Remote Monitoring of Lab Experiments to Enhance Collaboration Between Universities

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LabView is used to design the system to monitor and control lab experiments remotely over the Internet. Web based embedded system is designed and presented in this paper along with required hardware to perform experiments remotely in allocated time slot. A unique system is designed to monitor and control room temperature remotely. To assess the performance of the designed system and the hardware, an experiment is designed to control room temperature remotely. The Temperature Control System (TCS) publish over the internet by using web server along with embedded live video of the equipment to control and change various required variables. LabView and the equipment from National Instruments is used to perform the experiment and the designed system can be controlled anywhere from the planet by using secure login detail only which exist in the database of server. As the experiments take long time to be completed and during this time the performer need to be presented in the Lab. By implementing this type of system, it will save the time of the performer and it can be utilized in other activities. Also, by designing and implementing this approach students from other Universities can also utilized the hardware and collaboration between institutions will be enhanced. The designed system presented in this article shows promising results which are presented in coming sections of this paper. The performed experiments are recorded and banked in the repository of the institution for future reference along with results.

Povzetek: Članek skuša izboljšati sodelovanje med univerzami preko oddaljenega nadzora laboratorijskih eksperimentov.

1   Introduction

The importance of the remote lab experimentation has been observed during the COVID-19 pandemic when the academic institutes are closed or running distance learning in almost whole world. To prevent the spreading of COVID-19, the governments have to closed and impose lock down in all or affected areas. Due to this the mobility has been affected and academic institutes went online and distance learning to continue education. With the increasing number of things on the internet the concept of providing integrated services as a result of communication amongst heterogeneous networks is gaining momentum [3]. In last half century, advancement in electronics and communication technology enable the scientist to connect the machineries with computer system which can be operated over the internet remotely. With increasing the use of internet in the globe, many people work from home instead of going to office premises. It saves time as well as cost for both employer and employee. These technologies are also beneficial for students to perform experiments remotely instead of going into laboratories. In this way students do not have to wait for the equipment time slot, but they need to register for an online experiment slot according to their convenience. By registering, system allocate time slot to each user for conducting experiment.

In this context National Instruments has great contribution by developing Lab View which is graphical programming and Lab View has built in servers and can be configured those servers according to the requirements. After configuring the servers one can perform experiments from a remote computer [1]. In most of the organization the National Instruments equipment is also used in laboratories with Lab View software, but in various organizations this software is not used in this context. With the traditional laboratories this is not possible for all students to perform the experiment at the same time because experiment equipment limitation. By using the IoT based resources it is possible that all the students perform experiment sitting remotely from home or from anywhere in the world. In this way distant learning students can also perform their experiments from their residences.

The major aim of this research work is to make it able to perform and monitor experiments remotely and collaboration between the organizations to share the resources by using Internet of Things (IoT).

For monitoring purposes live video is also published in the panel by using web cameras to facilitate the experiment performer to monitor the hardware set up and other things in the laboratory while performing the experiments.
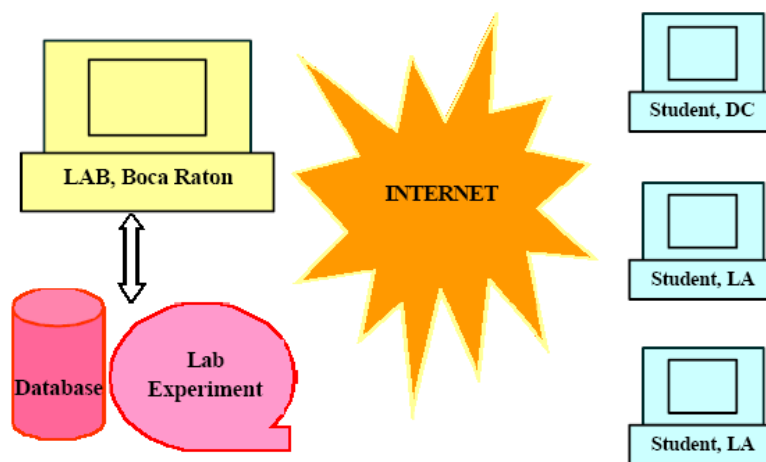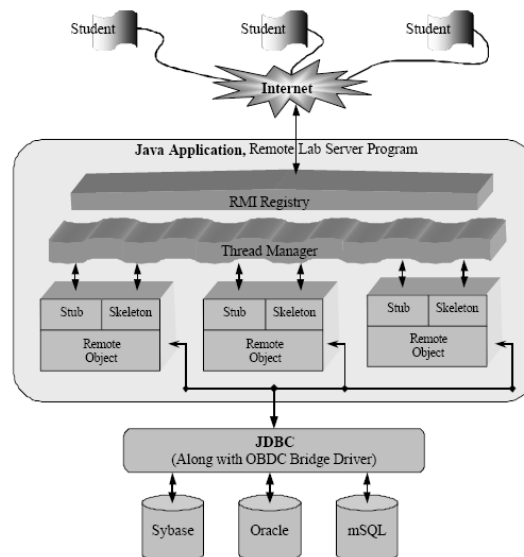
Figure 1: Framework of remote lab.

Figure 2: Java based client/ server communication model.

2 Related work

In last half century, the technology especially Internet related machines gained lot of attention from researcher who developed new models and architecture to build smart services, home and cities. Now a days traditional laboratories are not enough for all students to perform the experiment at the same time due to increased number of students in higher education sector especially in engineering and computer sciences. Due to lack of funds most of the laboratories don't have enough hardware for the labs to perform experiments. As a result, limited number of students can perform experiment in the daytime and tutors need to make groups to perform experiments. During the experiment time the laboratory supervisor needs to be present in the laboratory to supervise the students. However, there is another option that we can create virtual laboratories and at the same time many students can access that virtual experimentation but the drawback of this type of labs are that the experiment results of virtual lab are entirely different as compared with the real-world experiments results. Making the real setup of hardware in the laboratory and making it online for students to perform the experiment from anywhere in the globe. This reduces the costs and the time of the students. By making the Remote Labs it gives more opportunities to perform experiments more than once and gain the correct results of the experiments. The major benefit is for the distance learning students who learn from home, and they cannot come into the university every day or even once a week and making remote labs in universities, the student can get more practical knowledge than relying on theory [4].

By implementing the Remote Labs, it gives more opportunities to perform experiments more than once and gain the correct results of the experiments. The major benefit is for the distance learning students who learn from home, and they cannot come into the university every day or even once a week and making remote labs in universities, the student can get more practical knowledge than relying on theory [4,13]. Technologies are rapidly

growing and penetrate in every field of life in last few decades. In the education field it provides the new teaching techniques like Remote Monitoring or Tele Labs and etc. (e.g. a microscope is set up in NASA America and that is accessible from Russia and one benefit of this setup is that when Russian Scientists access that microscope at that time it is night time in USA). In this system both countries can utilize that microscope and other hardware. And there is no time clash between two countries because when it is daytime in Russia it is America's nighttime. Due to this time difference, scientists of both countries utilize that microscope with no time problem [6,14]. The operation modal of remote lab is show in figure 1. The figure shows that students present at different geographical location can access remote lab via internet to perform desired experiments. The hardware is setup for an experiment in remote lab. Multiple students can access the experiment at same time but only one student can control the experiment at same time. Every student can perform experiment in his allocated time slot and the results of experiments are stored in database and can be retrieved and analyzed later. [2]

The software design for remote lab for client/server Java based software model. The figure 2 shows major component of java based remote lab. The complete

software is composed of two parts. Client interface which is designed for the end user and other is remote lab that server part. Using JDBC the server objects are allowed to talk with the database. Any client who wants to talk with the database can do so by talking with the stub, which is in turn interacting with the skeleton. The following figure shows the actual experiment running in remote lab at Atlantic University. [2]

3 Remote lab architecture and hardware

3.1 Architecture

For connecting with the system through web serve by using username and password, the system verifies the credentials of the user then allow the user to start performing experiment. Then the client clicks on the remote panel for performing the experiment through web browser. Web browser sends a request to the experiment server and remote panel is downloaded for remote client and the whole system as shown in the following figure 3. The user can change the input variables and other required values to complete experiment. The data is automatically
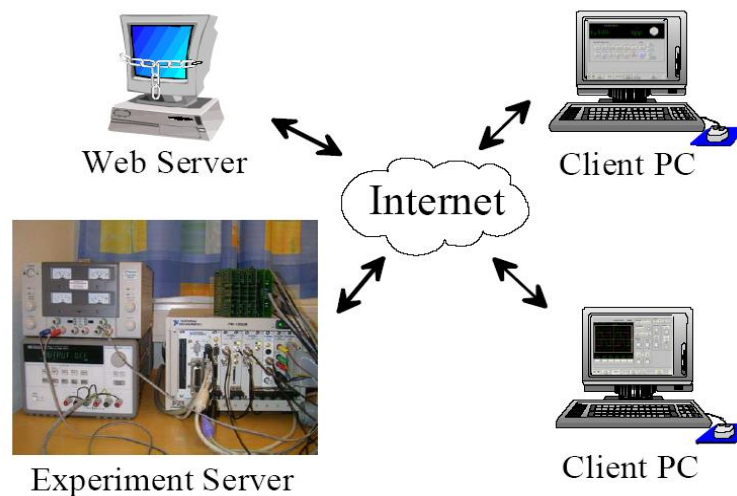

Figure 3: Client/server communication with experiment server.
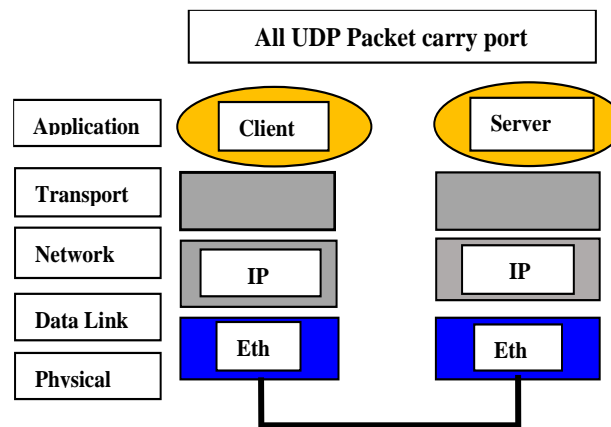

Figure 4: Client/server communication model.

Figure 5: Data acquisition card (DAQ).

saved on sever for future user and reference along with username and id.

3.2   User datagram protocol

User datagram protocol is the basically used as communication protocol to establish low latency and packet loss toleration between client/server communication over internet through web server. UDP transfer data very fast as it starts transferring data before agreement between sender and receiver. User datagram protocol is used for the for the purpose of transferring the input data to the hardware connected with experimental setup and UDP is connectionless protocol. It contains eight-bit header information, and it does not grantee to the destination for reliable data. The working of UDP is as follow.

3.3   Hardware

To demonstrate the proposed idea of remote monitoring of lab experiment, a sample experiment is designed by using following hardware components to access it remotely. To setup the experimentation following hardware is needed.

Transistor: The BDW93C is a silicon epitaxial-Base NPN power transistor in monolithic Darlington configuration mounted and is shown in the figure below.

Resistor: Light Bulb: 5-volt light bulb is used for increasing or decreasing the intensity of light and by varying the light of the bulb through DAQ input voltage, it varies the resistance of the Thermistor and by varying the resistance of the Thermistor temperature varies.

Power Supply: Power supply is needed to provide voltage to drive the circuit.

DAQ NI-USB 6008: DAQ is used for attaching all the hardware with the computer. The DAQ which is used in this project is shown below: [1]

3.4   Hardware Design

For controlling and monitoring room temperature remotely, the system is designed by using various hardware components and block diagram is shown in the figure 6.

A 5-volt supply is connected with designed system to switch on/off and reduce the intensity of heat in the environment to increase or decrease room temperature. 5-volt power is supplied through the DAQ and it can be varied between 1 and 5 volt to vary the brightness of the bulb.

3.5   Thermistor theory

Mathematical calculation of the VI is given below:

V = Voltage from supply, Vin = Voltage cross Thermistor, RA = Resistor Resistance, RB = Thermistor Resistance

r= R0 * e-B/T0

Where R0 resistance at   T0 (room temperature 289.15K) [25],   T = Temperature, B =Parameter at room Temperature,

By using the following equations

RB= (Vin* RA)/ (V-Vin)

Here RB is Thermistor resistance and it now equal to R

T= B/ln(R/r)

Temperature is in Kelvin, to calculate resistance across Thermistor

$$RB   = (Vin* RA)/ (V-Vin)$$
$$= (2.4 * 10000)/ (5-2.4)$$
$$=9231$$

By using the second equation, Here RB is a Thermistor resistance, and it is now equal to R

$$T = B/ln(R/r)$$
$$= 3450/ln (9231/0.0943296)$$
$$= 3450/ln (97859)$$
$$= 3450/11.4913$$
$$= 300.228 \text{ Kelvin}$$

4   Remote lab experiment setup

To verify the proposed idea an experiment is designed which consist of hardware components and software. The figure 8 below shows the block diagram of the system designed by using LabView programming tool. The purpose of selecting the LabView to design the system is basically in hardware component data acquisition card (DAQ) is used from national instrument which is
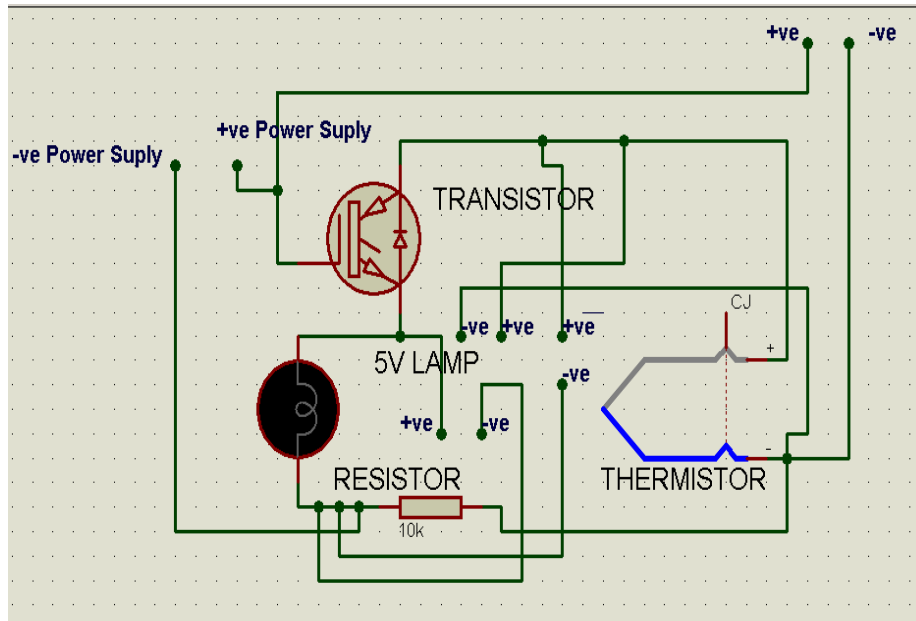
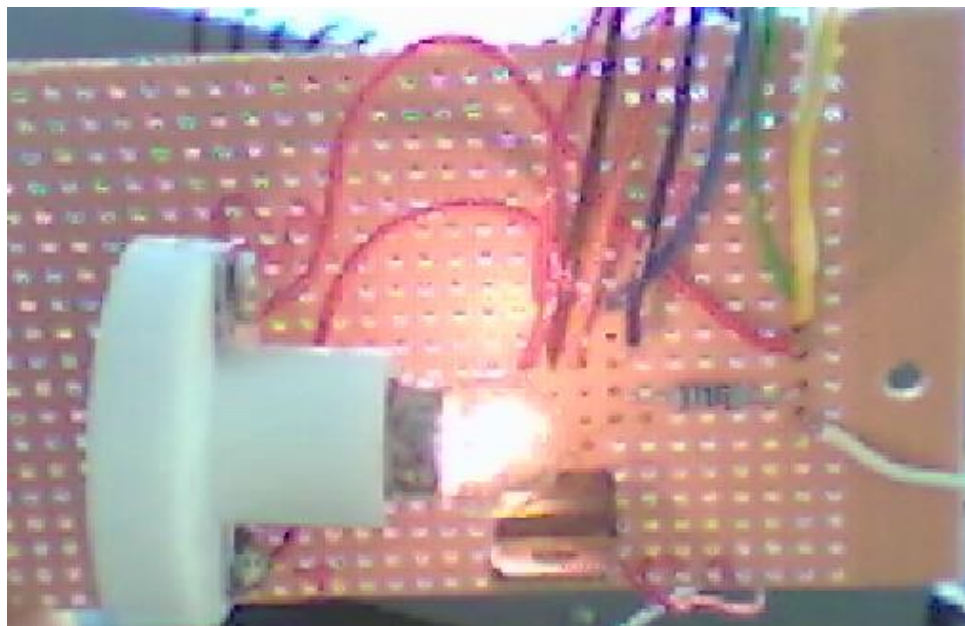Figure 6: Block diagram of experimentation hardware.

Figure 7: Experiment setup for temperature control.

compatible with LabView as both are developed by same vendor. The performer of the experiment can change the voltage which is going to bulb through resistor and due to change of voltage the temperature changes in the surrounding environment.

The DAQ Assistant is used to read the voltage across thermistor, supply voltage and voltage cross resistor.

The formula node is used to calculate temperature due to change of voltage across the Thermistor and supply voltage. For purpose of measurement, we need to configure DAQ with the number of samples, sample rate and timeout or delay between reading the samples from the circuit. If more readings are provided to the system, then it became slow, due to this reason less than 100 samples and timeout is 0.005 second is used and it gives

best results. If the number of samples are increased more than 100 and the timeout more than 0.005 second, then the system response becomes slow.

Second DAQ Assistant is used for voltage variation, varying the voltage to the circuit the brightness of the bulb is changed. By changing voltage to the bulb, the brightness of bulb changes, due to change in brightness the temperature of the surrounding is also changed which is read through the Thermistor. The voltage timeout can be changed and by changing the timeout, the speed of the system varies, and this is measured in seconds. By increasing the timeout, the update becomes slow and decreasing the timeout update becomes fast. It is tested by using different values and by analyzing the results.
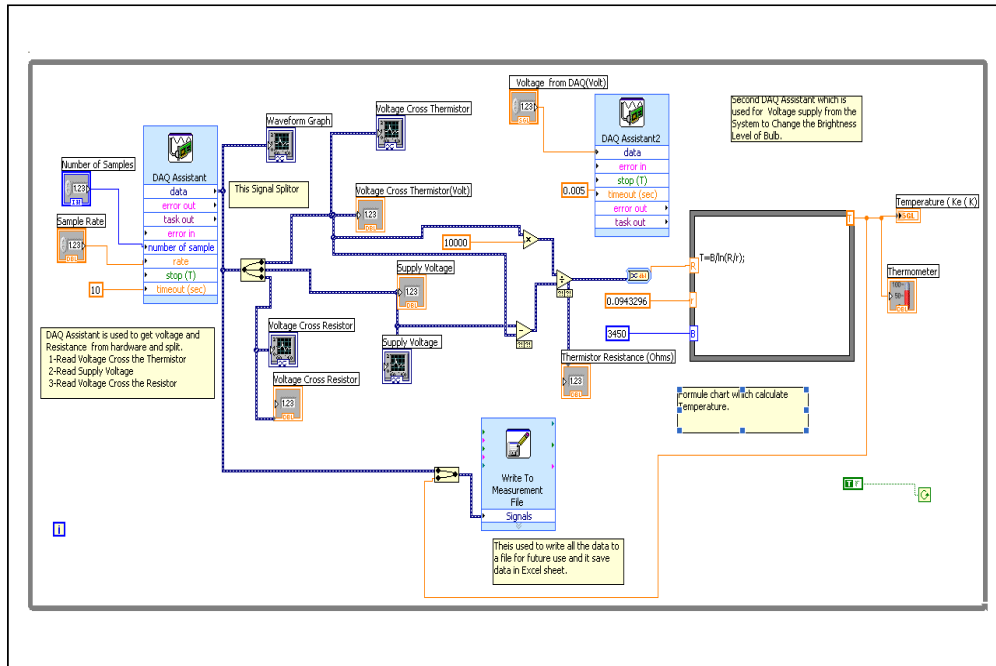
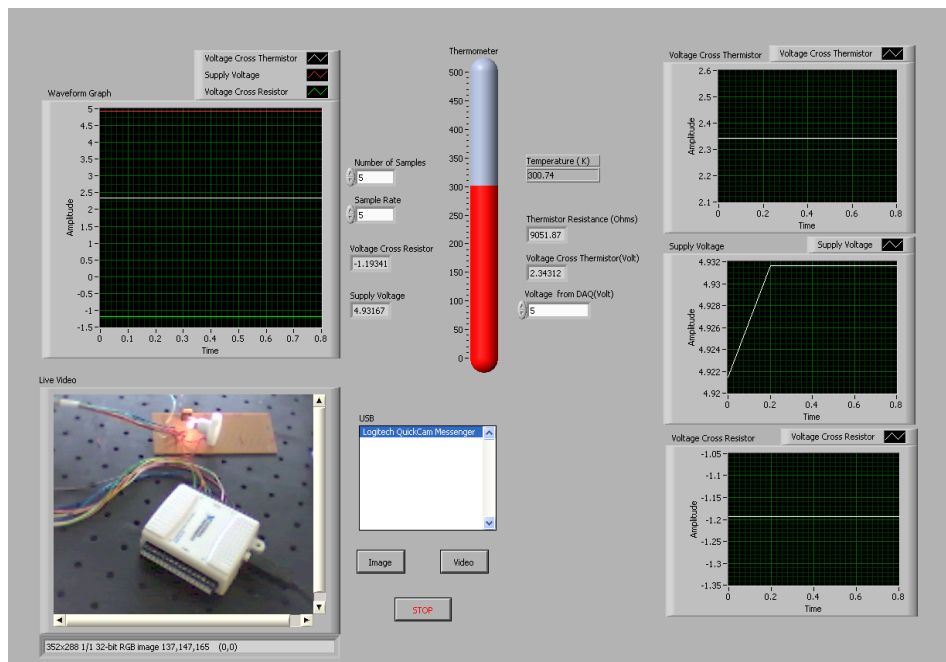Figure 8: Experiment Block diagram designed in Labview.

Figure 9: LabView based Front Panel for experiment.

A series of experiments performed it is found that 0.005 second is an ideal value for update to be sent to change the voltage. The experiment data is stored on the device by the using function "Write to Measurement File" provided by the LabView and it generate excel file for future retrieval. In the excel file, it records Voltage across the Thermistor, Supply Voltage and the Voltage across the resistor, and Temperature in Kelvin's. Live video of experiment setup is also embedded in the panel to provide live view of the experimental environment. The control for publishing video live is given to the experimental performer to stop or start video on the panel which is embedded in webpage. The panel includes the voltage supply and change of voltage to the DAQ. Due to change of voltage the temperature change in the environment and it reflect the change in embedded thermometer.

5   Results and discussion

After designing the required software for temperature measurement remotely and client can vary the supplied voltage to the bulb. Due to change in voltage the brightness of light bulb is also change, by change in brightness the environment temperature change which is measured with respect to voltage change. The following figure shows variation in temperature with respect DAQ
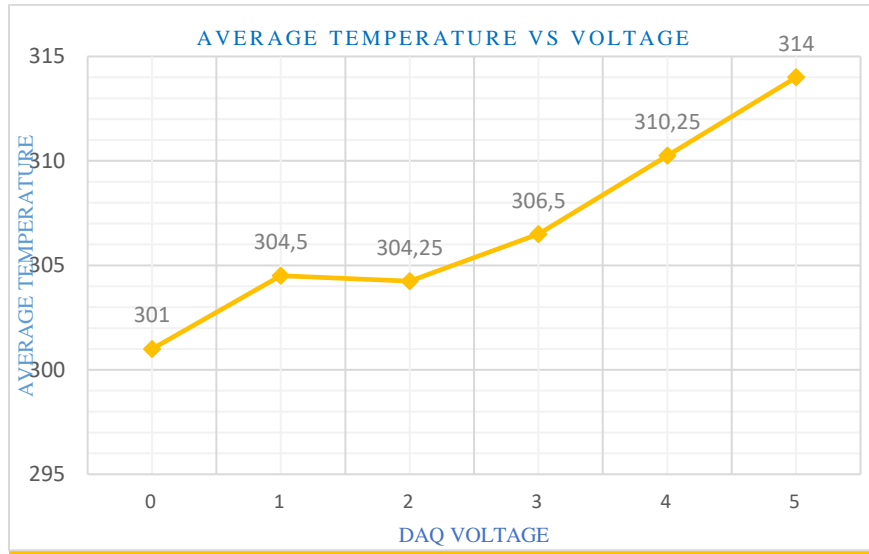
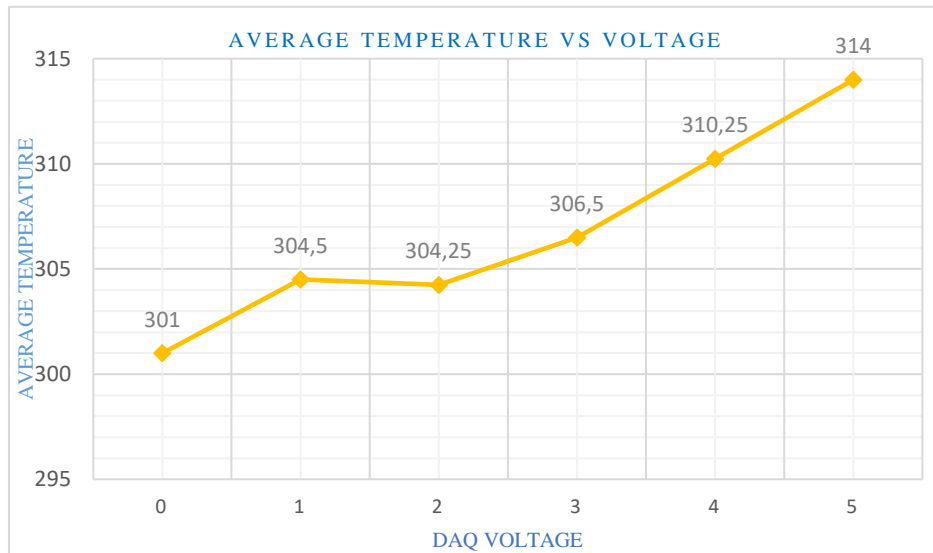Figure 10: Average temperature vs voltage variation.

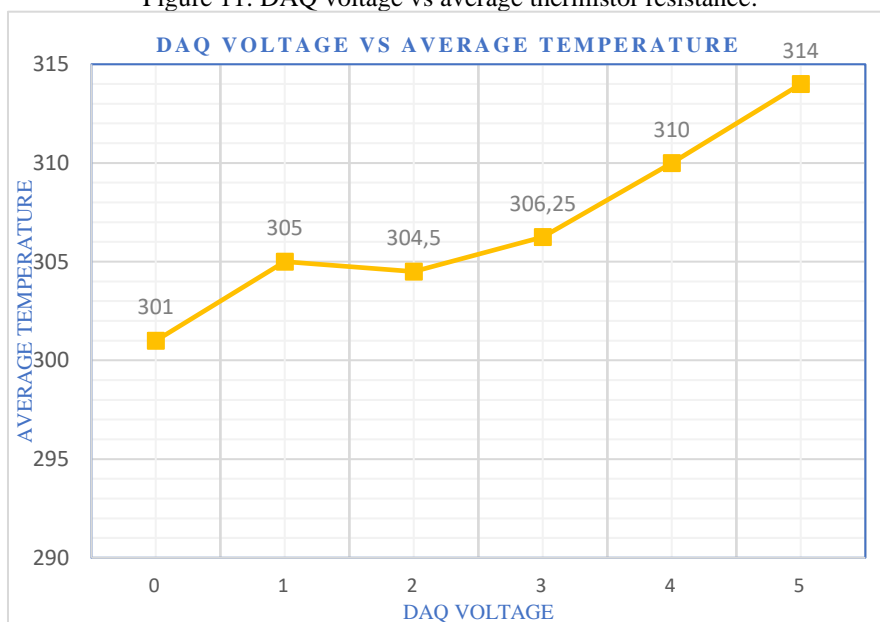Figure 11: DAQ voltage vs average thermistor resistance.

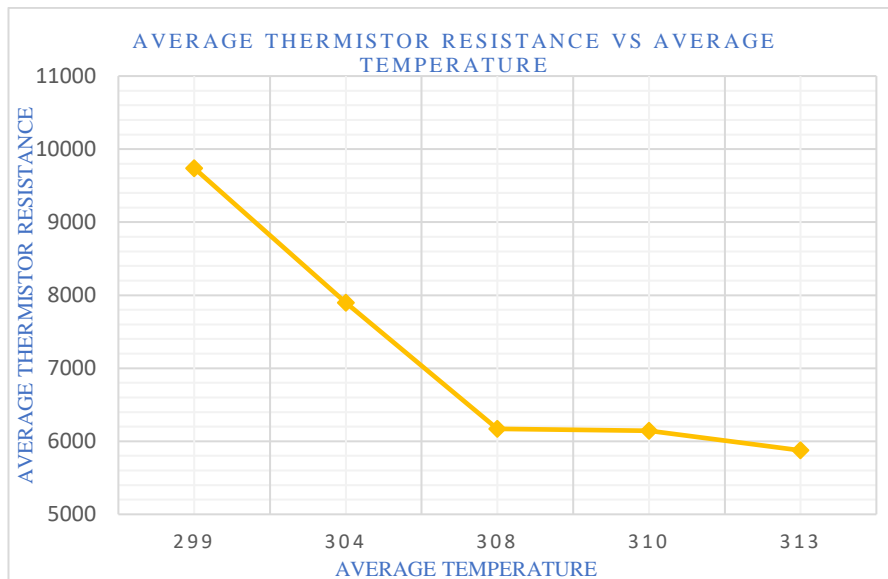Figure 12: DAQ voltage vs average temperature.

Figure 13: Average thermistor resistance vs average temperature.

voltage. By increasing the DAQ voltage the temperature increases because of the brightness of the light bulb. The presented graph below shows that by increasing the temperature the resistance of the Thermistor decreases and vice versa.

This graph shows the relationship between Thermistor resistance and DAQ voltage. DAQ voltage is taken along the x-axis and Thermistor resistance is along the y-axis. As the DAQ voltage increases the Thermistor resistance decreases and by decreasing DAQ voltage Thermistor resistance increase.

This figure 12 explains the relation between DAQ voltage and temperature, as the voltage increases the surrounding temperature increases. In this graph DAQ voltage is taken along the x-axis and temperature is along the y-axis. By analyzing the graph, one can concludes that by increasing the DAQ voltage to the circuit temperature increases and by decreasing the DAQ voltage to circuit temperature decreases.

Thermistor Resistance and Temperature relationship is shown in this graph. According to graph resistance decreases when temperature increases, and it increases when temperature decreases.

6   Conclusion

With the advancement of technologies and IoT devices in 21st century, it is very important that academia should enhance the collaboration between to utilize the resources of each other to benefit the learners. Due to COVID-19, it became more important for educational and technical institution that implement online laboratory systems in case to support online learning and experimentation. This project put the effort in regards of this area of research and development utilize online resources for remote experimentation along with enhancing collaboration between institutions. In this paper a remote-controlled experiment is designed and presented by using LabView integrated with web services for remote handling of lab experiments. The results presented in this paper is very

much satisfactory and proposed model can be use to enhance collaboration between academia. By using proposed model, the universities, which are lack of the latest experimental bed can be benefitted from other universities labs. By using the presented collaboration model, the lab experiments can be done any time even out of hours from home or anywhere from the globe.

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