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Rough-Fuzzy Classification with Two Thresholds-Algorithms and Implementations using C

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Abstract: In this paper, we propose three algorithms to index the records of a decision table with fuzzy decision attributes using two thresholds under Rough Computing. These algorithms are also implemented using C.
Keywords: Decision Table, Fuzzy Decision attributes, Rough Computing, Indexing.

1. Introduction

Z.Pawlak's rough sets [6,7,8] and L.Zadeh's fuzzy concepts [4] are widely in use in the area of knowledge engineering and hence, the hybridization of these two concepts is being focused by several researchers. In this line, G.Ganesan et. al., [1,2,3,5] introduced indexing techniques on the elements 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. The paper is organized into 6 sections. In section 2, the basic mathematical concepts pertained to the subsequent sections are dealt. In 3rd, 4th and 5th sections we provide lower, upper and rough indices algorithms respectively for a decision table with fuzzy decision attribute using two thresholds and these algorithms are implemented using C Programming. The 6th section deals with the concluding remarks.

2. Mathematical Preliminaries

Here, we describe the mathematical concepts involved in the subsequent sections.

2.1 Rough Sets

For a given finite universal set U and an equivalence relation R, let $U/R=\{W_1,W_2,\ldots,W_m\}$ denote the quotient space of U induced by R. For a given subset A of U, the lower and upper rough approximations [7,8] proposed by Z.Pawlak may be obtained by the following algorithms.
Lower Rough Approximations

\\$W_1, W_2, \ldots, W_m$ – Equivalence Classes

\\ A-Input

Let D=NULL

For i=1 to m do

If W_i is subset of A, then $D= D \cup W_i$

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Return D

Lower Rough Approximations

\\W_1, W_2, …, W_m – Equivalence Classes

\\ A-Input

Let D=NULL

For i=1 to m do

If A $\cap W_i \neq$ NULL then D= D $\cup$ W_i

Return D

2.2 Hybridization of Roughness and fuzziness through two thresholds

For a given Universal set U, let A be any fuzzy subset of U and let α and β denote two thresholds ($\alpha<\beta$) ranging between 0 and 1. Define $A[\alpha,\beta]=\{x\in U/\ \alpha < \mu_A(x) < \beta\}$. The lower and upper rough approximations of A with respect to α and β are given by $A_{\alpha,\beta} = \underline{A[\alpha,\beta]}$ and $A^{\alpha,\beta} = \overline{A[\alpha,\beta]}$ respectively.

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

Here, an algorithm is dealt to compute the lower index by using square and square root functions on two thresholds of a fuzzy input A. To compute the index, the lower rough approximations are used. This algorithm is illustrated using a decision table with fuzzy decision attribute.

3.1 Algorithm for Lower index of an element

Algorithm (alpha, beta, 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,beta"

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

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

else
    While ("x NOT belongs to A lower bound of alpha,beta")
        Begin
        alpha= sqr(alpha) //square of alpha
          beta = sqrt(beta) // square root of  beta
        x_index=x_index-1
          Compute "A lower bound of alpha,beta"
        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	Excellent	Good	Excellent	0.4
3	Good	Excellent	Very Good	0.5
4	Good	Good	Excellent	0.6
5	Poor	Very Good	Fair	0.4
6	Fair	Good	Fair	0.5
7	Poor	Excellent	Good	0.7
8	Excellent	Very Good	Fair	0.4
9	Excellent	Fair	Poor	0.1
10	Very Good	Very Good	Good	0.9
11	Fair	Poor	Fair	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 {(Excellent, {2,8,9}), (Very Good,{10}), (Good, {3,4}), (Fair, 6,11}), (Poor, {5,7}) }. For Attr_2, the grouping are {(Excellent,{3,7}), (Very Good,{5,8,10}), (Good,{2,4,6}), (Fair,{9}), (Poor,{11})} and for Attr_3, we obtain {(Excellent, {2,4}), (Very Good,{3}), (Good,{7,10}), (Fair,{5,6,8,11}), (Poor,{9})}.
The above example is implemented in C by using Attr_2 as the key and the threshold as 0.35 using the thresholds as 0.35 and we obtain the lower index of 3 as 51 and the lower index of 11 as 49

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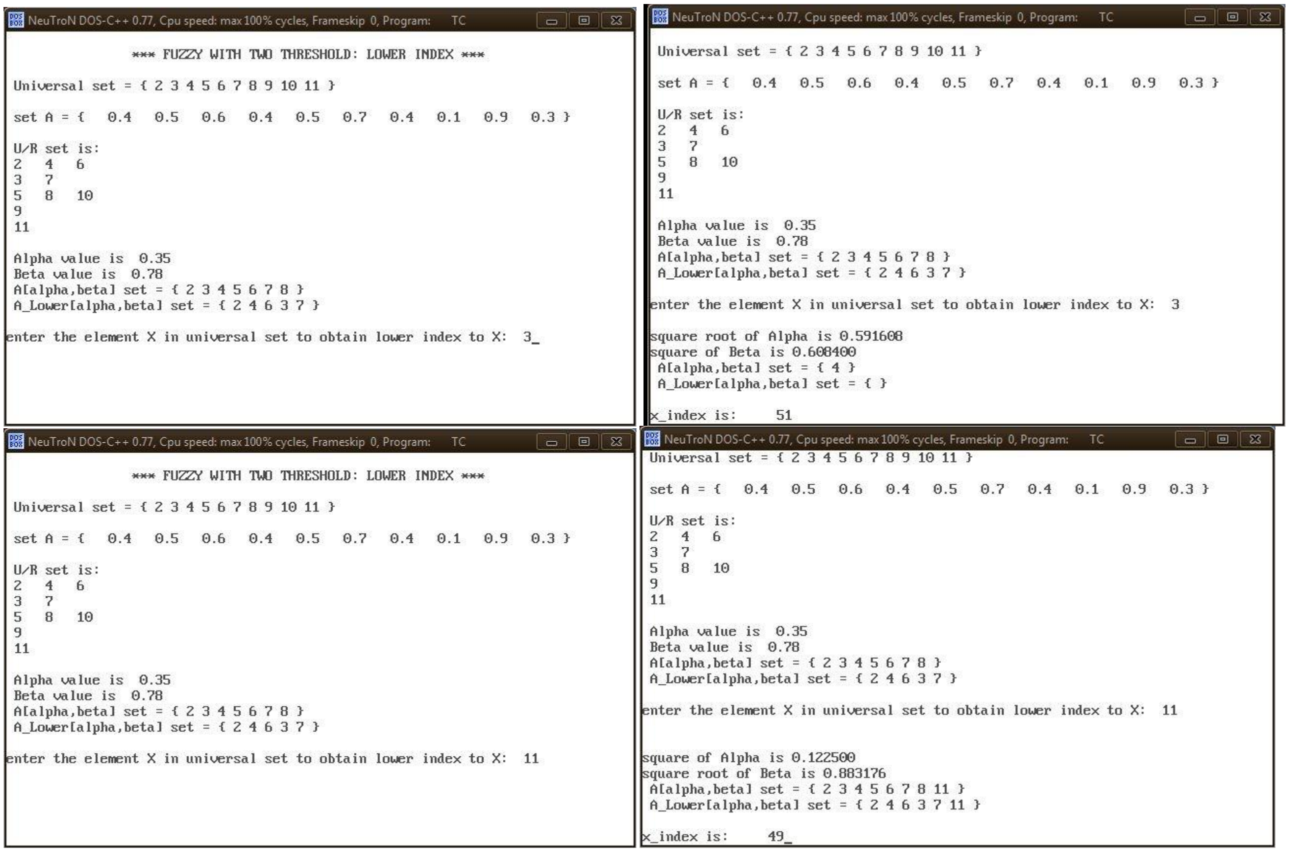


4. Upper Indices in a Decision Table with Fuzzy Decision Attribute

In this section, we propose an algorithm to compute index using upper rough approximations. Similar to third section, square and square root functions are used on two thresholds of a fuzzy input A. The algorithm is illustrated with a decision table consisting of a fuzzy decision attribute.

4.1 Algorithm for Upper index of an element (in Fuzzy Two threshold):-

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, beta"

6. If " x belongs to A upper bound of alpha, beta"
   While ("x belongs to A upper bound of alpha, beta")

   Begin

   alpha = sqrt(alpha) //square root of alpha

   beta = sqr(beta)

   x_index=x_index+1

   Compute "A upper bound of alpha"

   End

   else

   While ("x NOT belongs to A upper bound of alpha, beta")

   Begin

   alpha= sqr(alpha) //square of alpha

   beta = sqrt(beta)

   x_index=x_index-1

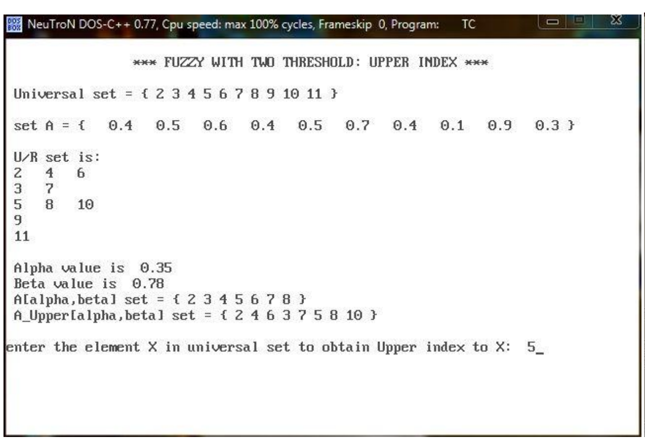
   Compute "A upper bound of alpha"

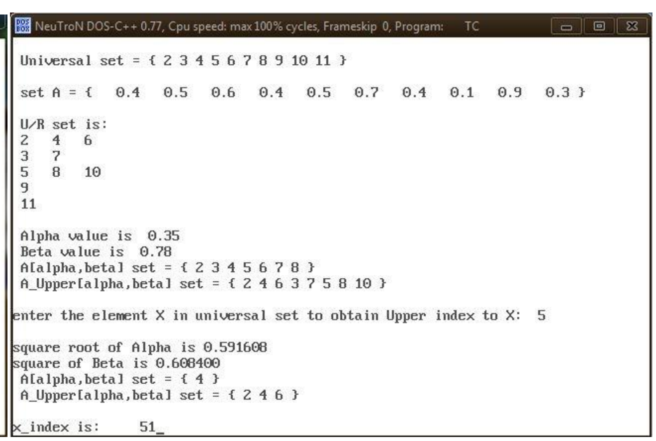
   End

7. Return x_index

4.2 Experimental Results

The above algorithm is implemented in C by considering the example as quoted for lower index, and we obtain the upper index of 5 as 51 and 9 as 48





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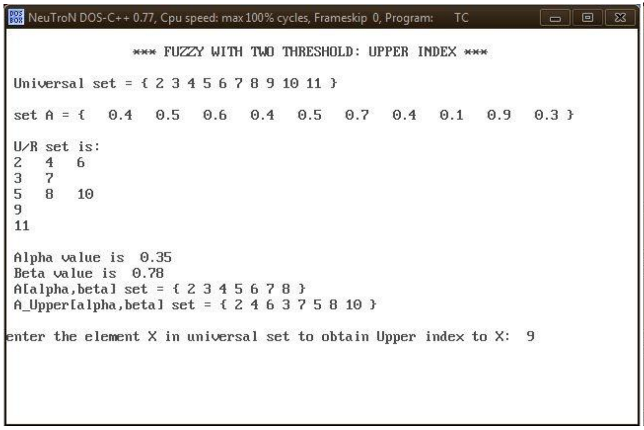
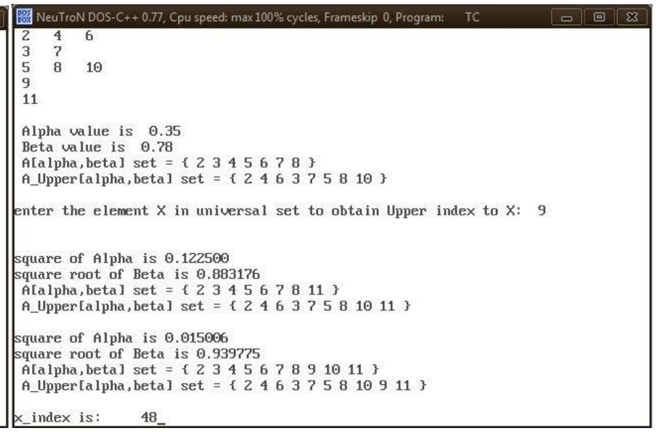




5. Rough Indices in a Decision Table with Fuzzy Decision Attribute

By hybridizing the lower and upper rough approximations, in this section we propose an algorithm to compute rough indices by squaring or square rooting two thresholds of the given fuzzy input A. The algorithm is demonstrated with a decision table containing a fuzzy decision attribute.

5.1 Algorithm for Rough index of an element

Algorithm (alpha, beta, 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 8
   End
4. If U(y)=1 for all y belongs to K
   goto 8
5. Compute "A lower bound of alpha, beta" , "A upper bound of alpha, beta"
6. If " x belongs to A lower bound of alpha, beta"
   While ("x belongs to A lower bound of alpha, beta")
   Begin
   alpha= sqrt(alpha) //square root of alpha
   beta = sqr(beta) // squre of beta
   x_index=x_index+1
   Compute "A lower bound of alpha, beta"
   End
   Goto 8

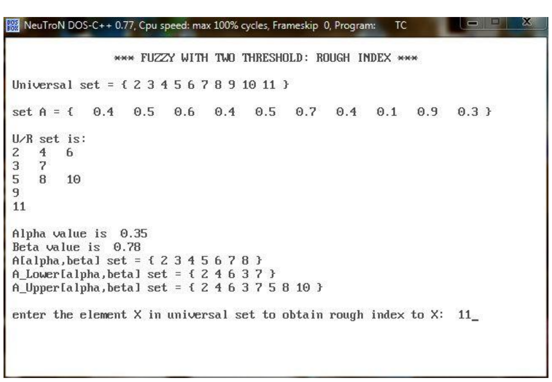
else

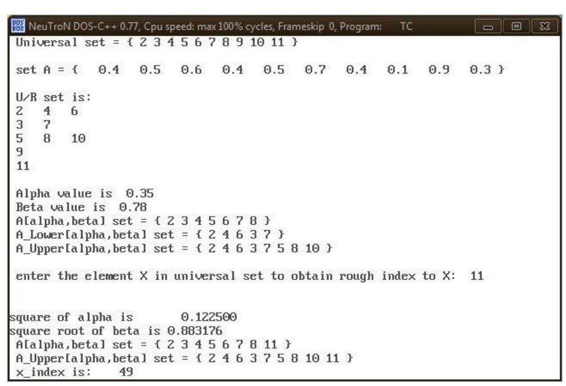
7. If " x NOT belongs to A upper bound of alpha, beta"
    While ("x NOT belongs to A upper bound of alpha, beta")
        Begin
        alpha= sqr(alpha) //square of alpha
        beta = sqrt(beta) // square root of beta
        x_index=x_index-1
        Compute "A upper bound of alpha,beta"
      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

8. Return x_index

5.2 Experimental Results

The above algorithm is implemented in C by considering the example as quoted for lower index, and we obtain the rough indices of 7 and 11 as 51 and 49 repsectively.





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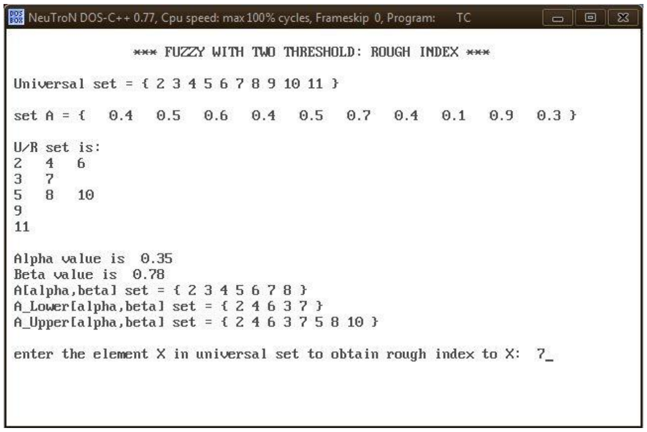

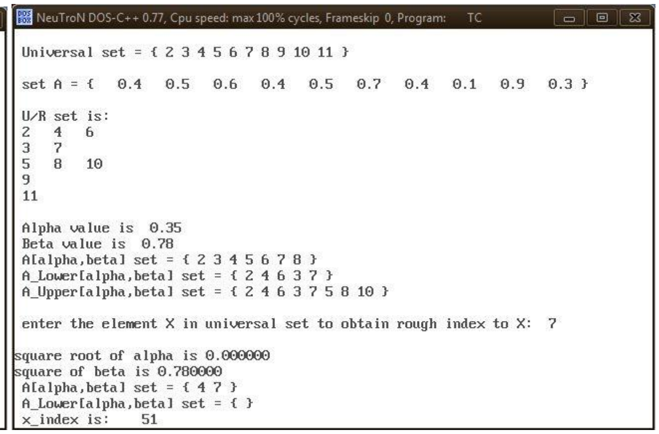

6. Conclusion

In this paper, through C, we implemented the algorithms which were proposed to index a decision table using rough approximations. The same approach may be further extended for any information system with fuzzy decision attributes.

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