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DISTANCE MEASUREMENTS WITH ULTRASONIC SENSOR DT020-1

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Abstract:
In this paper it is presented one model of distance measuring to some objects from an environment using an ultrasonic sensor. The objects are made from wood and have different shapes. For the measurements it is use a DT020-1 ultrasonic sensor. The operational principle of an ultrasonic sensor is based on the generation of acoustic waves and their detection when reflected by an object.

1. INTRODUCTION

Sonar uses the principle of echo location. Sonar sensors transmitter send out a short pulse within a specific direction. When the pulse hits an object, which does not absorb the pulse, it bounces back, after which the echo can be picked up by a receiver [1]. Some sensors have separate transmitter and receiver components, while another sensor combines both in a single piezoelectric transceiver. However, the basic operation is the same in both devices. The distance to the object can be determined by measuring the time between sending the pulse and detecting the echo. By multiplying the time between pulse and echo *t* (in seconds) with speed of sound *c*, you will get twice the distance *d* to the object in meters (since the sound traveled the distance twice to get to the object and bounce back).

$$2 \cdot d = c \cdot t \quad \text{or} \quad d = \frac{c \cdot t}{2} \ \text{[m]} \tag{1}$$

The accuracy of the distance measurement is directly proportional to the accuracy of the speed of sound used in the calculation [2]. The speed of sound in air varies as a function of temperature t [^{o}C] by the relation:

$$c = 331.5 + 0.61 \cdot t \ \text{[m/s]} \tag{2}$$

Sonic or ultrasonic sound is a vibration at a frequency above the range of human hearing, usually >20 kHz. Most ultrasonic sensors use a single transducer to both transmit the sound pulse and receive the reflected echo, typically operating at frequencies between 40 kHz and 250 kHz.

2. DEVICES USED FOR MEASUREMENTS

The ultrasonic sensor DT020-1 measures the distance between the sensor and an object in two ranges, one of 0,4 to 10,4 meters and the other of 0,4 to 2 meters with better resolution. The range is selected via the MultiLogPRO data acquisition system. The sensor can sample data at up to 50 times per second, making it an excellent choice for motion experiments [3].

Fig. 1. The ultrasonic sensor DT020-1.

Specifications of ultrasonic sensor DT020-1:
- Range: Two ranges 0.4 – 10.4 m or 0.4 – 2 m;
- 10-bit Resolution: 0,4 – 10,4 m range at 9.4mm, 0,4 – 2 m range at 1.8mm;
- Accuracy: 1% over entire range;
- Receiver viewing angle: ±15° to ±20°;
- Sampling rate: up to 50/s.

Fig. 2. Contents of the MultiLogPRO system.

1. The MultiLogPRO data logger;
2. Sensors (see your package list);
3. Four sensor mini-din cables;
4. Communication cables;
5. Web camera;
6. MultiLab software installation CD;
7. An AC-DC adaptor.

For data acquisition was used the MultiLogPRO system. The Fourier Systems MultiLogPRO is a powerful standalone 12-bit data logger with a clear LCD graphic display and a 128K internal memory. Recorded data is displayed in the form of graphs, tables, meters or digital displays, and can be analyzed with a number of pre-programmed analysis functions.

The MultiLogPRO's internal memory stores experiment notes and instructions for carrying out the experiment, which can be edited or expanded at any time. These features enable MultiLogPRO to function independently from a computer - a perfect solution for when there is a shortage of computers in the laboratory.

MultiLogPRO can record data from up to 8 sensors simultaneously; it is capable of recording at rates of up to 21,000 samples per second, and of collecting up to 100,000 samples in its internal memory [4].

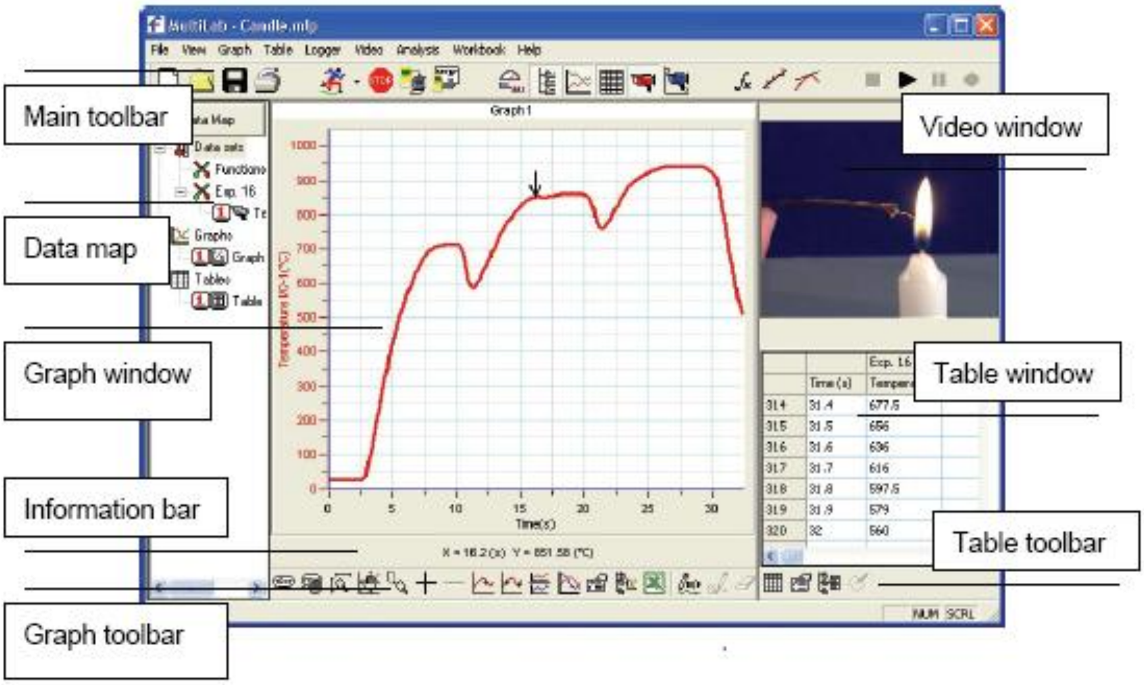

Fig. 3. MultiLab window layout.

For data analyzes was used the MultiLab software. MultiLab is a comprehensive program that collects data from the MultiLogPRO system, displays the data in graphs, meters and tables, analyzes it with sophisticated analysis tools and views online or recorded video movies of the actual experiment. The Video Motion Analyzer module enables you to capture position and time from video movies and analyze the data with MultiLab's analysis tools.

The program includes four windows: A graph window, table window, video window and a navigation window called the Data Map. You can display all four windows simultaneously or any combination of the four.

The most commonly used tools and commands are displayed on three toolbars. Tools that relate to all aspects of the program and tools that control the MultiLogPRO are located in the main (upper) toolbar. Tools specific to the graphs are located on the graph toolbar and tools specific to the tables are located on the table toolbar [4].

3. MEASUREMENTS

For the measurements with ultrasonic sensor DT020-1, it was made a working environment (square with 1,2 m side) and three obstacles, one plane, one with 90^{o} angle and one cylindrical.

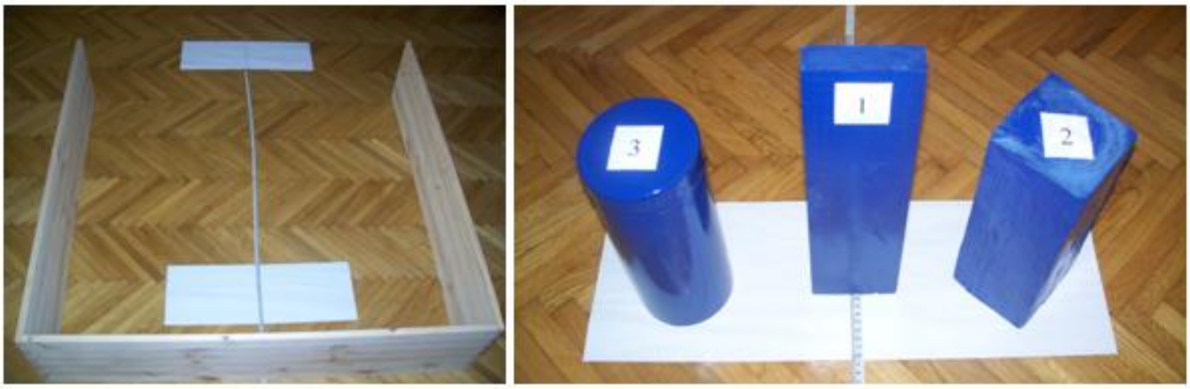

Fig. 4. The working environment and the obstacles

For the notice of obstacle shape influence, it was made distance measurements between sensor and the three obstacles. The obstacles were located successive at the same distance (1 m) over the ultrasonic sensor. There was made ten measurements for each obstacle, one per second.

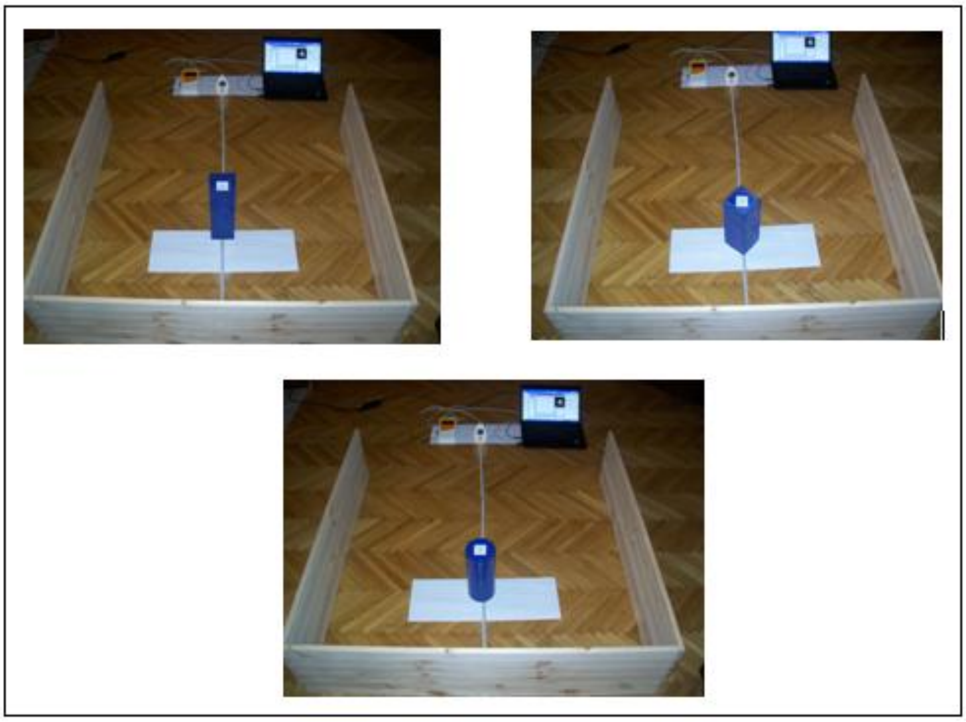

Fig. 5. The distance measurements over the three obstacles.

The measurements made with obstacle 1 (plane) was the most accurate (close to the seated distance) and the values obtained at the measurements with obstacle 2 (90^{o} angle) was the most inaccurate (it was not constant).

Table 1. Measured distance between sensor and obstacles.

	Obstacle 1	Obstacle 2	Obstacle 3
Time	Distance	Distance	Distance
[s]	[m]	[m]	[m]
0	1,002	1,026	1,004
1	1,002	1,026	1,004
2	1,002	1,017	1,004
3	1,002	1,014	1,004
4	1,002	1,014	1,004
5	1,002	1,014	1,004
6	1,002	1,017	1,004
7	1,002	1,017	1,004
8	1,002	1,014	1,004
9	1,002	1,014	1,004

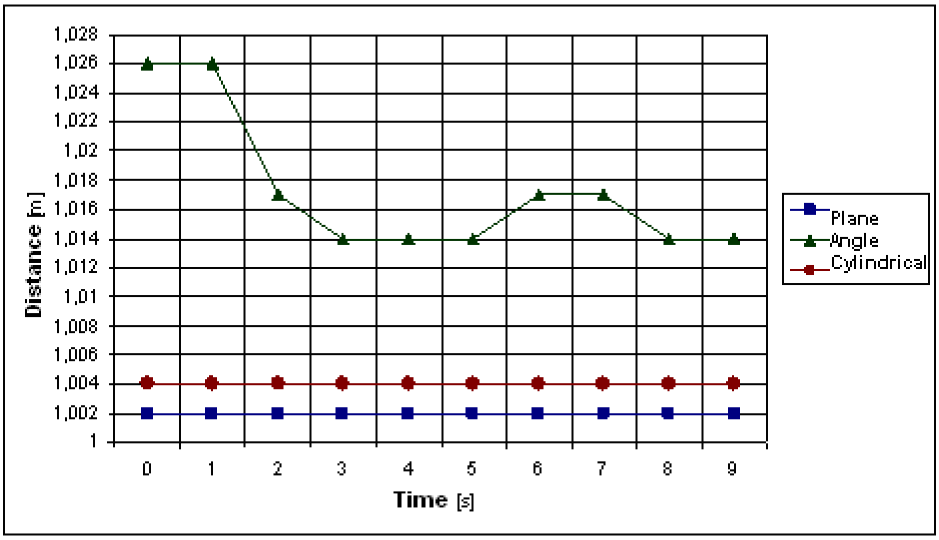

Fig. 6. The values obtained for the three obstacles.

To simulate a rotary sensor, the measurements were made with that sensor placed on a platform which has the possibility to rotate with a maximum 90^o angle.

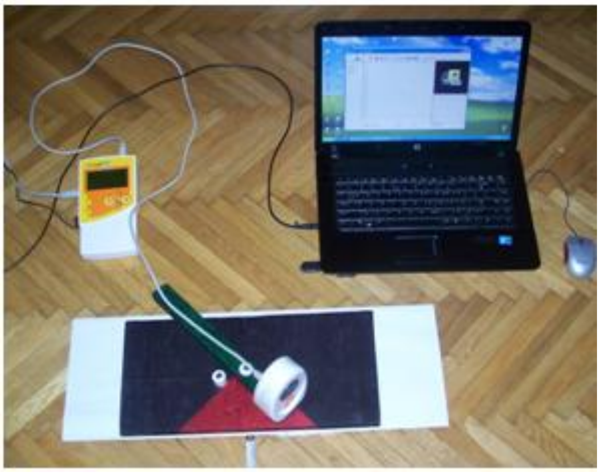

Fig. 6. The sensor placed on the platform.

The obstacles was placed at the same distance over the sensor to distinguish in which way are influenced the obtained values having in view the different shape of those.

Table 2. Measured distance between rotary sensor and obstacles.

Time	Environment dimensions	Obstacle 1	Obstacle 2	Obstacle 3
[s·10^{-1}]	[m]	[m]	[m]	[m]
0	1,522	1,522	1,508	1,508
1	1,508	1,508	1,508	1,508
2	1,498	1,508	1,453	1,5
3	1,416	1,431	1,421	1,441
4	1,402	1,434	1,402	1,389
5	1,394	1,192	1,219	1,194
6	1,394	1,192	1,209	1,189
7	1,394	1,192	1,212	1,189
8	1,397	1,194	1,216	1,197
9	1,421	1,434	1,401	1,402
10	1,495	1,505	1,416	1,453
11	1,505	1,505	1,448	1,505
12	1,515	1,522	1,522	1,513

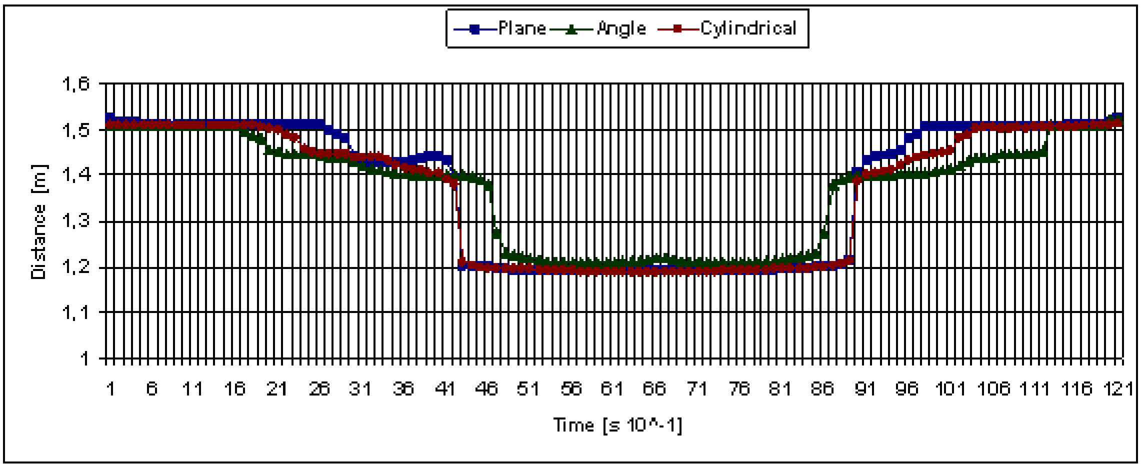

Fig. 6. The values obtained for the three obstacles.

5. CONCLUSIONS

Sonar sensing is influenced of the shapes of the obstacles and environment due to the values of the measurements. Anyway, the sonar and ultrasonic sensor are used in different types of applications due to the low cost and high precision compared with other distance sensors.

References:

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