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Design and Implementation of Visible Spectrophotometer Virtual Instrument Based on LabVIEW 8.0

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A chemical virtual instrument system of visible spectrophotometer is developed based on LabVIEW 8.0 with 723A spectrophotometer. This system completed automatic data collection, saving, display momentarily, results generation, *etc.* It not only avoids the tedious manual work, data processing and man-made error, but also improves the efficiency and veracity of determination. Experiment says that LabVIEW, as a virtual programming language, has a unique advantage in the development of virtual instruments, such as the compendious method of graphical programming approach and the special function in LabVIEW program. This virtual instrument is applied to evaluate the iron, chromium and phosphorus contents in feed.

Key Words: Virtual instrument, Serial port, Spectrophotometer, Feed.

INTRODUCTION

Virtual instrument is the combination of modern electronic technology, sensor technology, measuring instrumentation and computer technology. It is the hotspot of current automatic measurement and will be a new direction in development of future instrument technology[1]. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is an excellent platform in developing virtual instruments designed by national instruments. It has been widely used in the field of automated methods and management.

Visible spectrophotometer is a colorimetric analytical instrument commonly used in many fields like medicine, agriculture, *etc*. However, most of the traditional instruments can do some simple data processing computing, which is time-consuming and have lower operational capability. That does not satisfy the researchers who need depth data processing fleetly and correctly during the experiments. A chemical virtual instrument system of visible spectrophotometer is designed with a conventional visible spectrophotometer based on LabVIEW 8.0 and it realizes data acquisition, data saving and data processing, result generation automatically. The visible spectrophotometer type 723A is connected with computer through serial interface. This virtual instrument system has a huge advantage, such as friendly data interface, good video text, easy operation, *etc*. Thus it enhances and expands the function of conventional visible spectrophotometer. In virtual instrument system, hardware is with responsibility for input and output of signals. Software is the key and with the change of software, the function of virtual instruments change, when the hardware configuration is defined. That is, "The soft is the instrument"[2]. This virtual instrument system can also be applied to the test of other samples, if some necessary modifications are made.

EXPERIMENTAL

This virtual instrument is composed of 723A spectrophotometer and computer. Spectrophotometer gets the signal of absorbency and converts it into electric signal. The A/D conversion is done by SBC and then signal can be transported into computer *via* serial port. Data acquisition, display, processing and result generation would be finished by virtual instrument in LabVIEW 8.0 workstation. The structural illustration of this virtual instrument is shown as Fig. 1.

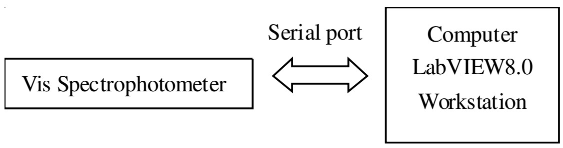

Fig. 1. Structure of virtual instrument

RESULTS AND DISCUSSION

Programming of main operation desk: Considering the practical applications, it often required to make colorimetric determination with different elements in same sample. Virtual instrument system should have the function of automatic data acquisition, automatic identification and data storage, data processing, results generation and so on. At the same time, it should be user-friendly operation. Programming start, the user's main operation desk of visible spectrophotometer virtual instrument based on LabVIEW 8.0 is shown as Fig. 2. Event structure is adopted in this programming[3]. The block program, shown as Fig. 3, contains one main virtual instrument, 5 sub-virtual instruments and some other program. Time automatically display is achieved through the function of get date/time in seconds. Click button on the main operation desk to start the corresponding sub-virtual instrument, at the same time, user's operation desk switches to the corresponding operating panel.

Programming of data acquisition and real-time display: RS-232 serial port realizes the communication between 723A visible spectrophotometer and computer. This serial communication follows the following protocol: asynchronous communication, one start bit, eight data bits, one stop bit and no parity check, baud rate 9600 b/s, ASC data transmission model. Fig. 4 shows the program of data acquisition and real-time display. In programming of data acquisition, VISA nodes are used to achieve VISA initialization, VISA read, VISA close and so on. The VISA configure serial port initializes the serial port specified by VISA resource name to the specified settings. The VISA class you wire to the VISA resource name input determines the polymorphic instance to use. The users can choose the right serial port on the operation panel of data acquisition. The measurement of standard solution and sample could be separated using case structure. While the data were collected, call function template → file I/O sub-template → write to spreadsheet file. Virtual instrument to save data to the hard drive. Save path is designated through function template → file I/O sub-template → open/create/replace file. Virtual instrument, which is settled in case structure shown[4] in Fig. 4.

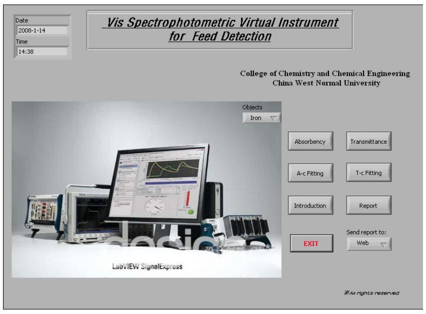

Fig. 2. Main operation desk

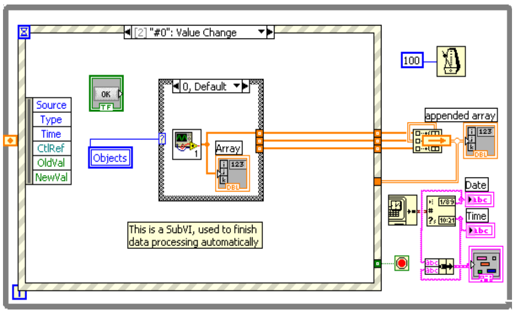

Fig. 3. Block diagram of main operation desk

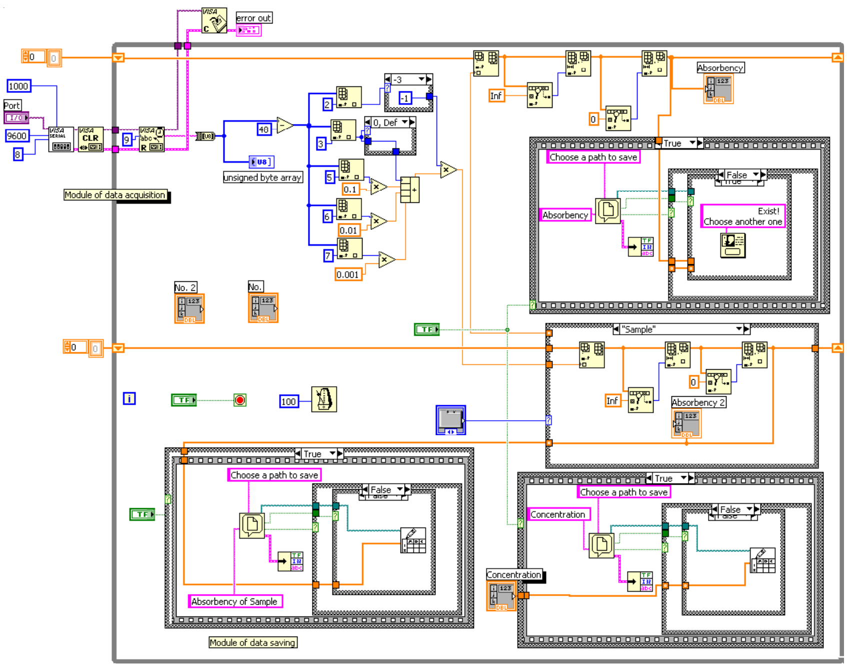

Fig. 4. Block diagram of data acquisition and displaying

Program of data processing and results display: Click the "A-c fitting" or "T-c fitting" on the main operation desk of this virtual instrument, enter data processing panel (Fig. 5). File paths selection through controls template → modern controls template → string and path template → file path control. XY Graph control real-time display of data collected and the value of the cursor will be displayed in the cursor legend. Click "equation", a linear equation will be given based on the relationship between concentration and absorbance or transmittance saved in data acquisition module. Click "curve", two curves appear in the XY graph control, the red one is the original curve according to experimental data and the green one stands for the fitted line. Data reading is done by calling function template → file I/O sub-template → read from spreadsheet file. Virtual instrument which reads specified numbers of lines or rows from a numeric text saved in module data acquisition. Automatic display of data is completed in the control of XY graph and in the "linear fitting" module, an ideal line will be fitted and the correlative attribute will be calculated. Linear fitting is finished by calling functions template → mathematics sub-template → fitting sub-template → linear fit. Virtual instrument (Fig. 6), which returns the linear fit of a data called by file path control using the least square, least absolute residual or bisquare method and the standard deviation will be calculated at one time[5]. Fitting equation is composed of string data, transformed from number obtained in data acquisition module, using concatenate strings node. The operation panel of data processing and result display is shown in Fig. 5. The block diagram of is illustrated as Fig. 6. The program is constituted mainly by while loop, for loop, case structure, event structure, formular node and sub-virtual instrument, *etc*. The protraction of "curve", calculation of concentration of samples and report generation will be completed in this platform.

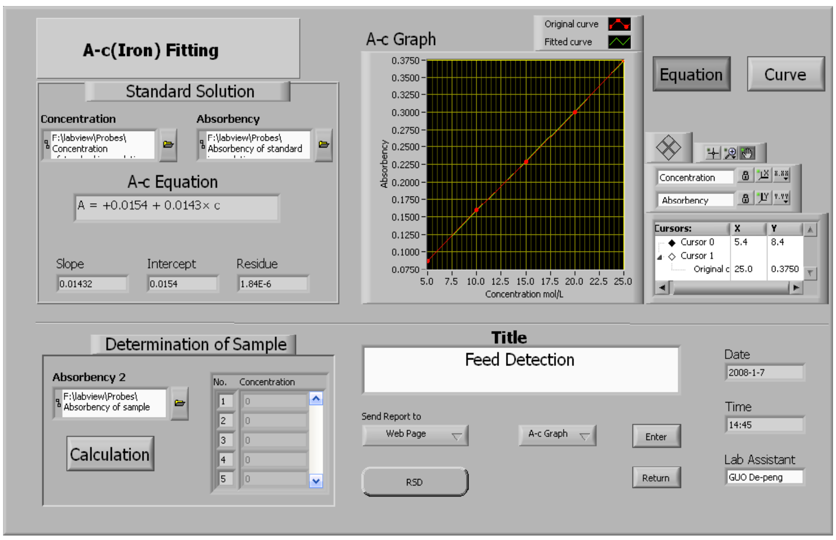

Fig. 5. Operation panel of data processing

In "calculation of the concentration of analyte" module, call the data of sample saved in data acquisition sub-virtual instrument through file path control, click "calculation" and then the concentration of analyte can be calculated according to the fitting equation. Read from spreadsheet file. Virtual instrument function achieves data reading and the calculation is completed by calling functions template → programming sub-template → structures → formula node, which evaluates mathematical formulas and expression. In this node, the formula is the fitting equation obtained in "working curve" module[6], programming of which is shown in Fig. 6.

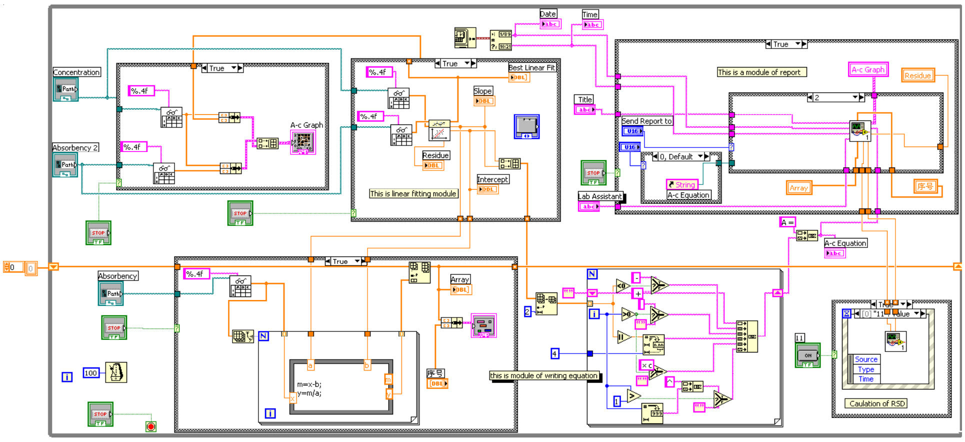

Fig. 6. Block diagram of data processing

In the data processing panels (Fig. 5), experimental report can generate automatically. Menu ring provides styles of report, such as "report preview", "print report" or "print front panel" and so on. The experimental results include graphics, equations, both standard deviation and concentration. In addition, the system can also provides HTML file report of specified data, thereby the HTML document can be directly sent to internet[7]. Thus test system realizes the connection between instrument and network. A total test report would be generated in the main operation desk. Sample ingredients and their contents would be shown in this report. The program of report generation, shown in Fig. 7, calls some functions in functions template → programming → report generation template, such as print report. Virtual instrument, printing a standard or HTML report to a designed printer or to the default printer on the computer.

Application

Determination of iron, chromium, phosphorus in animal feed: Animals need for a variety of mineral elements in the growth, therefore feed detection becomes the major task of feed quality inspection departments. The contents of iron, phosphorus and chromium in animal feed are detected using visible spectrophotometer virtual instrument consulting corresponding reference literatures. The automatic data acquisition, display and processing and result generation have been realized in this experiment.

The working curve of the iron standard solution, shown in Fig. 5, is generated by this virtual instrument according to the previous reports[8,9]. The fitting equation, automatically generated by this system, is: A = 0.0154 + 0.0143c (μg mL^{-1}), where c stands for the solution concentration and A is the solution absorbency. Standard deviation is 1.84×10^{-6}. The detection of phosphorus is made by early report[10] with standard solution of potassium dihydrogen phosphate and with vanadium ammonium molybdate as reagent. The working curve could be drawn automatically. The fitting equation is: A = 0.0223 + 0.0766c, standard deviation of which is 8.613×10^{-5}. The evaluation of chromium is carried out using method 2 of reference[11]. The relationship between concentration and absorbency of chromium is as follow: A= -0.0007 + 0.637c and the standard deviation is 6×10^{-6}. Result of experiment is shown in Table-1.

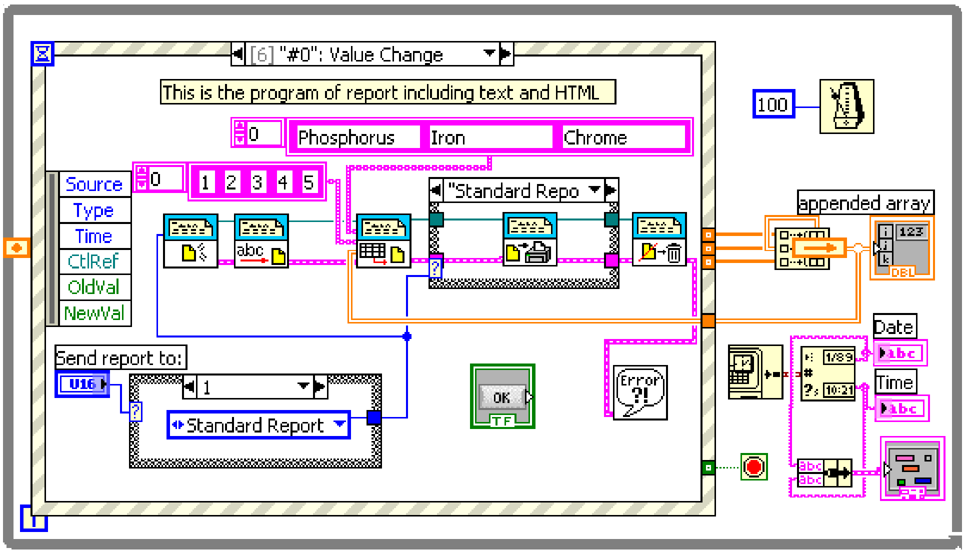

Fig. 7. Block diagram of report generation

TABLE-1
BLOCK DIAGRAM OF DATA PROCESSING

	Iron			Phosphorus			Chromium		
M	4.9672	4.9672	4.9672	4.9785	4.9785	4.9785	1.681700	1.528000	1.302600
A	0.2660	0.3870	0.5090	0.2640	0.3500	0.4360	0.012000	0.011000	0.009000
F	0.8800	0.8700	0.8700	0.1060	0.1070	0.1080	0.000119	0.000120	0.000117
A	–	0.8730	–	–	0.1070	–	–	0.000119	–
RSD	–	0.6600	–	–	0.0090	–	–	1.280000	–

*M: mass (g), A: absorbency, F: fraction (%), A: average (%), RSD: relative standard deviation (%).

Conclusion

Determination of mineral and trace elements in feed is completed using visible spectrophotometer virtual instrument, which expands the function of conventional instrument, improves the accuracy of experiment and saves time. The data of experiment can be stored or printed *via* text and can be sent to the internet. This virtual instrument is user-friendly operation and the result is reliable and accords with the state standards.

To sum up, visible spectrophotometer virtual instrument test system not only has the advantages of easy operation, friendly man-machine interface and other features, but also simplifies the experimental process to avoid the cumbersome manual calculation and larger man-made error. Virtual instrument is a breakthrough in the data processing, display, transmission, storage and other aspects. It realizes the real-time data acquisition and display, completes the automatic processing of experimental data and results generation. This system can generate executable file through the build executable wizard tool in LabVIEW so that it will become an ordinary application and stay working order in any personal computer. This is the best of both worlds: students get hands-on experience with the equipment without being burdened by hand recording of data. Therefore the development of this virtual instrument has great practical value. Whether in college teaching or in agricultural and industrial testing, this system can be widely used.

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