Remote control system of industrial manipulators by short-message

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Abstract: - In this paper an innovative method for robotic manipulator kinematic control and supervision is proposed, both locally, by operator panel, both remote by the use of short-message. A programmable logical controller (PLC) is adopted to obtain a versatile and applicable solution in any robotic system. In particular the problem of end effector positioning in a desired point of the work space of an industrial manipulator through a short message is solved. A PLC will provide to convert this message and to move the manipulator into desired position.

Key-Words: - Industrial manipulators, Short-message, Programmable logic controller, Kinematic control.

1 Introduction

A robotic system presents hardware and software proprietary control which are hard to connect with other control systems. Then there is a remarkable difficulty to introduce new possibilities of control and supervision of an existing robotic system. Open architectures for the control of automation systems have been the subject of considerable research. For example, the OSACA project (Open System Architecture for Controls within Automation Systems) [4] aims to create a common hardware platform on which then the software is created. Also in the production cells interface front-end which connect the devices of various brands to dialogue with the work stations is realized [3].

In this paper we propose a method for interfacing industrial manipulators to a generic control system. The problem is solved by using a programmable logic controllers (PLC) [5],[6],[7]. Through PLC any robotic system can be controlled and furthermore easily we can connect the manipulator to multiplicity of possible controls. To control the manipulator we use a serial interface of drivers of the manipulator. This paper is organized as follows. In section 2 the robotic system architecture and the control drivers are presented. In subsection 2.1 the protocol of serial communication is shown. In subsection 2.1.1 the CP340 communication processor is exposed. In subsection 2.1.2 the control through short message is presented.

2 Remote control of manipulators

Let us consider a robotic manipulator (see fig.1) with two joints and two degree of freedom. This manipulator is constituted by two rigid arm and the engines of the joints are Brushless type. An extremity of the robot is rigidly fixed on one of support base through an Brushless engine; the extreme part of the second arm can be instead provided with pliers to manipulate objects (end-effector).

Actuator position for each link is measured with a 150 pole resolver, which provides approximately 2 arc seconds resolution. The analog resolver signal however is processed by a resolver to digital converter (RDC) which is part of the brushless motor driver unit (see. fig. 2). The resolver RDC system also produces 150 TTL level index pulses per revolution which can be used for absolute position measurement. Besides, this signal is processed by a frequency to voltage converter to produce a voltage signal which is proportional to velocity. Therefore the rotation is realized through drivers (fig.2) that pilot Brushless engines [8]. The drivers acquire the signals of the resolvers and elaborate them through a microprocessor and furthermore they manage two PWM for the operation of the engines themselves.

There are also two limit switch detection for each joint. In this way the maximum rotation of each joint is of 240°.

The planar manipulator can be considered as an articulate open chain (see fig.3), established with two rigid bodies (link) connected by two rotating joint. A side of the chain is fixed to base of support and the other is generally equipped with pliers to move object from an initial to a final position.

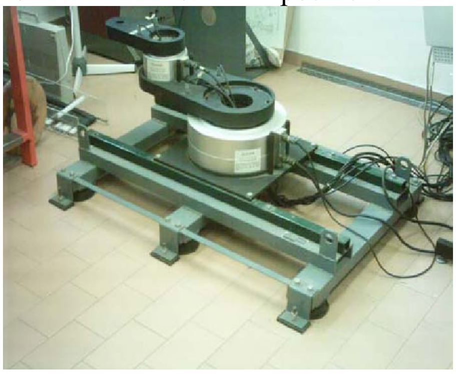

Fig.1. Robotic manipulator with two degrees of freedom.

Fig. 2. Drivers of Brushless engines.

The fundamental problem of this work is the positioning of the end effector of an industrial manipulator in a desired point of the work space [1], [2]. In particular the kinematics of the manipulator deals with the estimation of a set of end effector work space variables *(x,y)* (see fig. 3) which produce the joint angular position. Preliminarly we define:

- L1: length of the lower arm;
- L2: length of the superior arm;
- (x, y): work space coordinates of the end effector;
- ϑ_1: angular position of the lower joint;
- ϑ_2: angular position of the superior joint.

Then the kinematic model is the following:

$$\begin{aligned} x &= L_1 \cos\theta_1 + L_2 \cos(\theta_1 + \theta_2) \\ y &= L_1 \sin\theta_1 + L_2 \sin(\theta_1 + \theta_2) \end{aligned} \quad (1)$$

In other worlds the kinematic model (1) converts the trajectory from joint space coordinates(θ_1, θ_2) (see fig.3) to the work space coordinates (*x,y*). The system (1) represents the kinematic direct model of a planar manipulator with two joints and two degree of freedom.

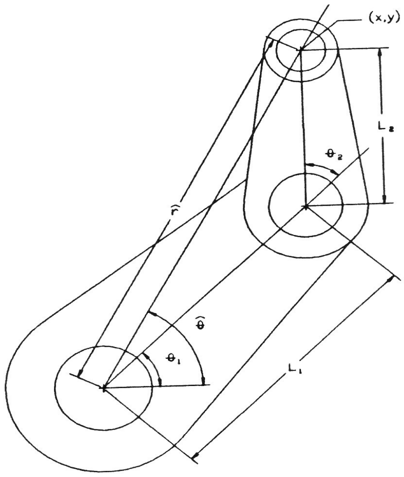

Fig. 3. Kinematic Open Chain Planar Manipulator.

2.1 Realization manipulator movement control

The drivers of the manipulator present a connector of RS232C serial communication, that allows to dialogue outside (in our case the PLC) to make the desired positioning . There are types of commands:

- Type of absolute commands: they execute the positioning in a stair of absolute position;
- Type of incremental commands: they execute the positioning moving of one specified distance from the current position.

Commands are provided in degree (0.01 °) and the various feasible commands are showed in Tab.1

Type of command	**Description**	**Optional code**
AD data	This type of absolute command executes the positioning in unity of 0.01 °. The engine rotates up to the position specified in "data" in unity of 0.01 °	/CW: clockwise rotation /CCW: anticlockwise rotation
ID data	This type of incremental command executes the positioning in unity of 0.01. The engine rotates of a corner specified in "data" suffering from the current position	
HS data	This command takes back the engine to the position of house	

Tab. 1. RS232C positioning commands.

Furthermore by RS232C communication the form of wave of the shifting, which can be trapezoidal or simply a breast curve, is communicated. Parameters necessary to obtain these trends are reported in Tab.2.

Type of command		**Description**
Speed	MV data	Maximum speed of the engine in r.p.s.
	MV data1, data2	This is the speed command for trapezoidal forms. Data1: maximum speed Data2: starting speed
Acceleration	MA data	He shows the acceleration of the equipment of the engine in r.p.s.^{2} for trapezoidal profiles
	MA data1, data2	This is the acceleration command for breast forms and the average acceleration is specified in data1 while in the data2 initial revolution

Tab. 2. Set forms of robot positioning.

2.1.1 Serial communication processor

To realize the above-mentioned control, a S7300 programmable logical controller with two serial communication modules CP340 RS232C is used (see Fig.4). This is opportunely linked to the driver of the brushless engines. Through the CP 340 communication processor the exchange of data between its controller and peripherical units (the manipulator) is possible by compatible serial interface pilot RS 232 C. For this purpose the processor must be parametrized by using the specific parameters for the driver: 9600 bits/s; character block: 8 bits of data the, 1 one stop bit, no equality; recognition of fine of a received telegram. Furthermore the user program must be created, which is considerably facilitated by the use of predefinited functional blocks in the S7300 system. In particular the P_SEND functional block transmits a section of a block of data, specified through the parameters DB_NO, DBB_NO and LEN, to the driver. The transmission of the data is started by a positive front in input REQ. Analogously the P_RCV functional block allows to move data from the CP340 to an area of S7 specified by the parameters DB_NO, DBB_NO and LEN. This function allow to know the position of the manipulator.

Fig. 4. PLC with serial communication modules CP340 RS232C.

2.1.2 Control and supervision with short message.

To realize a remote control and a supervision of the robotic manipulator there is an other module CP340 connected to a GSM modem (see. Fig.5). Through this connection we can control the robot from any telephone cellular and therefore we can send the new position to the modem. The communication processor will move the short-message to a PLC block data which will provide to convert the message and to move the robot to the desired angular position. When the order is executed, the same PLC will send a notification message to the GSM.

Fig. 5. GSM modem.

Also a local control connects an operator (see Fig.6) to PLC. So we can obtain the possibility of a local and remote control, through short message.

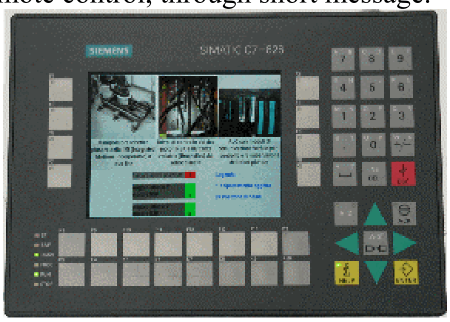

Fig. 6. Control and local supervision of the robot manipulator.

For example one motor of the manipulator has been moved from 0° a $\pi/2$, stopped for 0.5 sec and then take back to 0° (see Fig.7). In this measure the sample time is equal to 0.01s and also the selected parameters are:

- maximum velocity: 2.5 rad/sec;
- maximum acceleration: 0.5 rad/sec/sec.

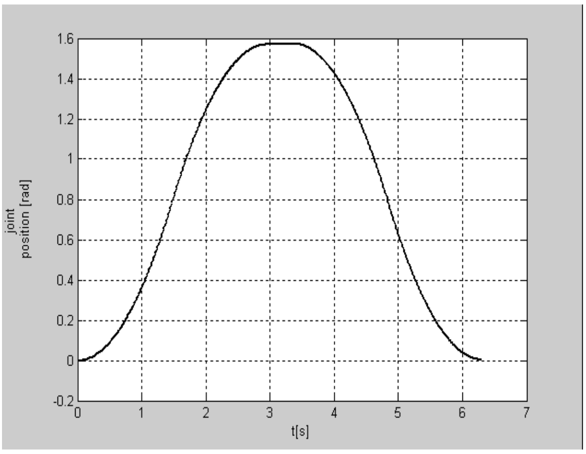

Fig. 7. Actual Joint Position.

3 Conclusions

In this paper a control of industrial manipulators through an interconnection with the serial connector of the relative engine driver is presented. The task of the control is the positioning of the end effector of a planar manipulator to a desired position of the work space. In this way it is possible to control a manipulator built several years ago and the interconnection to a modern control systems. Therefore this work shows that an opportune software interface and the flexibility of a PLC can control any system with a serial connection in efficient way.

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