DETERMINING THE TYPE OF LENS USING FUZZY LOGIC:

-By

Satya Medicherla

The Australian National University

Abstract:

The type of lens that can suit a person depends on a varied factors like age of the person etc.In the field of medicine selecting a suitable type of lens is very important since wrong selection of this might lead very bad effects on eye.This paper attempts to explain about determining the type of lens that a person use using Fuzzy Logic approach.

Introduction:

Initially we are given a data set that need to be analyzed and pre-processed before it is actually been implemented by an approach.Once the data is pre-processed we need a set rules to implement fuzzy logic.These set of rules are some conditional statements(if-else statements) that guides in determining the types of lens to be selected based on the values of different attributes specified in the data file.
Once this rules are generated we can use them in fuzzy logic.

Analysis of Data and Preprocessing:

The Data has 4 attributes and one output(target).
The 4 attributes are Age of the Person,Spectacle prescription,astigmatism and tear production rate.The values of all the 4 attributes are numeric nature.Age has values ranging from 1-3 and remaining 3 attributes have value either 1 or 2.Since Fuzzy logic is a replica of human logical approach to a problem the values are changed to text format so that it can be easily understood a person.The Range of values that each of the attributes can have is as follows:
1. age of the patient: young, pre-presbyopic,presbyopic
2. spectacle prescription:myope, hypermetrope
3. astigmatic: no, yes
4. tear production rate: reduced,normal
The output variable Result represents the type of variable that suits a person based on its corresponding attributes value.The values in this output are classified into 3 classes

1)Hard representing Hard contact lens are suited

2)Soft representing Soft contact lens are suited

3)Nill representing that contact lens are not suitable

Refer to [1] and [2] for more information about the data set

Now that the data is preprocessed we need to generate some set of rules to generate that can be used in fuzzy. We use Decision trees to generate this Rules

Decision Trees:

A Decision tree is a tree data structure with each node representing an attribute of the data set.At each node branches emerge based on the values that an attribute can have. Each leaf node represents a decision i.e The path that needs to be taken from node to reach that leaf node represents the values of various attributes to get this output[3]

Now to construct a decision tree we use an algorithm called ID3:

ID3 algorithm is a recursive algorithm based on the entropy of the attributes.

1. Calculate the entropy of every attribute using the data set S
2. Split the set S into subsets using the attribute for which the resulting entropy (after splitting) is minimum (or, equivalently, information gain is maximum)
3. Make a decision tree node containing that attribute
4. Recurse on subsets using remaining attributes.

For more information on ID3 algorithm refer to [4]

Applying this ID3 algorithm on the lens data set with attributes age,pres,ast and tear we will the following tree structure:

IF tear EQUALS normal AND ast EQUALS yes AND pres EQUALS hypermetrope AND age EQUALS young THEN hard

IF tear EQUALS normal AND ast EQUALS no AND age EQUALS pre_presbyopic THEN soft

IF tear EQUALS normal AND ast EQUALS yes AND pres EQUALS hypermetrope AND age EQUALS presbyopic THEN nill

IF tear EQUALS normal AND ast EQUALS yes AND pres EQUALS hypermetrope AND age EQUALS pre_presbyopic THEN nill

IF tear EQUALS normal AND ast EQUALS yes AND pres EQUALS myope THEN hard

IF tear EQUALS normal AND ast EQUALS no AND age EQUALS presbyopic AND pres EQUALS myope THEN nill

IF tear EQUALS normal AND ast EQUALS no AND age EQUALS presbyopic AND pres EQUALS hypermetrope THEN soft

IF tear EQUALS normal AND ast EQUALS no AND age EQUALS young THEN soft

IF tear EQUALS reduced THEN nill

Now that the set of rules are ready lets get started with fuzzy logic

APPLYING FUZZY LOGIC:

In Fuzzy logic we take a set input values and based on the rule set we try to predict the output.Here we are using mamdani fuzzy inference technique.

Firstly we need to make the inputs fuzzy in mamdani technique we use membership function to achieve this[5]

Membership functions:

The membership functions are used to define the degree of the fuzziness.Here the input values are distributed between 1 to 100 and the membership functions are created by triangle fm functions(please refer to python code) to create the following functions:
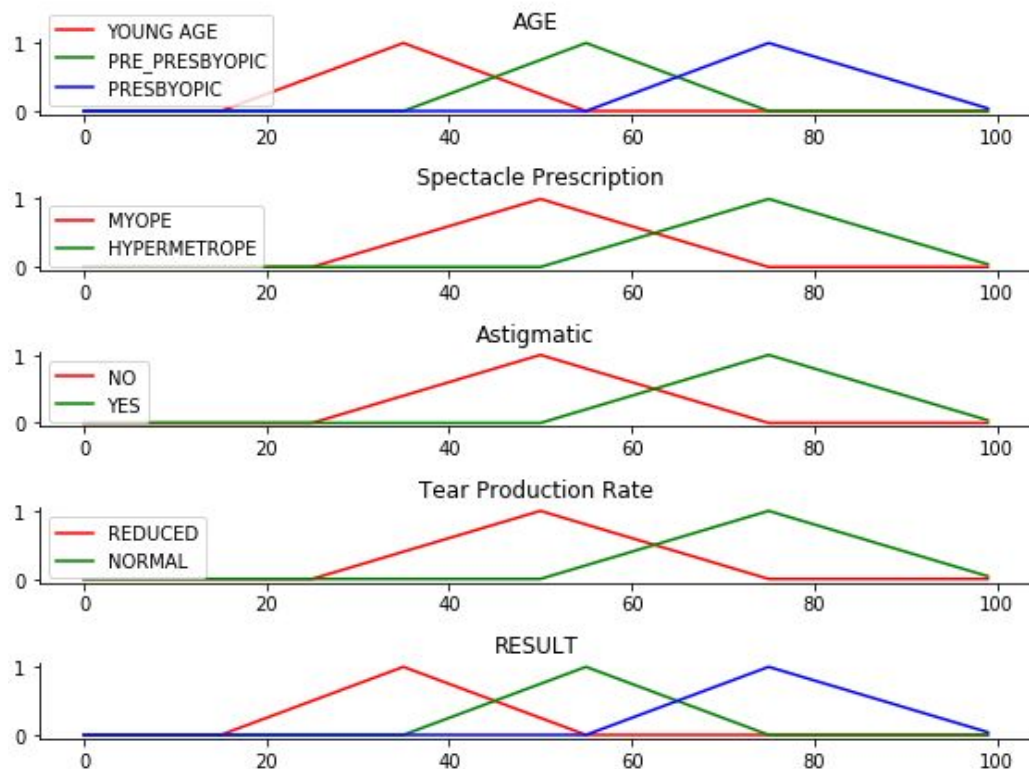
Fig2.membership functions for a)age b)spectacle prescription c)astigmatism d)Tear production rate e)result

Generating fuzzy rules:

We know that fuzzy logic deals with fuzziness but the set of rules we derived by decision tree are not i.e there values can be decided as completely true or false.Now these rules need to be converted into fuzzy.This can be done by function fuzz.interp_membership.

Aggregation of Fuzzy Rules:

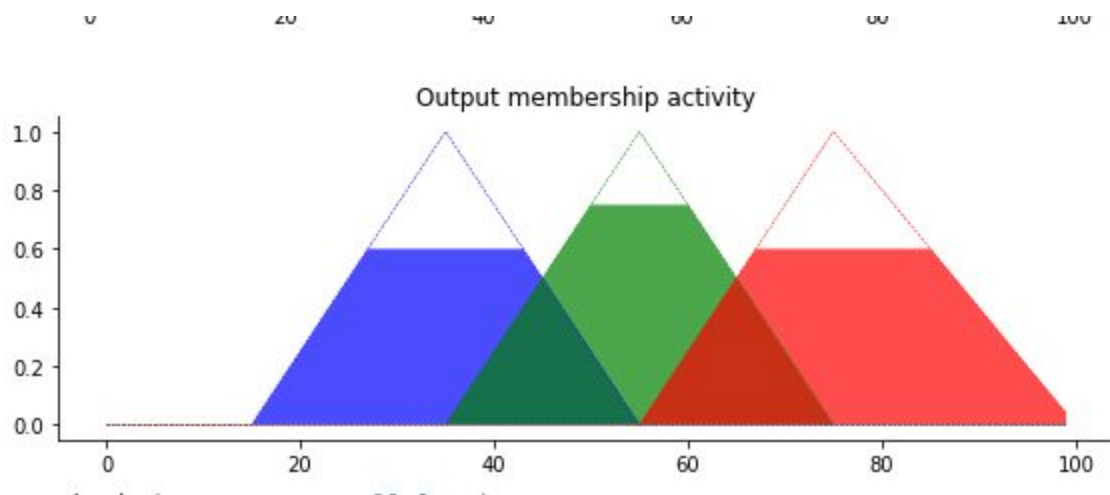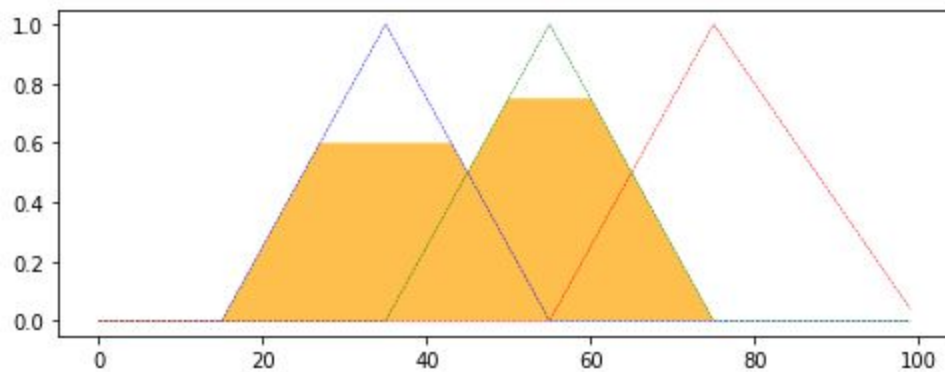The membership function and the fuzzy rules needs to aggregated.The aggregated fuzzy rules are as shown:

Fig2.Output Membership Activity

DEFUZZIFICATION:

Now that the input is fuzzy the output is also fuzzy which needs to be defuzzified

RESULTS:

From the decision tree there are 9 rules generated which matches with the information given in description of data set[2].Also the defuzzified output shows that a lot of the outcomes are of soft and very less goes to nill which matches to the data originally given

Conclusion And future work:

A lot of information in the real world is fuzzy i.e which completely defines to be true or false.To deal with this fuzziness fuzzy logic is a great and efficient tool.Once the fuzzy logic is been applied on the fuzzy data set we get a closely crisp output that can be used widely because of its less degree of fuzziness.Also it is noted that there is approach that closely resembles the human logical approach hence making easy for one to analyze the data. There are some limitations to this process since the id3 algorithm is greedy and can't be relayed on completely

Reference:

[1]Raw-dataSet :http://archive.ics.uci.edu/ml/machine-learning-databases/lenses/lenses.data
[2]Data Set
Description:http://archive.ics.uci.edu/ml/machine-learning-databases/lenses/lenses.names
[3]Decision tree-WIKI:https://en.wikipedia.org/wiki/Decision_tree
[4]ID3-ALGO:https://en.wikipedia.org/wiki/ID3_algorithm
[5]Fuzzy Logic: https://www.tutorialspoint.com/fuzzy_logic/fuzzy_logic_inference_system.html