The Open Manipulator System of the MHI PA-10 Robot

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[Abstract]
Robots are being applied to an ever wider and more sophisticated range of tasks. One notably rapid area of growth is in the use of robots connected to high precision sensors or different systems, to reinforce and improve integrated systems. In response to these needs, it is becoming necessary to make robot controllers "open". PC-based controllers are already on the market, but controllers cannot be made into "open systems" simply by introducing of PCs. For the MHI general purpose PA-10 robot, we made the controller open by giving the robot a layer structure to simplify the interface between the layers and to make it open to access. We also installed a PC at the highest layer. This gives the robot, now programmable using a general-purpose OS running the world's most popular programming language, infinite potential for expansion.

1. SATISFIED WITH INDUSTRIAL ROBOTS UP TO NOW ?

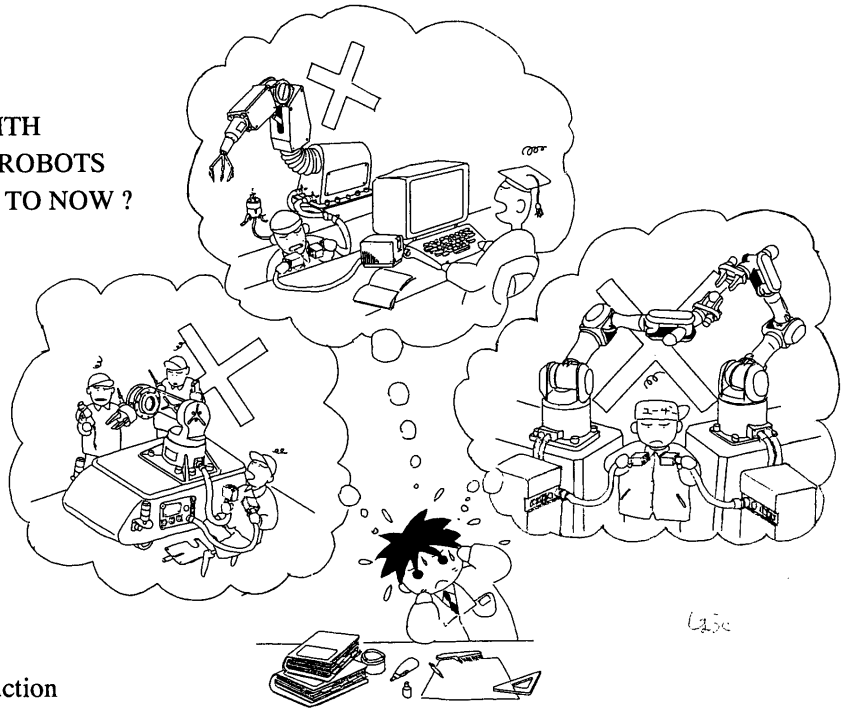
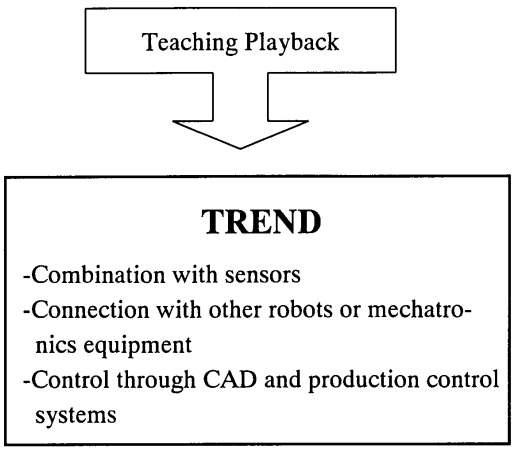


Figure 1 Introduction

The trend is towards increasing complexity:



Existing industrial robot controllers are, however, only black boxes which cannot be connected to different devices or systems. The choices left to those users who have a variety of needs for systems are:

1. To use dedicated peripheral devices (image processing equipment etc.) supplied by the robot manufacturers.
2. To ask robot manufacturers to develop complete systems.
3. To compromise by substituting local robot languages and a narrow interface such as RS 232C.
4. To give up using robots in the system and instead make a dedicated machine.

It is expected now that open robot controllers will be the key to solving this widening range of problems. But what does "open" mean?

2. MAKING THE SYSTEM "OPEN" ??

"Open" means generally to open something to the public. But *what would happen if suppliers opened their hardware drawings or the source codes of existing industrial robots directly to general users?* It would be extremely unlikely that ordinary users would be able to modify the "open?" hardware or install new software. A system like this would not really be "open."

3. WHY IS A PC OPEN?

It is open not only because the internal hardware specifications of PCs are open.
The points are:

Peripheral equipment interface (including bus) has been standardised and is easy to use.

The development environment (DOS, Windows or Linux OS) and development tools (languages like BASIC and C/C++) are already in use.

4. THE PC CONTROLLER ???

A robot cannot be made "open" just by using an open PC as its controller, because under these conditions the open PC is also changed into a black box once the relevant application-specific software is installed, just like a commercial word processor software to which general users cannot add new functions.

The problem is neither to introduce the open PC to the controller (ultimately it will simply turn into a PC-based controller), nor to open all the specifications of the controller. The most important thing is to make the controller open in the most user-friendly way possible (Figure 2).

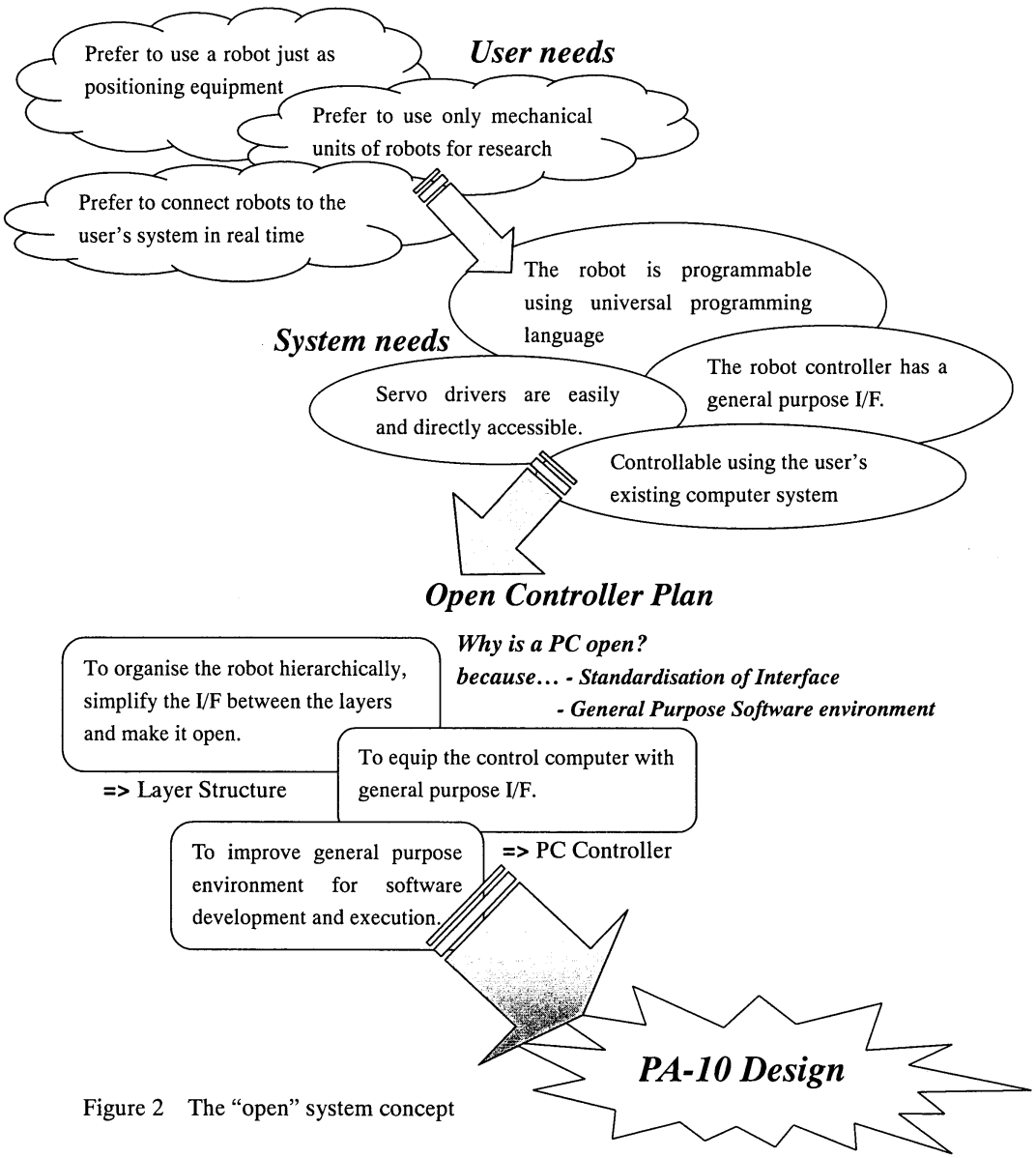


Figure 2 The "open" system concept

5. OPENING THE ROBOT CONTROLLER

We describe here the "Potable General Purpose Intelligent Arm PA-10 (hereafter called the PA-10)" Open System set up according to the plan in Figure 3.

The controller of the robot consists of four functional layers as shown in Figure 2.

These layers usually share a single dedicated board, forming a black box. We thought that an open system meeting user needs could be constructed in "open" fashion by separating the hardware clearly by layer, and simplifying the "connections" between the layers.

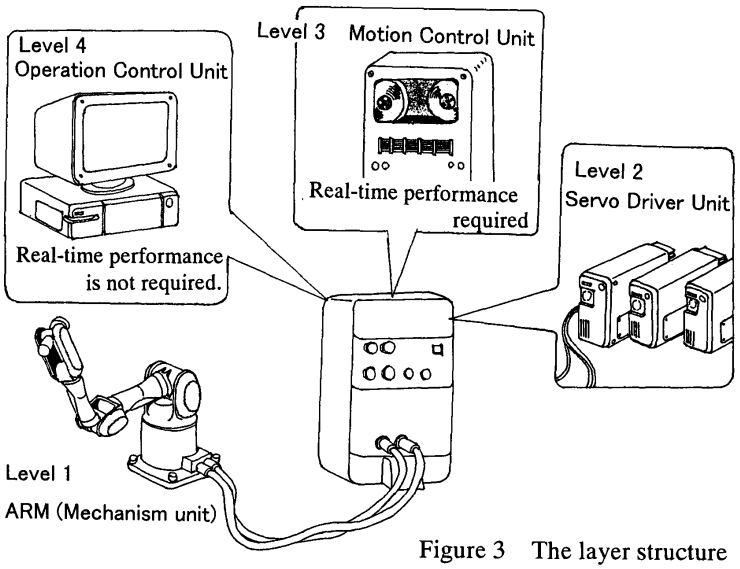


Figure 3 The layer structure

5.1 Connection to the servo-driver

We paid special attention to the connection to the servo-driver. The servo-driver usually needs a very broad-band interface based on analog signals and pulses. Taking into account the following two aims, we developed a new type of connection so that users can gain access to the servo-driver.

1. Minimising interface hardware. By the token passing method "ARCNET " LAN (double twisted pair line) connection, we shortened routes and ensured real-time performance (communication time of 1.2ms/ 7-axis.)
2. Providing the servo driver with minimum interlock functions peculiar to the robot (angle limiter, deviation error etc.) so that the whole system can be secured even if the user using the servo driver directly makes an erroneous command.

5.2 Connection to the Control Unit

We put an inexpensive general PC at the highest layer (Operation Control Unit) of the controller and adopted the method of inserting the Motion Control Unit where high-speed real time control is required into the ISA bus of the PC. We paid extremely close attention to the development environment of application. The robot has to be programmable using a general-purpose high-level language. So, instead of writing a dedicated robot language, we prepared a C library for describing robot movements. The open environment is constructed by using the C compiler in a Linux or DOS environment or the DLL library in a Windows 95/98/NT environment, under which conditions the robot can be controlled irrespective of language such as VB or VC++. Combining the PC-based controller and the library makes it possible to control even commercial peripheral devices, if connectable to the PC, as well as the robot itself, since they respond to the same control routines as the robot.

Photo 1 Portable general purpose arm PA-10

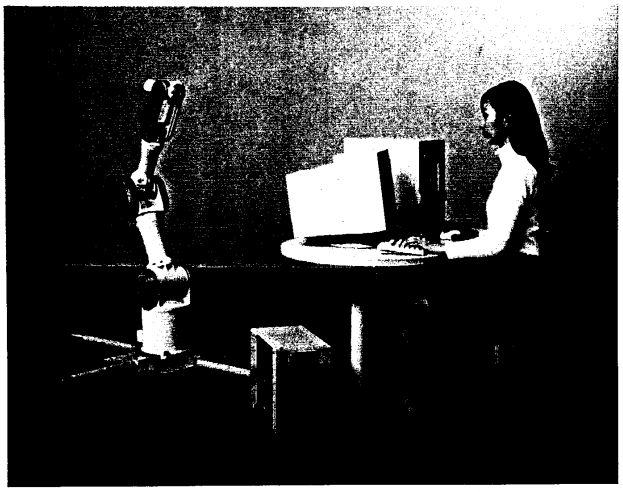
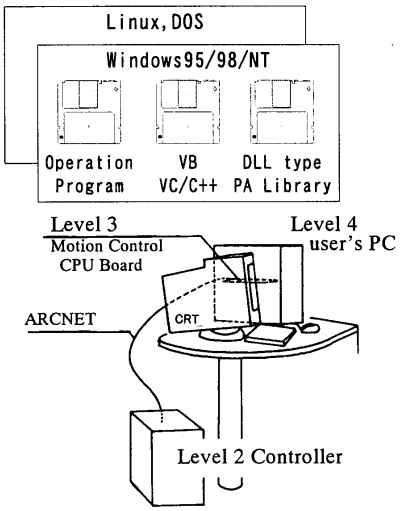


Photo 2 PA-10 connected to the user's PC

user's PC, it joins the same environment for development or execution as described above. (2nd config. from the right end in Figure 4.) Or if installing the ARCNET I/F board, the user can send a command directly to the servo driver. (Right end config. in Figure 4.)

The PA-10 has no dedicated teaching pendant because anyone can easily program it to achieve functions that replace the teaching pendant, using the controller equipped with a standardised open man-machine interface, namely, a PC, and one of the newly available low-priced liquid crystal CRTs.



7. CONCLUSIONS

Super-lightweight (only 35 kg) but powerful enough to carry a 10 kg load. Environmental resistance to rain, under-water, clean-room or temperature up to 50 °C. In addition, the PA-10 open system was originally developed for use in complex environments other than production, assembly, and fabrication lines.

The use of an open controller allows the rapid construction of a total system which includes the robot at low cost. We believe this great advantage will outweigh the greater cost of open system robot set-ups. We would most appreciate hearing your opinions on this issue. Kindly send your views to our HP. (http://www.robot-arm.com/)

6. PA-10 Open Controller

The PA-10 open system configuration is illustrated in Figure 4.

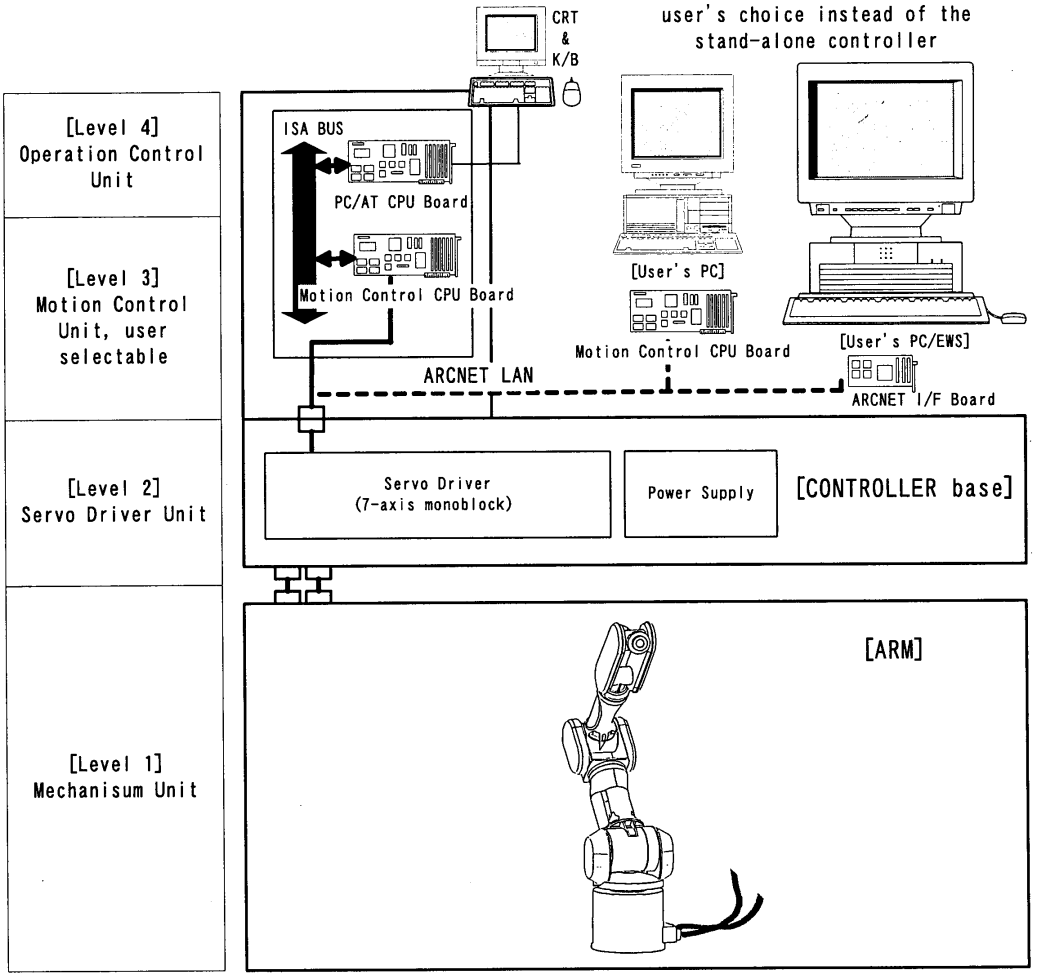


Figure 4 The open system of PA-10

The controller in Photo 1 is a stand-alone type with the servo driver to which an industrial AT-compatible PC (PICMG standard) is added. (Left end config. in Figure 4.) In addition, it is also possible to attach an additional PCI/ISA board, into whose ISA bus the Motion Control Unit of Level 3 can be inserted.

For Level 3 - Level 4, the user can select units depending on their requirements.

Development and execution of programs are performed on this AT compatible PC, using the library.

Photo 2 shows the system configuration for controlling the robot with the user's PC. If installing the motion control ISA board in the