Chapter 13
Temperature Modeling of a Greenhouse Environment

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ABSTRACT

This chapter presents the methodology to model the temperature inside a zenith greenhouse, without crop, using a Wireless Sensor Network (WSN) and the Recursive Least Square (RLS) Technique to estimate the modeling parameters. The greenhouse size is 6mx18m, the actuators are the motors located at the windows. The WSN collects the measurements and communicates the centralized control and the actuators located in different parts of the greenhouse, it is implemented using National Instruments devices, the graphical interface is developed in LabVIEW system design. There exist a lot of work about greenhouses in the literature; however, most of them did not use mathematical techniques to model the temperature or other environment parameter. Surprisingly, just few works use RLS techniques to estimate the parameters. The main contribution of this project is to integrate the National Instruments technology and the RLS techniques in a real experimental application.

INTRODUCTION

Several reasons motivate the continuous interest and development in protected agriculture around the world, one of them is the impact of climate change, which affects the open-field agricultural activities, as well as the dynamics and competitiveness of marketing systems (Moreno et al, 2011). For several countries, the adoption of new technologies has allowed to increase production and availability of vegetables for population, at affordable prices during different year seasons, which is possible by means of controlling environmental requirements of the crops.

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The common parameters to fulfill the ideal growth of the crop are temperature, relative humidity, soil moisture, ventilation, light and solar radiation, carbon dioxide, oxygen and fertigation, amongst others. It is possible to control them effectively in a greenhouse; however, a mathematical model is required to implement most of the control techniques (Leal et al, 2006).

The modeling and control of weather parameters inside a greenhouse has been studied in different parts of the world, such as: Almería, España (Díaz, 2002), Mexico (Leal et al, 2006), Israel (Seginer et al., 1993) and Japan (Morimoto & Hashimoto, 2000). An emphasis must be done in the studies of the Wageningen's University (Udink Ten Cate 1983, Tap, 2000), since Holland is the principal producer of Central Europe.

This topic has been studied since the 60's with the work of (Businger, 1963), where it was suggested to use methods of energy balance to model the greenhouses behavior, however the existing models were useful in stable conditions of the climate, after that (Takakura et al, 1971) started to studied the subject using Fourier series. The work of (Udink Ten Cate, 1983) was one of the first to include a mathematical model considering the temperature inside the greenhouse, and it was improve by (Tchamitchian et al, 1992) considering the temperature changes in the greenhouse pipes.

There exist several literature about mathematical models for greenhouses based on different techniques, such as: (Gupta & Chandra, 2002, Lafont & Balmat, 2002, Ghosal & Tiwari, 2004, Luo et al, 2005, Salgado & Cunha, 2005, Abdel-Ghany & Kozai, 2006, Singh et al, 2006, Álvarez-Sánchez et al, 2014). Some works, like (Tap, 2000), consider several parameters to model the greenhouse conditions and have been the basis for other researches. Unfortunately, these models are generally obtained in an empirical form, and considering only one kind of greenhouse.

Moreover, several works in the last decade consider the automation of greenhouses, they are called intelligent, and they use neuronal networking, fuzzy control or similar techniques (see for instance, Laribi et al, 2006, Salazar et al, 2007, Ferreira & Ruano, 2008, Mohammad et al, 2010, Pengzhan & Baifen, 2010, Ma et al, 2010, Eredics & Dobrowiecki, 2011, Eredics et al, 2011). However, artificial networking has the inconvenient that the internal variables did not have necessarily a physical interpretation (Ferreira & Ruano, 2008).

Most of the automated greenhouses use wireless technologies, like the zigbee protocol (see Qiu et al, 2014 and references included), or mainly the Wi-Fi protocol (Lakshmi et al, 2007, Kang et al, 2008, Pawlowski et al, 2008, Ahonen et al, 2008, Chuanan & Yongchang, 2010, Fezari et al, 2011, Xiaoyan et al, 2013, Mad et al, 2014). Wired protocols are implemented in minor quantity, though they can be observed in works as (Du et al, 2013, and Yulong and Jiaqiang, 2011) which uses the CAN-bus protocol and the RS485 bus, respectively.

Furthermore, there are just few works with remote monitoring system that use the National Instruments® technology, or LabVIEW™ as system design software (see for example, Guofang et al, 2010; Fang & Wang, 2011, and references therein). This work integrate the National Instruments® technology and the Recursive Least Square (RLS) techniques in a real experimental application.

The proposal of this chapter is to:

1. Estimate the parameters of the interior temperature of a classic zenithal greenhouse with natural ventilation to know his behavior without crop, using the RLS method.
2. Integrate the Wireless Sensor Network (WSN) devices of National Instruments®, like the NI WSN-3202 analog input node and the NI WSN-9791 ethernet gateway, to collect the measurements and the graphical interface to manipulate them, which was developed in LabVIEW™ system design.