Data Acquisition of Multiple Sensors in Greenhouse Using Arduino Platform

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Abstract. Continuous monitoring of environmental parameters is necessary in order to achieve maximum plant growth in a greenhouse system. The aim of this study is to perform a real time data monitoring from multiple sensors in greenhouse using Arduino and Excel add-ins. DHT22 sensors, BH1750 sensor are the main sensors used in this study which give the exact value of temperature, humidity, and light intensity, respectively. Arduino Uno board provides multiple inputs analogs and I/O digitals were utilized to read the data sensor aforementioned that applied for the greenhouse. The level of accuracy of each sensor was compared to the standard device results. The results show that the accuracy of the sensors measurement is very good. This system design is real time, simple and low cost that given ability for user to monitor, collect, and to plot their greenhouse environments data in an Excel sheet.

Keywords: Greenhouse, Data Acquisition, Arduino

1. Introduction

Data acquisition system (abbreviated with the acronym DAQ) serves as the bridge between analog waveforms and digital numeric values that can be operated by a computer. DAQs are widely used in laboratory for testing and measurements in various areas of industry, particularly well-suited for measuring voltage signals and current [1]. Generally, the digital numeric data are acquired by transducers and sensors for handling. However, the signals from these sensors or transducers are necessary to be customized before it can be acquired by a digital environment for further treating [2]. DAQ involves many systems in scientific application to acquired data and to transfer of data including parallel port, serial port, USB port, and Ethernet port [3]. To mention a few, a simple embedded system based DAQ using AT89C52 microcontroller and LCD was investigated in [4]. Web-based DAQ system was proposed for energy efficiency monitoring which provides the real time interface with sensors [5], image based DAQ system [6,7], also an inexpensive open source Arduino based DAQ system [8–10].

The Arduino has been used to implement the data acquisition and to interface both analog and digital sensors [10]. However, the Arduino integrated development environment (IDE) does not contain an appropriate tool for storing and analyzing the data. Typically, the data are collected and then manually imported into software analysis. There are several possibilities to collect the data from the Arduino and then imported in real time into a data analysis package, particularly by using LabVIEW and MATLAB program. These software have been implemented for collecting and analyzing data from the Arduino [11,12].
Modern greenhouse technologies need to be considered by providing and controlling environment condition in the plant field. Many studies have been performed by researchers to monitor the greenhouse environment. In the previous studies, the greenhouses were monitored using many sensors using data analysis package [12,13]. However, problem with these data analysis package is that they are expensive. The present study focusses on a real-time DAQ for data monitoring from multiple sensors in greenhouse using Arduino and Excel add-ins.

2. Methods

2.1 Materials

Several sensors and electronic devices were employed, particularly: Arduino Uno, DHT22 (temperature and humidity sensor), BH1750 (light intensity sensor), breadboard, lux meter (Voltcraft, Germany), digital thermometer (Chino, India) and digital humidity meter (Chino, India). The research was performed in the greenhouse facility of Agricultural Faculty, Universitas Syiah Kuala-Indonesia.

2.2 Methods

2.2.1 Arduino Uno

The Arduino board has 14 digital inputs (6 digital inputs can be used as pulse width modulation outputs) and 6 analog inputs with 10-bit resolution. It has a 16 MHz quartz crystal, a power jack, a USB connection, an ICSP header and also a reset button. This microcontroller connected to a computer with a USB cable or can also power it with an ADC adapter or battery. The Arduino Uno can be programmed with the Arduino software integrated development environment (IDE). The ATmega328 on the Arduino with a bootloader allows uploading new code without the use of an external hardware programmer.

2.2.2 Interfacing the Arduino into Excel

The architecture of the greenhouse data acquisition system consists of hardware and software as shown in figure 1. Interfacing the Arduino to Excel was done using Parallax Data Acquisition tool (PLX-DAQ) [14]. This software is free add-ins for Microsoft Excel®. In order to interface the Arduino to Excel, the sketch code with the Arduino software (IDE) should be prepared as shown in figure 2. Once the Arduino sketch is uploaded into the Arduino, the PLX-DAQ spreadsheet icon was open. The port of Arduino is chosen, the download data box was checked, and then click connect.

![Figure 1. Architecture data acquisition system in greenhouse using multiple sensors](image-url)
2.2.3 Testing the sensor in the greenhouse
The sensors were placed in the greenhouse based on figure 3. The DHT22 and BH1750 sensors outputs were tested with a standard measuring instrument. The relationship of both measurements was plotted into a linear regression to find the coefficient determination of the sensors tested.

3. Results and Discussion
The idea behind this study is to monitoring the greenhouse environment condition in real time based on data acquisition system. The system comprises three steps such as data monitoring, collecting, and analyzing with real time plotting of collected data. This study is implemented by using Arduino microcontroller and sensor circuits (figure 4a) as well as Arduino IDE (figure 4b).
The system begins by connecting the Arduino board into computer via USB cable, continues by launching the PLX-DAQ Excel macro. The serial port and baud rate should be the same as that used in the sketch code embedded in the Arduino IDE. After clicking connects, the output data will be showed in real time in the Excel sheet. Figure 5 shows the real time Arduino using PLX-DAQ data acquisition Excel. All sensors are successfully interfaced with the Arduino Uno and also successfully display on the Excel spreadsheet. The PLX-DAQ has the ability to acquire up to 26 columns of data as well as other features such as plot the data in real-time using Microsoft Excel [14].
Table 1 represents a comparison between the proposed DAQ and different standard instruments. The tested sensors show high accuracy with coefficient determination more than 0.97. It can be seen that the BH1750 and DHT22 sensors have small error value. The error value could be caused by environmental condition; therefore a calibration is needed in order to minimize the error value of sensor [15].

4. Conclusion
This study presents an Arduino data acquisition system (ADAC) to be used in the greenhouse. The system is inexpensive, since it is not required to buy expensive equipment. Moreover, it does not need access to commercial licenses. The ADAC is able to monitor, collect, and plot the data of the greenhouse condition into Excel sheet. This system has an easy-to-construct using widely available sensors, low cost microcontroller, and the PLX-DAQ Microsoft Excel macro. For further study, free Google spreadsheet can be used as an alternative of PLX-DAQ which allows data from Arduino send via internet remotely.

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