objects. Zenie's definition seems as good as any: "Robotics extends programmable computers to allow computers to do physical work as well as process data." Laboratory robots at the Pittsburgh Conference divided into those bearing some resemblance to the familiar industrial robot arms that have pivoting and rotating motions and those with a simple *x-y-z* motion and a more specialized function.

In the former category were Zymark, Perkin-Elmer (Norwalk, Connecticut), Johnson Scale Company (West Caldwell, New Jersey), and GCA/Instruments and Control Group (Chicago, Illinois), while Cavro Scientific Instruments, Inc. (Sunnyvale, California), Gilson Medical Electronics, Inc. (Middleton, Wisconsin), the Hamilton Company (Reno, Nevada), and Tecan U.S., Ltd. (Chapel Hill, North Carolina) showed instruments of the latter type. Finally, Perkin-Elmer and the Varian Associates Instrument Group (Sunnyvale, California) added robot arms to autosamplers.

In the former category, Zymark is the trailblazer with its Zymate system. The company designed a robot arm from scratch with characteristics appropriate for the rather lightweight physical tasks around the laboratory. The maximum weight that can be lifted is 3 pounds, for example, because company engineers reasoned that a liter of water is the heaviest item likely to be encountered. Similarly, the four basic motions (a rotation around a vertical axis through the base of the robot, a rotation around a horizontal axis along the robot arm, a vertical linear motion, and a horizontal linear motion) were chosen to accommodate common laboratory tasks such as picking up, transporting, and emptying test tubes.

The robot itself does none of the sample preparation steps. For each of these, such as dispensing liquid samples, mixing the samples, centrifuging them, capping sample vials, and so on, the company has devices or stations that carry out these functions. The robot transports samples between the stations and takes them to the analytical instrument. Because the robot is fixed at one spot on the laboratory bench, the arrangement of the stations and instruments is in a circle around the robot, thus accounting for the geometry of the St. Charles fume hoods. The Zymark robot and computer controller costs $19,000, while the various stations range from $500 for a mixer to $4000 for a centrifuge. A typical complete system might total $35,000.

From the prospective user's point of view, a stand-alone robot of whatever

^{252}Cf Plasma Desorption Mass Spectrometer

The first commercial time-of-flight mass spectrometer with a californium-252 plasma desorption source for ionizing large biomolecules was displayed at the 1985 Pittsburgh Conference by Kratos Analytical (Ramsey, New Jersey). The new BIN-10K was designed by investigators at Uppsala University in Sweden and is manufactured by Bio-Ion Nordic AB (Uppsala), a company formed specifically for that purpose. The technology was actually developed in 1974 by Ronald Macfarlane and David Torgerson of Texas A&M University. The delay in bringing it to the marketplace was apparently based on a perception by manufacturers that there was no demand for mass spectrometers that could handle such large molecules.

In the BIN-10K, the sample is deposited on a thin sheet of nickel foil that is then placed close to a small amount of ^{252}Cf. Fission fragments from the radionuclide pass through the nickel foil, creating localized temperatures of 20,000° to 30,000°C for about 10^{-11} second. The high temperatures vaporize ion impurities in both the sample and the nickel, principally hydrogen, sodium, and hydride ions. These secondary ions react with heated sample molecules to produce quasimolecular ions that are accelerated by an electric potential. At a constant potential, the time of flight to the detector is proportional to the mass of the ion. Each ^{252}Cf fission also produces a complementary fission fragment that is detected by a scintillation counter located on the opposite side of the source from the sample. Detection of the complementary particle establishes the starting time for the time-of-flight measurement.

The technique provides an effective way to ionize biological macromolecules with little sample degradation; it thus provides a much more intense peak for the quasimolecular ion than do other sources. The upper limit of the mass range is listed as 15,000 daltons for the BIN-10K, but prototype instruments have recorded masses as high as 23,463 daltons for porcine trypsin. At delivery, the spectrometer is equipped with a source containing 10 microcuries of ^{252}Cf, which should be useful for at least 2 years. The base system for a user who already has access to a large computer costs $120,000; that price includes an electrospray unit for preparing samples. With a complete data acquisition system, the price increases to about $180,000.—**T.H.M.**

New Spectrometer for Remote Sensing

Improvements during the last decade in the ability of optical fibers to carry light for long distances without substantial losses of intensity have provoked substantial interest in the use of such fibers to carry light from a remote sample cell to a central spectrophotometer (*Science*, 26 November 1982, p. 875). Such devices are particularly useful for performing analyses in hazardous environments or for remote monitoring of many sampling stations in a production process, but they are also becoming more useful in laboratory situations where the nature of a sample precludes easy use of conventional techniques.

At the 1983 Pittsburgh Conference, J & W Scientific, Inc. (Rancho Cordova, California), introduced the Focus 2000, the first commercial spectrophotometer for use with fiber optics. A month after the conference, however, the company dropped the instrument, apparently because of high development costs, and no units were ever shipped. Some of the engineers from J & W formed a new company, Guided Wave, Inc. (Rancho Cordova), and developed a completely new spectrophotometer.

The Optical Waveguide Spectrum Analyzer displayed at this year's conference has been specifically engineered for use with fiber optics and can measure absorbance, reflectance, fluorescence, and turbidity at distances as great as 200 meters from the instrument. Wavelengths from 190 to 1800 nanometers can be scanned at rates of up to 9600 nanometers per minute with high accuracy and reproducibility. Optical waveguides transmit signals to and from up to six probes in sequence.

A variety of probes are also available, including a new probe with a sample pathlength as long as 10 meters. The base price for the instrument is about $12,000 without probes; that price includes software that allows the instrument to be controlled by an IBM PC. Probes cost $1,000 to $3,000, and a typical system has a price of about $20,000.—**T.H.M.**

Automated Motion Analysis System

It has always been easy to record on film the trajectories of moving objects, even those traveling at high speeds, but analyzing the motion afterward with computers has presented problems. One traditional method is to digitize and store in the computer memory each frame of the video record. This approach is slow and uses up prodigious amounts of memory space. At the Pittsburgh Conference, a relatively new company, the Motion Analysis Corporation (Santa Rosa, California), demonstrated its first product, the ExpertVision automated motion analysis system, which operates by a different and more efficient principle.

ExpertVision's strategy starts out in the normal way. A video camera and recorder views the moving objects and stores the images frame by frame at a rate (in the standard system) of 60 frames per second. Higher recording speeds are possible, if one is willing to pay for a more expensive camera, and one can also use strobe methods to photograph very high speed events.

At this point, a proprietary video processor determines (by means of an operator-defined criterion, such as the gray level value) the outlines of the moving objects. Only the digitzed outlines are stored in the computer, thereby saving immense amounts of time and memory space. By selecting only the outlines of the moving objects of interest, the imaging processing can take place in real time.

Subsequently, analyses ranging from simple plotting of the objects' trajectories to complex statistical routines can take place completely automatically according to preprogrammed instructions or interactively, with the analyst at a graphics work station. A printer-plotter makes hard copy of anything that can be displayed on the work-station screen from raw data to tabulated results.

Motion Analysis shipped its first turnkey system last August and has four in the field now. Although anything that moves is a candidate for study by ExpertVision, the company plans to concentrate on mechanical engineering and life sciences applications, at least at first. One possibility is the monitoring of water quality by observing the behavior of organisms whose health is affected by pollution. Another possibility comes in the rapidly growing discipline of biomechanics, which plays a role in medical diagnostics, physical rehabilitation, sports medicine, and sports equipment design. For example, a manufacturer of running shoes has used ExpertVision to analyze foot motion in the hopes of designing a better shoe.

Cost of a complete system is $66,900.—**A.L.R.**


Motion Analysis Corporation

ExpertVision

Images recorded by the video camera are displayed on a monitor, while the video processor unit extracts only the information relevant to motion analysis.

An Inexpensive FT-UV/Vis Spectrophotometer for HPLC

The first inexpensive Fourier-transform ultraviolet-visible (FT-UV/Vis) spectrophotometer was displayed at the Pittsburgh Conference by Groton Technology, Inc. (Waltham, Massachusetts). The Groton LC/S is designed specifically as a detector for HPLC, but the company plans to bring out a benchtop model for routine spectroscopy in the near future. The principal advantage of the LC/S as a detector for HPLC is that it scans all wavelengths simultaneously. There is no need to preprogram the detector, specify spectral bandwidths, or set peak detection wavelengths. The output in real time is a full-spectrum composite that ensures detection of any absorbing species.

The starkly designed LC/S comes very close to being the ultimate "black box" spectrophotometer in which samples are fed in and answers pour forth. The key to this simplicity and the low price is the fact that there are no moving parts. Rather than a conventional Michaelson interferometer, the LC/S uses a common path holographic interferometer that relies on slight differences in pathlengths to produce an interferogram. This system requires no subsequent adjustments in pathlength, so the entire spectrophotometer can be constructed very sturdily and the entire optical system sealed to protect the components.

The common path interferometer generates an interferogram in the spatial domain rather than the time domain like the conventional interferometer. The spatial interferogram is then read with a 512-element photodiode array. Output from the array is collected with an EG&G optical multichannel analyzer, which forwards the data to the user's laboratory computer for transformation. The instrument can scan 20 times per second in the wavelength range 200 to 700 nm, but data acquisition can be accomplished in intervals as short as 50 milliseconds to detect and acquire spectra for fast peaks. Some resolution is lost in such fast scans, however. The cost of the system, including the EG&G interface and software for an IBM or Digital Equipment Corporation computer, is about $25,000.—**T.H.M.**