

Fuzzy Rule Based System Approach for the prediction of Respiratory Abnormalities in Solid Waste Workers

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Abstract—The prediction of diseases is a complex process, as it is influenced by number of factors. Medical science uses the symptoms, laboratory test and medical history of the person as diagnosis tools for prediction of diseases. In this paper, fuzzy rule-based system approach has been proposed to determine respiratory abnormalities among solid waste workers. For the prediction of diseases, studies of many biochemical parameters of healthy people with different age, BMI and habit data are required. Medical science considers the criteria of odds ratio for the study of disease occurrence pattern in which comparison is made with exposed and non-exposed group. In this paper, new proposed methodology is discussed which can determine person risk to suffer from respiratory diseases. In Fuzzy rule-based system approach, available information from medical experts is used to generate the person risk in 0 to 1 scale without any medical diagnosis or laboratory test. The determine risk value can be used to modify the factor for the occurrence of diseases in individual and preventive steps can be considered for curing of diseases before any medical diagnosis or test.

Index Terms—Fuzzy logic, respiratory diseases, risk, solid, waste workers

I. INTRODUCTION

Health risk analysis is a complex problem that has to deal with an uncertain situation, impress and inaccurate data problem. Conventional approaches cannot be used for modelling of risk effectively and efficiently. The probability analysis approach can be used for the prediction of risk where sufficiently large number of data is available. This approach can be used for analysis of risk at construction site, risk with certain hazardous chemicals.

Fuzzy set analysis is a very effective tool for problems where no sharp boundaries are available. The knowledge base of a fuzzy system is a database from which it is possible to attain the functional relation from the collected data, being CONSIDERED as associations of consequences, determined by a particular hypothesis condition. Fuzzy system elaborates qualitative, imprecise and sometimes contradictory information. They have proved to be particularly useful in solution of complex problems which, though they can't be formulated in precise algorithm, can however be described qualitatively, with linguistic expressions [1]. However, the information elaborated by a

fuzzy system must be complete and homogeneous so that the results themselves are significant.

II. FUZZY INFERENCE SYSTEM

Fuzzy inference system (FIS) has been successfully applied in a variety of fields such as automatic control, data classification decision analysis and expert systems. Fuzzy inference is the process of mapping a given set of inputs to an output using fuzzy logic “If then” rule database. The mapping provides a basis for computing the decisions.

A. Fuzzy Rule-based System

The solution of a problem through Fuzzy Rule based system approach can be broken down into the following operations [2].

- Definition of fuzzy sets of the input variable with output ones.
- Definition of rules that co-relate the input variables to output ones.
- Aggregation of contribution of rules.
- Defuzzification of results.

It can be observed how the numerical resolution of a fuzzy problem can require the use of a software. The analyst must instruct with the available data and on the basis of personal experience reducing the rule that define the problem through the clustering technique [3]. In this work, the quantitative solution of the fuzzy system is obtained using the MATLAB 6.5 fuzzy toolbox.

B. Problem Statement

Respiratory diseases are the main causes of mortality in many countries. Their prediction is a complex problem, as they are influenced by many factors [4]. The development of diseases takes a long time before the first symptoms appear and many times it is too late for the patient to identify and MODIFY the associated risk factor for taking effective preventive steps. The main objective of the present work is to develop the model for the prediction of respiratory abnormalities using fuzzy rule-based system approach for solid waste workers. The factors responsible for the occurrence of respiratory diseases can be easily identified and measurable in varying nature among solid waste workers [5]. So, the study population is selected as the door to door waste collecting workers of Surat city in India.

About the expert's perception and opinions: The health data and subjective judgement of experts were used to develop fuzzy logic system. The healthy discussions were made with a medical practitioner, dieticians. The solid waste management system and socio-economical condition of solid waste workers were studied in depth.

1) Identify Factors of Occurrence of Respiratory Diseases

From the expert opinions and perceptions, the factors responsible for respiratory diseases were considered. The factors responsible for computing the respiratory diseases are considered as an input variable, and output of the system is considered as risk. The rates of change of these factors are considered neither linear nor incremental, but it is complex in nature. The system has two types of inputs base and incremental. The base input variable for the system is age and BMI data and will vary from person to person. The BMI (Body Mass Index) is a measure that indicates if a person is overweight. It is calculated by dividing the weight into kilograms by the square of height in meters. $BMI = \text{weight}/\text{height}^2$ [6]. Incremental input variable deals with particular habits and typical characteristics of solid waste workers, such as tobacco chewing, alcohol drinking, smoking. With this diet, personal hygiene and different work environmental conditions are also considered as incremental input parameters for the development of the system.

Fuzzy logic system involves knowledge acquisition techniques to generate body information that could be useful in isolating the risk factor associated with the development of respiratory diseases.

Normally in a traditional system the first step of the solution is to define a mathematical relationship between the inputs and outputs of the system. Our objective is to obtain a numerical value that represents the possible risk of a person having respiratory problems due to various factors and physical characteristics. Risk is defined as having range of 0 to 1. For various factors, the value of risk 1 represents the maximum risk and near to 0 indicates no risk. For this example, five different sets of fuzzy rules are defined. The importance of breaking down the problem into smaller groups, in fact, is the decrease of the number of rules.

For this particular example, five different sets of fuzzy rules are defined. The first rule-based computes a risk 1 based on age and BMI. The second rule base computes a Risk 2 based on personal habits of workers like tobacco chewing, smoking and drinking habits. The third rule base computes a Risk 3 based on personal hygiene and works environmental condition of workers. The last rule base computes a Risk 4 based on diet of workers. A fifth rule base related Risk 1 to Risk 4 to determine final Risk to compute risk assessment. The importance, of breaking down the problem into smaller related groups, is to relate the number of rules in the system.

III. DEVELOPMENT OF FUZZY SETS

The fuzzy sets are represented by a linguistic variable, to each by them. Each of fuzzy sets is in turn represented by a

function known as a membership function i.e. function that associated a real number in the INTERVAL [0,1] to each point. The choice of function type (triangle, trapezoidal, Gaussian, etc.) depends on the quantity and homogeneity of the available data, and it influences the accuracy of results [7]. Development of fuzzy sets was made with a fuzzy toolbox in Matlab. The fuzzy sets are represented as shown in Fig. 1- Fig. 10.

A. Fuzzy Rules

In a FUZZY logic system, an expert defines the rule to describe the characteristics of risk assessment for each factor. The input variables are processed by rules to generate an appropriate output. The fuzzy rules represent the logical correlation between the input and output variables. They are deduced from past data or the experience of the analyst. The fuzzy rules are of a decisional type if...then i.e. the consequences occur only if, the premises are real, for this reason if a damaging event activates the terms of premises. The consequences are inevitably obtained. The AND logical operator is used here.

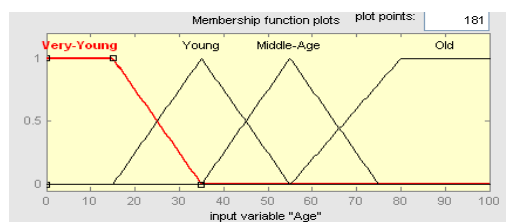


Figure 1. Membership function for "AGE".

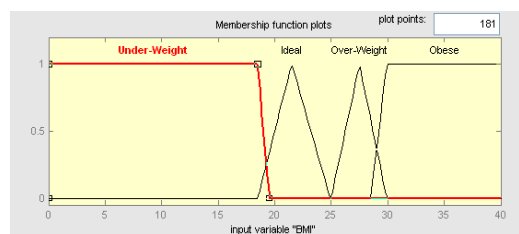


Figure 2. Membership function for "BMI".

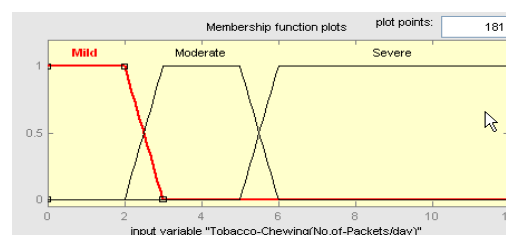


Figure 3. Membership function for "Tobacco-chewing".

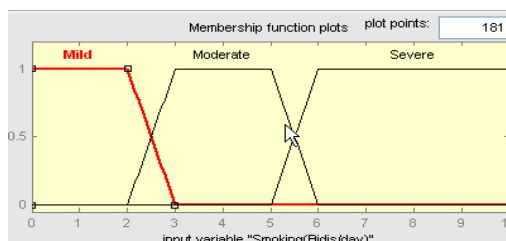


Figure 4. Membership function for "Smoking".

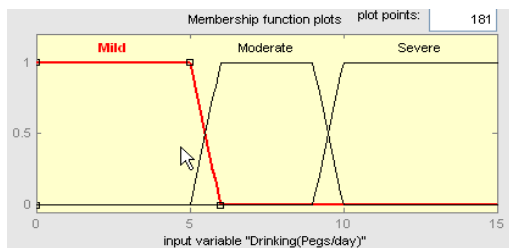


Figure 5. Membership function for “Drinking”.

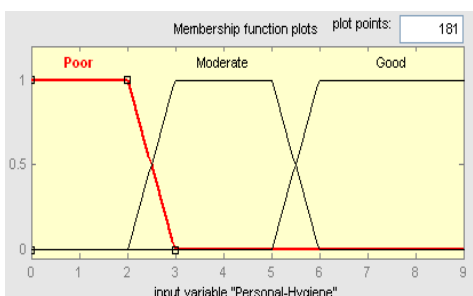


Figure 6. Membership function for “Personal Hygiene”.

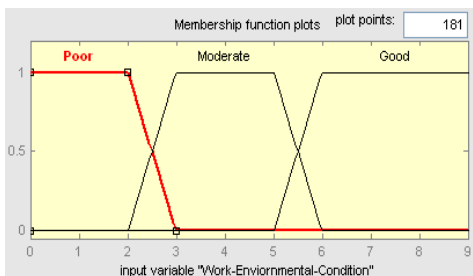


Figure 7. Membership function for “Work Environment condition”.

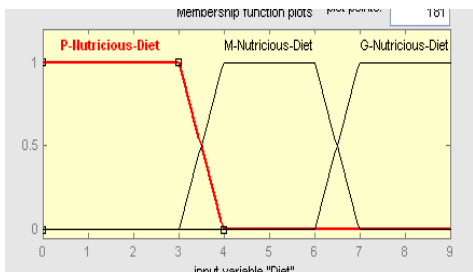


Figure 8. Membership function for “Diet”.

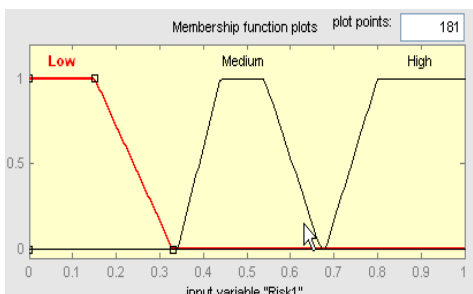


Figure 9. Membership function for “Risk 1 to Risk 4”

B. Defuzzification

Defuzzification is a process of combining all fuzzy outputs into specific composite results. When multiple inputs are used, the intention of defuzzification is often to

translate the obtained linguistics value and membership function into a crisp value [8].

The most accepted method of defuzzification is centroid i.e centre of gravity considered as most effective method because it considers the contribution of all fuzzy outputs and degree to which it is true [9]. Fig.11 represents the defuzzification process to obtain the crisp value.

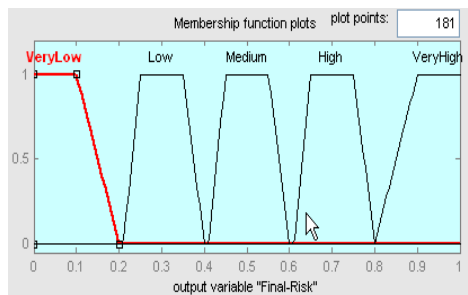


Figure 10. Membership function for “Final Risk”.

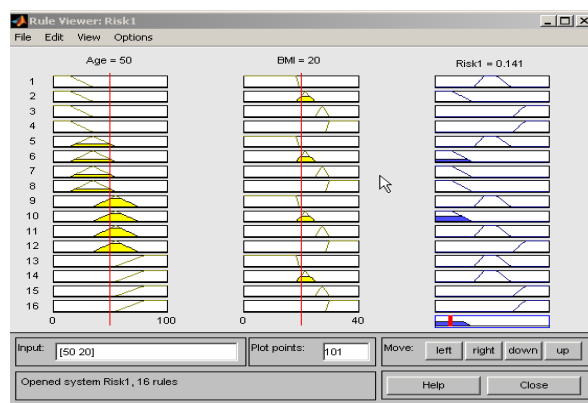


Figure 11. Defuzzification process to get the output.

C. Linguistic Outputs

The predictions obtained from the evaluation are fuzzy outputs. After the inferencing is completed, the output is the linguistic value that represents the risk of respiratory diseases associated with solid workers. The output value is one of the following:

1. Very Low Risk (0-0.2)
2. Low Risk (0.21-0.4)
3. Medium Risk (0.41-0.6)
4. High Risk (0.61-0.8)
5. Very High Risk (0.81-1)

1) Determination of Risk

A simplified model is presented in this paper having five steps; first steps having two inputs and one output with 12 inference rules. Second steps are having three inputs and one output with 27 inference rules. Third steps are having TWO inputs and one output with nine inference rules. Fourth steps are having ONE inputs and one output with four inference rules. And finally, fifth steps having four inputs and one output with 81 inference rules. The modelling process is made convenient by Fuzzy Logic Toolbox (Version R2008a).

2) Risk Evaluation for Solid waste Workers

Cross section study of a group of 300 male workers working at seven transfer stations of Surat city was selected as study population. Data were collected using questionnaires. The questionnaire was prepared referring ATS-DLD questionnaire. The factor selected for occurrence of respiratory diseases was measured among the study population of solid waste workers. It was easy to get the age, BMI data of solid waste workers. For the quantification of personal habits normal approach of collecting data from experts and medical practitioners, was considered. It is difficult to quantify the person hygiene, work. Environmental condition and diet of solid waste workers, for this relative weightage was given to individual solid waste workers referring some important criteria for the factors. For personal hygiene, and work environmental condition the relative weight-age of 0-9 was given to workers. For a diet, also, the weight age was given to 0 to 9. The individual diet pattern was related to the poor nutritious, moderate nutritious and good nutritious diet concept. Again, if the worker is falling under the category of good nutritious diet the relative risk for occurrence of respiratory diseases is considerably low. The data obtained for the solid waste workers of Surat city is as shown in Table I.

TABLE I. SUMMARY OF DATA

Parameters Measured among solid waste workers	Range	Mean ± SD
Age in Years	15 – 59	30.3 ± 9.81
BMI	13 – 35	20.0 ± 3.3
Tobacco Chewing (No. of Packets/day)	0-12	1.79 ± 1.91
Smoking (Bidis/day)	0-10	1.47 ± 1.66
Drinking (pegs/day)	0-10	1.94 ± 1.85
Personal Hygiene *	1-8	4.63 ± 2.22
Work Environment Condition *	1-8	5.02 ± 1.95
Diet *	2-8	5.8 ± 1.8

* For Personal hygiene, Work Environmental condition and Diet individual works are assigned weight age factor

Numerical value of each input parameters were considered as an input value and fuzzy operations were performed. Total 300 solid waste workers data were used, and the potential of the risk were obtained in scaler value between 0 to 1. The risk value was obtained between 0.12 and 0.91. The obtained value between 0 to 1 was categorised between very low risk (0-0.2) to very high risk (0.8 to 1.0). The obtained results were summarized as shown in Table II

TABLE II. PREDICTED OUTPUT FROM FRBS MODEL

Crisp Output	Variable	No. of Solid waste worker
0-0.2	Very low risk	89
0.21-0.4	Low risk	48
0.41-0.6	Medium Risk	35
0.61-0.8	High Risk	50
0.8-1	Very High Risk	78
	Total	300

IV. CONCLUSIONS

Proposed methodology is having new outcomes in risk assessment area. The model prediction results show that FRBS modelling is an effective approach for predicting respiratory risk levels without any diagnosis and by considering the available information as input parameters. The result obtained from the FRBS model at least gives the idea regarding the potential of risk value to get the symptoms of the diseases. Further, evaluation of the system with PFT test is necessary for complete validation of the system. Genetic disorders and difficulty in quantification factors were not considered for the study was the limitation of the model.

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