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学 位 論 文 要 旨
Dissertation Abstract

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学位論文題目： Environmental Condition Assessment of Tomato Production Systems based on Speaking Plant Approach for Supporting Intelligent Control Systems
Title of Dissertation

(知的制御システムを支援するためのスピーキング・プラント・アプローチに基づくトマト生産システムの環境条件評価)

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Environmental control of plant production systems affects crop productivity and quality. The efficiency of plant production in plant factories or greenhouses significantly depends on adjusting several components, particularly the internal temperature, relative humidity, carbon dioxide (CO_2) concentration, and water management. Optimization of these components can lead to better cultivation systems.

A concept that controls and manages the optimal environment for cultivation on the basis of the diagnosis of the growth status of a plant is known as the “speaking plant approach”. The concept of Speaking Plant Approach (*SPA*) was proposed and *SPA* based intelligent control technique consisting of a decision system and feedback control system was applied to the optimizations of tomato cultivation. The decision system consists of artificial neural networks (*ANN*), which is used for supporting the development of machine vision through the flower recognition. From the study, it is known that the shape of tomato fruits was affected by the flower shape. Fruit shape is one of the important quality parameters in market, and the uniform fruit-shaped is becoming our goal in the cultivation. In this study, the flower shape analysis was used as the computer vision technique for developing flower recognition program.

We also have studied the implementation of computational intelligent techniques, in particular multilayer neural networks for modeling and predicting weekly fluctuations of harvest rate and fruit size of tomatoes. This estimation based on meteorological data and crop growth parameters collected during one full growing season in between 2011−2012. The performance of neural networks models were good enough in estimating of harvest rate and fruit size of tomatoes grown inside greenhouse, having correlation coefficient of 0.77 and 0.85, respectively.

Another studies related to the required amount of water by crop was done due to its necessity in giving the proper irrigation and preventing the excess irrigation, by it means minimize chemical usage and improve on-farm water use efficiency. Crop water use is related to evapotranspiration (*ET*). Accurate determination of *ET* is essential to precisely compute crop water use and to assist growers for applying good irrigation management. An estimation based on a mathematical model to predict hourly evapotranspiration (*ET*) rates that occur inside a plant factory system was made using the Stanghellini model. The Stanghellini model is considered more appropriate for estimating the rate of *ET* inside the soilless culture of greenhouse tomatoes. The model requires some climatic data (e.g., solar radiation, air temperature, relative humidity, and wind speed) and plant growth parameters (leaf area index) as inputs. The *ET* rate of tomato (*Lycopersicon esculentum* Mill.) crop was measured using a weighing method. The results showed that solar radiation and vapor pressure deficit are important factors driving the *ET* rate. The model’s output showed good results for determining the *ET* rate and depicted crop water requirements on an hourly basis.

The overall idea of the dissertation is to provide some information about the implementation of artificial intelligent techniques in order to give an overview in the development of intelligent control system, which can be applied on plant cultivation.

Keywords: Artificial neural networks, evapotranspiration, flower recognition, plant factory, Stanghellini model, yield prediction.