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Rough-Fuzzy Classification on a Decision Table using a Threshold- Algorithms and Implementations

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ABSTRACT

Pawlak's tool of rough sets finds various applications in knowledge engineering. In this paper we developed three algorithms for computing rough computing based indices of similar objects in decision table with fuzzy decision attributes using a threshold on fuzziness and also we implemented these algorithms using C.
Keywords: Rough Sets, Decision table, Rough Indices, Knowledge Engineering

I. INTRODUCTION

Rough Sets [6,7,8] find wider applications in various areas of technologies as well as bio sciences as similar as Fuzzy tools. Considering the importance of these tools various researchers made contributions by hybridizing these concepts. In particular, G.Ganesan et. al., [3,4,5] discussed the procedure of indexing any element of the Universe of discourse through fuzzy a fuzzy subset using rough tools. In this paper, we worked on these contributions and developed the algorithms of three types of indices namely ***lower, upper*** and ***rough*** and implemented them using C Programming.

This paper is organized into six sections. In Second section, we provided the basic mathematical concepts related to the subsequent sections. In third section, we discussed the lower index algorithm on a decision table with fuzzy decision attribute with a single threshold and implemented the same using C Programming. In fourth section, upper index algorithm for a decision table with fuzzy decision attribute under one threshold is provided and the same has been implemented using C Programming. In fifth section, rough indexing algorithm using a threshold for a decision table with fuzzy decision attribute is provided and the same has been implemented using C Programming and the paper ends with concluding remarks as 6th section.

II. Mathematical Preliminaries

In this section we provide the basic concepts which are useful for reading other sections.

2.1 Rough Sets

Pawlak's concept of Rough Sets [1,6] is defined as follows: For a given finite universe of discourse U and an equivalence relation R, denote U/R ={X_1, X_2, …., X_n}be the collection of equivalence classes induced by R on U. For a given input A, the lower and upper approximations are algorithmically defined as

<u>Lower Rough Approximations</u>

\\X_1, X_2, …, X_n – Equivalence Classes
\\ A-Input
Let D=NULL
For i=1 to n do
    If X_i is subset of A, then D= D ∪ X_i
Return D

<u>Lower Rough Approximations</u>

\\X_1, X_2, …, X_n – Equivalence Classes
\\ A-Input
Let D=NULL
For i=1 to n do
    If A ∩X_i≠NULL then D= D ∪ X_i
Return D

2.2 Hybridization of Fuzzy Sets and Rough Sets

For a given fuzzy subset A on a finite universe of discourse U, let R be an equivalence relation defined on U and U/R={X_1, X_2, …., X_n} denote the partition on U induced by R. For a threshold α ranging between 0 and 1, let A[α] denote the strong α- cut on A. The lower and upper rough approximations of the fuzzy set A [2] are given by $A_\alpha = \underline{A[\alpha]}$ and $A^\alpha = \overline{A[\alpha]}$ respectively.

III. Lower Indices in a Decision Table with Fuzzy Decision Attribute

In this section, we propose an algorithm to compute the lower index using lower rough approximations. In the algorithm, single threshold is used on a fuzzy input A and using square and square root functions, the lower indices are obtained. Also, we illustrate the algorithm for a decision table with a fuzzy decision attribute.

3.1 Algorithm for Lower index of an element

Algorithm (alpha, A, x)
//Algorithm to obtain index of x an element of universe of discourse
//Algorithm returns the index

1. Let x_index be an integer initialized to M

2. Pick the equivalence class K containing x.

3. If U(y)=0 for all y belongs to K
        Begin
            x_index=-x_index
            goto 7
        End
4. If U(y)=1 for all y belongs to K
            goto 7
5. Compute "A lower bound of alpha"

6. If " x belongs to A lower bound of alpha"

While (" x belongs to A lower bound of alpha")
    Begin
    alpha= sqrt(alpha) //square root of alpha
    x_index=x_index+1
     Compute "A lower bound of alpha"
    End
else

While ("x NOT belongs to A lower bound of alpha")
    Begin
    alpha= sqr(alpha) //square of alpha
    x_index=x_index-1
     Compute "A lower bound of alpha"
    End

7. Return x_index

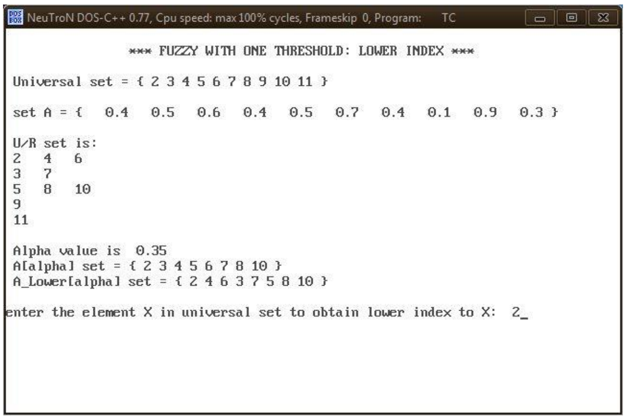
3.2 Experimental Results

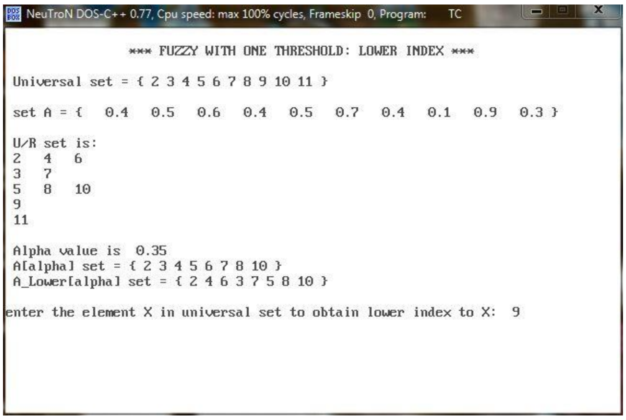
Consider the following decision table with 10 records namely 2,3,4,5,6,7,8,9,10 and 11 with three conditional attributes namely Attr_1, Attr_2, Attr_3 and a fuzzy decision attribute.

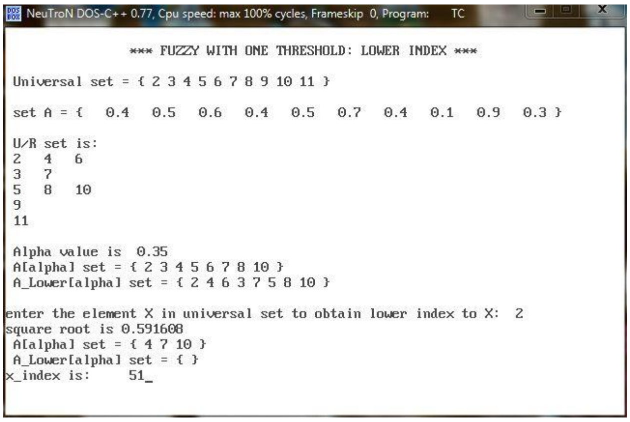
	Attr_1	Attr_2	Attr_3	Decision
2	Yellow	Red	Yellow	0.4
3	Red	Yellow	Green	0.5
4	Red	Red	Yellow	0.6
5	White	Green	Blue	0.4
6	Blue	Red	Blue	0.5
7	White	Yellow	Red	0.7
8	Yellow	Green	Blue	0.4
9	Yellow	Blue	White	0.1
10	Green	Green	Red	0.9
11	Blue	White	Blue	0.3

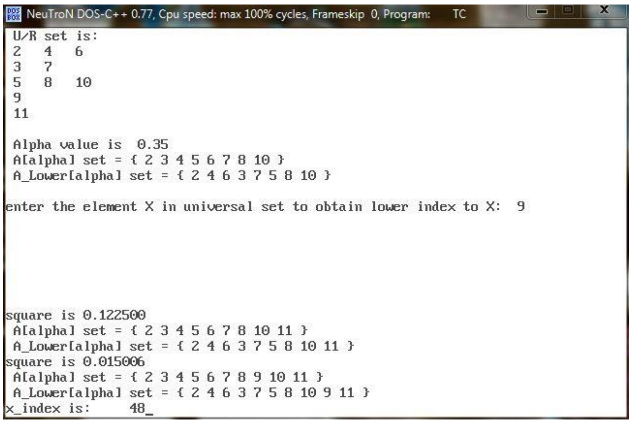
It may be noticed that the records are grouped according the similarity for each key or group of keys. i.e., the records are grouped as follows: For Attr_1, the grouping are {(Yellow,{2,8,9}),(Red, {3,4}), (White, {5,7}), (Blue, 6,11}), (Green,{10})}. For Attr_2, the grouping are {(Red,{2,4,6}), (Yellow,{3,7}), (Green,{5,8,10}), (Blue,{9}), (White,{11})} and for Attr_3, we obtain {(Yellow, {2,4}), (Green,{3}), (Blue,{5,6,8,11}), (Red,{7,10}), (White,{9})}.

The above example is implemented in C by using Attr_2 as the key and the threshold as 0.35 using the threshold as 0.35 and we obtain the lower index of 2 as 51 and the lower index of 9 as 48









IV. Upper Indices in a Decision Table with Fuzzy Decision Attribute

In this section, we propose an algorithm to compute an index using upper rough approximations. In this algorithm, a fuzzy input A is considered and using a single threshold. For each element, the upper index is obtained using square and square root functions. Also, we illustrate the algorithm for a decision table with a fuzzy decision attribute.

4.1 Algorithm for Upper index of an element

Algorithm (alpha, A, x)

//Algorithm to obtain index of x an element of universe of discourse
//Algorithm returns the index

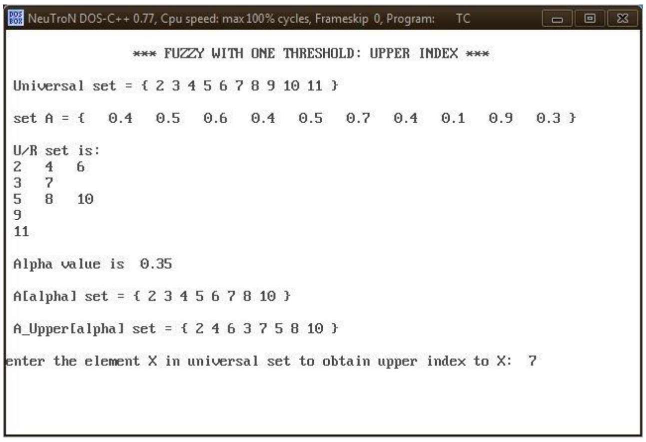
1. Let x_index be an integer initialized to M
2. Pick the equivalence class K containing x.
3. If U(y)=0 for all y belongs to K
   Begin
      x_index = -x_index
      goto 7
   End
4. If U(y)=1 for all y belongs to K
      goto 7
5. Compute "A upper bound of alpha"
6. If " x belongs to A upper bound of alpha"
   While ("x belongs to A upper bound of alpha")
      Begin
         alpha= sqrt(alpha) //square root of alpha
         x_index=x_index+ 1
         Compute "A upper bound of alpha"
         End

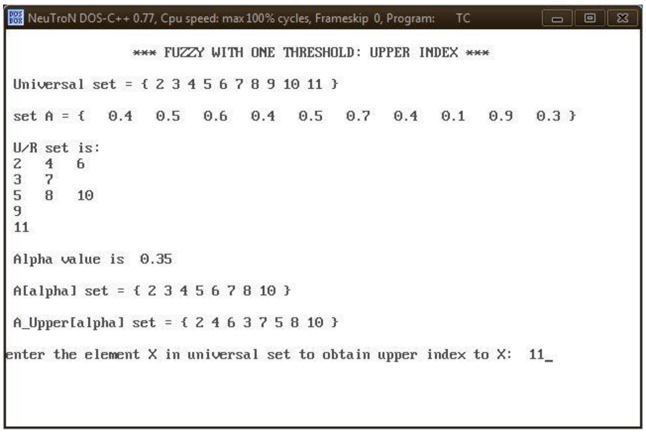
   else

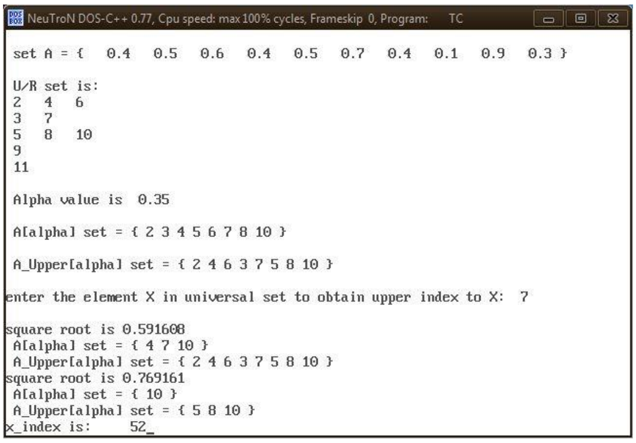
   While ("x NOT belongs to A upper bound of alpha")
      Begin
         alpha= sqr(alpha) //square of alpha
         x_index=x_index- 1
         Compute "A upper bound of alpha"
         End
7. Return x_index

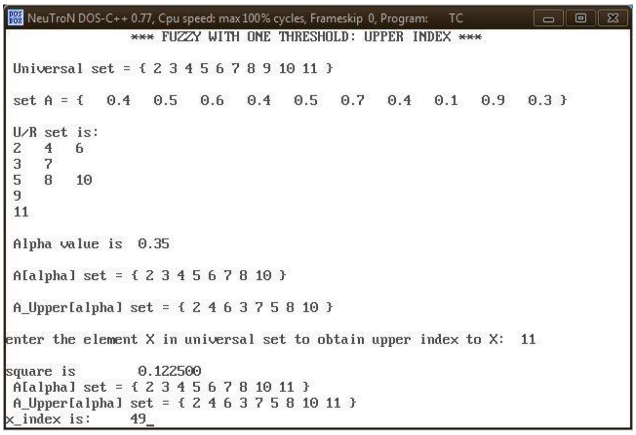
4.2 Experimental Results

For the example, the upper indices of 7 and 11 are computed as 52 and 49 respectively.









V. Rough Indices in a Decision Table with Fuzzy Decision Attribute

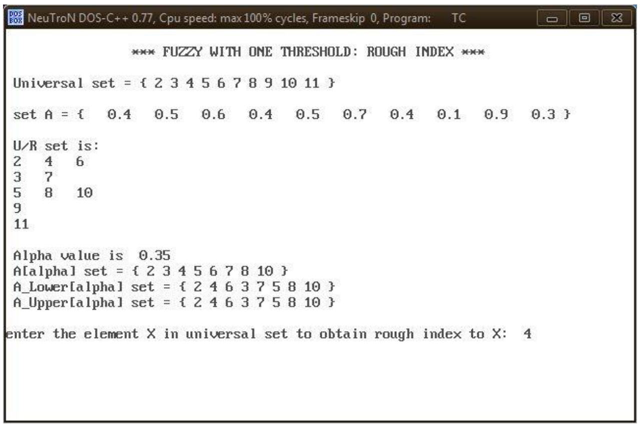
In this section, by hybridizing the algorithms described in sections 3 and 4, rough indices are obtained for each element of the Universe of discourse. Similar to the above algorithms, by applying square and/ or square root functions on the threshold of the fuzzy input A, the rough indices are obtained accordingly. The algorithm is illustrated for a decision table with a fuzzy decision attribute.

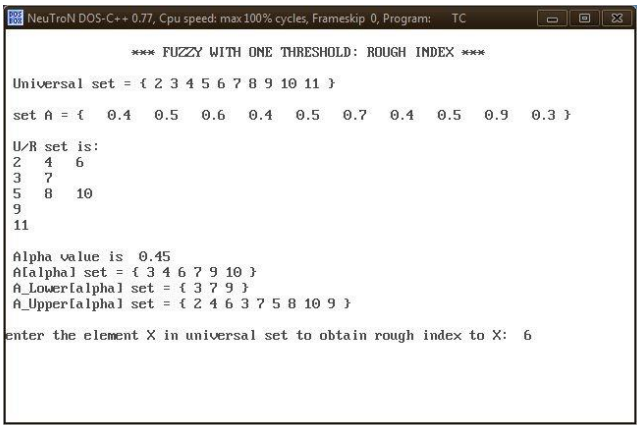
5.1 Algorithm for Rough index of an element

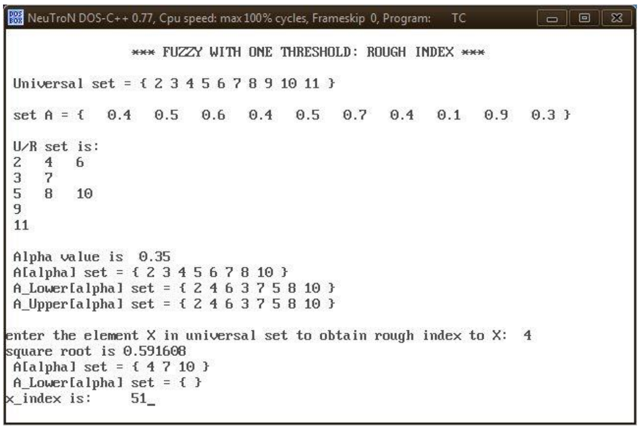
```
Algorithm (alpha, A, x)
//Algorithm to obtain index of x an element of
universe of discourse
//Algorithm returns the index
    1. Let x_index be an integer initialized to M
    2. Pick the equivalence class K containing x.
    3. If U(y)=0 for all y belongs to K
          Begin
                x_index = -x_index
                goto 7
          End
    4. If U(y)=1 for all y belongs to K
                goto 7
    5. Compute "A lower bound of alpha" , "A
       upper bound of alpha"
    6. If " x belongs to A lower bound of alpha"
          While (" x belongs to A lower bound
          of alpha")
                Begin
                alpha= sqrt(alpha) //square
          root of alpha
                 x_index=x_index +1
                 Compute "A lower bound of
          alpha"
                End

       else
    7. If " x NOT belongs to A upper bound of
       alpha"

          While ("x NOT belongs to A upper
          bound of alpha")
                Begin
                alpha= sqr(alpha) //square of
          alpha
                 x_index=x_index-1
                 Compute "A upper bound of
          alpha"
                End
       else
          Begin
                beta = alpha
                compute "A lower bound of
             alpha" , "A upper bound of beta"
                while("x NOT belongs to A
          lower bound of alpha" AND
                         "x belongs to A upper
                bound of alpha")
                      Begin
                      alpha = sqr(alpha)
                      beta = sqrt(beta)
                      compute "A lower
                   bound of alpha" , "A
                   upper bound of beta"
                      x_index=x_index+1
                      End
                If "x belongs to A lower
                bound of alpha"
                x_index=-x_index
          End

    8. Return x_index
```

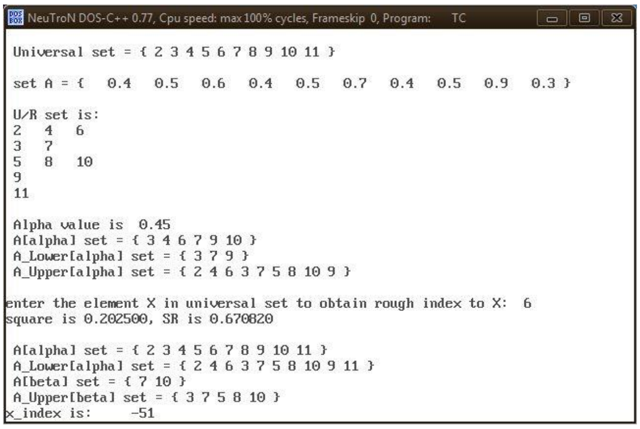
5.2 Experimental Results

For the above example, the rough indices of 4 and 6 are computed as 51 and -51 respectively.









VI. Conclusion

In this paper, we implemented rough sets based algorithms to compute indices for the objects in fuzzy decision tables using a threshold.

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