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UNIVERSIDAD DISTRITAL FRANCISCO JOSE DE CALDAS

VISIÓN ELECTRÓNICA

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VISIÓN ELECTRÓNICA

Control glove based on angular orientation.

Guante de control basado en orientación angular.

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Abstract

This document presents a prototype developed at the Francisco José de Caldas District University of a tool called Control Glove based on angular orientation that will be in charge of controlling different specialized systems, the system starts from the information that can be found in the movements of the hands, this information varies between acceleration, velocity and angular orientation with respect to the three-dimensional Cartesian plane (X, Y, Z).

The final prototype of the control glove may be used in industrial, manufacturing, educational, medicinal, and amateur applications, which will be determined depending on the use that the glove needs.

Keywords: Acceleration, accelerometer, angular, control, glove, orientation, prototype

Resumen

En este documento se presenta el prototipo de un “Guante de control basado en orientación angular” desarrollado dentro del grupo de investigación en Robótica Móvil Autónoma -

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ROMA- de la en la Facultad Tecnológica de la Universidad Distrital Francisco José de Caldas el cual, se basa en controlar y sensar algunos de los movimientos realizados por las manos, razón por la cual, la información varía en tres parámetros: aceleración, velocidad y orientación angular, en términos del plano cartesiano tridimensional (X,Y,Z).

El prototipo final del guante de control puede ser usado en aplicaciones industriales, manufactureras, educativas, medicinales, y amateur, las cuales se determinarán de acuerdo a su aplicación.

Palabras clave: Aceleración, acelerómetro, angular, control, guante, orientación, prototipo

1. Introduction

Technological scientific development has allowed man to solve different needs from his trade, providing electronic and electromechanical tools, which facilitate the man-machine relationship, therefore, the performance of different tasks becomes simpler and easier. in some cases safer [1]. Starting from the above, an experimental electronic prototype was made, based on a glove that allows converting some physical movements of the hands into information, to be able to store it and study it in different environments.

This prototype aims to control different systems of the electronic and virtual type, wirelessly; by means of a set of acceleration sensors, push buttons and communication protocols, reading and interpretation by radio frequency. It should be noted that each of these protocols are executed on an Atmega328p microprocessor, additionally, this prototype creates an immersion and a link between the human and the system. The prototype has the control capacity with different programmable systems, in comparison with other angular control systems, it denotes a change in its technology in addition to industrial capacity with the adaptation of sensors and high-level programming with the specific purpose of technological linkage - human. [2] [3]

2. Framework

2.1. Accelerometer.

It's A device that measures the acceleration of the movement of a structure or body; This sensor is based on a piezoelectric material that performs its reading, based on the force generated by the acceleration of the body, said force represents an electrical charge on the piezoelectric material that is proportional to the force exerted. These sensors are widely used in navigation, location and stabilization. [4]

2.2. Acceleration.

Acceleration is the physical phenomenon that is obtained from the change in speed; to change the acceleration you can change the speed, or its direction. Acceleration can be denoted as $a = \frac{dV}{dT}$, since it's the change in velocity with respect to time.

2.3. Angular velocity

The angular velocity is the speed with which the angle changes as a function of time, in other words, it's the variation of the angle with respect to time and is defined as $W = \frac{d\Theta}{dt}$

2.4. Accelerometer MPU6050

This sensor is a six degrees of freedom inertial measurement unit, capable of reading three axis gyroscope and three axis accelerometer. [5]

This accelerometer is an essential part of the prototype, since it will allow determining the three-dimensional spatial location of the glove, which will be worn by the device.

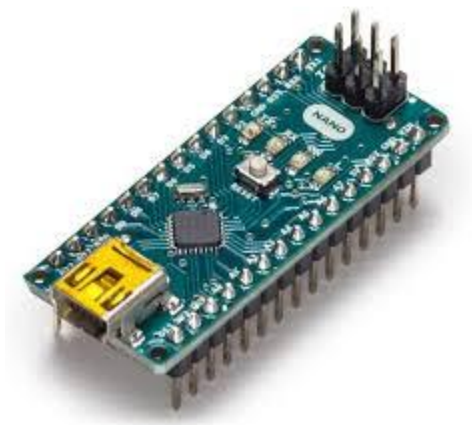
Figure 1. Accelerometer MPU6050. [5]

2.5. Arduino nano

It's an I/O board that conforms to a development environment, based on procession/Wiring that is based on an ATmega328P microcontroller.[7]. This board is used to develop interactive objects, it can also be used to establish communication between an electronic system and a computer.

In the prototype it fulfills the direct function of processing data from the sensors, reconfiguring the tasks and sending them to the communication ports.

Figure 2. Arduino nano.[7]



2.6. Radiocommunication

It's a means of communication that is based on radio waves, this principle is managed through electric fields and magnetic fields, this connection is based on a radioelectric spectrum, where different types of frequency are found; low frequency, medium frequency, high frequency, very high frequency and ultra high frequency. [5]

2.7. Radio frequency module

Radio frequency modules are widely used for wireless communication, since they are low cost; These systems use two modules, one for reception and the other for transmission, and the frequency at which they work is around 433MHz. [8]

3. Methodology

3.1. MPU6050 sensor calibration

The correct calibration of the MPU 6050 accelerometer can be done through a computing process; one of the most reliable processes for its correct calibration, in addition, is based on the correction of the sensor OFFSETS, in such a way that, by modifying their internal values, these OFFSETS reach 0 (their closest possible value); This calibration fulfills the function of leaving the sensor ready to function correctly. The calibration of this sensor can be done by any programmable board, capable of adopting the measurements and parameters that the supplier gives us in the technical sheet or datasheet. [5]

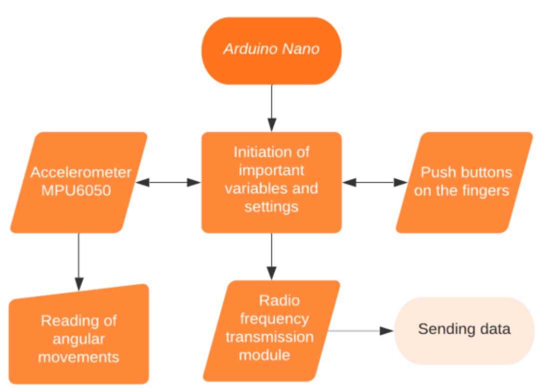
For the development of the project, four phases were taken into account:

1. Structuring the prototypes.
2. Sign production.
3. Signal reception.
4. Final usage

3.2. Structuring the prototypes

3.2.1. Transmission model

Figure 3. Transmission model.



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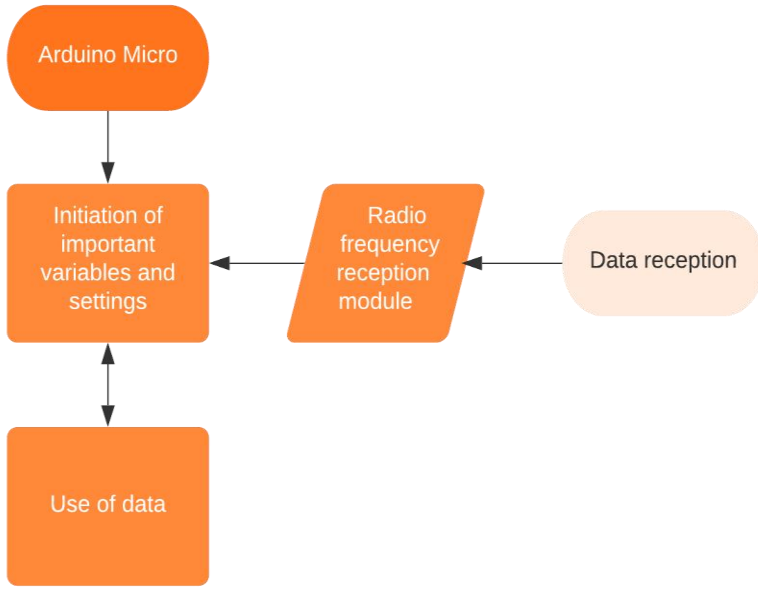
3.2.2. Reception model

Figure 4. Reception model.



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3.3. Signal production

The production of radio frequency signals is based on the correct reading of the angles in the axes (X, Y) with respect to the horizontal axis (Z = 0). This relates to different moments on each axis.

The values of each angle vary between 0 and ± 80 °

I. The first moment, when the angle of each axis has a reading ≈ 0 °

II. The second moment, when the angle of each axis is between 15 ° and 35 °

III. The third moment, when the axis angle is between -15 ° and -35 °

IV. The fourth moment, when the angle of each axis is less than -35 °

The following model of the relationship between angles allows a correct interpretation in the positive angular control.

Table 1. Relationship between the positive angles of each axis.

X axis	Y axis	Task number
0°	0°	1
>15°,35°<	0°	2
0°	>15°,35°<	3

Source: own.

Regarding the negative angular relationship, the following relationship is obtained.

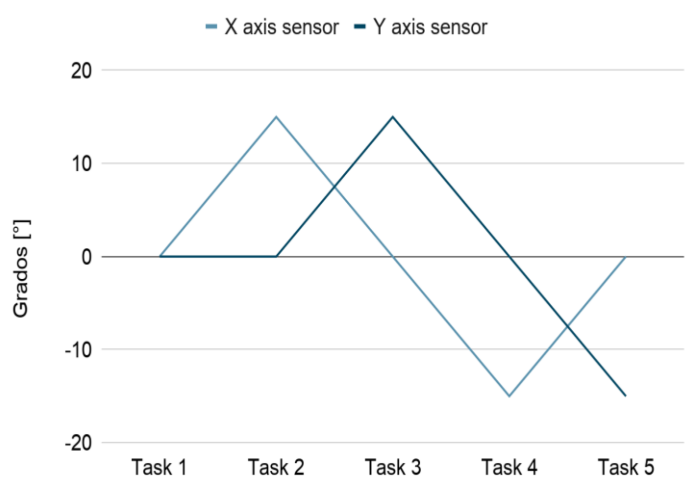
Table 2. Relationship between the negative angles of each axis. Source: own.

X axis	Y axis	Task number
0°	0°	1
>-15°, -35°<	0°	4
0°	>-15°, -35°<	5

Source: own.

All the fingers except the thumb internally have push buttons on the fingertips in order to interpret these movements, for each pulse a different signal is sent, this is how each finger generates a different task.

Figure 5. Interpretation of the angles and the tasks for each axis.



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In figure 5 it can be seen how the task scheme is done individually, referring to the fact that the sending of data and the list of tasks are executed one axis at a time, when two angles reach their threshold. task, the microcontroller will send one after the other.

The tasks on the fingers, as they do not affect or do not vary with respect to the orientation of the glove, are not shown in figure 5, while in figure 6 the behavior of the tasks according to the sensors on the fingers is seen.

Figure 6. Interpretation of tasks for each finger.

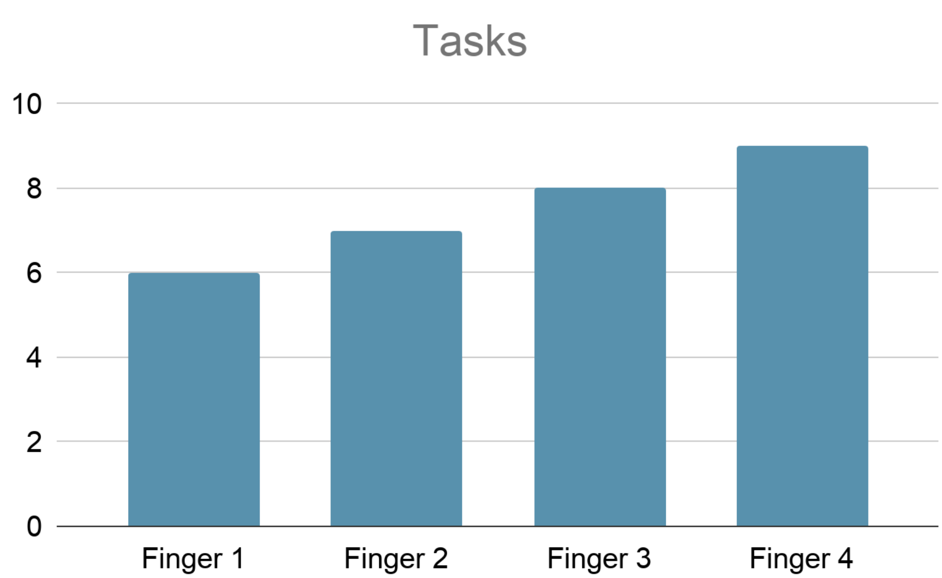

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Figure 6 shows the relationship of the functions in the fingers and their performances according to the corresponding tasks; each finger performs a different task.

3.4. Signal reception

The reception of signals is based on the readings of the characters or signals sent for each task, in the reception of signals it will be necessary to build or adapt the communication model adopted by the control glove and its clock, in order to require the final user.

3.5. Purpose

The final use of the control glove depends solely on the user who uses it; with the idea of not limiting its scope; the user will be able to adapt its functionality and task to their own needs, as test examples include handling equipment, robots, driving manned and unmanned vehicles, linking virtual reality, as well as augmented reality. [9] However, by not worrying about the limitations, the work area will be marked by the creativity of the end user, who will decide whether to adopt any of the applications already mentioned, or on the contrary decide to use it for personal or commercial use. [10]

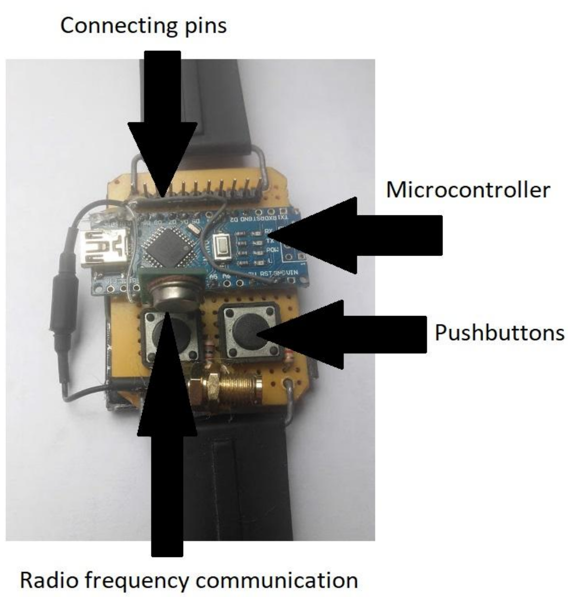
4. Development

The construction of the system is based on three essential parts:

4.1.1. Transmission clock

- The watch is responsible for reading the angles of the sensor in the orientation glove, to be able to be interpreted and sent through the RF Transmission module.
- The orientation glove and the transmission clock are wired.

Figure 7. Transmission clock.



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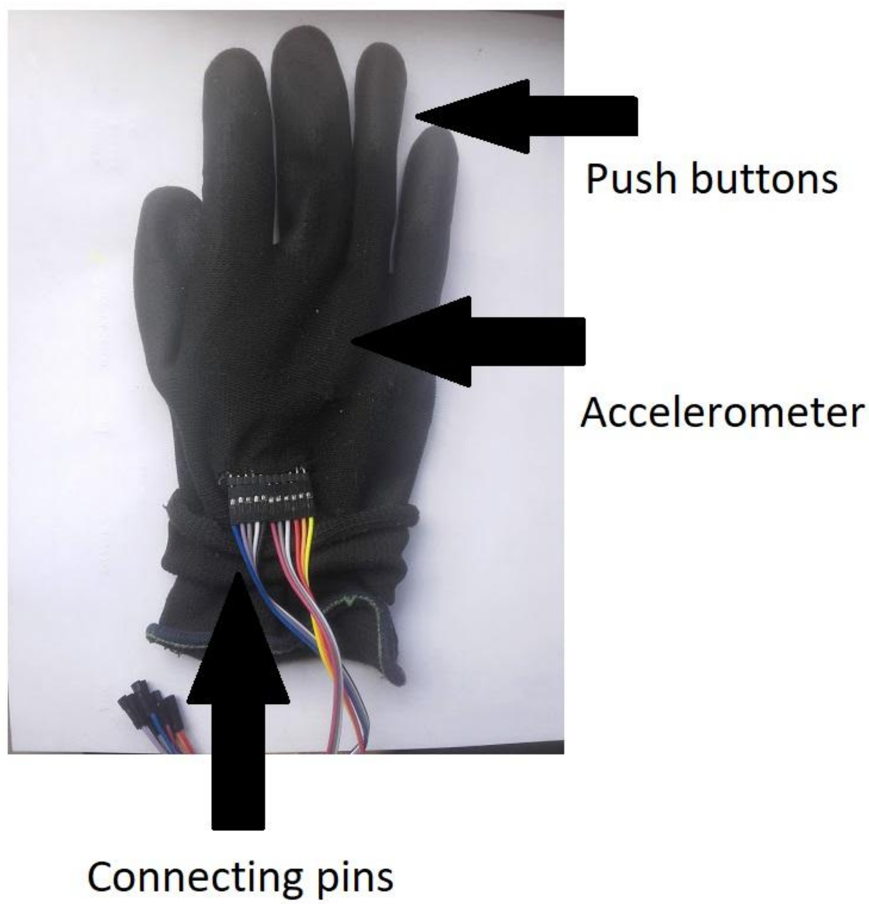
4.1.2. Orientation glove

- The glove fulfills the function of generating the orientation data that is interpreted by the transmission clock.
- In this prototype, the glove has two layers, one internal and one external, which fulfill the function of protecting the connections and the MPU6050 sensor, these are located in the middle of the layers.

Figure 8. Orientation glove**.**



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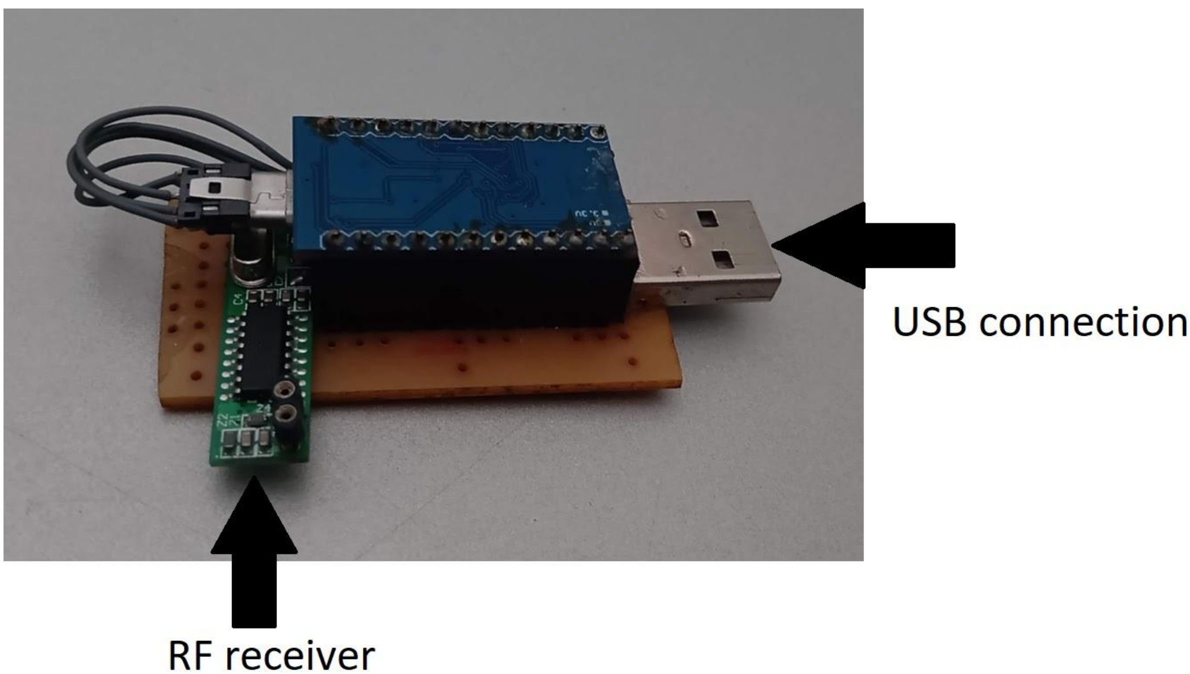
For the connection between the orientation glove and the transmission clock, there is a chain of quick connection cables, which are connected in an orderly way from left to right on both interfaces.

Once the system is connected and switched on, the devices are ready to send the signals of the angular coordinates read by the orientation glove.

4.1.3. Reception module

The signal reception modules are based on the different applications (such as those mentioned in the previous chapter: Final use), which can be given to the project, based on the reception model shown in Figure 4.

Figure 9. Reception module.



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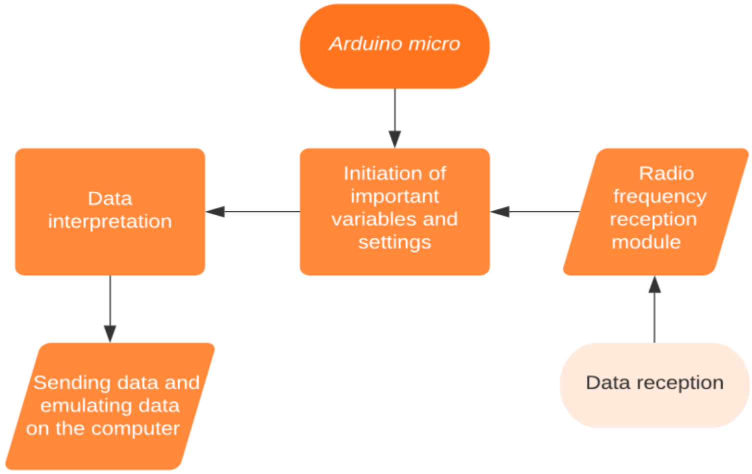
5. Tests and results

In the test system, the functions are performed by a computer, simulating the USB peripherals and the serial communication port, in order to view the tasks and move the pointer (Computer mouse).

Figure 10. Test scheme.



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In this phase, it's necessary to connect the glove and check that its connections are in the correct position, to later put on the orientation glove and adjust the transmission watch on the wrist. Once the glove is fitted, it remains to turn on the transmission clock and connect the test module via USB to the computer.

Figure 11. Correct use of the glove.

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In the computer it is not necessary to make extra configurations; It's enough to know which serial communication port the reception module is using and open a terminal that allows reading what is printed on the port, simultaneously with the reading of the data through the terminal, the pointer will move in the same direction that the glove moves

The receiving microcontroller is programmed to read the tasks sent by the glove, print them on the terminal and emulate the operation of the pointer, making movements every 15 pixels towards: up, down, left and right.

The glove receiver was specifically modified to be able to visualize the data with a 250 millisecond delay, enough time to see the variation in the movements interpreted by the glove; it clarifies that the response time in a normal environment is close to 15 milliseconds.

When connecting the reception module; the next thing is to open the terminal of the communication port that the computer assigned to the reception module.

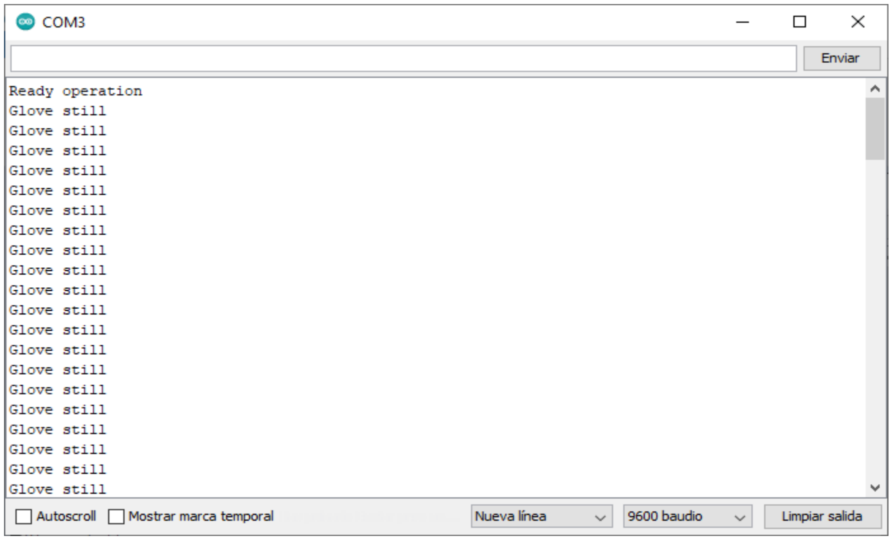
Once the receiver indicates that it is working, it's ready to receive the tasks from the glove.

In the following figures, two lines are drawn between its corners, forming an X in order to leave the pointer in the entire center of the console to have the consent of the mouse movement.

When the glove is turned on, the data will immediately begin to transmit; In this operating module, the glove is left in a horizontal position, so that the other movements are not seen.

The serial port shows how it receives task number 1 multiple times, according to Tables 1 and 2.

Figure 12. Communication port in task # 1, glove in horizontal position.



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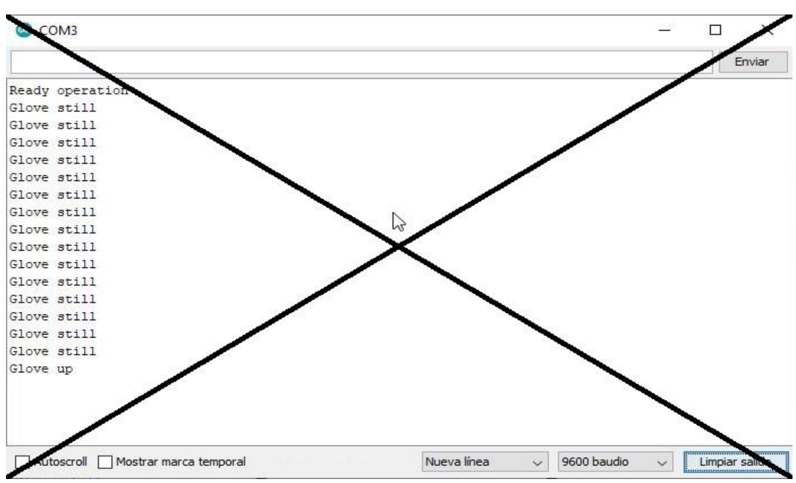
In figure 12, it can be seen how after starting communication with the computer, the transmitter shows its operation, followed by printing the task it is receiving and executing. Now, in the buffer it is seen that, every 250 milliseconds, the instruction that the glove emits will be seen, a clear example, if it's still and horizontal unless the position of the glove is changed; In figure 13 it is possible to perceive that the last instruction was that the glove was up, at that moment the glove was tilted to see its operation.

Figure 13. Communication port in task # 2, glove tipped up.



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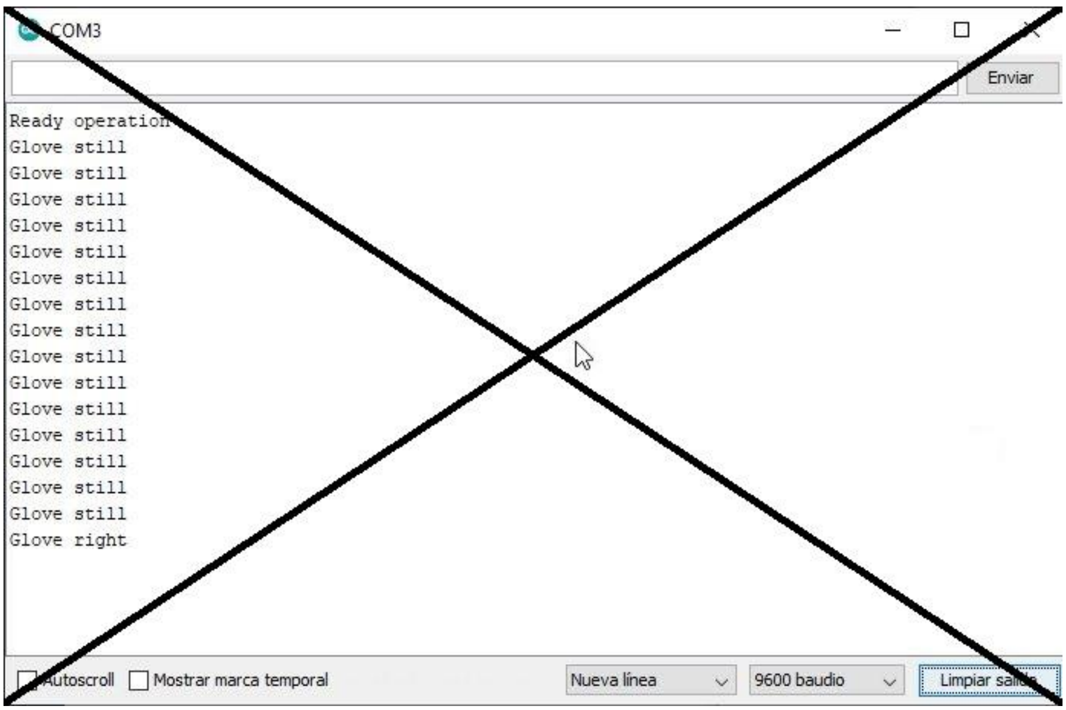
Consequently, it's identified that at the time the glove was tilted up, the computer pointer, (which was in the center of the X), moved 15 pixels above its initial position, if the glove remains In task 2, the computer pointer will move 15 pixels every 250 milliseconds; After the change of the pointer is denoted by the first instruction sent by the glove, it is put to horizontal rest and the pointer is repositioned in the center of the X on the screen.

The next instruction given to the glove was to tilt it to the right, as it relates to task 3.

Figure 14. Communication port in task # 3, right slant glove.



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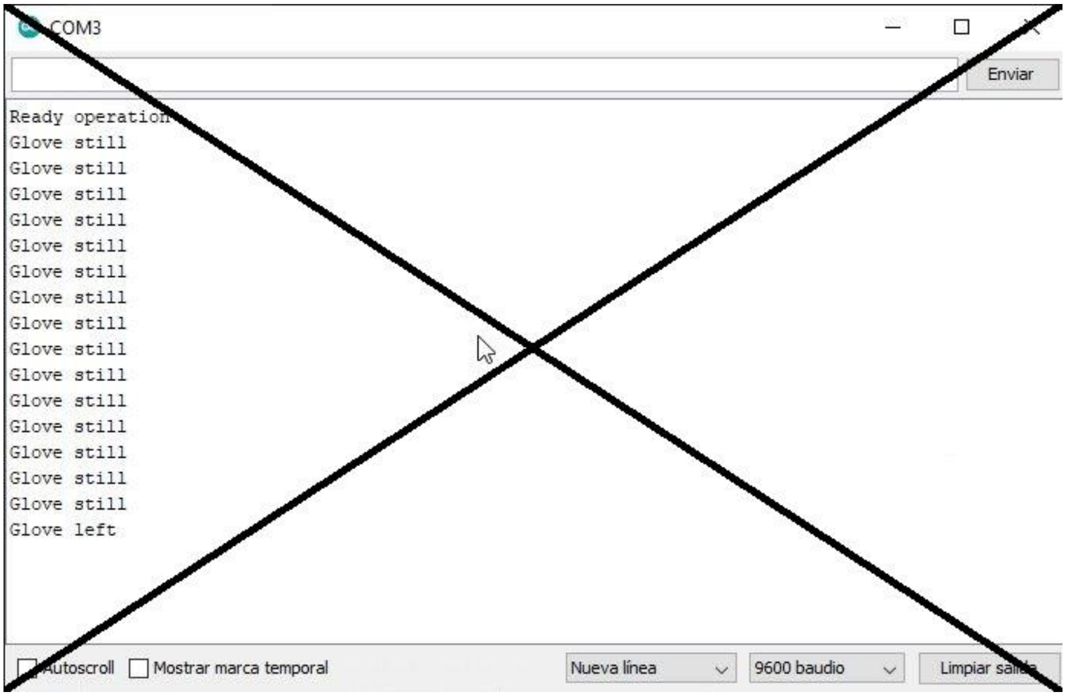
Starting from the same analysis of figure 14, it's observed that when the glove is tilted to the right, task 3 is printed on the console, in addition to seeing that the pointer moved 15 pixels in the right direction of the screen.

Task 4, referring to the movement to the left, which is observed in figure 15, where the pointer, as in previous movements, is seen 15 pixels towards the direction of the task with respect to the center of the X in the screen.

Figure 15. Communication port in task # 4, left slant glove.



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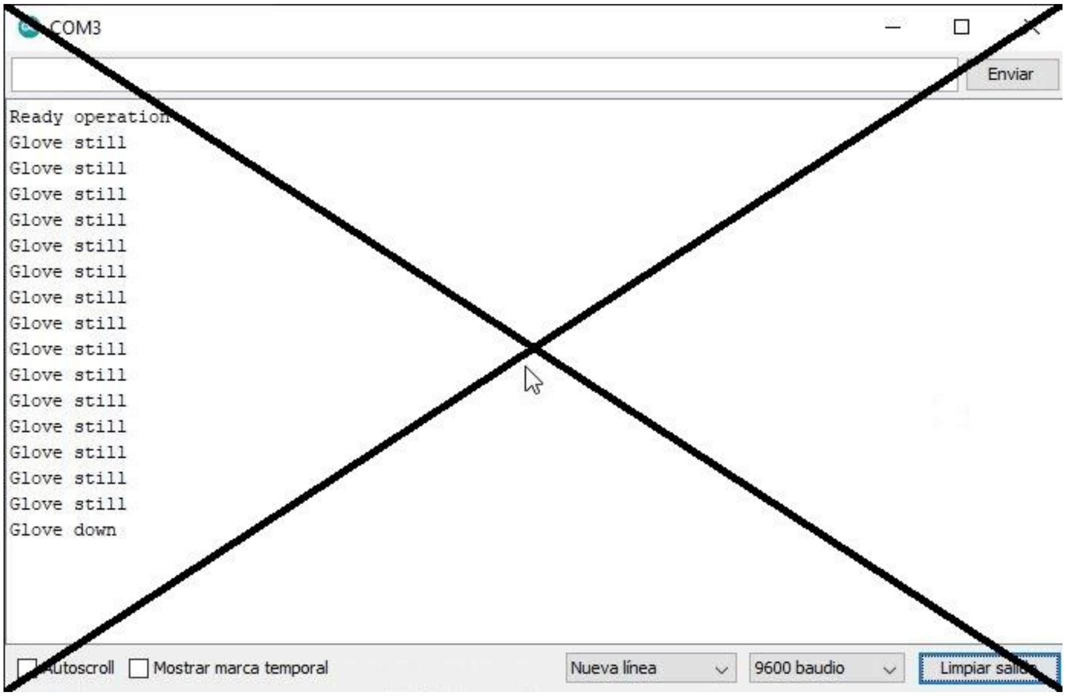
Regarding the last orientation task, it's clarified that the pointer when moving, doesn't move pixel by pixel, but the number that was chosen for the movement; the pointer generates a jump on the screen, telling it to go to the coordinate it was in, plus the pixels it has to move, that way the pointer can move freely throughout the screen; the jump of the pointer, having a difference in its coordinates, allows the machine to read it as a smooth or fast movement, depending on the number of pixels that it moves in a single jump; in figure 14, the same 15 pixels of the previous figures were used, demonstrating how it moved downwards, staying below the X, at the moment the glove was moved in the direction of the task.

Figure 16. Communication port in task # 5, glove tipped down.



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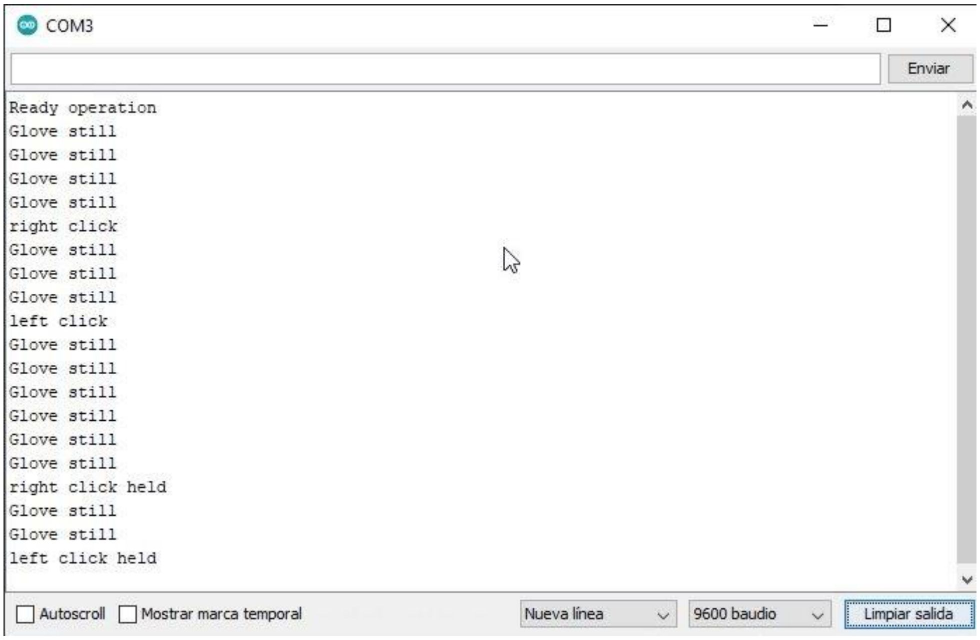
From figure 11 to figure 16, the operation and the own emulation of the demonstration of what the control glove based on angular orientation is capable of relating is shown.

In the same way, figure 17 shows the communication of the functions of the fingers; for this occasion, due to the context you can only read what function is being executed; Due to the architecture of the emulation, there are different functions to click and maintain the click, the click function doesn't work to maintain it. If the click function is maintained, clicks will be made in each response delay, while the sustained click is only necessary to press it once and it will hold the click, until it's pressed again.

Figure 17. Reading tasks on fingers from the terminal.



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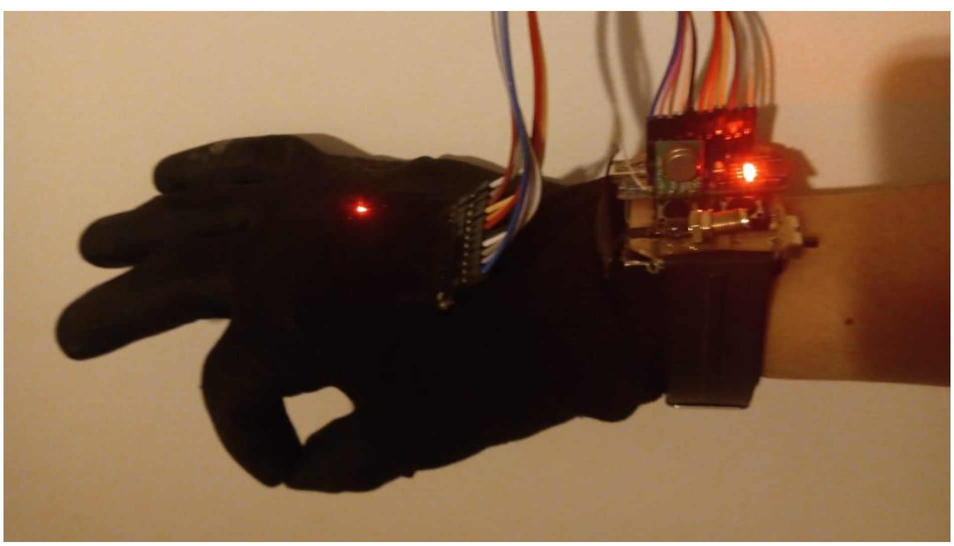
The glove is optimized in order to execute several tasks at the same time, that data is not confused or lost, when performing movements and testing finger functions, both the receiver with the transmitter, have the ability to differentiate the tasks and develop them in such a way that there is no delay.

Figure 18. Final prototype of the control glove.



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6. Conclusions

-Because of the dynamics of the glove, the way to use it without generating false signals and malfunctions is with the palm of the hand facing downwards, since the accelerometer is programmed to read the angles based on a horizontal orientation.

-The designed prototype is efficient, it was tested under different conditions, 9 out of 10 tests were satisfactory; thus yielding a 90% success rate in tests.

-The development of the prototype was direct, concise and satisfactory, since it met the control objectives set.

-The communication between the reception module and the angle control glove can range from 50 m to 70 m in open places.

-The glove, due to its functions, delays and number of pixels to move, is capable of being precise, such precision makes it susceptible to the buffer freezing for a few seconds until communication is resumed.

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