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LabVIEW™

Automating a Capillary Electrophoresis DNA Spectrometer with LabVIEW

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The Challenge: Automating a commercial DNA-sequencing capillary electrophoresis spectrometer.
The Solution: Using LabVIEW to create a multitasking, multithreaded graphical interface for controlling the instrument.

Introduction

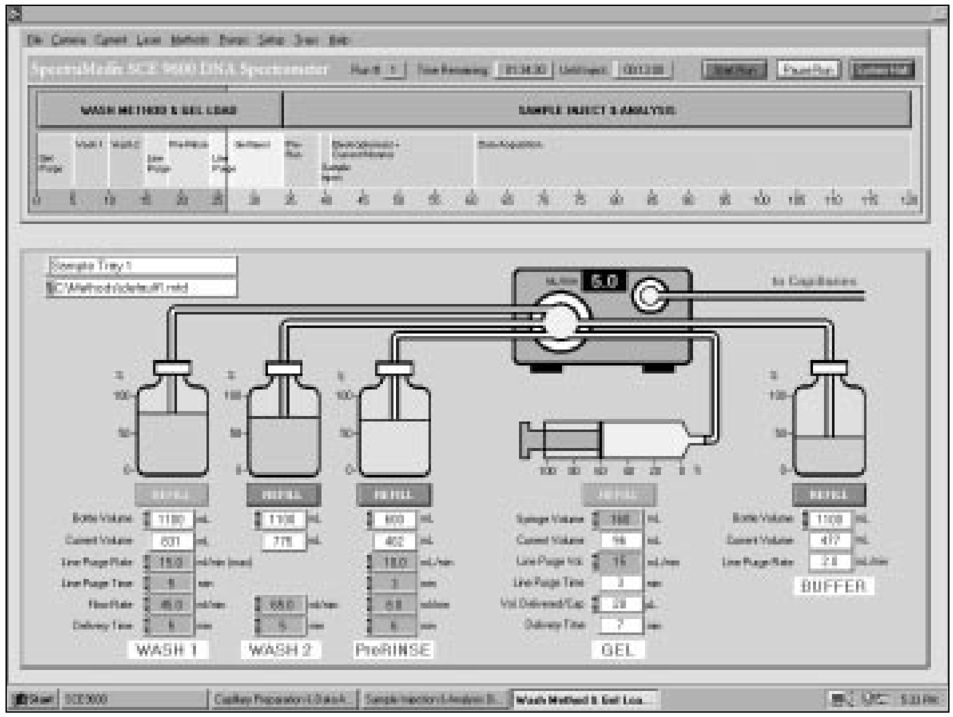
SpectruMedix Corporation entered the genomics instrumentation industry when it introduced the SCE 9600, a capillary electrophoresis, laser-induced fluorescence DNA-sequencing spectrometer based on innovative technology developed under DOE and NIH grants at Iowa State University.

In capillary electrophoresis for DNA sequencing, there are several steps required to properly condition a capillary array:

- Load the capillaries with gel medium
- Introduce the DNA sample to be separated
- Monitor the system
- Collect fluorescence emission data from a charge-coupled device (CCD) camera

Though many steps are sequential, many must be simultaneous.

Besides tools for a rich graphical user interface, we needed a flexible rapid-development software environment. Although we began the project using C++, we quickly switched to LabVIEW because it was obvious that with it we could achieve our design goals more effectively and more efficiently.



LabVIEW Screen Showing the Timeline (top) and Wash Method and Gel Loading Display (bottom)

Software

Our software design goals included user configuration of instrument parameters, logging details of the procedures performed, manual control of the instrument for setup and tuning, and configuration of all run parameters from stored "method" libraries. To further increase the challenge of this application, we needed the instrument condition and run progress to be visible and understandable at a glance and the user interface to be simple and logical yet attractive and intuitive in presentation. Besides tools for a rich graphical user interface, we needed a flexible rapid-development software environment to accommodate the changes in hardware configuration and features likely to occur during the development phase of the project. Although we began the project using C++, we quickly switched to LabVIEW because it was obvious that with it we could achieve our design goals more effectively and more efficiently.

Control

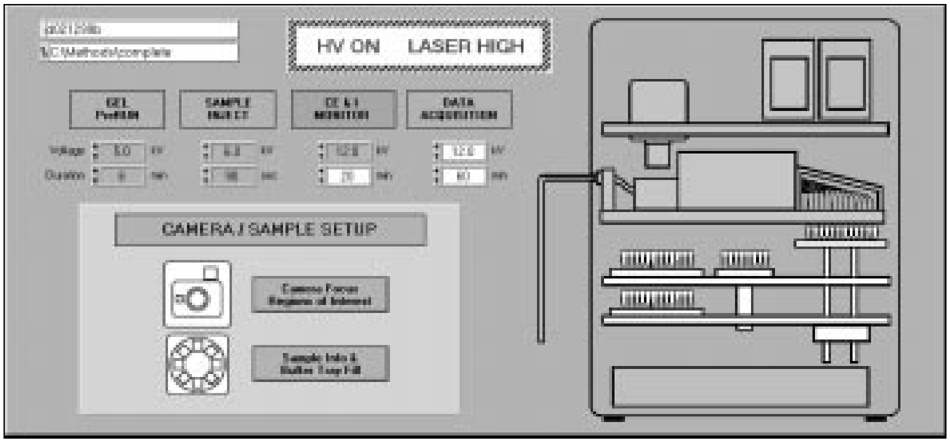
The instrument contains both custom and off-the-shelf parts and subassemblies that require mixed forms of communication for control. Functions such as motion or valve switching require logic level control provided through simple digital I/O. Other control functions require analog levels to set laser power or electrophoresis high voltage. We use the standard RS-232 serial interface to control:

- High-pressure pumps supplying the various liquids and gel media to the capillaries
- The CCD camera monitoring the emitted fluorescence

We acquire image data from the camera through a built-in high-speed parallel interface. We also monitor logic levels and analog voltages. Because each capillary in the 96 capillary array is essentially a separate entity, the SCE 9600 monitors currents individually.

The User Interface

The timeline display at the top of the figure is always visible to the user; it provides at-a-glance information detailing how much time is devoted to each step in the preparation and sequencing process and how much more time is required. The timeline receives run parameter and status information from the other two main displays and orchestrates all



Sample Injection and Analysis Window (Selectively Superimposed over the Wash Method and Gel Loading Display)

We could not have created this application as well or in as short a time with any other software package. Selecting LabVIEW as our software platform gave us the features, appearance, speed, and functionality to quickly and easily do things that would have been very difficult using other software.

instrument functions. Flat buttons depict each step in the timeline. The width and position of the buttons – adjusted in real time with LabVIEW attribute nodes as the user modifies the run parameters – provide immediate visual feedback on how much time is spent in each step and overall run time. The width of an additional dark gray button located behind the timeline depicts elapsed time during the run.

Below the Timeline are the other two main windows, separated to reduce clutter. Separating the two functions in two superimposed windows is logical, because the functions are temporally separate and automatically switch when appropriate. In addition, the user can easily switch between displays manually.

The wash method and gel loading screen, shown at the bottom of the figure on the previous page, contains more flat buttons and modified tank indicators with overlying bitmap images to achieve the custom look of the display. The program uses logic states and color array attributes of the various buttons to depict pump operation and color code the solutions being pumped. The user enters or displays run parameters with standard numeric controls and indicators. As a run progresses through each step, the program disables and grays the controls for completed steps using LabVIEW attribute nodes.

The sample injection and analysis window (the figure above) also uses modified buttons and bitmaps to depict the various motions of the sample handling mechanics in the instrument animation. For example, the program uses text indicators to alert the user of important steps not yet complete; it also selectively reveals or hides text to inform the user of instrument operations or alert the user to safety issues.

The current monitor display depicts current information for all 96 capillaries simultaneously and thus provides early operator notification of run integrity.

An intensity graph depicts all capillary currents by color; the user can also select any capillary of interest for more detailed study. The user calls various other dialogs to:

- Enter operator identification and sample information
- Operate the instrument manually
- Record reagent lot numbers
- Configure the CCD camera

Performance

Each main window runs in its own thread. Additionally, multiple loops run concurrently in the block diagrams to provide independent access to various instrument control or monitoring functions or to update display items. With so many separate threads and operations loading the CPU, we originally thought there might be performance delays. However, we have found the software to be very fast, with no evidence of overloading the 333 MHz Pentium-II PC during even the most data-intensive routines.

Conclusion

We could not have created this application as well or in as short a time with any other software package. Selecting LabVIEW as our software platform gave us the features, appearance, speed, and functionality to quickly and easily do things that would have been very difficult using other software.

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