

## NOISE MODELLING AND NOISE MAPPING IN MECHANIZED OPENCAST COAL MINE - A CASE STUDY

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### ABSTRACT

Increased mechanization has generated noise and vibration problems in opencast mines. Noise is generated by every activity or machinery present in the mines. Artificial Neural Network (ANN) and Adaptive Network-based Fuzzy Inference System (ANFIS) was applied to predict machinery noise in a mechanized opencast coal mine. This paper dealt with comparison of the prediction capabilities of ANN and ANFIS based soft computing models vis-à-vis existing statistical model (ENM) in order to find the actual noise status in an opencast coal mine. From the present study, it could be concluded that ANFIS gave better prediction results than the ANN (MLP and BP) methods. This paper also includes the preparation of a noise map in the opencast mine using two methods (Kriging and IDW) and ArcGIS.

**KEY WORDS:** Noise modelling, Noise mapping, ANFIS, ENM model, Opencast mines

### INTRODUCTION

Increased mechanization has generated noise and vibration problems in opencast mines. Noise generated from the mining and its allied industries are the most predominant noise sources and are considered as a global health issue (Tripathy, 1999). Noise levels of the sources are measured to study their impacts on the miners in their working environment. Noise assessment are based on kind of noise sources, intensity of the noise source, distance from the source to the receiver and the environment of the operational condition. Sound power level, meteorological parameters and geo-mining states are the factors that affect noise of a machinery in mines. In mining conditions, the environment constantly changes as the mining progress (Nanda *et al.*, 2010). Statistical models are complex and cannot be implemented in real time systems as they fail to predict the future from present and previous measurements. Hence, Artificial Neural Network (ANN) and Adaptive Network-based Fuzzy Inference System (ANFIS) were applied to predict machineries noise in a mechanized

opencast coal mine (Nanda *et al.*, 2010, 2011; Nanda, 2012).

Noise mapping is considered as an enhanced and effective method to measure and represent the noise level of huge study area having numerous sources, which are continuously or intermittently emitting noise in the environment. Noise map helps authorities to make plans to combat the noise problem in opencast mines and to sectionalise different zones, which can be helpful in making plans for noise control in the mine.

### METHODOLOGY

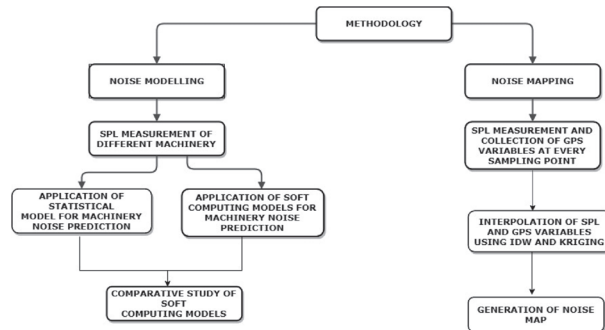
The detailed methodology followed in the paper is presented in Fig. 1.

#### Noise Measurement

The instruments used to conduct the noise assessment are discussed in this study along with the instrumentation specifications set out in ISO 9613-2:1996, ISO 6395:2008 and other related standards. Brief details of the instrumentation are given in **Table 1**.

**Table 1.** Details of the instrumentation

Sl. No	Name of the instrument	Make and Model	Purpose
1	Sound level meter	Type 2 Extech 407790 SLM	Measuring noise levels
2	Calibrator	Extech 407744 calibrator	Calibration of Extech SLM
3	Wind speed meter		Measuring wind speed
4	Anemometer		humidity and wind speed and direction
5	GPS	Garmin GPS 60CSx	Collecting GPS variables



**Fig. 1.** Methodology of work

**Measurement Procedure**

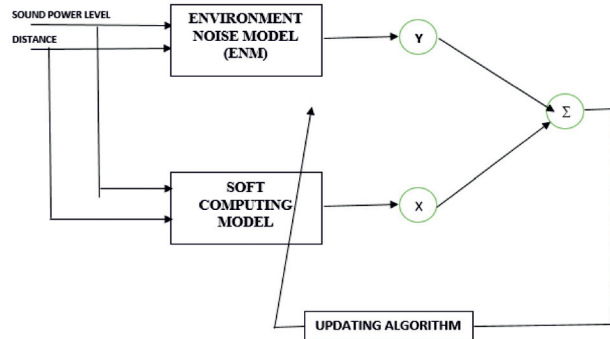
Acoustic instruments have been utilized for a considerable length of time to measure the physical features of sound like duration and amplitude. The instrumentation included two basic sound measuring instruments: SLM and GPS. Noise measurements were done utilizing an Extech octave band analyser for five different types of machineries in the opencast mine. In the opencast mine, measurements were made on a straight line at a distance of about 1m from the machine and 1.5 m above the ground in the open areas to depict the area noise levels. The measurement recorded was of the A-weighted linear equivalent continuous SPL ( $L_{eq}(A)$ ).

Noise mapping of the mine was carried by the most notable, noise sources affecting the mine.  $L_{Aeq}$  GPS positions, and ArcGIS program were used to develop the noise map of the opencast coal mine. The results are displayed in the form of color-coded noise maps, each colour relating to a given range of A-weighted noise levels, in the difference of 5 dB(A).

**Soft Computing Models for Prediction of Machinery Noise**

The study was conducted in a highly mechanized opencast coal mine situated in Odisha, India. Modelling of complex systems is of fundamental significance in all fields, because of its better comprehension of the system. In this study,

frequency based statistical noise prediction model (ENM) and soft computing models were used to predict different opencast mining machineries noise using statistical model (ENM) which is represented in **Fig. 2**. Different soft computing models like ANN (MLP and BP) and ANFIS were used in the present study and summary results are presented in **Table 2**.



**Fig. 2.** Application of soft computing technique for frequency based statistical models

**RESULTS AND DISCUSSION**

From **Table 2**, It can be observed that the RMSE of proposed ANFIS model for surface miner, hydraulic shovel, 100-Ton dumper, DTH drill machine and pay loader was found to be 0.39, 0.23, 0.44, 0.48 and 0.13 respectively

From the simulation study, it was revealed that the root mean square error of ANFIS model was lesser than MLP and BP. Hence, ANFIS based noise prediction model can be beneficial for mining engineers to assess the real noise situation of machines precisely.

**Noise Mapping**

Noise mapping is the geographic presentation of information associated with noise levels and noise exposure with related information on effect to the influenced population. At every location of noise sources, geographic coordinates were collected with

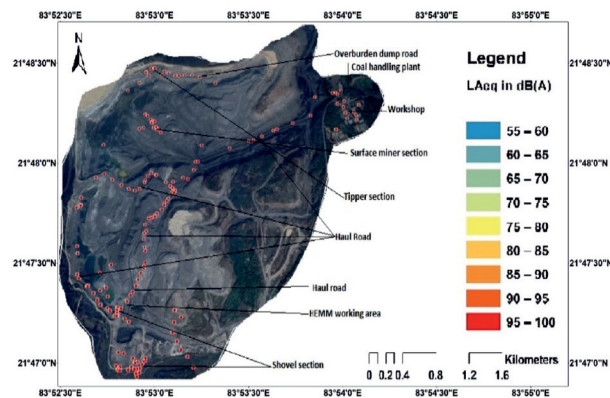
**Table 2.** Summary of comparative results of RMSE for different machinery noise with ENM, MLP, BP and ANFIS (Parmar, 2018)

Sl. no.	Machinery	RMSE			
		ENM	MLP	BP	ANFIS
1	Surface Miner	2.97	1.43	0.79	0.39
2	Hydraulic Shovel	3.04	1.87	0.89	0.23
3	100 Ton Dumper	3.03	1.77	0.95	0.44
4	DTH Drill Machine	2.99	1.35	0.78	0.48
5	Pay Loader	3.04	1.36	0.84	0.13

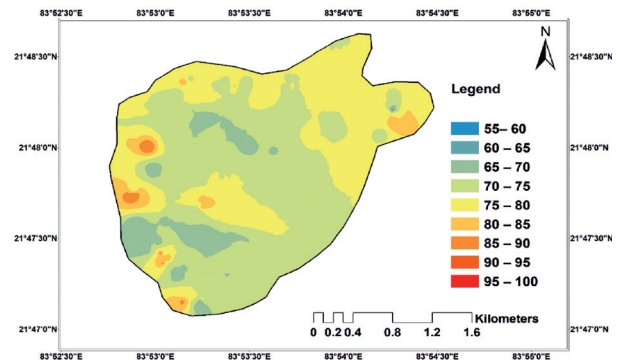
the help of Garmin GPS. Latitudes and longitudes were converted into degrees. Interpolation is a very effective method used by different researchers for noise mapping. Kriging and Inverse Distance Weighting (IDW) were used to evaluate the acoustic behavior of the area, as the root mean square error (RMSE) value using kriging interpolation method is less compared to Inverse Distance Weighting (IDW) and other interpolation methods. Kriging interpolation is otherwise Gaussian process regression, it processes the weighted average of the known estimations of the capacity in the area of the point. All the input data that affect the propagation of sound were imported in noise mapping software (ArcGIS). KML file was used for background boundary for noise mapping which was imported from Google earth. By using geoprocessing tool of ArcGIS interpolation of points and their SPL values was carried out. Noise level plotting produced using GPS data and measured noise in the coal mine is shown in Fig. 3. Noise map of the opencast coal mine produced using GPS data and measured noise (Kriging) is shown in Fig. 4.

**CONCLUSION**

This paper introduced the application of soft



**Fig. 3.** Noise level plotting produced using GPS data and measured noise in the coal mine (Parmar, 2018)



**Fig. 4.** Noise map of the opencast coal mine produced using GPS data and measured noise (Kriging) (Parmar, 2018)

computing noise prediction model for mechanized opencast mining machinery using ANN and ANFIS using a statistical model (ENM). From the simulation results, it was observed that ANFIS model gave better prediction result with less RMSE values as compared to MLP and BP.

Noise maps of a mine are important to see the region influenced from the noise. Noise mapping of the mine was to interpolate noise levels with GPS variables and produce noise map of the coal mine. Kriging and Inverse Distance Weighting (IDW) were used for noise plotting using ArcGIS. Accuracy was a major issue in plotting and was committed to enhancing the accuracy of interpolation, noise calculation, and noise effect studies.

It was noticed that the predicted noise levels were greater near machinery, which will affect the human health. Noise map of a mine can help to proper preventive control measures so that the workers working in the high level of noise can be avoided

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