FUZZY INFERENCE SYSTEM FOR NOISE POLLUTION AND HEALTH EFFECTS IN MINE SITE

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Abstract: Environmental noise of workplace always affects human health. 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. In assessing perfect working of human beings, the global Criterion is "Human Health" and periodic checkup of health is very important. The main parameters used in model are Noise level, age factor and exposure time. Appropriate fuzzification and de-fuzzification strategies have been used and the implementation in MATLAB 13 is done. These input variables i.e., Noise level, age and exposure time that affect health conditions and cause various adverse effects like annoyance, irritation, sleep disturbance, hearing loss, social behavior, psychological effects and other health disorders and Insomnia are predicted using these input parameters as the research area. Finally, the noise effects on the workers of the mine area based on the data collected using FIS toolbox and those which can damage the health conditions of human beings are predicted.

Keywords: Mine area workers, Noise pollution, Health Effects, Fuzzy logic system.

I. INTRODUCTION

The word "Noise" was derived from the Latin word "nausea" which implies 'unwanted sound'. The noise is originated from human activities, mostly in the development and urbanization of industry and transportation [1]. Millions of people in the United States are affected by noise in highways alone. Living of a person is destroyed and few permanent ill-effects like loss of hearing are caused. As a result, it is necessary to have a model that could predict the effect of noise on different age groups. Many factors that influence disturbed sleep are age, noise duration, noise level, type of noise, physical health, mental health, etc. The prominent ones are age, noise duration, noise level [2]. 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. Man has been living with Noise since the beginning of life. $L_{eq}$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 decibel [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 frequency (continuous or intermittent). The result of pressure changes is sound which is caused by vibration. Millions of people worldwide are affected by noise on a daily basis. 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. 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]. Boole introduced the binary set concept which is now the base for modern computer [5]. But the human intelligence and thinking process are not modelled by Boolean logic. Zadeh [6], for handling real world problems, introduced the concept of 'mathematics of fuzzy or cloudy quantities' in 1962and a seminal paper 'Fuzzy sets' in 1965. Parameters involved in this relationship are uncertain andcannot be dealt by conventional techniques. In order to deal with such situations, a fuzzy model approach based on fuzzy logic is said to be the most appropriate [7].

Studies found that relatively low level of noise can show high effects [3]. Disturbed sleep, Annoyance, Hypertension, Hindered development in children, gradual hearing loss may occur due to noise levels and may also cause psychiatric disorder, dizziness, nervous breakdown, deafness, heart troubles, high blood pressure, mental disorder, inefficiency, sleep disturbance and head-ache [8]. No serious efforts have been made to reduce noise even though noise pollution is a killer. Noise has been considered as a pollutant that can have adverse effects, off late [9]. One of the studies include, Disturbance in sleep caused due to noise, in which a fuzzy inference based model was designed to analyze the impact of noise factors on health and interrupted sleep. In Multiple Input and Multiple Outputsystemdesigned, disturbed sleep, health condition in the morning 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

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de-fuzzification strategies were drawn. Noise level and duration of noise, for e.g. a noise of low level has no significant effect on human being as of high level of noise [4].Studies on Mathematical models show that they are complicated and cannot be implemented in real time systems. They even fail to predict the future parameters using current and past measurement variables. Another study depicts, soft-computing models were used to overcome such drawbacks. 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 is the most effective and smart techniques according to the previous decade studies [2]. Noise causes number of serious effects which is listed below:

- Physiological effects
- Nervous system
- Sleeplessness
- Loss of hearing.
- Annoyance [10].

II. METHODOLOGY

II (A)PRINCIPLE

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. 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 are 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 labour 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.

II (B)APPLICATION OF DATA FOR NOISE LEVEL PARAMETERS USING MATLAB:

Data application has been done using MATLAB 13 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:

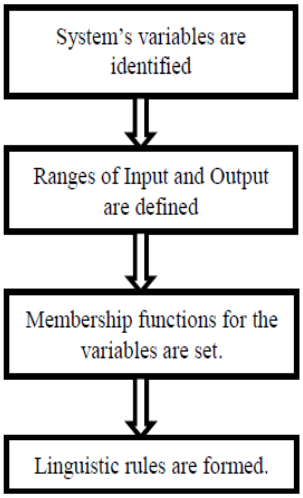

Figure 1: Flow chart of Methodology

II (C) FUZZY INTERVAL CLASSIFICATION

Table 1: Classification of Fuzzy Intervals of Input and Output Variables

	PARAMET-ERS	RANGE	FUZZY INTERVAL
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%

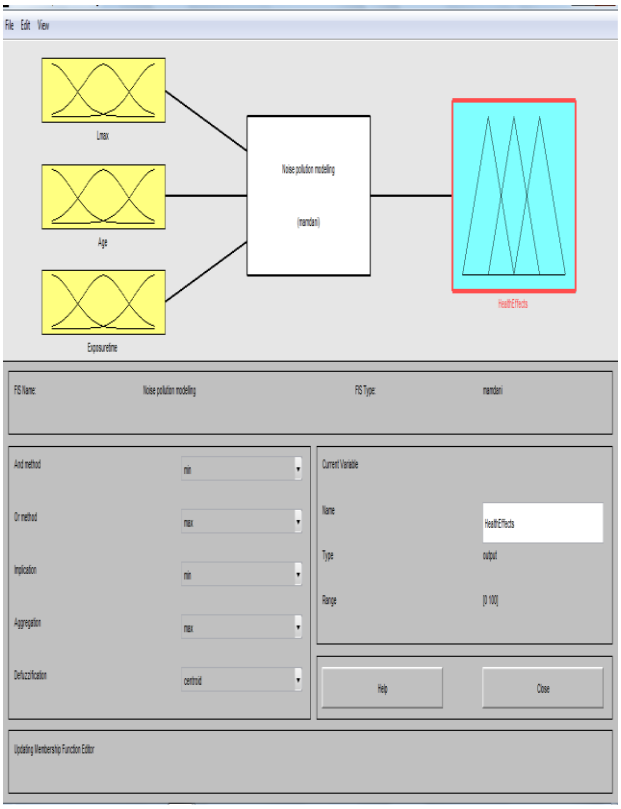

Figure 2: Fuzzy Inference System with Input and output variables.

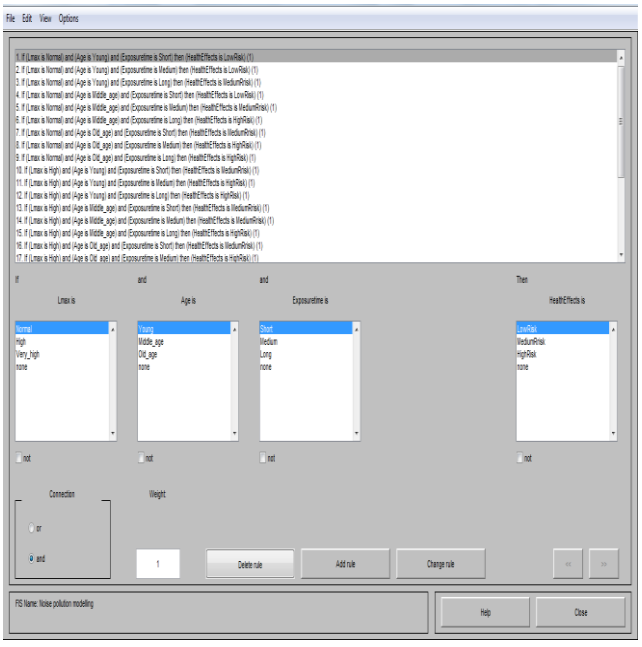

Figure 3: Rule Base editor.

III. 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 13. Figure 4(a) shows the First input variable as Noise Level. Figure 4(b) shows second input variable as Age. Fig. 4(c) show the third input variable as Exposure time. Fig. 4(d) shows output variable Health Effects as function of noise level, age and exposure time. Figure 4(e) shows the output variable in the rule view form. Figure 4(f) shows the output variable in the form of a surface view for the defined membership functions.

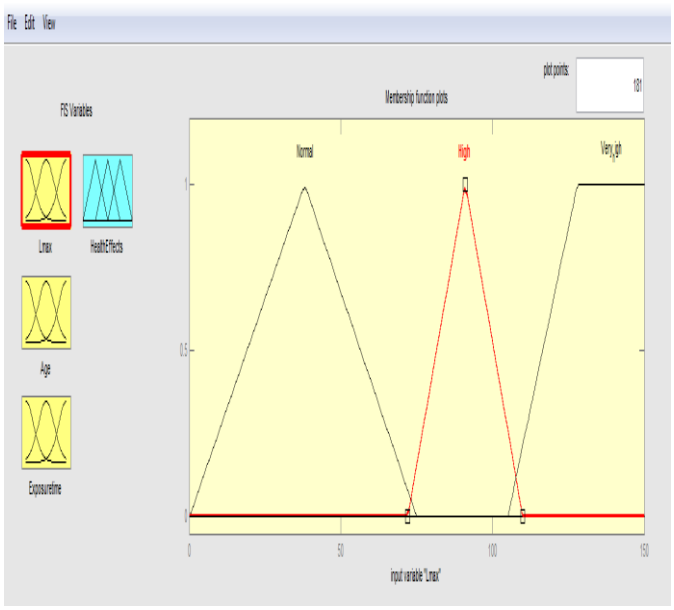

Figure 4(a): Noise Level

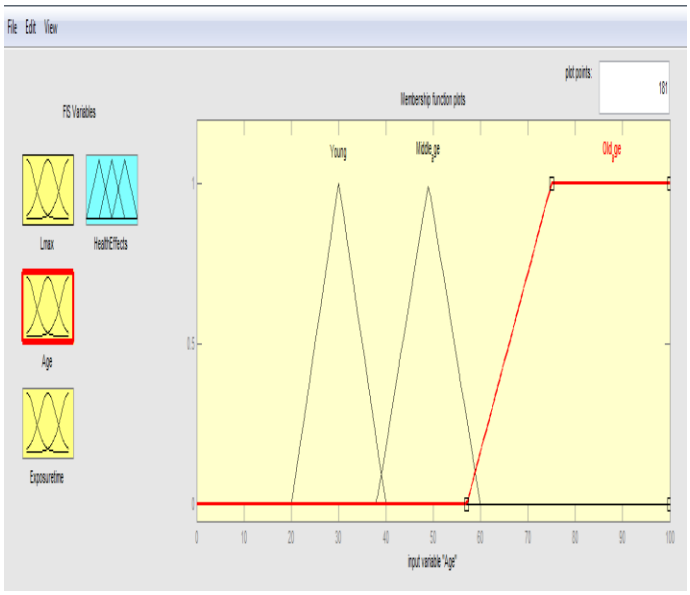

Figure 4(b): Age

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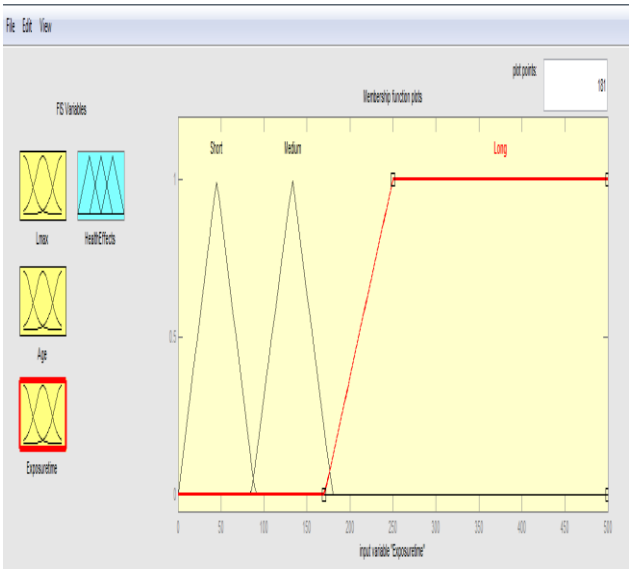

Figure 4(c): Exposure Time

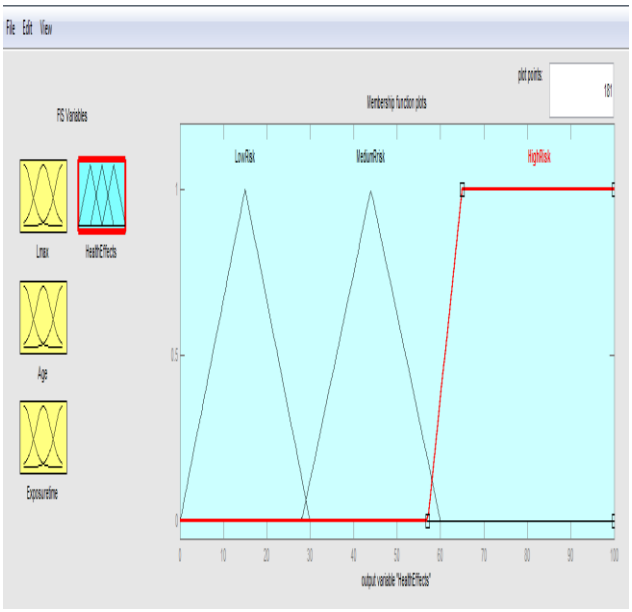

Figure 4(d): Output – Health Effects

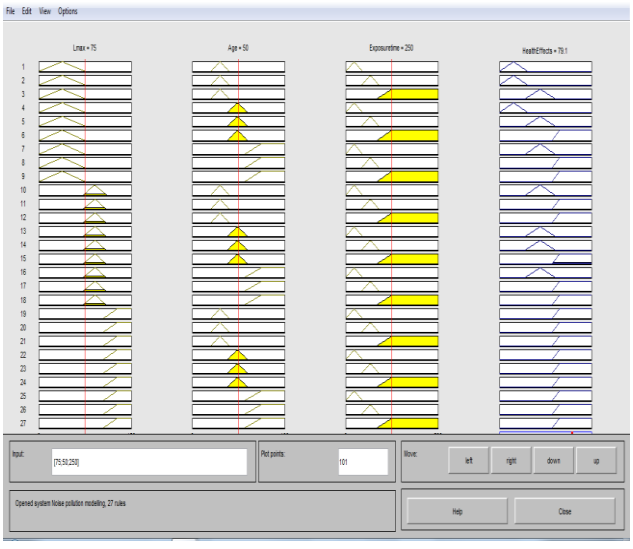

Figure 4(e): Rule View of the output

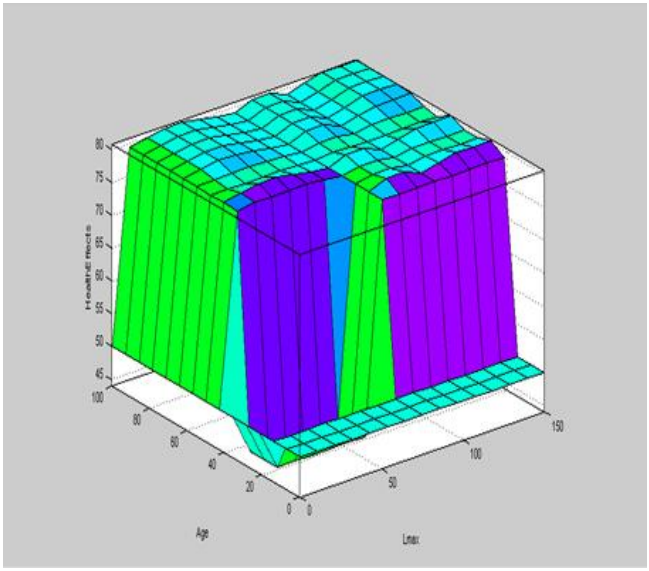

Figure 4(f): Surface View of the output

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(3×3×3)=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.

III (A) SET OF RULES

These are set of IF-THEN rules developed for the prediction of noise pollution 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).

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 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

IV. CONCLUSION

Fuzzy Inference System has been successfully implemented using MATLAB 13.Prediction is doneusing three input variables viz. noise level, age, and exposure time which gives output for health effects in percentage as per this design of the model. Fuzzy inference system can be used for knowing health effects in noisy region. From the results obtained, we can conclude that the health effect depends on exposure time in addition to age and noise level. Unaffected factor is the age when there is very high noise level for short exposure time, whereas for long exposure time, age is significantly affected at very high noise.Fuzzy Inference 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 in order to avoid serious health effects to human beings.Prediction concept was motivated by our experiment in [4]. This fuzzy expert system can be made use of, to study the health effects in noisy regions. Fuzzy Inference system will be an opportunity for making new logic and smart systems in future. It can be made use of, in medical engineering also to study the effects on human health and find solutions to the problems.

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