 から



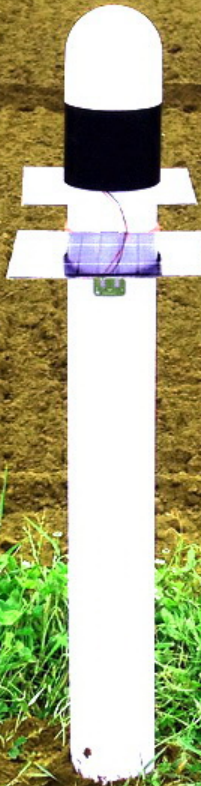
The screenshot shows a Google Maps browser window. The address bar contains the coordinates 42.8605,141.8571. The map displays a satellite view of a rural area with fields and forests. A red location pin is placed on the map, and a green arrow points to a specific spot. The interface includes navigation controls, a search bar, and a menu with options like 'ルート' (Route) and 'マイプレイス' (My Places). The footer of the map shows copyright information: '画像 ©2013 Cnes/Spot Image, DigitalGlobe, GeoEye, 地図データ ©2013 Google, ZENRIN'.



Researchers can uproot the Open-FS and take it for their experiment sites.



- nfa4324a** @nfa4324a
Battery 6.2 [V], Board-T 11.2 [deg-C], S-Moist 90811 [Hz], Soil-T 11.2 [deg-C], Top-FD 0, Bottom-FD 0
- nfa4324a** @nfa4324a
Battery 6.2 [V], Board-T 10.8 [deg-C], S-Moist 90861 [Hz], Soil-T 11.2 [deg-C], Top-FD 0, Bottom-FD 0
- nfa4324a** @nfa4324a
Battery 6.2 [V], Board-T 10.3 [deg-C], S-Moist 90767 [Hz], Soil-T 11.7 [deg-C], Top-FD 0, Bottom-FD 0
- nfa4324a** @nfa4324a
Battery 6.2 [V], Board-T 10.3 [deg-C], S-Moist 90826 [Hz], Soil-T 12.2 [deg-C], Top-FD 0, Bottom-FD 0
- nfa4324a** @nfa4324a
Battery 6.2 [V], Board-T 10.8 [deg-C], S-Moist 90927 [Hz], Soil-T 12.2 [deg-C], Top-FD 0, Bottom-FD 0

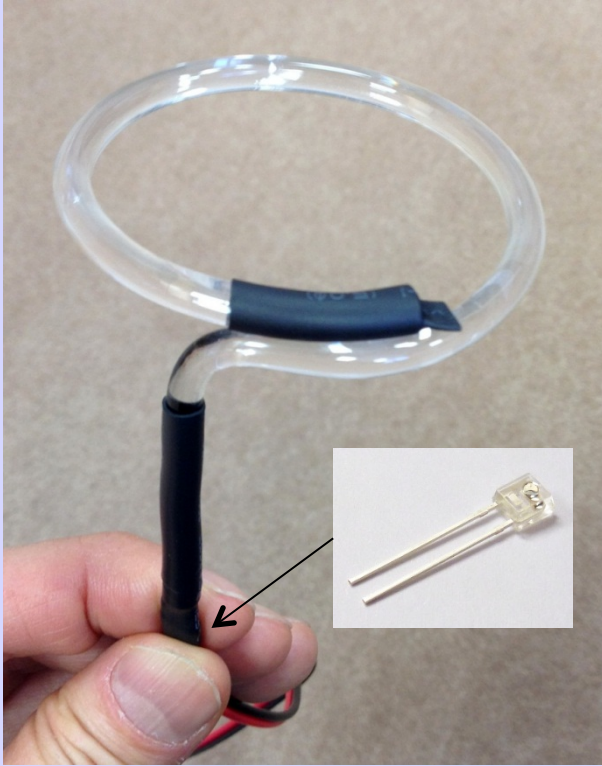
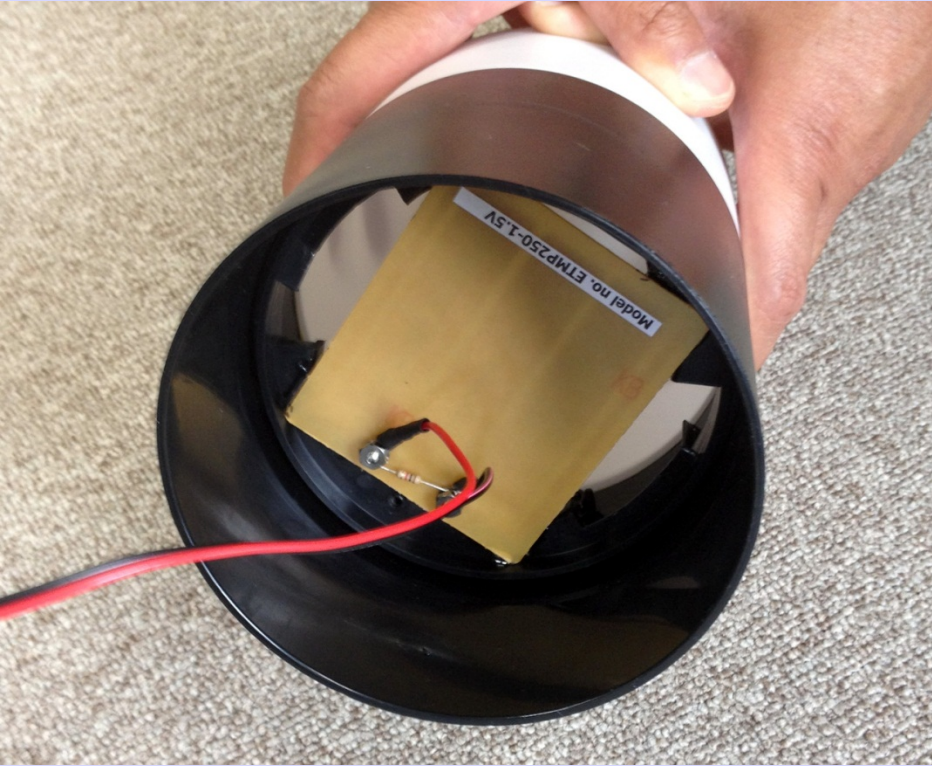


Tweeting data

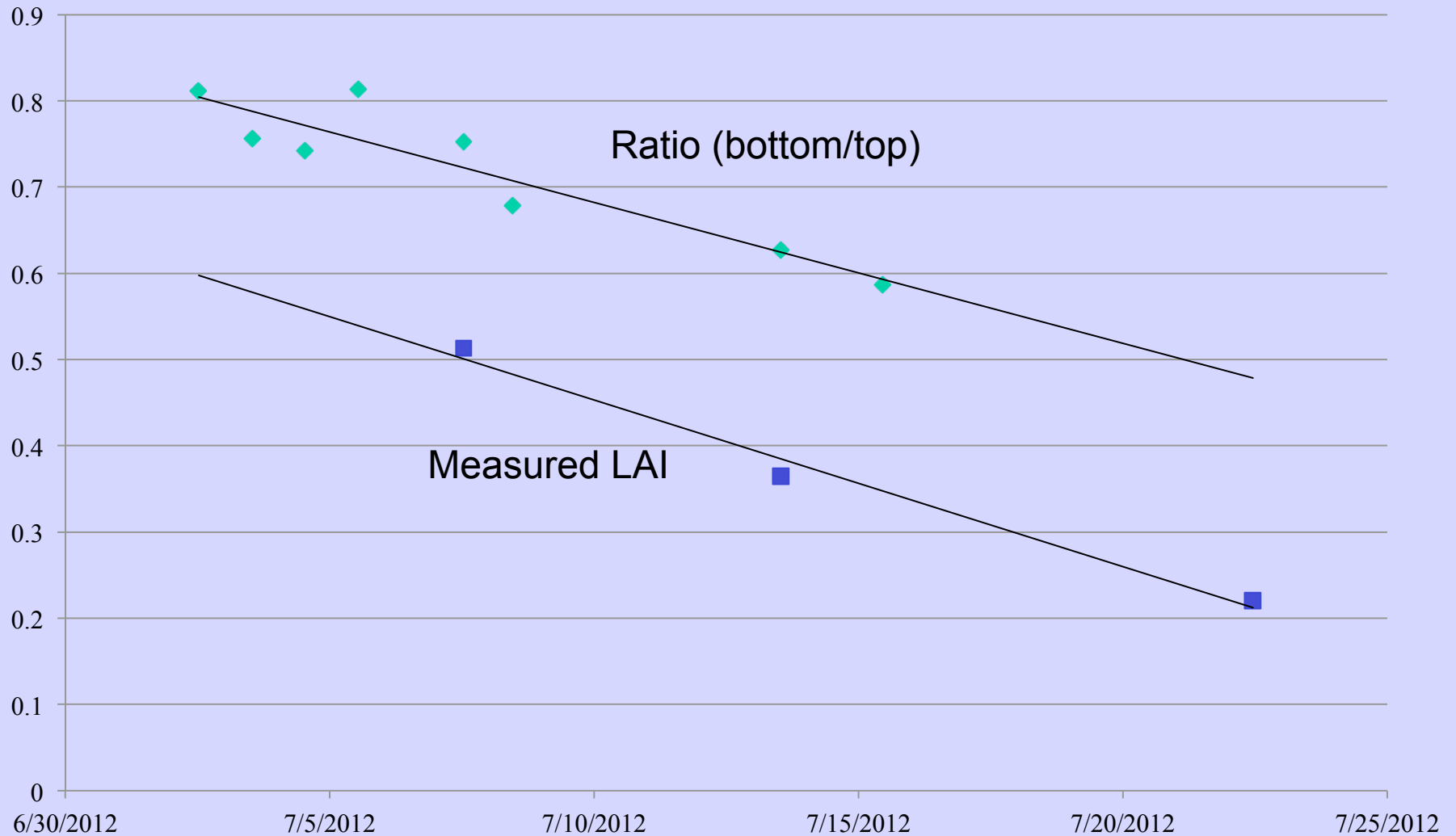
- nfa4324a** @nfa4324a 14時間
Battery 6.2 [V], Board-T 11.2 [deg-C], S-Moist 90811 [Hz], Soil-T 11.2 [deg-C], Top-FD 19, Bottom-FD 0
開<
- nfa4324a** @nfa4324a 15時間
Battery 6.2 [V], Board-T 10.8 [deg-C], S-Moist 90861 [Hz], Soil-T 11.2 [deg-C], Top-FD 0, Bottom-FD 0
開<
- nfa4324a** @nfa4324a 18時間
Battery 6.2 [V], Board-T 10.3 [deg-C], S-Moist 90767 [Hz], Soil-T 11.7 [deg-C], Top-FD 0, Bottom-FD 0
開<
- nfa4324a** @nfa4324a 19時間
Battery 6.2 [V], Board-T 10.3 [deg-C], S-Moist 90826 [Hz], Soil-T 12.2 [deg-C], Top-FD 0, Bottom-FD 0
開<
- nfa4324a** @nfa4324a 21時間
Battery 6.2 [V], Board-T 10.8 [deg-C], S-Moist 90927 [Hz], Soil-T 12.2 [deg-C], Top-FD 0, Bottom-FD 0
開<

Optical Sensing in Open-FS

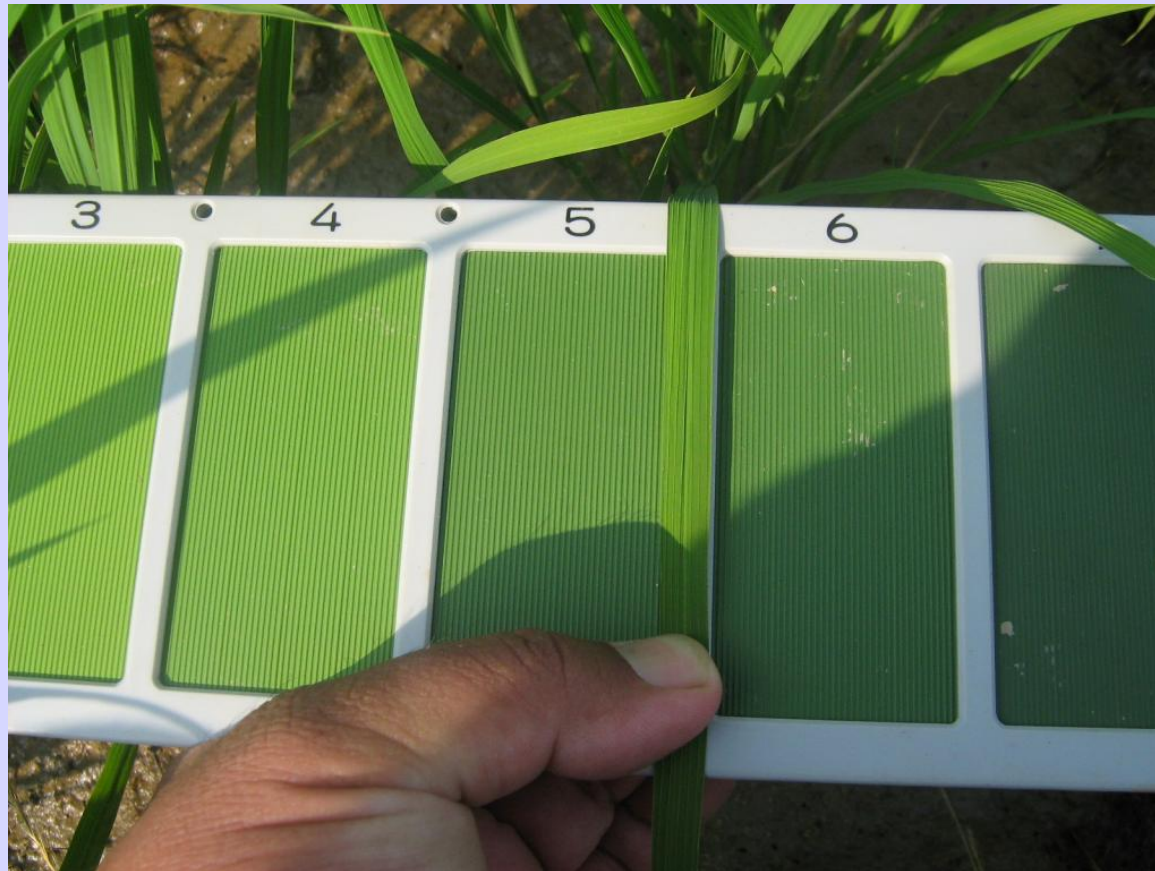
Photo Sensor Using Solar Cell and/or Photodiode



Relationship between The Ratio And Measured LAI

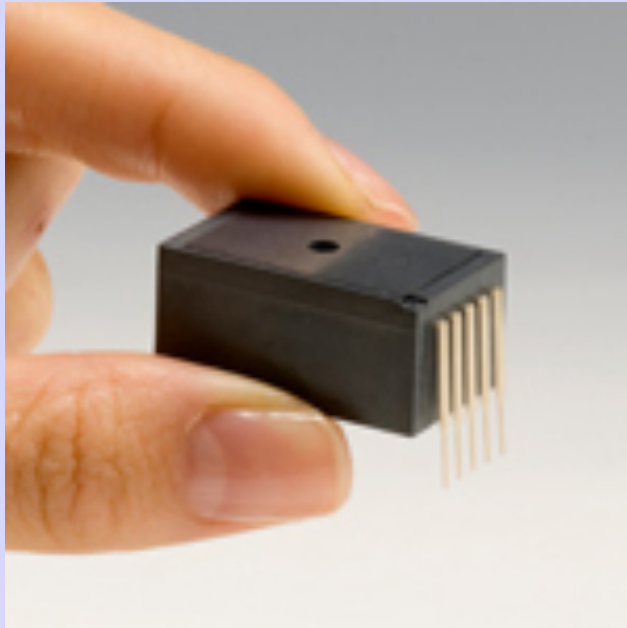


Farmers Estimate Chlorophyll Content Using A Color Scale



<http://blog.jcan.jp/pontaku/19011/>

Ultra-Compact Mini-Spectrometer Integrating MEMS And Image Sensor Technologies



Features

- Thumb size: 27.6 × 16.8 × 13 mm
- Weight: 9 g
- Spectral response range: 640 to 1050 nm
- Spectral resolution: 20 nm

<http://www.hamamatsu.com/eu/en/C11708MA.html>

Testing Mini-Spectrometer & Hyper-Spectrum Camera



MEMS Mini-spectrometer



Hyper-spectrum Camera

NDVI (Normalized Difference Vegetation Index)

$$NDVI = \frac{IR - R}{IR + R}$$

NOAA AVHRR Sensor

R: 620 - 670nm

IR: 725 - 1100nm

Terra MODIS Sensor

R: 620 - 670nm

IR: 841 - 876nm

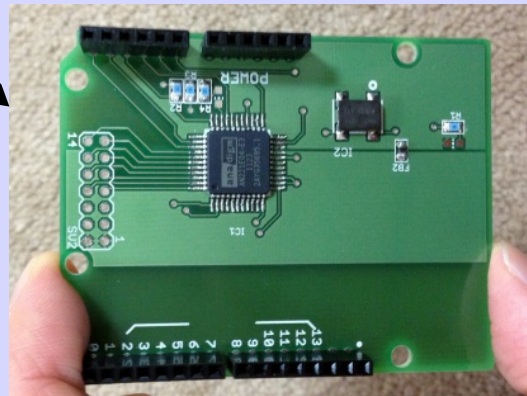
Interface for Multiple Photo Sensors



Infra-Red Photo transistor
(PARA LIGHT ELEC.)



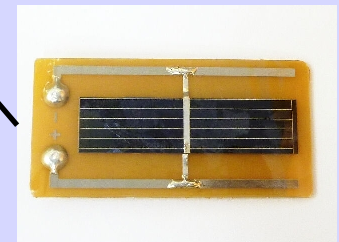
Visible Photo IC Diode
1300 times amplified
(Hamamatsu Photonics)



FPA Shield
(FPA: Field Programmable Analog Array)



Solar cell (0.37W)



Solar cell (0.13W)

Next Trial of Sensing

Ultrasonic Distance Sensor to Measure Water Level, Height of Plants, etc.



HRXL-MaxSonar MB7366



Features

- IF: pulse width, analog, serial (RS232C, TTL)
- Range: 30cm-10m
- Resolution
 - Analog: 10mm
 - Serial: 1mm

http://www.maxbotix.com/documents/HRXL-MaxSonar-WR_Datasheet.pdf

Thank You

This research has been partially carried out in the SCOPE (Strategic Information and Communication Promotion Programme) project (13040100) supported by MIC (Ministry of Internal Affairs and Communications) in Japan. Also this work was supported by JSPS KAKENHI Grant Numbers 24510238, 25660207.