2.5.13 Laboratory : Field Robotics

Member :	Associate Professor	Iida, Michihisa, Dr. Agric. Sci.
	Assistant Professor	Suguri, Masahiko, Dr. Agric. Sci.
	Assistant Professor	Masuda, Ryouhei, M. Agric. Sci.
	Master's Program	7
	Undergraduate	6
	Program-Specific Researcher	1

A. Research Activities (2009.4-2010.3)

A-1. Main Subjects

a) outline

It is afraid that a un-balance of the material cycle due to increase in the food import deteriorates environment in Japan.

This laboratory researches mainly on precision agriculture and field robot based on the thought with “Food should be produce within the country to preserve an environment of the country” and “Agriculture has always adopted the most advanced technology of the age.”

b) Precision agriculture based on the field map and variable rate fertilizer application.

Precision agriculture based on the field map and variable rate fertilizer application.

The Precision agriculture is the information-orientated agriculture that the field is separated virtually into small fields, and fertilizer is implicated based on the soil condition, plant growth and grain yield on those small fields, and copes with stabilization of the yield and the quality of the products and protection of the environment.

In order to decide the amount of fertilizer, the nutriment in the soil and the amount of growth must be measured. This laboratory in cooperation with Laboratories of Plant Production Systems and Irrigation, Drainage Hydrological Environmental Engieering starts research on precision agriculture in 2007. In 2008, the field tests were conducted in Yagi.

c) Estimation of nitrogen contents of rice plant using remote sensing.

The ideal amount of topdressing fertilizer is the amount possess subtracts from the necessity. Plant growth sensor is required to estimate the nitrogen possessed by the plant. In 2008, both basal- and top-dressing of methane digested sludge or chemical fertilizer were applied at the prescribed rate in five paddy fields of Yagi town, Nantan city, Kyoto, Japan. After that, the

airborne images were taken using hyper-spectral and multi-spectral meter in order to estimate the plant growth.

d) Estimation of nitrogen contents and proper time of harvesting for tea plant using remote sensing.

Tea cultivation requires enormous amounts of nitrogen fertilizer. Therefore, it is important to analyze the relationship between the amount of applied nitrogen and the quality of tea The quality of the tea and the optimum time of plunking were estimated using the portable plant growth measuring device and hyper-spectral camera.

e) Grain yield mapping by using a head-feeding combine with a grain yield monitor.

A head-feeding combine equipped with a grain yield monitor has been developed by collaboration with Mitsubishi Agricultural Machinery Co., Ltd. We measured grain yields in several paddy fields in Natan city, Kyoto, and then grain yield maps were made by processing the measured data. They showed the spatial valiability of grain yield in the field, depending on the applied amount of fertilizer and the application methods.

f) Development of robot combine harvester.

In order to automatically harvest grains such as rice and wheat by unmanned combine, a machine vision system using a monochrome CCD camera to detect crop rows was developed. In addition, a machine vision system using a color camera to detect a container for unloading grain was developed.

g) Small-radius turning behavior of the articulated vehicle by direct yaw-moment control.

Articulated vehicle like a wheel load takes advantages of the turning with a small radius and the almost same rut of the front and rear tires. The wheel loader is often used for working in narrow livestock barn in agriculture. It is important to improve the turning performance of the vehicle for working in the narrow workspace. It is so effective to enlarge the articulated angle of the vehicle for steering. However, the articulated angle is limited due to the construction and stability of the vehicle. Therefore, the final goal of this research is to achieve the small radius turn of the articulated vehicle by applying direct yaw-moment control by the braking control. In 2009, an active braking control system for direct yaw-moment control was developed and applied to the test vehicle with Caterpiller Japan Co., Ltd.. Experiments were conducted to measure the turning behavior such as side-slip angle and turning radius.

h) Variable rate application of soybean and wheat seeding in crop rotation fields.

This study was conducted in crop rotation fields, Ohnishi distinct, Sakurai, Nara, Japan, with the Laboratory of Plant Production systems. In June, soybean was seeded by a drill seeder. Interrow space and depth were changed. In November, wheat and fertilizer were applied by a drill seeder. Application rates of seeds were changed, depending on the location.

i) Reseach about mechanical properties and geometric characteristics of parenchyma.

It seems that geometric characteristics of root crop parenchyma cells, e.g. shape of the cells and distribution of the cells, influence upon mechanical properties of parenchyma. To clarify relation between mechanical properties and geometrical properties of parenchyma, it is needed to give a proper description to the geometrical properties of parenchyma cells. We have given consideration to the description of geometrical properties of calotte parenchyma by using images taken with the confocal laser microscope. Gabor filter were used to construct the description of geometrical properties.

j) Outdoor environment recognition by image processing

As a basic technology for the autonomous robot application to agricultural sector, the outdoor environment recognition technique is researched by the image processing.

The feature in the direction of the leaves of rice is detected in a rice field before heading with the Gabor filter, and rice plant and the levee road where weed grows thick are distinguished. Moreover, the pattern of ear was detected in the rice field after heading by using the higher moment, and the plant and road are distinguished as well as ahead. On the other hand, in the outdoor environment where trees exist irregularly, as coppices and orchards, a method of tree identification by using the Bayesian inference is researched.

A-2.Publications and presentations

a) Publications

Original Papers

- Iida, M., 2009: Variable rate control of equipment for wheat sowing and fertilizing applications, Journal of the JSAM, 71(4), 90-96.

- Iida, M., M.Fukuta, H.Tomiyama, 2009: Measurement and analysis of side slip angle of articulated vehicle, Engineering in Agriculture, Environment and Food (EAEF), 3(1), 1-6.

- Kondo, N., K.Yata, M. Iida, T.Shiigi, M.Monta, M.Kurita, H.Omori, 2010: Development of an End-Effector for a Tomato Cluster Harvesting Robot, Engineering in Agriculture, Environment and Food (EAEF), 3(1), 20-24.

- Ryu, C.S., M.Suguri, M.Iida, M.Umeda, 2010: Investigation into Possibility of Methane Fermentation Digested Sludgeas Liquid Fertilizer for Paddy Field, Engineering in Agriculture, Environment and Food (EAEF), 3(1), 32-37.

- Inamura, T., A.Yashikawa, S.Ikenaga, M.Iida,2010: Path analysis of tiller density of winter wheat, Plant Production Science, 13(1), 85-96.

- Ohdoi, K., R.Mori, M.Iida, C.S.Ryu, 2010: Optimization of the schedule for transport and application of wastewater from anaerobic digester as liquid fertilizer －Measurement and modeling of working hours at field－, Journal of Resource Recycling Section of JSIDRE, 5, 57-76.
- Ryu, C.S., M.Suguri, M.Iida, K.Ohdoi, M.Umeda, 2010: Application of methane fermentation digested sludge to large scale paddy as fertilizer, Journal of Resource Recycling Section of JSIDRE, 5, 77-93.
- Iida, M., K.Nonami, S.Tanaka, I.Nanba., 2010: Flow Control of Methane Fermentation Digested Sludge Applicator, Engineering in Agriculture, Environment and Food (EAEF), 3(2), 54-60.
- Ryu, C.S., C.K.Lee, M.Umeda, S.K.Lee., 2009: Analysis for influence of methane fermentation digested sludge as fertilizer for rice paddy, Journal of Biosystems Engineering, 34(4), 269-277
- Ryu, C.S., M.Suguri, M.Umeda,2009: Nitrogen contents prediction model for rice at panicle initiation stage using airborne hyperspectral remote sensing, Biosystems Engineering, 104, 465-475
- Ryu, C.S., M.Suguri, M.Umeda, 2010: Estimation of the quantity and quality ofgreentea using hyperspectral sensing, Journal of the JSAM, 72(1), 46-53.

Reports

- Iida, M., T.Kawabe., M.Umeda , 2009: Automatic positioning control of combine's unloading auger －Detection of imitated container by image processing－, Reports of Kansai Branch of JSAM, 106, 8.
- Iida, M., M.Fukuta, H.Tomiyama, M.Umeda, 2009: Turning behavior of an articulated vehicle ― Identification of cornering power ―, Reports of Kansai Branch of JSAM , 106, 9.
- Masuda, R., A..Ishikawa, M.Umeda, 2009：Returning behavior of autonomous robot in unknownenvironment, Reports of Kansai Branch of JSAM, 106, 10.
- Onoyama, H., C.S.Ryu , M.Suguri , M.Umeda, 2009: Estimation of rice growth and taste by hyperspectral sensing, Reports of Kansai Branch of JSAM, 106, 29.
- Masuda, R., H.Kiku , M.Umeda , 2009：Decision making method by population dynamics, Reports of Kansai Branch of JSAM, 106, 30.
- Tomita, S., M.Umeda, K..Yamazaki, 2009：Consideration for precision agriculture spread in Japan, Reports of Kansai Branch of JSAM, 106, 31.

- Sasaki, R., C.S.Ryu ,M. Suguri , 2010: Estimation of the green tea quality by the hyperspectral sensing, Reports of Kansai Branch of JSAM, 107, 22-25.

- Iida, M., H.Tomiyama , T.Oh , H.Nakashima, T. Nakamura , 2010: Measurement of turning behavior of an articulated vehicle applied a direct yaw-moment control (Part 1), Reports of Kansai Branch of JSAM, 107, 28-31.

- Kurita, H., R.Masuda , M.Umeda , 2010: A geometrical analysis of cell walls for root crop parenchyma tissues, Reports of Kansai Branch of JSAM, 107, 52-55.

- Onoyama, H., C.S.Ryu , M.Suguri , 2009: Estimation of rice growth and taste by hyperspectral sensing, Reports of Kansai Branch of JSAM, 107, 78-81.

- Iida, M., H.Tomiyama , T.Oh , H.Nakashima , T.Nakamura., 2009: Small Turning Behaviour of an Articulated Vehicle by Braking Control, Proceedings of Bio-Robotics IV, (The 4th IFAC International Workshop on Bio-Robotics, Information Technology and Intelligent Control for Bioproductuion Systems), CD-R, Illinois, U.S.A.

- Soneda, T., M.Iida , 2009: Navigation of a Crawler Type Vehicle by Q-Learning and Recurrent Neural Network, Proceedings of Bio-Robotics IV, (The 4th IFAC International Workshop on Bio-Robotics, Information Technology and Intelligent Control for Bioproductuion Systems), CD-R, Illinois, U.S.A.

- Masuda, R., H.Kurita , M.Umeda , 2009: Description of geometrical properties for root crop parenchyma cells, Proceedings of XXXIII CIOSTA CIGR V conference, Volume 3, Reggio Calabria, Italy, pp2071-2075

- Watanabe,S., K.Nakamura, C.S.Ryu, M.Umeda, S.Kawashima: Relationships between Fermentation Manure Liquid Nitrogen in Paddy Soil and Growth of Rice, Annual Meeting of the Japanese Society of Irrigation, Drainage and Rural Engineering in 2009, pp.818-819, 2009

- Nakamura,K., T.Hama, S.Watanabe, H.Higashioka, C.S.Ryu: Measurements of Solute Transport in Paddy Fields and Responses to Climate Change, Annual Meeting of the Japanese Society of Irrigation, Drainage and Rural Engineering in 2009, pp.90-91, 2009

Patents

- Norikazu Tohyama, Michihisa Iida, Hiroshi Nakashima, 2009-204791(Patent application): Small-radius turning cotrol equipment for articulated vehicle

b) Conference and seminar papers presented

- Bio-Robotics IV, Champaign, Illinois, U.S.A., September, 2009: 2 presentations

- XXXIII CIOSTA CIGR V conference, Reggio Calabria, Italy, June, 2009: 1

presentation

- 122th Regular Meeting of Kansai Branch of JSAM: 7 presentations
- 123st Regular Meeting of Kansai Branch of JSAM: 5 presentations

A-3.Off-campus activities

Membership in academic societies

- Iida.Michihisa, D.Agric.Sci : JSAM (Councilor), AABEA(Associate editor), JSME(Member of Special Issue Editor Board), Robotic Society of Japan, Japanese Society of Agricultural Informatics, The IFAC International Conference "Agricontrol 2010" (Chiair of National Organizing Committee)
- Suguri.Masahiko,D.Agric.Sci : JSAM, The IFAC International Conference "Agricontrol 2010" (Member of National Organizing Committee)
- Masuda.Ryohei,M.Agric.Sci : JSAM, The IFAC International Conference "Agricontrol 2010" (Member of National Organizing Committee)

Research grants

1. Grants-in-aid for Scientific Research(KAKENHI)

- Scientific Research (B)(2) : Michihisa Iida(collaborator), Masahiko Suguri(collaborator) : "Development of crop management in consideration of soil, crop growth and grain yield variation."
- Scientific Research (B)(2) : Michihisa Iida(collaborator) : "Mobile grading robot for citrus production and control of observation"
- Grant-in-Aid for JSPS Postdoctoral Fellows : Michihisa Iida (Host Researcher) : Development of application technology of methane fermentation sludge for biomass circulation

2.Other Research Grants

- Co-operation Research Project：Michihisa Iida, (collaborator; Masahiko Suguri, Ryouhei Masuda)："Investigation of rice grain yield and taste in Yagi (Subsidy Project for Creation of Biomass Circle)"
- Co-operation Research Project：Masahiko Suguri(collaborator)："Optimaization of transportation of methane digested sludge by mathematical programming"
- Industry-University Co-operation Research Project：Michihisa Iida："Turning control for articulated steered vehicle" Caterpillar Japan Co., Ltd.

A-4.International cooperation and overseas activities

Membership in academic societies

- Michihisa Iida: American Society of Agricultural and Biological engineering (ASABE)

Visiting Research Scholars

- Program-Specific Researcher 1（Korea）

B.Educational Activities(2009.4-2010.3)

B-1.On-campus teaching

a) Courses given

- Undergraduate level: Field Robotics (Iida), Practice in Computer Aided Design (Masuda), Vibration (Iida), Automatic Control (Iida), Applied Mathematics (Iida and others), Laboratory Course in Agricultural Machinery I (Iida, Suguri, Masuda and others), Laboratory Course in Agricultural Machinery II (Iida, Suguri, Masuda and others), Practice in Data Processing II (Iida, Masuda and others), Seminar in Agricultural Machinery (Iida, Suguri, Masuda and others), Seminar in Agricultural and Environmental Engineering (Iida, Suguri, Masuda and others), Experiments in Physics (Masuda and others)
- Graduate level: Advanced Seminar in Field Robotics I (Iida), Advanced Seminar in Field Robotics II (Iida, Suguri and Masuda), Laboratory Course of Field Robotics (Iida, Suguri and Masuda), Field Robotics (Advanced cource) (Umeda) , Field Automation (Iida)

B-3.Overseas teaching

International students

- International students : Undergraduate 1 (China) Master 1 (China)