Some Properties of IF Rough Relational Algebraic Operators in Medical Databases

Chhaya Gangwal, R. N. Bhaumik, Shishir Kumar

***Abstract*—**Some properties of Intuitionistic Fuzzy (IF) rough relational algebraic operators under an IF rough relational data model are investigated and illustrated using diabetes and heart disease databases. These properties are important and desirable for processing queries in an effective and efficient manner.

***Keywords*—** IF Set, Rough Set, IF Rough Relational Database, IF rough Relational Operators.

I. Introduction

SINCE Codd's inception of the relational database (RDB) model in 1970 [5] and Chen's introduction of the entity-relationship (ER) model in 1976 [4], these two models have gained great popularity owning to their fundamental in modeling, rigorousness in theory, and usefulness in practice. The two models have a underlying assumption that all data and information should be precisely given or represented and anything incomplete or uncertain is either artificially precisionized or precluded. However, in many cases, decision makers need to deal with uncertain and imprecise information. To manage impreciseness and uncertainty in relational databases, Fuzzy set theory [8], Intuitionistic Fuzzy (IF) set theory [1], rough set theory [2], [9] and fuzzy rough set theory [3] are finding wide usefulness. Recently [6], we presented an IF rough relational database model along with IF rough relational algebra for querying and applied [7] this model on diabetic patient databases. This paper deals with some properties of IF rough relational algebraic operators along with illustration by diabetes and heart disease databases which are important for query formulation and optimization in IF rough data manipulation.

II. Preliminaries

A. IF Rough Set [6]:

Let U be a universe and X, a rough set in U. An IF rough set A in U is characterized by a membership function $\mu_A: U \to [0,1]$ and a non-membership function $\nu_A: U \to [0,1]$ such that

Chhaya Gangwal is Research Scholar, Dept. of Mathematics, Tripura University, Suryamaninagar, Tripura-799022 (e-mail: c_hhaya@hotmail.com).

R.N.Bhaumik. is Emeritus Fellow (UGC) and Professor(Rtd.), Dept. of Mathematics, Tripura University, Suryamaninagar, Tripura-799022 (e-mail: bhaumik_r_n@yahoo.co. in).

Shishir Kumar is Assistant Professor (Biostatistics), Department of Community Medicine, Agartala Government Medical College, Agartala-799006(e-mail: shishirpunia@gmail.com).

$$\mu_A(\underline{R}X) = 1, \nu_A(\underline{R}X) = 0 \text{ or } [\mu_A(x) = 1, \nu_A(x)] = [1,0].$$

If $(x \in \underline{R}X)$ and $\mu_A(U - \bar{R}X) = 0, \nu_A(U - \bar{R}X) = 1$ or $[\mu_A(x), \nu_A(x)] = [1,0]$. If $(x \in U - \bar{R}X), 0 \leq \mu_A(\bar{R}X - \underline{R}X) + \nu_A(\bar{R}X - \underline{R}X) \leq 1$.

B. IF Rough Relational Database Model [6]:

In this model, a tuple t_i takes the form $(d_{i1}, d_{i2}, \ldots, d_{im}, d_{i[\mu,\nu]})$ where d_{ij} is a domain value of a particular domain set D_j and $d_{i[\mu,\nu]} \in [0,1]$, the domain for IF membership and non-membership values denoted as $d_{i[\mu,\nu]} = [d_{i\mu}, d_{i\nu}]$. In the relational database, $d_{ij} \in D_j$. In the IF rough relational database except for the membership and non-membership values $d_{ij} \subseteq D_j$ where $d_{ij} \neq \phi$.

Definition1: Let P(Di) be the power set of Di. An IF rough relation R is a subset of the product set $P(D_1) \times P(D_2) \times \ldots P(D_m) \times D_{[\mu,\nu]}$, where $D_{[\mu,\nu]}$ is the domain for membership and non-membership value of the closed interval [0,1] and P(Di) = P(Di) - ϕ.

Example1: For a specific relation, R, membership and non-membership are determined semantically. Given that D_1 is the set of names of patients, D_2 is the set of place of patients then, (Anil, Shamli Bazar, [1, 0]), (Gopal, {Durga Nagar, Rani Bazar}, [0.5, 0.5]) (Vishnu, Indra gandhi, [0,1]) are elements of the relation R(Patient Name, Place, [μ, ν]) .

C. IF Rough Relational Operators [6]

The IF rough relational operations on subsets of tuples are shown below. Let T_1 and T_2 be two IF rough relations, then

1) *IF Rough Difference:* The IF rough difference between T_1 and T_2 is an IF rough relation $T = T_1 - T_2$ where

$$T = \{t(d_1, .., d_n[\mu_i, \nu_i]) \in \underline{R}T_1 : t(d_1, .., d_n[\mu_i, \nu_i]) \notin \underline{R}T_2\} \cup t(d_1, .., d_n[\mu_i, \nu_i]) \in \bar{R}T_1 \text{ and } \{t(d_1, .., d_n[\mu_i, \nu_i]) \in \bar{R}T_2 \text{ if } \mu_i > \mu_j\} \cup \quad t(d_1, .., d_n[\mu_i, \nu_i]) \in \bar{R}T_1 \text{ and } t(d_1, .., d_n[\mu_i, \nu_i]) \notin \bar{R}T_2 \text{ if } \mu_i = \mu_j \text{ and if } \nu_i < \nu_j\}.$$

2) *IF Rough Union:* The IF rough union between T_1 and T_2 is an IF rough relation $T = T_1 \cup T_2$ where

$\underline{R}T = \{t : t \in \underline{R}T_1 \cup \underline{R}T_2\}$ and
$\mu_{\underline{R}T}(t) = MAX[\mu_{\underline{R}T_1}(t), \mu_{\underline{R}T_2}(t)]$, and if $\mu_{\underline{R}T_1}(t) = \mu_{\underline{R}T_2}(t), \nu_{\underline{R}T}(t) = MIN[\nu_{\underline{R}T_1}(t), \nu_{\underline{R}T_2}(t)]$,
$\bar{R}T = \{t : t \in \bar{R}\,T_1 \cup \bar{R}T_2\}$ and
$\mu_{\bar{R}T}(t) = MAX[\mu_{\bar{R}T_1}(t), \mu_{\bar{R}T_2}(t)]$, and if $\mu_{\bar{R}T_1}(t) = \mu_{\bar{R}T_2}(t), \nu_{\bar{R}T}(t) = MIN[\nu_{\bar{R}T_1}(t), \nu_{\bar{R}T_2}(t)]$.

3) *IF Rough Intersection:* The IF rough intersection between T_1 and T_2 is an IF rough relation, $T= T_1 \cap T_2$, where

$\underline{R}T = \{t: t \in \underline{R}T_1 \cap \underline{R}T_2\}$ and
$\mu_{\underline{R}T}(t) = MIN[\mu_{\underline{R}T_1}(t), \mu_{\underline{R}T_2}(t)]$, and if $\mu_{\underline{R}T_1}(t) = \mu_{\underline{R}T_2}(t), \nu_{\underline{R}T}(t) = MAX[\nu_{\underline{R}T_1}(t), \nu_{\underline{R}T_2}(t)]$,
$\bar{R}T = \{t: t \in \bar{R}\,T_1 \cap \bar{R}T_2\}$ and
$\mu_{\bar{R}T}(t) = MIN[\mu_{\bar{R}T_1}(t), \mu_{\bar{R}T_2}(t)]$, and if $\mu_{\bar{R}T_1}(t) = \mu_{\bar{R}T_2}(t), \nu_{\bar{R}T}(t) = MAX[\nu_{\bar{R}T_1}(t), \nu_{\bar{R}T_2}(t)]$.

4) *IF Rough Select:* The IF rough selection $\sigma_{A = a}$ (x), of tuples from T_1 is an IF rough relation T_2 having the same schema as T_1 and where

$$\underline{R}T_2 = \{t \in T_1 : \cup_i [a_i] = \cup_j [b_j]\},$$
$$\bar{R}T_2 = \{t \in T_1 : \cup_i [a_i] \subseteq \cup_j [b_j]\}, a_i, b_j \in dom(A)$$

5) *IF Rough Project:* The IF rough projection of T_1 onto Y, $\pi_Y(T_1)$ is an IF rough relation T_2 with schema $T_2(Y)$ where

$T_2(Y) = \{t(Y) : t \in T_1\}$.

6) *IF Rough Join:* The IF rough join, T_1 join T_2, of two relations T_1 and T_2, is a relation

$T(C_1, C_2, \ldots, C_{m+n})$ where T = {t: $\exists t_{T_1} \in T_1, t_{T_2} \in T_2\}$ for $t_{T_1} = t(X), t_{T_2} = t(Y)$ and $t_{T_1}(X \cap Y) = t_{T_2}(X \cap Y), \mu = 1, \nu = 0$ for $\underline{R}T$ and $t_{T_1}(X \cap Y) \subseteq t_{T_2}(X \cap Y)$ *or* $t_{T_2}(X \cap Y) \subseteq t_{T_1}(X \cap Y), \mu = MIN(\mu_{T_1}, \mu_{T_2})$ and if $\mu_{T_1} = \mu_{T_2}, \nu = MAX(\nu_{T_1}, \nu_{T_2})$, for $\bar{R}T$.

III. Properties of IF Rough Relational Algebraic Operators

To consider above IF rough relational operators for data modeling and querying, we need to investigate the properties of the operators to address the issues such as how a certain operation could be formulated with other operations and how an expression could be transformed. In this section some properties of IF rough relational algebraic operators are investigated and the expressive power of the model demonstrated through its IF rough relational algebra taking examples of queries to the ‘‘diabetic’’ and “heart” patient database. Here, the indiscernibility relation is used for equivalence of attribute values rather than equality of values for all of these operators.

A. Intersection Operator

The IF rough intersection operation, a binary operation on relations T_1 and T_2 can be expressed in terms of IF rough difference $T_1 \cap T_2 = T_1 - (T_1 - T_2)$.

Let us first evaluate the left-hand side of the equation using the data from Table XIII and XIV of the Appendix. Let T_1 = DIABETIC PATIENTS and T_2 = HEART PATIENTS and we can calculate $T_1 \cap T_2$ by applying IF rough relational intersection operator-

TABLE I
Result of ($T_1 \cap T_2$)

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
414	F	Young-adult	Medium	{Normal, High}	{Normal, High}	[0.3,0.6]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]

Now, we can compute the right-hand side of the equation and find $T_1 - T_2$.

TABLE II
Result of (T_1- T_2)

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
402	M	Adult	Normal	Medium	Normal	[0.3,0.6]
410	M	Senior	High	High	Normal	[0.7,0.2]
419	M	Senior	Very high	Very high	Very high	[0.8,0.1]
420	F	Senior-Citizen	High	Very high	High	[0.7,0.2]
422	M	Adult	Medium	High	High	[0.4,0.3]

So we can find the results of $T_1 - (T_1 - T_2)$ in the following IF rough relation:

TABLE III
Result of T_1 – (T_1 - T_2)

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
414	F	Young-adult	Medium	{Normal, High}	{Normal, High}	[0.3,0.6]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]

Which is certainly not equal to $T_1 \cap T_2$.

Now we reverse the original relations, supposing T_1 = HEART PATIENTS and T_2 = DIABETIC PATIENTS. The left-hand side of the equation will be unaffected since $T_1 \cap T_2 = T_2 \cap T_1$. On the right-hand side, we can calculate. $T_1 - (T_1 - T_2)$. First we obtain the difference $T_1 - T_2$ which is (HEART PATIENTS - DIABETIC PATIENTS):

TABLE IV
T(1) = Heart Patients - Diabetic Patients

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
408	M	Adult	High	Medium	High	[0.4,0.4]
418	M	Senior	High	Medium	Normal	[0.8,0.1]
424	M	Senior	High	High	Normal	[0.7,0.2]

We now subtract this IF rough relation from to obtain

TABLE V
RESULT OF $T_1-(T_1-T_2)$

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
414	F	Young-adult	Medium	{Normal, High}	{Normal, High}	[0.3,0.6]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]

This is equal to the left-hand side $T_1 \cap T_2$ and not the same result as before. Therefore, because of the varying levels of uncertainties in similar tuples and the properties of the IF rough difference operator, the property $T_1 \cap T_2 = T_1 - (T_1 - T_2)$ does not always hold in the IF rough relational database.

B. Select Operator

Property: IF rough select is a unary operator on relations. An interesting property is the distribution of the IF rough select operator over the Boolean operations. This property states that for an operator γ and two IF rough relations T_1 and T_2 over the same schema,

$$\sigma_{A=a}(T_1 \gamma T_2) = \sigma_{A=a}(T_1)\ \gamma\ \sigma_{A=a}(T_2)$$

where $\gamma \in \{\cup, \cap, -\}$.

The proof of this property is given below for distribution of selection over intersection:

Proof : $\sigma_{A=a}(T_1 \cap T_2) = \sigma_{A=a}(T)$, where $\underline{T}$={t: $t \in \underline{T_1}$ and $\exists\ s \in \underline{T_2}: t \approx_R\ s\} \cup$ and {s : s $\in \underline{T_2}$ and $\exists\ t \in \underline{T_1}: s \approx_R\ t\}$

$= t' \in \{\{t: t \in \underline{T_1}$ and $\exists\ s \in \underline{T_2}: t \approx_R\ s\} \cup t \in \underline{T_2}$ and $\exists\ s \in \underline{T_2}: t \approx_R\ s\}\} \cup_i [a_i] \subseteq \cup_j [b_j]\}, a_i \in a,\ b_j \in t'(A)$

$$= \left\{\{t: t \in \underline{T_1} \textit{ and } \cup_i [a_i] = \cup_j [b_j]\} \cap \{t: t \in \underline{T_2} \textit{ and } \cup_i [a_i] = \cup_j [b_j]\}\right\}$$

$= \sigma_{A=a}(\{t: t \in \underline{T_1}\}) \cap \sigma_{A=a}(\{t: t \in \underline{T_2}\})$

$$\sigma_{A=a}(\underline{T_1}) \cap \sigma_{A=a}(\underline{T_2}) \qquad (i)$$

and $\overline{T}$\{t: $t \in \overline{T}_1$ and $\exists\ s \in \overline{T}_2: t \approx_R\ s\} \cup$ and {s : s $\in \overline{T}_2$ and $\exists\ t \in \overline{T}_1: s \approx_R\ t\}$

$= t' \in \{\{t: t \in \overline{T}_1$ and $\exists\ s \in \overline{T}_2: t \approx_R\ s\} \cup t \in \overline{T}_2$ and $\exists\ s \in \overline{T}_2: t \approx_R\ s\}\} \cup_i [a_i] \subseteq \cup_j [b_j]\}, a_i \in a,\ b_j \in t'(A)$

$$= \left\{\{t: t \in \overline{T}_1 \textit{ and } \cup_i [a_i] = \cup_j [b_j]\} \cap \{t: t \in \overline{T}_2 \textit{ and } \cup_i [a_i] = \cup_j [b_j]\}\right\}$$

$\sigma_{A=a}(\{t: t \in \overline{T}_1\}) \cap \sigma\_(A = a)\ (\{t: t \in \overline{T}_2\})$

$$\sigma_{A=a}(\overline{T}_1) \cap \sigma_{A=a}(\overline{T}_2) \qquad (ii)$$

From (i) and (ii)

$$T = \sigma_{A=a}(\{t: t \in T_1\}) \cap \sigma_{A=a}(\{t: t \in T_2\})$$
$$T = \sigma_{A=a}(T_1) \cap \sigma_{A=a}(T_2).$$

Consider the following example, which refer to Table XIII and XIV of the Appendix. Let T_1 = DIABETIC PATIENTS and T_2= HEART PATIENTS, and let us first evaluate the left-hand side of the proof using the data from DIABETIC PATIENTS and HEART PATIENTS.

T(1) = DIABETIC PATIENTS ∩ HEART PATIENTS yields :

TABLE VI
T(1) = DIABETIC PATIENTS ∩ HEART PATIENTS

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
414	F	Young-adult	Medium	{Normal, High}	{Normal, High}	[0.3,0.6]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]

Now let us perform a selection operation on T(1) to complete the left-hand side of the equation of the previous proof. $LHS = \sigma_{\text{LIPID PROFILE} = \text{'High'}}\ T(1)$ yields the following IF rough set of tuples:

TABLE VII
Σ LIPID PROFILE = 'HIGH' T(1)

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]

Now the right-hand side of the equation $T(2) = \sigma_{\text{LIPID PROFILE} = \text{'High'}}(\text{DIABETIC PATIENTS})$ yields

TABLE VIII
Σ LIPID PROFILE = 'HIGH'(DIABETIC PATIENTS)

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
410	M	High	High	High	Normal	[0.7,0.2]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]

and $T(3) = \sigma_{\text{LIPID PROFILE} = \text{'High'}}(\text{HEART PATIENTS})$ yields

TABLE IX
Σ LIPID PROFILE = 'HIGH'(HEART PATIENTS)

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
408	M	Adult	High	Medium	High	[0.4,0.4]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
418	M	Senior	High	Medium	Normal	[0.8,0.1]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]
424	M	Senior	High	High	Normal	[0.7,0.2]

When the intersection of T(2) and T(3) is taken next, the result is the same as that computed for the left-hand side of the equation: RHS = T(2) ∩ T(3), which yields

TABLE X
T(2) ∩ T(3)

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]

C. Project Operator

Intuitionistic fuzzy (IF) rough project operator is also a unary operator on relations and chooses a subset of the columns. If two projections are performed in a row, the latter subsumes the former. Let T_1 be an IF rough relation on the schema R, if π_Y is applied to the result of applying π_Y to T_1, the result is the same as if π_Y were applied directly to T_1 , if the original application of π_Y was proper. More precisely, given $T_1(R)$ and $Y \subseteq X \subseteq R$, $\pi_Y(\pi_X(T_1)) = \pi_Y(T_1)$.

A property of the IF rough projection operator is that for a string of projections upon a relation T_1 having schema R, where only the outermost projection operator is necessary. Due to the indiscernibility, we are dealing with equivalence class values and not ordinary values in the removal of redundant tuples:

$$\pi_{Y_1}(\pi_{Y_2}(....(\pi_{Y_n}(T_1))...)) = \pi_{Y_1}(T_1).$$

Because each set of attributes Y_i is included in the set Y_{i+1}, and because at every step of the sequence of projections on the left side of the equality a subset of the attributes is retained and redundant tuples removed until we reach the minimum subset Y_1, the same IF rough relation would result by taking the subset of attributes Y_1 to begin with and removing redundant tuples all at once.

The operations on both sides of the equality produce relations which are equal in the sense that every tuple in one IF rough relation has a corresponding tuple in the other IF rough relation such that the tuples are indiscernible from each other. In other words, every tuple of one relation is redundant with one and only one tuple of the other relation. For example, the operation

$$\pi_{\text{LIPID PROFILE}}(\pi_{\text{LIPID PROFILE,FBS}}(\text{HEART PATIENTS})).$$

This is equal to $\pi_{\text{LIPID PROFILE}}(A)$, where A is the result of the inner projection shown in the following:

TABLE XI
Π LIPID PROFILE (Π LIPID PROFILE, FBS (HEART PATIENTS))

Lipid Profile	FBS	[μ,ν]
Medium	{Normal, High}	[0.3,0.5]
{High, Very high}	Very high	[0.4,0.4]
High	Normal	[0.8,0.1]
High	High	[0.6,0.3]

The second projection operation results in the following:

TABLE XII
Π LIPID PROFILE (A)

Lipid Profile	[μ,ν]
Medium	[0.3,0.5]
{High, Very high}	[0.4,0.4]
High	[0.8,0.1]

which is the result that would have been obtained by the operation

$$\pi_{\text{LIPID PROFILE}}(\text{HEART PATIENTS}).$$

IV. CONCLUSION

The IF rough relational database is a sound model which incorporate the various types of uncertainty into the underlying data model and its algebra. The properties of IF rough relational algebraic operators investigated, in this paper, are important for query formulation and optimization in IF rough data manipulation.

APPENDIX

Consider the following three tables namely Diabetics and Heart disease having different attributes for getting the results of various operators and queries-

TABLE XIII
ATTRIBUTES OF DIABETIC PATIENTS

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
402	M	Adult	Normal	Medium	Normal	[0.3,0.6]
410	M	Senior	High	High	Normal	[0.7,0.2]
414	F	Young-adult	Medium	{Normal, High}	{Normal, High}	[0.3,0.6]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
419	M	Senior	Very high	Very high	Very high	[0.8,0.1]
420	F	Senior-Citizen	High	Very high	High	[0.7,0.2]
422	M	Adult	Medium	High	High	[0.4,0.3]

TABLE XIV
ATTRIBUTES OF HEART PATIENTS

ID	Sex	Age	Lipid Profile	BP	FBS	[μ,ν]
408	M	Adult	High	Medium	High	[0.4,0.4]
414	F	Young-adult	Medium	{Normal, High}	{Normal, High}	[0.3,0.5]
415	F	{Senior, Adult}	{High, Very high}	High	Very high	[0.4,0.4]
418	M	Senior	High	Medium	Normal	[0.8,0.1]
420	F	Senior-Citizen	High	Very high	High	[0.6,0.3]
424	M	Senior	High	High	Normal	[0.7,0.2]

TABLE XV
SUMMARY OF ATTRIBUTES

Attribute	Description	Value description	
Sex	Gender	M if male;	F if female
Age	Age	18-30 years 31-34 years 45-64 years ≥65 years	Young-Adult Adult {Senior or Elderly person} Senior-Citizen
Lipid Profile	Total cholesterol, [LDL-C, HDL-C and TGs]	<200 mg/DL 200-239 240-249 ≥250	Normal Medium(Boderline) High Very high
BP	Blood Pressure	<120/80 120-129/80-85 130-159/86-99 ≥160/≥100	Normal Medium High Very high
FBS	Fasting blood sugar	<100 mg/DL 100-125 mg/DL ≥126 mg/DL	Normal High Very high

REFERENCES

[1] Atanassov, K.: Intuitionistic Fuzzy Sets, Fuzzy Sets and Systems 20(1986)87–96.

[2] Beaubouef, T Petry, F.E.: Extension of the relational database and its algebra with rough set techniques. FE. Comput Intell:11(1995) 233-245.

[3] Beaubouef, T Petry, F.E.: Fuzzy rough set techniques for uncertainty processing in a relational database. Intl. Journal of Intelligent Systems:15(2000) 389–424.

[4] Chen, P.P.: The Entity-Relationship Model: Toward a Unified View of Data, ACM Trans. on Database Systems, 1(1)(1976) 9-36.

[5] Codd, E.F.: A relational model of data for large shared data banks. Comm. ACM: 13(1970) 377–387.

[6] Gangwal, C., Bhaumik,R.N.: Intuitionistic fuzzy rough relational database model. International Journal of Database Theory and Application: 5(3) (2012) 91-102.

[7] Gangwal, C., Bhaumik,R.N., Kumar S: Applications of IF Rough Relational Model to Deal with Diabetic Patients. RSFDGrC 2013, LNCS 8170(2013), 191--199. Springer, Heidelberg.

[8] Zadeh, L.A.: Fuzzy sets, Information Control: l8 (1965) 338-353

[9] Pawlak, Z., Rough sets, Internat. J. Comput. Inform. Sci: 11 (1982) 341-356.