An Algorithm for Quality Analysis of Contact Lens in Opthalmology (QACLO) Using Fuzzy Expert System

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Abstract : This paper focus on an algorithm for identifying the quality contact lens material in the field of ophthalmology. The algorithm was generated by using Fuzzy Expert System. Contact lenses such as RGP, Soft and Hybrid are considered as the dataset for this research. An algorithm has been proposed to provide a unified model in the field of contact lens manufacturing and quality control unit. This algorithm identifies and reduces the impact of side effects on wearing the contact lens. The algorithm was designed using Fuzzy logic and implemented in Java. The logic of the algorithm focuses on identifying the appropriate contact lens, which can be used as a second opinion tool for the opticians, ophthalmologist and optometrists.
Keywords : Contact Lens, Expert System, Fuzzy Logic, opticians, ophthalmologist

I. Introduction

The expert system is the branch of applied artificial intelligence and were developed by the AI community in the mid – 1960s. Expert system is domain specific[1]. An Expert or knowledge based system is a computer program that is designed to mimic the decision making ability of a decision maker. The main objective of Expert system techniques is to recognise the integration of human expertise into computer processes [2]. These components are identified as facts, rule-based and inference-based methods. This component once created as an expert domain generates its own decision or conclusion. Assisting the human expert is one of the most commonly found applications of expert systems [3].

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh by the University of California at Berkeley in the 1960s. It is a mathematical logic that solves the problem by assigning the values to a set of data in order to reach the most accurate decision. Fuzzy logic solves the problem in the same way as the human does. It computes based on the degrees of truth rather than "true or false" values. Fuzzy logic data are formed with numerous partial truths which is aggregated further into higher truths which in turn when certain thresholds are exceeded causes certain results such as motor reaction.

For decision making, fuzzy logic uses "If – Then" rule in the main. The fuzzy set theory uses fuzzy operators on fuzzy sets. The fuzzy operators such as AND, OR and NOT of Boolean logic are defined as maximum, minimum and complement respectively. Fuzzy logic is implemented in the expert system and used as a collection of fuzzy membership functions and rules instead of Boolean logic, to identify the data. The fuzzy expert system performs the operation using four steps such as Fuzzification, Inference, Composition and defuzzification.

Fuzzification is the process of generating membership function based on the input variables which are applied to their actual values to obtain the degree of truth for each rule defined. Inference is the process of checking the truth value for each rule using maximum, minimum and complement operation. The composition of all fuzzy subsets are assigned to each output variable that are combined together to form a single fuzzy subset. Defuzzification is used to convert the fuzzy output as the crisp data.

Karem R Dominguez Hernandez et al (2013) [4] developed an expert system that is used as a diagnostic support machine for cervical cancer in glandular cells using fuzzy logic. This expert system shows a great effectiveness in predicting the patient having cervical cancer according to their background and risk factors.

Smita Sushil Sikchi et al (2013) [5] developed a fuzzy expert system for diagnosing various medicinal diseases. The development of this expert system paves a way in the medical field as an intelligent, interactive, interdisciplinary and hybrid system. This may be called as third generation expert system. An enhanced fuzzy rule based diagnostic model is developed for examining lung cancer. This system acts as a suggestion tool to know the symptoms, priority and severity values of the cancer stage in each patient[6].

[7] suggests a fuzzy rule based inference system for detection and diagnosis of lung cancer based on the symptoms. This expert system checks and shows the stage of lung cancer in each patient. Heart disease can be detected using various methods, but the implementation of fuzzy logic provides a way to check whether the patient have severe heart disease or not. This tool can be directly used by the patients as a self analysis tool [8].

The fuzzy expert tool such as MYCIN, DENDRAL, PUFF and PROSPECTOR were invented to identify blood disorders, structure of chemical components, diagnosis of respiratory condition and identifying the sites for drilling or mining respectively. The researcher has suggested that difference social science methodologies such as psychology,

cognitive science and human behaviour could implement expert system in their domain [9].

[10] and [11] also generated fuzzy expert system to diagnosis the heart diseases of the patient based on their severity and priority of the disease. Skin Diseases can be diagnosed using Fuzzy expert system. In this system the patients have to check the symptom shown on the screen. By identifying the symptom they can identify types of skin disease and obtain relevant medication to eradicate that skin disease [12]. Many expert systems have been developed using fuzzy logic to identify Asthma, Viral infections, tropical diseases and malaria.

II. Material and Methodology

The QLAA (Quality Lens Analysis Algorithm) was initially designed and tested using fuzzy logic maximum and minimum function. The fuzzy expert system using max and the min method generated maximum rule and takes more execution time. To minimize the rules and execution time a new methodology named Fuzzy logic was implemented and tested. The fuzzy XOR operation involved to QLAA is to identify the quality contact lens material among the three contact lens types such as RGP, Soft and Hybrid lens.

The QLAA is used as an Expert system in the field of ophthalmology to identify the quality contact lens material. This provides a unified method to develop a quality contact lens material by the manufactures and also to be tested in the quality control section. The processing of the QLAA – Fuzzy XOR Expert system model is as shown in figure 1.1.
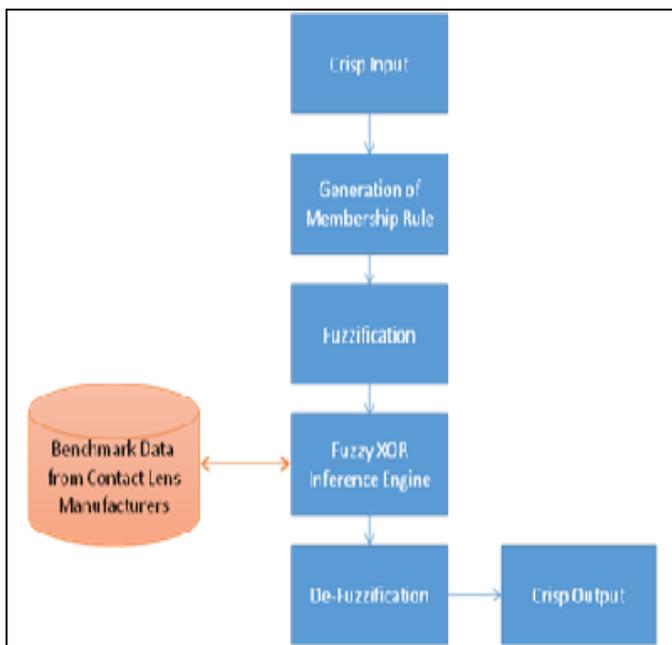

Figure 1.1 QLAA Fuzzy XOR Expert System Model

III. Results and Tables

The QLAA using Fuzzy XOR is shown in Figure 1.2 to identify the quality contact lens material among the three given contact lens types such as RGP, soft and hybrid. This algorithm defines an effective method to predict the quality contact lens material for long period usage.
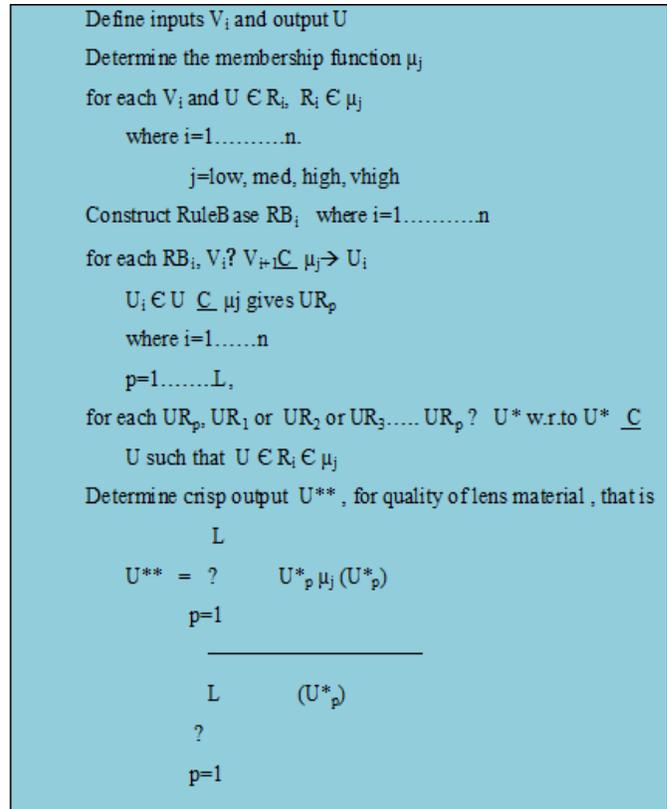

Figure 1.2 Quality Lens Analysis Algorithm

V_i - inputs of variables v1,v2...v6
U - output variable
R_i - Range for the input and output variable
μ_j - characteristics functions or membership functions of input and output variable
Rb_i - Rule base for the membership function of the input and output
$\oplus$ - Fuzzy XOR
UR_p - output Region for each output obtained from the rule base
U^*_p - output region of all output
U^{**} - Crisp output gives quality of the lens
$\mu_j(U^*_p)$ – Center of output membership function

The fuzzy expert system uses XOR operation in the rule base to identify the quality lens material. The essential parameters such as water content, Dk/t, thickness, diameter and refractive index are taken from factor analysis. To enhance the quality analysis of contact lens material Dk/t was added as a new parameter which is correlated with other parameters.

IV. Conclusion

Quality Lens Analysis algorithm with the fuzzy XOR operation focuses on highly correlated attributes with reduced cost in manufacturing the contact lens material. This model in the contact lens era gives importance for new approach in identifying the quality contact lens material. On using Fuzzy XOR logic in the proposed algorithm reduces the number of rules than other approach in fuzzy logic. This model can be implemented in any software tool and used as a second opinion tool by the experts in the field of ophthalmology.

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