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Fuzzy Logic Technique for Noise Induced Health Effects in Mine Site

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ABSTRACT: Utmost importance to design appropriate noise prediction model to ensure accuracy of noise levels from different mining equipment because prolonged exposure of miners to the high levels of noise can cause noise induced hearing loss other than various non-auditory health effects. The prominent adverse effects of noise pollution on human beings include noise-induced hearing loss, work efficiency, annoyance responses, interference with communication, the effects on sleep and social behavior that can be predicted using Fuzzy Logic Technique. The main parameters used in model are Noise level, age factor and exposure time. Here, in the study, there is an effort made to design a fuzzy model that can predict the health effect due to noise pollution. Appropriate fuzzification and de-fuzzification strategies have been made use and implementation in MATLAB (R2013a) has been done. Finally, the noise effects on the workers of the mine area inline with the data using FIS toolbox and those which can damage the health conditions of human beings will be predicted.

KEYWORDS: Noise pollution, Mine Site Workers, Health Effects, Fuzzy Logic Technique.

I. INTRODUCTION

Man has been living with Noise since the beginning of life. It has been described as an unwanted sound. WHO declared noise as a kind of pollution which was the first International declaration made in 1972. Noise can be occur due to various sources. L_{eq} is used to measure noise and it is known as the average essential parameter to measure noise. It represents a level equivalent and is measured in decibels. Noise usually is measured with Sonometer and corresponds to the average energy in a variant sound level as inspired by Paras Kumar [1]. Several factors that will disturb sleep are age, noise duration, noise level, type of noise, physical health, mental health, etc. but the main factors are age, noise duration, noise level and type of noise which was told by Santosh Kumar Nanda, [2]. The word Noise is derived from the Latin word "nausea" which implies 'unwanted sound' or 'sound that is loud, unpleasant'. The noise usually is originated from human activities, mostly the development and urbanization of industry and transportation as said by Narendra Singh *et al.*, [3].

Noise problem consists of three inter-related elements – the source, the receiver and the transmission path. The atmosphere is usually the transmission path through which the noise propagated but can include other materials that have receiver. Noise is characterized by the frequency, intensity, duration of sound and periodicity (continuous or intermittent). The result of pressure changes is sound which is caused by vibration. Compared to stress, noise has more effects. Millions of people are affected by noise on a daily basis. Hundreds and Millions of people in United States and worldwide are affected by noise alone in highways alone. Not only the living of a person is destroyed but also some

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permanent ill-effects like hearing loss are caused due to noise. Therefore it is necessary to have a model that could predict the effect of noise on different age groups.

The prominent adverse effects of noise pollution on human beings are noise-induced Sleep disturbance, hearing loss, work efficiency, annoyance responses, interference with communication, effects on social interaction and sleep. The global criterion in assessing the noise-induced effects is “Human Health”. Health is “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” as defined by the World Health Organization. The effect of noise duration and noise level on the health of human beings is very high, for e.g., if the noise duration is very less but the noise level is 75db (A) then hearing loss is likely to be caused, and if the noise duration is long and noise level is low then there is no danger to human ear [4]. The beautiful notion of binary sets, which is the foundation of modern digital computer, was introduced by Boole in 1996, [5]. But the human intelligence and thinking process are not modelled by Boolean logic. The two valued logic is not very efficient in mapping real world situations because of its rigid boundaries. For handling real world problems, introduced the concept of ‘mathematics of fuzzy or cloudy quantities’ was introduced by Zadeh in 1962 [6].

II. RELATED WORK

Fuzzy Logic Technique utilizes the fuzzy toolbox in the inference system and is considered as the best and smart technique in today’s soft-computing world. This can be shown or proven as summarized below:

Studies were carried out to study the Noise impact assessment in mines using soft computing techniques- Mathematical models. They are generally complex and which cannot be implemented in real time systems. They even fail to predict the future parameters using current and past measurement variables. As a part of earlier studies, soft-computing models were used to overcome such limitations. Noise level prediction is a non-stationary process and such soft-computing techniques had been tested for non-stationary time-series prediction for nearly two decades as it has been seen that soft-computing system based noise prediction models were developed for predicting far field noise levels due to operation of specific set of mining machinery. Soft Computing models like: Fuzzy Inference System- Mamdani and Takagi-Sugeno Kang fuzzy inference systems, MLP (multi-layer perceptron or back propagation neural network), RBF (radial basis function) are the most effective and smart techniques according to the previous decade studies [2].

One of the studies include, Fuzzy Expert System for Noise Induced Sleep Disturbance and Health Effect where efforts were made to develop a fuzzy based model to study the impact of various noise factors on Sleep disturbance and Health. Detailed survey of the existing literature of the deficiencies in the existing models in this field was done. According to one of the study, In this MIMO Expert system developed, sleep disturbance, health condition in the morning and health were given as output variables and noise level, short noise duration, long noise duration, age and Type of noise were given as Input variables. Fuzzification and de-fuzzification strategies were drawn appropriately. The prominent factors that are the deciding effect on hearing and output factor had been discussed. Noise level and duration of noise, for e.g. a noise of low level does not have prominent effect on human being as of high level of noises [4]. Noise can cause various effects on human beings in the following ways which can be more than just affecting hearing:

- Physiological effects: Physiological features like breathing amplitude, blood cholesterol, blood pressure, pulse rate and heart-beat rate are affected.
- Nervous system: Pain and ringing in the ears, feeling of tiredness, thereby effecting the functioning of human system due to damage to the nervous system.
- Sleeplessness: People become restless and lose concentration and presence of mind during their activities as they start to lose sufficient amount of sleep.
- Loss of hearing: Hearing loss occurs due to long and high level exposure to noise which goes mostly unnoticed, but will have an adverse impact on hearing function.
- Annoyance: Noise creates annoyance to the receivers due to sound level fluctuations. The sound due to its irregular occurrences causes unpleasantness to hearing which causes annoyance [9].

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Studies were found that an even a relatively low level of noise can show adverse effects on human health. Hypertension, disrupt sleep, annoyance, gradual hearing loss and hindered cognitive development in children may occur due to noise level. The high levels of noise on human beings would be so severe that either there is a permanent loss of memory or a psychiatric disorder. It may also cause dizziness, nervous breakdown, deafness, heart troubles, high blood pressure, mental disorder, inefficiency, sleep disturbance and head-ache. Very little efforts have been made to ameliorate noise even though noise pollution is a slow and subtle killer. Noise has now become a hazard to quality of life just like other types of pollution. Actions taken in India, against noise and its pollution are very weak. Wide variety of population nowadays, do not take it as a nuisance and they tend to take it as a part and parcel of life. Noise has been considered as a pollutant that can have adverse effects, off late [10].

III. METHODOLOGY

To develop a fuzzy model for determining the work efficiency of humans as a function of noise level, exposure time, age, and the type of noise. The modelling technique is based on the concept of fuzzy logic, which offers a convenient way of representing the relationships between the inputs and outputs of a system in the form of IF-THEN rules. It has been established on the basis of surveys that the impact of noise on work efficiency depends to a large extent on the type of tasks. The complex tasks get significantly affected even at much lower noise levels whereas the simple tasks remain unaffected up to very high noise levels. In addition, the duration of noise exposure is an important factor in determining the work efficiency. Finally, compare modelled results with the deduction based on the criterion of Safe Exposure Limit recommended for industrial workers. The study for noise level in the study area has been carried out by selecting a noise monitoring station based on the following criteria.

- Source of noise- from which activity the noise is generated.
- Proximity, effects and the outcome of the noise generating source to the human settlements.
- Exposure time i.e. for how long the noise is being exposed to the human ear.
- Age of the working labor in the mine area.

The impact of noise on the surrounding community generally depends upon the following aspects:

- Characteristics of the noise source.
(i.e.either instantaneous or a continuous source).
- Noise generation period during the day.
- Location of the noise generating source with respect to the noise sensitive areas.

Data application has been done using MATLAB R 2013(a) version. The parameters of noise are put into effect using a toolbox in MATLAB called FIS Toolbox. The methodology applied can be shown as below flow chart:

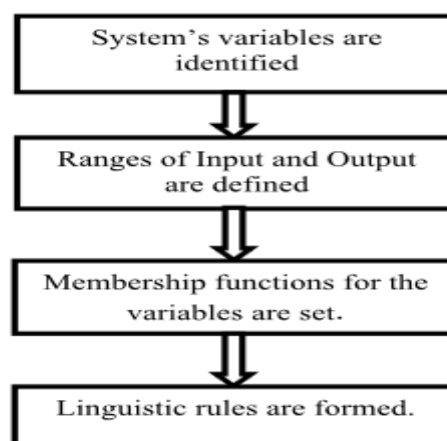


Figure 1: Flow chart of Methodology

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Figure 1, explains the neat flow chart of all the steps followed in the methodology of fuzzy logic system in order to form linguistic rules to derive the output. First of all, the variables required for the system are identified to form the linguistic values. Then these are put into ranges of input and output is defined that is coordination with the values or data available. Thirdly, the membership functions are defined and set. Finally these membership functions are converted to linguistic rules which will give the output for the desired study.

Table 1: Noise Level Standards According to Central Pollution Control Board (CPCB) 2012, INDIA

Area Code	Category of Area	Limits in dB(A) L_{eq}	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

The classification of fuzzy intervals of noise levels are made in line with the Noise Level standards according to the Central Control Pollution Board as mentioned in the above Table 1. For the mining area studies, Industrial Area standards are taken into consideration in regard to the noise type and its high level due to heavy earth machineries and its activities.

Table 2: Classification of Fuzzy Intervals of Input and Output Variables

	PARAMETERS	RANGES	FUZZY INTERVALS
INPUTS	NOISE LEVEL	Normal	0 – 75dB(A)
		High	72 – 110dB(A)
		Very High	105 – 130dB(A)
	AGE	Young Age	20 – 35 years
		Middle Age	38 – 60 years
		Old Age	≥57 years
	EXPOSURE TIME	Short	0 - 90 secs
Medium		85 – 180secs	
Long		≥170 secs	
OUPUT	HEALTH EFFECTS	Low Risk	0 – 30 %
		Medium Risk	28 – 60%
		High Risk	≥57%

The fuzzy intervals are the variables that are assigned to the input and output parameters. In this study three inputs i.e., Noise Level, Age and Exposure Time are taken for the study. The interval classification is done depending on the obtained values during the monitoring and they classified into various zones or ranges as shown in the Table 1 above.

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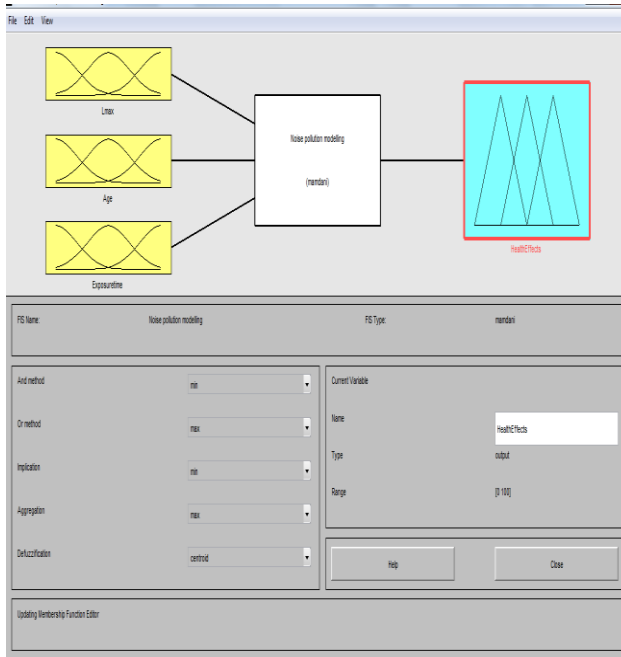


Figure 2: Fuzzy Inference System with Input and output Variables

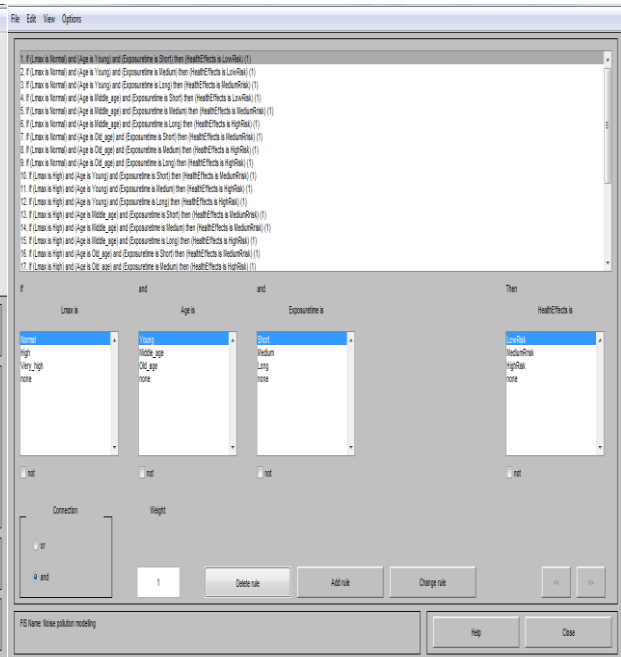


Figure 3: Rule Base editor

Above figure 2, shows the Fuzzy Inference system where in the input and output variables are created using the toolbox. The input 1 is the Noise Level in the value of L_{max} dB (A), Input 2 is the Age in years, and input 3 is the Exposure time in seconds. After the inputs are defined, the rule base editor is used to write the rules and then the output is obtained. This study has one output which is the health effects of noise on human beings.

Figure 3, shows the rule base editor where rules are written after the input and output variables are created. These rules are written using IF and THEN rules which give an easy way to determine the relation in between the input parameter and the output parameters.

IV. EXPERIMENTAL RESULTS

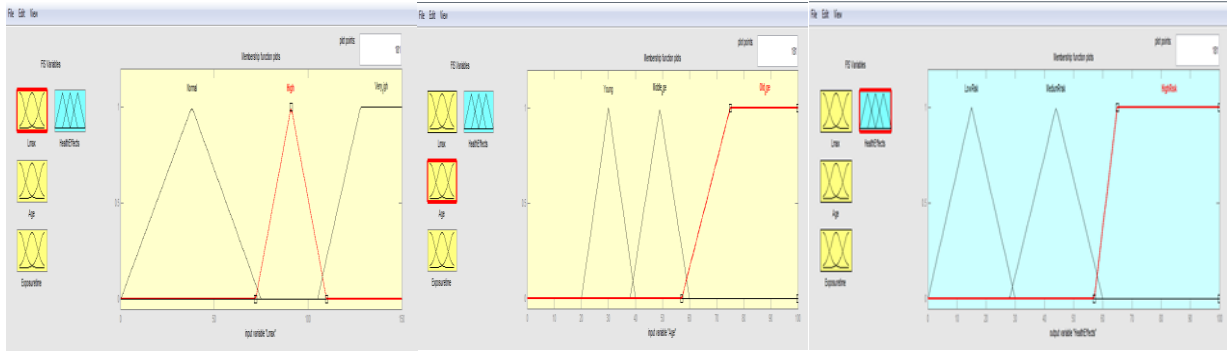
Health effects of human beings are considered to be a function of noise level, age and exposure time in Fuzzy Inference System where the input variables are processed according to the rules written, in Mamdani fuzzy logic model. The noise levels obtained are on the higher side in the core zone than the Noise Standards prescribed. The results are plotted using MATLAB R 2013(a).

Usually the noise levels when measured in the mining sites are high due to the various activities that involves huge machineries and operators. The noise is either continuous or intermittent. Therefore the results obtained are calibrated in the fuzzy inference system and centroid graphs are derived as shown in the following figures.

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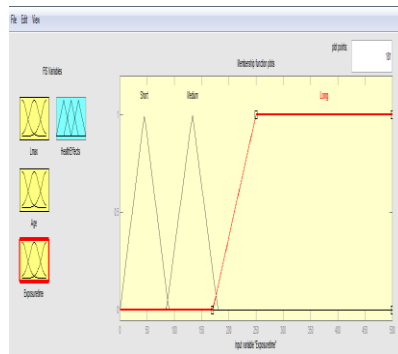
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4(a)

4(b)

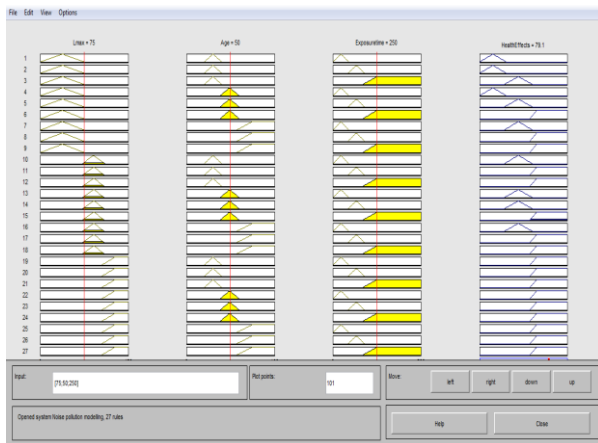
4(c)



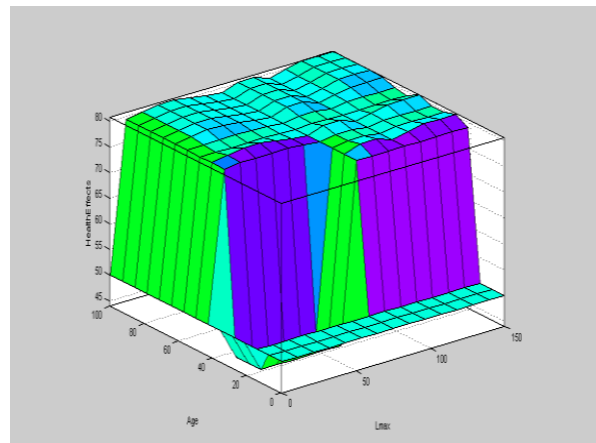
4(d)

The above figure 4(a) shows the membership functions drawn for the input parameter noise level which is classified into Normal, High and Very High. And the figure 4(b) shows the defined membership functions defined for the input parameter age in years, which is classified as Young age, Middle age and Old age.

The above figure 4(c) shows the membership functions drawn for the input parameter exposure time which is classified into Short, Medium and Long. And the figure 4(d) shows the defined membership functions defined for the output parameter Health Effects which is classified as Low Risk, Medium Risk and High Risk.



4(e)



4(f)

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The above figure 4(e) shows the rule view editor for the input variables and output variables that were defined earlier after writing the rules base. Figure 4(f) shows the surface view of the rules written in the rule base editor which is function of age and exposure time. A total of 27 rules were developed on the basis of available datasets and expert’s inference. Since, the first group consists of three input variables and each parameter consists of three membership functions, the rule base for these group equals $(3 \times 3 \times 3) = 27$. Mamdani implication of Max–Min operator was applied in the proposed fuzzy logic model. From each rule, a minimum value is taken and stored in the group using fuzzy minimum operator and then a maximum value is chosen from that group which gives the belongingness of that particular noise parameter to the specific membership function.

Results of the rules were combined and de-fuzzified using centre of centroid method which forms a centroid shape graph. Based on this, 4 locations were taken and the data was collected for Noise Levels. The significance of FIS method is shown where in the parameter’s values are placed in a definite limit borders. Taking into account the definite limit borders, uncertainties play a very vital role in the decision making process.

These are set of IF and THEN rules designed for the prediction of noise pollution to obtain a convenient relation between the input and output variable as shown below in Table 2 and the rule base viewer as shown in the below figures.

1. If(Lmax is Normal) and (Age is Young) and (Exposure Time is short) then(health effect is low risk)(1).
2. If (Lmax is Normal) and(Age is young) and (Exposure time is medium) then (health effect is Low risk)(1).
3. If (Lmax is Normal) and (Age is young) and (Exposure time is Long) the (health effect is medium risk)(1).....
26. If (Lmax is Very High) and (Age is Old Age) and (Exposure Time is Medium) then (Health Effect is High risk)(1).
27. If (Lmax is very High) and (Age is Old Age) and (Exposure Time is Long) then (Health Effect is High Risk)(1).

The Prediction of noise levels which gives the health effects of in the ranges of low risk, medium risk and high risk are as shown below which is taken as the output when the values are applied are as shown in the below Table 2.

Table 2: Prediction of Noise Pollution Level and its related Health effects

Ranges	Ranges for the Parameters	Fuzzified output in percentage(%)	Health Effect
Normal	20, 30, 50	15	Low Risk
	68, 35, 74	15	Low Risk
Medium	78, 45, 90	44	Medium Risk
	100, 55, 119	44	Medium Risk
High	125, 85, 199	79.5	High Risk
	145, 95, 449	80.7	High Risk

V. CONCLUSION

This innovative type of Fuzzy Logic system has been successfully implemented using Matlab R(2013a). This system predicts the health effect by taking three different types of input variables viz. noise level, age, and exposure time. This fuzzy logic system can be used for knowing health effects in noisy region. This fuzzy logic system will be one of the best techniques for creating new logic systems in future and can smartly be used in environmental engineering to predict and control noise pollution caused due to various activities in the mine areas and by accurately measuring noise levels and taking more precautions in order to avoid serious / adverse health effects occurring to human beings. This fuzzy expert system can be made use of, to study the health effects in noisy regions. Fuzzy logic system will be an opportunity for making new logic and smart systems in future.

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