Studies Using the MATLAB® Data Acquisition Toolbox Bring Researchers Closer to a Cure for Lung Disease

The Challenge

To study the role of the lung in acute respiratory distress syndrome (ARDS) in order to develop protections against the disease.

The Solution

Use MathWorks tools to acquire data and analyze the results of experiments on normally functioning rat lungs.

The Results

- Analysis and visualization of both online and stored data
- Fast and easy analysis of post-experiment data
- Increased probability of lung-disease cure

A research team in the Department of Biochemical Pharmacology at the University of Konstanz, Germany, is performing lung research in order to improve the diagnosis and cure of lung disease. The researchers, Professor Albrecht Wendel, Dr. Stefan Uhlig, and Dr. Michael Wunder, report that using data acquisition and analysis tools from The MathWorks improved their experiments—and their results—"dramatically."

The Challenge

With a surface area about 50 times greater than the surface of the entire body, the human lung is particularly vulnerable to microorganisms, viruses, and other aggressive agents. These attacks commonly cause inflammation, which increases the production of mediators in the lung, frequently resulting in acute respiratory distress syndrome (ARDS).

Researchers needed to study the role of the lung in detail in order to develop effective pharmacological protection against this high-mortality disease.

The University of Konstanz research team needed to study fully operational lungs outside the network of the body. They also needed much more efficient methods for collecting, presenting, and analyzing data than the commonly used statistics and simple linear equations.

The Solution

The researchers focused on rat lungs because both rats and humans suffer from ARDS. Isolating the lungs would enable the researchers to access all the physiological and biochemical parameters of fully functional organs.

For the experiment, rat lungs were removed and then isolated, perfused, and ventilated. The researchers were able to assess lung mechanics, segmental vascular resistance, gas exchange, vascular permeability, and biomedical mediators that contribute to inflammation. Sensors and transducers attached to the lungs monitored pressures, fluxes (both air and liquid), weight, and breath trigger. Temperature and pH values were controlled and recorded separately.

Dr. Wunder used MATLAB®, the Data Acquisition Toolbox, and the Signal Processing Toolbox to develop software to control the experiment and analyze the results.

The setup for the experiment consisted of a National Instruments (NI) E-series data acquisition board with a PC-Pentium II that ran MATLAB under MS-Windows 98. The Data Acquisition Toolbox was used to control and communicate with the NI board and to acquire data from the sensors and transducers.

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"This is software as it should be: highly specialized, easy to use, and with obvious functionality. Such tools allow us to step beyond technical details and focus our attention on the pharmacological and physiological part of the experiment."

— Dr. Albrecht Wendel, Faculty of Biology, University of Konstanz, Germany

To determine pH values and temperature, an RS232 (serial) interface was used to communicate with a pH meter.

Using Guide, an interactive tool for building graphical user interfaces (GUIs) in MATLAB, Dr. Wunder designed a GUI to control the experiment, including the data acquisition portion, and to display data as it was being acquired. With the GUI, just four buttons—*start record pH*, *start acquisition*, *restart clock*, and *quit*—controlled the entire experiment. Applying a GUI front-end to the MATLAB program allowed researchers to collect and analyze results without needing to become involved with the program's details.

Data on air and perfusate fluxes, air and liquid pressures, and pressure differences was recorded from eight analog input channels. Each channel was configured to automatically convert the acquired data to physical units.

The Data Acquisition Toolbox also allowed the researchers to easily send out signals; for example, a deep breath was initiated every five minutes with a digital output using a 0V-5V step.

Data was displayed in five plots: tidal-volume and pressure, air flux and pressure, tidal-volume and time, resistance and time, and spectral density of pressure and frequency. The researchers' MATLAB application generated these plots automatically as the data was being acquired, and the analog input object's `TimerAction` callback function was used to update the display.

To derive the breathing parameters, the differential equation

$$P(t) = k_1 * V(t) + k_2 * \frac{dV(t)}{dt} + k_3 * \frac{d^2V(t)}{dt^2}$$

(with pressure P, volume V, and the parameters k_1: elasticity = 1/compliance, k_2: resistance, and k_3: inertia) was fitted to P-V curves of every breath. Parameters were displayed and stored for later use.

The research provided a better understanding of lung function. In particular, acethylsalicyl acid was identified as an effective protection against acute lung injury (ALI), an early phase of ARDS.

The Results

- **Analysis and visualization of both online and stored data.** Because the Data Acquisition Toolbox is completely integrated with MATLAB, the researchers were able to analyze and visualize the data while they were collecting it and then make iterative updates to the test setup.
- **Fast and easy analysis of post-experiment data.** The GUI built in MATLAB enabled the researchers to perform the final analysis, including printing diagrams and reports, with a simple button-click. "Amazing. I remember how much time I used to spend on that," commented one technician.
- **Increased probability of lung-disease cure.** Understanding the lesser studied functions of the lung has enabled the identification of an effective protection against ALI, the early phase of ARDS. Results from the study continue to be used to investigate potential cures.

Application Areas

Data acquisition
Data analysis
Biomedical

MathWorks Products Used

MATLAB®
Data Acquisition Toolbox
Signal Processing Toolbox

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