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Nearness Matrix in pattern recognition

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ABSTRACT

The article explores the Concept of nearness matrix in Pattern recognition and its application in cluster analysis. In this paper we aim to provide a comprehensive understanding of the nearness matrix and its role in pattern recognition, along with practical implications for improving clustering algorithms.

***Keywords*:** *Nearness matrix, Fuzzy set, Fuzzy logic, Boolean matrix theory, pattern recognition*

Introduction

The objectives of the present paper are to outline a conceptual frame work for pattern recognition and cluster analysis based on the theory of fuzzy sets and “Nearness relation". The process of recognition and classification is one of the most fundamental of human activities. Every where in our activities either daily behaviour or long term behaviour consists of sorting items into groups. These groups are prescribed by patterns and what we perform is the act of recognition of certain patterns and then classification of them into groups. As for example in our daily activity we sort out rotten vegetables and green vegetables in our kitchen. The rotten vegetables can father be sorted out by nearness relation more rotten or less rotten. Such behavior or activities can be explained mathematically using “Nearness Relation" for cluster analysis in pattern recognition. This “Nearness Relation” generates a special type of matrix called "Nearness Matrix". The members of this matrix are the members of the close interval [0,1]. Our discussion is centered on these properties that can be applied towards the solution of classification problem of static pattern sunder measure of similarity. Let N* be "Nearest Algebra" which is distributive lattice with unique identities under operation '+' and 'o' respectively. The

unique identities under these operations are e^+ and e_o respectively. Let us further consider N^*_{mn}, the complete set of m x n matrices with elements in N*

Two matrices (elements) P=[p_{rs}] and Q = [q_{rs}] are said to be equal iff $p_{rs} = q_{rs}$ ∀ r and s.

Let us define following compositions in N*mn :

(a) **Sum-** P ⊕Q = L iff $l_{rs} = p_{rs} + q_{rs}$ ∀ r and s

(b) **Lattice Product** – P ⊕ Q = L iff $l_{rs} = p_{rs} \geq q_{rs}$ ∀ r and s.

(c) **Order -** P ≥ Q iff $p_{\underline{rs}} \geq q_{rs}$ ∀r ands

(d) P = $\bar{Q}$ iff $p_{rs} = q_{rs}$ ∀ r and s ('-' stands for transpose.

The system [N*mn, ⊕, ⊗] is a lattice with the universal element U* (all entries e*and the zero element 0_+ (all entries e_+)

Let us define following operation Scalar multiplication- A = rB iff $a_{ij}=rb_{ij}$ b ϵ N*mn and rϵN*

Matrix product- A = BC iff

$a_{ij} = \sum_{j=1}^{n} b_{ij}c_{jk}$, BϵN*$_{m,n}$, CϵN*$_{n,p}$ and AϵN*$_{m,p}$ The symbol "∑" has been used to denote the sum with respect to operation ⊕ (max) of N*

Transpose- A = B^t iff $a_{ij} = b_{ji}$, BϵN*$_{m,n}$; AϵN*$_{n,m}$;

Permanent- Per(B) = $|B| = \sum[\Pi(b)]$ where bϵN*$_{mn}$, $|B|^i$ ϵN* and the summation is taken over all permutation,(i_1, i_2,.....i_p)

Adjoint- A = adjB iff $a_{ij}=b_{ij}$ where AϵN*$_{m,m}$; BϵN*$_{m,m}$ and b_{ij} is the cofactor of b_{ji} in $|B|$.

Under these operation N*$_{m,n}$ is a lattice ordered semi group with the matrix product as third binary operation and the matrix I of all diagonal entries $e_\otimes$ and $e_\oplus$ behaves as unity.

Inexact vector- A vector is called inexact iff all its entries are elements of N*. A matrix is called inexact iff all its rows are inexact vectors Nearness symmetric matrices can be refereed to as Nearness matrices. For the set of all mxm Nearness symmetric matrices N*$_{m,m}$ we have the following definition. Definition: Let A = [a_{ij}] and B = [b_{ij}] be two mxm Nearness matrices

I. $A+B = [\max(a_{ij} , b_{ij})]$

II. $AB = [\overset{\max}{k} \{\min (a_{ik} , b_{kj})\}]$

III. $A \leq B$ exists iff $a_{ij} \leq b_{ij} \forall$ i,j

The set of mxm Nearness matrices is a monoid under matrix multiplication. The set of mxm Nearness matrices is closed under Nearness Matrix multiplication and the unit mxm matrix (all diagonal entries 1 and all oher 0) is nearness matrix.

Definition: A "Nearness Matrix" P is called constant if all its rows are equal. If 'P' is a constant Nearness matrix and Q is Nearness matrix of the same order then PQ and QP are constant Nearness matrix Example:

Let $P = \begin{bmatrix} 0.5 & 0.3 \\ 0.5 & 0.3 \end{bmatrix}$ and $Q = \begin{bmatrix} 0.1 & 0.4 \\ 0.7 & 0.1 \end{bmatrix}$

$QP = \begin{bmatrix} 0.4 & 0.3 \\ 0.5 & 0.3 \end{bmatrix}$

Which is clearly not constant. In a very fundamental way, the intimate relation between the theory of fuzzy sets and the theory of pattern recognition and classification rests on the fact that the most real world are fuzzy in nature.

Thus given an object P and a cluster C, the basic question in most problems related to cluster analysis is not weather P is or P is not an element in C, but the degree to which P belongs to C (grade of membership in C) the problem is that most partical problems in pattern analysis do not tend themselves to a precise formulation and thus less precise techniques might have some solution to the intrinsic imprecision that in most case is incorporated in the recognition and classification problems.

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