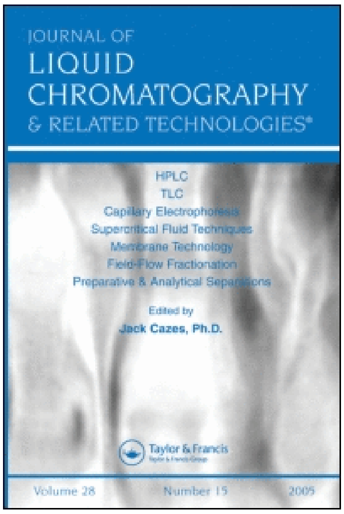

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IMPLEMENTATION OF ROBOTICS WORKCELLS IN THE LABORATORY

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The last few years have seen numerous developments to help laboratory scientists increase their productivity through the use of computers. The newest area of interest is the use of robotics systems to automate the required physical manipulations of certain laboratory procedures. This new technology allows human talents to be concentrated on sample selection and submittal, and scrutiny of the resulting data, rather than monotous tasks that lead to boredom and mistakes. The desired results of this automation are of course better data and reduced costs.

One of the key element in the growth of this new automation area is the recent availability of smaller scale robots suitable for laboratory tasks. A wide variety of dexterities and dimensional accuracies are now available, and most of these robots can be made intelligent by adding sensory inputs from various types of sensors. Implicit however in the wide variety of systems available is the realization that no single robot is the best answer for all automation applications. In the chemistry laboratory, care must be taken to match the capabilities of the robot and its controller to the procedural requirements of each

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case.

Flexible Automation Defined

Commercially available robots are referred to by most engineers as flexible automation devices, as opposed to hard automation manipulators which are single purpose in design and function. An instrument auto loader is an ideal example of hard automation in the laboratory. The robotics industry defines a robot as a multifunctional, reprogrammable device. Several suppliers to the laboratory marketplace are indeed starting to misuse the robotics term; a programmable X-Y automatic dispenser is certainly more flexible than a HPLC autosampler, but it will never be able to open a sample container and weigh out an aliquot on a standard laboratory balance prior to dispensing the required amount of solvent. A flexible robotics system can do all of these and more.

In addition to the standard long-term flexibility concept which is so key to industrial assembly automation, the laboratory provides an excellent environment to utilize robots' short-term flexibility. A properly engineered system can quickly change from one chemical test procedure to another, either with assistance from an operator, or in some cases automatically based on certain key parameters. This changeover capability means that laboratories do not need a single high-volume repetitive task to justify automation; several lower volume procedures can be combined to keep a single robotics system fully productive. Unlike the manufacturing world, there are very few serial assembly line applications in the laboratory; most of the work cells are developed around batch-mode, stand alone operations.

APPLICATION ENGINEERING

A key difference in the robotics industry from the laboratory marketplace is that considerable effort is required after the system is delivered to make the robot perform an application successfully. A few 'canned', 'ready-to-run' procedures are now available from the system manufacturers, but nearly every lab runs a procedure according to its own specifications, so customization is generally required to get the maximum benefits in productivity. The robot and its controller must be engineered to reliably perform a given procedure in a safe and efficient manner, and most manufactures leave this applications engineering role to the end-user's automation staff or to independent systems integrators who specialize in automation engineering.

The industry rule of thumb is that this application engineering will usually cost from one to three times the cost of the robot itself, and this amount can be an even higher multiple for less expensive robots which require additional sensors to perform safely. Peripheral fixing and tooling that allows the robot to perform its tasks make up a large part of this additional cost, the remainder including software to drive the system through its paces and communicate with other devices. There is a tremendous learning curve involved in an application development; often a procedure which is a relatively simple project for an experienced robotics engineer will present an insurmountable problem to a first timer without access to development expertise. Naturally, there is a wide variation in the effectiveness of different applications depending on the skill of the developer.

CELL ARCHITECTURE

As mentioned above, a major task of the implementation project is to design the automation cell so the robot is completely integrated. Whereas early efforts usually involved giving the robot's controller the major role in this integration, the robotics industry is turning increasingly to the cell controller concept. Most robots' controllers (whether they are microprocessors, micro-computers, or mini-computers) have severe limitations when it comes to coordinating digital data to and from multiple peripherals in additional to controlling the motion of the robot. A dedicated cell controller can be a more effective manager of the various periphals, and the robot can be considered a peripheral with its own controller. Figure 1 shows a typical laboratory work cell using this architecture to control a representative group of equipment.

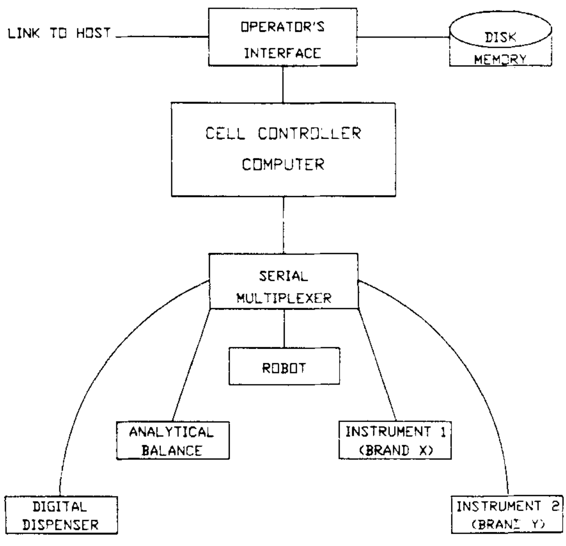

Figure 1. A typical robotic workcell configuration.

IMPLEMENTATION TASKS

Once an application procedure has been selected, preferably from a list of several candidates, the real work begins. The tasks below provide a general framework for engineering a workable solution.

Develop Application Profile including Procedure Protocol

Select Candidate Robot for Application

Desk Top Feasibility Analysis for Chosen Robot

Preliminary Financial Justification

Prototype Analysis to Answer Key Questions

Formal Financial Justification

Develop Production Tooling and Software

Integrate System with Peripherals and Instruments

Test and Debug

Document System (Hardware and Software)

Install System, Train Operators

Maintain and Support System

Most end-users who do their own application development readily admit that it is very easy to underestimate the amount of man-time required to complete the implementation. Quite often, this lack of experience leads to missed deadlines, overrun budgets, and less than adequate systems. The documentation and support areas are often the ones shortchanged in the 'rush to finish', yet these are the most important tasks for a successful long-range implementation.

SUMMARY

The potential for using modern robots to completely automate laboratory operations is now a reality due to the increased availability of suitable flexible automation systems. However, these systems must be engineered to solve laboratory problems by developing peripheral hardware and applications software. This implementation step will usually cost more than the robot itself, and the type of talent required for this development is not available in most laboratories. Until an organization successfully develops these skills, it can use the services of a systems integrator familiar with robotics to implement solutions in a timely and cost-effective manner. Properly engineered applications will produce tremendous benefits for the laboratory manager, not only in reduced direct costs, but also indirect benefits such as better quality and repeatability of results. The most valuable benefits of this flexible automation will become apparent in the long term as it makes it easier for the lab to respond to new methods and changing workloads.