DESIGN OF ALGORITHMS AND DEVELOPMENT OF A COMPUTER APPLICATION FOR THE EVALUATION OF TRAVEL STRATEGIES FOR A MOBILE CRAWLING ROBOT

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ABSTRACT:

KEY WORDS:

1. Introduction

The aim of the paper is the theoretical as well as the physical realization of a robot that moves with crawling motion, similar to the movement of a snake or a worm, this being useful for rough terrain or small and closed spaces, where a typical robot could not move normally. The objectives pursued were to achieve the movement by crawling, to achieve a sufficiently strong skeleton to shocks and other geo-climatic factors. The 3d model of the robot was made using Solidworks 3D CAD. The initial tests were performed using an Arduino Unor R3 board, an SG90 servo motor and an HC-SR04 ultrasonic sensor, and the algorithm was created using Labview for component control. The servomotors are used for movement, the microcontroller for robot control, and the ultrasonic sensor for detecting the distance of obstacles.

2. The current stage

We made a final 3d model of the robot, which was made and improved after 2 previous versions. I made an elaborate documentation related to the realization of the movement by crawling, models and prototypes made by other companies and universities, from which I learned how I could improve the robot and what it needs. I found several libraries for Arduino and ESP32, which will help me to realize the navigation algorithm. Currently, I have several components, as I mentioned before, on which I will perform several tests. We performed torque calculations so that I could choose the servomotors correctly and to know that they will be able to operate the modules from which the robot is made.

3. Equations

To realise the crawling movement I will use MG996R servo motors, which have a locking torque of 13kg-cm. The mass of each module was calculated using Soldiworks software, based on the material chosen and the weight specified in the technical detail of each component in the system.

$$F = mg = 13kg * 9{,}80665 m/s^2$$

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$$F = 127{,}48N$$

$$\tau = 1{,}27Nm$$

Torque calculation for a module at a 45° angle:

$$\tau = rF$$
$$F = 0{,}292kg * 9{,}80665m/s^2$$
$$F = 2{,}86N$$
$$\tau = (9{,}35cm * \cos(45°)) * (2{,}86N)$$
$$\tau = (0{,}0935m * \cos(45°)) * (2{,}86N)$$
$$\tau = 0.06611 * (2{,}86N)$$
$$\tau = 0{,}189N\mathrm{m}$$

Torque calculation for a module parallel to the ground:

$$F = 0{,}292kg * 9{,}80665m/s^2$$
$$F = 2{,}86N$$
$$\tau = (9{,}35cm) * (2{,}86N)$$
$$\tau = (0{,}0935m *) * (2{,}86N)$$
$$\tau = 0{,}267Nm$$

From the equations used, it follows that servo motors are powerful enough to drive these torques.

4. Tables

Table 1. Material Data Sheet: Z-ABS

Physical Properties	Metric
Density	1.04 g/cm^3
Linear Mold Shrinkage	0.0055 cm/cm
Melt Flow	3.9 g/10 min
Mechanical Properties	
Hardness, Rockwell R	108
Tensile Strength, Yield	30.3 MPa
Elongation at Yield	1.8 %
Tensile Modulus	1.86 GPa
Izod Impact, Notched	1.33 J/cm
Charpy Impact, Unnotched	NB
Charpy Impact, Notched	0.700 J/cm^2 1.600 J/cm^2
Thermal Properties	
Vicat Softening Point	104°C
Flame Class Rating	HB
CTE, linear, Parallel to Flow	74.0 µm/m-°C
Deflection Temperature at 1.8MPa (264 psi)	98.9°C

The moduless will be realized using additive manufacturing technology

5. The figures

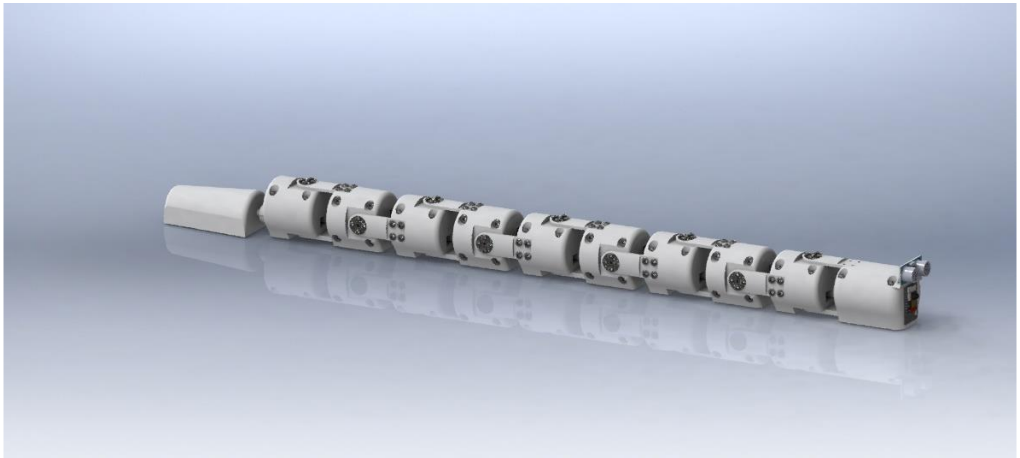

Figure 1 Final version of the robot

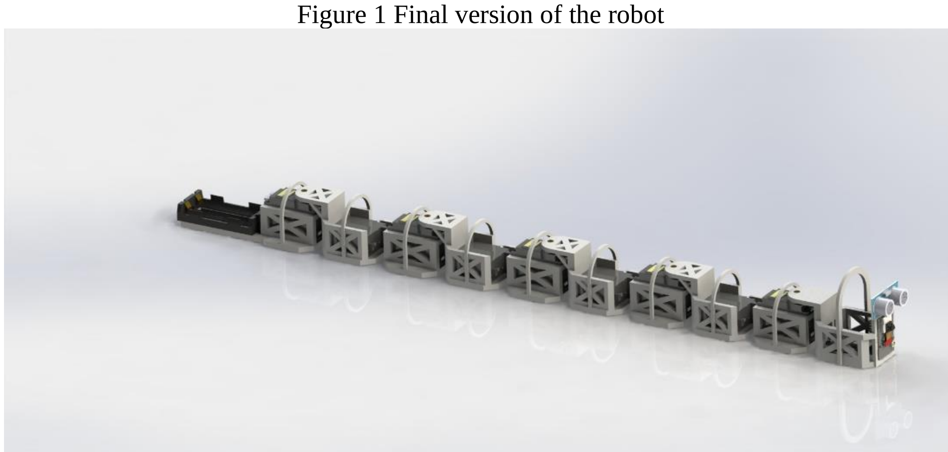

Figure 2 Previous Version

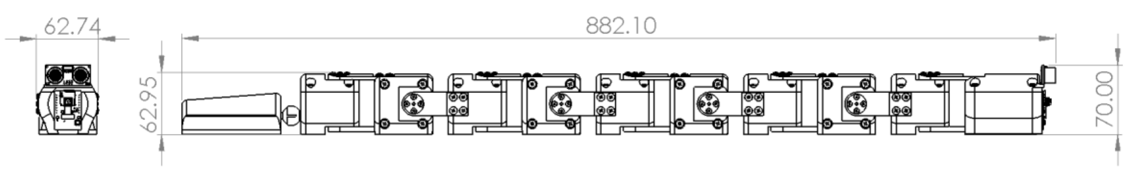

Figure 3 Overall dimensions

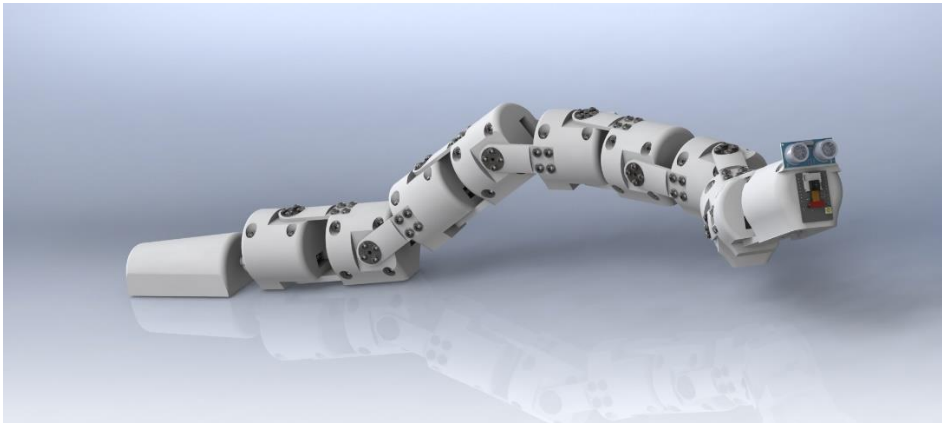

Figure 4 Movement by crawling

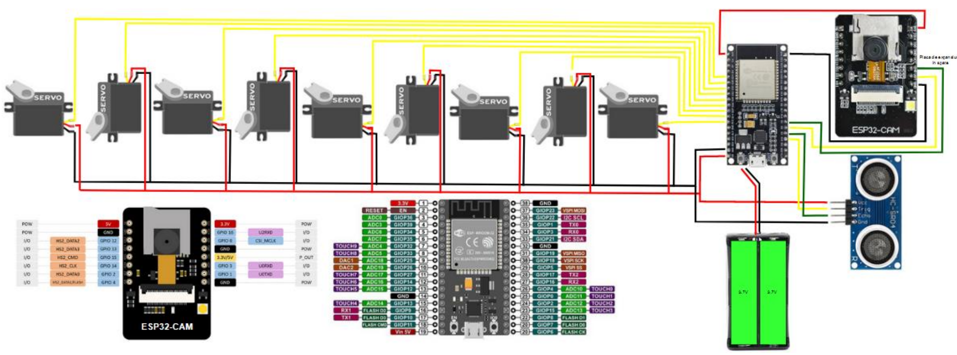

Figure 5 Wiring diagram

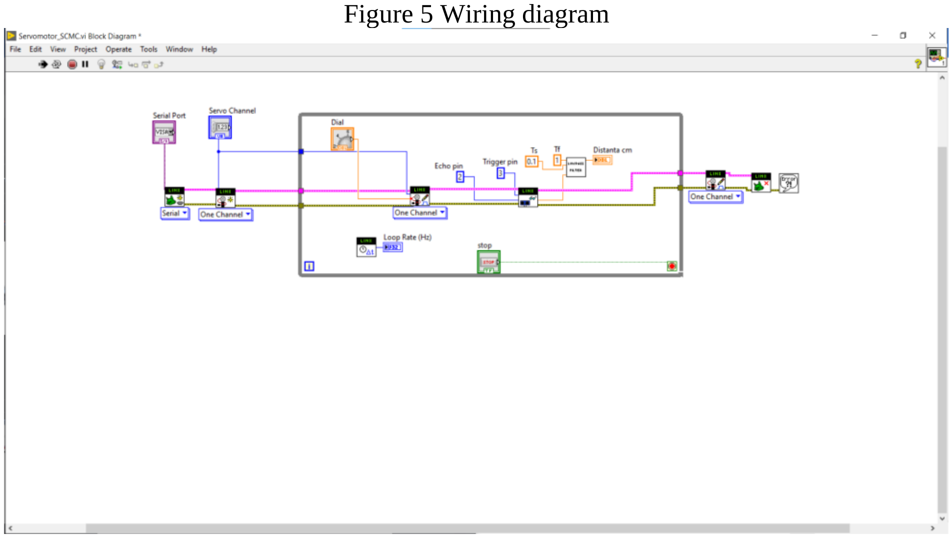

Figure 6 Block Diagram

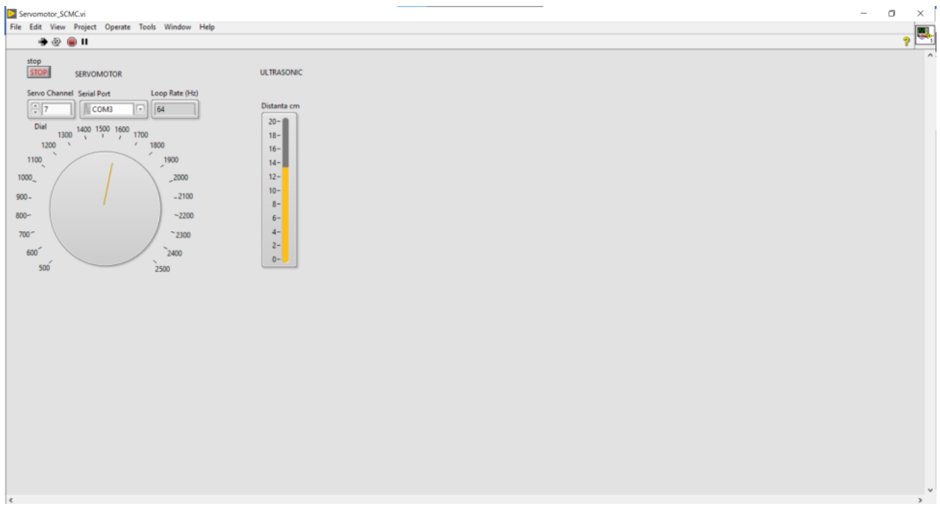

Figure 7 Front Panel

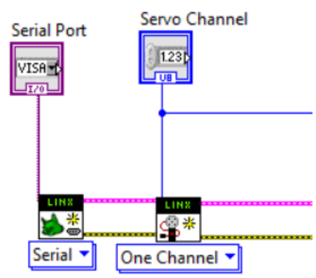

Figure 8 Labview

COM3 serial port opening for servomotor and ultrasonic. It connects to the Servo Open Channel to set the channel to which the servomotor is connected.

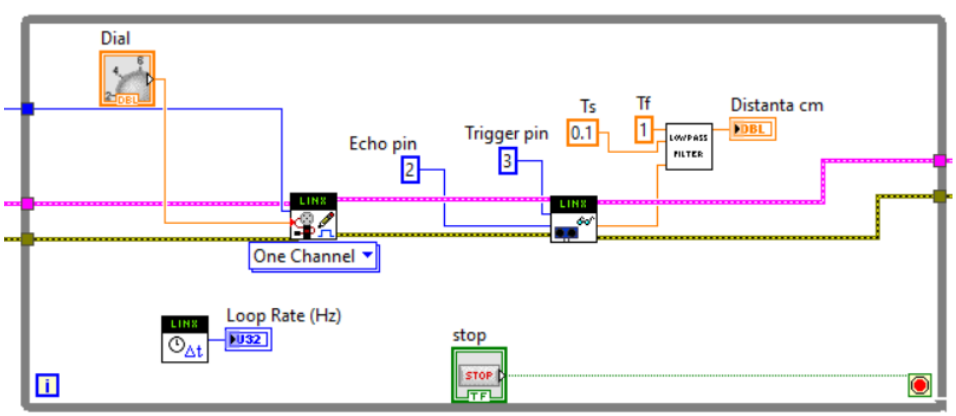

Figure 9 Labview

A While Loop is created, in which the Set Pulse Width One Channel function will be used to open the specific channel for the servomotor. Also, the Ultrasonic Read function will be used, in order to be able to read the Ultrasonic sensor, two constants called Echo Pin have been created to produce a pulse when receiving the signal, and respectively Trigger pin for initiating the pulse. Connected to the Ultrasonic Read function is also connected a LowPass filter function, to filter the noise received by the ultrasonic sensor

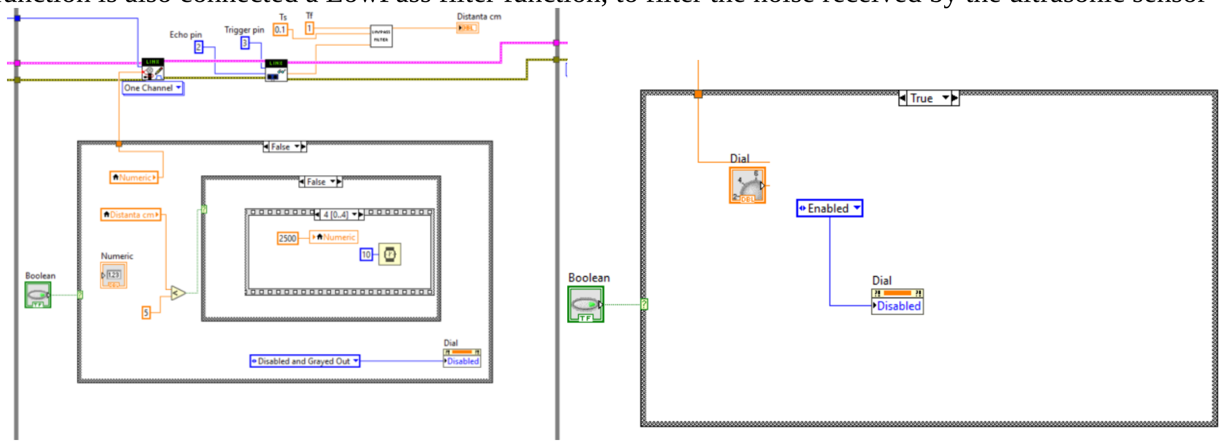

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Figure 10 Labview

A Structure Case has been created inside the Loop, when the value is true, the servomotors operate normally, when it is false, the servomotors stop in the neutral position at 90 degrees (1500uS, the servomotor can rotate between 500 and 2500uS) when the servomotor detects a distance of less than 5cm to avoid contact.

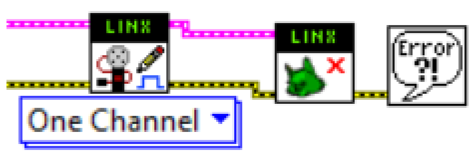

Figure 11 Labview

The final function is connected, outside the While Loop, to the Servo Pulse Width One Channel output and then to the Close function to close the serial communication.
MakerHub - Linx functions were used to realise the Vi

6. Conclusions

The original contribution made in the paper is the 3d model, which was created with the intention of protecting the robot's components as much as possible and not to get stuck on the ground on which it moves. I am going to further research the crawling movement in robots, it is a necessary field, but with an incipient development.

7. Bibliography

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