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Biocinética en robótica: Diseño y desarrollo de sistemas de agarre inspirados en el pulpo

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ABSTRACT

Research was conducted and a theoretical prototype developed in research centers was implemented. The project stemmed from a review of various proposed models, most of which were theoretical since implementation had not yet taken place due to a wide range of challenges, such as a lack of resources. First, information was gathered regarding the octopus and how its tentacles function—which was what we sought to replicate in the prototype. Certain aspects had to be improved during the development process; a clear example was the modification of the three pulleys used in the contraction mechanism that control specific points along the arm. Ultimately, the results were satisfactory, as the arm was able to move and manipulate heavy objects without overloading its motors, providing a secure grip and a wide range of motion. An analysis was conducted to identify materials that could improve the prototype, such as motors with higher performance than those currently used.

Keywords: *Controllers, CNC, drivers, motors, octopus.*

ABSTRACT

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Research and implementation of a theoretical prototype developed in research centers were carried out. The project stemmed from a review of various proposed models, most of which were theoretical since their implementation had not been carried out due to a wide range of difficulties, such as a lack of resources. First, information regarding the octopus was gathered, focusing on how the tentacles function—which was what we sought to replicate in the prototype. Some aspects had to be improved during the development process; a clear example was the refinement of the three pulleys used for the contraction mechanism that acts on specific points of the arm. Finally, the results obtained were satisfactory, as the movement and handling of heavy objects could be performed without overloading the arm's motors, providing us with a firm grip and a wide range of flexibility. An analysis was conducted of materials that could enhance the prototype, such as motors with higher performance than those used.

Keywords: *Controllers, CNC, drivers, motors, octopus.*

INTRODUCTION

This report presents a comprehensive account of an experimental project focused on the design, construction, and evaluation of a robotic arm prototype. The fundamental challenge of this project was not simply to build a robot, but to do so under very specific conditions; the system had to be functional, precisely controllable, and, above all, assembled from very low-cost components that were easy to obtain.

Studying nature to solve human problems. Specifically, the extraordinary movement of an octopus's tentacles was observed. The biology of these animals offers an astonishing model of flexibility, strength, and adaptability, allowing them to manipulate objects with a dexterity that traditional rigid robots cannot match.

The initial idea was, therefore, to attempt to replicate this organic movement using "soft actuators" or "artificial muscles"—materials that can change shape or contract when electricity or air is applied. Second, the complexity of manufacturing and controlling these soft actuators was beyond the scope of the resources and time available for this project.

Faced with this reality, a change in approach was necessary. It was decided to pivot from the idea of a soft, flexible arm to that of a rigid arm, but one whose precision of movement could be digitally controlled—the system used by Computer Numerical Control (CNC) machines. This is the same principle that powers 3D printers and laser cutters. This approach relies on the use of stepper motors (specifically the NEMA 17 model), which do not rotate continuously but move in small, discrete, and precise "steps."

This allows a computer to know exactly where the motor is at all times, without the need for complicated sensors. In the following sections of this report, the entire process of this experiment will be broken down. First, the materials and methods will be detailed, explaining the two key software programs that made the robot work: the Arduino IDE, which was used to upload the GRBL firmware to the robot's "brain," and the UGS (Universal G-code Sender) software, which was used on the computer to send G-code instructions to the arm. GRBL is the translator that converts those commands into the electrical pulses that drive the motors.

METHODOLOGY

Depending on the sector in which the robotic arm is used—whether in an industrial or everyday setting—it will have one application or another. Some examples of tasks a robot can perform in an industrial setting include: screwing, gluing, welding, painting, transferring a part from one conveyor belt to another, and assembling components. Generally, industrial robotic arms operate by running software used to program their main functions and by using sensors that measure various factors such as location, force, acceleration, temperature, etc. This makes it possible to carry out a wide variety of automation tasks with a high degree of safety and precision.

Advantages

Improved efficiency in production and logistics. 2. They enable the automatic handling—that is, without direct human intervention—of heavy objects and tasks requiring high precision. 3. Improved safety and ergonomics for employees. Robots replace humans when performing heavy tasks in hazardous environments, thereby preventing the risk of accidents and injuries. 4. Maximum productivity. Industrial robotic arms can operate tirelessly 24 hours a day, seven days a week. This allows companies to maintain production while reducing labor costs.

Market Outlook

The industrial robotic arm market is experiencing sustained growth, driven by the need for automation in key sectors such as the automotive, electronics, food, and pharmaceutical industries. The target audience consists primarily of large manufacturing corporations seeking to optimize assembly, welding, and parts-handling processes. However, there is also an emerging niche among small and medium-sized enterprises that, thanks to the emergence of more affordable collaborative robots, are beginning to adopt these technologies to improve their competitiveness and reduce operating costs. In terms of competition, the landscape is dominated by global leaders such as ABB, FANUC, KUKA, Yaskawa, and Mitsubishi, which offer high-end solutions integrating artificial intelligence, machine vision, and IoT connectivity. At the regional level, lower-cost Asian and European manufacturers are putting pressure on prices and forcing established brands to differentiate themselves through technological innovation and value-added services, such as predictive maintenance, training, and consulting.

In addition, emerging startups are exploring specific niches, such as modular robotic arms or those integrated with 3D printing, further diversifying the market offering. The commercial viability of this market is high, as automation has become a strategic necessity for companies seeking to increase productivity and reduce their dependence on a skilled workforce, which is becoming increasingly scarce. Projections indicate significant annual growth through 2030, opening up opportunities for new players offering flexible and cost-effective solutions. However, there are associated risks, such as high initial investment that limits adoption among SMEs, low-cost competition that erodes margins, and cultural resistance in traditional companies that require training to integrate these technologies.

Building a digitally controlled robotic arm involves integrating concepts from robotics, power electronics, control systems, and embedded computing. This project is based on several theoretical principles that provide insight into how the prototype works and the technical decisions made.

A. Robotics and Manipulator Kinematics

Robotic manipulators are mechanical systems capable of moving an end-effector in space via rotational or linear joints. Although this prototype employs a rigid architecture, the design was initially inspired by soft robotics, a field that studies the imitation of flexible biological structures using deformable materials. Due to technical constraints, the project ultimately adopted a rigid structure, but it maintains the goal of positioning accuracy, an essential characteristic of any robotic manipulator.

B. NEMA 17 Stepper Motors

Stepper motors are actuators widely used in CNC machines and 3D printers due to their ability to divide a full revolution into discrete steps. A NEMA 17 motor operates through the ordered sequence of activation of its internal coils, which allows its position to be determined without requiring additional sensors. These motors can be controlled in full-step or microstep modes; the latter improves the smoothness and resolution of motion but requires proper handling of electrical signals at the driver's configuration pins.

Figure 1. *Stepper motor*.

Source: *(basic electromechanical component, authors' digital archive).*

C. A4988 Drivers

A4988 drivers are modules designed to manage the current sent to stepper motors. These drivers allow selection between full-step and microstep modes via three configuration pins (MS1, MS2, and MS3). When these pins are connected to ground, the motor operates in full-step mode, which reduces precision. Applying a proper 5 V supply to these pins enables microstepping, which is essential for achieving fine movements in a CNC system. For this project, it was necessary to correct errors in the CNC Shield and adjust connections to ensure proper operation of the microstepping mode.

D. GRBL Firmware

GRBL is open-source firmware widely used in CNC systems due to its ability to interpret instructions in G-code format and convert them into electrical signals for stepper motors . It functions as a state machine that transforms motion commands into precise sequences of pulses. GRBL runs on Arduino-compatible microcontrollers and allows for pin mapping configuration, which was essential due to the modifications required to adapt the CNC Shield used in this project.

E. G-code Instructions and the UGS Interface

Figure 2. *G-code*.

Source: *(Best GRBL Software for Laser Engraving, by Tyvok EU).*

G-code is a standard language used to describe movements in CNC machines, using commands that specify coordinates, speeds, accelerations, and trajectories. To transmit these instructions to the GRBL firmware, the Universal G-code Sender (UGS) is used—an application that acts as an interface between the user and the controlled system. UGS allows users to send commands, monitor the robot's position, and continuously run test routines, which is necessary to evaluate the robotic arm's precision.

F. Open-Loop Control Architecture

The system is based on an open-loop control scheme, which is characteristic of many low-cost CNC machines. In this approach, the motors receive commands without a sensor providing feedback on the actual position achieved. While this type of control simplifies the design and reduces costs, it has the limitation of being unable to correct errors in real time caused by mechanical slippage, missed steps, or thermal overload in the drivers. For this reason, current calibration, proper ventilation, and the adjustment of motion parameters are essential factors for maintaining the prototype's accuracy.

Application of the Selected Experimental Instruments and Methods

The development of the prototype was based on the integration of hardware and software tools selected for their low cost, accessibility, and ability to perform precise control in CNC systems. The Arduino Nano board was used as the main microcontroller due to its compatibility with GRBL firmware and its ease of programming using the Arduino IDE. A CNC Shield v3 equipped with A4988 drivers was used to control the stepper motors; these components provide the necessary current for the movement of the NEMA 17 actuators.

The control method adopted the typical architecture of CNC machines: the system receives commands in G-code, which are interpreted by GRBL and converted into electric directi , and step pulses. The Universal G-code Sender (UGS) software was used to send these instructions, allowing commands to be viewed, monitored, and executed in real time.

The experimental application also required modifications to the CNC Shield due to design flaws, such as the grounding of the microstep pins. This procedure involved cutting traces and manually wiring the MS1, MS2, and MS3 pins to a 5 V line, thereby ensuring the ability to use microstep modes during testing. Finally, inspection methods using a multimeter and continuity tests were implemented to confirm correct pin mapping and ensure system integrity before beginning functional testing.

Figure 3. *Implemented design.*

Source: *(Author's own work).*

Development of the Methodology

The project methodology was structured into three main phases: system assembly, firmware configuration, and motion validation.

First, the robotic arm was physically assembled, beginning with the soldering of components and the integration of the CNC Shield v3 with the Arduino Nano and the A4988 drivers. Given the low cost of the components, it was necessary to carefully inspect the board's traces and make manual corrections to ensure stable operation.

Next, the GRBL firmware was adapted. To do this, the latest available version was downloaded, and the cpu_map.h file was modified to adjust the control pins for the X, Y, and Z axes according to the actual wiring found on the CNC Shield. Specifically, the step pins were remapped to 5, 6, and 7, while the direction pins were assigned to 2, 3, and 4, respectively.

Once the firmware was configured, the program was uploaded to the Arduino Nano using the Arduino IDE, and its operation was verified using basic movement commands. Finally, the operational phase began using Universal G-code Sender, which allowed us to execute repetitive movement sequences and verify the arm's behavior under controlled conditions

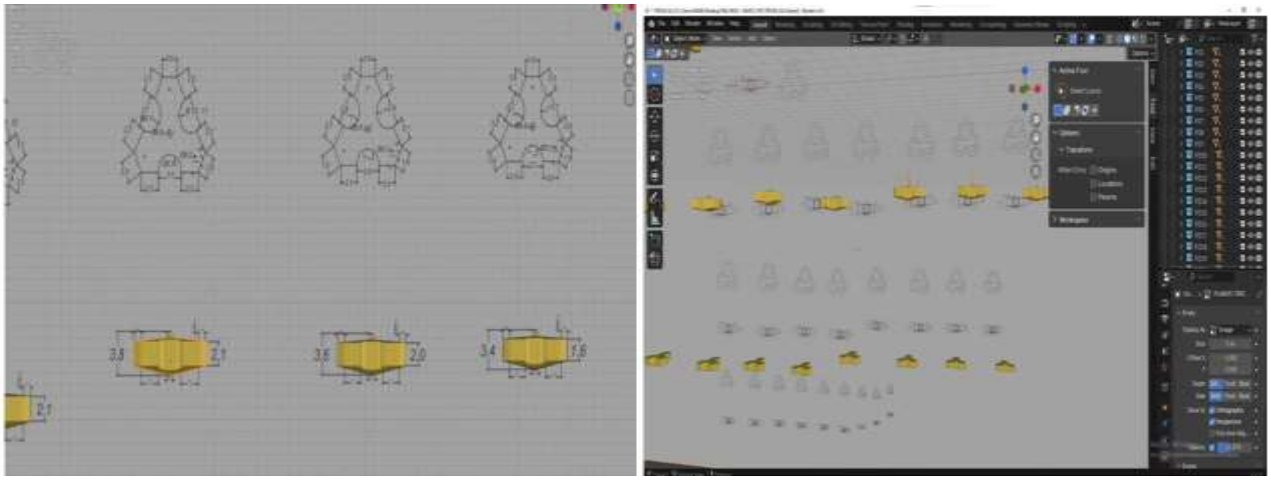

Figure 4. *Computer-aided design of the parts*.

Source: (Author's *own work*).

Adjustment and Correction of the CNC Shield v3

During the experimental process, multiple limitations and design flaws were identified in the CNC Shield v3, so a procedure was developed to adapt it to the project's needs. The process was carried out by following the steps described below:

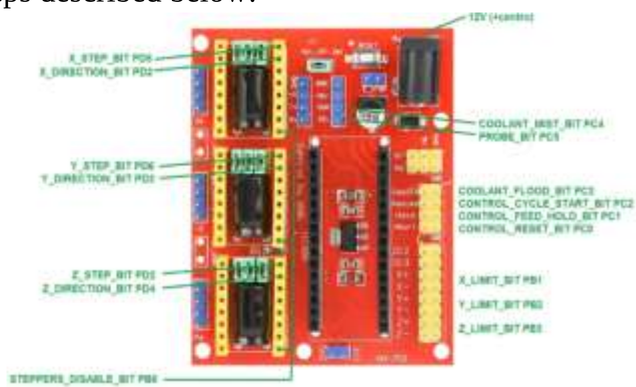

Figure 5. *CNC Shield v3 board***.**

Source: *(Arduino Nano CNC Shield V4.0 Pinout Diagram, by Electronic Parts Fast.)*.

Step 1: Selecting the Supply Voltage

- The board's specifications and community usage reports were reviewed.
- Although the board can accept up to 24 V, it was determined that the internal regulator cannot safely handle that limit.
- 15 V was selected as the maximum safe voltage, also taking into account the power consumption of the NEMA 17 motors.

Step 2: Verifying Emergency Pins and External Power Supply

- The RESET, EN, and STOP pins, intended for emergency stop functions, were identified.
- It was verified that the adjacent pins can activate the power supply from an external regulator when jumpered.

Step 3: Confirmation of actual pin mapping

The control area for the three axes was located, yielding the following result:

Table 1. *Pin assignments*.

Axis	Step Pin	Direction Pin
X	D5	D2
Y	D6	D3
Z	D7	D4
Enable (global)	—	D0

Source: *(Own work)*.

These values were verified by tracing the copper traces and measuring continuity.

Figure 6. *Board components***.**

Source: *(Author's own work)*.

Step 4: Identifying Errors in the CNC Shield Design

- It was observed that all limit pins are connected to GND, which prevents distinguishing between the limits of each axis.
- It was found that the MS1, MS2, and MS3 pins of the A4988 drivers were connected directly to ground, which forces full-pass mode.

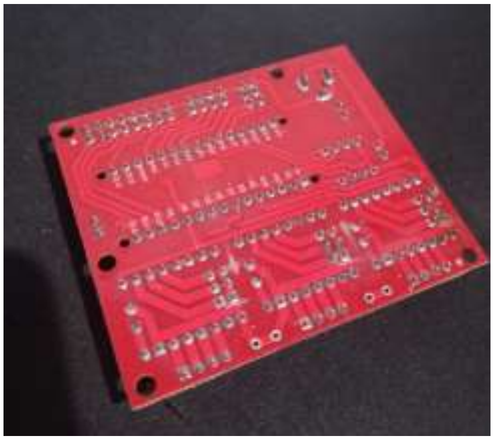

Figure 7. *Board Pins***.**

Source: *(Author's own work)*.

Step 5: Correcting the microstep Pins

- The traces connecting MS1–MS3 to ground were cut.

- These pins were rewired to the 5 V line, enabling microstepping.
- Continuity was checked to ensure there were no remaining ground connections.

This adjustment was essential for achieving finer and more stable movements in the robotic arm.

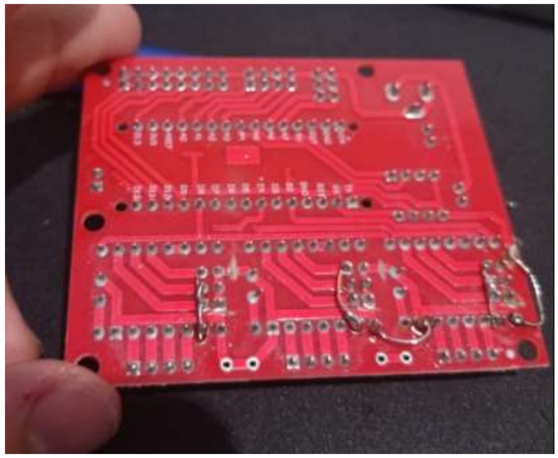

Figure 8. *Pin modification***.**

Source: *(Author's own work)*.

GRBL Firmware Configuration

The GRBL firmware was prepared and adapted according to the board's electrical and pin-mapping requirements.

Step 1: Downloading and Preparing the Firmware

- GRBL was downloaded from its official repository.
- The ZIP file was unzipped, and the **grbl-master** folder was located.
- The **grbl** folder was copied to the Arduino library

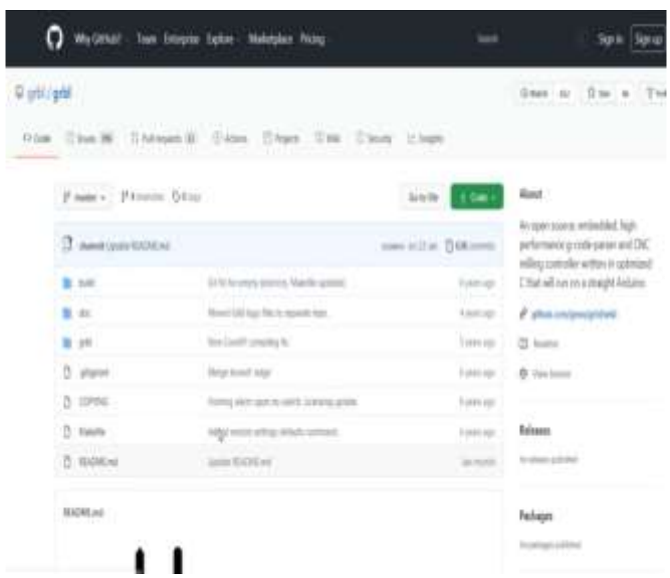

Figure 9. *GRBL firmware***.**

Source: *(official grbl/grbl repository, by Chamnit (n.d.), GitHub (github.com))*.

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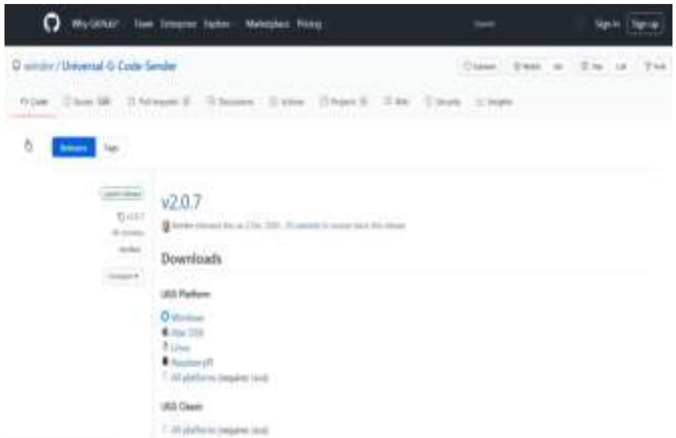

Figure 10. *Application data***.**

Source: *(official grbl/grbl repository, by Chamnit (n.d.), GitHub (github.com))*.

Step 2: Identifying Files to Modify

- The cpu_map.h file was located inside the firmware directory.
- This file contains the definition of the control pins for each axis.

Step 3: Editing the pin mapping

The default values were replaced with the actual pins of the modified CNC Shield:

- **STEP** pins for X, Y, and Z → **5**, **6**, **7**
- **DIRECTION** pins for X, Y, and Z → **2**, **3**, **4**

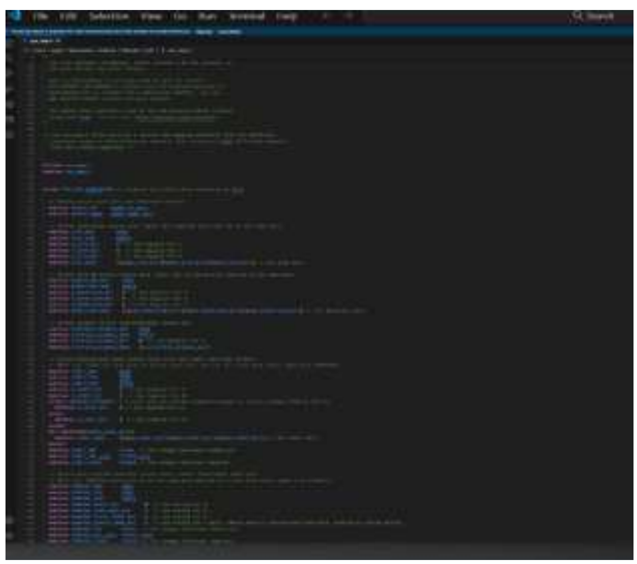

Figure 11. *Pin mapping***.**

Source: *(Created by the author)*.

Step 4: Uploading the firmware to the Arduino Nano

- The Arduino IDE was opened.
- Under *File* → *Examples*, the included GRBL template was selected.
- The firmware was compiled and uploaded to the microcontroller.

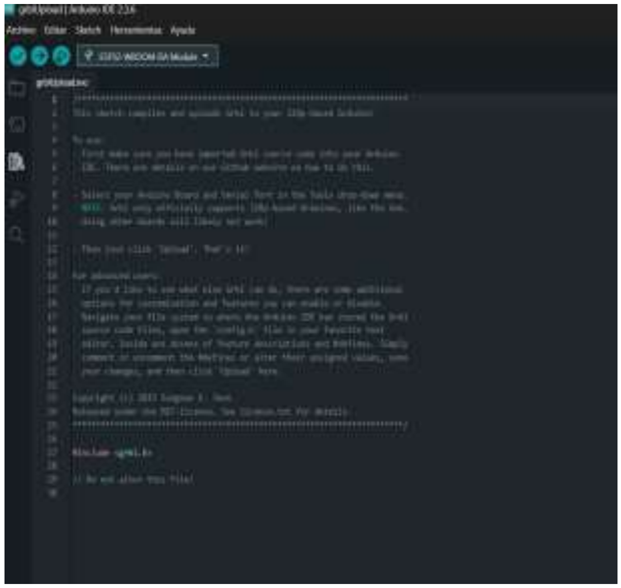

Figure 12. *Firmware uploaded to the Arduino Nano***.**

Source: *(Created by the author).*

Step 5: Installing the UGS Software

- From the downloaded folder, the 64-bit version of ugsplatform-win was run.
- **Java** installation was verified, as UGS relies on this environment to function.
- Serial communication with the Arduino was confirmed.

With these steps completed, the arm was ready to receive G-code instructions and run the experimental tests.

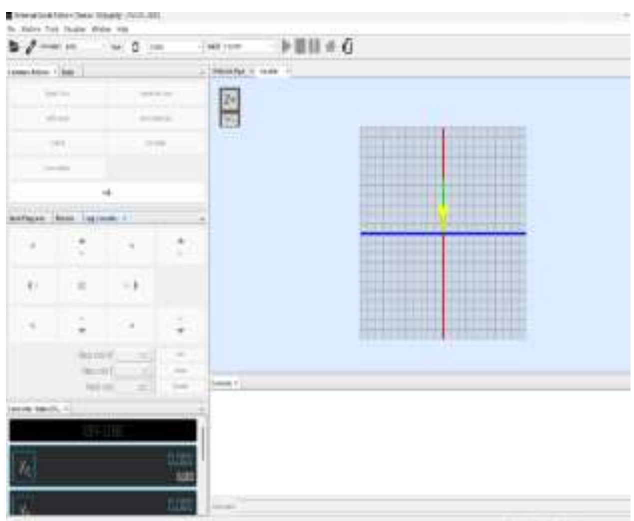

Figure 13. *UGS software***.**

Source: *(Screenshot of the Universal Gcode Sender (UGS) software, by Winder (n.d.)).*

Data Collection and Processing.

Data collection was performed by continuously executing G-code commands designed to move the robotic arm to specific positions along the X, Y, and Z axes. These tests consisted of sending repeated movement commands with known magnitudes, allowing us to observe the system's repeatability and precision.

During the test sessions, several parameters were recorded manually:

- Displacement accuracy, evaluated visually and using physical reference points.
- Thermal stability, monitored by observing the gradual heating of the A4988 drivers.
- Mechanical behavior, documented by noting vibrations, missed steps, or irregular noises during movement.

The collected data was organized into descriptive tables comparing expected movements with observed movements. Additionally, notes were taken on any anomalous behavior, such as reduced torque, sudden interruptions, or overheating. These observations made it possible to identify patterns related to microstep mode, execution speed, and the current configured in the controllers.

Generative AI Disclosure

We hereby declare that **Google's Gemini** tool was used as an aid in searching for preliminary technical information, clarifying concepts related to computer numerical control (CNC), and providing conceptual support in structuring the research, with the authors assuming full responsibility for the content of the manuscript.

Responsibility

All signatory authors declare that they have contributed equally, intellectually, and directly to the comprehensive development of this research. Likewise, all team members jointly and severally assume full responsibility for the technical content.

Methodological Limitations

The scope of the methodological testing was constrained by time limitations and laboratory availability, which restricted data collection to short-term operational tests under controlled conditions. Neither the mechanical wear of the components nor the thermal behavior of the controllers during prolonged continuous operation was evaluated.

RESULTS

Analysis of the data obtained showed that the prototype was able to execute movements with an acceptable degree of precision, although this was limited by the inherent characteristics of the open-loop system. When the system operated in microstep mode, the movement became smoother and more stable, confirming the importance of the correction made to the CNC Shield to properly enable pins MS1–MS3.

It was observed, however, that precision decreased when the motors operated for extended periods or at high speeds, a situation attributed to overheating of the A4988 drivers. This phenomenon caused step loss, which directly affects positioning accuracy. It was also found that the lack of feedback prevented these deviations from being automatically corrected.

Despite these limitations, the system proved to be functional, replicable, and suitable for educational or prototyping applications. A comparative analysis of expected versus actual movements suggests that improvements such as increasing ventilation, recalibrating the driver current, and optimizing feed rates can significantly increase the system's performance without the need to change its main components.

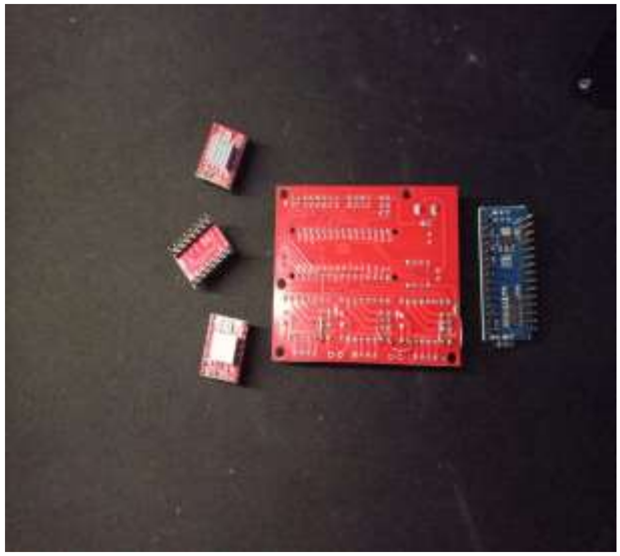

Figure 14. *Bottom view of the motor control board and the Arduino NANO board*.

Source*: (Author's own work).*

Figure 15. *Top view of the motor control board and the Arduino NANO board*.

Source*: (Author's own work).*

Following the implementation and experimental testing phase, the prototype proved to be a functional, replicable, and highly effective solution for educational and rapid prototyping purposes. The system successfully executed motion sequences along the X, Y, and Z axes by interpreting G-code commands, validating the feasibility of using low-cost components for controlled automation tasks.

Key Findings

Effectiveness of Microstepping: The technical modification made to the CNC Shield v3—which consisted of manually reconfiguring the tracks to enable the microstepping pins (MS1–MS3)—was decisive. This adjustment allowed for a transition from rudimentary movement to one that was significantly smoother, more precise, and more stable, validating the importance of this modification for the system's performance.

Limitations of Open-Loop Control: As expected in an open-loop control system, it was confirmed that the absence of feedback sensors limits the robot's ability to correct positioning errors in real time. It was found that external factors, such as overheating of the A4988 drivers during prolonged use or at high speeds, cause step loss, which degrades the accuracy of the movement.

Operational Performance: Despite the mechanical and thermal limitations identified, the arm demonstrated consistent operational capability under controlled conditions. The use of GRBL firmware and the UGS interface proved to be a robust and efficient combination for trajectory management and robot monitoring.

Technical Conclusions

The project leads to the conclusion that it is possible to achieve an acceptable level of precision by optimizing technical parameters without having to replace the main components. The system's stability is directly linked to the balance between feed rate, microstep configuration, and thermal management of the components.

In summary, the prototype meets its technical objective by providing a cost-effective and adaptable automation platform. The shortcomings identified, far from being critical flaws, have helped establish a clear roadmap toward optimization.

Costs

Table 2. *Prices of components and services used in the development of the arm*.

Materials Used	Quantity	Unit Cost	Net Cost
NEMA 1717H stepper motor	3	$158.90	$476.70
3DV4 CNC SHIELD V3	1	$130	$130
HC-05 Bluetooth Module	2	$115	$230
A4988 Driver	3	$40	$120
Arduino Nano 3.0	2	$180	$360
Macocel	1	$320	$320
Resistol 5000	1	$52	$52
Kola Loka	3	$40	$120
1.0mm Fishing Line Spool	1	$40	$40
Furniture Corner Bracket	16	$5	$80
3D Printing	25	$56	$1,400
56.6mm pulleys	8	$64.25	$514
Hundred screws	1	$1	$100
Transportation and fuel			$700
Total Cost			$4,642.70

Source: *(Prepared by the author)*.

Proposed Adjustments to Research Parameters and/or the Prototype

Based on an analysis of the results obtained and considering the practical limitations of the project—primarily in terms of time, budget, and component availability—we propose making a series of minor adjustments to the configuration and design, without changing the overall methodology or the base materials.

1. Proposed Adjustments to Technical Parameters

2. Reduction of the feed rate:
Adjusting the F parameter in the G-code to values between 300–500 mm/min has been shown to improve precision and prevent motor step losses.

Figure 16. *NEMA 17 motors.*

Source*: (Author's own work).*

3. Use of intermediate microstepping in A4988 drivers

Configuring the drivers to 1/8 step instead of 1/16 or full step maintains a good balance between motion resolution and torque, reducing system vibrations.

4. Driver current

Manually calibrating the A4988 to limit the current to approximately 0.8 A, using passive heat sinks, allows it to operate without the risk of overheating during extended test sessions.

5. Prototype Adjustments

Improve the drivers' cooling system

Install **aluminum heat sinks** and, if possible, a small fan (5V or 12V) over the driver area to extend their service life and allow for a higher workload without thermal failures.

6. Stabilizing the Mechanical Structure

Secure the motors and moving parts more firmly to prevent play or vibrations that could cause inaccuracies.

Similarly, the use of artificial muscles or soft actuators—which more closely mimic the natural movement of an octopus—was temporarily ruled out due to their high cost and complexity of implementation. The CNC approach using stepper motors has proven to be a practical and functional alternative, provided that the aforementioned parameters are optimized.

DISCUSSION

Following the experimental tests, the prototype proved to be a functional and replicable solution for educational purposes. The integration of GRBL firmware and the UGS interface allowed for the efficient management of trajectories, while the manual reconfiguration of the tracks on the CNC Shield v3 (pins MS1–MS3) transformed an initially rudimentary movement into smooth operation. However, to validate the scope of this development, the empirical results must be compared with the existing indexed literature on continuous systems:

First, the methodological shift from a soft structure to a rigid-segmented mechanism contrasts with the dominant trends in soft robotics. Pioneering research argues that mimicking the octopus requires deformable elastomers with infinite degrees of freedom for a secure, adaptive grip. However, such systems involve high mathematical complexity and prohibitive costs. As proposed by Bhalkikar [17], discretization into rigid segments using pulleys approximates complex geometries while drastically reducing the computational load, which enables the use of open-source environments such as GRBL.

Second, the loss of steps and positional inaccuracy due to overheating of the A4988 controllers in L.A. coincide with the thermal challenges reported by Hernández-Ibarra [18]. In continuous robots driven by cables and low-end microcontrollers, direct motion profiles without feedback generate force spikes and thermal overshoots in the drivers that degrade repeatability. To mitigate this vulnerability without increasing hardware costs, Fei [19] suggest adopting input shaping algorithms or controllers with software-based input saturation, optimizing accelerations to prevent thermal stress on the components.

Third, the risk of structural failure due to extreme tension in the contraction threads under high torque demands is a challenge in continuous robots driven by tendons. Wang [20] argues that low-cost systems with base-mounted actuators experience severe stress concentrations at the anchor points. While our Macocel chassis experienced extreme deformation, Wang [20] demonstrate that a dual mechanical tensioner counteracts wire slack under continuous loads. This supports our recommendation to stabilize clearances and calibrate the *feed rate* between 300–500 mm/min to balance chassis integrity with motor torque.

CONCLUSIONS

In conclusion, this project highlights that the operational viability of a low-cost robotic arm depends not only on programming but also on a dynamic balance between electromechanical capability and mechanical integrity. While the prototype meets its objectives, it is clear that the identified limitations require an optimization strategy based on improving driver ventilation, fine-tuning the *feed rate*, and, most importantly, reinforcing the mechanical structure to prevent material fatigue. These observations allow us to establish a clear roadmap, transforming experimental failures into valuable lessons for future iterations aimed at achieving greater reliability and robustness in working environments.

Future Research Directions

Based on the findings and operational limitations identified in the evaluation of this prototype, the following guidelines are proposed to continue this line of research:

- Implementation of a closed-loop control system: Integrate positional feedback sensors so that the software automatically corrects lost steps and deviations caused by overheating and structural fatigue of the chassis.
- Transition to a hybrid architecture with physical intelligence: Incorporate flexible elastomer coatings and passive suction cups at the ends of the rigid segments, enabling the potential application of adaptive control.

DATA AVAILABILITY STATEMENT

Study data:	The data supporting the findings of this study are available upon reasonable request to the author.
Protocol / Code / Questionnaire:	Not publicly available.
Funding Source:	This research did not receive external funding.
Conflict of Interest:	The authors declare that there is no conflict of interest related to this manuscript.
Ethics approval:	Not applicable.

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AUTHOR CONTRIBUTIONS (CRediT Taxonomy)

CRediT Role	Santiago Pérez Erandi Abdiel	Rosa Isabel Hernández Sánchez	Héctor Javier Jarquin Flores	Isaias Velasquez Cruz	Martin Vidal Reyes
Conceptualization	✓ / ✓				
Methodology	✓ / ✓	✓ / ✓			
Software					
Validation		✓ / ✓		✓ / ✓	

Formal Analysis		✓ / ✓			✓ / ✓
Research	✓ / ✓				
Resources	✓ / ✓				
Data Curation			✓ / ✓		
Drafting – original draft	✓ / ✓				
Writing – Review and Editing	✓ / ✓				
Visualization					✓ / ✓
Supervision		✓ / ✓			
Project Management			✓ / ✓		
Fundraising	✓ / ✓				

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ARTÍCULO

Biocinética en robótica: Diseño y desarrollo de sistemas de agarre inspirados en el pulpo

https://doi.org/10.61117/ipsumtec.v9i2.472

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Estudiante de **Ingeniería Electrónica** en el Tecnológico Nacional de México con destacada trayectoria en innovación. En mayo de 2025, obtuve el tercer lugar en el concurso **Electrorally** (Instituto La Salle Oaxaca) por un dispositivo de detección de contaminantes en el agua desarrollado en equipo. Posteriormente, en mayo de 2026, participé en el concurso institucional **Innovatec** presentando un rastreador de ganado en tiempo real sin internet basado en tecnología **LoRA**.

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