

Remote Data Acquisition, Control and Analysis using LabVIEW Front Panel and Real Time Engine

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ABSTRACT

Students and faculty from South Carolina State University (SCSU) are collaborating with the staff at the Pisgah Astronomical Research Institute (PARI) to allow the SMILEY radio telescope to be accessed and controlled over the SCSU Network and the Internet. National Instruments (NI) LabVIEW software package has been used to design a Virtual Instrument (VI) for the system that has a front panel that will request a users name and password to either view and/or control the SMILEY. To publish the Web page, students used Hypertext Markup Language, Internet Protocol and a Uniform Resource Locator. The earlier versions of LabVIEW provided a number of VI options such as VI server, Data Socket Server, and Visual Basic and Active X to design and develop modules for remote data acquisition and control, usually in a local network. It also required that both the client and server must have LabVIEW and design and development of modules for remote control using the Internet was more involved. The recent LabVIEW 6.1 version introduced remote front panels to view and control a VI in any Web browser. The objective of this paper is to discuss the design, development and testing of VI modules using LabVIEW front panel and real-time engine. This work was funded in part by a PAIR (Partnership Award for the Integration of Research) grant from NASA-MURED to SCSU under NCC 5-454.

1. INTRODUCTION

The fields of engineering, science, and technology at present are very dynamic, due to recent advances in computer and other technologies. These advances resulted in a number of computer programs that solve traditional as well as novel problems. These programs, using the computer's increased computational capabilities, are key to the explosion and success of the Internet and the Web. This also led to the revolution of the Internet-enabled instrumentation using

programs like Laboratory Virtual Instrument Engineering Workbench (LabVIEW). The Internet-enabled instrumentation is flexible, cost-effective, powerful, and increases productivity. Since LabVIEW is based on graphical programming, users can build instrumentation called "virtual instruments" (VIs) using software objects. With proper hardware these virtual instruments can be used for remote data acquisition, analysis, design and distributed control. VIs built using LabVIEW are the easiest to be controlled and shared over Internet as LabVIEW has a number of VIs such as VI server, Data Socket server and Visual Basic and Active X, Java and Java Script that can be used to design and develop Internet-enabled virtual instruments. It has been used to create many types of Internet based solutions some of which are [1]:

- Design and development of virtual laboratory for the students of a university to perform their experiments anywhere in the world.
- Design and development of VIs that allows multiple users to collaborate in real time.
- Design and development of Web servers and e-commerce site.

There are many other applications where LabVIEW can be used to design and develop cost-effective and user-friendly Internet-based VIs. These applications can be broadly categorized into four different areas [1]:

- Remote Monitoring
- Remote Control
- Collaboration
- Distributed Computing

The recent version of LabVIEW, LabVIEW 6.1 introduced remote panels and real-time engine that can be used to view or control a VI in any Web browser. This feature greatly expanded the application because an operator can run an

application from anywhere. In addition, it provided the capability of multiple users at different locations to access the VI simultaneously [2]. This feature required the following:

- The client machine must have LabVIEW real-time installed (a free download is available from NI website).
- The server must have LabVIEW 6.1 installed and must have multiple licenses for LabVIEW real-time and front panel.

This paper is arranged as follows:

Section 2 discusses various application areas of LabVIEW. Section 3 discusses different requirements and components associated with the design and development of the remote control module. Section 4 presents the code to activate the LabVIEW front panel and front panel of some of the VIs used the design and development of the remote control module. Section 5 deals with the conclusion and discussion. Section 6 deals with acknowledgement and future work. Section 7 deals with the references.

2. LabVIEW APPLICATION AREAS [3]

The following are some of the application areas of LabVIEW:

Simulation - simulates physical processes

Data Acquisition - data acquisition from outside source

Data Processing - built in analysis library that includes signal generation, measurement, filters, windows, curve fitting Probability and statistics, linear algebra, numerical methods

Instrument and Control - Virtual Instruments (VI)

Program Development - Object oriented/graphical programming

ToolKits - Fuzzy Logic, Internet, Signal Processing, Control Systems, etc.

3. COMPONENTS, REQUIREMENTS AND LIMITATIONS OF THE REMOTE CONTROL VI

We designed a VI called "MENU1.VI" using LabVIEW front panel and remote control engine for remote control and data acquisition. As mentioned earlier the primary objective of this VI is to control SMILEY located at PARI using any Web browser. But this VI can be used to conduct remote experiments simply by modifying its component calculation and data acquisition Sub VIs. The following is a list of Sub VIs used in MENU1.VI:

- a. Login.VI
- b. Coordinate Calculation VI
- c. Position Dish VI
- d. Data Acquisition VI
- e. Stop execution of the VI

A view of the front panel the MENU1 VI is shown below in Figure 1.

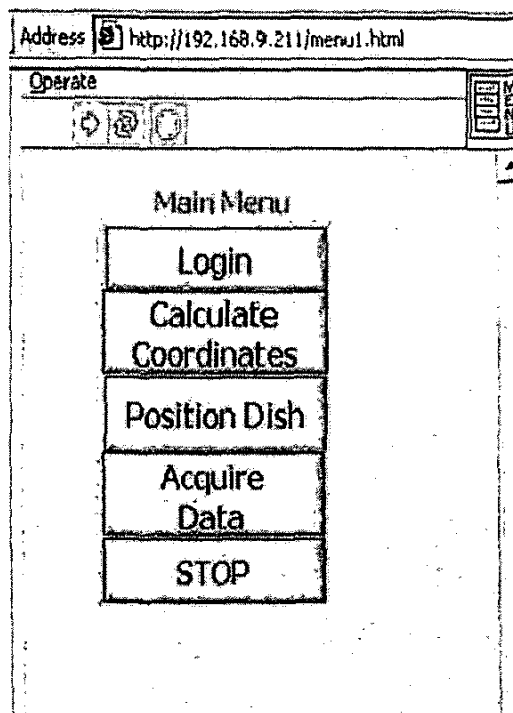


Figure1 – Front Panel of MENU1 VI

The Login VI checks the client number and date that the user will be able to use the Smiley program. For instance if a user try's to log on before or after the set date, the program will notify them that they will not be allowed to access SMILEY that day and provides the user the date or range of dates in which they were or /are scheduled for if logged on the wrong day. A text file named "clientlist.txt" consisting of user names, client ID, password, and scheduled date of experiment was created for this purpose. The Login.VI prompts the user for client number and uses the client number to determine password and scheduled dates of experiment. If everything matches then the VI displays a message asking the user to proceed to the experiment otherwise the VI displays another message indicating Login failure and asks the user to try again. The Login.VI terminates after three unsuccessful attempts by the user. Section 4 provides a view of the front panel of the Login.VI and the clientlist.txt file.

The Coordination Calculation VI, Position Dish VI and Data Acquisition VI are initially disabled. These VIs are enabled only when the user successfully logs in. This arrangement prevents unauthorized users to operate the VI.

The Coordinate calculation VI uses a set of astronomical equations to calculate the position of an object (SUN or MOON). To perform these calculations the user provides information such as local sidereal time, right ascension, and declination to this VI. The VI uses formula node to execute the equation and provides the azimuth and elevation of the object. This information is written to text files for future use and is made available to the Position Dish VI for rotating the dish to

the desired position. Section 4 provides a view of the front panel of the Coordinate calculation VI.

The Position Dish VI uses the position calculated by the Coordinate Calculation VI. This VI is responsible for moving the dish and deals with number of relays, motors, and electronic circuits. This VI is developed by another group of students and faculty mentor(s) associated with the NASA/PAIR project and this paper will not discuss about this VI.

After the dish is positioned the Data Acquisition VI is activated to acquire data and perform various analysis on the collected data. We used a simple VI called "Ohms Law VI" to test this part of the design. The server (an IBM compatible COMPAQ computer with WINDOWS 2000, Network Interface CARD (NIC)) with LAB PC 1200 DAQ card and SC-2075 signal conditioning Accessory, both from NI, were used to test the remote control MENU1.VI. The Ohms Law VI uses built in DAQ VIs such as Analog Input VI and Analog Output VI to acquire voltage (approximately 5 Volts) from the SC-2075 signal conditioning accessory board, changes the voltage in increments of 0.5 volt, calculates the current and power. It saves these results in a spreadsheet file (Ohms.txt) in the server, displays and plots them against voltage on the client machine. Section 4 provides a view of the front panel of the Ohms Law VI and the contents of the spreadsheet file Ohms.txt.

Some of the requirements of our remote control VI are as follows:

1. The client(s) must be able to access the VI from anywhere using the Web and display the Main Menu screen of the VI in client's computer with Login and Stop options enabled and other options (Coordinate Calculation, Position Dish and Acquire Data) disabled. It must also display the day and date on the screen.
2. The VI must prompt the user to click on Login VI to Login and upon completion of that, the VI must prompt user for his/her client number and then authenticate the user by checking user ID, password, and date from the clientlist.txt file. It must also display the date and time.
3. The VI must check date to ensure that the user is scheduled to login and perform experiment on that day.
4. The VI must provide the user with appropriate message if either item 2 or item 3 is not satisfied and provide the user with two more chances to successfully login.
5. It must enable other options and disable Login option once steps 2 and 3 are satisfied.
6. The VI must allow the user to experiment with Coordinate Calculation, Position Dish, and Acquire Data as many times as he/she desires once successfully login. The VI must provide means to

toggle between these options (Back to Main Menu Button) in each of these options.

7. Once the STOP option is activated, the VI stops execution and must disable the options mentioned in step 6 and enable the Login option.

Some of the limitations of our remote control VI are as follows:

1. The text files generated by the Coordinate Calculation VI and Acquire Data VI are saved on the server and are not available to the client computer. The client can only view the results. This is because of the limitations of the LabVIEW front panel and can be overcome by incorporating Data Socket capability to our remote control VI. The other way to accomplish this task is to through File Transfer Protocol (FTP).
2. The server must have multiple licenses of LabVIEW front panel and real-time engine from NI to handle multiple clients.
3. The VI must be running on the server for the client to access it otherwise the client will get an error message "The requested VI is not loaded to server memory".
4. The client will not be able to see an image of the experiment being controlled remotely as our VI currently does not have the image acquisition provision.

4. CODE TO ACTIVATE LabVIEW FRONT PANEL WITH TIME AND FRONT PANEL OF SOME OF THE COMPONENT VIs IN MENU1 VI

A. Code to activate LabVIEW front panel with time stamp.

The code shown in Figure 2 is used to activate the LabVIEW front panel with time stamp. The code shown in the shaded region is a Java Script code for time stamp and other part of the code is used to activate LabVIEW front panel.

```
<SCRIPT LANGUAGE = "JavaScript">
function Timeoutfunc()
{
    timeout = window.setTimeout("Timeoutfunc()", 1000);
    var today = new Date();
    document.forms[0].elements[0].value = today.toString();
}
</SCRIPT>
<body bgcolor = "yellow" onload = "timeout =
setTimeout("Timeoutfunc();",1000);">
<center>
<form>
<input type = "text" Name = "disp" value = "" size = "30">
</form>
</center>
</body>
<OBJECT ID= "LabVIEWControl"
CLASSID="CLSID:A40B0AD4-B50E-4E58-8A1D-
8544233807AA"
WIDTH=300 HEIGHT=300>
```

```

<PARAM name="LVFPVNAME" value="menu1.vi">
<PARAM name="server" value="http://167.7.160.211">
<EMBED>
SRC="http://167.7.160.211/LV_FrontPanelProtocol.rpvi"
LVFPVNAME="menu1.vi"
TYPE="application/x-labviewrpvi" WIDTH=300
HEIGHT=300>
</EMBED>
</OBJECT>

```

Figure 2 – Code to activate LabVIEW front panel with timestamp.

This code must be saved as a Hyper Text Markup Language (HTML) file in the WWW directory in LabVIEW 6.1. For our VI we have saved this code as Menu1.html. The user provides the server IP address/host name with the html file name in his/her browser to activate the front panel as shown below:

<http://X.X.X.X/menu1.html>, X.X.X.X is the IP address of the server for remote access.

B. Front Panel of Login VI

The front panel of the Login VI is shown below in Figure 3. This figure consists of two views, one prompting the user to enter the client number and the other displaying the login status.

Figure 3 – Front Panel of Login VI

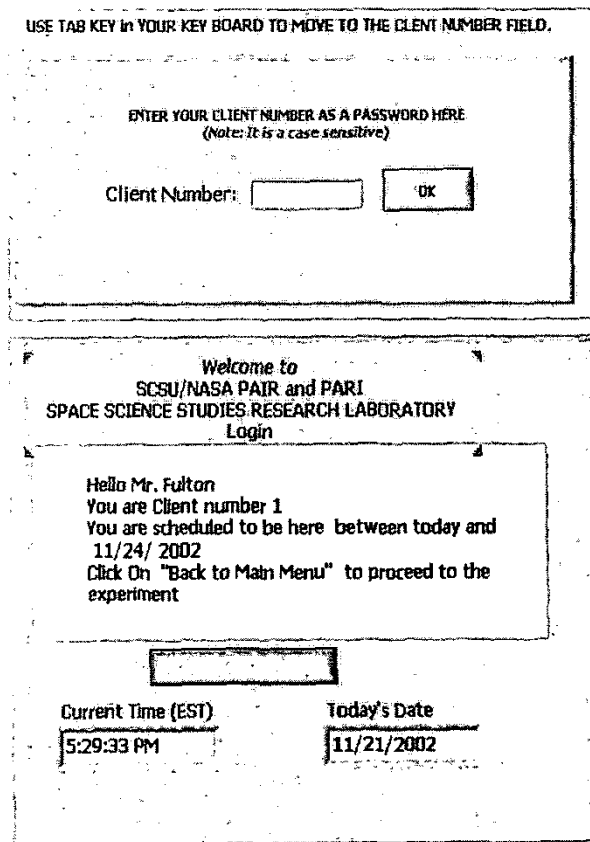


Figure 4 shows a sample "clientlist.txt" file. This file consists of the client ID, Name, an index number or client number, and the time period allocated for experiment. The names in this file are the names of some of the individuals who are involved in some way with this project.

```

706191C,Mr. Fulton,1,11/24/2002
716919H,Mr. Garrett,1,11/24/2002
765640I,Ms. Tucker,1,11/24/2002
123456S,Dr. Swain,1,11/24/2002
768931A,Dr. Basher,2,7/31/2002
774339N,Dr. Payne,3,7/31/2002
743560H,Dr. Walter,9,7/31/2002
734956S,Mr. Sadighi,4,7/31/2002
968141E,Dr. Inmiss,2,7/31/2002
944859O,Mr. Arnette,3,7/31/2002
933740J,Ms. Beharry,4,7/31/2002
928346M,Mr. Brown,3,7/31/2002
937751P,Mr. Cohen,2,7/31/2002
567459F,Ms. Ingram,4,7/31/2002
456430U,Ms. Jenkins,3,7/31/2002
879546R,Ms. Nesbit,4,7/31/2002
567781N,Mr. Raju,3,7/31/2002
793461D,Ms. Terry,2,7/31/2002

```

Figure 4 – Clientlist file

C. FRONT PANEL OF CALCULATE COORDINATE VI

The front panel of Calculate Coordinate VI is shown in Figure 5. This VI uses number of equations provided by physics faculty at SCSU to perform the calculations.

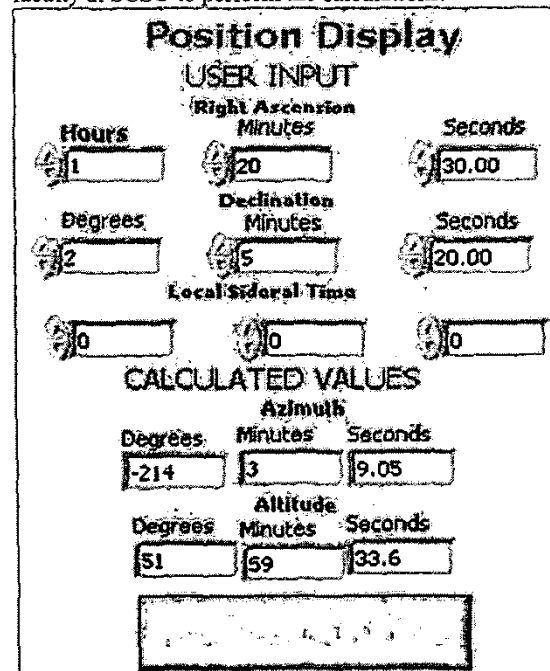


Figure 5 – Front Panel of Calculate Coordinates VI

This VI also saves the calculated parameters in two files named "Azimuth.txt" and "Elevation.txt". The contents of these files are displayed in Figure 6.

-214.000, 3.000, 9.053 – Azimuth.txt
 51.000, 59.000, 33.628 – Altitude.txt

Figure 6 – Contents of calculated parameter files

D. ACQUIRE DATA AND ANALYZE DATA

As mentioned earlier, the position dish and acquire data part of our MENU VI is developed by another group of students and faculty involved in this NASA/PAIR project. We are unable to provide the front panel of that VI. But we tested our remote control VI using a simple data acquisition VI named Ohms Law VI. The front panel of that VI is presented below in Figure 7.

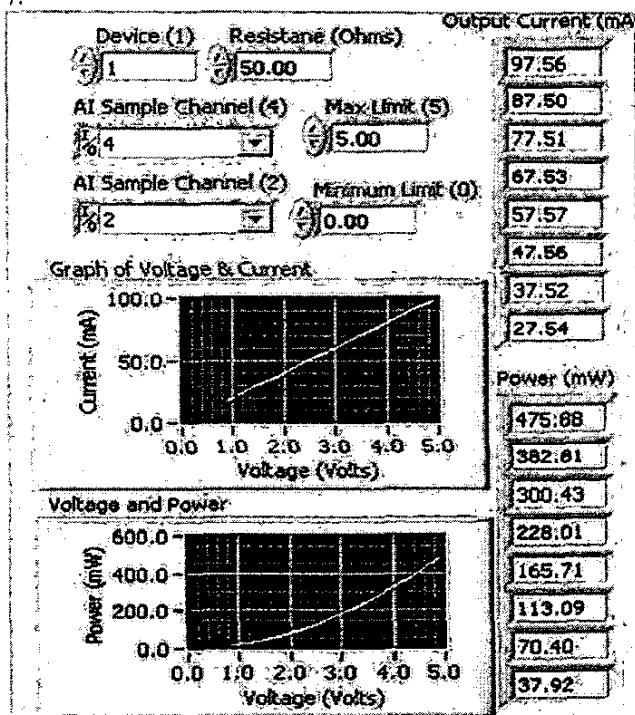


Figure 7 – Front Panel of Acquire Data and Perform Analysis VI

This VI also creates a spreadsheet file named "Ohms.txt". The contents of this file are presented in Figure 8.

Volts	mA	mW
4.878	97.559	475.884
4.375	87.500	382.812
3.876	77.515	300.426
3.376	67.529	228.010
2.878	57.568	165.706
2.378	47.559	113.091
1.876	37.524	70.404
1.377	27.539	37.920
0.878	17.554	15.407

Figure 8 – Contents of spreadsheet file "Ohms.txt"

5. CONCLUSION AND DISCUSSION

The combination of virtual instruments and the Internet can create more powerful, flexible, and cost-effective instrumentation systems. Some of the advantages and applications of the Internet Based Virtual Instrumentation are as follows:

- Move information rapidly from source to destination.
- Remote Monitoring and Control
- Collaboration with other researchers
- Distribute Computing.

Some of the limitations are:

- System may fail to deliver if the network is down.
- Information may be contaminated due to viruses.
- Competitors may steal information by tapping into the network.
- Remote access may not be possible if the system is in side a "firewall" and the appropriate port(s) must be opened for remote access.

Proper network design and user training can adequately address these limitations.

VI based instruction will provide a truly modern environment in which students and faculty members can study engineering, technology, and sciences at a level of detail, and this will be possible because of the versatility of LabVIEW and other products from NI. The Internet based Virtual Instrumentation using front panel and real-time engine of LabVIEW will assist us to provide laboratory experience for our off campus graduates.

6. ACKNOWLEDGEMENTS AND SCOPE FOR FUTURE WORK

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We plan to incorporate the following provisions to our VI in future:

1. Data Socket and FTP provisions to save files in the client machine generated by the VI.
2. Real time image acquisition using Web camera and web camera software.
3. Increase number of licenses and made this VI available in the web for experimentation by other academic institutions.
4. Modify and use this VI to perform remote experiments on various engineering, technology, and science subjects.

7. **REFERENCES**

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