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AUTOMATED SYSTEM FOR ENGINE NOISE MEASUREMENTS

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ABSTRACT: The goal to develop robotized equipment which can make automated measurements of sound level in engine near field is to decrease the cost of experiments and eliminate the error possibilities. To develop such equipment a precise planning of robot trajectories is need. The robot will position the microphone in the nodes of a grid which can be defined with resolutions according to required measurements precision. With this system the measurements can be made repeatedly always with the same accuracy.

1. INTRODUCTION

Acoustic measurements are made using two kind of experimental setups. Using a single microphone, when the microphone has to be placed in several points near the noise source and acquiring signals from the microphone sequentially, in order to measure the pressure level field which varies with the distance from the source and the configuration of the environment (nearby objects will produce reflection and diffraction phenomena). The second experimental setup requires the use of a microphone array and acquiring the signals from all the microphones simultaneously.

Although the microphone array system allows a faster signal acquisition procedure, it lacks flexibility because the microphones are fixed on a support and a certain configuration cannot satisfy different applications in which the source positions can be outside the range of the array or different environments. In other words we must have as many supports for the microphones as many applications.

The first type of configuration instead, is hard to work out due to the long time required to manually position the microphone and to acquire the signals for each position. This disadvantage can be reduced if the positioning of the microphone and the signal acquisition is done with an automated system.

Such an automated system was developed by the author, using a 6 axes robot and an automated acquisition system which is described in the present paper.

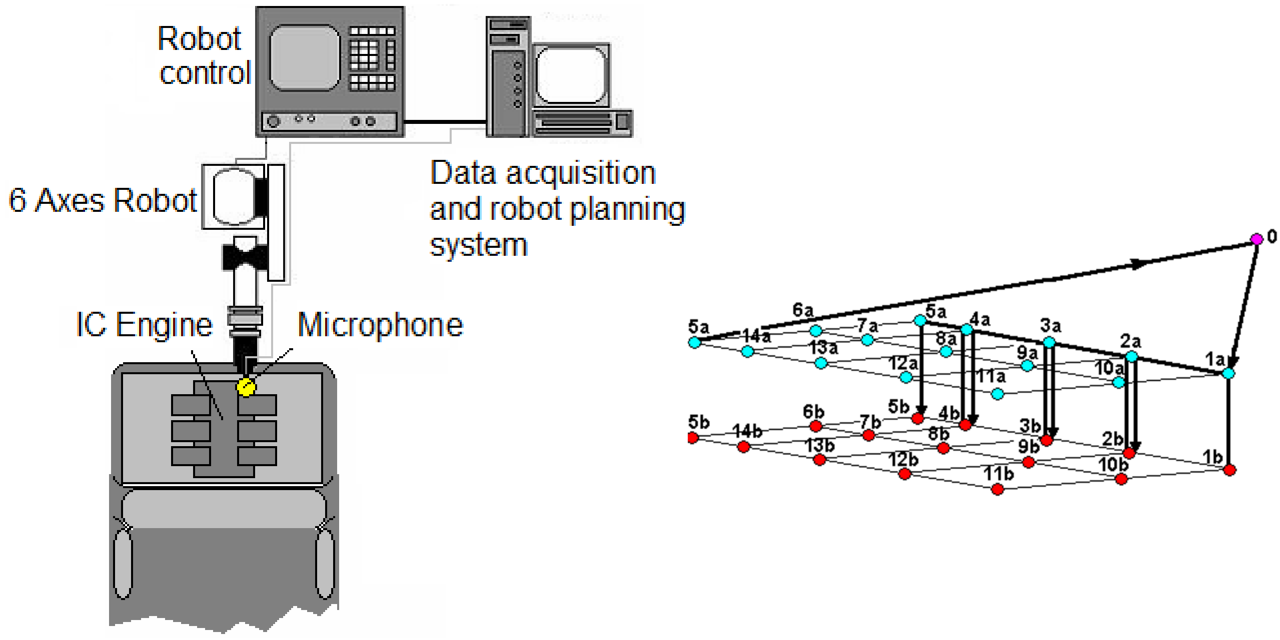
2. EXPERIMENTAL SETUP

The system layout is presented in figure 1.a. The robot has 6 axes and holds the microphone in a special device, in the robot gripper. The robot is commanded by the Robot Control System, which in turn receives instructions from the "Data Acquisition and Robot Planning System". The main control program is made in MATLAB language and launches the robot control instructions and the data acquisition module successively. The program moves the robot along the paths defined in figure 1.b. and in each acquisition point (marked with a red point on the figure), starts the data acquisition module which saves the data in a file for later processing. When the acquisition was terminated, the following instruction sequences are transmitted to the robot control equipment. The program will run until the last point on the grid is processed and returns to the home position.

After the data acquisition is completed, the data files are processed with a MATLAB program. In the data processing program every acquired signal is filtered to eliminate background noise and then a mean value of the signal is computed. These values are then grouped to form a 3D diagram of the sound levels, versus the coordinates of the grid points.

So, two kinds of measurements can be done:

- the measurement of acoustic pressure field near the car engine in static and transient regime, in order to analyze the possibilities of noise level reduction;
- detection of noise source in order to identify operation defects or failure, for engine diagnosis purposes.



a. *b.*

Fig. 1. Robot system for microphone positioning (a); and the measuring grid with the microphone positioning path (b).

Fig.2. Pictures of robot arm with microphone in two different positions above the IC engine .

3. DATA PROCESSING AND RESULTS

The measurements were made in 6 different conditions of engine operation.
The data sets represents the following conditions:

1. normal operation with engine cover in place;
2. normal operation with engine cover removed;
3. failure condition of cylinder 1 (only 3 cylinders running), with the engine cover removed;
4. failure condition of cylinder 2 (only 3 cylinders running), with the engine cover removed;
5. failure condition of cylinder 3 (only 3 cylinders running), with the engine cover removed;
6. failure condition of cylinder 4 (only 3 cylinders running), with the engine cover removed;

During some of the measurements the fan of the engine had started in order to cool the engine. The fan operation cannot be stopped because is absolutely necessary for the engine cooling, so the processing program had been designed to filter out the fan noise from the signal.

An example of result diagram is given in figure 3. The colors are proportional to the value of sound levels represented on the vertical axis. The sound level is represented in non-dimensional units, because no absolute value of sound level is needed for the proposed analysis, the diagrams are only compared one relative to the other.

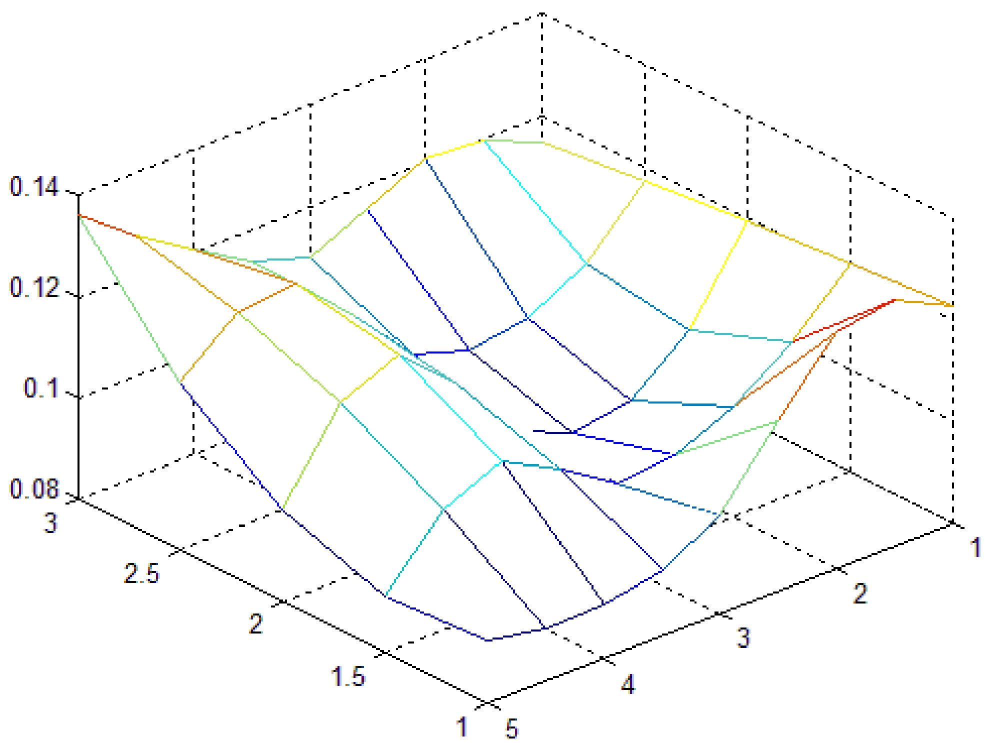


Fig.3.Diagram of signal mean values on the measuring grid.

4. CONCLUSIONS

The developed automated sound level measuring system can be successfully used for the measurement of acoustic pressure field near the car engine in static and transient regime, in order to analyze the possibilities of noise level reduction or for the detection of noise source in order to identify operation defects or failure, for engine diagnosis purposes.

Measured data are in accordance with the estimated noise levels, knowing the sources position and intensity.

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