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Design of Fully Automated Low Cost Hydroponic System using Labview and AVR Microcontroller

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***Abstract*— The blooming development in hydroponics has demanded the need of a self-controlled automated hydroponics system. Presently there are not many tools available and the existing ones have significant shortcomings for using the real time information. In this paper, a method is proposed to effectively use the data in real time to influence the counteractive steps. The work aims to build a self-controlled automated system which will be in itself smart and intelligent by optimizing the use of present technology. The real time data will be imported from a low cost AVR microcontroller board and the NI LabVIEW to monitor and automate the process in real time and to send this data over the network for IoT applications. The control will be provided by the traditional PID controller tuning. The system has been rigorously tested which proves the validity of the work and is cost effectiveness in such a way that it can be successfully implemented worldwide and in the developing states of India.**

Keywords*— *Automation, Hydropnonics, LabVIEW, Microcontrollers, Real time information, PID, Deep water culture

I. Introduction

Hydroponics is an efficient way of cultivating crops in a soil less manner with increased productivity per area, reduced water and fertilizer usage. Hydroponics can be used to produce variety of plants/crop in compact spaces such as the backyard, terrace, or in offices, by using a nutrient rich water solution. The areas of the world with poor or infertile soils can completely rely on hydroponics system. This gives people in these areas access to healthy and fresh produce. Other advantage of this method is that it enriches the crops with full flavor and taste delicious with higher nutrients values. The proposed method would be tremendously used as main crop production technique to support the ever increasing world population and mainly for the countries with severe draught over the time.

In this paper we present a framework for streaming real time data produced by process control equipment and to seamlessly integrate with the available methods to monitor and optimize the present system. The system makes use of LabVIEW, developed by National Instruments, which is a graphical programming language which makes use of dataflow model instead of text code making it easier to program. [9]. The LV requires a DAQ (Data Acquisition) card for data acquisition and hardware to software interface which is essentially provided by National Instruments and is way too costly for domestic and non-industrial usage. In the proposed work, an effort has been made to reduce the cost of this DAQ card by implementing a low cost Atmel's AVR (Advanced Virtual RISC) microcontroller for the same purpose. The microcontroller can be trimmed to perform the same task as of a conventional DAQ card.

II. Related Work

Although the hydroponics is quite old technique of plant cultivation, not much work is done for its automation or smart systems as the technique was not popular up until now. The control of hydroponic systems recently is based on expert systems and artificial intelligence methodologies coupled with biophysical models that have been developed as a result of extensive research on plant physiology [1]. K. Kalovrektis et al. [1] use a complex labVIEW based wireless system to monitor plant growth. The system uses various sensors coupled with ZigBee or similar wireless protocols to wirelessly send/receive data and NI-DAQ cards for hardware and software interface. For a completely automated hydroponic system, only a few methods are available in literature. Saaid, M.F. et al. [2] developed a system in which only pH level was monitored and maintained using the combinations of microcontroller and sensor. Prof. Nivedita Wagh et al. [4] propose a PLC based hydroponic system. Various sensors and control elements have been paired with the PLC system and timers/counters/actuators from the PLC unit are used to control these devices. Later on Rajeev lochan Mishra and Preet Jain [3], introduced an ARM processor based automatic hydroponic system to measure the electrical conductivity of the nutrient solution

A thorough review of the above work shows that there are only a few studies concerning real time processing system, using graphical interface with the use microcontroller technology in particular. The current paper considers these problems and proposes a graphical LV approach for real time data processing for a completely automated hydroponic system.

III. PROPOSED METHOD

Explanation

Although the soil maintains its natural moisture content, nutrients, temperature requirement by itself, it needs to be manipulated in the case of hydroponic cultivation. The plants are also required to provide support as they cannot anchor themselves without soil. The nutrient solution must be provided timely with proper amount of nutrients and acceptable pH levels. For such, continuous monitor and corrective actions are required for the healthy and appropriate growth of the plant. Automation greatly reduces the human error and improves the stability and accuracy of the system.

HARDWARE OF THE SYSTEM

Microcontroller

The microcontroller is selected in such a way that it should fulfill basic operations like AD conversions, PWM, data acquisition and communication with the computer along with a reasonable price. Atmel's Atmega 328P which is an 8 bit microcontroller ensures all these functions with a flexible PDIP packaging for easy mounting. The microcontroller has on board ADC and 6 PWM channels with a power on reset circuit along with one serial interface for USART. The microcontroller needs a 5V DC source for its operation. Fig. 1 shows the block diagram of the microcontroller used as a DAQ card.

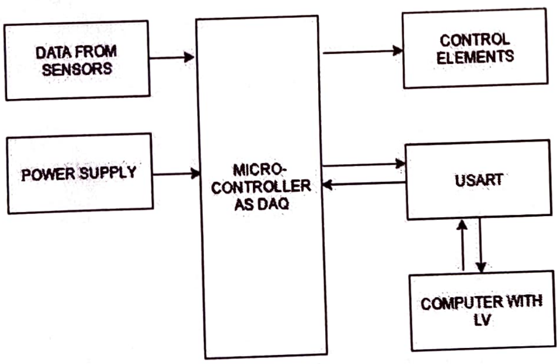

Fig. 1 Block diagram of microcontroller used as DAQ

Sensors and control Elements

Various sensors are used simultaneously for a considerably fine control of the system. The sensors are placed in the field at equidistant locations and the signal is brought to the main microcontroller.

The sensors used humidity measurement is DHT11, for temperature LM 325, electrodes for pH, and ambient light sensors. The control elements include fans, blowers, halogen light bulbs, pumps and motors.

CONTROL

Interface

The microcontroller can communicate with the LV through the USART serial RX/TX TTL logic via USB port. The LV provides VISA serial interface for data flow through the microcontroller and computer hardware. LV provides a rich user interface which can be easily trimmed according to the needs and accessibility of the user. The designed user interface has been shown in Fig. 2.

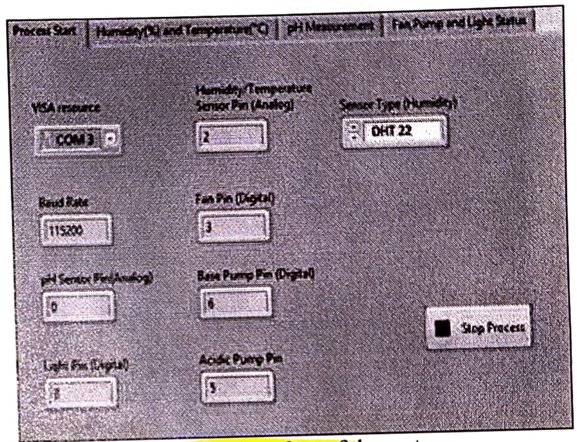

Fig. 2 User interface of the system

The interface seamlessly integrates with the connected hardware and provides real time data monitoring as well as control actions and ability to override the given conditions. Fig.3 and Fig. 6 shows the LV sub vi of the system program.

PID control

PID the most commonly used controller, is by default provided by LV which can be modified according the requirements. Fig. 3 shows the LV PID vi.

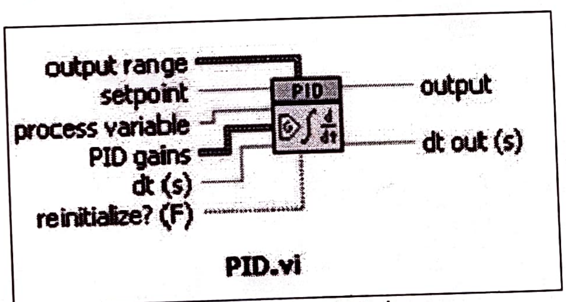

Fig. 3 LabView PID vi.

PID provides smooth control action and makes the system highly stable. The PID was tuned as per Zeigler-Nicholas closed loop tuning methods in which T_i=0, T_d=0 and K_i is increased from 0 until it reaches the ultimate gain K_u to be modified. The SP was obtained through a thorough literature study of the plant anatomy and system behavior.

The PID gives numeric output that ranges from high to low. The sensor input and the PID output should be mapped with a closed range to work in harmony. The PID output for the control elements will be driven through PWM channels.

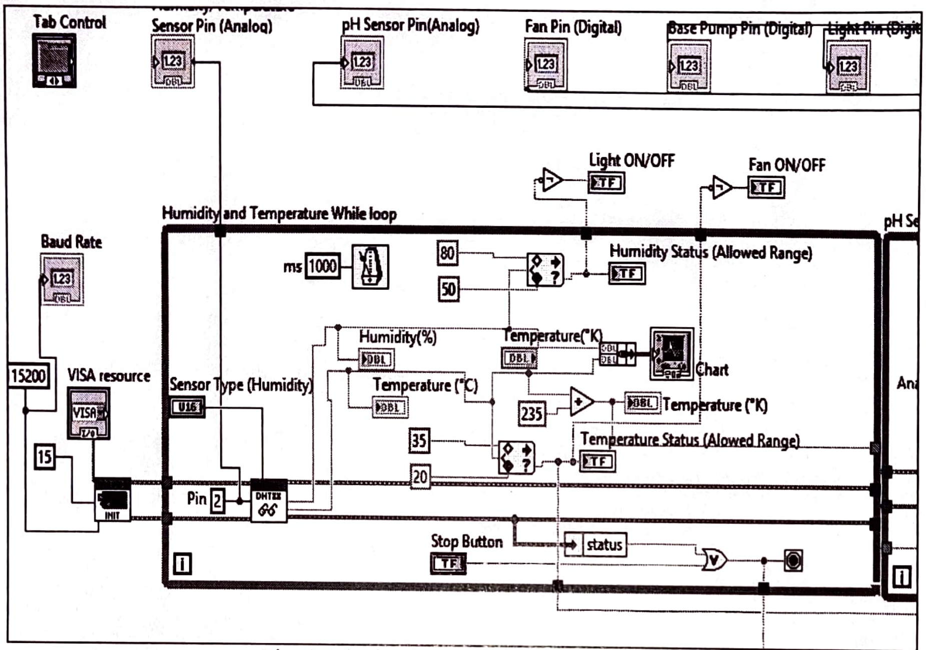

Fig. 4 Sub vi of the system program in LV.

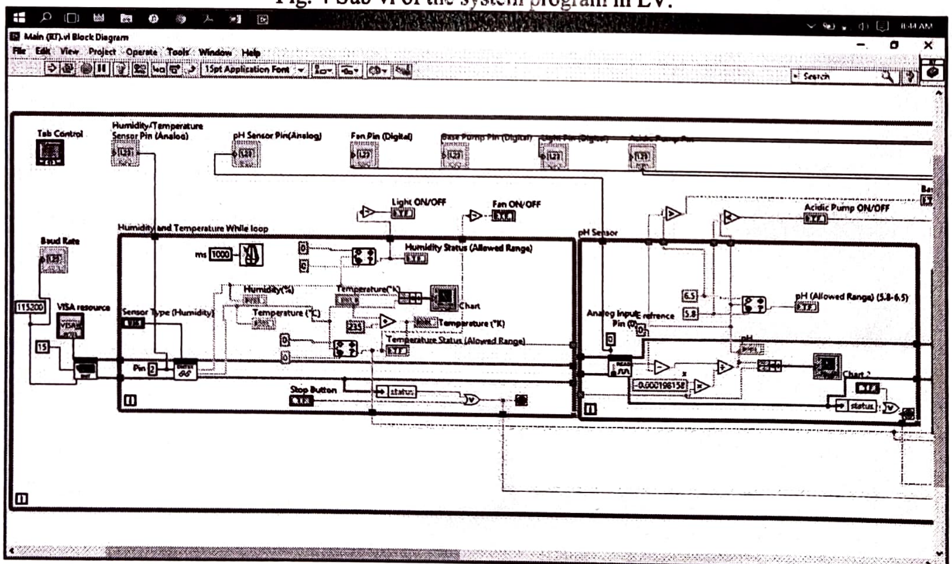

Fig. 5 Sub vi of the system program in LV.

Software Design

LV provides easy rendering of the user interface and real time data handling and processing with great flexibility to edit and modify the program at any given time. The flow chart of the LV program is shown in Fig. 6.

The sequencing of the program is as follows:

- Acquire the data from sensor modules via microcontroller and USART.
- Check for SP via LV user interface. If the sensor data

matches with the SP take no action otherwise, forward the data to the PID controller.

- After the optimal tuning of the PID, send this data to the control elements via PWM channels.
- Again the program checks for the SP and system stability through a feedback system

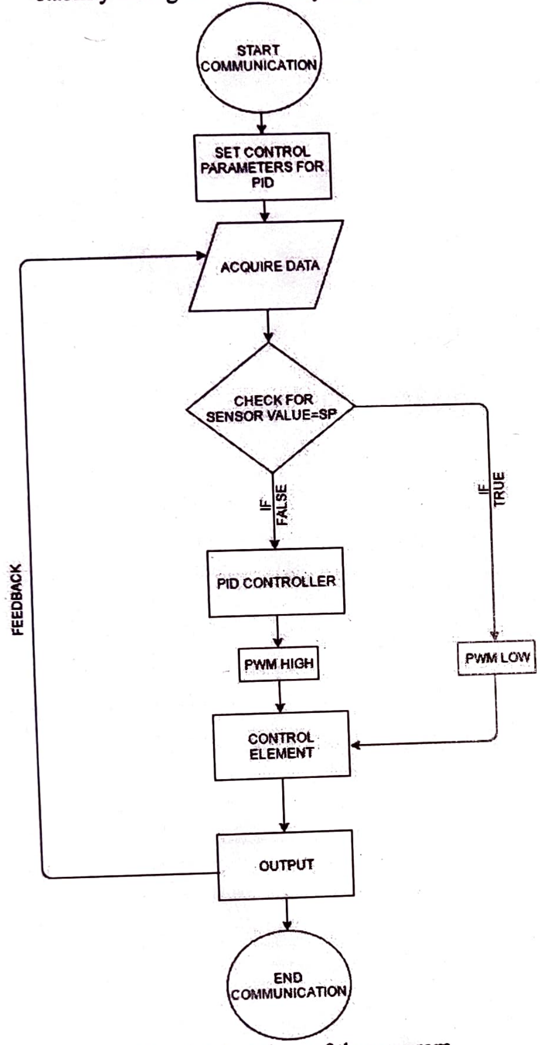

Fig. 6. Flow chart of the program

IV. RESULTS AND CONCLUTIONS

The proposed work shows that how the hydroponic farming can be efficiently automated using minimum resources and cost. The proposed system can be very successfully implemented with severe environmental condition locations. The performance of the system is validated by the experimental results. The system shows great stability and smooth control actions when controlled by PID controller. Also the following conclusions are drawn:

- The whole setup was fully self-controlled and automated, no human intervention was required neither monitoring.
- The cultivation equipped with this system was rather productive than the cultivation without any automated system.
- The system has a user friendly interface which is easy to read and easy to control with real time data.
- The cost of the system was drastically reduced by using the microcontroller based DAQ card.

The world demands a sustainable method and using hydroponics will meet the future demands of this ever increasing population and the proposed method will have good prospects for future development.

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