Computer Based Virtual Engineering Laboratory (CBVEL) And Undergraduate Engineering, Technology & Science Research

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I Introduction

Advanced electronics and computerization are revolutionizing today's industries and the engineering technology and science programs are under pressure to modernize their programs to meet the challenges of this changing technology or to maintain the accreditation of the programs. This requires upgrading laboratories with modern equipment and calls for increased funding and resources. But in recent years there is an increase in enrollment and decrease in resource allocation making it increasingly difficult to modernize the laboratories to provide adequate levels of laboratory and course work. This calls for alternate innovative and cost-effective solutions such as Computer Based Virtual Engineering Laboratory (CBVEL). At South Carolina State University (SCSU), the PC and Virtual Instruments (VI) based system concept is used to design and develop a laboratory called Computer Based Virtual Engineering Laboratory (CBVEL). The CBVEL consists of IBM compatible computers with software and hardware from National Instruments (NI), and is connected to School of Engineering Technology and Sciences (SETS) network and existing equipment. This CBVEL can also be accessed from remote sites using Internet.

This CBVEL is also used to conduct research activities related to a NASA funded project grant. This is a multi-year project involving space science related activities, and generally involves the use of a graphical programming language called Laboratory Virtual Instrument Engineering Workbench (LabVIEW) for instrumentation, data acquisition, and analysis. This visualization software allows one to design, build, and test VI modules that are then interfaced with real equipment in the laboratory. The LabVIEW software suite is widely used in industry, government labs, and higher education and is an integral component of this NASA project. More specifically, one of the project activities is to design and develop methodologies for real time control of a space telescope locally and remotely using LabVIEW.

The objective of this paper is to discuss the use of CBVEL to provide inter-disciplinary research experience to engineering, technology, science, and K-12 students during Summer 2000.

This paper is arranged as follows: Section II discusses various components used in CBVEL, and LabVIEW application areas. Section III discusses composition of student research teams and weekly assignments of the student team. Section IV deals with on-going work. Section V presents the conclusion. Section VI presents the acknowledgement and Section VII presents the references.

II. Components used in CBVEL and application areas of LabVIEW

a. Components in CBVEL

The following are some of the components of CBVEL. The major components of this CBVEL are 12 PXI, 166 Mhz computers from NI and 20, 350 Mhz INTEL Pentium computers from Gateway. The PXI systems are industry standard systems with high-speed data acquisition (DAQ) cards. Each PXI system has number slots with Windows 95 operating system. Each PXI system is equipped with NI components such as Function Generator Cards, Multimeter Cards, Oscilloscope Cards, Training Modules, Stepper and Servo Motion Control Cards, Virtual Bench Software, IMAQ Vision Cards, Field Point Dist. Systems (distributed computing), and Switches.

b. Application Areas of LabVIEW Software[1]

The following are some of the application areas of LabVIEW:

Simulation; Data Acquisition; 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; Object oriented/graphical programming; Fuzzy Logic; Genetic Algorithm; and Joint Time and Frequency Analysis. Many industries, academic institutions, and federal agencies such as DOD, DOE, and NASA use it.

III. Student Research Teams and their Weekly Assignments

One of the unique aspects of this project is the cross-departmental student research team that will work together for a full year under the supervision of a faculty member on topics with ties to space science. Each team will have at least one student from each of the three departments (Engineering Technologies, Mathematics and Computer Science, and Physical Sciences). Each student team is required to give several presentations about their project, including one on campus to the student body as well as at a professional meeting. Four teams of four/five students each began their research during the summer of 2000. The student teams spent the entire summer 2000 (8 weeks) in getting extensive exposure to its use and application in our mathematics, science, and engineering technology (MSET) courses as well as in laboratories. The following sections present a brief overview of the work completed by the student team.

A. *Exposure to LabVIEW* [2, 3,4,5]

As mentioned earlier one of the major components of this project is the use of LabVIEW, and each project participant must have some experience with the use of LabVIEW to successfully complete the project mission. Every year the faculty mentors will use the first eight weeks of the project to introduce the team to the basics of LabVIEW. Also during this period the project PI will arrange a two to three day LabVIEW workshop to introduce the project participants to advance topics in LabVIEW. During the summer of 2000, we had a three day advanced LabVIEW workshop. The following is a list of items that were covered during this period:

1. LabVIEW Environment

   The participants were introduced to toolbars and tools palette, menus, different objects and editing different objects, text, labeling, wiring, and saving VI to the library file.

2. Creating and Troubleshooting a VI

   The participants were introduced to viewing a VI, creating a VI, creating Icons and connectors for a VI, Data types, representation, precision, and troubleshooting a VI.

3. Structures

   The participants were introduced to repletion structures such as While Loop and For Loop, the Shift Register, selection structures such as If/Else and nested If/Else, case structure such as Boolean case structure and Numeric case structure, sequence structure and formula node.

4. Arrays

   The participants were introduced to one-dimensional and two-dimensional arrays, array functions such as max and min, array size, build array, index and transpose 2D array, and array subsets.

5. Charts and Graphs

   The participants were introduced to waveform graph, X-Y graph, and waveform chart.

6. Strings

   The participants were introduced to strings, string controls and indicators, string functions, string subset and string length, concatenate strings and other string functions.

7. Files

   The participants were introduced to reading from a file and writing to a new file and to an existing file, reading from a spreadsheet file and writing to a spreadsheet file.

8. Data Acquisition

   The participants were introduced to different data acquisition VIs.

B. *Mini projects and exercises*

The team members were exposed to all of these through suitable mini projects and exercises. Here is a list of some these mini projects and exercises:

1. Design a calculator VI to perform Addition, Subtraction, Multiplication, and Division of two numbers.

2. Modify the calculator VI to incorporate a menu with Addition, Subtraction, Multiplication, and Division as menu items. Also, the VI must address the "Division by Zero" scenario.

3. Design a VI to display and plot Y for the following equation:

   $Y = 3X^2 + 2X + 5$, as X changes from 0 to 20 in increments of 2. Use a waveform graph to plot X Vs Y.

4. Modify the above VI so that the user provides the initial value, final value, and increment for X. Also use a X-Y graph to plot X Vs Y.

5. Design a VI to solve the following quadratic equation:

   $AX^2 + BX + C = 0$. The user provides the values of A, B, and C. Your VI must display both real and complex roots. It must also address the "division by zero" scenario.

6. Design a VI that solves for voltage, current, and power in a

   a. DC Series Circuit b. DC Parallel Circuit c: DC Series-Parallel Circuit

7. Design a VI to study the frequency-response of a

   a. Series R-L-C Circuit b. Parallel R-L-C Circuit

8. Design a VI to study

   a. Charging and Discharging of a capacitor
   b. Growth and Decay of current in an inductor

9. Design a VI to simulate

   a. Amplitude Modulation
   b. Frequency Modulation

10. Design a VI to simulate

    a. Number System Conversions

b. Truth Table of Logic Gates
c. Combinational Logic Circuits

11. Design a VI that acquires two channels of data and stores the data to a spreadsheet.

12. Design a VI that opens the spreadsheet file, retrieves the data, and displays the data on waveform graph.

13. Design a VI to control a small DC motor using Pulse Width Modulation technique.

14. Design a VI to control a stepper motor.

All these VIs were constructed and tested in the laboratory. We are unable to provide it here because of the page limitations. However, we will be glad to present few of them during our conference presentation.

C. *Team Presentations to K-12 community*

The team presented their work in local conferences. We are glad to say that one of their presentations received a second prize in a local conference. They also demonstrated their work to third graders, fifth graders and seventh graders to simulate their interest in math, science and engineering technology. The teachers and students liked the presentation/demonstration to the K-12 community.

IV. On-going Work

The student team is currently working on VIs related to Internet. We plan to use these VIs for remote control, data acquisition, and distributed computing. The team plans to complete most of them by the end of Spring 2001. Here is a list of few of these VIs:

1. TCP/IP and IP addressing
2. Client-Server VI
3. Accessing a VI over the WEB
4. Controlling a VI over the WB
5. Design a WEB page using LabVIEW
6. Deign a VI to control a Robot

V. Conclusion

The Computer based Virtual Engineering at South Carolina State University, once fully developed, will be one of its kind in the State of South Carolina. It 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. LabVIEW is based on graphical programming. Graphical programming is easy to use, as the user does not have to remember or write the code. He or she simply manipulates the objects or icons on the computer’s screen. A number of software packages are currently being used in engineering, technology, and sciences curriculum. This creates a problem for the student and faculty. This also creates problem for upgrading and maintenance. LabVIEW has features and VIs identical to most of the features found in all these software packages. Therefore, one can use LabVIEW only to address the needs of various courses. This will be beneficial for students and faculty and introduce standardization across the curriculum.

VI. Acknowledgements

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VII. References

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