ON THE REAL-TIME CONTROL OF AN INTELLIGENT ROBOTIC SYSTEM

G. N. Saridis and K. P. Valavanis
Department of Electrical, Computer and Systems Engineering
Rensselaer Polytechnic Institute, Troy, New York 12181

Abstract
The high level decision making of the digital computer and the advanced mathematical modeling and synthesis techniques of system theory, provide the tools towards the realization of an Intelligent Robotic System, capable for performing complex and various but specific tasks. A unified approach of the different steps needed for the utilization of such a system is presented and the real-time problems are discussed. As an application of the approach suggested, a Unimation PUMA-600 series robot arm is used.

1. Introduction
Robotic systems demonstrate nonlinear variations of their dynamics which are almost impossible to model. Based on the fact that the dynamic performance of such a system is directly associated with the dynamic models derived for them, it is apparent that the results are imprecise control laws or strategies to achieve the desired response. This desired response of an arm is to maintain a prescribed motion along a prespecified time-based trajectory by applying corrective compensation torques to the actuators for adjustment of possible deviations of the arm from the trajectory.

The industrial approach for the control of such a robot arm is inadequate, since each joint of the arm is treated as a simple servomechanism, neglecting the possible changes of the motion and configuration of the whole arm mechanism. In order to improve the performance of such a system, sophisticated controllers and utilization of the power of the digital computer is needed. In the following sections two different configurations with the digital computer on-line will be presented.

2. The Controller of the Unimation PUMA Robot Arm
The PUMA-600 has six revolute joints as shown in Figure 1 (shown on next page) along with the axes and degrees of joint rotation. The most important component of the whole robot system is the controller whose components are: DEC LSI-II computer, digital and analog servoboards, interface board, clock/terminator board, power supplies, power amplifier assembly, high power discharge board and arm cable board.

The LSI-II system contains the LSI-11/02 processor, memory and communication boards. System software resides in EPROM and user program information is stored in RAM. Communication between the processor and the other components of the PUMA system is
accomplished via a four-part asynchronous serial I/O board, the DLV II-J, and via a
DRV II that provides parallel-line communication to and from the digital servoboards
and links the processor to the interface board. The interface board connects the
LSI-II computer system of the controller with the servoboards that control the six
joints of the arm. The behavior of the arm is thus controlled by the digital and
analog servoboards as dictated by the LSI-II commands. [1], [2].

Given the structure of the controller, observe that it can be considered as
"hierarchically arranged" and as the series connection through an interface board of
a higher level - the computer level - and a lower level - the joint control level -
whose performance is dominated by the six joint microprocessors, the 6503s,
attached on the digital servoboards. [3], [4].

The purpose of the LSI-II/02 computer is to perform two major tasks:

i) on-line user interaction and subtask scheduling from the user's VAL (the
language used by the PUMA robot arm) commands and

ii) subtask coordination with the six joint microprocessors to carry out the
command.

The on-line interaction with the user includes parsing, interpreting and decoding
the VAL commands and also report error messages to the user. Once a VAL command has
been decoded, internal routines residing in the EPROM of the LSI-II/02 computer are

Figure 1  Robot Arm: Degrees of Joint Rotation