International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 11 (2018) pp. 9474-9479

Implementing Fuzzy Technique to Expert System - A Case Study on Salt Analysis

Kriti Asija[1] , Harkiran Kaur[2]

Computer Science and Engineering Department
Thapar Institute of Engineering and Technology, Patiala, India.

Abstract

An Expert System is a program which is implemented mainly in fields where human experts are needed. The first Expert System 'MYCIN' was developed at Stanford University by Edward Feigenbaum, Bruce Buchanan and Randall Davis. After this, many expert systems have been implemented in field of Medicine and also in areas such as Education and Sports. But, till date, no expert system has been implemented in the field of Chemistry. This paper implements an architecture design of a Fuzzy Expert System for physical tests for qualitative analysis of inorganic salts. A Fuzzy Expert System is a program, which uses the concept of Fuzzy Logic to fuzzify the knowledge and prepare it for the Inference Engine and further, Fuzzy Logic is used to draw conclusions based on the fuzzified knowledge. In this paper, the proposed Expert System uses concept of Fuzzy-Inference to identify which Cation or Anion may be present in the salt after getting its color, smell and state as input from the user.

Keywords: Expert Systems, Fuzzy Logic, Qualitative Analysis, Salt Analysis.

INTRODUCTION

An Expert System is a software which uses knowledge and reasoning to give advice just as a human expert. An Expert System can easily deal with problems for which precise solutions do not exist such as probability percentage of person having a particular disease and many more. It mainly consists of four parts: a Knowledge Base, an Inference Engine, a User Interface and an Explanation System.

The Knowledge Base consists of knowledge about a particular field which is acquired from an expert of that field and it also contains rules according to which the knowledge is used to make the decisions. The Inference Engine interprets the input given by the user and applies the rules in the Knowledge Base to it and draws a conclusion which is displayed to the user through the User Interface as shown in Fig. 1. The Explanation System explains the user why and how the conclusion has been reached. The expert systems can be implemented using many methods such as Forward Chaining method, Backward Chaining method, Fuzzy Logic, Decision Tree based methods and many more.

Fuzzy Logic is a logic which gives real values to variables rather than just 0 or 1[13]. It can be seen as an attempt to automate two main capabilities of human mind which include thinking and making decisions in a situation with imperfect information and to perform intelligent tasks without accurate measurements or intensive computation [11]. To implement Fuzzy Logic a member function has to be selected to assign a certain value of a variable to a certain fuzzy set. Member functions usually selected are the ones which return value between 0 and 1. These member functions are the ones with trapezoidal and triangular shape because they provide ease of implementation and less computational complexity. Fuzzy rules capture human knowledge using its special syntax and they easily use linguistic variables which can have linguistic values. Hedges, the special words like slow, fast, very slow, very fast etc. are also used in Fuzzy Logic. The Fuzzy Inference System maps the inputs to an output. Fuzzy Logic based Expert Systems are the most popular application of Fuzzy Logic these days because they are largely utilized in a number of subjects such as Chemistry, Medicine, Mechanical and many more. One of the standard problems in the field of Chemistry is Salt Analysis. [12]

Salt Analysis or Qualitative Analysis is a branch of Chemistry which deals with the determination of chemical composition of inorganic salts. A salt contains one acidic and one basic radical. Identifying various elements that is acidic and basic radicals present in a salt is known as Salt Analysis. Mainly these ions are detected in an aqueous solution of the given salt. The common procedure of testing these salts is by making their solution and testing these solutions with various reagents for verifying the presence of Cations and Anions in them. While testing these salts with various reagents they present some characteristic reaction which indicates the presence of a particular Cation or Anion. The reaction may be a color change, a solid formation or any other visible change. There are two separate procedures for detecting Cations and Anions known as Cation and Anion analysis respectively. There are many tests for Cation and Anion analysis and these tests are often preceded by some Preliminary Tests including the examination of color and smell of the salt, dry heating test and many more. [14]

LITERATURE REVIEW

Agarwal M. and Gael S. (2014) in [3] have stated that for an Expert System to be successfully implemented, it is important that its requirements are properly understood. This is because, even if the Expert System works fine but it does not fulfil the requirements of the user then it will be of no use. So, it is very important for a person to firstly know what an Expert System

is and what are its requirements. A Knowledge Base which is the database, has all the domain specific facts and rules written in a natural language. The Inference Engine uses the existing knowledge contained in the Knowledge Base to generate new knowledge from it. The Working Memory consists of the existing problem and the User Interface is used to interact with the user. This paper proposed a number of techniques used for requirements engineering, its process and the need for them.

Hazman M., Amira M. Idrees (2015) in [6] have proposed an Expert System for making a diet chart for children of different age groups, both male and female. They also considered the special case of children with diabetes or any other diseases. They have used three knowledge layers in an expert system including the Knowledge Base, Inference Knowledge and Task Knowledge. The goal of Task knowledge layer is to coordinate with all the inference steps to reach the goal. The authors of this paper projected the problem of children nutrition by using different domain models such as *"Age Stage model", "Determine Meals Schedule"* and *"Calculate needed calories"*. The "Age stage model" calculates the age of the child and the age stage (growth stage of the child: toddler, preschool, gradeschool and teen). *"Calculate needed calories model"* tells the relation between child's age and the amount of calories needed according to the gender and activity of the child. The "Determine Meals Schedule Model" generates meals schedule of the children while considering the special cases such as child's gender, activity, diabetes etc. Here, the inference knowledge works in three main parts: i. Calculate age state with the help of the date of birth of the child. ii. Calculate feeding requirements based on gender, age activity status and amount of calories required. iii. Determine meals schedule through inference system based on the feeding requirements considering the health status of the child. The authors have developed a website for this system, which was tested using two case studies: one of a healthy child and the other for a child with diabetes and the results were verified by a local nutritionist.

Rumaisa F., S.T., M.Kom and Junaedi D., S.T., M.T. (2016) in [9] have proposed an Expert System for the early diagnosis of Meningitis in children because this is a disease which is the major reason of death of a number of infants. The authors had taken the age data and symptoms data of children for this system. Three main types of processes have been developed by them in this expert system which are the formation of rule, process of determining a patient's illness and the process of determining the therapy. The Expert System developed by them, does not repeat the questions given to a patient and it stores all the questions already asked and the data is used to answer the questions of the patients. The expert system also saved the tentative conclusion after comparing the result with some other Inference Engine. The Expert System also discovered that the disease is not meningitis but some other set of diseases such as fibris cramps, fever, typhoid and encephalitis and the treatment for these three diseases was also given by the expert system.

Ula M., Mursyidah, Hendriana Y., Hardi R.(2016) in [8] have proposed a system which detects the Vitamins and Mineral deficiency in a person as the symptoms of these deficiencies are often ignored by people and then they may lead to serious problems. Therefore, the authors proposed an Expert System for early detection of these deficiencies. The proposed system is a prototype which can be easily used by the user. The study of the paper has been divided into several stages to build an expert system. It begins with the identification of knowledge and problem and the data collection phase. The data is collected from various users on whom the research is performed and also from the various experts of the area. Then, the acquired knowledge is drafted in a systematic form and is encoded in the Knowledge Base and the Rule Base. In this paper, the authors have studied 17 diseases and 46 symptoms. They have handled the uncertainty of this expert system by the Certainty Factor Method. Along with the certainty factor the user's confidence level is also taken into consideration by them and then they have explained how system provides explanations about the result, the deficiency detected and the confidence level of the individual. The results are displayed in form of Decision Tables (DT) that show relationship between symptoms and diseases. The expert system also displays the output as a diagnosis form, which gives the patient's diagnostic codes, that enables the patient to view the percentage of vitamin and mineral deficiency in his body.

Acevedo E., Acevedo A., Felipe F., Avilés P. (2016) in [4] have proposed a system for diagnosis of Vertebral Column Diseases. Vertebral column is very important for human body, as any problem in it affects the impulses which are sent to and from the brain. The system of impulses in our body is basically based on Morphological Associative memories and these memories are based on the primary morphological mathematical operations dilation (+) and erosion (-). The expert system developed by the authors used the dataset which had three classes; where two classes correspond to diseases and the third one corresponds to a healthy person. Using this dataset and the algorithm of Morphological Associative memory their system gave the result.

Ghunaim M. H., Alkhalaf K. S., Altwaijri B. A. and Seddiq Y. M. (2016) in [2] have proposed an expert system named PHEWnA (Personal Health Early Warning and Awareness). They have mainly designed this system for the child users so that the children can take care of their health from the beginning itself. PHEWnA provides a diabetes self-assessment system for children, containing interactive graphics and friendly interface. The self-assessment tests made by them not only help in checking oneself but also increases health awareness among children. The main actors of this expert system software included the developer, the physician and the user. This paper explained how the developer made the software, the physician provided relevant questions to be answered by the child. The questions are kept short and simple so that they are easy to answer for the child. The physician can add more questions or information easily and whenever required. The authors have also summarized the uses and advantages of the expert systems and also explained the components of the expert systems.

Mohamed Aly W., Eskaf K. A., Selim S.A. (2017) in [12] have developed an Android Application to help the college students to decide which course to take up in college. They have used fuzzy logic to implement the system. To implement fuzzy logic a member function has to be chosen to assign a

certain value of a variable to a particular fuzzy set. Member functions usually chosen are the ones which return value between 0 and 1. Fuzzy rules capture human knowledge using its special syntax. They easily use linguistic variables which can have linguistic values. Hedges are the special words like slow, fast, very slow, very fast etc. The Fuzzy Inference System maps the inputs to an output. The Mamdani style of fuzzy inference is used by the authors and four steps of this technique have been explained that are Fuzzification, Rule Evaluation, Aggregation, Defuzzification. The authors have explained the flow of building the system. The authors have used order structure of linguistic value technique to define the linguistic terms. The range of input values was represented using values from 0 to 5 and the output was defuzzified using centroid technique. The authors have defined 25 rules using which the human expert would decide which course to choose. Some are straightforward rules and some rules have union and intersection fuzzy set operations. The member functions usually chosen are the ones with trapezoidal and triangular shape because they provide ease of implementation and less computational complexity. The authors have built the system with the help of open source Fuzzy Inference Engine for Java. Special classes have been defined to explain the concept and operation of hedges. The students have to answer 6 inputs on a scale of 100 for every question or give stars from half star to 5 stars. The system will respond by giving a value between 0 and 100 as a recommendation to join a course or not. The root mean square error was used to calculate errors.

Ilham N. I., Saat E. M., Rahman N. A., Rahman F. Y. A. and Kasuan N. (2017) in [7] have proposed an Automatic Time Table Scheduling expert system which generates time table for the electrical engineering department of Universiti Teknologi MARA (UiTM), Pasir Gudang. The authors have proposed a system which makes time table for the lecturers, students, courses and classrooms and takes into consideration some hard and soft constraints which have to be taken care of which scheduling the time table. They have used Xampp and visual basic for database management and developing the GUI respectively. Some of the hard constraints defined by them are: i. The teacher and students should have one class at a time ii. There should be no more than one class in a classroom at a given time. iii. Lab session is to be allotted prior to classes iv. Lecturer and student should not have classes for more 4 hours consecutively. Some soft constraints defined for the system include: i A lecturer can choose his preferable time slots ii. Lecturer can request to teach only within his expertise area, and many more. These constraints along with the number of classes, students and lecturers act as input to the system and an algorithm is applied which has some priority rules, which are used to generate the time table. If there are some conflicts or missing classes they are left for manual scheduling.

Y. Acikmese, B. C. Ustundag and E. Golubovic (2017) in [10] have proposed an expert system which is used for giving basketball training. This expert system used six types of training datasets as input and these datasets are then used to train the model. They collected the data using wearable devices which had Gyrosensors and Accelerometers to sense the movements such as Forward-Backward Dribbling, Left-Right Dribbling, Regular Dribbling, Layout and Two- Hands Shooting etc. Followed by this step, the datasets are preprocessed and classified for labelling. SVM was used to classify the training type. The authors used comprehensive experiments to evaluate the stability of the approach on the basis of accuracy, precision, recall and many more. To improve the performance of the model, feature reduction was performed using information gain, test and Fischer Score. The further scope of this project was to include more training exercises for basketball and more data would be used to make the model better. Finally, they planned to automate the entire process so that feedback could be given to the trainee.

Khanna S., Sethi Y. and Nambiar A. R. (2017) in [5] have proposed an expert system which used image recognition and machine learning to identify a number of skin diseases. This gave a solution for the problem of low availability of existing dermatologists. The authors described a number of skin diseases such as Impetigo, Lyme Disease, Psoriasis and Skin Cancer and classified them as the fourth leading fatal diseases in the world. With the advancement of technology the people with good financial status are able to access the various facilities and not the people from underdeveloped and poor backgrounds. The authors aimed to provide such people with access to a system which can provide a good diagnosis of the disease and can help them to cure it. The proposed system allowed the user to upload a photograph of the affected area of skin and used various algorithms of pattern recognition, image recognition and big data analytics to identify which disease it was and suggested its cure. This system had two primary components- the iskin specialist app and the expert system.

Nkuma-Udah K. and Chukwudebe G. (2017) in [1] have proposed an expert system to help doctors diagnose Malaria in the patients because malaria is a disease which is very difficult to detect because same symptoms can be of some other diseases also. The authors have implemented the system using the C Language Integrated Production System (CLIPS) which is an expert system containing four major components: the Knowledge Base, the Explanation System, Inference Engine and the User Interface. In order to acquire the knowledge of symptoms for diagnosis a questionnaire was filled by a set of experts. The symptoms were divided into the symptoms into three categories: Strongly required (Sr), Relevant but not necessary (Rn), and Not related/relevant (Nr) for the diagnosis of Malaria. Two strongly related symptoms were connected with an AND operation. The Rn symptoms were connected with an OR operation and the Nr symbols were connected with a NOT operation. Thus by observing these combinations the result was declared by the system. The user's responses to these questions determine whether the person has Malaria or any other related disease then their system gives recommendations for the treatment and medicines for the disease.

COMPARITIVE ANALYSIS

TABLE I.

S.No.	Approach	Application Area	Outcome
1.	Basic [3]	Requirement Elicitation	Methods to acquire requirements, understand and manage them are explained.
2.	Machine Learning [6]	Medical	A balanced diet chart for healthy children as well as for children with some disease using parameters like age, gender, health and previous health records.
3.	Certainty Factor Method [9]	Medical	An Expert System which helps in early diagnosis of Meningitis (a deadly disease among infants) and also tells cure for it.
4.	Certainty Factor Method, Forward Chaining [8]	Medical	An Expert System which helps in early diagnosis of mineral and vitamin deficiency whose symptoms are often ignored by people.
5.	Associative Model [4]	Medical	An Expert System which helps in early diagnosis of Vertebral Column diseases and the cure for them.
6.	Rule-Based Expert System [2]	Medical	An Expert System which helps children take care of themselves by making them aware of potential health hazards and monitor their health status time to time.
7.	Fuzzy Logic [12]	Education	An expert app which helps students to choose courses of their interests by telling positive probability of one passing a particular course with good grades based on their interests and abilities.
8.	Machine Learning [7]	Education	An Expert System which automatically generates a schedule for lectures, labs and classes using some constraints as input.
9.	Support Vector Machine [10]	Basketball	An Expert System which uses inputs from gyrosensors and accelerometers for training itself about moves once and then can give basketball training to players.
10.	Data Analytics and Image Processing [5]	Medical	An Expert System which tells the type of skin disease by seeing and analysing the image of the affected area.
11.	CLIPS Expert System [1]	Medical	An Expert System which recognises symptoms and tells if it is Malaria or some other disease and its cure.

PROPOSED ARCHITECTURE DESIGN IMPLEMENTATION FOR SALT ANALYSIS

As per the extensive literature review conducted for Expert system, it has been identified that Expert Systems have been implemented in many fields such as Medicine, Education and Sports. But till now, an Expert System has not been made for Salt Analysis or Qualitative Analysis. The authors of this paper propose an Expert System which has been implemented using Fuzzy Logic. Salt analysis is a method by which Cations and Anions of the salts are identified. The salt to be examined is tested using various methods. Then, the results of the tests are analyzed by human experts and they illustrate which particular Cation or Anion is present in the salt. So, using Fuzzy Logic the proposed expert system would give results of the physical tests of Qualitative Analysis. The prototype system can be implemented as follows:-

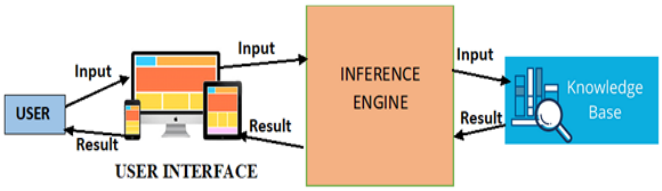

Figure. 1. Architecture of an Expert System

Phase 1:- The User Interface of the system can be easily designed in Android Studio for making an android application. The inputs that a user can enter are: color, state and smell of the salt under consideration.

Phase 2:- . The data is taken from a published Chemistry book [15].

The Knowledge Base would contain the following knowledge:

TABLE IIA. [15]

Colour	Ions
Blue or Bluish Green	Cu^{2+} ion may be present
Light green	Fe^{2+} ion may be present
Yellow or Yellowish green	Fe^{3+} ion may be present
White	Pb^{2+}, Zn^{2+},Ca^{2+},Na^{+},K^{+},Nh_4^{+}, ion may be present

TABLE IIB. [15]

Smell	Ions
Smell of ammonia Gas	Nh_4^{+} ion may be present
Smell of hydrogen sulphide gas	S^{2-} ion may be present
Smell of sulphur dioxide gas	SO_3^{2-} ion may be present

TABLE IIC. [15]

State	Ions
Amorphous Salt	CO_3^{2-} ion may be present
Hygroscopic or deliquescent salt	Cl^{-} or NO_3^{-} ion may be present

Phase 3:- The user will give three inputs after physically examining the salt. The three inputs include color, smell and state of the salt. The Fuzzy Inference Engine will then use these inputs and map them to some output. This output will be evaluated against the knowledge in the Knowledge Base and the Inference Engine will give a fuzzy output value. This output value can be then defuzzified to comprehend whether a particular ion may be present in a salt or not as shown in Fig. 2. [16] Fuzzy logic can be used to make this system because it gives a probability of the outcome and not the exact result, which is the actual scenario of physical tests in Salt Analysis.

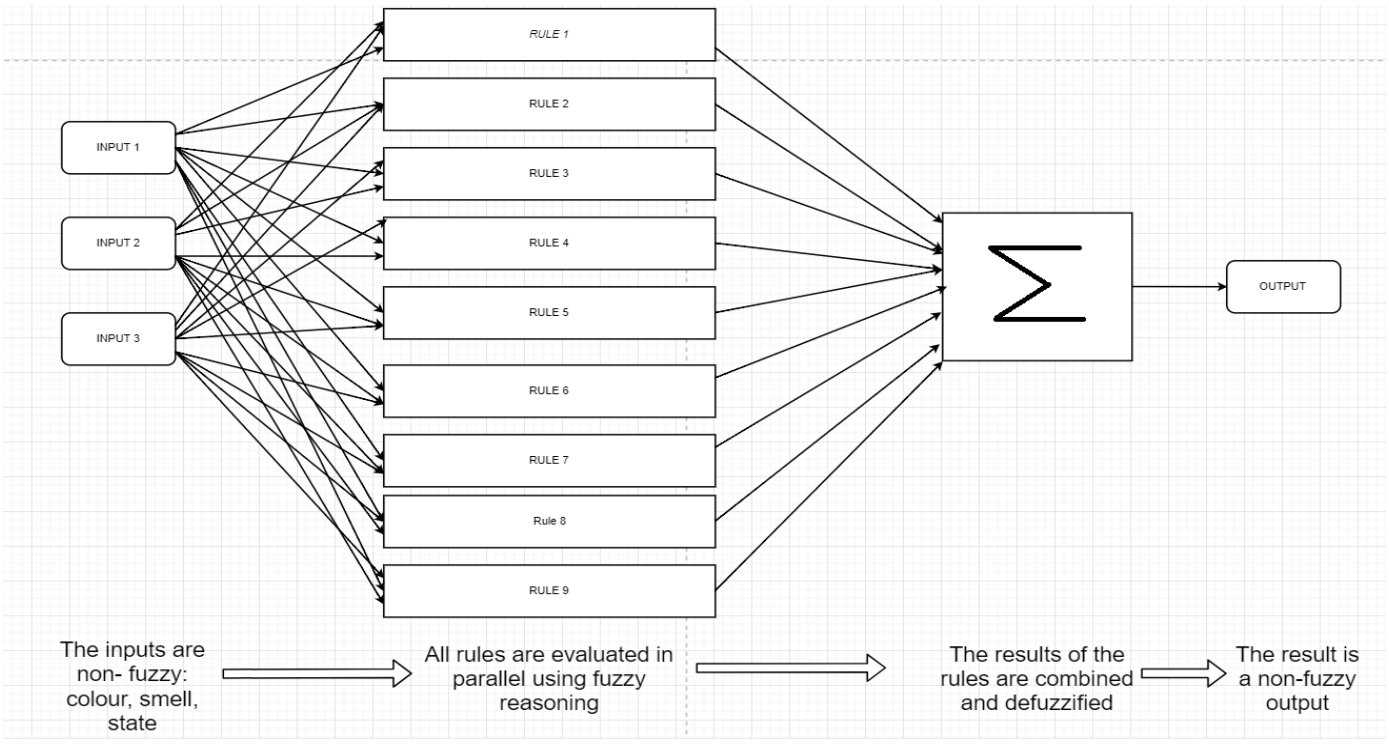

Figure.2. Proposed Fuzzy-Inference System

Phase 4: Finally the User Interface will display the results showing which ions (Cations or Anions) may be present in the salt.

CONCLUSION AND FUTURE WORK

In this paper, a prototype of a Fuzzy-Logic based Expert System for physical tests for qualitative analysis of salts has been proposed. The paper explains how Fuzzy Logic can be used to implement this Expert System. No such Expert System

has been proposed or implemented before this for Salt

Analysis, so an attempt has been made in this paper to propose an implementation of an expert system for this branch of Chemistry. As Fuzzy Logic can only give probabilistic results so the Expert System has been proposed only for the physical tests, which tell that a particular ion (Cation or Anion) may be present in a given salt. The confirmation tests of salts cannot be implemented using Fuzzy Logic. However, an expert system for these confirmation tests can be considered for future work.

REFERENCES

[1] K. Nkuma-Udah and G. Chukwudebe, "Medical Diagnosis Expert System for Malaria and Related Diseases for Developing Countries," 2017.

[2] M. H. Ghunaim, K. S. Alkhalaf, B. A. Altwaijri and Y. M. Seddiq, "PHEWnA: An Expert System Framework for Children Health Care and Awareness," 2016.

[3] M. Agarwal and S. Gael, "Expert System and it's Requirement Engineering Process," 2014.

[4] E. Acevedo, A. Acevedo, F. Felipe and P. Avilés, "Expert system for the diagnosis of vertebral column diseases," 2016.

[5] S. Khanna, Y. Sethi and A. R. Nambiar, "iSkin Specialist – A Big Data Based Expert System for Dermatology," 2017.

[6] M. Hazman and A. M. Idrees, "A Healthy Nutrition Expert System for Children," 2015.

[7] N. I. Ilham, E. M. Saat, N. A. Rahman, F. Y. A. Rahman and N. Kasuan, "Auto-Generate Scheduling System Based on Expert System," 2017.

[8] M. Ula, Mursyidah, Y. Hendriana and R. Hardi, "An Expert System for Early Diagnose of Vitamins and Minerals Deficiency On The Body," 2016.

[9] S. Fitrah Rumaisa, M.Kom, S. Danang Junaedi and M.T., "Expert System For Early Diagnosis Of Meningitis Disease Using Certainty Factor Method," 2016.

[10] Y. Acikmese, B. C. Ustundag and E. Golubovic, "Towards an Artificial Training Expert System for Basketball," 2017.

[11] Duisenbayeva, L. Atymtayeva and I. Beisembetov, "Using Fuzzy Logic Concepts in Creating the Decision Making Expert System for Cardio - Vascular Diseases (CVD)," 2016.

[12] W. M. Aly, K. A. Eskaf and A. S. S. , "Fuzzy Mobile Expert System for Academic Advising," 2017.

[13] M. Rouse, "Fuzzy-logic," 2016.

[14] V. Vidyapeetham, "Qualitative Analysis," 2014.

[15] D. S. Singh, Concise Chemistry, Selina publishers, 2011

[16] Fuzzy Inference process," 2018.