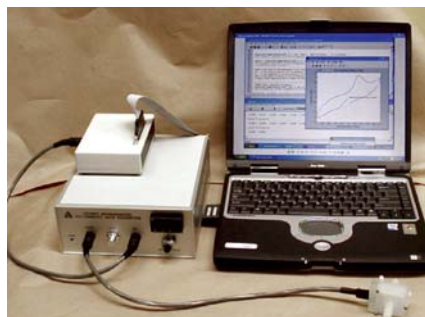


Argonne National Laboratory Develops Sensor for Chemical Agent Detection Using MathWorks Tools

Exposure to toxic chemicals accounts for many respiratory illnesses and deaths each year worldwide. The remedy lies in precisely identifying harmful chemical agents before they are inhaled. With thousands of chemical agent compositions in our atmosphere, however, this is a daunting task.

The Smart Sensor Developer Kit (SSDK), a multiagent chemical microsensor, can identify almost any air-bound gaseous chemical. The award-winning sensor was developed by researchers at Argonne National Laboratory, a U.S. Department of Energy laboratory operated by the University of Chicago, using MATLAB® and related toolboxes.

“SSDK would not have been possible without the integrated environment and toolboxes that we have with MATLAB,” says Dr. Michael Vogt, the SSDK instrumentation developer at Argonne.



The Smart Sensor Developer Kit.

and the chemistry behind the sensor, they needed to avoid developing custom software for each hardware model.

They also needed to filter and classify the acquired data using signal processing and neural network algorithms and develop a graphical user interface for controlling the acquisition process and visualizing the results.

THE CHALLENGE

To develop an instrument to reliably detect and identify gaseous chemicals

THE SOLUTION

Use MATLAB and related toolboxes to develop a highly sensitive microsensor that can be incorporated into a wide range of instruments

THE RESULTS

- Measurement software code performance increased by two orders of magnitude
- Research and development time reduced from one year to two weeks
- SSDK recognized with prestigious award

THE CHALLENGE

The Argonne team set out to develop an advanced gas microsensor that exploited a well-established liquid chemical analysis technique. The SSDK would comprise measurement software, a miniature sensing element, and minimal specialized hardware.

The measurement software required complex data acquisition capabilities. Researchers would need to output specifically shaped analog waveforms to excite chemical reactions on the microsensor while simultaneously acquiring chemistry-specific analog data.

The researchers sought support for a variety of PCM, ISA, USB, and external parallel port data acquisition hardware to promote easy adoption of the experimental technology. Because they wanted to focus on the material science

THE SOLUTION

Using MathWorks tools, the researchers developed simple data acquisition code that could access a variety of data acquisition cards. “The Data Acquisition Toolbox allows us to perform a one-time configuration of the hardware,” explains Vogt. “With less than a page of code, I could perform my data acquisition on four different platforms—each one with different hardware.”

The SSDK uses voltammetry, an advanced chemical analysis technique that translates chemical reactions into voltammetric “signature” outputs, enabling the detection of minute quantities of gaseous chemicals—something that was not previously possible.

The researchers implemented gaseous voltammetry using the Data Acquisition Toolbox to output precisely shaped analog

waveforms, each consisting of 100 to 1,000 points of data, and to excite chemical reactions on the microsensor. Using the Data Acquisition Toolbox, they also sampled the resulting signals with an analog input channel. They then used filters from the Signal Processing Toolbox to remove line noise. The resulting signals, or voltammetric signatures, included information that identified the chemicals to which the sensor was exposed.

The researchers used the Neural Network Toolbox to perform pattern recognition and identify the chemicals by comparing their signatures to those in a prestored library.

“With the Neural Network Toolbox, we can take an unknown sample signature, compare it to a signature library, find the best match, and calculate a confidence factor indicating how certain the match is,” Vogt says.

To generate the sensor signal-processing algorithms, Argonne used the Sensor Algorithm Generation Environment (ChemSAGE). This Department of Defense-funded software tool, written in MATLAB, helps sensor researchers code and analyze complex signals from experimental sensors.

To complete their application, researchers developed a graphical user interface in MATLAB that enables users to set voltammetry parameters and visualize the voltammetric signatures. “The application runs easily on any notebook computer,” Vogt says.

Using the MATLAB Compiler, Argonne recoded the MATLAB algorithms in C for execution on popular single-chip microcontrollers.

Argonne’s sponsors plan to develop commercial instruments based on SSDK, including intelligent fire detectors and air pollutant monitors.

APPLICATION AREAS

- Data acquisition
- Data analysis
- Algorithm development
- Test and measurement

PRODUCTS USED

- MATLAB
- Data Acquisition Toolbox
- Signal Processing Toolbox
- Neural Network Toolbox
- MATLAB Compiler

“A scientist needs to focus on science and shouldn’t have to recreate or debug math libraries or support code. MathWorks tools are proven, so researchers can concentrate on new algorithms and new approaches.”

Dr. Michael Vogt, Argonne National Laboratory

Doctors Michael Vogt, Laura Skubal, Erika Shoemaker, and John Ziegler developed the SSDK. Vogt, Dan MacShane, Christopher Klaus, and Maria Poulos developed the measurement and ChemSAGE software.

THE RESULTS

- **Measurement software code performance increased by two orders of magnitude.** Early-generation measurement software voltammetry code written in another commercial product executed in approximately 20 seconds. The new measurement software code, written with the Data Acquisition Toolbox, can execute the same functions in as little as 0.25 seconds.
- **Research and development time reduced from one year to two weeks.** “It took me six months to write the original software in another language and another six months to interface it to MATLAB,” Vogt says. “I was able to duplicate all of that functionality within two weeks with the Data Acquisition and Neural Network toolboxes.”
- **SSDK recognized with prestigious award.** Argonne’s active microsensor technology received a 2002 R&D 100 award, which recognizes the year’s 100 most significant research projects.

To learn more about Argonne National Laboratory, visit www.anl.gov

www.mathworks.com