Intelligent Greenhouse Monitoring and Control System Based Arduino UNO Microcontroller

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***Abstract*—Nowadays, there is a significant diminution in agricultural production due to the unpredictable control of crop climate conditions. Thus, to alleviate the crops exposure from excess cold or heat and unwanted pests, an intelligent environment monitoring and control system based Arduino UNO board consisting of ATmega 328P microcontroller has been developed for a small-scale agriculture namely greenhouse. The system user can monitor and control the greenhouse climate conditions remotely via web interface/mobile applications and GSM in a real-time manner. To deliver the environmental conditions in a timely manner, low-cost wireless sensor network (WSN) is used to monitor the temperature, humidity, soil moisture and light of the greenhouse. The sensor network constitutes a multi-hop network structure for large coverage. The developed system is implemented and tested in laboratory conditions using Proteus toolkit. Arduino Integrated Development Environment (IDE) tool is used to develop necessary software. The results show that the proposed system can closely monitor and evaluate greenhouse farming field conditions accurately. Finally, the user can send control decisions instantly to boost the yield growth conditions and thus, increase the crop production considerably.**

***Index Terms*—Intelligent Greenhouse; WSN; Multi-Hop; Large Coverage; Monitoring and Control System; Arduino Uno; Microcontroller; Proteus Toolkit.**

I. INTRODUCTION

Currently, the global demand for food is greatly increasing due to the rapid growth of population. On the other hand, the production of sufficient food becomes a huge challenge because of climatic unpredictability [1]. Even thus, numerous studies did prove that most of crops produce well into a greenhouse, it is important to highlight that the control of environmental factors is one of the most significant and tough parameters to ensure the efficiency of greenhouse [2]. Thus, the agricultural environmental monitoring and control play a vital role in the production of abundant and sustainable food as the crop growth conditions will be closely scrutinized and the risk of disease will be identified [3].

The advent of wireless sensor network (WSN) technology provides a suitable platform for developing remote monitoring and control system of greenhouse conditions [4]. Hence, authors in [5], [6] and [7] did propose greenhouse monitoring and control systems based on WSN technique. However, their systems are not well-suited with the modern devices as an old 8-bit 8051 microcontroller is implemented. On the other hand, authors in [8], [9] and [10] did initiate a greenhouse monitoring and control system using a programmable Interface Controller (PIC) microcontroller. Nevertheless, the unintended PIC reset caused by errata in its library/documentation makes these systems unstable for real-time applications. Furthermore, the complexity and high price of the S3C2440 microprocessor makes the system developed in [11] too expensive for rural people and small-scale agriculture [12]. Moreover, despite using Arduino UNO as microcontroller, the system developed in [13] is limited because it can only monitor the greenhouse conditions. Finally, even thus, the author in [14] did develop a greenhouse monitoring and control system based on WSN, the GUI creation in LabVIEW is more complex and difficult to implement. Hence, in this research, a low-cost and real-time system based Arduino UNO Atmega 328 microcontroller was developed to intelligently monitor and control the crop growth conditions in a small-scale agriculture using Proteus toolkit. Thus, based on the sensed environmental conditions, the system will automatically act on the actuators either to open/close the fan to regulate the temperature or to open/close water pump for water irrigation, etc.

II. SYSTEM BLOCK DIAGRAM

As shown in Figure 1, the proposed intelligent greenhouse monitoring and control system is composed of three main functional bloc systems. First, Monitoring Bloc System (MBS) configured by a multi-hop wireless sensor network (WSN) to cover a large area while sensing several environmental parameters such as temperature, humidity, soil moisture, light, etc. Second, Control Bloc System (CBS) that comprises of Arduino UNO with various interfaces to provide connection with global system for mobile communication (GSM) module along with Internet Server to operate the Arduino UNO microcontroller, a Liquid Crystal Display (LCD) to show the instant field environment conditions and various motors/actuators to react on Arduino instructions. A User Block System (UBS) is located at last position. Through the web interface/mobile application, the cultivator/system user can monitor and act on various actuators/motors based on collected/sensed field data to enhance the crop growth conditions.