

DESIGN AND EXPERIMENTAL ASSISTED DIGITAL COMAND AND CONTROL TRAJECTORY FOR PERIROBOTS COMPONENTS

Adrian OLARU, Șerban OLARU, Theodor MANTEA, Dănuț PĂUNE

Abstract: *The paper shows the simple construction of two axis didactical linear and rotary tables, the design of the electronic interface between the motor's table and the digital command, the programming of the robot movement and tables in some simultaneously movements and temporal control trajectory. In the world isn't used the digital command and programming with temporal control trajectory. The paper presents one new method for the simultaneously movements of the didactical arm type robot and the perirobot components like the rotary and linear two axis didactical tables with LabVIEW digital command.*

Key words: *two axis table, digital command, temporal control, LabVIEW instrumentation.*

1. INTRODUCTION

The paper describes design of the two axis didactical linear and rotation tables to obtain with the arm type robot, some complex trajectories with simple digital programming and temporal control. Now, in the world, the digital programming is used more and more in automation of the manufacturing systems [1, 2, 3, 4]. The paper shows one application of the perirobot components, like the linear and rotary two axis tables to obtain some plane conventional or unconventional curves. The research has been made in a Dynamic Behavior Industrial Robots Laboratory, DIRI, from Machines and Manufacturing Systems Department, IMST faculty, University "Politehnica" of Bucharest, Romania. The digital program of the six simultaneously movements was tested on the two didactical tables and one arm type didactical robot (Figs. 1, 2 and 3). The command program has been made with the digital command on six bits, in the two output ports, two bits for each direct current servo motors. The programming used the temporary control of each of the six movements with the timer of the computer and with the acquisition board from National Instruments, USA. Disadvantage of the method was that all simultaneously movements were had the same duration, not in concordances with the reality movements.

2. DESIGN OF THE EXPERIMENTAL TABLES

The didactical cartesian and rotary tables contents for each axis the DC motor, simple mechanism of reduction the velocity and tooth belts (Figs. 1 and 2). The application used one didactical arm type robot (Fig. 3) with DC servo motors in each axis. In all joints of the robot there are the reduction of the velocity with the gears, or reduction mechanisms. The control of the movements is temporary by using the electronic interface and National Instruments acquisition board. The software of the command, control and data acquisition is proper [1, 5].

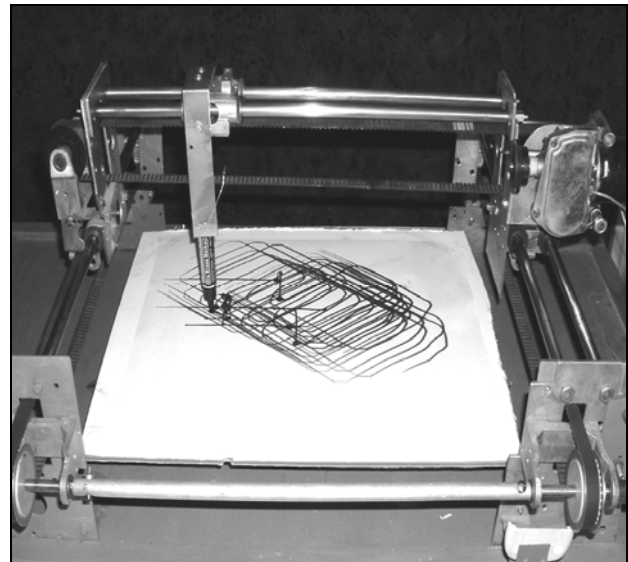


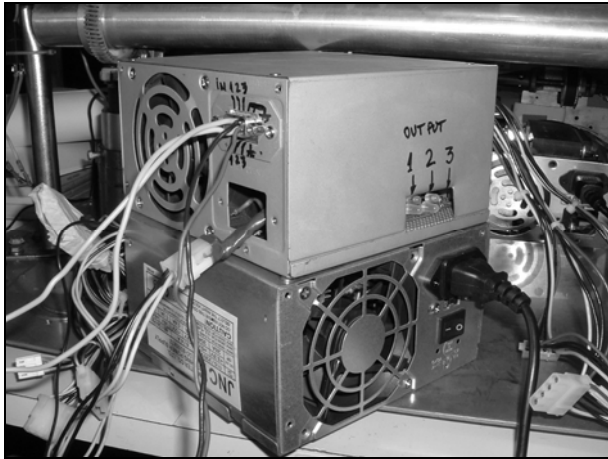
Fig. 1. Two axis didactical Cartesian table.



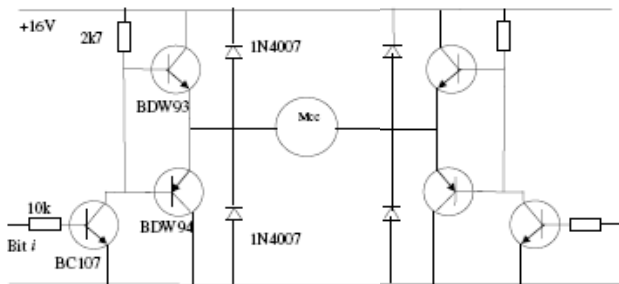
Fig. 2. Two axis didactical rotary table.



Fig. 3. The arm type didactical robot.



a



b

Fig. 4. The interface of the digital programming of the tables with control on three axes: a - the apparatus; b - the electronic schema.

The electronic interface of the digital command was realized in the didactical activities of the DIRI laboratory with the students of the IV year of study (Fig. 4). All LabVIEW applications with digital command and temporal control were researched in the doctoral activities with PhD students and were contents the realization of the space and planar complex curves with many combinations of the simple movements of the robot and perirobot components. One of them, repetitive rhombus planar complex curve, is show in the paper.

3. LABVIEW DIGITAL PROGRAMMING

The LabVIEW instrumentation of the digital command and temporal control contents many VI-s with the block diagrams shown in Figs. 5, 6 and 7. In the first step was necessary to assure the movement and the stop with the manual command, assuring the measure of the

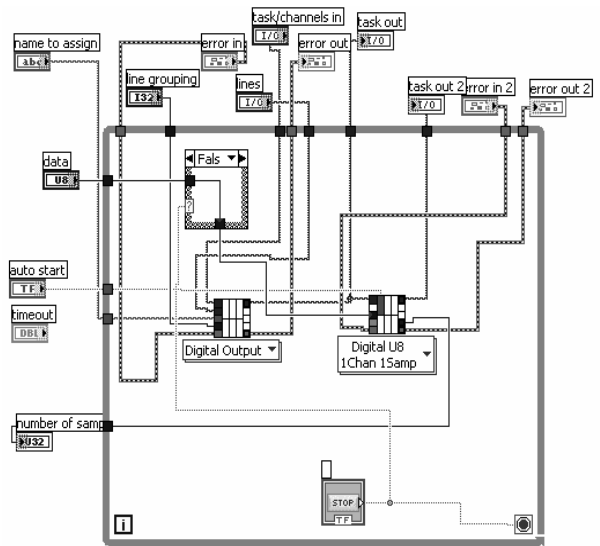


Fig. 5. Virtual LabVIEW instrument for the manual command.

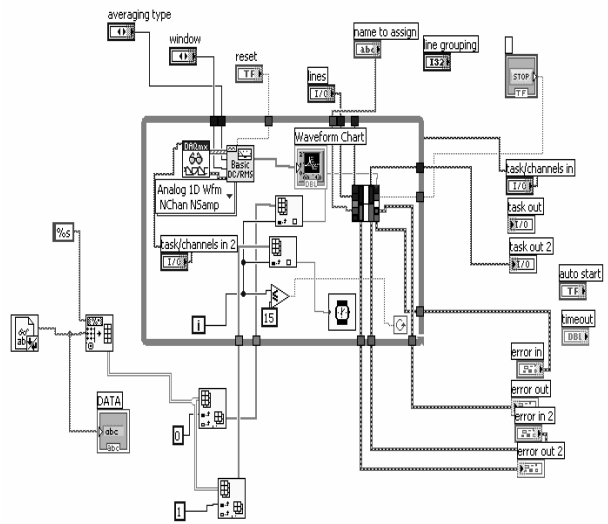


Fig. 6. Virtual LabVIEW instrument for the automat command with digital programming and temporal control.

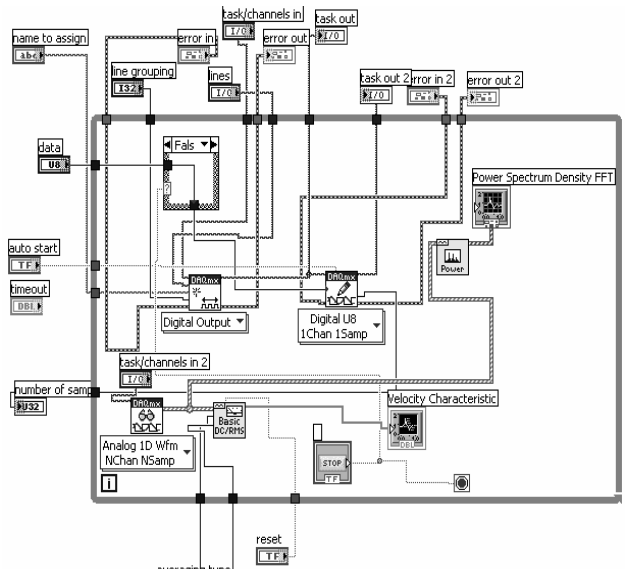


Fig. 7. Virtual LabVIEW instrument for the automat programming and control and with data acquisition.

distance with the temporal control and to verify the errors of each axis with the final goal, to correct some of the movements times. For that, this first VI (Fig. 5) have the following components: closed loop with the while cycle, input data with: the command channel, the number of samples, the number of digital port, the name of the task, and, the stop button with the double control of the while cycle and of the command channel. In the second one VI-s (Fig. 6) we introduce the read of the input data from the file and, acquisition and design of the angular velocities with the goal to obtain, by integration, the spaces curves and to design them. This VI-s have the temporal control of the while cycle by the time generator of the computer. The last VI-s (Fig. 7) was introduced the data acquisition with the Fourier transform to obtain the frequency spectrum of each movements of the robot and perirobot components with the possibility to change some of the movements parameters to obtain one good dynamic response.

The first line of the file contents the number of the command port and the information about the activated bits in a centesimal version. The second line of the file contents the information about the time of the movement in *ms*.

4. PROGRAMMING THE REPETITIVE COURVES

In the paper was shown one planar repetitive rhombus curve (Fig. 8).

The rhombus repetitive curve has the following dimensions: each side 120 mm and the step 20 mm. The file of the digital command and temporal control is shown in Table 1. The first line of the file contents the following information: the number of the digital port, the centesimal number of the command channels and the time of each movement.

The port of the command was 1 that mince was used one of the perirobot components (Table 2 – task 2 – digits output 1). The 5 number of the digital command channels mince the simultaneously movement of the linear perirobot table in up and right direction ($2^0 + 2^2$), 9 number mince the simultaneously movement in down and right direction ($2^0 + 2^3$), 10 number mince the simultaneously movement in left and down direction ($2^1 + 2^3$), and 6 number mince the simultaneously movement in left and up direction ($2^1 + 2^2$). The time control, 1000 ms and 800 ms mince that the space of the table movement was 120 mm, respectively 100 mm for the last rhombus side, to obtain the repetitive character of the curves. This sequence of the file we can repeat what will be necessary.

The input data of the manual command of the robot and perirobots components and the assisted real and Fourier characteristics of the linear velocity of the table with the trapeze signal of the command are shown in Fig. 9. We can see that for the command is necessary to introduce the number of task, the line of the command and the centesimal command of ports. For the data acquisition was necessary to define the channels and to create the virtual characteristics with the data (for example the Fourier spectrum of the vibration during some movement component). With the Fourier known spectrum is possible to avoid the resonance frequency

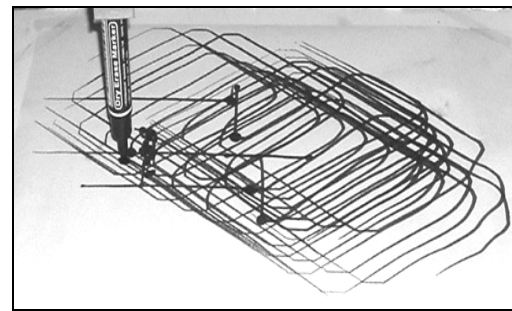


Fig. 8. The example of the repetitive rhombus curve realized with the didactical linear two axis table and the propre LabVIEW program.

Table 1

Example of the command file

1_5	1_9	1_10	1_6	1_5	1_9
1000	1000	800	800	1000	1000

Table 2

The digits allocation

Task 1 - Digits output 0					
Servo drive M ₃ - RI arm about the horizontal axis		Servo drive M ₂ - rotation about the vertical axis of the CPR ₁		Servo drive M ₁ -horizontal translation of the CPR ₁	
down	up	CRW	CCRW	forward	back
2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰
Task 2 - Digits output 1					
Servo drive M ₆ - rotation of the CPR ₃		Servo drive M ₅ - longitudinal translation of the CPR ₂		Servo drive M ₄ transversal translation of the CPR ₂	
horizontal	vertical	up	down	left	right
2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰

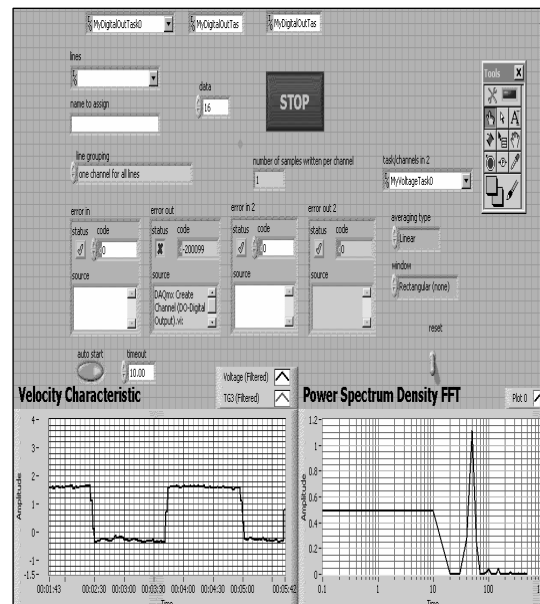


Fig. 9. The real and Fourier characteristics of the tables movements.

Table 3

Example of the command file

0_9	1_9	0_21	1_42	0_21	1_22
2500	2500	3500	3000	3000	2000

with the robot in one application robot-perirobot components. The way is to choose one acceleration time in the trapeze characteristic of the robot command what determine one other first frequency of the spectrum, different that the perirobot component. After analyze these characteristics remarks that the first frequency from the table spectrum is 50 Hz, the others are 100, 150, 250 Hz. This first frequency of the spectrum is obtain in a didactical condition (only for simulate, with marker, the periodical curve and to see the programming errors) without the load on the linear table. All these frequencies are after the resonance frequency of the didactical arm type robot in a low domain 12Hz, determined and shown in other proper research [1, 5, 6].

5. DISCUSSIONS AND REMARKS

The shown VI-s assures the data acquisition for the velocity, work on-line and assures the assisted real and frequency characteristics of the robot and perirobot components. After the analyze of the assisted characteristics results that the more important frequency of the Fourier spectrum of the linear table, in a movement in the two directions is near 50 Hz and the other components were 100, 150, 250 Hz. By the simultaneously traces of the characteristics is possible to see how each of the sequence of the movement influence the Fourier spectrum and what is the components frequency of the complex 3D trajectory what is in a low domain, the frequencies what influence the precision and the stability of the movement.

All programs work on-line and we can see what is the changes of the Fourier spectrum when the robot arm or the perirobot components are in a different space position. With this facility is possible to change some of the simple movements, or to change the velocity characteristics by changing the trapeze characteristic of the command and to change the spectrum, finally to obtain one desired Fourier spectrum and one good precision and stability.

The digital command, for example 101010, corresponds to the centesimal command 42, what will determine the linear movement comeback, the CCRW of the vertical rotation of the perirobotic component and the movement up of the robot arm.

All these three movements will be happened in the same programmable time, the value from the second row in a data file (Table 3).

In a repetition of the same movement, the velocity characteristic not remains the same because the damper forces, the didactical position of the marker and of the different external electrical influences.

These influence the 3D trajectory, the Fourier spectrum and the velocity characteristic.

The example shown in the paper demonstrates how easy is the programming of the complex movements with composition of the simple movements, and how was possible to control many components of the manufacturing systems like the robots and perirobot components, with the digital command and temporal control.

6. CONCLUSIONS

The digital programming and temporal control are more necessary used in an automation of the manufacturing systems because his simple programming and implementation.

All the shown VI-s work on-line and have one general character, we can be used in all other mechanical application. By using the virtual LabVIEW instrumentation in the command and control of the automation manufacturing systems movement, is open the way to the assisted optimization of the 3D space curves with the perirobot components and obtaining the complex curves by combination the simples.

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Authors:

PhD Eng., Adrian Olaru, Professor, University "Politehnica" of Bucharest, Machines and Manufacturing Systems Department, Dynamic Behavior Robots Laboratory,

E-mail: aolaru_51@yahoo.com

Eng. Șerban Olaru, PhD Student

Theodor Mantea, Student, University "Politehnica" of Bucharest, Machines and Manufacturing Systems Department, Robotics Specialization,

Eng. Dănuț Păune, PhD Student.