Greenhouse watching system using multi-technologies

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Abstract

Traditional agriculture uses empiric methods and is very exposed to meteorological conditions. To increase the agriculture production, greenhouses had appeared to allow crops with higher quality. Greenhouses also permit the study of cause-effect concepts that by them allow building models that improve the crop's production and quality.

Based on this reality, this paper presents a system developed by researchers of two schools of the Instituto Politécnico of Castelo Branco(IPCB) to monitor a greenhouse located in the campus of Escola Superior Agrária (ESA). This proposed system uses several different technologies.

1. Introduction

The development and growth of plants is conditioned by several environmental variables. These variables exercise its influence according to standards in which sometimes the plants answer is the best in a limited range of those variables. However, in natural conditions the physical variables which affect the plants growth and development, present a higher variability than the optimal range points required by the plants [1].

The greenhouses are then a mean to surpass the conditions imposed by the environmental factors in natural conditions, so that variables such is the case of light, temperature, CO2 concentration and air humidity take values within de optimal range values for each crop [2][3][4].

These aspects have additional importance if we take in consideration that:

a) The markets aim to guarantee the traditional products supplying during extended periods of time, many of them out of the natural production seasons;

b) There are a higher number of products advertised in areas in which they don't exist naturally or in areas where the environmental conditions are significantly different from the product origin region.

Although the traditional greenhouse has a higher plants protection level, but generally our capability to control the environment factors is limited in those greenhouses. With that in mind, surveillance and control systems were developed to approach the values of these environment factors to the optimal range for each crop; allowing us to profit from the productions capabilities of those crops and overcoming the limitations imposed by the environmental factors. So, many research efforts are being done to improve the production in controlled greenhouses [4][5][6][7].

Comparing the production in open field against production using greenhouses, due to the dimension, the last ones allow better results. Some of the greenhouses advantages are [4]: Ability to produce crops out of season; improve crops quality; increase crops precocity; allow better disease control of the plants; Increase productivity; better safety work conditions; Protection against adverse climate factors.

Greenhouses allow the construction of models dedicated to a specific crop [8]. There are several equipments and/or models that can be used to achieve the desired goals, like: sensors, actuators and A/D systems (using microcontrollers or computer systems) allowing real time control [9].

These control systems are important when optimal values of the monitored variables (temperature, CO_2, humidity, solar radiation, etc.) are needed to improve the production.

After this brief introduction about the importance of the monitoring and control of greenhouses, we will describe the problem that was in the origin of the system described in this paper and focus on it's implementation.

Greenhouse

Fig. 1. Greenhouse exterior

The greenhouse that we want to monitor is located in the ESA campus, figure 1. It is a tunnel greenhouse with controlled environment with 15.3 m length and 8.5 m width ((total area of about 130 m^2), [9][10].

This greenhouse is mainly used for:

1. Ornamental and forestal plants production through vegetative multiplication;
2. Experiment and research in the areas of vegetal improvement and plants multiplication;
3. Pedagogical support to several disciplines lectured in the scope of ESA courses.

The greenhouse control system has:

1. A cooling system based on two porous pads installed on the topside of the greenhouse, which are maintained wet. On the opposite side, are installed two exhaust fans. The air admitted through the pad becomes cooler by evaporation effect [9][11];
2. Solar radiation control using shadow nets, automatically controlled. The shadow nets are used to create an artificial shadow, this decreases the solar radiation energy that enters the greenhouse in the hot summer [9];
3. Irrigation system and humidity control based on micro diffusers (fog system) controlled by sensors suspended over the benches placed inside the greenhouse [9];
4. Bench temperature control system is based on a set of electrical resistances. This maintains the soil and plants at suitable temperatures allowing a proper development of the crops.

Figure 2 shows the interior of the ESA greenhouse.

Fig. 2. Greenhouse interior

Goals

The main goals to the system are:

i) Monitor some physical variables (temperature and humidity) and the hydrodynamic status of the reservoir that feeds the *cooling* system;

ii) Inform the agricultural engineer responsible for the greenhouse maintenance of the monitored conditions through different communication means.

In the next sections of the paper we will describe the system architecture and components that allows this desired goals.

2. Proposed approach

The proposed system uses dedicated hardware to allow the acquisition of data from several sensors (temperature, humidity and water level) placed inside the greenhouse. After the data acquisition, with a defined sampling period, this data is stored into a database (DB) of the host PC, placed in the greenhouse and properly protected against dust and other effects of rural environment.

The responsible engineer for the greenhouse maintenance is advised every time that an anomaly condition occurs (ex. temperature limits exceeded). There are several ways to get information about the greenhouse status. The first is by a messages sent to a mobile phone, through Short Message Service (SMS) using Global System Mobile Communications (GSM) technology [12], every time that anomaly conditions occurred (ex. maximum or minimum exceeded). We have included a GSM link to a previous implementation to improve timing, since there were long delays using only the www notification [10]. A second way allows the user to see, in real-time conditions, the data values stored in the database of the host PC, using *Wireless Application Technology* (WAP) technology [13][14]. This feature make possible the analyses and monitor of the environmental conditions at any time from a remote place, even from outside Portugal. Beside these features, the implemented system allows the access to a World Wide Web site with all the information, through an Internet link. To implement this feature we used *Active Server Pages* (ASP) [15] and LabVIEW languages. The architecture of the implemented system is showed in figure 3.

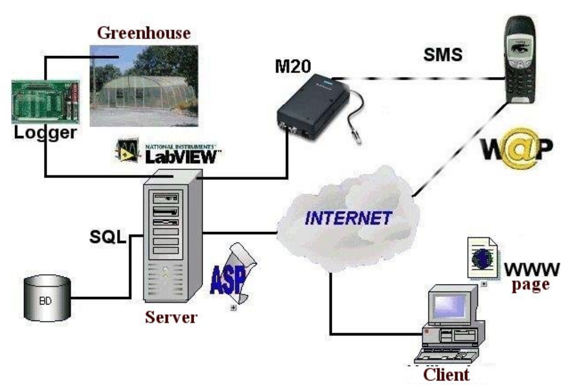

Fig. 3. System Architecture

3. System Implementation

To implement the proposed system, commercial hardware was used and software was developed to reach the desired goals. A prototype greenhouse was built to test the system in the laboratory during the development stage. In the next part of this paper we will summary expose the main blocks of the monitoring system.

A) Hardware

To acquire data we use a data logger that acts as an interface between the sensors, physic world, and the PC database [16]. The used logger allow, in a future stage of the system development, digital control over actuators like valves, fans, or others. Some features of the logger are:

- Temperature inputs from 14 thermocouples;
- Up to 60 readings/s;
- ±0.42 °C thermocouple accuracy;
- 24-bit ADC resolution;

Thermocouples had been used to read the temperature values inside the greenhouse. To monitor the status of the water reservoir that feeds the cooling system, level sensors had been used [17].

Other used equipment is the M20 GSM module [12]. This equipment allows the SMS notification when irregular detected conditions occurred in the greenhouse.

B) Software

The software component of the system uses several different languages/technologies: LabVIEW 6i [18], SQL [19], ASP [20], HTML e WML [13][14]. Its usage is:

- LabVIEW 6i is used to process the data acquired through the logger and store it in the host PC database. The choice of this software-developing tool was mainly because it's a powerful, optimized and robust tool to develop data acquisition applications.
- MS ACCESS is the database where the collected data is stored using SQL statements. The data manipulation consists basically in actions of average calculation, maximum value calculation, minimum value detection, data sort, etc. The data comes from the sensors readings, figure 4.
- ASP is used to allow the connection with the database. The connection is done using an ODBC redirected to the database. This technology is related with the SQL, HTML and WML, and is the way of we can get information from the database.
- HTML was used to build a WEB page. This page allows the graphical presentation of the data read by the logger in "real time". HTML also uses ASP and LabVIEW to accede to the database, using SQL *queries* embedded in ASP and LabView code [20].

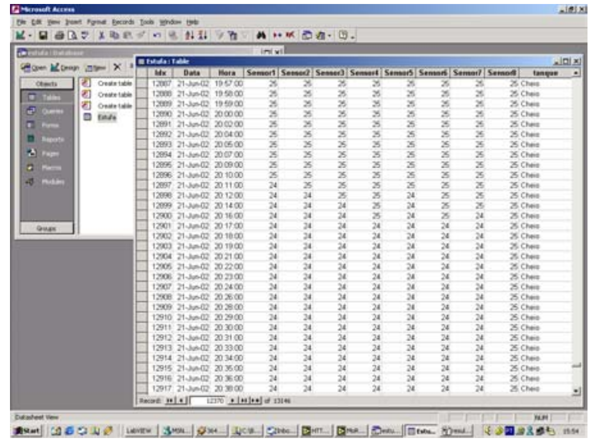

Fig. 4. Database

- WML was used to create the WAP site. This site has similar functions to the ones of the WEB page. However only textual information is available.

4. Results

We test our watching system using our small model greenhouse. The developed watching system allows temperature measurement and monitors the hydrodynamic status of the reservoir that feeds the *cooling* system of our prototype. Data is stored into a database to allow results treatment by technical staff, figure 4. Access to some specific stored data through a cellular phone is possible as long as it has the WAP functionality through the link, (http://moreawap.cjb.net/) shown in Fig. 5. The system automatically sends E_mail and SMS notifications every time that a non-regular situation occurs (ex. empty water reservoir). The system set points (maximal and minimum desired values) can be changed from a remote place using an Internet access only by authorized users (http://morea.cjb.net/). A non-authorized and regular Internet user can see instant acquired values and obtain information about the application but cannot change the set points due to security reasons. The browser screen is showed in Figure 6.

Fig. 5. WAP screens

Fig. 6. WWW site

75. Conclusions

The system exposed in this paper attempt to allow, the remote monitoring of a greenhouse located in the ESA-IPCB campus.

Using wireless communication, WAP and SMS, or through a PC with link to the internet the agricultural engineer of ESA can be advised about anomaly conditions or see the variables status of the watched greenhouse. Several languages/technologies where used to implement the designed system (WML, ASP, SQL, LabView 6i, GSM, SMS, HTML etc).

This application was made to achieve goals based on the requirements of this specific greenhouse (monitoring of physical variables and the hydrodynamic status of the reservoir that feeds the cooling system). The used tolls and/or technologies can be extended to other similar applications and allow the implementation of systems with monitoring and/or Control requirements. In this implementation we focus our attention to the monitoring part and not to the actuation part, but this can be done in future work.

This is a case where technologies can help in traditionally areas like agriculture.

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