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学 位 論 文 要 旨
Dissertation Abstract

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学位論文題目：
Title of Dissertation　Development of a Multi-operation System for an Intelligent Greenhouse
(太陽光植物工場におけるマルチオペレーションシステムの開発)

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The global agriculture sector is facing problems such as food crisis, rapidly increasing world population, deterioration of productive agricultural land, declining work force etc. In the current situation, greenhouses can be a solution to provide considerably significant output despite limited resources. Therefore, applying automation to greenhouse technology can play a vital role in mitigating the above-mentioned issues, although the application of automation technology in agriculture is comparatively slower than in the industrial sector. Due to seasonal nature of agriculture and limited capability of developed prototypes, there are very few multi-operation agricultural robots available to work in greenhouse conditions. More flexible robots capable of performing (almost) all the operations needed in the complete cultivation cycle of a single crop or different operations for different crops are essential for considerably reducing operational, production, or harvesting costs. In considering the above issues, we are developing a multi-operation system inclusive of travelling unit, artificial pollination unit, pest monitoring unit, harvesting unit, and potentially other units.

In a greenhouse being well structured it can significantly helps in using robotic systems inside greenhouses, especially guidance systems. We have developed an auto-guided travelling unit named AGTU-scanner, as a base for a multi-operation system. A SZ-04M laser scanner, absolute encoders and PLC are used for autonomous navigation control. AGTU-scanner can host different agricultural units, making it economical and adaptable. Different experiments were carried out to check the performance of the control system to accurately guide the AGTU-scanner in greenhouse. The results confirm that the AGTU-scanner can safely navigate along transversal corridor and can accurately enter the corridors.

Due to increasing food crisis and rapidly declining in population of pollinators

the need of developing an artificial pollination unit as one of the unit of multi-operation system was felt. Pollination of tomato is studied by - a) bumblebee, b) vibration with an artificial pollination unit, c) hormone (4-CPA), and d) control treatment. The results obtained from this study shows that all treatments were effective in increasing fruit set, although hormone treatment produced the best results. Bumblebee and pollination unit's performance was found almost similar. Shape factor analysis showed best results for bumblebee treatment and lowest for hormone treatment.

Integrated pest management is vital to produce high quality food without disturbing environmental balance. We have developed a pest monitoring system as one of the unit of multi-operation system to have optimal control in accordance with the pest occurrence. Yellow insect trapping sheets were image analyzed to obtain timely pest occurrence data at multiple points and compared it with manual counting. The standard deviation of the difference between the correct answer data and image count result of the pest population was found to be 9.26. Though the result is less accurate it can be considered to be effective to show a relative trend of pest occurrence in greenhouse. It helps to do early detection of pest occurrence. Further by mapping pest occurrence it was found that entrance was source for entry of the pest inside greenhouse and preventive measures can be taken.

Cucumber is one of the most popular vegetable cultivated in Japan. Its harvesting is time consuming and laborious. Moreover its faster growth rate demands harvesting at proper time. Therefore, automation of cucumber harvesting operation is essential. Thus, an autonomous robot for harvesting cucumbers grown in greenhouse with inclined trellis training system was developed as one of the unit of multi-operation system. The novel concept of cucumber harvesting using distance information obtained from ultrasonic and laser sensors to harvest cucumbers of length more than 180 mm is introduced. Three fruit recognition algorithms were designed and tested with an aim to improve fruit detection, gripping and harvesting efficiency in laboratory conditions with model fruits of different lengths. Third algorithm showed improved results over first and second algorithm with detecting 97.5% of fruits, 72.5% gripping position determination and 97.5% harvesting success rate. In order to perform harvesting operation in the green house, travelling unit and harvesting unit were linked. Laboratory testing confirmed the feasibility of the cucumber harvesting by using distance information concept. Further field study is desirable to test the feasibility of cucumber harvesting unit.