RESEARCH ON THE DESIGN AND IMPLEMENTATION OF AN EXPERIMENTAL MODEL OF A MOBILE SYSTEM FOR ACOUSTIC SCANNING OF AN ENCLOSURE

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ABSTRACT: This paper aims to familiarize the reader with mobile robots, namely line follower robots (the principle of operation and their control part), as well as the acoustic measurement part (the norm that imposes the rules for measurement and the theoretical part behind unit / method of measurement used).

KEYWORDS: line follower,PWM,noise level;

1. Introduction

The basic idea is that on a mobile system we have attached a device with which we will determine the acoustic power of a landmark positioned in a predetermined area.

In our case, the mobile system is represented by a mobile robot, and the device for acoustic measurement will be a sound sensor with a high sensitivity.

“Mobile robots are robots that are capable to navigate in their environment with the help of sensors and software. To do this, mobile robots must have energy and information autonomy. Informational autonomy refers to the robot's ability to perform the task for which it was programmed, being able to make decisions in extreme situations. The easiest way to navigate a mobile robot is to follow the line (line follower robots)”. [1]

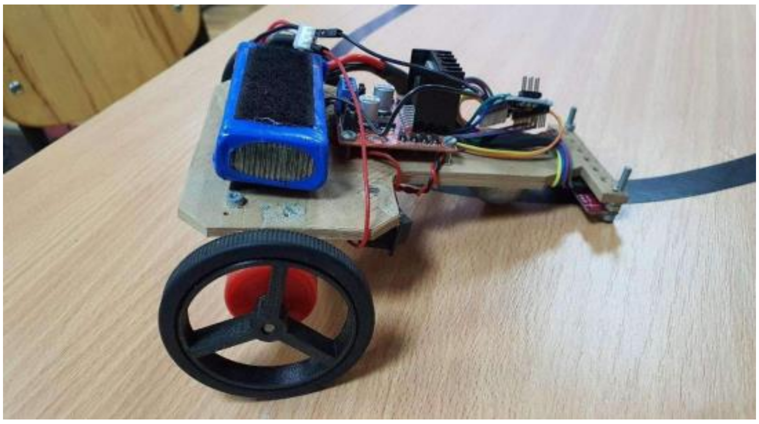


Fig 1 Line follower type robot [1]

Principle of operation of the line follower robot:

“Infrared sensors are used to position and hold the robot on the line, which are based on the property of dark materials to absorb more infrared light than light ones.

The sensor has an infrared light emitter that generates a light wave to the tread. The wave hits the surface on which the robot moves and depending on the material and color encountered, the wave is absorbed more or less.

Then where it is reflected by the work surface and returns to the receiver the sensor that measures the degree of absorption of the wave. If the degree of absorption is low it means that the wave has encountered a light-colored surface and if the degree of absorption is high it means that the generated wave encountered a dark surface. Based on this principle, the sensor can send a signal to the microcontroller which interprets whether the robot is above the tracking line or not.

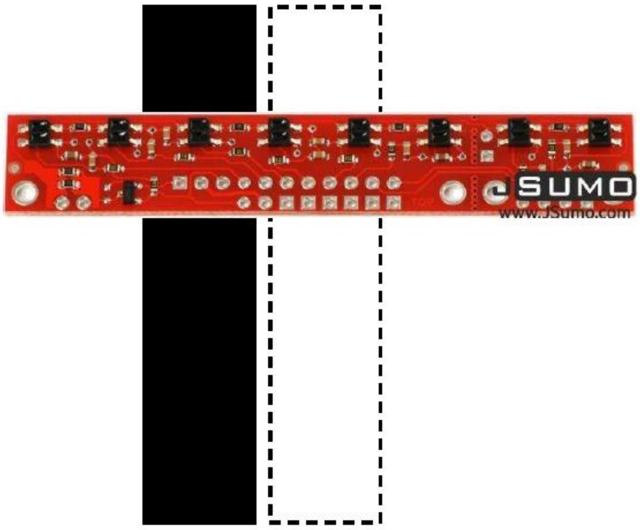


Fig 2 Reading the sensors and interpreting the position of the robot[1]

After reading the sensors, the program continues with the calculation of the correction on the robot’s position,so that if the line moves left or right, the robot will vary the speed on one of the motors to return the robot to the center position.

Varying the motor supply voltage can change the shaft speed and the speed of the robot. The ability to change the speed of each crankshaft is required for the mobile robot to make turns.

For example, a lower speed on one of the wheels will cause the robot to turn in that direction.

Fig 3 Trail of line follower robot [1]

The method of varying the average supplied voltage of a DC motor is via a PWM (Pulse Width Modulation) signal. This is a rectangular, constant frequency signal at which the filling factor can vary. Specifically, it changes the time the signal has a maximum value (if the range is 0-5V then the maximum value is 5V) over a period of time, depending on the frequency of the signal.

This type of signal is often used for command and control applications and is easily generated by microcontrollers. ” [1]

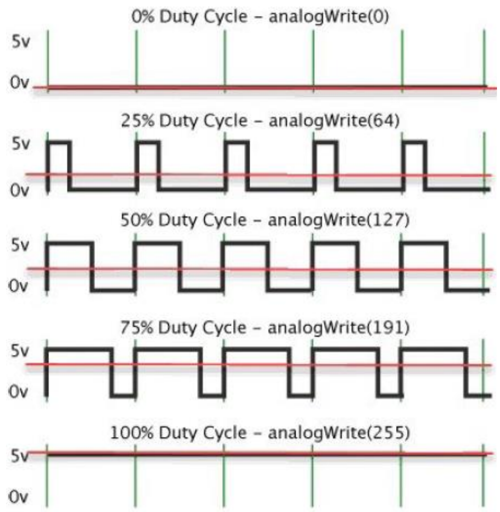


Fig 4 Voltage variation depending on the fill factor of a PWM signal [1]

For the acoustic scanning part we will use a high sensitivity sound sensor to measure the acoustic power level (in decibels).

"The original definition of the decibel is based on the power ratio

$$L_P = 10 \lg \frac{P}{P_{ref}} \text{(dB)} \qquad (1)$$

$P_{ref} = 10^{-12}$ w is the reference power and P is the acoustic power of the source.

The acoustic power of a source is obtained by integrating the acoustic intensity on any closed surface S around the source

$$P = \int_S I_n \cdot dS \qquad (2)$$

The intensity of normal component must be measured in a direction perpendicular to the dS area element.

If a spherical surface is chosen, then the acoustic power of an omnidirectional monopoly source ($I_n = I = ct$) becomes

$$P_m = 4\pi r^2 I \; ; \; P_m = \frac{p_{rms}^2}{\rho c} 4\pi r^2 \qquad (3)$$

The last relation is transcribed to

$$P_m = \frac{p_{rms}^2}{Q\rho c} 4\pi r^2 \qquad (4)$$

in which the directivity factor was noted with Q. This factor takes the values 1,2,4,8 as the source is placed in the air, on a rigid floor, on the edge between two rigid surfaces, respectively in the corner of a room, at the intersection of three walls. " [2]

The response given by the sensor is transmitted to the microcontroller, this being a voltage analog response, and for displaying the results in decibels we will use the formula provided by the manufacturer in the technical data sheet of the sensor.

The role of this experiment is to observe if the measured benchmarks correspond to the current standards and if the values given by the manufacturers are true.

2.The current stage

“NOISE LEVEL - In the context of this standard, abbreviated name for “ACOUSTIC PRESSURE LEVEL”, Lp, expressed in dB, dB (A) or Cz curve number.

- dB is a unit of measurement for characterizing noise physically. Its spectrum is used to define a noise; values - in 1/1 or 1/3 octave frequency bands - are given in dB.
- dB (A) is a unit of measurement for the characterization of noise from a physiological point of view (weighting on the weighting curve A takes into account the perception of the human ear). In specific cases, weighted levels in frequency bands are useful.
- The number of the Cz curve is the value in dB at 1000 Hz of the sound pressure level curve that cannot be exceeded at any point in the spectrum.

In the case of expression of the noise level in dB (A), the measurement is made using an electro-acoustic system that weights the components on noise frequencies, similar to the response of the human ear. The A-weighting curve, originally set for noise levels below 55 dB, is generally accepted today for measurements in the context of noise protection. "[3]

“Measuring sound pressure levels:

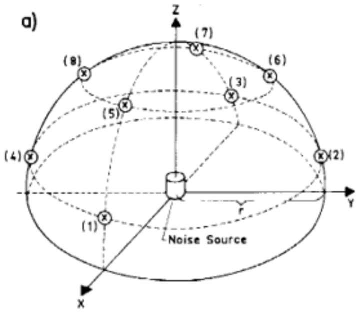
- a parallelepiped reference surface is defined; the dimensions of the reference parallelepiped shall be calculated as the minimum parallelepiped containing the apparatus being tested; constructive elements of the device which are not significant acoustic emitters but which will be mentioned in the test report may be neglected; calculate the characteristic size of the source d0 according to the dimensions of the reference parallelepiped and the location of the device (in the center of the horizontal plane, near a wall or at the corner);

- the shape of the measuring surface (on which the microphones will be placed) and the number and positions of the microphone placement points are established, taking into account the shape of the measuring surface and the location of the device; measuring surface that can be used are:

-parallelipipedic; recommended for normally mounted sources and / or to be measured in unfavorable acoustic rooms or spaces (eg many reflective objects and high background noise levels), at which the measuring distance must be small; the distance between the parallelepiped reference surface and the measuring surface is recommended to be 1m, but not less than 0.25m (possible values: 0.25, 0.5, 1, 2, 4 or 8m);

-hemispherical; it is recommended for sources usually mounted and / or to be measured in large open spaces, with favorable acoustic conditions, at which the measuring distance is recommended to be large; the radius of the hemispherical surface must be equal to or greater than twice the characteristic distance of the source but not less than 1m (possible values: 1, 2, 4, 8, 10, 12, 14 or 16m);

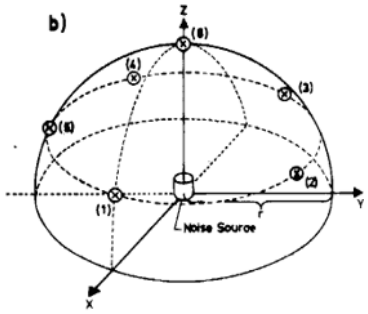
- the area of the measuring surface is calculated;



Micr. Pos.	X	Y	Z
(1)	0.97r	0	0.25r
(2)	0	0.97r	0.25r
(3)	-0.97r	0	0.25r
(4)	0	-0.97r	0.25r
(5)	0.63r	0	0.78r
(6)	0	0.63r	0.78r
(7)	-0.63r	0	0.78r
(8)	0	-0.63r	0.78r

r= Radius of Hemisphere

⊗ = Microphone Positions



Micr. Pos.	X	Y	Z
(1)	0.89r	0	0.45r
(2)	0.28r	0.85r	0.45r
(3)	-0.72r	0.53r	0.45r
(4)	-0.72r	-0.53r	0.45r
(5)	0.28	-0.85r	0.45r
(6)	0	0	r

Fig 5 Distribution of measuring points on a hemisphere

No.	x	y	z
1	a	0	$0,5c$
2	0	b	$0,5c$
3	$-a$	0	$0,5c$
4	0	$-b$	$0,5c$
5	a	b	c
6	$-a$	b	c
7	$-a$	$-b$	c
8	a	$-b$	c
9	0	0	c

$$S = 2(2bc + 2ac + 2ab)$$

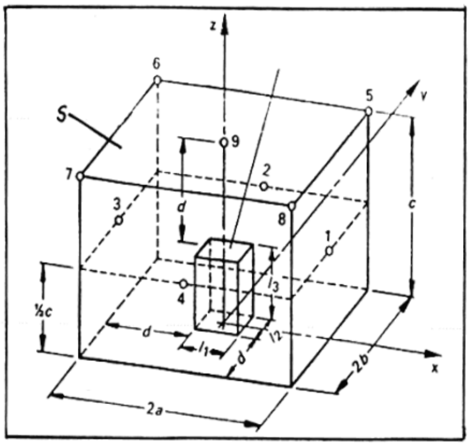


Figure 6 Distribution of sound pressure level measurement points
on a parallelepiped surface (9 points) **[2]**

- before each series of measurements, the device for stabilizing the operating conditions is put into operation;

-the appliance will be tested in normal operation; if in operation it goes through several operating cycles, the testing for all cycles will be done and all these values will be noted; in practice, testing at multiple regimes will be avoided, applying only if the cyclic operation is the basis for the equipment to perform the tasks for which it is designed; priority must be given to simple regimes that ensure satisfactory repeatability and reproducibility of measurements;

- the sound pressure level is measured for each position of the microphone locations at a time-mediated level over the typical period of operation of the source, both in octave or one-third octave bands and as an A-weighted global level (if there are a number of microphones available equal to the number of measuring points, simultaneous measurement at all points is recommended, and if the number of available microphones is less than the number of measuring points, it is acceptable to move the microphone (s) to the points where no measurements and resumption of testing have been performed, the number of measurements must be kept to a minimum, as large errors may occur in determining the acoustic emission for non-stationary emission devices over time);"[4]

3. Conclusions

Since the way to determine the noise level is in a large proportion identical to the one used in the field, our contribution with this project is to significantly reduce cost because for acoustic determination we use a single measuring device and the orientation in the positions of measurement is performed by the mobile robot on a predetermined route, the input of human personnel will decrease.

Another benefit of this system its flexibility. To measure different landmarks it's enough to change the default route and a small adjustment of the code.

And last but not least, the system is easy to purchase. Being a modular system, the parts for it are easy to change with others from other manufacturers or with those available in the respective geographical area.

It does not have a high acquisition cost, and its assembly does not require expensive equipment.

4. Bibliography

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