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Elimination of Attributes in Chronic Kidney Disease using Basis in Nano Topology

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Abstract

The main objective of this paper is to apply eliminination of attributes in information systems through nano topological spaces. The risk factors that cause chronic kidney disease are identified by generating the basis in nano topological spaces.

Keywords: *Nano topological space, basis, attributes.*

1. Introduction

Chronic kidney disease also called chronic kidney failure describes the gradual loss of kidney function. The disease is chronic because the damage to the kidney happens slowly over a long period of time. Kidneys filters wastes and excess fluids from the body, which are then excreted. When chronic kidney disease reaches an advanced stage, dangerous levels of fluid, electrolytes and wastes build up in the body. Treatment for chronic kidney disease focuses on slowing the progression of the kidney damage, by controlling the underlying cause. Chronic kidney disease can progress to end stage kidney failure which is fatal without artificial filtering or a kidney transplant. In this paper an attempt is made to identify the risk factors that cause chronic kidney disease from the information among some patients.

2. Preliminaries

We recall the following definitions.

Definition 2.1. [2] Let U be a non empty finite set of objects called the universe and R be an equivalence relation on U named as indiscernibility relation. Then U is divided into disjoint equivalence classes. Elements belonging to the same equivalence class are said to be indiscernible with one another. The pair (U,R) is said to be approximation space. Let X $\subseteq$ U. Then

(i) The lower approximation of X with respect to R is the set of all objects, which can be for certain classified as X with respect to R and is denoted by $L_R(X)$.

$L_R(X) = \bigcup_{x\in U} \{R(x): R(x) \subseteq X\}$ where R(x) denotes the equivalence class determined by $L_R(X)$.

(ii) The upper approximation of X with respect to R is the set of all objects which can be possibly classified as X with respect to R and is denoted by $U_R(X)$.

$U_R(X) = \bigcup_{x\in U} \{R(x): R(x) \cap X \neq \emptyset\}$.

(iii) The boundary region of X with respect to R is the set of all objects which can be classified neither as X nor as not-X with respect to R and it is denoted by $B_R(X)$.

$B_R(X) = U_R(X) - L_R(X)$.

Remark 2.2. [2] If $\tau_R(X)$ is a nano topology on U with respect to X, then the set B = $\{U, L_R(X), B_R(X)\}$ is the basis for $\tau_R(X)$.

Patients	Diabetes	Smoking and Alcohol	Hypertension	Obesity	Family History	CKD
1	√	√	×	√	×	Sure
2	√	×	√	×	√	Sure
3	×	√	×	√	×	Not Sure
4	√	√	×	√	×	Not Sure
5	×	√	√	√	×	Sure
6	√	√	√	√	×	Sure
7	×	√	√	√	×	Not Sure
8	√	×	×	×	√	Not Sure

3. Application of Nanotopology in Elimination of Attributes

Table 1

3.1 **Algorithm**

Step 1: For a limited Universe U, a limited set of attributes A which is partitioned in to two classes S and D and an equivalence relation R on U corresponding to S.

Step 2: Find the lower boundary, upper boundary and boundary region with respect to R.

Step 3: Generate the Nanotopology $\tau_S(X)$ and its basis $\beta_S(X)$.

Step 4: Eliminate an attribute Y from S and determine lower boundary, upper boundary and boundary region for S-Y.

Step 5: Generate the Nanotopology $\tau_{S-Y}(X)$ and its basis $\beta_{S-Y}(X)$.

Step 6: Repeat steps 4 and 5 for each attribute.

Step 7: The CORE attributes are those for which $\beta_S(X) \neq \beta_{S-Y}(X)$.

Step 8: Eliminate an attribute not in CORE. Repeat steps 4 to 7 and determine the CORE in all the cases.

Step 9: The attributes in CORE are the risk factors that cause the disease.

The concept of elimination of attributes in Nano Topology is applied to identify the key factors that cause Chronic Kidney Disease. Consider the table 1 which gives the information about patients having Diabetes, Smoking and Alcohol, Hypertension, Obesity and Family History.

Here the set of patients is $U = \{1,2,3,4,5,6,7,8\}$ and $A = \{$Diabetes, Smoking and Alcohol, Hypertension, Obesity, Family History and Chronic kidney disease$\}$. A is classified into two classes $S = \{$DB, SA, HT, OB, FH$\}$ and $D = \{$Chronic Kidney Disease$\}$. The family of equivalence classes U/S corresponding to S is given by $U/R(S) = \{1,4\},\{2\},\{3\},\{5,7\},\{6\},\{8\}\}$.

Case I. Patients with Chronic Kidney Disease:

Here the set of patients with CKD is $X = \{1,2,5,6\}$. Then $LB_S(X) = \{2,6\}$, $UB_S(X) = \{1,2,4,5,6,7\}$ and $BR_S(X) = \{1,4,5,7\}$ .Therefore the nano topology on U is given by $\tau_S(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}, \{1,2,4,5,6,7\}\}$ and the basis is given by $\beta_S(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}\}$. The issue is to find the key factors that cause chronic kidney disease.

Step 1:

When the attribute DB is deleted from S, $U/R(S - DB) = \{1,3,4\},\{2\},\{5,6,7\},\{8\}\}$ and hence $LB_{S-DB}(X) = \{2\}$, $UB_{S-DB}(X) = \{1,2,3,4,5,6,7\}$ and $BR_{S-DB}(X) = \{1,3,4,5,6,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-DB}(X) = \{\emptyset, U, \{2\}, \{1,3,4,5,6,7\}, \{1,2,3,4,5,6,7\}\}$ and $\beta_{S-DB}(X) = \{\emptyset, U, \{2\}, \{1,3,4,5,6,7\}\} \neq \beta_S(X)$.

If the attribute SA is removed from S, $U/R(S - SA) = \{1,4\},\{2\},\{3\},\{5,7\},\{6\},\{8\}\}$ then

$LB_{S-SA}(X) = \{2,6\}$, $UB_{S-SA}(X) = \{1,2,4,5,6,7\}$ and $BR_{S-SA}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-SA}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}, \{1,2,4,5,6,7\}\}$ and $\beta_{S-SA}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}\} = \beta_S(X)$.

When the attribute HT is ignored from S, $U/R(S-HT) = \{1,4,6\}, \{2,8\}, \{3,5,7\}\}$ and hence $LB_{S-HT}(X) = \{\emptyset\}$, $UB_{S-HT}(X) = \{U\}$ and $BR_{S-HT}(X) = \{U\}$. The corresponding nano topology and its basis are given by $\tau_{S-HT}(X) = \{\emptyset, U\}$ and $\beta_{S-HT}(X) = \{\emptyset, U\} \neq \beta_S(X)$.

If the attribute OB is removed from S, $U/R(S-OB) = \{1,4\}, \{2\}, \{3\}, \{5,7\}, \{6\}, \{8\}\}$ then $LB_{S-OB}(X) = \{2,6\}$, $UB_{S-OB}(X) = \{1,2,4,5,6,7\}$ and $BR_{S-OB}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-OB}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}, \{1,2,4,5,6,7\}\}$ and $\beta_{S-OB}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}\} = \beta_S(X)$.

If the attribute FH is deleted from S, $U/R(S-FH) = \{1,4\}, \{2\}, \{3\}, \{5,7\}, \{6\}, \{8\}\}$ and therefore $LB_{S-FH}(X) = \{2,6\}$, $UB_{S-FH}(X) = \{1,2,4,5,6,7\}$ and $BR_{S-FH}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-FH}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}, \{1,2,4,5,6,7\}\}$ and $\beta_{S-FH}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}\} = \beta_S(X)$. Therefore CORE = {Diabetes, Hypertension}.

Step 2:

Let T = S-SA = {DB, HT, OB, FH},then $\beta_T(X) = \beta_S(X)$.

When the attribute DB is deleted from T, $U/R(T-DB) = \{1,3,4\}, \{2\}, \{5,6,7\}, \{8\}\}$ and hence $LB_{T-DB}(X) = \{2\}$, $UB_{T-DB}(X) = \{1,2,3,4,5,6,7\}$ and $BR_{T-DB}(X) = \{1,3,4,5,6,7\}$. The corresponding nano topology and its basis are given by $\tau_{T-DB}(X) = \{\emptyset, U, \{2\}, \{1,3,4,5,6,7\}, \{1,2,3,4,5,6,7\}\}$ and $\beta_{T-DB}(X) = \{\emptyset, U, \{2\}, \{1,3,4,5,6,7\}\} \neq \beta_S(X)$.

When the attribute HT is ignored from T, $U/R(T-HT) = \{1,4,6\}, \{2,8\}, \{3,5,7\}\}$ and hence $LB_{T-HT}(X) = \{\emptyset\}$, $UB_{T-HT}(X) = \{U\}$ and $BR_{T-HT}(X) = \{U\}$. The corresponding nano topology and its basis are given by $\tau_{T-HT}(X) = \{\emptyset, U\}$ and $\beta_{T-HT}(X) = \{\emptyset, U\} \neq \beta_S(X)$.

If the attribute OB is removed from T, $U/R(T-OB) = \{1,4\}, \{2\}, \{3\}, \{5,7\}, \{6\}, \{8\}\}$ then $LB_{T-OB}(X) = \{2,6\}$, $UB_{T-OB}(X) = \{1,2,4,5,6,7\}$ and $BR_{T-OB}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{T-OB}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}, \{1,2,4,5,6,7\}\}$ and $\beta_{T-OB}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}\} = \beta_S(X)$.

If the attribute FH is deleted from T, $U/R(T-FH) = \{1,4\}, \{2\}, \{3\}, \{5,7\}, \{6\}, \{8\}\}$ and so $LB_{T-FH}(X) = \{2,6\}$, $UB_{T-FH}(X) = \{1,2,4,5,6,7\}$ and $BR_{T-FH}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{T-FH}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}, \{1,2,4,5,6,7\}\}$ and $\beta_{T-FH}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}\} = \beta_S(X)$. Therefore CORE = {Diabetes, Hypertension}.

Step 3:

Let V = S-SA = {DB, SA, HT, FH},then $\beta_V(X) = \beta_S(X)$.

When the attribute DB is deleted from V, $U/R(V-DB) = \{1,3,4\}, \{2\}, \{5,6,7\}, \{8\}\}$ and hence $LB_{V-DB}(X) = \{2\}$, $UB_{V-DB}(X) = \{1,2,3,4,5,6,7\}$ and $BR_{V-DB}(X) = \{1,3,4,5,6,7\}$. The corresponding nano topology and its basis are given by $\tau_{V-DB}(X) = \{\emptyset, U, \{2\}, \{1,3,4,5,6,7\}, \{1,2,3,4,5,6,7\}\}$ and $\beta_{V-DB}(X) = \{\emptyset, U, \{2\}, \{1,3,4,5,6,7\}\} \neq \beta_S(X)$.

If the attribute SA is removed from V, $U/R(V-SA) = \{1,4\}, \{2\}, \{3\}, \{5,7\}, \{6\}, \{8\}\}$, then $LB_{V-SA}(X) = \{2,6\}$, $UB_{V-SA}(X) = \{1,2,4,5,6,7\}$ and $BR_{V-SA}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{V-SA}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}, \{1,2,4,5,6,7\}\}$ and $\beta_{V-SA}(X) = \{\emptyset, U, \{2,6\}, \{1,4,5,7\}\} = \beta_S(X)$.

When the attribute HT is ignored from V, $U/R(V-HT)=\{1,4,6\},\{2,8\},\{3,5,7\}\}$ and therefore $LB_{V-HT}(X)=\{\emptyset\}$, $UB_{V-HT}(X)=\{U\}$ and $BR_{V-HT}(X)=\{U\}$. The corresponding nano topology and its basis are given by $\tau_{V-HT}(X)=\{\emptyset,U\}$ and $\beta_{V-HT}(X)=\{\emptyset,U\}\neq\beta_S(X)$.

If the attribute FH is deleted from V, $U/R(V-FH)=\{1,4\},\{2\},\{3\},\{5,7\},\{6\},\{8\}\}$, then $LB_{V-FH}(X)=\{2,6\}$, $UB_{V-FH}(X)=\{1,2,4,5,6,7\}$ and $BR_{V-FH}(X)=\{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{V-FH}(X)=\{\emptyset,U,\{2,6\},\{1,4,5,7\},\{1,2,4,5,6,7\}\}$ and $\beta_{V-FH}(X)=\{\emptyset,U,\{2,6\},\{1,4,5,7\}\}=\beta_S(X)$. Therefore CORE = {Diabetes, Hypertension}.

Step 4:

Let W = S-FH = {DB, SA, HT, OB},then $\beta_W(X)=\beta_S(X)$.

When the attribute DB is deleted from W, $U/R(W-DB)=\{1,3,4\},\{2\},\{5,6,7\},\{8\}\}$ and hence $LB_{W-DB}(X)=\{2\}$, $UB_{W-DB}(X)=\{1,2,3,4,5,6,7\}$ and $BR_{W-DB}(X)=\{1,3,4,5,6,7\}$. The corresponding nano topology and its basis are given by $\tau_{W-DB}(X)=\{\emptyset,U,\{2\},\{1,3,4,5,6,7\},\{1,2,3,4,5,6,7\}\}$ and $\beta_{W-DB}(X)=\{\emptyset,U,\{2\},\{1,3,4,5,6,7\}\}\neq\beta_S(X)$.

If the attribute SA is removed from W, $U/R(W-SA)=\{1,4\},\{2\},\{3\},\{5,7\},\{6\},\{8\}\}$ then $LB_{W-SA}(X)=\{2,6\}$, $UB_{W-SA}(X)=\{1,2,4,5,6,7\}$ and $BR_{W-SA}(X)=\{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{W-SA}(X)=\{\emptyset,U,\{2,6\},\{1,4,5,7\},\{1,2,4,5,6,7\}\}$ and $\beta_{W-SA}(X)=\{\emptyset,U,\{2,6\},\{1,4,5,7\}\}=\beta_S(X)$.

When the attribute HT is ignored from W, $U/R(WT-HT)=\{1,4,6\},\{2,8\},\{3,5,7\}\}$, and therefore $LB_{W-HT}(X)=\{\emptyset\}$, $UB_{W-HT}(X)=\{U\}$ and $BR_{W-HT}(X)=\{U\}$. The corresponding nano topology and its basis are given by $\tau_{W-HT}(X)=\{\emptyset,U\}$ and $\beta_{W-HT}(X)=\{\emptyset,U\}\neq\beta_S(X)$.

If the attribute OB is removed from W, $U/R(W-OB)=\{1,4\},\{2\},\{3\},\{5,7\},\{6\},\{8\}\}$ and therefore $LB_{W-OB}(X)=\{2,6\}$, $UB_{W-OB}(X)=\{1,2,4,5,6,7\}$ and $BR_{W-OB}(X)=\{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{W-OB}(X)=\{\emptyset,U,\{2,6\},\{1,4,5,7\},\{1,2,4,5,6,7\}\}$ and $\beta_{W-OB}(X)=\{\emptyset,U,\{2,6\},\{1,4,5,7\}\}=\beta_S(X)$. Hence CORE = {Diabetes, Hypertension}.

Case II. Patients not with Chronic Kidney Disease:

Here the set of patients with CKD is $X=\{3,4,7,8\}$. Then $LB_S(X)=\{3,8\}$, $UB_S(X)=\{1,3,4,5,7,8\}$ and $BR_S(X)=\{1,4,5,7\}$ .Therefore the nano topology on U is given by $\tau_S(X)=\{\emptyset,U,\{3,8\},\{1,4,5,7\},\{1,3,4,5,7,8\}\}$ and the basis is given by $\beta_S(X)=\{\emptyset,U,\{3,8\},\{1,4,5,7\}\}$. The issue is to find the key factors that cause chronic kidney disease.

When the attribute DB is deleted from S, $U/R(S-DB)=\{1,3,4\},\{2\},\{5,7\},\{6\},\{8\}\}$ and hence $LB_{S-DB}(X)=\{8\}$, $UB_{S-DB}(X)=\{1,3,4,5,7,8\}$ and $BR_{S-DB}(X)=\{1,3,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-DB}(X)=\{\emptyset,U,\{8\},\{1,3,4,5,7\},\{1,3,4,5,7,8\}\}$ and $\beta_{S-DB}(X)=\{\emptyset,U,\{8\},\{1,3,4,5,7\}\}\neq\beta_S(X)$.

If the attribute SA is removed from S, $U/R(S-SA)=\{1,4\},\{2\},\{3\},\{5,7\},\{6\},\{8\}\}$, then $LB_{S-SA}(X)=\{3,8\}$, $UB_{S-SA}(X)=\{1,3,4,5,7,8\}$ and $BR_{S-SA}(X)=\{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-SA}(X)=\{\emptyset,U,\{3,8\},\{1,4,5,7\},\{1,3,4,5,7,8\}\}$ and $\beta_{S-SA}(X)=\{\emptyset,U,\{3,8\},\{1,4,5,7\}\}=\beta_S(X)$.

When the attribute HT is ignored from S, $U/R(S-HT)=\{1,4,6\},\{2,8\},\{3,5,7\}\}$ and hence $LB_{S-HT}(X)=\{\emptyset\}$, $UB_{S-HT}(X)=\{U\}$ and $BR_{S-HT}(X)=\{U\}$. The corresponding nano topology and its basis are given by $\tau_{S-HT}(X)=\{\emptyset,U\}$ and $\beta_{S-HT}(X)=\{\emptyset,U\}\neq\beta_S(X)$.

If the attribute OB is removed from S, $U/R(S-OB)=\{1,4\},\{2\},\{3\},\{5,7\},\{6\},\{8\}\}$, then

$LB_{S-OB}(X) = \{3,8\}$, $UB_{S-OB}(X) = \{1,3,4,5,7,8\}$ and $BR_{S-OB}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-OB}(X) = \{\emptyset, U, \{3,8\}, \{1,4,5,7\}, \{1,3,4,5,7,8\}\}$ and $\beta_{S-OB}(X) = \{\emptyset, U, \{3,8\}, \{1,4,5,7\}\} = \beta_S(X)$.

If the attribute FH is deleted from S, $U/R(S-FH) = \{1,4\}, \{2\}, \{3\}, \{5,7\}, \{6\}, \{8\}\}$, then $LB_{S-FH}(X) = \{3,8\}$, $UB_{S-FH}(X) = \{1,3,4,5,7,8\}$ and $BR_{S-FH}(X) = \{1,4,5,7\}$. The corresponding nano topology and its basis are given by $\tau_{S-FH}(X) = \{\emptyset, U, \{3,8\}, \{1,4,5,7\}, \{1,3,4,5,7,8\}\}$ and $\beta_{S-FH}(X) = \{\emptyset, U, \{3,8\}, \{1,4,5,7\}\} = \beta_S(X)$.

Therefore CORE = {Diabetes, Hypertension}.

4. Conclusion

In this paper the concept of elimination of attribute and basis in nano topology has been applied to identify the key factors that cause chronic kidney disease. It was identified that the risk factors that cause CKD are Diabetes and Hypertension. This risk can be prevented by taking healthy food and proper medical care.

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