Title:
Development and 3D printing of a system with a displacement of increments of less than 3mm using Arduino UNO programming

Authors:
Dina Rochman, drochman@cua.uam.mx, Metropolitan Autonomous University - Cuajimalpa

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Introduction:
The field of robotics is booming thanks to additive manufacturing. Among the 3D-printed robots, we find humanoid robots, four-legged robots, and small-scale robots. Robotic arms, and automata robots [6].

In the literature, we find some articles related to the 3D printing of robots and the use of stepper motors and servomotors. In these articles, the authors mention that they designed and manufactured the robots for various purposes [2, 3, 4, 5, and 6].

We begin this writing with the primary goal of the project we are carrying out at the Metropolitan Autonomous University - Cuajimalpa "Development of a 3D printing robot to move a threaded prism in less than 3mm increments on the x-axis left/right and the y-axis up/down using a stepper motor and Arduino Uno".

In this paper, we present the development of the prototype in 3D printing of one of the robot's parts formed by a structure that supports a threaded rod, a system of spur gears, a threaded prism, and a prism with an arrow (Fig. 1). In this case, the threaded prism of the 3D printing prototype will move left/right.

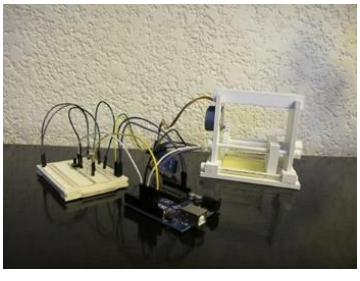

Fig. 1: Prototype in 3d printing.

We use a 28BYJ-48 stepper motor with a driver, and program on the Arduino UNO, to perform various tests to verify that the interval increments when the threaded prism moves to the right and left are less than 3mm.

All the prototype was modeled in the Fusion 360™ program and printed on the MakerBot Replicator 2 printer using PLA (polylactic acid) material.

Main Sections:

Our research aims to design and 3D print a robot that can precisely move a threaded prism along a threaded rod using Arduino Uno programming and maintain its orientation perpendicular to the axis of the threaded rod.

Two threaded rods were modeled. The first is M8x1 (M = ISO metric; 8 = the basic major diameter of the thread, and 1= is the pitch), and the second is M8x1.25 (M = ISO metric; 8 = the basic major diameter of the thread; 1 = is the pitch, and 0.25 = is the length of the shift).

The spur gear system consists of a 10-tooth drive gear with a 10mm diameter attached to the stepper motor. And a 25-tooth driven gear with a 25 mm diameter to reduce speed.

The transmission ratio (i) of the gear is equal to 0.4, defined by the formula [2] (2.1). Were Ze = 10 and Zs = 25

$$i = \frac{Z_e}{Z_s} \tag{2.1}$$

The driven gear speed (Ws) is equal a 400 rpm, defined by the formula [2] (2.2). Were We, is the velocity of the driver gear, 1000 rpm.

$$W_s = \frac{Z_e * W_e}{Z_s} \tag{2.2}$$

In the prototype design, the threaded prism will move according to the threaded rod's thread pitch at the motor's speed. The prism with an arrow is used to observe in which direction the threaded rod rotates and to count the number of turns the driven gear gives.

Development of the graphical interface and programming in Arduino UNO:

For the user to interact between the prototype and the Arduino Uno programming, the graphical interface (Fig. 2(a)) in NetBeans IDE 8.2 Scene Builder and the interface schematic were designed (Fig. 2(b)).

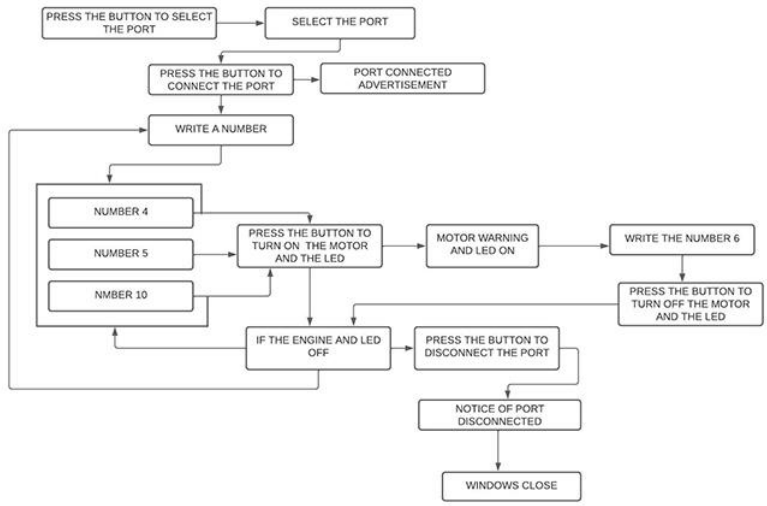

Fig. 2: (a) Graphical interface, and (b) Interface schematic.

The Arduino Uno was programmed with different speeds (30, 20, and 10), with three motor steps (10, 4, and 2), and the motor rotation in both directions (- and +). And a led that turns on and off to check when the motor turns on and off.

In the programming, we use a delay of 2000 microseconds (two seconds) so that when the processor waits, we mark the line on the paper where the threaded prism stops (Fig. 3).

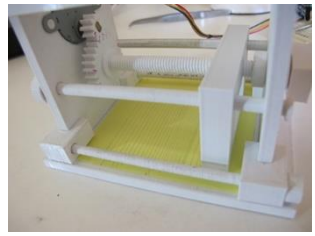

Fig. 3: Lines marked on the paper on the prototype.

Methodology:

The methodology used to reach the results of the proposed objective is the following (Fig 4):

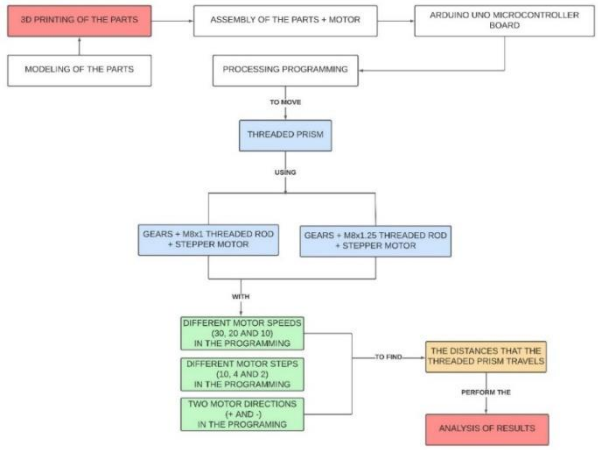

Fig. 4: Methodology.

Results:

We performed several tests with the graphical interface to verify that the 3D-printed threaded prism moves correctly in less than 3mm increments along the threaded rod and maintains its orientation perpendicular to the axis of the threaded rod using Arduino Uno programming.

According to the proposed methodology, with the data in Table 1, the analysis of the 3D printing system will be carried out in the displacement of increments of less than 3mm through the Arduino UNO programming.

	Case 1 Gear + M8x1 road	Case 2 Gear + M8x1.25 road
motor speed	30, 20 and 10	30, 20 and 10
motor steps	10, 4 and 2	10, 4 and 2
motor direction	+ and -	+ and -
delay	2000	2000

Tab. 1: Cases 1 and 2.

Case 1: in this case, we use the 3D-printed threaded rod M8x1.
Due to residues left by 3D printing, the threaded prism was not initially coupled to the threaded rod. After several passes, the 3D printing residues were removed due to friction.

With stepper motor speeds of 30 and 20, the thread of the prism skipped the thread pitch of the threaded rod. Finding that the distance that the threaded prism moved was variable and the line that was marked on the paper was not parallel to the prism.

With stepper motor speeds of 10, motor step 10, and in the two directions (+ and -), the thread of the prism did not skip the pitch of the threaded rod. In this case, the driving gear makes five turns, and the driven gear makes two turns. By marking the lines on the paper, we verify that the distance between the lines is the same distance that there is in the pitch of the threaded rod, 2mm.

We continue the analysis by marking the lines of the steps on the paper, first of 10, 4, and 2 steps at every ten intervals, and second, we alternate steps 10, 4, and 2 at a single interval.

In all cases, the lines that were marked on the paper are parallel to the threaded prism (Fig. 5). The distance that the threaded prism will move according to the number of steps is indicated in Table 2.

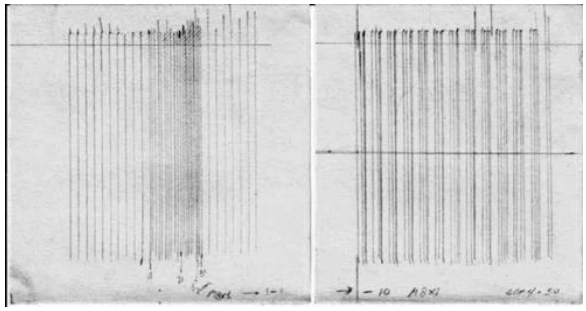

Fig. 5: Lines marked on the paper, case 1.

Steps	10	9	8	7	6	5	4	3	2
Distance (mm)	2	1.8	1.6	1.4	1.2	1	0.8	0.6	0.4

Tab. 2: Steps and distances case 1.

Case 2: in this case, we use a 3D-printed threaded rod M8x1.25.
As in case 1, initially, the threaded strip did not couple to the threaded rod due to the residues left by the 3D printing. After several passes, the 3D printing residues were removed due to friction.

With stepper motor speeds of 30, 20, and 10, the threaded prism did not skip the thread pitch of the threaded rod.

With stepper motor speed of 10, motor step 10, and in the two directions (+ and -), the driving gear makes five turns, and the driven gear makes two turns. By marking the lines on the paper, we verify that the distance between the lines is the same distance that there is in the pitch of the threaded rod, 2.5 mm.

We continue the analysis by marking the lines of the steps on the paper, first of 10, 4, and 2 steps in intervals of ten, and second, we alternate steps 10, 4, and 2 at a single interval.

In all cases, the lines marked on the paper were parallel to the threaded prism (Fig. 6). The distance that the threaded prism will move according to the number of steps is indicated in Table 3.

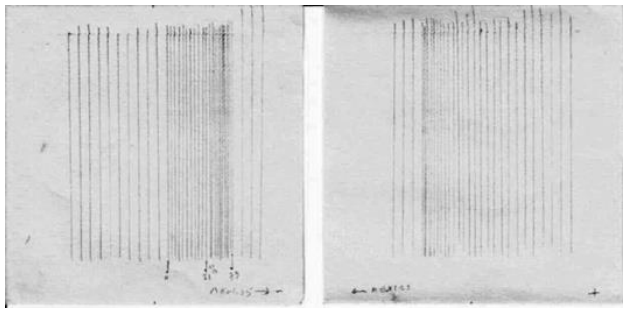

Fig. 6: Lines marked on the paper, case 2.

Steps	10	9	8	7	6	5	4	3	2
Distance (mm)	2.5	2.25	2	1.75	1.5	1.25	1	0.75	0.5

Tab. 3: Steps and distances case 2.

Conclusions:

We have presented the design, development, and programming of a robot prototype manufactured by 3D printing, consisting of a stepper motor, a gear system, a threaded rod, a threaded prism, and Arduino UNO. Our research objective is to verify that the threaded prism moves in increments less than 3mm and that it remains perpendicular to the axis of the threaded rod by using a stepper motor programmed in Arduino UNO. The most relevant aspect of our project is that increments smaller than 3mm are achieved through different steps and turns, and we can program a matrix in Arduino UNO with the values found in Figures 16 and 18.

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