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Noise Source Determination By Using Artificial Neural Network In A Metal Workshop

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***Abstract*— While the improvements in technology are ensuring some eases in human life, it also causes some negative effects. Although these effects are usually unimportant, some of them could threaten the human health seriously. Noise pollution, beside daily life, especially in business life such as metal works, textile, construction or automotive sector is one of the most important factors that affect human health. In this study, the noises produced by the Grinder, Saw, Lathe, Milling workbench in the machinery laboratory of Karamanoglu Mehmetbey University Technical Sciences Vocational School have been measured. The CEM DT-8820 voice level measurement device has been used during measurements. The measurement has been done while each workbench is handling wooden, propylene, metal material or free running. In each measurement of noise of a workbench, 50 samples have been collected. So for 4 workbenches a dataset consists of 200 samples has been obtained. With this dataset, various types of Artificial Neural Networks have been trained by using different training algorithms. By changing number of neurons in the hidden layer and hidden layer activation functions, it has been tried to obtain the best structure. With the best structure obtained in the study, the minimum errors in MAE and RMSE determined as 0.018552 and 0.11744 respectively.**

Keywords—Noise Pollution, Artificial Intelligence, Artificial Neural.

I. INTRODUCTION

Environment is a physical, biological, social, economic, and cultural environment in which people and other living beings interact with each other throughout their lives. The degradation of the environment, a system of relations, and the emergence of environmental problems have usually begun with the disruption of natural balances by human factors. In daily life, the presence of sounds is necessary for people to feel good about themselves. Speech, music, sounds in the nature, indispensable for our lives. However, the noise, defined as unwanted sounds, adversely affects human health. By the World Health Organization's definition about human health, it is not just for weakness or lack of healthy, but also being physical, mental, social well-being and happiness [1].

The direct or long-term negative effects of noise on human health are a well-known phenomenon. In a report issued by the Organization for Economic Co-operation and Development (OECD) in 1996, the direct negative effects of noise in the Table 1 have been determined [2, 3].

TABLE I. THE IMPACTS OF NOISE ON HEALTH

Noise Level	Noise Exposure Level (dBA)	The Effects of Noise
1.level noise	30-65	Inconsistency, discomfort, anger, anger, sleeps disorder and impaired concentration.
2.level noise	65-90	Blood pressure increase, increase in heartbeat and respiration, decreased pressure on brain fluid, sudden reflexes
3.level noise	90-120	Physiological reactions, headaches.
4.level noise	120-140	Permanent damage to the inner ear, impaired balance
5.level noise	>140	Serious brain damage, eardrum burst

There is suggestive evidence that consistent and prolonged noise exposure is associated with a greater incidence of cardiovascular morbidity. Sleep disturbances and some psychological problems have also been associated with continuous noise exposure [4, 5, 6]. Many studies about effects of noise pollution are there in the literature. Kahn et all. (1998) have studied about the effects of noise in the hospitals in ICU environments [7]. Rizk et all. (2016) have investigated the health effects of aircraft noises. They have point out that hearing impairment, raised blood pressure, headaches, disturbed sleep, and symptoms of anxiety were more prominent among the exposed workers than the control [8]. Maisonneuve et all.

(2009) have suggested a new way to show noise pollution created by citizens. To measure the personal exposure to noise, GPS-equipped mobile phones have been employed as noise sensors and collected noise levels in the daily environment in a platform called Noise Tube [9].

In metalworking industry, the existence of noise in working areas may pose some risks like permanent occupational disease, working accidents and performance losses [10]. In metalworking industry, the most common occupational disease is loss of hearing. And also loss of hearing due to the noise is the most common occupational disease all over the world [11]. To determine the noise sources is important to reduce noises in the environment. In industrial areas, noise sources vary due to the type of production of the industry. For instance, while in building sector the noise sources could be a saw, nailer or cutting machine, in an office it could be a not properly working air conditioner or a bad insulated wall etc. In this study, the noises existing in metalworking workshop have been investigated. The dominant noise source in metalworking is always workbenches. The noise in metalworking depends on the type of workbench and also the material that has been handled in the workbench. In this study, noises in a workshop have been recorded while different workbenches are handling various materials. By using these records estimation has been attempted to determine which workbench is working.

II. Material and Methods

A. *Artificial Neural Networks*

Artificial Neural Network (ANN) is a system that was inspired from data process techniques of the human brain. An ANN mimics the way of basic biological neural system work. This system consists of neurons. These neurons connect to each other in various shapes to create a network. These networks have the capacity to learn, memory, and reveal the relationship between data and attributes. In other words, ANNs produce solutions to the problems that normally require a person's natural abilities like thinking and observing. The fundamental reason for a person to be able to produce solutions for the problems that require his / her ability to think and observe is the ability learning by living or trying [12].

In biological systems, learning occurs through the adjustment of synaptic connections between neurons. From birth, the creatures enter the learning process by living. In this process, the brain develops continuously. With life and experience, synaptic connections are established and even new connections are established. Learning occurs by this way [13]. This also applies to ANN. Learning happens by using examples through training. In other words, learning is achieved by repeatedly adjusting the connection weights until the convergence is achieved by processing the input / output data with the training algorithm [14].

ANN does not need to be notified about inputs and outputs. The output information corresponding to the input information is provided to make the ANN to understand the relationship between them. This learning method is known as supervised learning [15]. Artificial neural networks are divided into two groups as feed forward and backward propagation depending on the shape of the connections of neurons that they contain.

Feed Forward Networks: In forward-feeding networks, neurons are arranged in regular layers from entry to exit. There is a bond only from one layer to the next layer. The data arriving to the artificial neural network passes through the input layer and then through the hidden layer and then the output layer respectively [14].

Feed Backward Networks: Unlike the Feed Forward Networks, in this network, the output of a neuron is given not only to the next layer but also as input to the previous layer or any neuron in its own layer [14].

The data arriving at the artificial nerve cell is multiplied by the weight of the links before reaching the kernel. By this way, the effect on the output to be produced could be adjusted. The values of these weights can be positive, negative or zero. Entries with zero weight have no effect on output. The Merge function is a function that computes the net input of an artificial neural cell by multiplying inputs. The activation function determines the output to be created against this input by processing the net input of the cell. The activation function is always a nonlinear function. The most common activation functions used in applications are linear activation function, step activation function, sigmoid activation function and tangent hyperbolic activation function [16].

B. *Dataset*

In this study, the noise levels in the mechanic workshop while four different workbenches is processing three different material have been measured. Measurements have been taken with abide by TS EN ISO 9612:2009. Measurement device has been fixed to the side where the workers hear highest level of noise at the ear level of worker by using a tripod.

CEM DT-8820 voice level measurement device which was calibrated by OMKA calibration center, has been used for noise measurements. This measurement device has been presented in Figure 1. Some of technical parameters of the voice measurement device have been presented in Table 2.

TABLE II. TECHNICAL PARAMETERS OF THE VOICE MEASUREMENT DEVICE

Range	Lo (Low) 35 dB – 100 dB / Hi (High) 65 dB – 130 dB
Precision	± 3.5 dB (at 94 dB)
Resolution on The Screen	0.1 dB
Device Dimensions	251 × 63.8 × 40 mm

TABLE III. TECHNICAL PROPERTIES OF THE WORKBENCHES

	Grinder	**Saw**	**Lathe**	**Milling**
Brand	Makita	Cuter al 280	JET	FALCO
Power (kW)	0.55	2.69	2.2	4
RPM (Round per Minute)	2850	-	40 – 1800	58 – 1800
Dimensions (cm) Length Width Height	-	230 100 140	200 70 115	185 200 190

Fig. 1. *CEM DT-8820 voice level measurement device.*

The names and technical properties of workbenches, whose noises have been measured, are presented in Table 3.

During measurements the Lathe and Milling workbenches have been operated with the rotation value 770 rpm and 1325 rpm respectively.

During measurements 200 samples have been taken and recorded into a dataset. This dataset is classified by using ANN algorithm on MATLAB. Randomly chosen 60% of the dataset has been assigned as training dataset to use during training. Rest of the dataset (40% of the dataset) has been reserved to use during tests.

In this study, single hidden layer has been proposed. Two activation function have been used in hidden layer. These activation functions are logarithmic sigmoid and tangent hyperbolic sigmoid. The linear activation function has been chosen in the output layer. The number of the neurons in the hidden layer has been determined by using trial and error method. The training algorithms proposed in this study are Bayesian Regularization Backpropagation (BR), Gradient Descent with Momentum and Adaptive Learning Rule Backpropagation (GDX), Levenberg–Marquardt Backpropagation (LM), Scaled Conjugate Gradient Backpropagation (SCG) and Gradient Descent Backpropagation (GD). For each situation the MAE and RMSE errors have been calculated. The common parameters of proposed ANN are presented in Table 4.

TABLE IV. COMMON PARAMETERS OF USED ANN MODEL

Number of hidden layer	1
Number of input	3
Number of output	1
Activation function of output layer	Purelin
Learning rate	0.01
Momentum constant	0.9
Performance goal	0
Minimum performance gradient	0.5

The proposed Artificial Neural Network is presented in Figure 2.

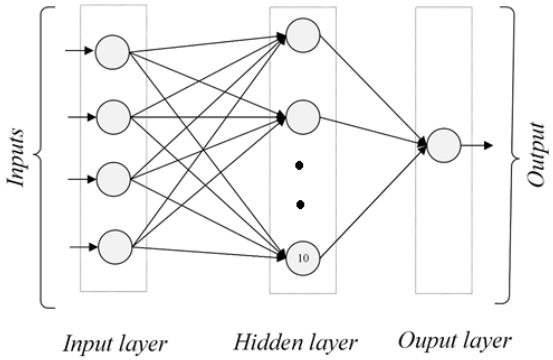

Fig. 2. *The artificial neural network model*

III. RESULT AND DISCUSSION

In the study, mean absolute error (MAE) and root mean squared error (RMSE) techniques have been used as performance indicator. The mathematical expressions of these statistical methods have been presented in (1) and (2) numbered equations respectively.

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|Y_i - Z_i| \quad (1)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i - Z_i)^2} \quad (2)$$

During training to achieve the structure that has the best performance, a search has been done in the number of neurons in the hidden layer, activation function of the hidden layer and training algorithms. While number of neurons in the hidden layer has been being changed from 1 to 10 step by step, various activation function in the hidden layer with various number of training algorithm has been used. For each step, the MAE, RMSE values have been collected. The logarithmic sigmoid function and tangent hyperbolic sigmoid function have been examined for best performance as activation function search. The examined training algorithms are Bayesian Regularization Back propagation (BR), Gradient Descent with Momentum and Adaptive Learning Rule Back propagation (GDX), Levenberg–Marquardt Back propagation (LM), Scaled Conjugate Gradient Back propagation (SCG) and Gradient Descent Back propagation (GD), Conjugate gradient back propagation with Fletcher-Reeves updates (CGF). The best performances for these situations have been presented in Table 5.

TABLE V. ANN STRUCTURES AND MSE, MAE AND RMSE VALUES

ANN Model	Learning Method	Hidden Layer Activation Function	Number of Neurons in the hidden layer	MAE	RMSE
1	LM	Tansig	10	0.034709	0.14812
2	LM	Logsig	10	0.018552	0.11744
3	SCG	Tansig	8	0.073114	0.15602
4	SCG	Logsig	3	0.078526	0.15134
5	GD	Tansig	8	0.284550	0.39914
6	GD	Logsig	7	0.441830	0.53780
7	GDX	Tansig	10	0.133890	0.19172
8	GDX	Logsig	2	0.149440	0.21055
9	BR	Tansig	2	0.114980	0.20096
10	BR	Logsig	10	0.045336	0.17906
11	CGF	Tansig	3	0.074587	0.15206
12	CGF	Logsig	2	0.084960	0.15952

Logsig: The logarithmic sigmoid function
Tansig: The tangent hyperbolic sigmoid function

The performance changes versus ANN model have been presented in Figure 3.

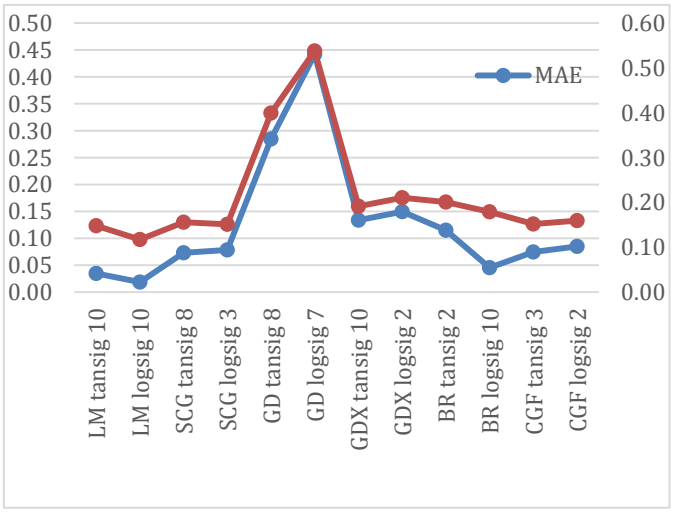

Fig. 3. *The performance change versus ANN model*

IV. DISCUSSION

In this study an estimation about dominant noise source in a workshop has been done. The dataset consist of 333 samples which contains noises of four different workbenches while processing 3 different materials. The dataset has been classified by using Artificial Neural Network into four group as lathe, grinder, saw or milling workbench on MATLAB. With various learning algorithms and activation function in hidden layer, the performance of ANN has been examined when there are different numbers of neurons in the hidden layer. As seen in Table 5, the best estimate has been obtained by using Levenberg–Marquardt Backpropagation (LM) learning algorithm with logsig hidden transfer function and when there is 10 neurons in the hidden layer. In the best performance, MAE and RMSE values are 0.018552 and 0.11744 respectively.

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