não cerrado staffcpac

LABORATORY AUTOMATION[1]

Ken Taniwaki[2]

1. Background

Cost, quality and market focus are factors that must be managed to optimize production. Research work is a type of production, ie: the production of information, know-how, and new technology. Thus to achieve a high output of good quality products, it is necessary to organize research production systems. Laboratoroy Automation Systems are essential for the development of efficient research activities.

Laboratory Automation has been developed in parallel with the development and improvement of microcomputers. The impact of microcomputers is due to their powerful performance and low cost. The Microcomputer is nothing but a small machine (kids' stuff) but I hope to show how it serves us in the laboratory with an example of part of a Laboratory Automation System that I developed for agricultural machinery testing in CPAC.

2. The importance of performance testing of agricultural machinery in the field

In agricultural production it is as important to minimize the cost of production as in other industries. In order to minimize the cost of production we have to consider the total production system. Machinery, labor, fertilizer, and other chemicals are essential components of production. Climate, soil, and water resources are conditions that cannot be controlled. So we concentrate on the cost of controllable factors. The factor which most affects costs is farm machinery. The cost performance of different size machines in relation to the acreage of a farmstead is shown in Figure 1. For small machines, the initial cost is low, but the most effective cost performance is achieved at the point P1 (in Figura 1); as the acreage increases beyond this point, cost performance will go down and finally, more machines and operators will be required.

[1] Techinical Seminar presented at CPAC in 12/03/1991.

[2] Agricultural Mechanization Specialist, Consultant from EMBRAPA/JICA.

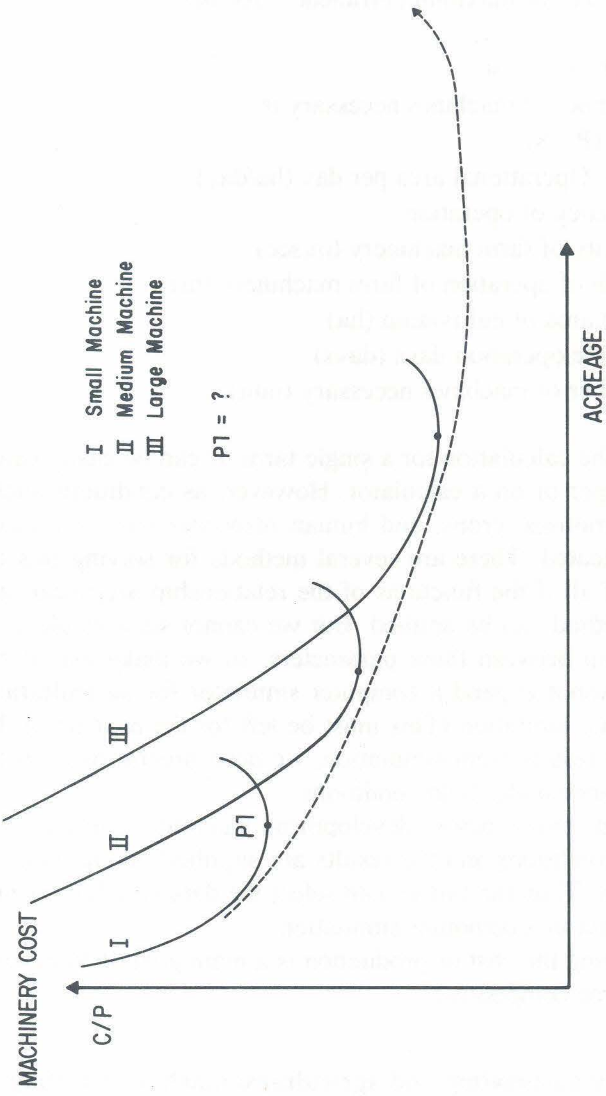

FIG. 1 - The relationship between machinery costs and size of farm for different size machines.

For a given size farmstead one must choose the number and size of machines to be used for maximum efficiency. As an example:

$S = 2.88 . e . v . w$

and Number of machines necessary is

$N = A / (P . S)$

where S: Operational area per day (ha/day)

e: Efficiency of operation

v: Velocity of farm machinery (m/sec)

w: Width of operation of farm machinery (m)

A: Total area of cultivation (ha)

P: Suitable operation days (days)

N: Number of machines necessary (unit)

This is the calculation for a single farm. It can be easily calculated with pencil and paper or on a calculator. However, as conditions such as combination of operations, crops, and human resources vary, the calculation becomes complicated. There are several methods for solving this type of problem. First of all if the functions of the relationship are linear, a linear programming method can be applied. But we cannot set a single coefficient for the relationship between these parameters, so we make use of computer simulation. I cannot expand a computer simulator for agricultural production because of time limitation (This must be left for the next time). But in order to get precise results from simulation, we need precise data on farm machinery performance under field conditions.

In Japan, every newly development machine is tested under several typical field conditions and the results are supplied, along with industry primary test data. Thus the farmer can select the data suitable for his own farm and use the data in a computer simulation.

Minimizing the cost of production is a main goal of Japanese farmers in order to become competitive.

3. Laboratory automation and agricultural machinery testing

There are two phases of agricultural machinery testing. One is laboratory performance testing. This is the test to ensure that a machine is produced as it was designed. We have to test engine power output, gears, wheels etc. This is the responsibility of farm machinery manufature's. The process is fully automated and is called factory automated performance testing. Our responsibility is performance testing in the field.

In the field, tractors should work at, or near, maximum capacity. However, they usually do not perform at full power in the field. The reason is that performance is a nonlinear function of several elements including soil moisture, previous machinery traffic and width and depth of tillage. Performance parameters include: velocity, fuel consumption, load or draw bar draft. To collect these data, several instruments are used. These instruments are combinations of transducers and amplifiers.

All physical parameters are converted into electronic signals by the transducer and amplifier. These data are recorded in the pen recorder, in the case of low frequency signals, or with a galvanometer for high frequency signals. In Laboratory Automation one may use analog to digital converters and personal computers.

This is the starting point for Laboratory Automation (LA). All analog electronic data are changed into computer recognizable digital data. Data recorded are raw and can not be used directly for technical papers. It is necessary to process the data into understandable fashion. In this process, LA has its main role.

4. Laboratory Automation

4.1 Communication

Laboratory Automation is a system that helps us in every phase of research work. Let us think through the flow of research work. At first, we have to read the literature to learn what has been done before, and decide what should be studied. This is the process of literature survey. In LA we can collect any kind of data from the thousands of databases maintained worldwide. We must equip personal computer with psk (phase shift keyed) or fsk (frequency shift keyed) modulator-demodulator (commonly called a modem) and communication software. After surveying the literature, one can request reprints of key papers if necessary, for the authors and their addresses are included in the databases.

4.2 Database

You don't need to develop your own database in order to use a modem. But to concentrate the data in one project, we often do have to develop our own database. In doing so we again need the help of a personal computer. Many other well developed relational and/or card type database management software packages are available in the world market.

4.3 CAD and CAE

In developing farm machinery or other equipment, we first have to design the system. This task is usually done with paper, pencil, ruler, calculator, and drafter. But it can better be done with a personal computer which together with a pointing device (mouse), digitizer and appropriate soft are the modern design tools called "CAD" (Computer Aided Designing). There are thousands of CAD software packages available in the market. Also there are several different types of CADs depending on the purposes. I brought two type of CAD systems to CPAC. One is a general purpose drafting system called "Hanako". Another is CAD for electronic circuit designing.

Once the machine is developed from the design that was produced with the CAD system, we have to test it. After testing the real machine, if it fails to meet specifications (this is a human decision) we will have to develop another prototype. This process of trial and error may result in thousands of useless (junk) prototypes. To avoid this problem, sophiscated CAD systems include simulation programs that can test the design in the computer before building the real machine. These are called CAE (Computer Aided Engineering Systems). As an example, consider the building of a dam in a river. After the structure is developed, we can calculate its strength and duarability with the help of numeric integration methods (FEM Fenite Element Method) or (BEM Boundary Element Method). If the concentration of stress is found to be too large, we will have to change the structure of the dam and calculate it again. By repeating this procedure, we can develop an appropriate structure.

Using CAE systems we can estimate the strength, durability, and vibration of a machine. This is a great advantage. CAD and CAE systems are also used in the design of electronic circuits. The system is powerful enough to develop a complex electronic circuit in a day. There are also several simulators available in the market for circuit designs. SPICE2 was developed in California as a general purpose analog simulator for any kind of semiconductor. SILOS is used for digital LSI. They both are equipped with libraries of a vast range of electronic parts. Standard circuitry is included in these libraries.

Using CAD and CAE systems, we can develop machinery and accumulate and store our knowledge in libraries. This is another powerfull tool to aid in machinery development. One can simply extract devices from personal library to improve machinery or circuitry. These examples show how Laboratory Automation is a powerful tool in the design process.

4.4. Simulator

A computer can simulate the real world. Computer simulators became well known to the public when the first world model was developed by the Rome Club of OECD in 1970. Twenty years have passed, and many computer simulators have been developed. There are also many agricultural simulators. Nowadays these simulators can run on a small lap-top or palm-top personal computer, so even an individual farmer can afford them. But these simulators are specific to a specific area, since agricultural conditions vary from one place to another. It has been concluded that the simulator for the CERRADOS should be developed in CPAC. There are many methods of creating a simulator. It is quite complicated to draw a conclusion because the relationship between agricultural conditions and the conclusion is not linear. So it is important to introduce a method of handling nonlinear functions for agricultural systems engineering. Owing to recent advances in heuristic information processing, we can make some use of Expert Systems. Neural Networks are potentially powerful tools for analyzing agricultural management options. These new tools are also available for the small computers.

4.5 Data processing

Data processors are quite popular. Large volumes of data are produced in our research. These data must be analysed and interpreted before they are published. Data processing is done with personal computers and appropriate software. You are probably acquainted with Lotus 1-2-3, Microsoft Excel, or Mac's Hyper Cards.

The signals of phenomena detected by sensors or transducers include noise. We have to eliminate this noise from the signal through the use of data processing and signal processing. All data should be carefully inspected for important information. The purpose of signal processing is to extract this information from the sea of noise which accompanies t he data.

Signal processing is very complex. We could develop our own signal processing program but many are already available in the market. Lab-View or Lab-Windows are examples of popular signal processing soft ware.

4.6 Interface and Networking

To achieve LA in the laboratory we need to match the interface of the instrument to the personal computer. The simplest interface for this is EIA standard RS-232C, a serial communication interface. Ninety percent of personal computers are now equipped with this port. We need to use measuring instruments with this serial port. Some instruments have GPIB (General Purpose Interface Bus) interface ports. This is the sophisticated parallel data and command communication interface developed first as HPIB (Hewlett-Packerd Interface Bus), and approved as the IEEE-488 standard. This can perform at higher speeds and even has a control function for LA instruments. Some other interfaces like CAMAC (for laboratory), or MAP (for industry) are standardized, but they are not so popular. They are used for the connection of PC's and instruments. Through these connections, data are transferred directly into the file of the computer. After it is in the file, we can do any kind of processing and use it for drawing figures with a plotter, charts with a dot printer, and so on.

Sometimes we need to communicate with other laboratories. Communication is greatly facilitated by Ethernet, one of the most popular local area networks (LAN). Ethernet was first developed by Intel and Xerox in the early 80's, and became a world standard approved by IEEE. Ethernet is a computer network linking many different types of computers. You may choose any kind of computer which interfaces with Ethernet. Networking is still new even in advanced countries. The Tsukuba Science City research complex in Japan has just been equipped with this network.

Using Ethernet we can make use of files that are located in other computers as files in our own machine (NFS,FTP). We can use programs of other computers as well. An important aspect of the network is the thousands of "free ware" packages available. Anyone in the world can make use of these "jewels" of software. The network makes it possible to become current on the latest information on data processing, computer science in general, and the latest in advanced technology.

In the United States, most computers in university and research stations are linked through networks such as ARPANET, BITNET or CSNET. These networks are based on Ethernet. Japanese computers are also linked with these networks through the JUNET. Ideas and knowledge are transferred worldwide via these networks.

Another function of the network is written communication. You can write a letter to a friend in any coast or mountain in the world. Many announcements of scientific meetings are now mailed through networks. You may even write personal letters to your family.

5. Postscript

I should go into greater detail on UNIX, MS-DOS, micro-processors, knowledge engineering, neural networks, development systems, desktop publishing, hyper media, digital image processing, artificial satellites, and so on. This is what I do in Japan. But because of the limitation of time, I will show how the Robotic Laboratory of NARC works (Figura 2) and the fruits of the combination of these technologies applied to the agricultural field.

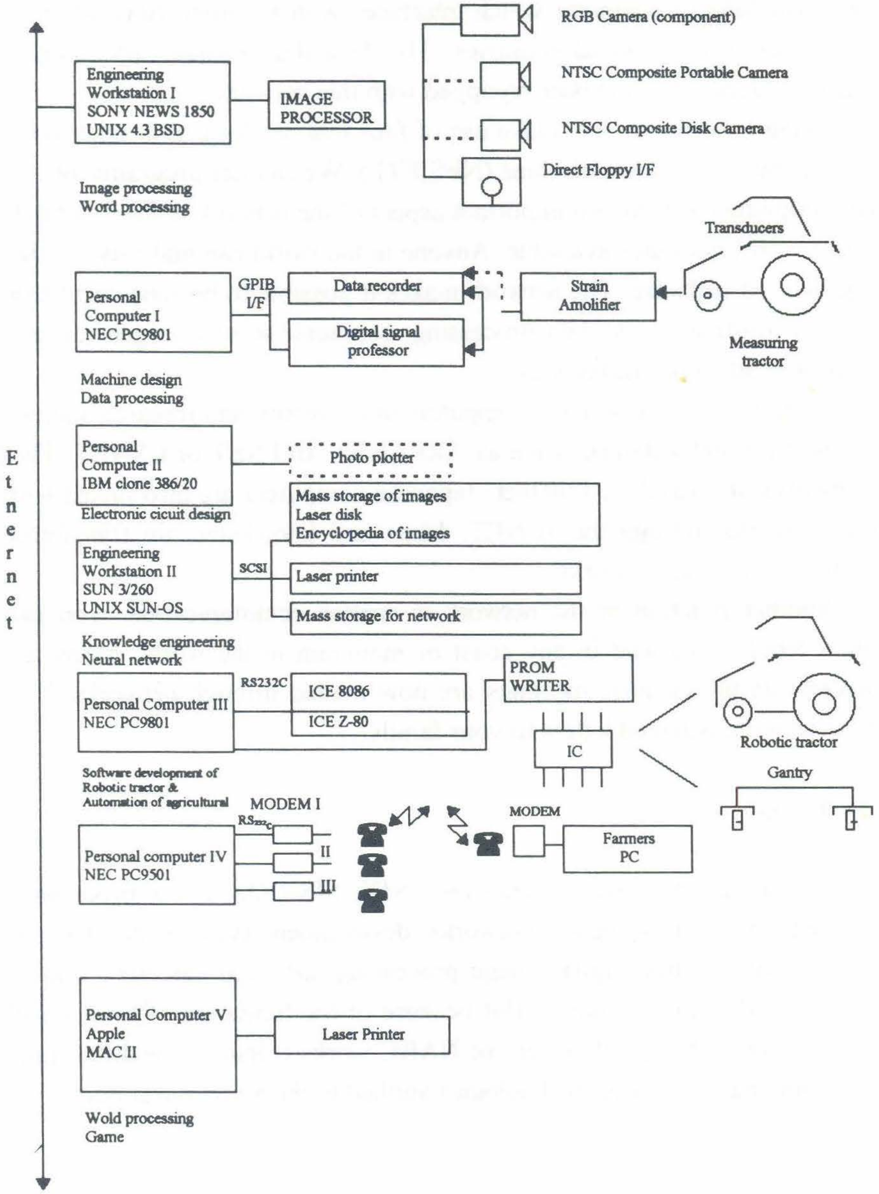

FIG. 2 - Laboratory Automation: An example of robotic lab. of NARC..