Sensors and Materials, Vol. 34, No. 10 (2022) 3813–3822
MYU Tokyo

S & M 3078

Remote Accessible PC-based Data Acquisition System

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(Received May 19, 2022; accepted October 4, 2022)

Keywords: remote access, DAQ, Google Drive, IoT, Google Apps Script

PC-based data acquisition (DAQ) systems are irreplaceable in terms of capacity and flexibility for data processing. Data acquisition systems serving IoT are a recent development trend. It is necessary to develop a remotely accessible PC-based DAQ system. In this paper, we present a PC-based DAQ system that can be accessed remotely via the internet. The system consists of several sensors connected to a microcontroller. A two-sided application is developed to set up data access, namely, a local application on the DAQ PC and a web-based application in Google Drive (GD) that can interact with applications on the PC. Local data can then be sent to GD and accessed remotely from a PC. Applications on local PCs will provide a user interface (UI) for managing the data, while those on GD will provide access from the internet. The mean time delay for sending data from a PC to Google Sheets is 2.346 s with minimum and maximum values of 0.874 and 5.863 s, respectively.

1. Introduction

In instrumentation and control, the need for data acquisition (DAQ) is continuously increasing. The data obtained from a microcontroller is sent to a PC as the main data processor to increase the capability of an existing system. In the need for remote data access has become important in the presentation of data, both for acquisition and for managing results by the control system when system management must be carried out remotely. One should address how a local PC-based DAQ system can be accessed remotely.

The first DAQ systems were bulky and expensive, and required significant programming and setup expertise. National Instruments Corp. (NI) with their product devices (GPIB DAQ cards, DAQ boards, and LabVIEW) first offered such a service. MATLAB offered its Data Acquisition Toolbox with featured apps, which was the first solution to this problem.[(1)]

A low-cost, small, and lightweight DAQ system can be created using microcontrollers or a mini-PC.[(2)] A low-cost DAQ system was developed for effective fault diagnosis in fused

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https://doi.org/10.18494/SAM4094

ISSN 0914-4935

deposition modeling (FDM)-based 3D printing products. An Arduino microcontroller is used to collect real-time multisensor signals using vibration, current, and sound sensors.(3) Osinowo *et al.* developed a weather monitoring system based on Arduino Mega 2560. For data analysis, the data is stored in Excel format and can be copied directly from an additional microSD card.(4) An ac field measurement DAQ system uses a programmable logic device field-programmable gate array (FPGA) and an A/D converter, and realizes serial data communication using PC-developed software based on the Java+MySQL database platform. This system improves DAQ and processing efficiency. Research results have been of great significance for the detection and evaluation of surface defects.(5)

A PC-based DAQ system is one of the main elements in the data retrieval and recording process. A PC has a very important role in supporting complex analyses such as that based on genetic algorithms to ensure high accuracy.(6) DAQ solutions and the escalating demand for DAQ systems across the food and beverage sector to improve product quality have created a positive outlook for the market.(7)

The involvement of IoT leads to flexibility and low costs.(8) Owing to the high demand for and constant development of information and communication technology, there is a need to build improved low-cost sensor systems that rely on new concepts such as IoT or Web of Things (WoT).

The essence of the remote access DAQ system is the implementation of Web-accessible software. Meet *et al.* built a DAQ system by implementing a Web access application to facilitate users through the internet.(9) A versatile and configurable DAQ system for measuring engine parameters, which used instrumentation software package integration, LabVIEW, and the MySQL relational database, was presented by He and Xia.(10) This system is supported by database engineering, the internet, a real-time operating system, a network communication module, a DAQ module, a graphical monitoring module, and a data management module integrated into the system.

Goto *et al.* discussed a remote access system built with a client–server connection and a virtual private network (VPN) internet connection.(11) For monitoring in difficult situations and locations, a DAQ system was developed into a remote access system by Guo *et al.* The system was controlled remotely using an Android terminal-based data collection system developed to facilitate interactive DAQ.(12) In another study, a system that used a mobile terminal to control data and computer-assisted instruction (CAI) computer resources in the PC terminal was developed.(13)

The current technological status of PC-based DAQ systems can be seen from review papers and also observed in new products. The development of DAQ systems always involves two sides, namely, hardware and software, in applications to manage the system.(14)

The development of remote access software components such as remote desktops is a landmark in DAQ system development.(15) The most important factor in the success of remote access DAQ systems is the availability of a server that can be accessed via the internet.(16) Despite the rapid development of DAQ hardware, the role of the PC has not been replaced.

Santoso *et al.* implemented IoT with a PC-based remote access DAQ system for recording and processing seismic data. The DAQ system consisted of several modules of both hardware and software. The data was processed using a PC.(8)

A low cost is essential for a DAQ system, which usually uses expensive hardware including servers. In this study, we built a DAQ system using popular IoT hardware, namely, Arduino, with applications built using Python on a local PC and a web application from Google on the Google Drive (GD) data server side.

2. Research Methods

The developed system is shown in the diagram in Fig. 1. The application on the local PC sends data to the application on GD. In addition, it plays a role in designing the user interface (UI) displayed on the remote PC and the screen of the remote mobile user. The GD web application presents the data and UI, and interacts with the local PC in relation to the UI design. The functions of the application are shown in Fig. 2.

The main stages of this research are presented in Fig. 3. In detail, the research includes the following stages:

i. Design a PC-based DAQ system with an Arduino microcontroller as the sensor input/output interface.
ii. Design applications that run on local computers to perform computer-based DAQ processes.
iii. Design web applications to transmit data to the internet.
iv. Design a UI to manage the data access locally and remotely.
v. Test the DAQ system locally.
vi. Test the DAQ system UI for remote access.
vii. Analyze the performance of the DAQ system in retrieving the data.
viii. Compile documentation and reports.

The circuit diagram of an Arduino-based sensor interface with a connection on a laptop PC for two sensor modules, namely, DHT and MQ Gas (CO_2), is shown in Fig. 4.

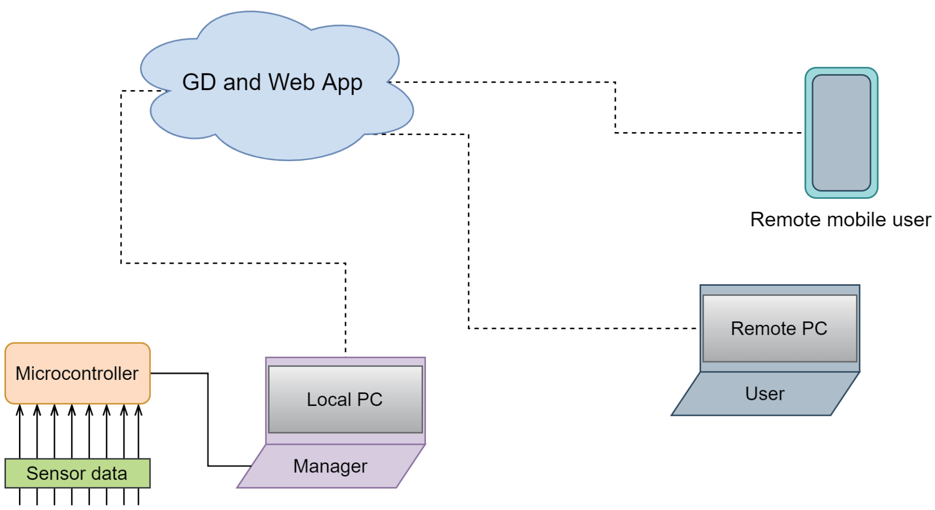


Fig. 1. (Color online) System diagram.

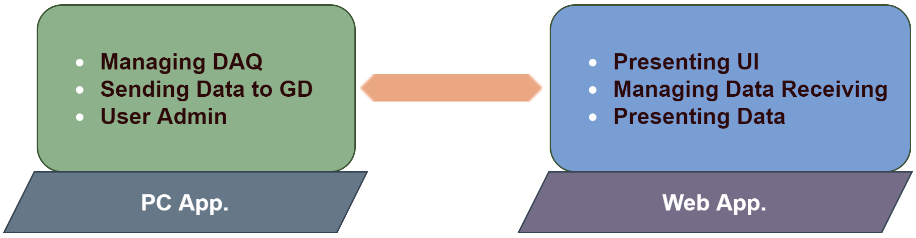


Fig. 2. (Color online) Application functions.

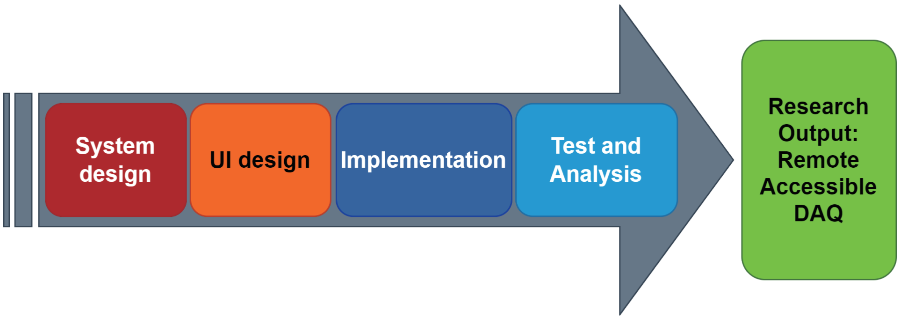


Fig. 3. (Color online) Stages of research.

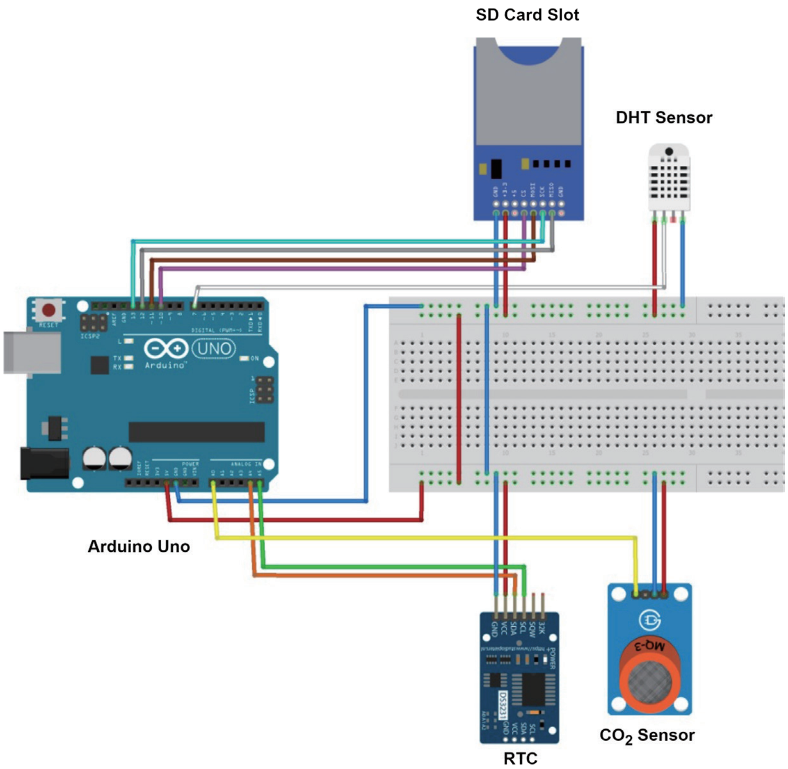


Fig. 4. (Color online) Sensor interface.

Three groups of code are used to handle the system. Each group of code works as described in the flowchart in Fig. 5. The first flowchart explains the code that is run on Arduino to read and send data from the sensor to the PC. This code runs in parallel with that in the second flowchart. The third flowchart corresponds to the code running on the remote device served by Google Apps Script (GAS). With this design, the PC-based DAQ is remotely accessible, enabling a user to view the data using an internet connection.

3. Discussion

This study has two contributions. The first is PC-based DAQ system hardware for logging temperature, relative humidity (RH), and CO_2 gas. The second is an application to handle the system that allows a user to access the data remotely via the internet. Figure 6 shows a box containing the hardware with the SD card and the sensors mounted on the top.

The PC running a Python code program with the setup for data collection in the laboratory is shown in Fig. 7. A fan is used to circulate fresh air from the outside to improve ventilation.

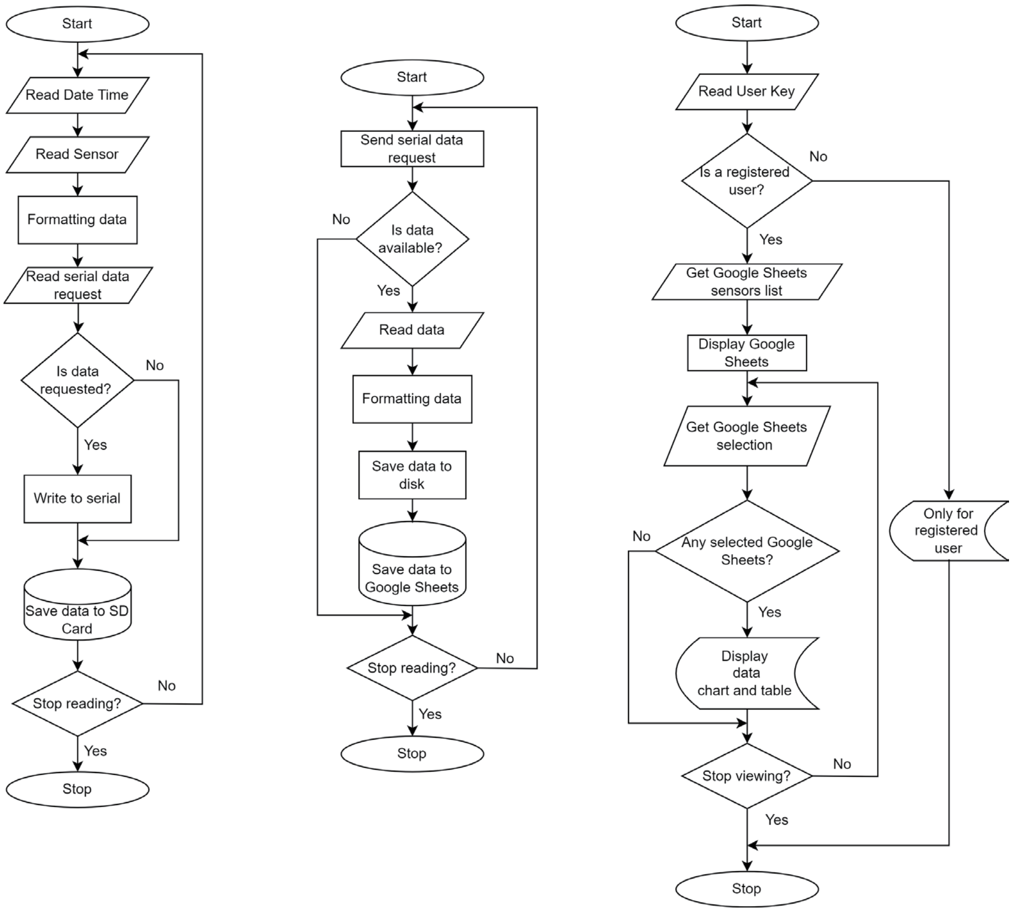
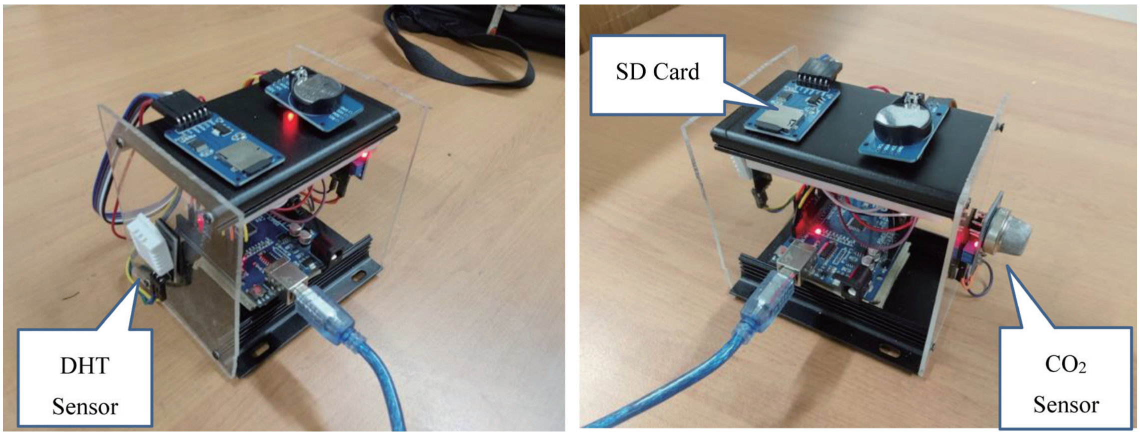


Fig. 5. Flowcharts of Arduino, Python, and HTML/JavaScript codes.



(a) (b)

Fig. 6. (Color online) (a) Right and (b) left sides of the DAQ hardware.

Fig. 7. (Color online) Measurement setup.

According to the flowcharts in Fig. 5, the Python code is written to enable data communication between Arduino and the PC. At first glance, building a DAQ system that can be accessed via the internet looks simple, involving simply placing the data in internet storage. However, it is less simple than it initially appears, because the more complete the access facilities, the more complicated the system becomes.

To develop a PC-based DAQ system that can be accessed remotely via the internet, we first add the ability to send data to Google Sheets in the acquisition program. This can easily be performed by involving the API key provided by Google.

A new column must be added to Google Sheets, i.e., the time the data was received, for which an additional program is needed. GAS and trigger commands are also added. After this step, the

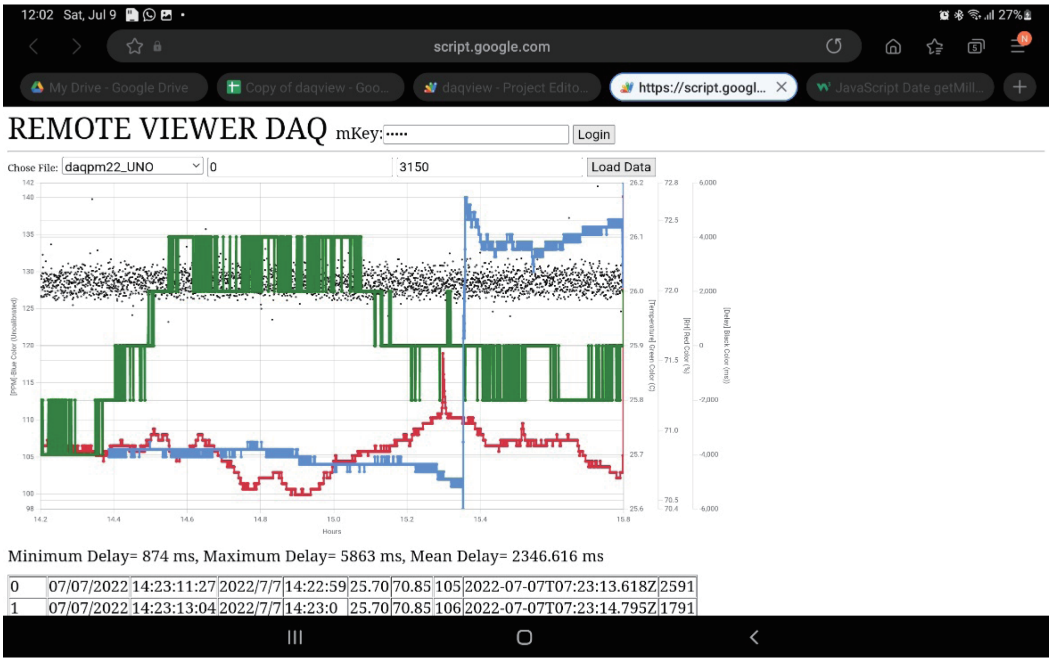


Fig. 8. (Color online) Remote DAQ UI.

recorded data can be directly accessed by opening Google Sheets using the shared link through a web browser. Thus, the DAQ system can be accessed remotely via an internet connection.

To help users access the data easily, a UI was built by GAS code programming. The DAQ remote access UI is shown in Fig. 8, which displays chart data from a Google Sheets file where data is sent and recorded. The chart shows small dynamic changes in room conditions for about an hour and a half starting at 2:20 PM. The laboratory used is not air-conditioned; thus, the changes in the conditions that occur in the laboratory occur purely owing to human activities, fan operation, and the environment. The rapid changes in RH and gas concentration are caused by two people talking around the sensor box. In this study, we focus on the discrepancy in the timing and values sent to the Google Sheets compared with the values read or recorded at the local site. The dynamic data recording is not about sensor accuracy, even though sensor precision is still important.

A close observation of the data in the chart (Fig. 8) reveals that the gas sensor data has an uncertainty of about 2 scale units and that the DHT sensor has an uncertainty of 0.2 scale units for temperature, while the uncertainty for RH is 0.03 scale units. The black dots in the chart show the time distribution for data transmission from the PC to Google Sheets. The minimum value is 0.874 s, the maximum value is 5.863 s, and the average value is 2.346 s.

4. Conclusion

The conclusions from this research are as follows:

1. The PC-based DAQ system can be accessed remotely by implementing algorithms for sending data to the internet server.

2. An application on the internet server and UI is needed to make it easier for users to access, visualize, and analyze data.
3. The uncertainties of the data read by the sensors used are 2, 0.2, and 0.03 scale units for gas concentration, temperature, and RH measurements, respectively.
4. The mean time delay for sending data from the PC to Google Sheets is 2.346 s with minimum and maximum values of 0.874 and 5.863 s, respectively.
5. The proposed method is a flexible and low-cost method for developing remotely accessible DAQ systems.

Acknowledgments

The authors thank the Electronics Cooling and Fuel Cell Laboratory of the Department of Refrigeration, Air Conditioning and Energy Engineering of National Chin-Yi University of Technology, Taiwan (R.O.C.), and Research Center and Community Service of Politeknik Negeri Bandung, Indonesia, for support in the system design research and experimental activities.

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