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# Remote Monitoring of Agricultural Robot using Web Application

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Abstract: This paper describes a remote monitoring system of the agricultural robot using Web application. We developed the system in order to make clear condition about robot combine and adequately manage agricultural task data. The system makes the combine data accumulated in database so that it can be seen from remote-situated PC.

*Keywords:* Agriculture, Robots, Remote Monitoring, Applications, Networks, Systems, Web

## 1. INTRODUCTION

In Japan, aging and decreasing of farmer have been grown into a serious problem (Ministry of Agriculture, Forestry and Fisheries of Japan 2011). To deal with these problems, Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) recommends community farming and incorporate farming. The number of these organizations is increasing year by year (Fig. 1).

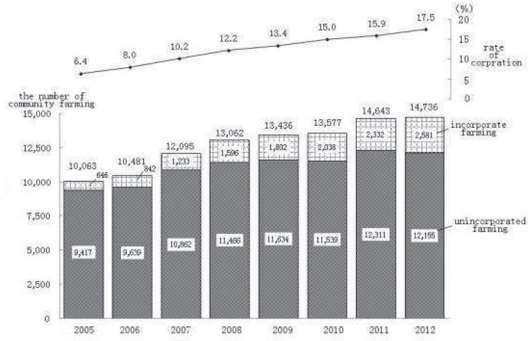


Fig. 1: Transition of the number of community farming (MAFF 2012).

Farmers of these organizations are going to use multiple agricultural robots simultaneously. The managers of the organizations have to understand troubles and task records of agricultural robots in order to manage the robots adequately.

On another front, researches (e.g. Iida et al 2013 and Kurita et al 2011 and 2012) have been developing self-driving agricultural robots to deal with the aging and decreasing of farmer. After these robots become a commonplace, users of these robots need to oversee their robots at their office.

Monitoring or management systems of agricultural robots have been developed by private companies. Hitachi Solutions Ltd. developed the GeoMation Farm to manage agricultural robot in real time (Hitachi Solutions Ltd. 2011). This system associates location data from Geographical Information System (GIS) with agricultural robot's information, motor rotation speed, error information, and other information, and visualizes these to make task more efficient and sensitive. YANMAR Co., Ltd. developed Smart assist (YANMAR Co., Ltd. 2012). This one is machine-to-machine system, and monitors data, location and mode, will be send to database from each agricultural robot in order to keep robots out of trouble or to recover robots quickly.

These systems cost user a lot and farmer cannot adopt these system easily. Hence we developed economical remote monitoring system that monitors agricultural robots and accumulates data of task, and alerts error of robots.

## 2. FRAMEWORK OF THE SYSTEM

We designed the system to be used lightly and anywhere. Therefore we made the system in form of Web application, for its feature that enables the user to access to the data anywhere by using personal computer (PC) or smartphone without special software. Fig.2 shows the framework of the system.

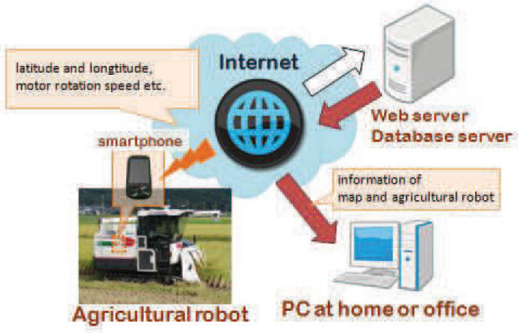


Fig. 2: Framework of the system.

First, PC placed in an agricultural robot gathers robot's condition information, latitude and longitude and motor rotation speed, and other information. PC sends gathered data as a dataset of binary data to smartphone through Bluetooth at intervals of a second. Next, Smartphone checks sum of the dataset and sends the dataset to database server through 3G mobile communication using HTTP PUT in every acceptance. The database server accumulates the dataset accepted in series. Finally, user accesses specified Web page by browser and browses agricultural robot's data.

## 3. Material

### *3.1 Agricultural Robot and Sensor*

We used two types of Robot Combine (VY446 and VY50) as agricultural robots. Both of them was made by Mitsubishi Agricultural Machinery Co., Ltd and equipped with global positioning system (GPS) and GPS compass. About VY446, GPS was AGI-3 (TOPCON CORPORATION) and GPS compass was SSV-102 (Hemisphere Inc.). About VY50 GPS was Legacy-E+ (TOPCON CORPORATION) and GPS compass was V-110 (Hemisphere Inc.). Smartphone sending data to database server from robot combine was IDEOS (Huawei Technologies Co., Ltd.) and its operation system (OS) was Android 2.2.1 (Open Handset Alliance).

### *3.2 Development environment*

PC server's OS was FreeBSD 7.3-STABLE (The FreeBSD Project). Database server was SQLite 3.7.12.1(D. Richard Hipp) and Web server was Apache HTTP Server 2.2.22(The Apache Software Foundation.). We developed CGI by using Python 2.7.3 and made Web page by using HTML and JavaScript. Finally, we used Firefox 17.0.1(Mozilla Foundation) to check the operation of Web page.

## 4. DATA

### *4.1 Sending Data*

VY446 sends 39 item (Table.1) and VY50 sends 16 item (Table.2). We added extra byte, beginning data, check sum, and ending data to each record by a minute.

### *4.2 Framework of Database*

Table3 shows the framework of database. The acc_id table is records of data insertion. The combine_VY446_data and combine_VY50_data are record of VY446 and VY50.

**Table1. Data contents of VY446**

| No | data name | data type |
|---|---|---|
| 1 | beginning data | unsigned char |
| 2 | UTC | unsigned long |
| 3 | latitude | double |
| 4 | longitude | double |
| 5 | altitude | double |
| 6 | azimuth of GPS compass | float |
| 7 | quality of GPS | unsigned char |
| 8 | the number of satellite | unsigned char |
| 9 | AD converted value | unsigned short *4 |
| 10 | AD reaper motor speed | unsigned short |
| 11 | AD reaper potentiometer | unsigned short |
| 12 | switch of reaper | unsigned char |
| 13 | switch of rowed depth | unsigned char |
| 14 | dial of filtering configuration | unsigned short |
| 15 | sensor of airflow | unsigned short |
| 16 | potentiometer of oscillation fin | unsigned short |
| 17 | auto switch of filtering | unsigned char |
| 18 | switch of clutch | unsigned char |
| 19 | potentiometer of auger motor | unsigned short |
| 20 | potentiometer of auger cylinder | unsigned short |
| 21 | switch of auger | unsigned char |
| 22 | sensor of engine rotation | unsigned long |
| 23 | flag of engine | unsigned char |
| 24 | sensor of mission rotation | unsigned long |
| 25 | running distance | unsigned short |
| 26 | flag of mission | unsigned char |
| 27 | error code | unsigned short |
| 28 | 7SEG display code | unsigned short |
| 29 | warning | unsigned char |
| 30 | sensor of rice hull | unsigned char |
| 31 | manipulator command | unsigned short |
| 32 | robot command A0 | unsigned char |
| 33 | robot commandA1 | unsigned char |
| 34 | HST command | unsigned short |
| 35 | patlite command | unsigned char |
| 36 | auger motor command | unsigned short |
| 37 | auger cylinder command | unsigned short |
| 38 | reaper height command | unsigned short |
| 39 | robot command B0 | unsigned char |
| 40 | robot command B1 | unsigned char |
| 41 | check sum | unsigned short |
| 42 | ending data | unsigned char*2 |

**Table 2. Data contents of VY50**

| No | data name | data type |
|---|---|---|
| 1 | beginning data | unsigned char |
| 2 | ASCII | unsigned char |
| 3 | UTC | unsigned long |
| 4 | quality of GPS | unsigned char |
| 5 | the number of satellite | unsigned char |
| 6 | latitude | double |
| 7 | longitude | double |
| 8 | altitude | double |
| 9 | azimuth of GPS compass | double |
| 10 | count data of T/M rotation sensor | float |
| 11 | sensor data of reaper rotation | float |
| 12 | pick up data of engine rotation | float |
| 13 | status 1 of combine control | double |
| 14 | status 2 of combine control | double |
| 15 | potentiometer of preprocessing lift | unsigned char |
| 16 | potentiometer of manipulator lever | unsigned char |
| 17 | data of feed sensor | unsigned short |
| 18 | data of fuel tank | unsigned short |
| 19 | check sum | unsigned short |
| 20 | ending data | unsigned char*2 |

**Table3. Framework of Database**

| table name | table summary | column name | data summary |
|---|---|---|---|
| acc_his | records of data insertion | acc_id | access id |
| | | acc_time | access time |
| | | combine_type | combine type |
| combine_VY446_data | data of VY446 | acc_id | access id in acc_his |
| | | data_id | data id |
| | | each data name | 39 data sent from VY446 |
| combine_VY50_data | data of VY50 | acc_id | access id in acc_his |
| | | data_id | data id |
| | | each data name | 16 data sent from VY50 |

## 5. REMOTE MONITORING APPLICATION

### *5.1 Operation*

User accesses specified Web page, and then the screen displayed select box, "Start data acceptance" button, map, and meter gauges.

When the user selects data time in select box and clicks "start data acceptance" button, the icon like robot combine appears on the map and figure on the screen start to move (Fig.3).

The icon on the map shows the location of the robot combine, and draws its track on the map. Meter gauges show robot combine speed, motor rotation speed, and reaper rotation speed, moreover there are the number of satellite and quality of GPS and filling rate of grain tank around the meter gauges. Under the meter gauges, there is error window which changes color and displays error messages when the problem of robot combine occurs. Furthermore under the error window, there are 4 lumps. When quality of GPS is poor, the first red lump to the left lights up, similarly when the robot combine is robot mode, the yellow lump lights up; when the buzzer of the robot combine screams, the red buzzer lump lights up; when the grain tank of the robot combine overflow, the first red lump to the right lights up (fig.4).

### *5.2 Flowchart of Program*

Fig.5 shows the flowchart of screen-displayed program.

When the user accesses Web page, user's browser requests the data list of acc_time in acc_his table to the database server, then the browser displays select box, button, map, and mater gauges when the browser get the response of the server. Next, when the user selects data time at select box and clicks "Start data acceptance" button, browser sends acc_id of selected data time to Web server. Then Web server identifies combine_type by sent acc_id. If combine_type indicate VY50, Web server sends VY50's data list of selected data time to the browser; similarly if combine_type was identified as VY446, Web server sends VY446's data. The browser gets data list, draws combine icon on the map and moves needle of meter gauges and other contents in chronological order until the end of data list. The browser request data list to the server to check database for remaining data after the browser displayed all data, when there were remaining data in database, the browser displays data list again, when there are no data, the browser finishes drawing.


Fig. 3: Screenshot of clicking "Start data acceptance" button.


Fig. 4: Screenshot of robot combine error.

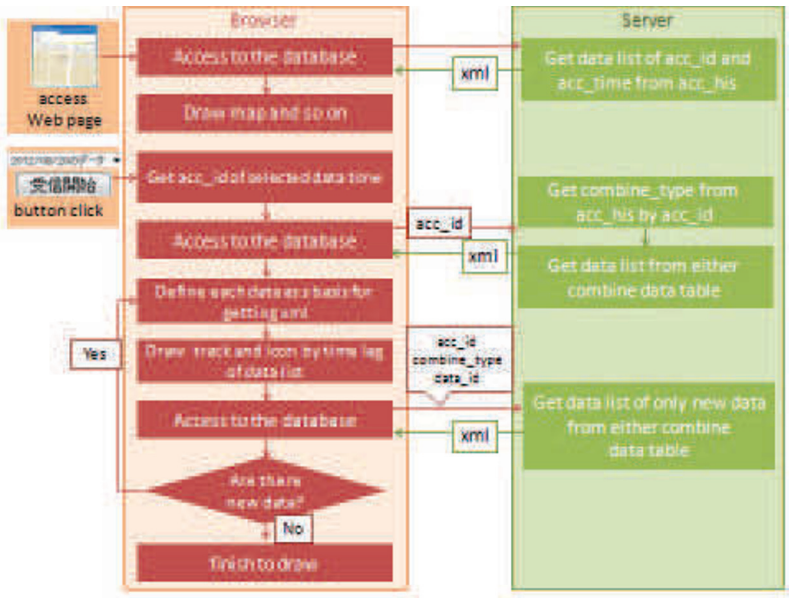


Fig. 5: Flowchart of Program

## 6. EVALUATION

We evaluated viewability and usability the Web page of PC, tablet PC, and smart phone. The PC's OS was Windows7 and its display size was 24 inch, the tablet PC's OS was Windows7 and its display size was 10.1 inch, and the smart phone's OS was Android 4.2 and its display size was 4.2 inch.

### *6.1 PC*

The Web page on PC was most viewable in 3 devices because of its big screen. We checked the Web page on PC to run normally only by firefox. By other browser, the meter gauges on Web page did not work well.

### *6.2 Tablet PC*


Fig.6: screen shot of the Web page on tablet PC

Fig.6 shows screen shot on the Web page on tablet PC. There was no problem to show map and meters on Web page by tablet PC. However, the select box and button was too small to tap.

*6.3 Smart Phone*


Fig7: screen shot of the Web page on smartphone

Fig.7 shows screenshot of the Web page on smartphone. There were many problems of viewability and usability on the Web page on smartphone. The map and meter gauges on Web page were too small to see robot combine data. The marker and combine icon was not show normally because of smallness of the map. Moreover we did not tap button on Web page on horizon smartphone because the button hid behind map.

PC was more optimum device for the system compared with the other devices because of its big display. The Web page on smartphone, which has smallest display, would optimization small display, for instance cutting off map.

## 7. CONCLUSIONS

We developed a remote monitoring system which monitors 2 types of robot combines and accumulated data of task and alerted error of the combines in order that the community farming and the incorporate farming manage multiple agricultural robots. The system preserved robot combine data in database server and made Web page where user accessed robot combine data, and drew trace and other condition data of robot combines.

In the future, we will try to upgrade the Web page to be more viewable and useable Web page on any device and to access the Web page by other than Firefox. Moreover we will try to upgrade the system to display real time condition of robot combine and to increase the amount of content like video picture from robot combine.

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