Exercise on Environmental Monitoring and Control of Green house by IoT Devices toward Smart Agriculture

Yuya Nishida[*1]
Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka 808-0196, Japan

Ryugo Mchizuki[*2]
Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka 808-0196, Japan

Shinsuke Yasukawa[*3]
Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka 808-0196, Japan

Kazuo Ishii[*4]
Kyushu Institute of Technology
2-4 Hibikino, Wakamatsu, Kitakyushu, Fukuoka 808-0196
*E-mail: y-nishida[*1], s-yasukawa[*3], ishii[*4]@brain.kyutech.ac.jp, mochizuki[*2]@lsse.kyutech.ac.jp*
https://www.kyutech.ac.jp

Abstract

As crops in greenhouses are widely distributed, IoT devices placed near the crops should be stand-alone and modular, and data from the devices are collected over the networks. Smart agriculture requires knowledge of a wide range of fields including electricity, information, and image processing. We have designed an AI and IoT technology exercise on environmental monitoring and control of a greenhouse where we have been preparing for grow up of tomatoes and other vegetables.

Keywords: Smart agriculture, green house, mechatronics exercise, MATLAB/Simulink exerciese

1. Introduction

In the future estimation of 2050, the food demand increases 70% and the production decreases 15% caused by global warming, and farmer population be 1/5 of current workers. We need an agricultural system of twice production with the same farmland area and 5 times effective operations until 2050 [1]. For the sustainable society, smart agriculture including robot technology, AI, IoT is one of the solutions for food issues. As crops in greenhouses are widely distributed, IoT devices placed near the crops should be stand-alone and modular, and data from the devices are collected over the networks. Camera is often used for monitoring of growth status of the crops, and only resulted information by image processing should be transmitted [2-3]. Smart agriculture requires knowledge of a wide range of fields including electricity, information, and image processing [4-5].

Authors have designed an AI and IoT technology exercise on environmental monitoring and control of a greenhouse where we have been preparing for grow up of tomatoes and other vegetables. The exercise that was

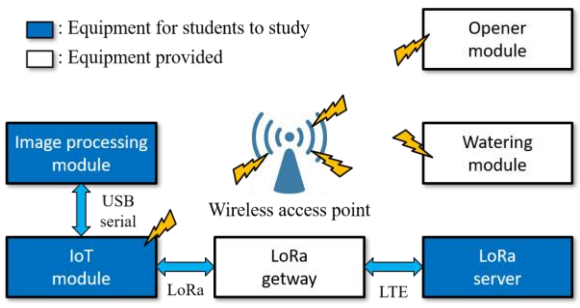


Fig.1 System architecture for acoustic communication

a part of the joint graduate school consists of mechatronics exercise using micro-computer, MATLAB/Simulink exercise for image processing, and system construction exercise for smart agriculture. This paper explains detail of the exercise, and shows system constructed by the students and results of rubric.

2. Exercise outline

2.1. *The exercise in the joint graduate school*

Graduate schools of engineering of Kyushu Institute of Technology, the University of Kitakyushu, and Waseda University established joint graduate school car electronics course supported by strategic university collaboration support project of ministry of education, culture, sports, science and technology in 2008. Then, the graduate schools established intelligent car robotics course based on the car electronics course, with Kyushu Institute of Technology as the representative school. Car electronics and robotics intelligences is taught in the course, supported by program for promoting inter-university collaborative education. To develop highly professional human resources that become a leader in the next generation of intelligent robotics and AI technology, joint graduate school intelligent car robotics & AI that AI sub course for acquiring the basic technology of AI was added has been started since 2019. Authors offered Exercise on Environmental Monitoring and Control of Green house by IoT Devices as comprehensive practicum subjects in the joint graduate school in 2021. The exercise has mechatronics exercise, MATLAB/Simulink exercise and system construction exercise toward smart agriculture, using the system shown in Fig.1. Students learn how to use each module and how to communicate with each module.

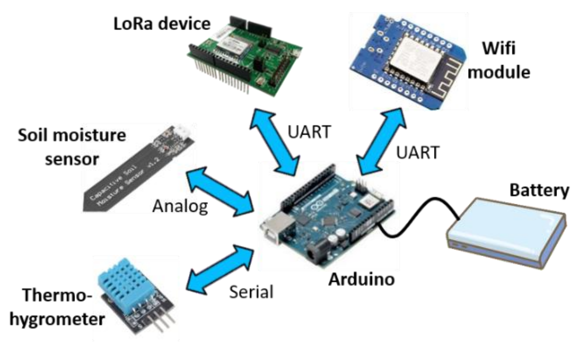


Fig. 2 IoT module using an Arduino

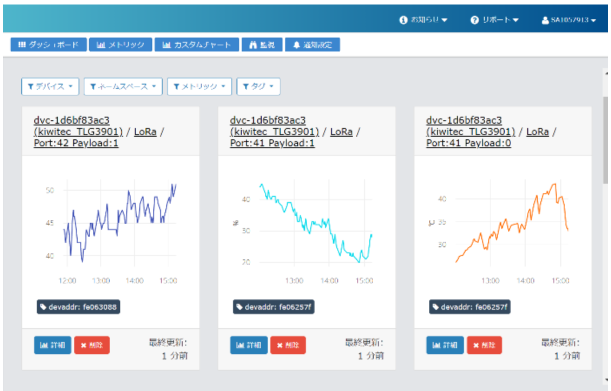


Fig.3 Graphs on the LoRa server

2.2. *Mechatronics exercise*

The mechatronics exercise is separated three sections, and IoT module using an Arduino as shown Fig.2 is used for the exercise. In first section, students make simple peripheral circuits using Arduino and program for that circuits, and learn Arduino functions of digital I/O and A/D conversion. The first section is easy for students who have learned Arduino, but some students are new to Arduino, so they learn about basic electrical circuits and how to use Arduino. DC motor driver using n-channel enhancement type FET and motor drive by PWM signal from Arduino are taught in second section. The driver has a tachometer for measurement angular velocity of the motor, and low pass filter is located between signal pin of the tachometer and A/D pin of Arduino. Students implement PID controller using PWM in the driver with Arduino to learn feedback control for the motor. In third section, LoRaWAN communication that is the part of LPWA (**L**ow **P**ower **W**ide **A**rea) is taught using IIJ

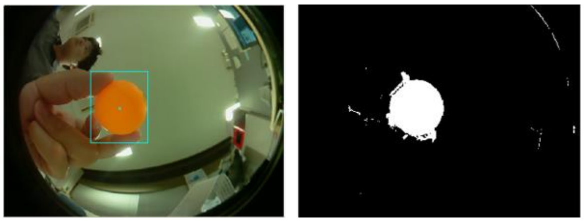
(Internet initiative Japan) LoRa device and LoRa gateway. The device transmits data received from Arduino to the gateway up to 10km away by LoRa of class C that transmits at any time unlike other classes, and the gateway uploads the data by LTE communication to LoRa server. Arduino program for communication to the device and LoRa script on the gateway for data upload are provided by teachers. Students make Arduino program that data measured by soli moisture sensor and thermo-hygrometer are sent to the device, and set the server to display a graph of the data as shown in Fig.3.

2.3. *MATLAB/Simulink exercise*

The MATLAB/Simulink exercise is separated two sections, and image processing is learned by using Raspberry Pi with a dedicated camera. By installing support package for Raspberry Pi on the MATLAB/Simulink, it is possible to develop and debug the program for Raspberry Pi on the MATLAB/Simulink. In first section, basic image processing is taught to learn method required to monitor the condition of crops. Students learn color object detection, noise filter and edge extraction, and implement the ball detection program in Raspberry Pi as shown Fig.4. Image enhancement which is the part of pre-processing method is taught in second section. The appearance of craps in photo-image changes greatly with time and weather because the intensity of sun light depends on its position and the percentage of clouds. Image enhancement is often used before the object detection because simple image processing may not detect the crops in outdoor. Students learn single scale retinex filter how human perceive color and light is modeled in the section. The retinex filter that is high-pass filter removes illumination component from the image as shown in Fig.5. Crop detection becomes robust against sun light by incorporating pre-processing by retinex filter.

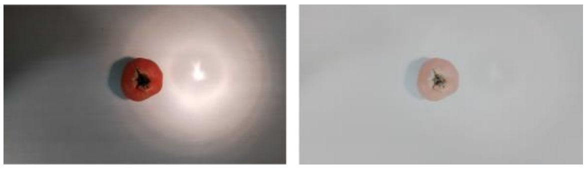
2.4. *System construction exercise*

Students who have finished mechatronics and MATLAB/Simulink exercises are divided into groups to work system construction in system construction exercise. Each group develop IoT system for agriculture by utilizing the technology learned in the exercises and explain its development purpose, concept, functions, performance to teachers and audience. Students can use watering and opener modules shown as Fig.1, and Arduino can control moisture of the ridge by using watering module and house temperature by using opener module. Teachers who hear group's presentation evaluate by usefulness, perfection, operability, quality of presentation and quality of demonstration.



(a) Detection results (b) Binarized image

Fig.4 Orange ball tracking by image processing



(a) Original image (b) Enhanced image

Fig.5 image enhancement using retinex filter

Fig.6 Students who measure soil moisture

3. Results of the exercise

Authors gave the exercise that was taken seven students in the first and second year of the master's program on September 2021. Mechatronics and MATLAB/Simulink exercise were conducted in a hybrid of face-to-face and online by using Zoom. Almost students had no experience using Arduino and MATLAB/Simulink, and making electronic circuits. Because actual equipment is used for the exercise, teachers was difficult to completely support for the students who participated remotely. However, all students have completed all the exercises.

Fig.7 Students who work near outdoor culture

Seven students who have completed the two exercises were divided into team A and team B for the system construction exercise. At this time, the opener module could not be used because it failed. Team A worked on the development of a system used in the green house. Figure 6 shows students who measures soi moisture of ridges in the house. Team A developed soil moisture monitoring system for cucumbers using a camera and sensors. The system can upload the data measured by image processing and soil moisture sensor every few minutes, and users can monitor its data on the LaRa Sever. Team B worked on the development of a system for outdoor culture as shown in Fig.7, and developed the system measures degree of ripeness of green pepper. The system judges the degree of ripeness based on the color information in HSV color model, and transmits its results on the LaRa server. Although the systems of two teams were not perfect, students understood and utilized the techniques that they learn in the exercise to develop the system. Rubric results before and after our exercise as shown in Fig.8 shows that almost students acquired knowledge of micro-computers, image processing and MATLAB/Simulink by our exercise.

4. Conclusions

We have designed an AI and IoT technology exercise on environmental monitoring and control of a greenhouse where we have been preparing for grow up of tomatoes and other vegetables. The exercise consists of mechatronics, MATLAB/Simulink and system construction exercises, technology required for smart agriculture can be learned in the exercise. Almost students who took the exercise acquired technology related to micro-computers, image processing technology and control by MATLAB/Simulink, but a few

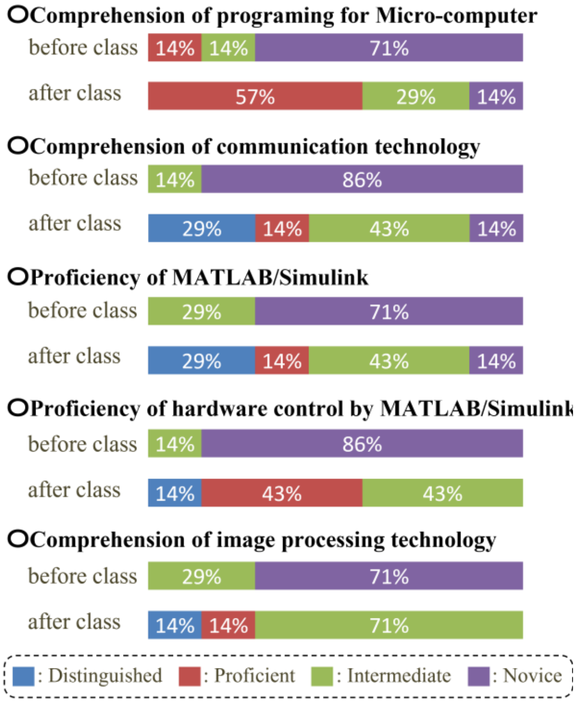


Fig.8 Rubric results before and after our exercise

students couldn't acquire them. In the next school year, authors plan to teach from a little more basic technology.

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Authors Introduction

Dr. Yuya Nishida

He is an Associate Professor at Graduate School of Life Science and System Engineering, Kyushu Institute of Technology, Japan. His research area is about filed robotics, its application, and data processing.

Dr. Ryuugo Mochizuki

He is a researcher at Graduate School of Life Science and System Engineering, Kyushu Institute of Technology, Japan. His research topic during the PhD course was image processing. Currently, he is involved in signal processing of ultrasonic.

Dr. Shinsuke Yasukawa

He is an Associate Professor at Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology. His research interests include information processing in biological systems and their applications in robotics.

Prof. Kazuo Ishii

He is a Professor at Graduate School of Life Science and System Engineering, Kyushu Institute of Technology, Japan. His research area is about field robots and intelligent robot systems