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Algorithms on Rough-Intuitionistic Fuzzy Classification with a Threshold and Implementations

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Abstract:
Hybridization of Rough Sets with intuitionistic fuzzy sets is commonly in use for deriving several real time applications. In this aspect, we describe three types of algorithms namely lower, upper and rough indexing algorithms to index the records of decision table with intuitionistic fuzzy decision attributes and the same are implemented using C Programming.

Keywords: *Rough Sets, intuitionistic fuzzy sets, indexing, decision table*

1. Introduction

Considering the importance of the theories on rough sets [4,5], fuzziness and intuitionistic fuzziness [1], a few hybridizing techniques are in practice. In Particular, G.Ganesan et. al.[2,3] developed naïve indexing technique using one threshold in intuitionistic fuzzy input. In this paper, we developed three kinds of indexing techniques using one threshold on intuitionistic fuzzy decision attribute of a decision table.

This paper is organized into 6 sections. In 2nd Section, we narrate the basic mathematical concepts which are required for the forthcoming sections. In 3rd and 4th sections, we propose the lower and upper index algorithms respectively for a decision table with intuitionistic fuzzy decision attribute using one threshold and they are implemented using C Programming. In 5th section, both indexing algorithms are consolidated and rough indexing algorithm is proposed a decision table with intuitionistic fuzzy decision attribute using one threshold and the same has been implemented using C Programming and the paper ends with concluding remarks as 6th section.

2. Mathematical Preliminaries

In this section, we describe the concepts of rough sets, fuzzy sets and intuitionistic fuzzy sets.

2.1 Rough Sets

Let U be a finite universe of discourse U and R be an equivalence relation on U. Let U/R = $\{X_1, X_2, \ldots, X_n\}$ denote the set of all equivalence classes of U induced by R. For a given input Y, the rough approximations are defined as $\underline{R}Y=\cup\{X\in U/R: Y\supseteq X\}$ and $\overline{R}Y=\cup\{X\in U/R: Y\cap X\neq\Phi\}$ where $\underline{R}Y$ and $\overline{R}Y$ are said to be R-lower and R-upper approximations of Y. The following algorithms may be implemented to compute Lower and Upper Rough Approximations.

Algorithm of Lower Rough Approximations

\\X_1, X_2, …, X_n – Equivalence Classes
\\ Y-Input

Let D=NULL
For i=1 to n do
    If Y is superset of X_i, then D= D $\cup$ X_i
Return D

Algorithm of Lower Rough Approximations

\\X_1, X_2, …, X_n – Equivalence Classes
\\ Y-Input

Let D=NULL
For i=1 to t do
    If Y $\cap X_i \neq$NULL then D= D $\cup$ X_i
Return D

2.2 Rough and intuitionistic fuzzy Hybridization

Since Intuitionistic fuzziness is one of the effective tools whenever crisp data is not arrived, in this section, we describe the procedure of hybridizing it with rough approximations.

For a given finite universe of discourse U and for the equivalence relation, denote the quotient space as U/R = {X_1, X_2, …, X_n}. Lat A be an intuitionistic fuzzy subset of U. For a given threshold α (ranging between 0 and 1), define $A[\alpha]=\{x\in U/\mu_A(x)>\alpha$ and $\gamma_A(x)<1-\alpha\}$ where μ_A, γ_A represent membership and non-membership values in A respectively. The lower and upper rough approximations of A are given by $A_\alpha = \underline{A[\alpha]}$ and $A^\alpha = \overline{A[\alpha]}$ respectively.

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

In this section, an algorithm is introduced to compute the lower index using lower rough approximations. In the algorithm, single threshold is used on an intuitionistic 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 intuitionistic 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

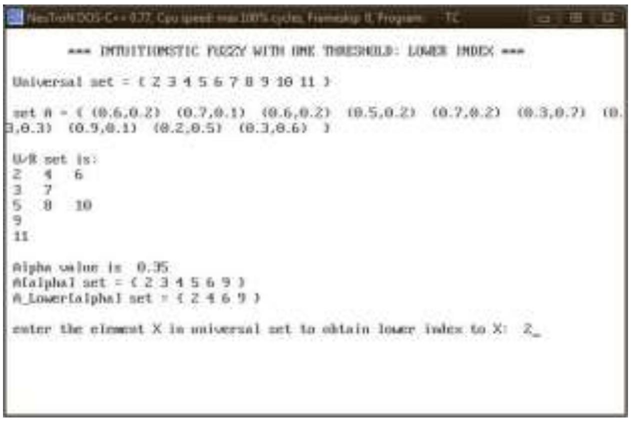
3.2 Experimental Results

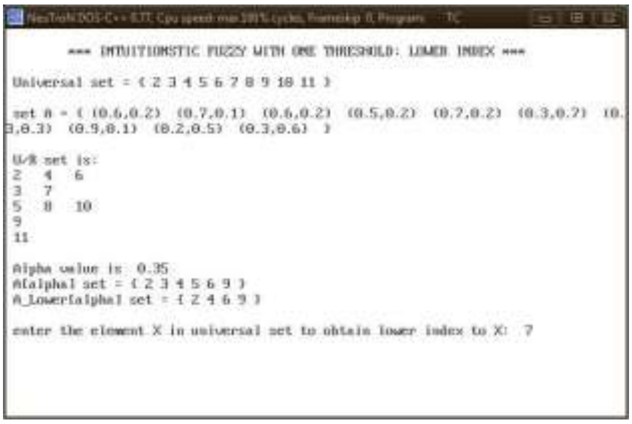
Consider the following decision table with 10 records namely 2,3,4,5,6,7,8,9,10 and 11 with three conditional attributes namely Attr_1, Attr_2, Attr_3 and an intuitionistic fuzzy decision attribute.

	Attr_1	Attr_2	Attr_3	Decision	
				Membership	Non-Membership
2	Violet	Pink	Violet	0.6	0.2
3	Pink	Violet	Red	0.7	0.1
4	Pink	Pink	Violet	0.6	0.2
5	Purple	Red	Black	0.5	0.2
6	Black	Pink	Black	0.7	0.2
7	Purple	Violet	Pink	0.3	0.7
8	Violet	Red	Black	0.3	0.3
9	Violet	Black	Purple	0.9	0.1
10	Red	Red	Pink	0.2	0.5
11	Black	Purple	Black	0.3	0.6

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 {(Violet, {2,8,9}), (Red,{10}), (Pink, {3,4}), (Black, 6,11}), (Purple, {5,7}) }. For Attr_2, the grouping are {(Violet,{3,7}), (Red,{5,8,10}), (Pink,{2,4,6}), (Black,{9}), (Purple,{11})} and for Attr_3, we obtain {(Violet, {2,4}), (Red,{3}), (Pink,{7,10}), (Black,{5,6,8,11}), (Purple,{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 52 and the lower index of 7 as 49





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

In this section, we propose an algorithm to compute an index using upper rough approximations. In this algorithm, an intuitionistic 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 an intuitionistic 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

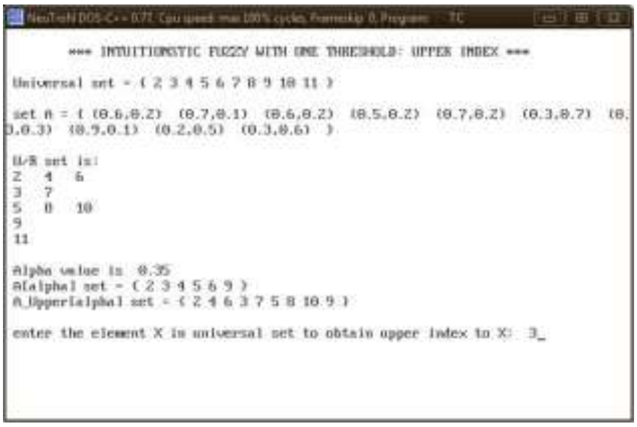
   else

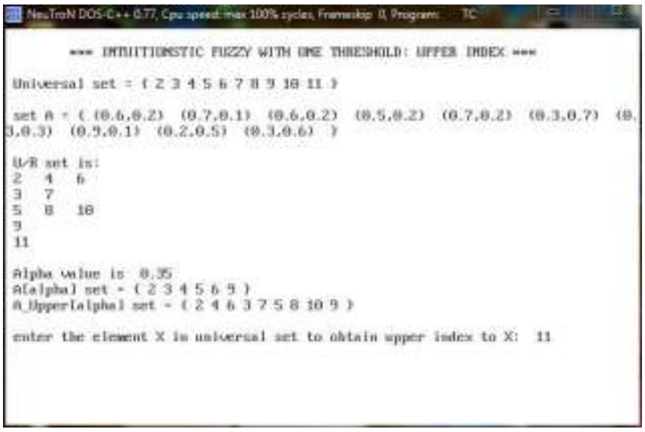
   While ("x NOT belongs to A upper bound of alpha")
   Begin
   alpha= sqr(alpha) //square of alpha
   x_index=x_index- 1
   Compute "A upper bound of alpha"
   End

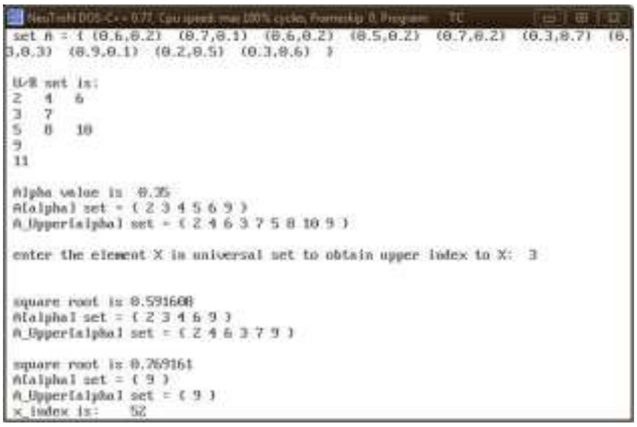
7. Return x_index

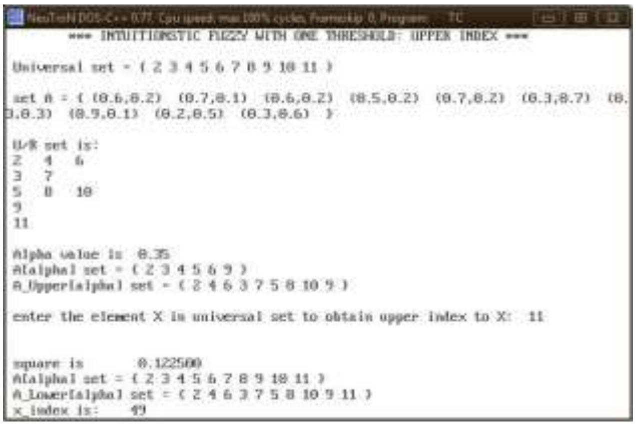
4.2 Experimental Results

In the example, the upper indices of 3 and 11 are computed as 52 and 49 respectively.









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

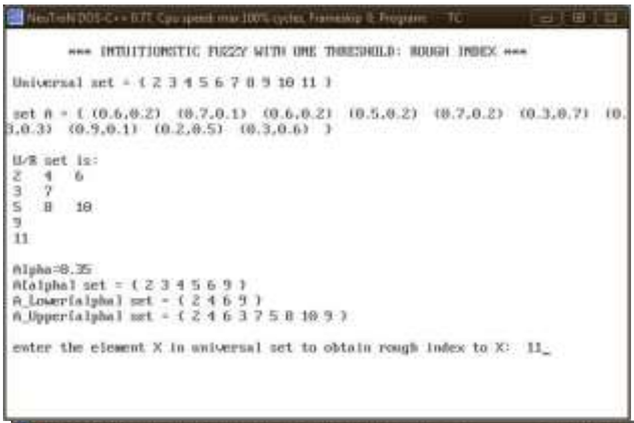
In this section, by hybridizing the algorithms described in sections 3 and 4, rough indices are obtained for each element of the Universe of discourse. Similar to the above algorithms, by applying square and/ or square root functions on the threshold of the intuitionistic fuzzy input A, the rough indices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

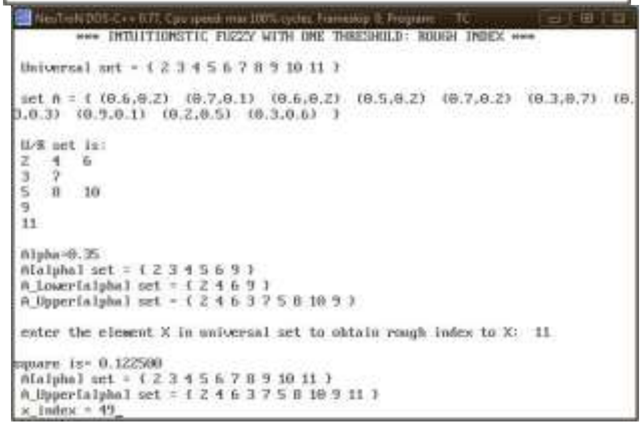
5.1 Algorithm for Rough index of an element

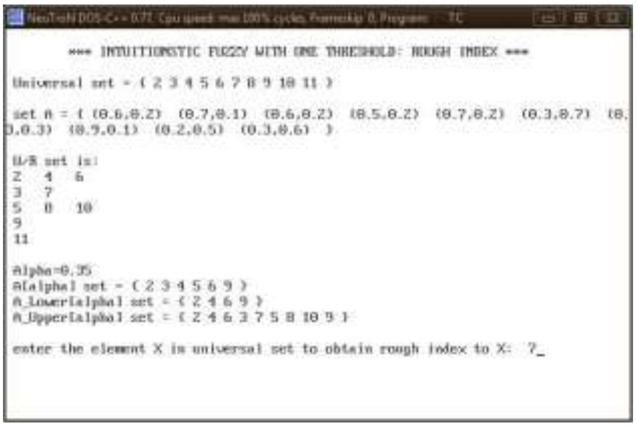
```
Algorithm (alpha, A, x)
//Algorithm to obtain index of x an element of
universe of discourse
//Algorithm returns the index
    1. Let x_index be an integer initialized to
       M

    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
```

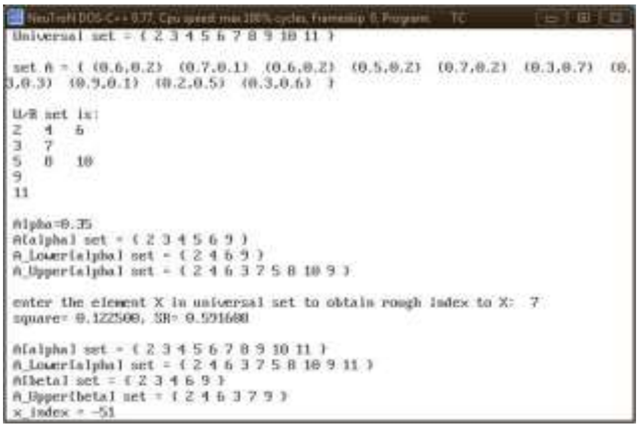
5.2 Experimental Results

In the above example, the rough indices of 7 and 11 are -51 and 49 repsectively.









6. Conclusion

In this paper, we implemented three algorithms using C Programming for computing indices of the records of the decision table with intuitionistic fuzzy decision attributes.

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