32-Channel Cost-Effective Data Acquisition (DAQ) Device and its Application Study Case: Advancement in University Library

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Abstract**—**The purpose of this article is to introduce the application of 32-channel system in the university library. The primary aim is to aid students and help them feeling relaxed during learning. In this research, a 32-channel cost-effective data acquisition device (DAQ) and its software application for an advancement of digital library is designed, configured and implemented. The design process includes the circuity, sensing and controlling hardware. The 32-channel DAQ was chosen due to its adaptable use for technologically advancing the learning process in the library. The proposed DAQ is a cost-effective device using a low-cost Arduino family device. All the simulations and the interface were created using LabVIEW and Maker Hub. Due to their characteristics (processing power, clock speed and processor size), the Arduino family controller are suitable to a large are of applications including in library spaces. In this work, in a library, a set of four students are allowed to sit on one table where a 32-channel device with specific software is being shared by all of them, thus allowing one student to use 8 channels at a time. Circuitry for temperature measurement, controlling chair positions, top AC thermostat temperature and setting the brightness for optimal reading were placed at the specific parts of or along the table in the library. Using a combination of the data from sensors, several angles for the chair positioning, vital AC temperature and brightness control can be achieved. The touch screen computer interface inside the table allows the student to digitally control the atmosphere parameters i.e., temperature, air and light in the surrounding region. By controlling these parameters, optimal conditions for reading in the library can be achieved. The temperature panel also displays the temperature in the atmosphere. The system can work in manual and automatic mode. The system, once set to operate automatically, works using basic decision making techniques and triggers the alarm service once required.
This is the first research work of its sort using 32-channel that can help student in achieving the ideal learning environment.

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Index Terms— Data Acquisition, Arduino, LabVIEW, Circuitry, Sensors.

I. INTRODUCTION

Improvements in hardware and computer technologies have led to an increase in the usage of intelligent and communicating systems supporting human activities. Computing machine capabilities are considered as extensions and expansions, where the machines are tools, and people are tool builders and tool users (Roth, 1987). The computing machine can help in advancing the system inside the digital library.

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As technology becomes more intertwined with the daily life of every human, the concept of ambient intelligence (“a digital environment that proactively supports people in their daily life”) becomes a new reality, as well as, a standard of progress and quality of life (Ramos, 2008). The main components of ambient intelligence (AmI) are: smart materials, sensor technology, embedded systems, ubiquitous communications, I/O device technology, and adaptive software. Although in its infancy, the AmI concept is well covered by multiple technologies, case studies, and has a great influence on multiple aspects of life (Cook, 2009).

In this research study, first, a 32-channel DAQ was designed, created, and then sensors were attached in order to create a complete system that could be considered as being allied with the AmI concept and improves the learning process inside the library. The technique used to create the 32-channel system is represented by the Supervisory Control and Data Acquisition (SCADA) system (Daneels, 2007), which is a broadly dispersed automated system primarily applied to remotely control and monitor the condition of field-based assets from a central location. SCADA can gather and analyse real-time data and it is frequently used for equipment manipulation (Boyer, 2009). It allows to accumulate records from distant locations and to send control instructions to those locations. This is the reason why SCADA is highly applicable to processes that are spread over large areas.

Data acquisition is a technique used to take data from the real world and process into digital domain. After digitally processing the data, the data is converted back into analogue form. This analogue data then controls the hardware in the form of output parameters. The DAQ device takes the digital and analogue I/O signal and produces the output I/O signal. The output signal controls the hardware. The I/O port is also called channel. The DAQ contain many numbers of channels. In this research a 32-channel DAQ system has been used. The DAQ device works actively with a remote front panel designed in LabVIEW. LabVIEW is used because of its vast scope in engineering education. LabVIEW is a software designed by NATIONAL INSTRUMENTS (NI). The data from the 32-channel DAQ appears at the PC COM port. The LabVIEW reads the data from the COM port and provides the I/O signal for any controlling actions. The Arduino used in the DAQ device acts as a communication device between the external hardware and the PC used(Taylor, 1986). The system has a vast scope in engineering education. Besides the study case

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discussed in this research, various other study cases can be implemented and the 32-channel system can be used for many purposes. For instance, traffic monitoring and control system, street light monitoring system, plant irrigation systems and many other study cases can be implemented.

The 32-channel system is implemented using a combination of analogue and digital channels (Walden, 1999). The system is provided with graphical user interface software that can be used to actively monitor the connected array of sensors and thus allow the user to customize the settings. The graphical software is in an executable form. Different arrays of sensors can be connected for different applications. The 32-channel system is first tested. Once designed and tested, the system can be used for different applications. The scope of this research is limited to the application of the 32-channel system in the university library to create a comfortable environment. The sitting table in the library can be provided with a GUI interface and the student performs the monitoring and control action from the panel screen on the library table. The table is attached with miscellaneous circuitry and the sensors arrays. The sensors array, circuitry for motor and light brightness control, once installed at specific locations, can be used in the library for creating the ideal reading environment. The data from the sensors can be stored for future processing (Qiu, 2015). Similarly, other sensors can be used with the 32-channel system to create further applications that can help the students in learning inside the library.

Libraries and their programs for promoting education, play an important role in educational processes (Carpan, 2011). Using the knowledge of engineering education, more study cases for the 32-channel system can be implemented and used in advancing the library. More of these cases can include complete E-health, security system and smart student management etc. For every study case, using the contextual information of engineering, hardware for the 32-channel has to be built by connecting the required sensors.

The 32-channel system is a complete computer-controlled monitoring system. The system can be allowed to operate automatically or manually. In the case of automatic mode, once the input data has passed the specified limit, the system itself controls the output factors. The system works with two types of data signals: digital and analogue. The 32-channel system works with the data logger feature that includes storing the data in the form of databases. The data, once stored, can be retrieved and further processed by making the system a class of causal systems. A causal system depends on the present and past value of the system to produce the output value. In order for the system to be causal, the system must be able to store the previous data in the data logger. The casual systems are the intelligent memory based systems. The 32-channel system can be manually controlled to operate on the occurrence of an unnecessary condition which is not pre-programmed. The system can be programmed with further case studies to increase its development and usages to assist human life. The 32-channel system can be used in engineering education since students can be encouraged to develop the new study cases that can be implemented inside the library. The system is specifically designed for educational purposes. In this research, an application of 32-channel system to aid students in the university library during learning process is introduced. Using sensors and by controlling the actuators with 32-channel system allows the students to control parameters in their surroundings. With the 32-channel system, an environment for optimal reading in the university library can be achieved.

II. LITERATURE REVIEW

Libraries in universities are the places that contains collection of books and informative materials where a student or group of students can read, write and share information with each other but as the world is growing, more and more countries are creating universities that are making different categories and types of libraries. The objective of this research is to introduce the application of 32-channel system inside the library that can aid students in the learning process. 32-channel system is DAQ hardware, the software of which is programmed using LabVIEW.

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments (NI) (Travis, 2006). LabVIEW is used for creating the interface of the 32-channel system. LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms. It includes extensive support for interfacing instruments, cameras, and other devices. It also includes built-in support for NI hardware platforms such as compact DAQ and compact Reconfigurable I/O (RIO), with a large number of device-specific blocks for such hardware, the Measurement and Automation Explorer (MAX) and Virtual Instrument Software Architecture (VISA) toolsets.

In terms of performance, LabVIEW has a compiler that produces native code for the CPU platform. The run-time environment makes the code portable across platforms. Generally, LabVIEW code can be slower than equivalent compiled C code, although the differences often lie more with program optimization than inherent execution speed.

Many libraries with a large number of functions for data acquisition, signal generation, mathematics, statistics, signal conditioning, analysis, etc., along with numerous graphical interface elements, are provided in several LabVIEW package options. LabVIEW has many applications in engineering studies and is good for teaching (ERTUGRUL, 1999). In engineering education, it is used to create control systems, communication systems and graphical programming works etc.

With LabVIEW, there is no facility to monitor and process data directly from real-world hardware (i.e., Arduino, STM32, Raspberry pi etc.), unless the necessary drivers and libraries are installed. The data cannot be extracted from the micro-controller used here, and, consequently, some necessary custom packages and libraries (that take data from the PC COM and process it in LabVIEW) are required. One such toolkit is LINX Maker Hub, and it was used in the current work as a means to link the 32-channel system with LabVIEW.

III. ANALYSIS

A. Block Diagram of the system

Fig.1 shows the block diagram of the system using the open source hardware Arduino mega 2560 (Barrett, 2013).

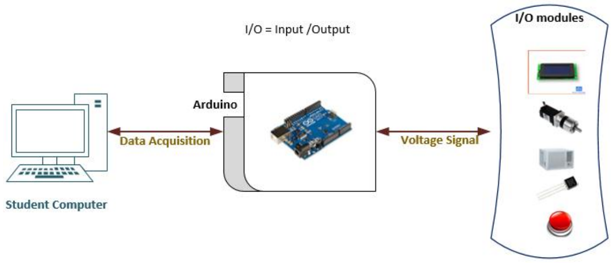

Fig.1. Block diagram of the system

B. Hardware in the loop simulation with LabVIEW and Arduino:

With the availability of the LabVIEW Maker Hub library, LabVIEW provides the support for the open source hardware containing Arduino and a few other family devices. The function such as analog read, analog write, digital read, digital write and some sensors can be directly monitored and controlled using the LabVIEW interface screen. The LabVIEW can be graphically programmed using the Maker Hub Library and the firmware can be uploaded on the Arduino to get started. The LabVIEW program can actively view the results from the sensors and buttons. Based on the data attained, output actions can be taken using the output devices such as motors, bulbs, LCD's, Dot Matrix and displayed on the LabVIEW Engineer panel display as well. The response time between the input and output reading is quite fast and depends on the core processing power of PC CPU frequency whereas the display time, once the action is triggered, depends on the processing power of the Arduino. It is necessary to compute the real-time response and speed of the device since the framework is associated with real-time applications (Salzmann & Gillet, 1997).

Using the Intel Core – i3 1.9 GHz processor,

$$Response\ Time = \frac{1}{1.9\ GHz} = 0.52\ ns$$

The response time is amazingly fast and can be compared with the advanced Distributed Control systems (DCS) and PLCs (Programmable Logic controller). The VI (Virtual instruments – Alternatively pronounced as LabVIEW code File) file is being programmed with code and the run bottom from the Top bar in LabVIEW is used to run the graphical monitoring program. The basic library blocks are shown in Fig.2.

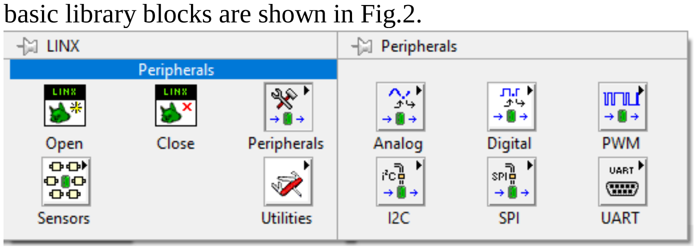

Fig.2. LINX Library

The LINX Library consists of basic Open (Start program) and Close (End of program) operation blocks that need to be placed at the beginning and the end of the code. The peripheral blocks contain the I/O operation blocks. The sensors block contains the commonly used sensor library. The utilities block let the programmer to change the Arduino frequency, configure the Wi-Fi etc. operations.

C. VR Lab Hardware

Here in this research, a 32-channel system is being utilized in the library to create the formal learning user friendly environment. One table in library X is being set with 4 chairs. There are total Y number of tables in the library. The system has a total of 32-channels, thus letting one student control the 8-channel for his chair.

D. Chair Control

Each of the chairs, out of 4, is being configured with two brushless direct current (BLDC) geared motor to allow the smooth control of the chair in dual axis. The motor can move both in X and Y-axis along dual directions. One motor, when rotating forth and back, allows the control in X and -X axis. Similarly, the other motor allows the control in Y and -Y axis. This operation requires two channels. Two channels for connecting the motor and the position control is being provided by the auxiliary or imaginary channel from the LabVIEW front panel screen. The chair control allows the forth and back motion of the chair. This allows the student to change his position without disturbing his learning position.

The BLDC geared motor was chosen because it is smaller in size, it produces low sounds is good for moving chairs and can be controlled efficiently using driver circuits.

E. Air Conditioner Control

Every student is provided with an Air conditioner (AC) system at the top of the table. The control to the AC is in the form of the graphical interface that is embedded in the same LabVIEW touch screen control. The imaginary channel takes the data from the LabVIEW panel screen and output is being assigned to the channel connected to the AC thermostat. When the knob data from the LabVIEW graphical screen is changed, the voltage to the thermostat will change. This helps in achieving the desired temperature.

F. Temperature and Display panel

The temperature sensor is required to display the temperature in the environment, since the temperature displayed at the AC is different from the surrounding temperature. Temperature Sensor TMP36 measures the temperature and the display panel will display the temperature and other graphical properties. The temperature sensor and display panel covers a total of 3 channels.

IV. METHODOLOGY – EXPERIMENTAL METHOD:

A table with a touch panel is set to be ready for the experiment. Four chairs are placed with each chair connected to two motors. The two motors are to ensure the right, left, back and forth motion. Each chair is housed by AC and the lightning connected in two rows. The touch panel is connected to the PC

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on which LabVIEW is installed and the front panel act as the main screen for the program. The main screen allows the student to actively control and monitor the parameters. The AC temperature and the brightness is also displayed on the touch screen panel. A complete touch screen panel is connected to a 32-channel hardware that allows the student to control the complete environment parameters that aid them during studies. If a student wants to feel cool air around, he can adjust the temperature parameter to get to the desired results. The brightness can also be controlled from the touch panel.

G. Performance Evaluation: Estimation Time for complete process:

The computer used for obtaining the result contains a Core – i3 1.9 GHz CPU containing 4 cores. The complete graphical code contains 100 processing blocks. This result in an estimation time of:

$$Estimation\ Time = 100x\frac{1}{1.9\ GHZ} = 52.63ns$$

The complete running time for the 32-channel system can be estimated using the below given formula:

$$Running\ Time = 32x\frac{1}{16\ MHz} = 2\ us$$

The running time, in other words, can be classified as the hardware running time. After 2us, a new cycle will start.

H. LabVIEW Simulation

The LabVIEW consists of two screens. One screen is known as the front panel and the other is a block diagram or code panel. The front panel diagram for the project is shown in the Fig.3.

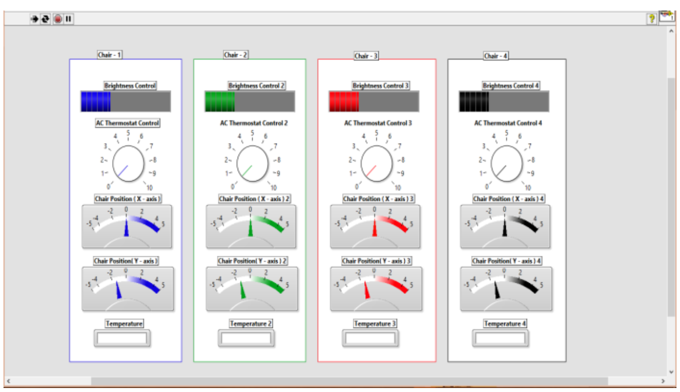

Fig.3. LabVIEW front panel diagram for the 32-channel library simulation

The front panel screen shown in Fig.3 consists of data from 1 table placed in the library containing 4 chairs. The chair – 1 is supposed to be the student -1 on table – 1 and chair -2 is supposed to be the student – 2 on the table – 2 and vice versa. Chair – 1 student controls the brightness in the scale from 0 – 100% illuminance resulting in the control of bulbs in an array of two rows. By changing the brightness on the scale from chair – 1, the lightning required to study for the student sitting on the chair – 1 will vary. The environment and positioning of the light is designed in such a way that lights from chair -1 bulbs does not go towards the other chairs. In other words, the light from the certain bulb only affects the specific chair for which it is designed. The AC Thermostat control initiates the control of AC temperature once the knob is varied. The chair positioning control is divided into two parts. One marker control allows the variation in X-axis, which is in fact the motion in the left and right direction. The Chair position marker (Y-axis) permits the motion in the forward and backward by 5 units of distance. The temperature field displays the temperature around the student. The front panel is a touch screen which allows the control action via tapping on the monitoring screen.

The control of the motor is a feedback process. The programming in the LabVIEW is done through a feedback algorithm for the motor control that allows the control of the motor in an efficient way by not letting it slip by even 1 degree of rotation. To reduce the error motion, BLDC geared motors are used. The reason for using this motor is low noise and geared action. Geared motor carries more load than the normal motors. This makes the motor most suitable for this chair positioning control application.

V. ADVANTAGES AND DISADVANTAGES OF THE SYSTEM:

I. Advantages of the 32-channel System:

1. The 32-channel system can be used for creating the effective learning environment in the library.
2. The 16-channel system can be used only for monitoring but in this there is no hardware based alarm that can be activated or certain parameters have to be ignored, so that is why the 32-channel system was created, to activate the alarm upon the detection of an abnormal condition and measuring the complete quantities.
3. A smart robot can be created to manually check for the system performance and alert.
4. Smart e-learning and controlling environment can be designed.
5. Student's behavior can be tested on the basis of their usability of the system.
6. The 32-channel system has software which enables remote monitoring.
7. The system is flexible towards other applications. Different sequences of sensors can be connected to create further applications.
8. The 32-channel system can be extended to create any other system, such as librarian monitoring system (a system that measures working performance of the librarian).

J. Disadvantages of the 32-channel System

1. Using the current system with few sensors and actuators means that this system can only measure and control certain parameters. In short, the system is limited to 32 – channels. For large systems, parallel processing is required which becomes complex.
2. Almost all the parameters, in fact more than 32 can be indicated but indirectly. The system does not inform about the reading performance and concentration level of the student. In order to do so, sensors such as brain electrodes are required.

VI. CONCLUSIONS

The cost-effective 32-channel system is created using the SCADA (Supervisory Control and Data Acquisition) technique with the help of LabVIEW software, due to its effectiveness in aiding students in the learning process. The system is designed in such a way so that it can be configured to work with any type of channel (digital or analog). In this work, a combination of an analog and digital channels is being used. Sensor data can be digitally monitored via LabVIEW front panel and actuating actions can be enabled from a computer screen. This feature is created in order to introduce the emergency control to the 32-channel system. Required actions can be performed manually or can be set to operate automatically. Further experiment cases can be designed based on certain applications.

The library study case was implemented using a 32-channel system. This system includes monitoring the temperature, brightness and other atmospheric factors in the surrounding of students to help them get the ideal environment for learning. This system can be efficiently used for educational purposes across the globe.

In summary, a 32-channel system and its library application are designed and implemented. Similarly, other applications that can help student in learning process inside the library can be designed and implemented using this 32-channel DAQ device. This system is better than predictable 16-channel systems when it comes to supporting learning inside the library via this DAQ device because it rooms more number of channels that are enough to trigger an alarm, with the help of which certain positions, brightness, and temperature around the table can be achieved. There are endless possibilities and study cases that can be created using this 32-channel hardware.

REFERENCES

[1] Roth EM, Bennett KB, Woods DD. (1987), " Human interaction with an intelligent machine", *International Journal of Man-machine Studies,* 27(5):479-525.

[2] Ramos C, Augusto JC, Shapiro D. (2008), “Ambient intelligence—the next step for artificial intelligence”. *Intelligent Systems*, IEEE, 23(2):15-18.

[3] Cook DJ, Augusto JC, Jakkula VR. (2009), “Ambient intelligence: Technologies, applications, and opportunities. Pervasive and Mobile Computing”, 5(4):277-298.

[4] Daneels A, Salter W. (1999), “What is SCADA? In: International Conference on Accelerator and Large Experimental Physics Control Systems”, Triestre.

[5] Boyer SA: SCADA (2009)," Supervisory control and data acquisition”, *International Society of Automation*.

[6] Taylor JL. (1986), “Computer-based data acquisition systems: Design techniques”, *ISA*.

[7] Walden RH. (1999), “Analog-to-digital converter survey and analysis”, *Selected Areas in Communications*, IEEE Journal, 17(4), 539-550.

[8] Qiu YP, Liao JK, Zhang M, Fan CT, Li GW. (2015), “Storing method and apparatus for data acquisition”, *Google Patents*.

[9] Carpan, C. (2011). “Library services in the age of Google: The importance of library liaison programs”. *College and Undergraduate Libraries, 18*, 104-110. DOI: 10.1080/1069 1316.2011.550536.

[10] Travis J, Kring J. (2006)," LabVIEW for everyone: Graphical programming made easy and fun (National Instruments Virtual Instrumentation Series)" *Prentice Hall PTR*.

[11] Barrett SF. (2013)," Arduino microcontroller processing for everyone! Synthesis Lectures on Digital Circuits and Systems”, 8(4):1-513.

[12] NESIMI ERTUGRUL. (1999), “Towards Virtual Laboratories: a Survey of LabVIEW-based Teaching/ Learning Tools and Future Trends”.

[13] Ch. Salzmann, D. Gillet, R. Longchamp and D. Bonvin. (1997), “Framework for fast real-time applications in automatic control education”, 4th IFAC Symp. *Advances in Control Education*, Istanbul, Turkey, pp. 345–350.

Further Readings

[1]. D. L. Walters. (1999), “Integration of equation solving software with data acquisition equipment for a senior engineering measurements course”, *ASEE*, Session 3225, available at http://www.asee.org.

[2]. D. Gillet, Ch. Salzmann, R. Longchamp and D. Bonvin. (1997)," Telepresence: an opportunity to develop real-world experimentation in education”, *European Control Conference*, Brussels.

[3]. Ch. SALZMANN, D. GILLET, and P. HUGUENIN. (1999), “Introduction to Real-time Control using LabVIEW with an Application to Distance Learning”.

[4]. Edwards, M., Kuman, S. & Ochoa, M. (2010). Assessing the value of embedded librarians in an online graduate educational technology course. *Public Services Quarterly, 6,* 271-291.

[5]. York, A. C., & Vance, J. M. (2009). Taking library instruction into the online classroom: Best practices for Embedded Librarians. *Journal of Library Administration, 49*, 197-209.

[6]. Kling, R., Rosenbaum, H., & Sawyer, S. (2005). *Understanding and communicating social informatics: A framework for studying and teaching the human contexts of information and communication technologies.* Medford, N.J.: Information Today.