ANNALS OF FACULTY ENGINEERING HUNEDOARA
– INTERNATIONAL JOURNAL OF ENGINEERING
Tome IX (Year 2011). Extra Fascicule. (ISSN 1584 – 2673)

[1.] József SÁROSI

ACCURATE POSITIONING OF HUMANOID UPPER ARM

[1.] FACULTY OF ENGINEERING, UNIVERSITY OF SZEGED, HUNGARY

ABSTRACT: Several control ways have been applied to control different humanoid or robot arms, manipulators, prosthetic and therapy devices driven by pneumatic artificial muscles (PAMs). The early control methods were based on classical linear controllers and then some modern control strategies have been developed (e. g. adaptive controller, sliding-mode controller, fuzzy controller, neural network controller and others) ([1], [2] and [3]).
This paper presents a humanoid upper arm and discusses its positioning using sliding-mode control.
KEYWORDS: humanoid or robot arms, pneumatic artificial muscles, sliding-mode control

❖ INTRODUCTION

Nowadays, pneumatic actuators have been considered as a substitute of conventional motors because of its high power/weight and power/volume ratios. The newest type of pneumatic actuator the McKibben muscle possesses all advantages of traditional pneumatic actuators without the main drawback such as low power to weight ratio. The main disadvantages are connected with the accuracy of control and nonlinearities of pneumatic systems [4].

The behaviour and structures of PAMs are well described in literature ([5], [6] and [7]).

Many researchers have studied to generate easier model of PAM to overcome difficulty in control because of it’s nonlinearity, also some have tried to control robot using that model, but their studies are limited on simulation and their good performances are valid only being applied to simulation model. Physical implementation is more complicated problem [4].

Pneumatic artificial muscles show similarity to biological muscles, for this it’s very effective to implement humanoid. The PAMs are one-way acting, we need two ones to generate bidirectional motion: one of them moves the load, the other one will act as a brake to stop the load at its desired position and the muscles have to change function to move the load in the opposite direction. This specific connection of the muscles to the load is generally named as an antagonistic setup.

The layout of this paper is as follows. Section 2 (The study) is devoted to display our test-bed and the LabVIEW program for positioning. Section 3 (Results and discussion) presents several experimental results. Finally, section 4 (Conclusions) gives the investigations we plan.

Fluid Muscles DMSP-10-250N-RM-RM (with inner diameter of 10 mm and initial length of 250 mm) produced by Festo company were selected for our newest study.

❖ THE STUDY

In [8] and [9] can be found detailed descriptions of our test bed and former experimental results for positioning.

The newest setup for positioning a humanoid upper arm is shown in Figure 1. The PAMs were installed horizontally and can be controlled by MPYE-5-M5-010-B type proportional valve made by Festo. Because of the difficulties caused by the nonlinear properties of pneumatic systems a LabVIEW based sliding mode control was designed. The purpose of positioning is to move the arm from a starting position to a desired position. With the use of sliding-mode control the positioning error can be minimized.

The positioning of the arm was measured with a BDF-6350-3-05-2500-65 type (produced by Balluff) rotary incremental encoder.

The signals from the encoder have to be acquired by the LabVIEW program so that they can be used by computer. The device is a NI 6251 card equipped with a PCI interface, to this a SCB 68 type I/O device has been attached with a special connecting cable, on the data acquisition card there are 16 16-bit analog inputs and two 16-bit analog outputs also there are 24 digital inputs and two 32-bit counters as well.

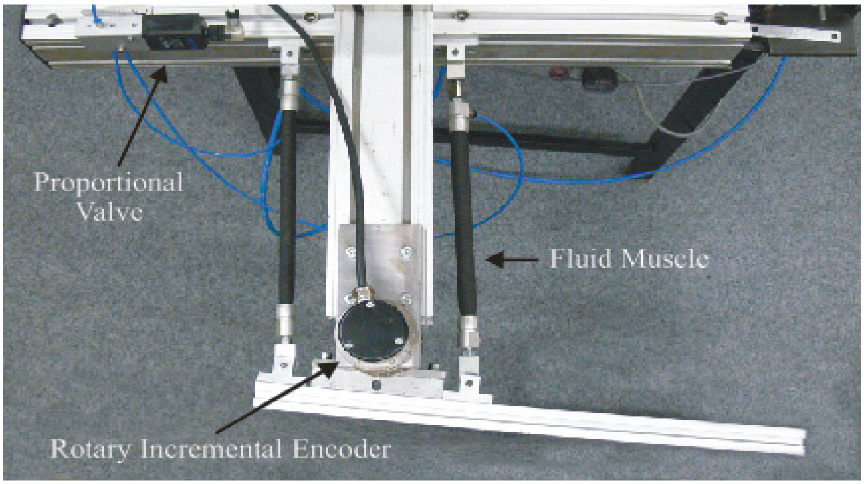
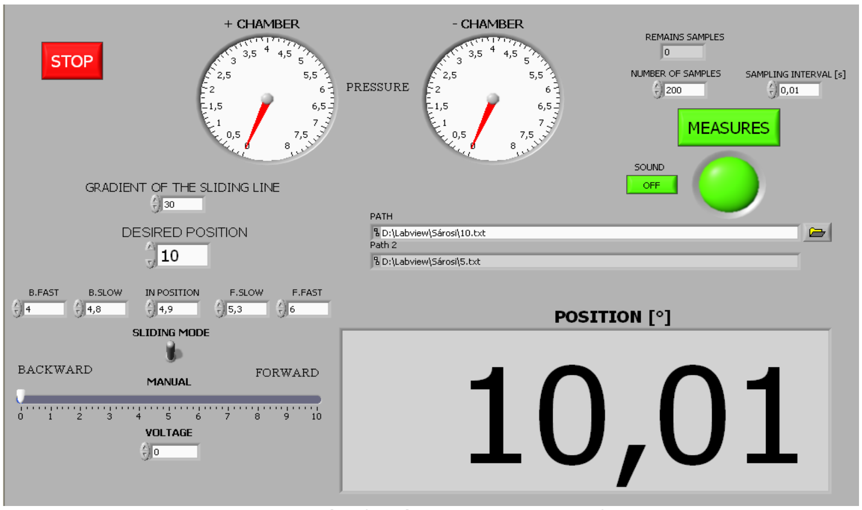


Figure 1. Experimental setup



REMAINS SAMPLES 0
NUMBER OF SAMPLES 200
SAMPLING INTERVAL [s] 0,01
GRADIENT OF THE SLIDING LINE 30
DESIRED POSITION 10
PATH D:\Labview\Sárosi\10.txt
Path 2 D:\Labview\Sárosi\5.txt
B.FAST 4
B.SLOW 4,8
IN POSITION 4,9
F.SLOW 5,3
F.FAST 6
VOLTAGE 0
POSITION [°] 10,01

Figure 2 Front panel of LabVIEW program for positioning

The Figure 2 shows data acquisition and positioning that can be achieved in LabVIEW environment. Aside from the desired position the number of samples and the sampling time can also be set. The data can be saved into a text file.

❖ RESULTS AND DISCUSSION

Positioning was first done in room temperature on the pressure of 6 bar. The desired positioning was set to 10°, the number of samples was set to 200, while the sampling rate was set to 10 ms, thus the measurement took 2 s. The quality of the positioning (overshot, steady state error) can be manipulated with the slope of the sliding line. When choosing the slope of the sliding line the optimum between two concurrent properties must be found (speed, accuracy). The smaller the slope the faster the trajectory reaches the sliding line, but it will take longer to set. For the slope of the sliding line a value of 30 was set.

Figure 3 shows the positioning as a function of time. It took about 1 s for the position to reach the set value. To show the accuracy of positioning the area around the desired position has been magnified (Figure 4). It has been observed that the value of the steady state error is quite favorable, 0.04°.

The measurements were repeated in 20° position. The desired positioning was set to 20°, the number of samples was set to 200, while the sampling rate was set to 10 ms, thus the measurement took 2 s, and the slope of the sliding line a value of 30 was set. Figure 5 shows the positioning as a function of time. It took about 1.2 s for the position to reach the set value. To show the accuracy of positioning the area around the desired position has been magnified (Figure 6). This Figure shows the accuracy of positioning is within 0.04°.

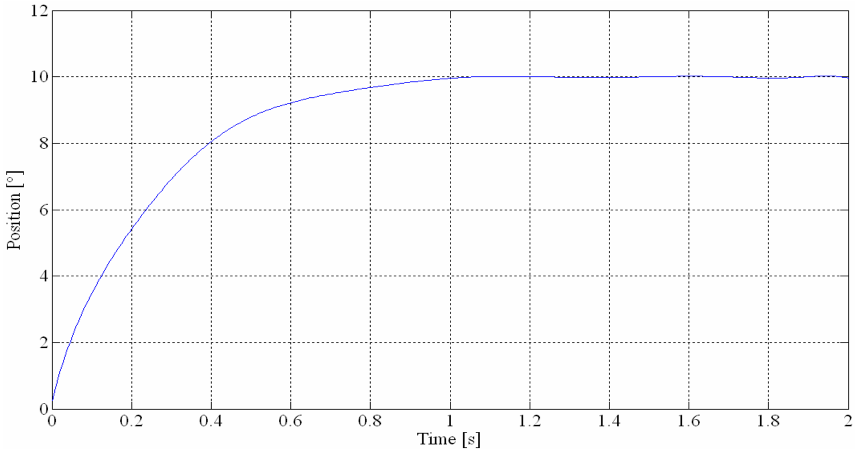


Figure 3. Position as a function of time in desired position of 10°

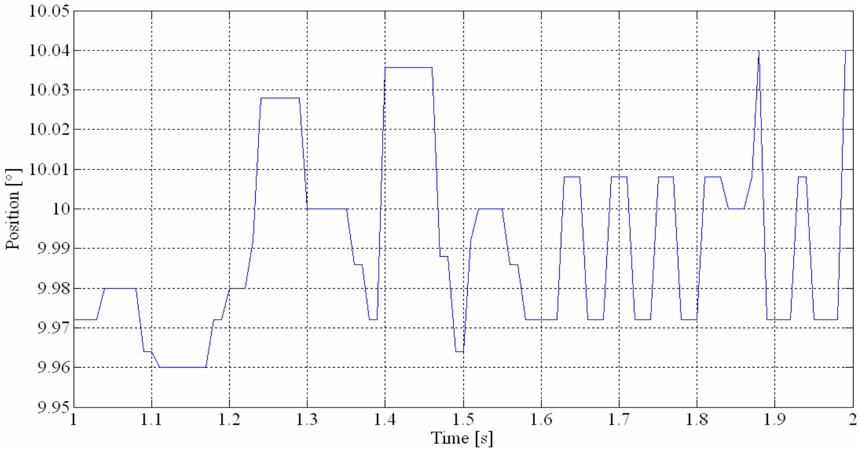


Figure 4. Position as a function of time in desired position of 10° (enlarged)

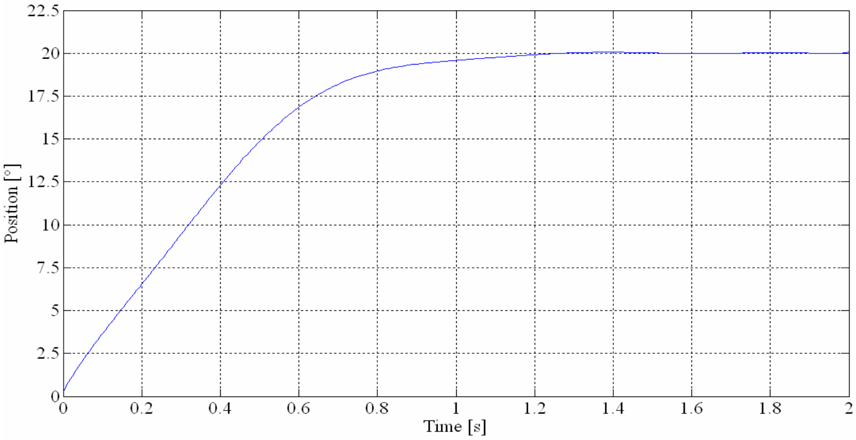


Figure 5. Position as a function of time in desired position of 20°

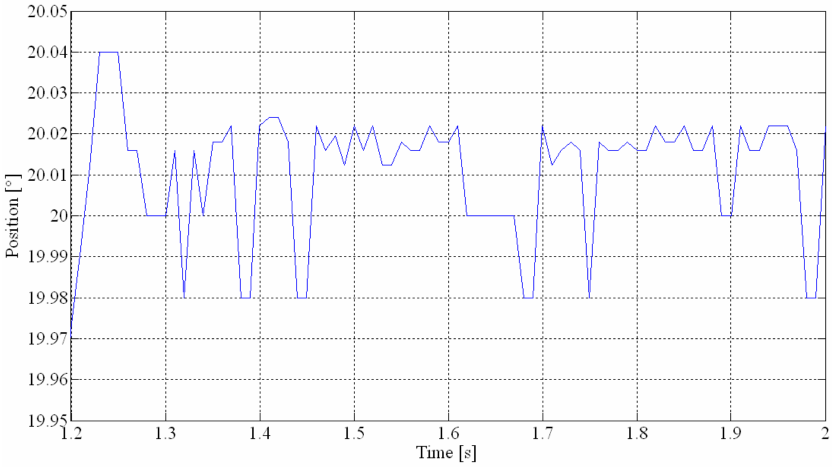


Figure 6. Position as a function of time in desired position of 20° (enlarged)

CONCLUSION

From these experiments we concluded is that the sliding-mode control can be used for precise robust control of positioning of a humanoid upper arm, for it is fast, robust to external interferences and the changing of internal parameters. Our plans include building a new arm with more muscles and more degrees of freedom for more complex movement and analyzing the data.

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