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# Rough-Intuitionistic Fuzzy Classification with Two Thresholds- Algorithms and Implementations

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**ABSTRACT**

The theories of Rough sets and Intuitionistic fuzzy sets are commonly in use in various technical applications. In this paper, we propose three types of indexing algorithms to index the records of the decision table with intuitionistic fuzzy decision attributes and we implement them using C Programming.

**Keywords:** indexing, rough sets, decision table, intuitionistic fuzziness

## 1. INTRODUCTION

Theory of rough sets [4,5] is commonly in use for the researches pertained to knowledge engineering and in some of the real time applications; the data may not be crisp in nature. Hence, a few researchers have been concentrating on dealing uncertainty in knowledge engineering. In Particular, G.Ganesan et. al., [2,3] demonstrated an indexing technique using two thresholds in intuitionistic fuzzy input. In this paper, we developed three kinds of indexing techniques using two thresholds on intuitionistic fuzzy decision attribute of a decision table.

The paper is organized into 6 sections. In 2nd section, 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 intuitionistic 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

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

### 2.1 Rough Sets

For a given finite universe of discourse U and an equivalence relation R on U, let U/R = {$Y_1$, $Y_2$, …, $Y_t$} denote the set of all equivalence classes of U induced by R. For a given input X, Pawlak's rough approximations are defined as $\underline{R}X=\cup\{Y\in U/R: Y\subseteq X\}$ and $\overline{R}X=\cup\{Y\in U/R: Y\cap X\neq\Phi\}$ where $\underline{R}X$ and $\overline{R}X$ are said to be R-lower and R-upper approximations of X. For the purpose of implementation of these approximations, we provide the algorithms to compute Lower and Upper Rough Approximations [4,5] as follows:

Algorithm of Lower Rough Approximations

\\$Y_1$, $Y_2$, …, $Y_t$ – Equivalence Classes
\\ X-Input

Let D=NULL
For i=1 to t do
    If X is superset of $Y_i$, then D= D $\cup$ $Y_i$
Return D

Algorithm of Lower Rough Approximations

\\$Y_1$, $Y_2$, …, $Y_t$ – Equivalence Classes
\\ X-Input

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

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Attanassov's intuitionistic fuzzy sets [1] are commonly in use as the effective tool than fuzzy tools whenever the non-membership is not a compliment of membership. Now, we focus on hybridizing roughness and intuitionistic fuzziness.

### 2.2 Hybridization of Roughness and Intuitionistic Fuzziness

Let U ={$x_1$,$x_2$,…$x_n$} be any universe of discourse and A be any intuitionistic fuzzy subset of U. If $\mu_A$ and $\gamma_A$ be the membership and non membership functions defined on the universe of discourse U to [0,1] with $0\leq\mu_A(x)+\gamma_A(x)\leq 1$ for every x in U, Then the intuitionistic fuzzy subset A of U is denoted by

$$A = ((\mu_A(x_1), \gamma_A(x_1)), (\mu_A(x_2), \gamma_A(x_2)), \ldots, (\mu_A(x_n), \gamma_A(x_n)))$$

Now, define $A\begin{bmatrix} \alpha_1 & \alpha_2 \\ \beta_1 & \beta_2 \end{bmatrix} = \{x \in U / \alpha_1 < \mu_A(x) < \alpha_2 ; \beta_1 < \gamma_A(x) < \beta_2\}$ . Let X be any partition of U, say {$B_1$,$B_2$,…,$B_t$}. For the given intuitionistic fuzzy set A, the lower and upper approximations with respect to α and β can be defined as

$$A_{\begin{bmatrix} \alpha_1 & \alpha_2 \\ \beta_1 & \beta_2 \end{bmatrix}} = \underline{A\begin{bmatrix} \alpha_1 & \alpha_2 \\ \beta_1 & \beta_2 \end{bmatrix}} \text{ and } A^{\begin{bmatrix} \alpha_1 & \alpha_2 \\ \beta_1 & \beta_2 \end{bmatrix}} = \overline{\begin{bmatrix} \alpha_1 & \alpha_2 \\ \beta_1 & \beta_2 \end{bmatrix}}$$

### 3. LOWER INDICES IN A DECISION TABLE WITH INTUITIONISTIC FUZZY DECISION ATTRIBUTE

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

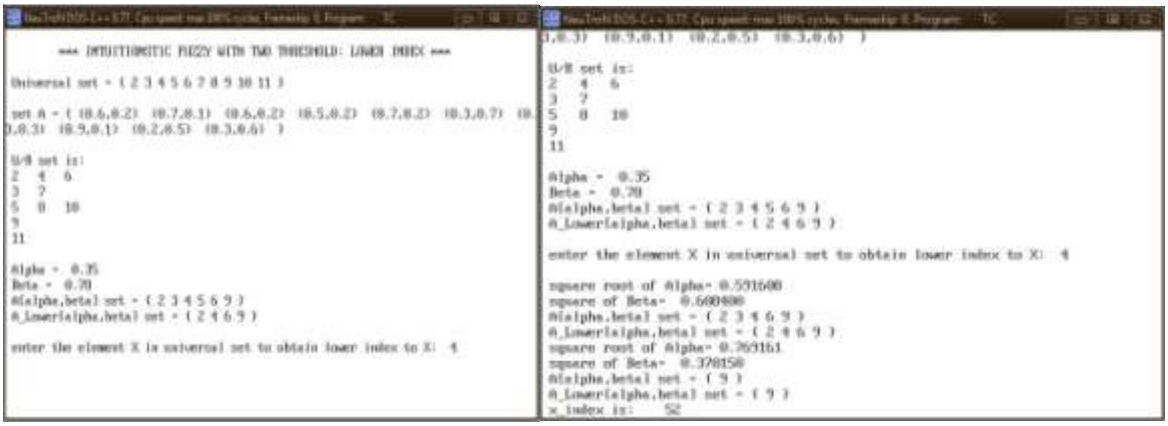
**3.2 Experimental Results**

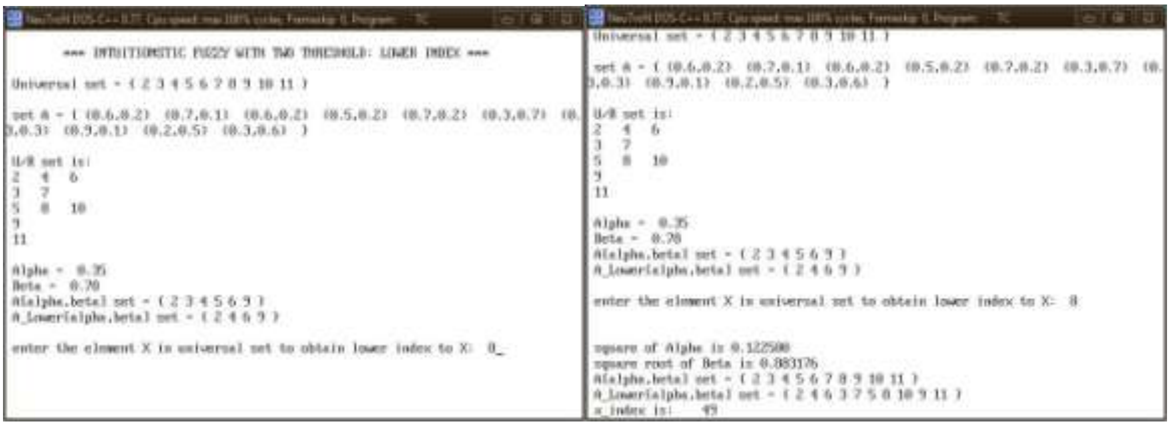
Consider the following decision table with 10 records namely 2,3,4,5,6,7,8,9,10 and 11 with three conditional attributes namely Attr_1, Attr_2, Attr_3 and an intuitionistic fuzzy decision attribute.

| | Attr_1 | Attr_2 | Attr_3 | Decision | |
|---|---|---|---|---|---|
| | | | | Membership | Non-Membership |
| 2 | Satisfactory | Brilliant | Satisfactory | 0.6 | 0.2 |
| 3 | Brilliant | Satisfactory | Average | 0.7 | 0.1 |
| 4 | Brilliant | Brilliant | Satisfactory | 0.6 | 0.2 |
| 5 | Poor | Average | Worst | 0.5 | 0.2 |
| 6 | Worst | Brilliant | Worst | 0.7 | 0.2 |
| 7 | Poor | Satisfactory | Brilliant | 0.3 | 0.7 |
| 8 | Satisfactory | Average | Worst | 0.3 | 0.3 |
| 9 | Satisfactory | Worst | Poor | 0.9 | 0.1 |
| 10 | Average | Average | Brilliant | 0.2 | 0.5 |
| 11 | Worst | Poor | Worst | 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 {( Satisfactory, {2,8,9}), (Average,{10}), (Brilliant, {3,4}), (Worst, 6,11}), (Poor, {5,7}) }. For Attr_2, the grouping are {(Satisfactory,{3,7}), (Average,{5,8,10}), ( Brilliant,{2,4,6}), (Worst,{9}), (Poor,{11})} and for Attr_3, we obtain {( Satisfactory, {2,4}), (Average,{3}), (Brilliant,{7,10}), (Worst,{5,6,8,11}), (Poor,{9})}.

In this example, for Attr_2, the algorithm is implemented in C with the thresholds 0.35 and 0.78. It is observed that the lower index of 4 and 8 are 52 and 49 respectively.






## 4. UPPER INDICES IN A DECISION TABLE WITH INTUITIONISTIC 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 an intuitionistic fuzzy input. The algorithm is illustrated with a decision table consisting of an intuitionistic fuzzy decision attribute.

### 4.1 Algorithm for Upper index of an element

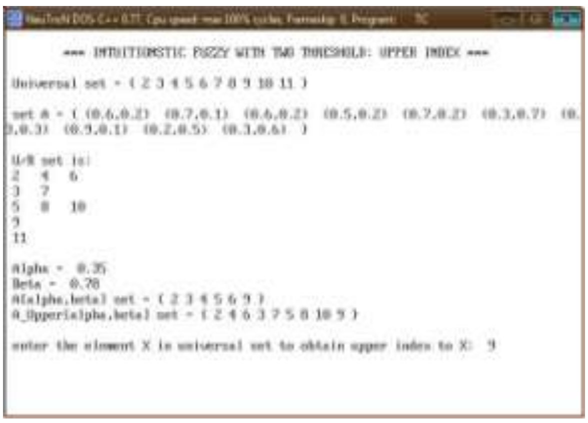
Algorithm (alpha, A, x)
//Algorithm to obtain index of x an element of universe of discourse
//Algorithm returns the index

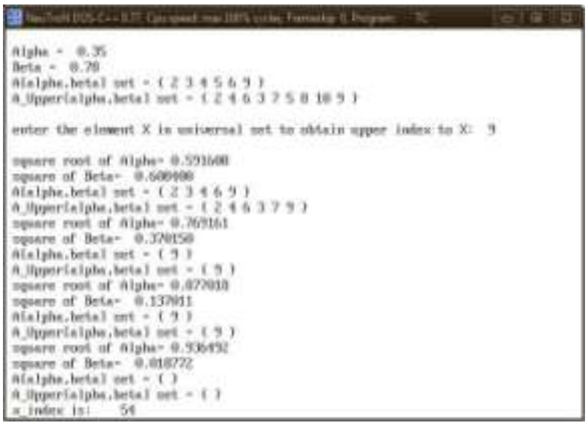
1. Let x_index be an integer initialized to M.
2. Pick the equivalence class K containing x.
3. If U(y)=0 for all y belongs to K
   Begin
      x_index = -x_index
      goto 7
   End
4. If U(y)=1 for all y belongs to K
      goto 7
5. Compute "A upper bound of alpha, beta"
6. If " x belongs to A upper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

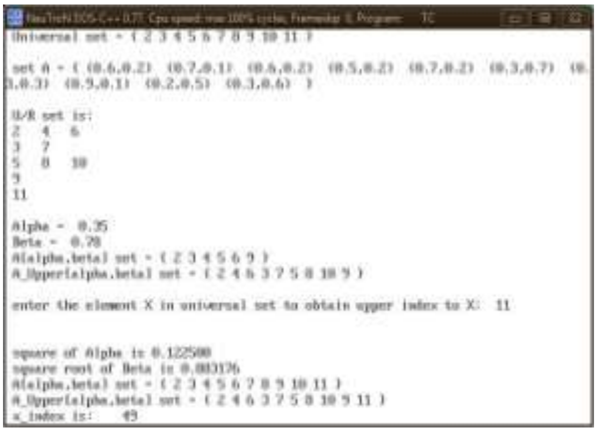
```
        While ("x belongs to A upper bound of alpha, beta")
                Begin
                alpha = sqrt(alpha) //square root of alpha
                beta = sqr(beta)
                x_index=x_index+1
                  Compute "A upper bound of alpha"
                End
    else
        While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

In the above example, we obtain the upper indices of 9 and 11 as 56 and 49 respectively.




## 5. ROUGH INDICES IN A DECISION TABLE WITH INTUITIONISTIC FUZZY DECISION ATTRIBUTE

By hybridizing 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 intuitionistic fuzzy input. The algorithm is demonstrated with a decision table containing an intuitionistic 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"

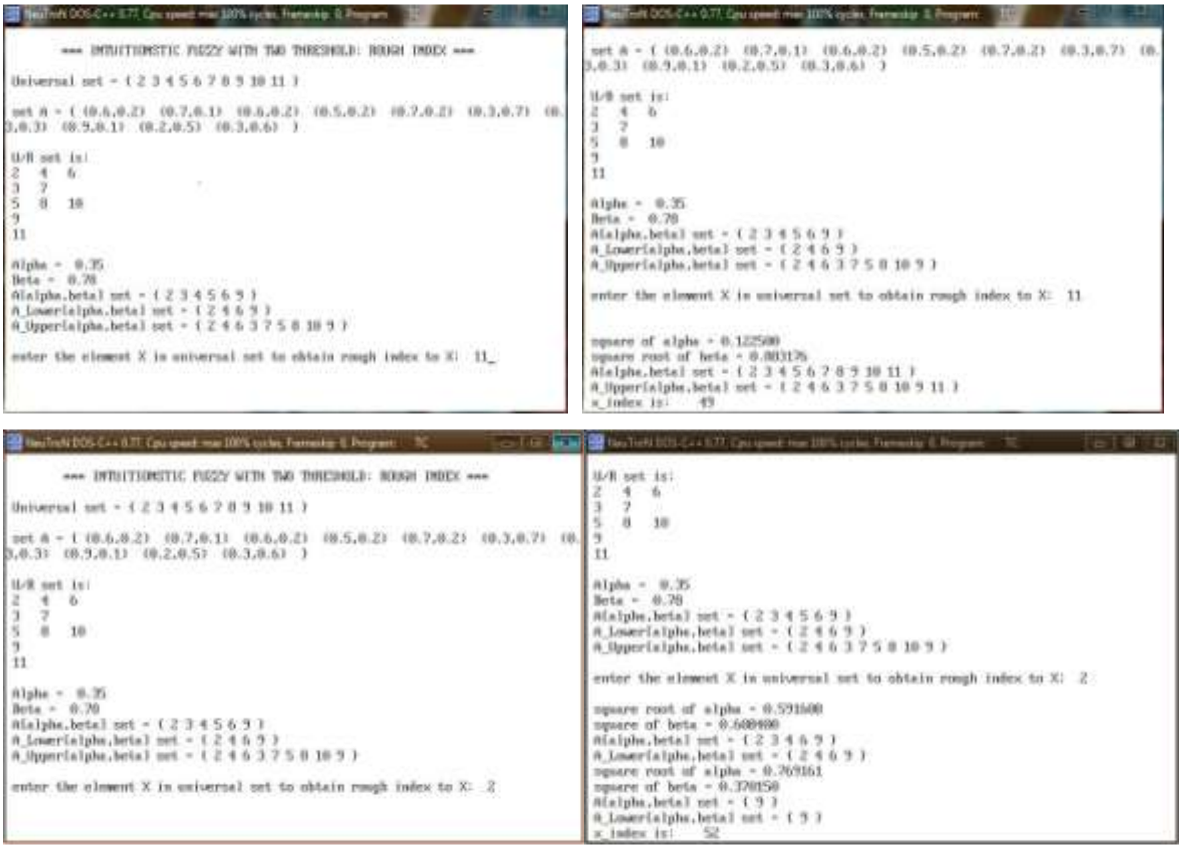
x_index=-x_index

End

8. Return x_index

### 5.2 Experimental Results

In the given example, we obtain rough indices of 2 and 11 as 52 and 49 respectively.



## 6. CONCLUSION

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

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