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An application of circulant fuzzy matrices for finding the disease in animals

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Abstract

In this paper focuses its attention on circulant fuzzy matrices combined with medical diagnosis for animal diseases and a new method to find the animal diseases of circulant fuzzy matrix.

Keywords

Fuzzy matrices, disease in animals, medical diagnosis.

AMS Subject Classification

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Contents

1. Introduction

Fuzzylogic and fuzzy set theory are important role for developing mathematical knowledge based on systematic analysis for finding medicine in various animal disease. Fuzzy matrices deal with different type of complicated disease in animal. Sanchez formulated in diagnostic method involves fuzzy matrices represented in medical knowledge between symptoms and disease in [2,3].

In [4] Diagnosis knowledge of animal disease is fuzzy matrix and the developing to representing and reasoning model of animal diagnosis knowledge based on fuzzy set theory can reflects the nature of the medical diagnosis to same expendable.

I extend Sanchez's method [2,3] animal disease diagnosis used to the notion of circulant matrix theory and notion of circulant and their applications are explained in [1], kim and rough. The method of circulant medical diagnosis involves circulant ordered explained.

2. Preliminaries

2.1 Circulant matrix

An $m \times n$ circulant matrix has the form

$$C = \begin{pmatrix} C_1 & C_2 & C_{n-1} & \dots & C_n \\ C_n & Q & C_2 & \cdots & C_{n-1} \\ C_{n-1} & C_n & Q & \cdots & C_{n-2} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ C_2 & C_3 & C_4 & \dots & C_1 \end{pmatrix}$$

2.2 Circulant fuzzy matrix

For any given $\mathrm{C_0},\ \mathrm{C_2},\ \ldots\ldots \mathrm{C_{n-1}} \in \mathrm{f_{m\times n}}$ be the circulant fuzzy matrix $\mathrm{C} = \left(\mathrm{c_{ij}}\right)_{\mathrm{m\times n}}$ is defined by $(C_{ii}) = (C_{j-1(\mathrm{mod n})})$

A circulant matrix is the form of

$$C_1 = \begin{pmatrix} C_1 & C_2 & C_{n-1} & \cdots & C_n \\ C_n & C_1 & C_2 & \cdots & C_{n-1} \\ C_{n-1} & C_n & C_1 & \cdots & C_{n-2} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ C_2 & C_3 & C_4 & \cdots & C_1 \end{pmatrix}$$

With entries in [0,1]

2.3 Complement of circulant fuzzy matrix

Let $C = (C_{ij})_{max}$ be a fuzzy matrix of order $m \times n$ then the complement of C is denoted by $C^c = (d_{ii})$ where $d_{ii} = 1 - c_{ij}$ for all i and j.

2.4 Product of circulant fuzzy matrices

Let f_{mn} denote the set of all $m \times n$ matrices over F, set of elements are called fuzzy membership value of matrices. For $C = (C_{ij}) \in f_{m\times p}$ and $D = (d_{ij}) \in f_{p\times n}$ the max-min product $C(\circ)D = (\sup_K [\inf\{C_{iK} : d_{Kj}\}]) \in f_{mn}$

3. Application of circulant fuzzy matrix in animal disease

We introduced an application of circulant fuzzy matrix in animal diseases. Let S is a set of symptoms, D is a set of disease and A is a set of animals.Analogous to Sanchez's notion of medical knowledge as an circulant ordered relation C from the symptoms S to the diagnosis D.

The methodology involves mainly the following 3 jobs.

1. Determination of symptoms
2. Formulation of medical knowledge based in circulant order relations.
3. Determination of diagnosis on the basis of composition of circulant order relations.

Let as consider S is a set of symptoms of certain diseases. D is a set of diseases and A is set of animals, Construct an circulant matrix S over D. A relation matrix say, $\tilde{C}_1$ is construct from the circulant matrix (F, D) and called symptom disease matrix. To give another relation of matrix S over D, say $\tilde{C}_2$ is called non symptom disease matrix. Analogous to Sanchez's notion of medical knowledge, We refered to each matrices C_1 and C_2 as medical knowledge of an circulant matrix. Similarlywe construct another circulant matrix (F.P) over S, where F is an mapping by $F : P \to F(S)$. This circulant fuzzy matrix gives another relation matrix Q called patient-symptom matrix. Algorithm

Algorithm

Step:1

Input the circulant fuzzy matrix value the set of symptoms S over diseases D and write the input value over the symptoms S over D denoted by the knowledge matrix $\tilde{C}_1$ and C_2 respectively.

Step:2

Input the circulant fuzzy matrix over the set A of animals over S and write its relation Q.

Step:3

Compute the relation matrices under the composition (0)

(i) $\tilde{T}_1 = Q \circ \tilde{C}_1$

(ii) $\tilde{T}_2 = Q_\circ \tilde{C}_2$

(iii) $\tilde{T}_3 = Q \circ (J - \tilde{C}_1)$

here J is the matrix with all its entries I, and I is the greatest element of F.

(iv) $T_4^2 = Q_0 (J - C_2)$

(v) Compute the diagnosis score SC_1 and $SC_2^{\sim}$

$$ST_1 = \max\{T_1(a_i, d_j), T_3(a_i, d_j)\} \text{ for } i = 1,2,3; j = 1,2,3$$

$$ST_2 = \max\{T_2(a_i, d_j), T_4(a_i, d_j)\} \text{ for } i = 1,2,3 : j = 1,2,3$$

Step:4

Find $S_k = \max[ST_1(a_i, d_j) - ST_2(a_i, d_j)]$ then we conclude the animals a_i is suffering from the disease d_k

Step:5

If S_k has more than one value then go step 1 and repeat the process by reassessing the symptoms for the animals.

Case study

Suppose there are three dog's A_1, A_2, A_3 in a hospital with symptoms hair loss, itching, reness and possible diseases related to the above symptoms be Demodicosis.Canine scabies, Walking dandruff.

Step:1

$$\tilde{C}_1 = \begin{matrix} & d_1 & d_2 & d_3 \\ s_1 & 1 & 0.6 & 0.9 \\ s_2 & 0.9 & 1 & 0.6 \\ s_3 & 0.6 & 0.9 & 1 \end{matrix}, \quad \tilde{C}_1 = \begin{matrix} & d_1 & d_2 & d_3 \\ s_1 & 0.6 & 0.8 & 0.3 \\ s_2 & 0.3 & 0.6 & 0.9 \\ s_3 & 0.9 & 0.3 & 0.6 \end{matrix}$$

Step:2

$$Q = \begin{matrix} & d_1 & d_2 & d_3 \\ A_1 & 1 & 0.6 & 0.7 \\ A_2 & 0.7 & 1 & 0.6 \\ A_3 & 0.6 & 0.7 & 1 \end{matrix}$$

Step:3

$$\tilde{T}_1 = \begin{matrix} & d_1 & d_2 & d_3 \\ A_1 & 1 & 0.7 & 0.9 \\ A_2 & 0.9 & 1 & 0.7 \\ A_3 & 0.7 & 0.9 & 1 \end{matrix}, \quad \tilde{T}_2 = \begin{matrix} & d_1 & d_2 & d_3 \\ A_1 & 0.7 & 0.8 & 0.6 \\ A_2 & 0.6 & 0.7 & 0.8 \\ A_3 & 0.8 & 0.6 & 0.7 \end{matrix}$$

$$\tilde{T}_3 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 0.4 & 0.4 & 0.4 \\ 0.4 & 0.4 & 0.4 \\ 0.4 & 0.4 & 0.4 \end{pmatrix} \end{array}, \tilde{T}_4 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 0.6 & 0.7 & 0.7 \\ 0.7 & 0.6 & 0.7 \\ 0.7 & 0.7 & 0.6 \end{pmatrix} \end{array}$$

Step:4

$$S\tilde{T}_1 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 1 & 0.7 & 0.9 \\ 0.9 & 1 & 0.7 \\ 0.7 & 0.9 & 1 \end{pmatrix} \end{array}, S\tilde{T}_2 = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 0.7 & 0.8 & 0.6 \\ 0.6 & 0.7 & 0.8 \\ 0.8 & 0.6 & 0.7 \end{pmatrix} \end{array}$$

Step:5 Now we have the difference for and against the disease From the table, it is obvious that, if the doctor agree the A_1

Table 1

$S\tilde{T}_1 - S\tilde{T}_2$	d_1	d_2	d_3
A_1	0.3	−0.1	0.2
A_2	0.2	0.3	−0.1
A_3	0.1	0.2	0.3

suffer from Demodicosis disease and A_2 suffer from Canine scabies disease and A_3 suffer from walking dandruff disease.

4. Decision making under fuzzy environment

We applied Sanchez's method of the medical diagnosis for the decision making method of circulant fuzzy matrix. In this method is an attempt to improve the section.

4.1 Fuzzy relations

A fuzzy relation Q in $U_1 \times U_2 \times \ldots. \times U_n$ is defined as $\{(u_1 \times u_2 \times \ldots\ldots \times u_n), \mu_Q(u_1 \times u_2 \times \ldots x u_n) f(u_1 x u_2 \times \ldots \times u_n) \in (u_1 x u_2 \times \ldots\ldots x u_p)\} \to [0,1]$ Where $\mu_0 : (u_1 x u_2 \times \ldots\ldots x u_n) \to [0,1]$

4.2 Max-min composition

Let A be a fuzzy relation in $X \times Y$ and B be a fuzzy relation in $Y \times Z$. The max-min composition of A and B is a fuzzy relation in $X \times Z$, such that

$$\mathbf{A} \circ \mathbf{B} = \max\{\min\{\mu_R(\mathbf{x},\mathbf{y}), \mu_S(\mathbf{y},\mathbf{z})\}\}/(\mathbf{x},\mathbf{z})$$

4.3 Maximum product composition

Let A be a fuzzy relation $X \times Y$ and B be a fuzzy relation in $Y \times Z$. The maximum product composition of A and B denoted by A.B is a fuzzy relation in $X \times Z$, such that $\mathbf{A} \circ \mathbf{B} = \max\{\mu_R(\mathbf{x},\mathbf{y}), \mu_Z(\mathbf{y},\mathbf{z})\}/(\mathbf{x},\mathbf{z})$

4.4 Relativity function

Let X and Y be variables defined on a universal set X. The relativity function is denoted by $f(x/y)$ where, $F(x/y) = \mu_x(x) - \mu_x(y)/\max\{\mu_y(x), \mu_x(y)\}$ Where $\mu_y(x)$ is the membership function of x with respect to y.

4.5 Composition matrix

Let $A = \{x_1, x_2, \ldots\ldots x_{i-1}, x_i, x_{i+1} \ldots . x_n\}$ be a set of n variables defined on a universal set X. Form a matrix of relativity values $f(x_i/y_i)$ where xi's (for $i = 1$ to n) are n variables defined on a universe X. The square matrix $R = (r_{ij})$ is called the composition matrix with $f(x_i/x_i) = \mu_{xj}(x_i)$

Proposed Algorithm

Let S be the set of symptoms of some diseases, D is a set of diseases and A is a set of animals.

Step:1

Construct a symptom disease circulant fuzzy matrix $C = (c_{ij})$ of order $m \times n$.

Step:2

Construct a patient-symptom circulant fuzzy matrix $Q = (q_i)$ of order mxn.

Step:3

Compute the complement of both circulant fuzzy matrices C and Q. Let it be C^c and Q^c.

Step:4

Compute the relational matrix under the maximum product composition (.) $T_1 = C_\circ Q, T_2 = C^c, Q^c$.

Step:5

Compute $T = T_1 - T_2$ where "_ "is the maximum of T_1 and T_2.

Step:6

Calculating the relativity values $f(p_i/d_i)$ and form the comparison circulant fuzzy matrix

$$\mathbf{W} = (\mathbf{w_{ji}})_{\mathbf{m \times n}} = [\mathbf{f}(\mathbf{p_i}/\mathbf{d_i})]_{i=1,2,3}$$

Then maximum value in each of the rows of the W-circulant fuzzy matrix will have the maximum possibility for ranking purposes. This gives the solution to the required problem.

5. Illustrative examples

Suppose there are three dog's A_1, A_2 and A_3 in a vertinary hospital with symptoms Hairloss, Itching , Reness. Let the possible diseases relating to the above symptoms be Demodicosis, Canine scabies, Walking dandruff.

Step:1

Consider a symptom-disease circulant fuzzy matrix C of order 3×3 such that,

$$C = \begin{array}{c} \\ s_1 \\ s_2 \\ s_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 1 & 0.6 & 0.9 \\ 0.9 & 1 & 0.6 \\ 0.6 & 0.9 & 1 \end{pmatrix} \end{array}$$

Step:2 Consider a animal-symptom circulant fuzzy matrix Q as

$$C = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 1 & 0.6 & 0.7 \\ 0.7 & 1 & 0.6 \\ 0.6 & 0.7 & 1 \end{pmatrix} \end{array}$$

Step:3

Finding the complement of both circulant fuzzy matrices of step:1 and step:2

$$\mathrm{C^c} = \begin{pmatrix} 0 & 0.4 & 0.1 \\ 0.1 & 0 & 0.4 \\ 0.4 & 0.1 & 0 \end{pmatrix}, \quad Q^{c}= \begin{pmatrix} 1 & 0.4 & 0.3 \\ 0.3 & 1 & 0.4 \\ 0.4 & 0.3 & 1 \end{pmatrix}$$

Step:4

Finding the relational matrix under the composition "○".

$$\mathrm{T_1 = C \circ Q} = \begin{pmatrix} 1 & 0.63 & 0.9 \\ 0.9 & 1 & 0.63 \\ 0.63 & 0.9 & 1 \end{pmatrix},$$

$$\mathrm{T_2 = C^c \circ Q}^c = \begin{pmatrix} 0.1 & 0.03 & 0.9 \\ 0.9 & 1 & 0.03 \\ 0.03 & 0.9 & 1 \end{pmatrix}$$

Step:5

Computing $T = T_1 - T_2$ where '-' is the maximum of T_1 and T_2.

$$T = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 1 & 0.63 & 0.9 \\ 0.9 & 1 & 0.63 \\ 0.63 & 0.9 & 1 \end{pmatrix} \end{array}$$

Represents the relation between the Animals and the diseases.

Step:6

Calculate the relativity values of $\mathrm{f}\left(\mathrm{p}_i/\mathrm{d_j}\right)$ and form the comparison on circulant fuzzy matrix

$$\mathrm{W} = (\mathrm{w}_{ij})_{\mathrm{m\times n}} = \mathrm{f}\left(\mathrm{p_i/d_j}\right)_{i=1,2,3}$$

$$\mathrm{f}(\mathrm{p_i/d_i}) = \mu_{\mathrm{di}}(\mathrm{p_i}) - \mu_{\mathrm{pi}}(\mathrm{d_i}) / \max\left\{\mu_{\mathrm{di}}(\mathrm{P_i}) \cdot \mu_{\mathrm{pi}}(\mathrm{d_i})\right\}$$

$$\mathrm{f}(\mathrm{p_1/d_1}) = 0 - 0/\max\{1,1\} = 0$$

$$\mathrm{f}(\mathrm{p_1/d_2}) = 0.63 - 0.9/\max\{0.63, 0.9\} = -0.03$$

$$\mathrm{f}(\mathrm{p_1/d_3}) = 0.9 - 0.63/\max\{0.9, 0.63\} = 0.03$$

$$\mathrm{f}(\mathrm{p_2/d_1}) = 0.9 - 0.63/\max\{0.9, 0.63\} = 0.03$$

$$\mathrm{f}(\mathrm{p_2/d_2}) = 0 - 0/\max\{1,1\} = 0$$

$$\mathrm{f}(\mathrm{p_2/d_3}) = 0.63 - 0.9/\max\{0.63, 0.9\} = -0.03$$

$$\mathrm{f}(\mathrm{p_3/d_1}) = 0.63 - 0.9/\max\{0.63, 0.9\} = -0.03$$

$$\mathrm{f}(\mathrm{p_3/d_2}) = 0.9 - 0.63/\max\{0.9, 0.63) = 0.03$$

$$\mathrm{f}(\mathrm{p_3/d_3}) = 0 - 0/\max\{1,1\} = 0$$

$$T = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} d_1 & d_2 & d_3 \end{array} \\ \begin{pmatrix} 0 & -0.03 & 0.03 \\ 0.03 & 0 & -0.03 \\ -0.03 & 0.03 & 0 \end{pmatrix} \end{array}$$

From the ranking of the problem, conclude that dog A_1 is easily affected by d_3 (walking dandruff) dog A_2 is affected by d_1 (Demodicosis) and dog A_3 is affected by d_2 (Canine scabies).

6. Conclusion

We clarify the theory of circulant fuzzy matrices in the field of animal diseases for medical diagnosis. We develop some new notions such as complement to the max of circulant fuzzy matrix. There are hundreds of diseases for animals, and the special degree is relatively lower in veterinary, any veterinarian have to solved internal medicine sickness,the obstetrical disease, surgical sickness, parasitic disease and so on. Therefore, the expert system for animal disease must conform to the objective law of veterinarian clinical. Hence in this paper, Fuzzy set structure has been utilized is several different approaches to model the medical diagnostic process and decision making process. At the conclusion from the above analysis it is obvious that, Dog (A_1) suffer from walking dandruff (d_3), Dog(A_2) suffer from demodicosis (d_1) and dog(A_3) suffer from d_2 (canine Scabies).

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