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Smart System Model to Disinfect SARS-CoV 2 in Physical Environments

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Abstract

The present research project is the development of a de-disinfectant robot model (intelligent system), capable of moving and recognizing the physical environment to disinfect it from SARS-CoV2, by means of Ultraviolet C and Ozone light, having double disinfection. To this end, certain systematized actions have been carried out, such as achieving the training of artificial neural networks (ANN), multilayer perceptron using Matlab software, later programming logic in Arduino IDE, and then the implantation of the code in the Arduino microcontroller. The simulations of the disinfecting robot processes have allowed observing the behavior of its movement, location, obstacle detection, activation of the disinfectant module, timing of stages and disinfection of the environment. All this has been carried out and achieved within the Concurrent Design methodological framework that contains five stages: conceptual design, kinematic analysis, dynamic analysis, mechanical design and simulation. As a concrete result, there is the design of the disinfecting robot with a height of 1.35 meters, and that in its structure it has sensors, actuators and peripherals. In addition, estimates of time, distance, travel, motor rotation and displacement of the ANN disinfectant robot have been obtained using mathematical models, such as odontometric equations, state space system and fundamentally neural networks.

Key words: Smart system, disinfecting robot, artificial neural networks, SARS-COV 2.

1. Introduction

Currently The World Health Organization (WHO) defines COVID-19 as: “the most recently discovered infectious disease caused by coronavirus. Both the new virus and

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the disease were unknown before the outbreak in Wuhan, China, in December 2019." It is a virus that causes respiratory diseases that is killing many people in the world (OMS, 2020). The survival of the coronavirus outside the body is one of the issues that is being studied the most. The fact that you stay "for days" on the surfaces where the infected respiratory drops fall increases the risk of contagion simply by touching and then putting your hand to your face. The World Health Organization (WHO) indicates on its website that, according to the available studies, this coronavirus "can persist on surfaces for a few hours or even several days" (Tardón, 2020). The World Health Organization has pointed out that one of the most important tools available to combat it is frequent and deep hand washing, since soap and alcohol-based disinfectants can kill the virus and thus prevent it from being found. in the hands or some surface the virus can reach our organism (Hospital, 2020).

In this regard, through a press release, at the University of Colombia they have reported the development of a technique that eliminates viruses in the air thanks to ultraviolet light of short wavelength, which could be a Powerful and promising weapon to reduce the spread of COVID-19 in closed public places. The technology, developed by the university's Radiological Research Center, uses very specific lamps that emit continuous and low doses of a particular wavelength of far ultraviolet light, known as far UVC, which can kill viruses and bacteria without damaging the skin. human, eyes and other tissues, as is the problem with conventional ultraviolet light (Flores, 2020). In order to bring the mobile robot to a desired position along a path, different control strategies (Kwon and Chwa, 2012), (Jingkui, Wenxin and Liangliang, 2010), (Rezaee and Abdollahi, 2014) and (Li, Wang, and Zhu, 2010) have been proposed. Odometry is an important part of the location system of a mobile robot, improving the accuracy and precision of the parameters that model it leads to a significant improvement in the general navigation system. In addition, good odometry calibration reduces operational costs as fewer updates to the robot's absolute position are required. A simple calibration method consists in the direct measurement of the parameters using the Encoder (Navarro, Benet, Ríos and Bueno, 2007). The use of neural networks is considered a technique of great contribution in the analysis of internal motor parameters (León, Maldonado and Contreras, 2020) and (Li, Sun, Lu, Krabicka and Yan, 2012). Using the Matlab software ANN platform, different configurations were made to obtain a generalization of the network with minimal error (Contreras, Maldonado and León, 2019). Type C ultraviolet light lamps have a shorter wavelength between 200 to 280 nm, destroys the DNA structure of viruses, bacteria, as well as SARS-CoV2. Ultraviolet UVC can kill the vast majority of bacteria and other microorganisms in the air and water in seconds, and ozone will kill quickly and oxidatively decompose substances with organic or inorganic odors.

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As antecedent it is mentioned Hossian et al. (2015) he carried out his research work “Development of Experiments of a Robot Navigator with Networks Neuronal in a Structured Environment: Behavior Programming with Backpropagation Algorithm”, concluded that the training pattern has been sufficient for some trajectories, but in certain cases this pattern does not turn out to be representative of the environment in the which operates the robot, since most of the exits is to advance and for this reason it collides starting from other positions. Or, it enters a loop without being able to resolve that situation, remaining immobile.

The study by Arellano (2015), published his thesis entitled "Design and implementation of a mobile robot with trajectory control using odometric principles", came to the following conclusion, finally it was possible to demonstrate that it is possible to carry out efficient and precise control of a mobile robot using only two encoders as the acquisition system and using a control system embedded within a microcontroller. The present project is justified because today due to the pandemic, it is necessary to disinfect SARS-CoV2, because according to the WHO this virus spreads through the air, and it is necessary to disinfect environments such as hospitals, offices, homes, etc., for this A disinfecting robot model was developed with UV light C and Ozone, having double disinfection. This research work aims to model an intelligent system to disinfect SARS-CoV2 in physical environments. The structure and dimensions of the robot were designed. Ultrasonic sensors were installed to detect obstacles and for the control of displacement, the Arduino microcontroller was used. In conclusion, the proposed design and the feasibility of the simulations were achieved, verifying with response time to the entire system and subject to failures for its verification, giving an expected functional result, for future implementation.

2. Materials and methods

The type of research is non-experimental at the descriptive, purposeful level, since it is desired to inform, describe and design a disinfecting robot to eliminate SARS-CoV-2, by means of ultraviolet light C and Ozone (since it is based on a need or empty, constituting an opportunity for solution). The research design is of a transectional type, because the collection will be carried out in a single moment.

The methodology used is the concurrent design (Sabater and Martínez, 2012), which contains five stages:

Conceptual design, in this first stage the functional characteristics and technical specifications are developed, the requirements are identified, such as the structure and dimensions of the disinfecting robot, the types of movement, trajectories, operating time, load capacity and precision.

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Kinematic analysis, in this stage the disinfection robot movement analysis is performed, for this the differential type robot is established and odometry is used to measure the robot position. The positions, speed and acceleration of the mentioned robot are also calculated.

Dynamic analysis, in this stage the dynamic study is developed that allows the selection of the motors, design of control strategies, implementation of ANN, simulation of movement and tension analysis.

Mechanical design, at this stage the kinematic and dynamic issues are integrated and the different stages that make up the methodology are listed based on the creation of projects and the development of electronic circuits.

Simulation tests, computer tools for verification and simulation of neural networks and electronic circuits were introduced. The Matlab program was used to simulate the Neural Networks and the Proteus 8 Professional program was used to verify the behavior of the disinfecting robot, since it has a graphical environment that is easy to use and allows all necessary simulations to be carried out.

3. Proposed model and motivation

For the development of this disinfecting robot, the following block diagram was proposed, which is shown in Figure 1, and where a system with a structure of 3 microcontrollers, each with a specific function, is observed; in the first, an ANN is programmed to recognize the area to be disinfected, in the second, the displacement control is carried out, and in the third, the rise and fall of UVC with Ozone is controlled, as well as the on and off control of the same.

The UVC device block has 16 ultraviolet light tubes installed, 4 UVC tubes per side connected. In addition, 6 ultraviolet light tubes are installed in the lower part in a fixed way.

The power supply block is responsible for supplying the entire circuit, as well as the power stage to control the motors and the UV lights. The sensory system is in the sensors stage, which detect any mishap on the outside. The listening block is so that the robot can send audio signals. Finally, there are equipment for the user interface, which will be external to the robot.

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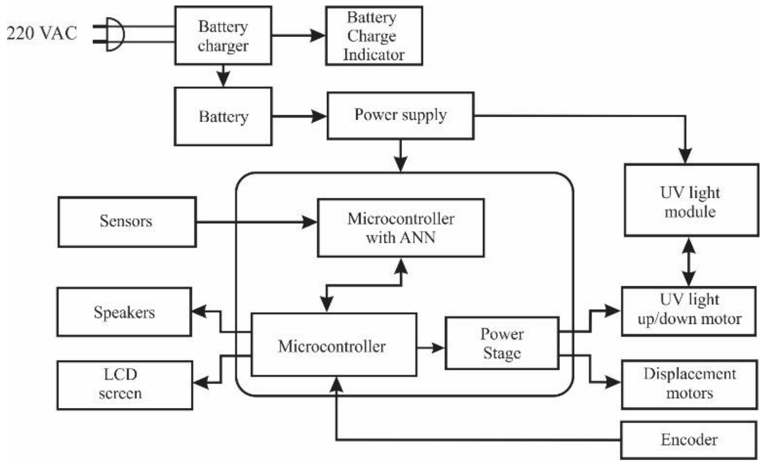

Figure 1. Block diagram of the disinfecting robot
Source: Elaboration Own

Structure of the disinfectant robot with UVC and Ozono.

The physical structure of the disinfectant robot will be made of materials whose characteristics respond to factors such as: resistance, compression, flexibility, impact, and corrosion. The material to be used for the robot structure will be galvanized sheet, which is covered with a zinc layer that acts as an anticorrosive agent, prolonging the life of the disinfecting robot under wet or rainy conditions.

The design of the physical structure of the surveillance robot is shown in figure 2, with a height of 1.35 m.

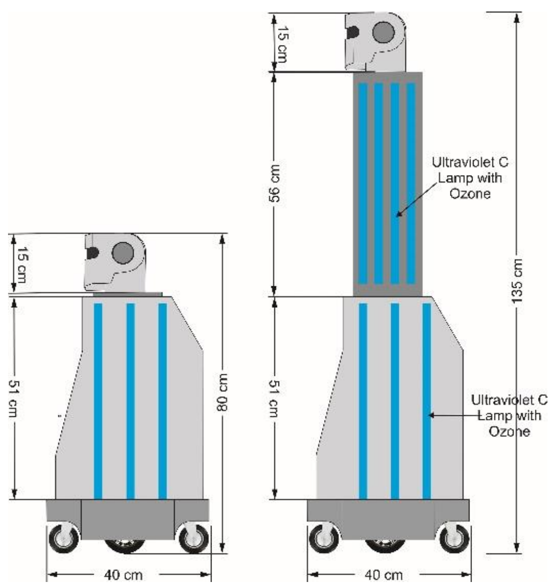

Figure 2. Disinfectant robot dimensions
Source: Elaboration Own

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Robot position

Figure 3 shows the position of the robot, which is the general way that we can locate the robot. For the equation, the robot is not moving on the X or Y axis, but in a linear combination of both. Total Speed (VT) is the average of the speeds of the left tire (VL) and the speed of the right tire (VR). To find the velocity in Vx and Vy, by Pythagoras we must know the angle φ, which is the angle that the robot moves. L comes to do the distance of the wheels.

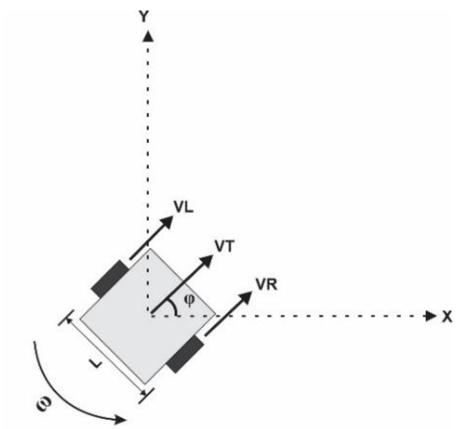

Figure 3. Robot position
Source: Elaboration Own

Odontometric equations

It is a system of equations that describe the speed in x, the speed in y, the angular speed ω, with respect to the speeds of the robot tire and the angle φ is the direction in which the robot is moving.

$$Vx = Vt\cos\varphi \qquad (1)$$

$$Vy = Vt\sin\varphi \qquad (2)$$

$$Vx = \left(\frac{VR+VL}{2}\right)\cos\varphi \qquad (3)$$

$$Vy = \left(\frac{VR+VL}{2}\right)\sin\varphi \qquad (4)$$

$$\omega = \frac{VR-VL}{L} \qquad (5)$$

To find the speed of the robot in position (x, y), we related the tires with respect to the positions of the robot. The velocity Vx is what is called the first derivative of the position $\dot{x}$, the velocity Vy is the change in position in $\dot{y}$, the change in position $\dot{\varphi}$ is the velocity ω. These equations are called the state space system, it is a well-known system in control systems (Urquijo, Izaguirre and Hernández, 2017).

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$$\dot{x} = \left(\frac{VR+VL}{2}\right)\cos\varphi \qquad (6)$$
$$\dot{y} = \left(\frac{VR+VL}{2}\right)\sin\varphi \qquad (7)$$
$$\omega = \dot{\varphi} \qquad (8)$$

Sampling time

Every time we do the simulation, the idea is that the time is fixed, so that every so often a control action is executed, that time that is taken is called the sampling time (Dormido, Sánchez and Kofman, 2008).

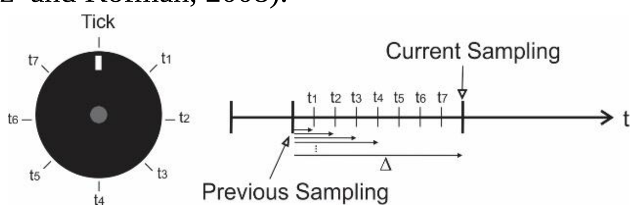

Figure 4**.** Sampling time with the encoder
Source: Elaboration Own

For this case, 2 encoders will be used, with a slot called Tick, this means that the entire encoder revolution represents one motor revolution. The times are sampled and since the speed is constant, we can determine how much time does the motor rotate in one turn? With this we can estimate the distance traveled at constant speed.

Delta = Current sampling - Previous sampling

Distance

$$D = 2\pi R\frac{\Delta Tick}{N} \quad (9)$$

Where:

N is the number of encoder slots; in our case it will be 1.

R is the radius of the tire

Frequency

$$f = \frac{1}{Delta} \qquad (10)$$

Angular velocity

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$$\omega = \frac{\frac{2\pi}{N}}{\text{Delta}} \qquad (11)$$

$$\omega = f * \frac{2\pi}{N} \qquad (12)$$

Linear Speed

$$V = \omega * R \qquad (13)$$

Robot displacement Flow with Artificial Neural Network

A multilayer perceptron neural network was created, for the recognition of the area, the input data of the neuron, will be ultrasonic sensors and the outputs of the neurons, connect to the Arduino of control of the displacement motors

The disinfecting robot has 4 ultrasonic sensors installed, to detect the walls of the area to be disinfected and can recognize the entire area, for this a multilayer perceptron was implemented, whose inputs are sensors S1, S2, S3 and S4, and 2 output neurons O1 and O2, each output neuron has 2 states 1 or 0. This Neural Network was developed in the Matlab program and implemented in an Arduino microcontroller.

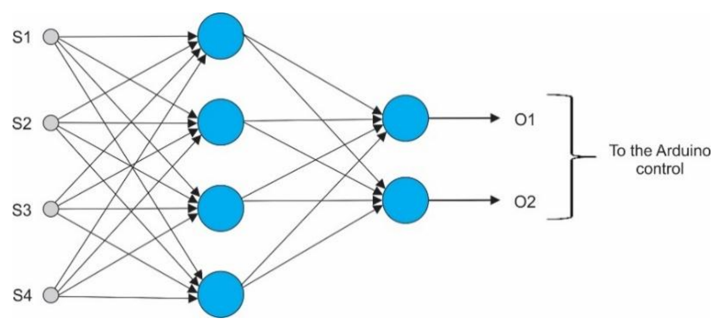

Figure. 5**.** Multiplayer perceptron with 2 output neurons
Source: Elaboration Own

Control circuit

In this stage 3 Arduinos are used, one that controls all the ultrasonic sensors with ANN, the other Arduino controls the displacement motors and is in charge of timing the time and distance to be disinfected. The third Arduino, will detect people through body temperature, an ultrasonic sensor connected in front and below the robot to detect stairs or other holes in the area, it also controls the motor to remove and save the UVC block. Figure 6 shows the total circuit of the disinfecting robot.

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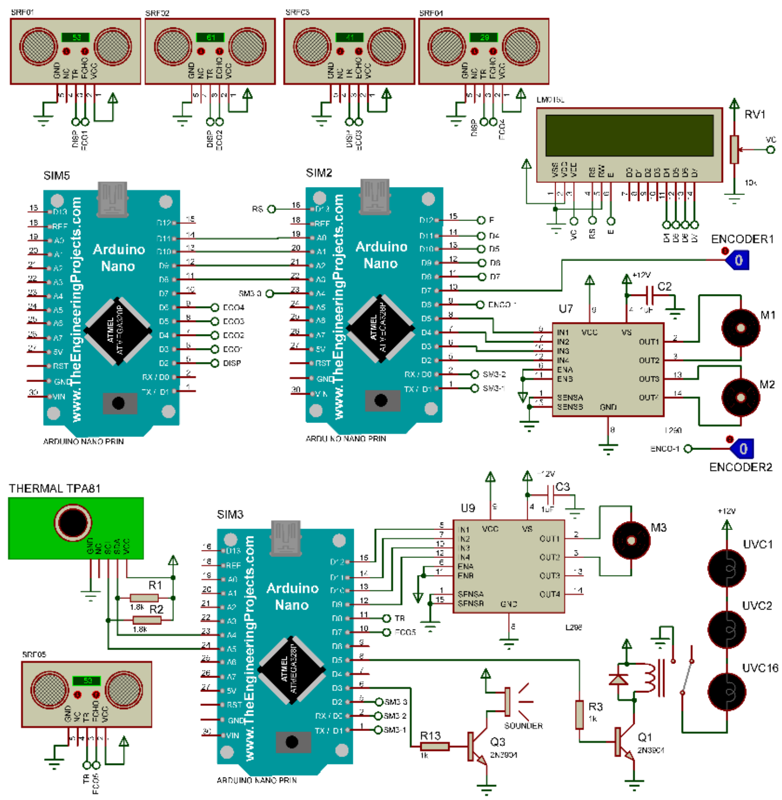

Figure. 6. Control circuit
Source: Elaboration Own

The 4 ultrasonic sensors are located on the 4 sides of the robot, sensor 1 (S1), left (S2), right (S3) and back (S4) are connected in front, they are the ones that will detect any obstacle at 50 cm, collects and stores this information in the ANN.
At the time of disinfecting, it starts in a certain area stopping and the UVC lamps that were stored inside the robot come out, the disinfection in this area will be for a time of 3 minutes, after that disinfection time, the robot moves for 3 meters, due to the encoder that the robot has, then it stops and starts disinfecting that area for the same time of 3 minutes, after that time it is repeated so on until the entire environment is disinfected. phobia.

4. Simulation Results

Simulation of the robot with ANN

The Neural Network was simulated with the Matlab program, as shown in figure 7, the input corresponds to the 4 ultrasonic sensors, in the hidden layer there are 4 neurons with their respective weights (w) and polarization (b), in the output layer

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there are 2 neurons, with their respective weights (w) and polarization (b) and at the output 2 binary states are obtained.

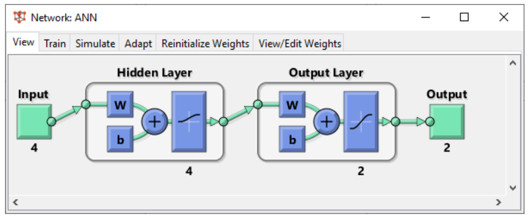

Figure. 7. ANN Simulation in Matlab
Source: Elaboration Own

In figure 8, we can notice that only 4 verifications are shown, in the first upper left, the 4 sensors are shows 0, 1, 1, 0, indicating that S1 is ahead, there is no obstacle, on the left S2 and right S3, there is an obstacle, and behind S4 there is no obstacle, therefore, output shows us 1 and 0, which means that the robot is going forward. In the second upper right, the 4 sensors are showing 1, 1, 0, 1, indicating that S1 is ahead and S2 on the left there is an obstacle, on the right S3, there is no obstacle, and behind S4 there is an obstacle, therefore output shows us 0 and 0, which means that the robot goes to the right. In the lower left third, the 4 sensors are showing 1, 0, 0, 1, indicating that S1 that there is an obstacle ahead, S2 on the left and S3 on the right, there is no obstacle, and behind S4 there is obstacle, therefore exit shows us 1 and 1, which means that the robot goes to the left. In the lower right fourth, the 4 sensors are showing 1, 0, 0, 0, which indicates that S1 that there is an obstacle ahead, S2 on the left, S3 on the right and S4 behind there is no obstacle, therefore output shows us 0 and 1, which means that the robot is going to back up.

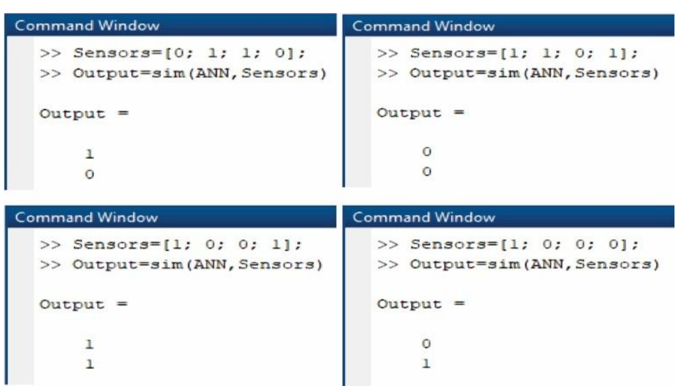

Figure 8. ANN verification
Source: Elaboration Own

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In table 1 we can see that each time a sensor detects an obstacle at 50 cm, it sends a pulse “1” and if there is no obstacle it sends “0” to the Neural Network, as the neuron has already trained, according to the data coming from the sensors, we will have a binary value at the output of the Artificial Neural Network, these obtained values will be sent to the control stage. In this robot it was established in this way, in the sensor column, it corresponds to S1, S2, S3 and S4, according to the detection of the sensors, we will have a value at the output of the ANN, such as 1 0, it corresponds that the robot to advance, if it is 0 0 the Robot goes to the right, if it is 1 1 the robot goes to the left and if the result is 0 1 the robot goes back.

Table 1. Result of ANN simulation tests

Sensors	ANN Output	To move
0 1 1 0	1 0	Get moving
1 1 0 1	0 0	Right
1 0 0 1	1 1	Left
1 0 0 0	0 1	Back off
0 1 1 1	1 0	Get moving

Source: Elaboration Own

Simulation of robot displacement with ANN

The simulation tests carried out in the control circuit showed the desired behavior, checking the displacement in all directions. Figure 9 shows the simulation where the data from the Arduino with ANN, due to the detection of the sensors, we can see that S1 and S4 are a long distance away, S2 and S3 are obstacles, the output of the Arduino with ANN is 1 and 0, sending this data to the second Arduino, to control the motors, according to these data received by this Arduino, the robot will advance, therefore motor 1 (M1) and motor 2 (M2) rotate clockwise , resulting in the robot moving forward, and the robot movement can also be viewed on the LCD screen.

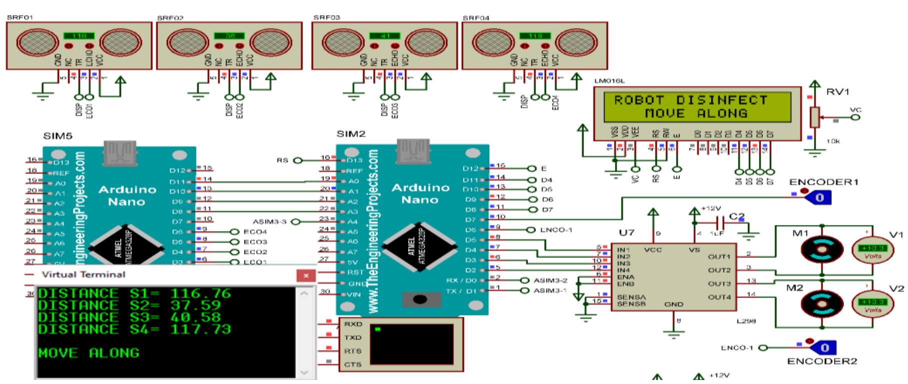

Figure 9. Control circuit simulation

Source: Elaboration Own

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To evaluate the efficient operation of the disinfectant robot, all the displacement tests were performed, and the operation of the 2 encoders was simulated, giving an efficient displacement. To calculate the distance traveled by the robot, 9 cm wheels were used, as 1 turn of the encoder is equal to one turn of the wheel, therefore, one turn of the wheel equals 28.2 cm, when moving 3 meters, the wheel has rotated 10.5 turns. The rise and fall of the ultraviolet light circuit was also simulated, as well as turning it on and off. To verify the robot's displacement, a voltmeter corresponding to V1 and V2 was connected to each motor in parallel, and the values obtained are measured in voltage. The results of the tests can be seen in Table 2.

Table 2. Results of the simulation tests of the motor rotation

ANN Output	V1 (Volts)	V2 (volts)	Displacement
1 0	+10,3	+10,3	Get moving
0 0	+10,3	-10,3	Right
1 1	-10,3	+10,3	Left
0 1	-10,3	-10,3	Back off
1 0	+10,3	+10,3	Get moving

Source: Elaboration Own

From the previous table we can point out that the voltage values in V1 and V2 correspond to the voltage applied to each motor, if it is + 10.3V the motor turns clockwise and if the -10.3V the motor turns clockwise counterclockwise, as we can see, when the ANN sends signals 1 and 0, each motor has a voltage of + 10.3V, checking that the two motors rotate in the same direction, therefore the disinfectant robot advances, when the ANN sends signals 0 and 1, the two motors have -10.3V, indicating that the two motors rotate in the same opposite direction, therefore the disinfectant robot reverses.

5. Discussion

The results obtained in table 1 show that the sensors detect obstacles, collecting this information and stored in the Artificial Neural Network, which is programmed in the Arduino 1, at the output binary values are obtained that are sent to the control Arduino for the movement of the disinfecting robot. These results are related to what Hossian et al. (2015) hold in the research called “Development of Experiments of a Navigator Robot with Neural Networks in an Environment Structured: Behavior Programming with Backpropagation Algorithm ”, who points out that the training pattern has been sufficient for some trajectories, but in certain cases said pattern does

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not turn out to be representative of the environment in which the robot operates, since most One of the exits is to advance, just as this investigation was able to verify that the training of the ANNs always the robot begins to advance, but in this investigation the training of the ANN was achieved with ultrasonic sensors, resulting in an efficient result for the trajectories to be performed. the robot.

In the control circuit, different simulation tests were carried out with respect to the rotation of the motors, which are verified satisfactorily, the signals from the Arduino with ANN correspond to a particular movement of the motors, giving the result of displacement of the robot. These results are corroborated with the study of Arellano (2015) who in his research entitled "Design and implementation of a mobile robot with trajectory control using odometric principles", came to the following conclusion, which could finally be shown to be It is possible to carry out an efficient and precise control of a mobile robot using only two encoders as the acquisition system and using a control system embedded in a microcontroller. Taking the results of Arellano's research, it was possible to verify by means of the simulation the different trajectories of the disinfecting robot with the two encoders. Furthermore, this research has a contribution from the robot, to disinfect the SARS-CoV2 by means of Ultraviolet C light and Ozone, having double disinfection.

6. Conclusions

The intelligent system model was carried out to help disinfect possible environments contaminated with SARS-CoV2 and a multi-layer perceptron neural network was created, the Matlab program was trained, where sensors detect obstacles and are stored as patterns, giving as an optimal result the displacement control of the disinfecting robot.

The correct operation of the control system was simulated and verified, who is in charge of controlling the movement of the motors to move the disinfecting robot. The tests carried out could be verified, both forward, backward, left and right according to the training patterns by the ANN. At the time of the virtual interaction it was subjected to failures for its verification, giving an expected functional result, for a future implementation.

7. Acknowledgements

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