Integration and Optimization of Encoder Data Acquisition in Matlab-Simulink. Case Study

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Abstract. This paper focuses on the development and implementation of a robotic disinfection system using a differential drive robot. To measure the traveled distances, decoding sensors, also called rotary encoders, are used, mounted on the motor axes, essential for determining the number of revolutions and implicitly the traveled distance. For the virtual localization of the robot, the simulation and modeling platform Simulink-Matlab will be used, but in this paper we will present the working method of the main signal decoding block scheme.

1. Introduction

The importance of robotic disinfection systems is to optimize the exposure time for different rooms, to cover as high a percentage as possible of the minimum exposure areas where most operators cannot clean with products and substances that kill viruses, but also to automate the exposure process by irradiation.[1][2]

Irradiation for example in spaces that are used for commercial purposes, public institutions, institutions where thousands of people pass every day with the possibility of contacting Covid-19, as well as in tourist spaces, airports, constant cleaning must be carried out, which forces the hiring of different cleaning companies, in airplanes they switched to irradiation with mobile systems, but also with limited coverage, because many areas are not covered in the maximum percentage.[3] Germicidal irradiation being the most common for maximum percentage coverage, the determination of the irradiation percentage can also be determined according to the exposure time to which it must be done, because many times a maximum saturation of some components is reached, and others be partially shaded and have less exposure.[4][5]

2. Proposals for technological solutions

The use of such a system will prepare rooms, laboratories, operating rooms, which are often sterilized and disinfected with chemical agents by the operators. Most areas that are not fully covered can be disinfected with these autonomous robot systems, which by using recognition and navigation systems can reach a very high percentage of coverage.[6][7]

The information flow is mainly composed of the information received, both through distance sensors, mapping systems, depth-vision camera systems, but also systems for checking exposed areas by silicon photodiodes.[8][9][10]

The automatic retrieval of objects from the rooms must be done by the observation system, by all the sensor systems, so that no optimized route will damage the robot, the disinfection system or even its devices, nor the furniture, or the equipment of the laboratories.

3. Control of robot movements

The research objectives are the cornerstone of this effort dedicated to the development and implementation of robotic disinfection systems. In a global context marked by increasingly present pathogenic threats, our objectives are well defined and oriented towards the creation of a robotic disinfection system that is efficient and autonomous. In the case of moving robots forward and backward, a differential drive robot is considered, which is driven by two motors, one motor for the left, one motor for the right.[11]

The first step for distances traveled, the problem of locating the robot must be considered, to make this localization possible, decoder sensors or also called rotary encoders, mounted on the motors, are used to determine the number of revolutions, resulting in the distance traveled. This localization can also be done with distance sensors, GPS, Lidar camera.

To do the virtual localization of a robot, we use Simulink-Matlab. The system components of this differential driving robot model are the logic input sensors of the robot, with the help of these simulations we can check the obtained results and also observe the position of the moving robot.[12] All reading variables are received as a function of time, both distance traveled and speed.[13]

The distance determination block uses the following calculation formula:

$$\text{Traveled distance} = \frac{Total\ encoder\ ticks}{Ticks\ count\ per\ rotation} \times 2 \times \pi \times R$$

The block to determine the input signal must be observed, so another Scope block is created, which will only be used as the tick counter and is connected to the output of the Encoder Count, or ramp signal.

In the following scheme, the right and left encoder counting is used to track the results obtained.

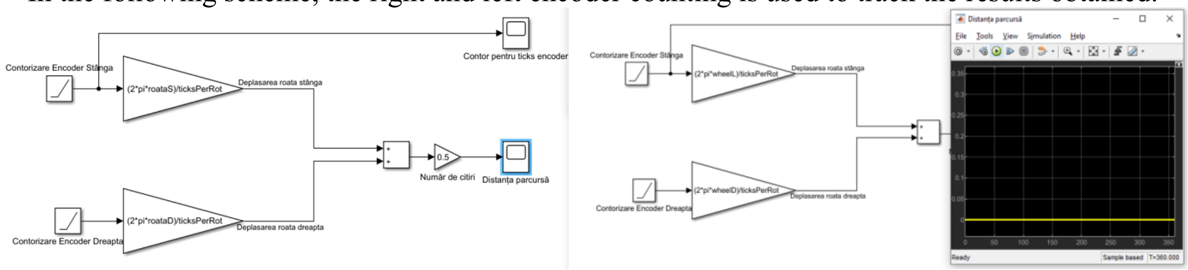

Figure 1. a)Odometer scheme with 2 motors driving the robot b)The system has equal pulse value for both motors

In Figure 1. the notion of robot movement or robot movement control was created. These schematics can be made in a working template in Simulink. If at one second the system was told to count, then the simulation is told to run for 360 seconds, so the encoder waits for 360 ticks to be reached, and at the end of the simulation a full rotation of the wheel will be done .

It is observed that the distance traveled is a straight path, it is observed from the distance traveled that it has a displacement on an x-axis only, since the speed of the motors is equal, the robot only moves forward. The counter for the number of readings, causes each reading per revolution to be added to the initial ones, this is a counter that can be used to validate readings, if the 2 blocks of readings from both motors are not equal, then the robot has a deviation from the established route. If the reading value in a system is equal to the rotation value, then the system has no deviations from the trajectories, which means that both the robot's wheels have a good rolling surface and the environment it is in is flat. In the next stage, we will use the signal processing of an incremental encoder to convert them into revolutions per minute and angular position, also using Simulink. Usually these controllers have libraries available for this, but we'll use the following pattern to solve some problems that appear in the ready-made libraries already.

In the next step we will use a 6V direct current motor, which has 2 control phases, i.e. the read waves are of the tachometer type, which will have a signal on phase A and phase B, both out of phase by 90 degrees, their advantages are determining rotation whether it is of positive or negative trigonometric type, which helps us to process information in a code more easily.

To use Matlab Simulink we will use the Matlab package also called Support Package and Simulink Support Package Arduino to use the hardware parts we will use, connected to Arduino Uno, we need this package to communicate with Matlab Simulink, with the created scheme. When implementing the Arduino Uno hardware, the first setting is to configure the parameters, one is to declare the Arduino Uno system, the readings are done on the serial port, so we will be able to select a reading speed of 9600 baud rate for better connectivity . Along with the initial parameter configuration, we can also configure the initiation time as 0.0, and a final setting can be the signal sending time, which will be set to 0.5 seconds. When using a DC motor we will use the Digital Input block function, which will be connected to the motor through digital pin 2 of the Arduino Uno.

In decoding the received signal, we will use the Arduino's digitalWrite reading system, entering these readings, we will add them to the system used, and continuous counting will be done, to monitor the corresponding signal. In the next schematic we will add our reverse readout, ie negative readout, to change direction sense.

This block will read the input signal, the counterclockwise signal will be added to the Scope block, and the clockwise signal will be subtracted, and at this stage we can already generate a controlled and read signal correctly, for the use of encoders.

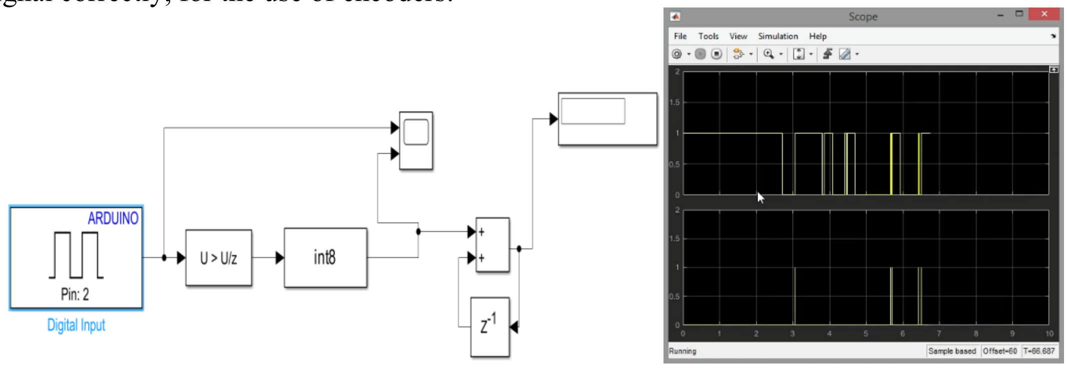

Figure 2. a) Pulse reduction functions scheme of the operation diagram for detecting the pulses received by the encoder, made by hourly rotation of the motor shaft b) Diagram that provides us with the signals received from the rotary encoder

The results obtained for the manual signal reading can be seen in the graph above, which specifies the signal parameters, with values of 0 or 1, parameters that are declared and counted in the following scheme. In prototype models of line follower robots, the PWM adjusts autonomously and proportionally to the area where it is on the tracked route. For conditions of loss of route, rules are imposed to simplify the process of resuming the route, rules that can take into account the last area where the robot was in relation to the route. In most cases, pwm tuning is the most useful type of autonomous tuning, as it always determines the speed of the moving robot, taking full account of the sensor systems and the data received from them. The rules for defining a pwm adjustment are always done both at the lowest travel speeds, these speeds are mandatory defined according to the environment in which the robot will work.

If in a special case, the robot is on the ramp with a fairly small angle, and its speed is automatically adjusted by the processing system for the minimum travel speed, we can encounter the problem of not being able to start from the place. In these cases, the signals received from the encoders must be taken into account, as they are the only ones that can tell us if the robot has moved. For the maximum travel speed, the robot system can be taken into account, because if it does not work with the disinfection system, it can operate at a speed equal to ~0.5-1 m/s, if there are no objects around the robot to there may be route changes.

The pwm tuning rules for the robot's movement, must also be for counting forward and backward movement, but also be added by the processing system. For robots, any movement in an environment must create a virtual simulation, in order to create the most optimal routes, in addition to optimizing the route, they must be able to automatically generate the route traveled and the point where they are during disinfection.[14][15]

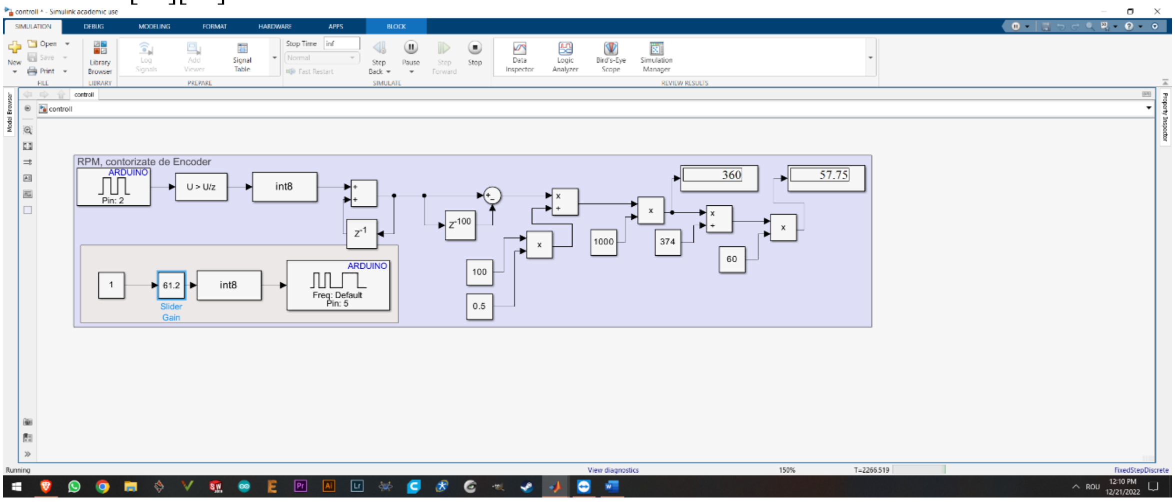

Figure 3. Block diagram reading rpm according to setting 61.2 PWM

In this phase, the system is built according to the following formula, because the signal that will come out after the first equation with 2 inputs, these being one of addition one of subtraction, will only add to the output signal an application of z^{-100} with the impulses that come out , if on the last pulses of data it shows that this is not a frequency measurement, so it will correct with a first multiplication of the formula below to read the received pulses and are used as data, without knowing what happened during the sample readings and index had.

$$\frac{\Delta puls}{(100\ x\ Tm)ms}\ x \left(\frac{1000\ ms}{1\ s}\right) x \left(\frac{1\ rev}{IMP\ puls}\right) x \left(\frac{60\ s}{1\ min}\right) \quad (1)$$

So to create a constant at the number of samples of 100 and will also add a sampling in seconds, which will be set to 0.5 seconds. Likewise another multiply block will be created again to 1000. Now the frequency of encoder readings, number of readings per second can be displayed.

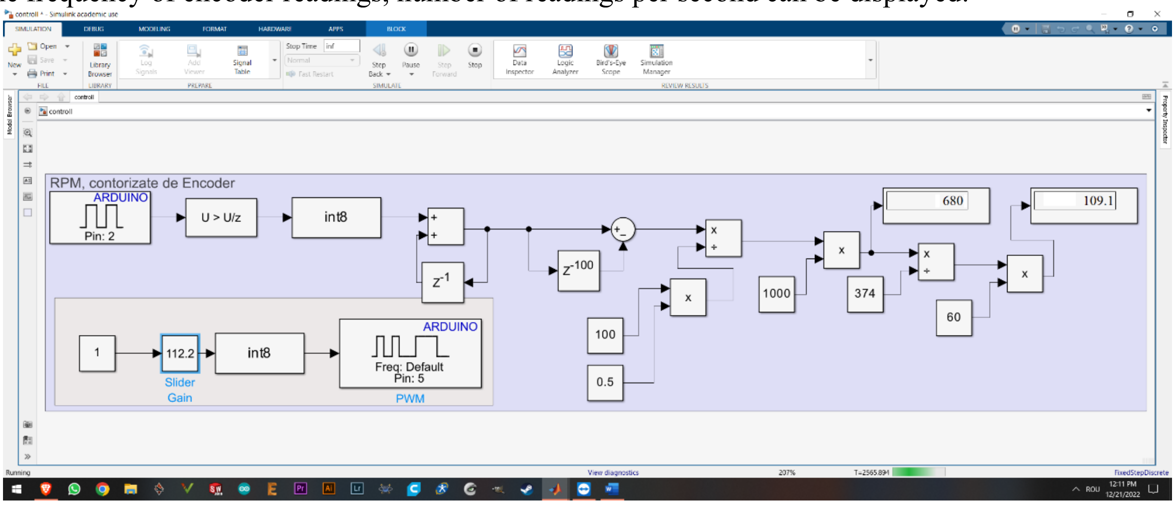

Figure 4. Block diagram reading rpm as a function of 112.2 PWM setting

Being able to use a PWM control system helps to tune motors, but for PID tuning it helps much better to control an integrated system.

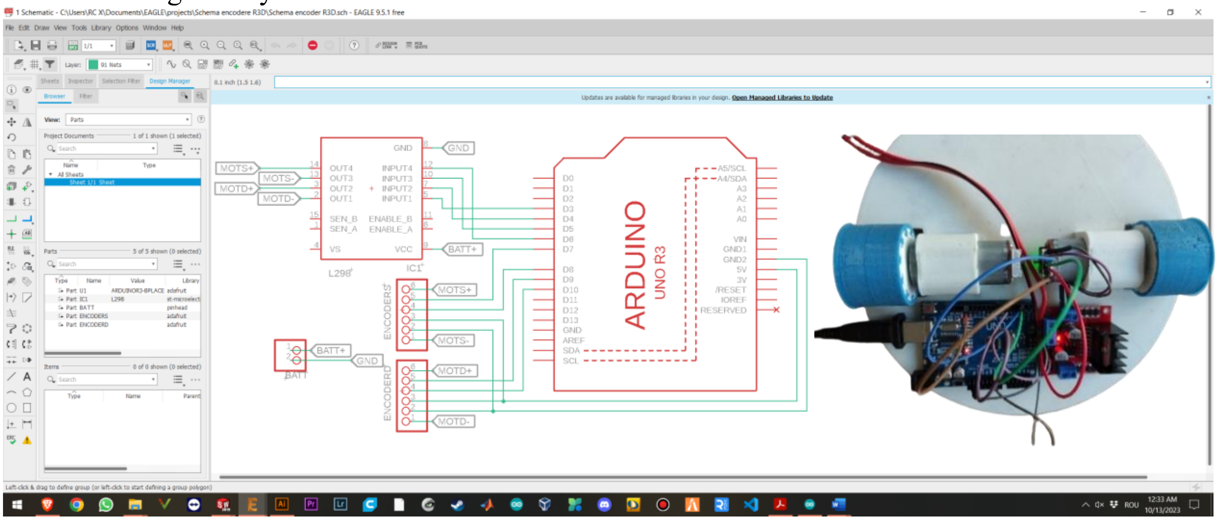

Figure 5. a) Wiring diagram for circuit testing for two motors b) Robot system with data acquisition from left encoder

The mobile robot for testing the Simulink program created, consists of a round chassis, in order to optimize the scanning area as best as possible in the future, it uses 2 wheels attached directly to the axis of the motors, already equipped with an internal reduction in their housing, an Arduino Uno microcontroller and an L298 motor driver to be able to control the motors.

The wheels of this robot are obtained by 3D modeling of an inner mold that will be the support of the attached silicone and an outer mold that will determine the outer area of the wheel, this area will be the one that will run in the working environments. This prototype is used for program testing and used for algorithm integration, with the aim of rapid testing and integration of new ideas.

In most test cases, using a much smaller scale prototype helps implement sensor systems, mechanics, or even test algorithms that are unpredictable to determine an optimized route, or obtain working views of the environment, which they can cause problems in running the program and work conditions must be optimized.

4. Conclusions

To further create autonomous systems, to be able to determine a system we need to determine its territory, in short a map. Since the functionality of robots in predefined systems, generates their mapping with the help of data acquisition systems, the instructions for generating the map consist strictly of the logic of the operation of the robot, or the operation of the robot in some system.

A robot to generate a map of its environment must follow a certain operating logic and use an appropriate data acquisition system. The mapping process typically involves detecting and measuring environmental features such as obstruction, edges, and contours, then integrating this information to create a coherent perspective image of the environment. This information can be collected by the robots' sensors through sonars or lidars, but mostly also cameras, and is processed in real time to generate the map. The results of the simulations are checked to confirm the correctness of the data, including distance traveled and speed. By integrating various technologies and sensors, this work paves the way for advanced applications in the field of autonomous robots, having significant implications in the context of the development of autonomous disinfection technologies.

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