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ON THE PICTURE FUZZY DATABASE: THEORIES AND APPLICATION

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ABSRACT

Around the 1970s, the concept of the (crisp) relational database was introdued which enables us to store and practice with an organized collection of data. In a relational database, all data are stored and accessed via relations. The extension of the relational data base can be done in several directions. Fuzzy relational database generalizes the classical relational database. In this paper, we introduce a new concept: picture fuzzy database (PFDB), study some queries on a picture fuzzy database, and give an example to illustrate the application of this database model.

Keywords: Picture fuzzy set, picture fuzzy relation, picture fuzzy database (PFDB).

Cơ sở dữ liệu mờ bức tranh: lý thuyết và ứng dụng

TÓM TẮT

Những năm 1970, khái niệm cơ sở dữ liệu quan hệ (rõ) được đề xuất cho phép chúng ta có thể lưu trữ và thao tác với một họ có tổ chức của dữ liệu. Trong một cơ sở dữ liệu quan hệ, tất cả các dữ liệu được lưu trữ và truy cập thông qua các quan hệ. Sự mở rộng của cơ sở dữ liệu quan hệ có thể thực hiện theo nhiều hướng khác nhau. Cơ sở dữ liệu quan hệ mờ là một sự mở rộng của cơ sở dữ liệu quan hệ cổ điển. Bài báo này xin giới thiệu một khái niệm mới về cơ sở dữ liệu mờ bức tranh (PFDB), nghiên cứu một vài truy vấn trên một cơ sở dữ liệu mờ bức tranh và đưa ra một ví dụ minh họa cho ứng dụng của mô hình CSDL này.

Từ khóa: Cơ sở dữ liệu mờ bức tranh, quan hệ mờ bức tranh, tập mờ bức tranh.

1. INTRODUCTION

Fuzzy set theory was introduced since 1965 (Zadeh, 1965). Immediately, it became a useful method to study in the problems of imprecision and uncertainty. Since, a lot of new theories treating imprecision and uncertainty have been introduced. For instance, Intuitionistic fuzzy sets were introduced in 1986 by Atanassov (Atanassov, 1986), which is a generalization of the notion of a fuzzy set. While fuzzy set gives the degree of membership of an element in a given set, intuitionistic fuzzy set gives a degree of membership and a degree of non-membership. In 2013, Bui and Kreinovich (2013) introduced the concept of picture fuzzy set, which has identifies three degrees of memberships memberships for each element in a given set: a degree of positive membership, a degree of negative membership, and a degree of neutral membership. Later on, Le Hoang Son và Pham Huy Thong (2014); Le Hoang Son (2015) reported an application of picture fuzzy set in the clustering problems. Nguyen Đinh Hoa et al. (2014) proposed an innovative method for weather forecasting from satellite image sequences using the combination of picture fuzzy clustering and spatio-temporal regression. These indicate the effective application of picture fuzzy set in the actual problems.

Around the 1970s, Codd introduced the concept of the (crisp) relational database (the classical relational database) which enables us to to store and practice with an organized collection of data. A relation is defined as a set of tuples that have the same attributes. A tuple usually represents an object and information about that object. A relation is usually described as a table, which is organized into rows and columns. All the data referenced by an attribute are in the same domain and conform to the same constraints. In a relational database, all data are stored and accessed via relations. Relations that store data are called base relations, and in implementation are called tables. Other relations do not store data, but are computed by applying relational operations to other relations. In implementations, these are called queries. Derived relations are convenient in that they act as a single relation, even though they may grab information from several relations. Also, derived relations can be used as an abstraction layer.

Fuzzy data structure was first studied by Tanaka et al. (1977) in which the membership grades were directly coupled each datum and relation. Fuzzy relational database that generalizes the classical relational database by allowing uncertain and imprecise information to be represented and manipulated. Data is often partially known, vague or ambiguous in many real world applications. There are several methods to describe a fuzzy relational database. For instance, either the domain of each attribute is fuzzy (Petry and Buckles, 1982) or the relation of attribute values in the domain of any attribute in the relational database is fuzzy relations (Shokrani-Baigi et al., 2002; Mishra and Ghosh, 2008). The extension of the relational database can be done in many different directions. Roy et al. (1998) introduced the concept of intuitionistic fuzzy database in which, the relation of attribute values in the domain of any attribute in the relational database is intuitionistic fuzzy relations. After that, some application of intuitionistic fuzzy database was studied. Kelov et al. (2005) applied the Intuitionistic Fuzzy Relational Databases in Football Match Result Predictions. Kolev and Boyadzhieva, (2008) extended the relational model to intuitionistic fuzzy data quality attribute model and Ashu (2012) studied the intuitionistic fuzzy approach to handle imprecise humanistic queries in databases.

Hence, the extension of concepts of relational database is necessary. In this paper we studied picture fuzzy relations and introduced a new concept: picture fuzzy database in which, the relation of attribute values in the domain of any attribute in the relational database is picture fuzzy relations. Which is an extension of a fuzzy database, intutionistic fuzzy database. The remaining of this paper: In section 2, we recalled some notions of picture fuzzy set and picture fuzzy relation; we consider some properties of picture fuzzy tolerance relation in section 3; finally, we introduce new concept: picture fuzzy database and some queries on PFDB.

2. BASIC NOTIONS OF PICTURE FUZZY SET AND PICTURE FUZZY RELATION

In this paper, we denote U be a nonempty set called the universe of discourse. The class of all subsets of U will be denoted by $P(U)$ and the class of all fuzzy subsets of U will be denoted by $F(U)$.

Definition 1. (Bui and Kreinovick, 2013) *A picture fuzzy (PF) set A on the universe U is an object of the form:*

$$A = \{(x, \mu_A(x), \eta_A(x), \gamma_A(x)) | x \in U\}$$

where $\mu_A(x) \in [0,1]$, the "degree of positive membership of x in A"; $\eta_A(x) \in [0,1]$, the "degree of neutral membership of x in A" and $\gamma_A(x) \in [0,1]$; and the "degree of negative membership of x in A", and μ_A, η_A and γ_A satisfied the following condition:

$$\mu_A(x) + \eta_A(x)) + \gamma_A(x) \leq 1, (\forall x \in X).$$

The family of all picture fuzzy set in U is denoted by $PFS(U)$. The complement of a picture fuzzy set A is denoted by $A = \{(x, \gamma_A(x), \eta_A(x), \mu_A(x)) | \forall x \in U\}$

Formally, a picture fuzzy set associates three fuzzy sets, they are identified by

$\mu_A: U \to [0,1], \eta_A: U \to [0,1]$ and $\gamma_A: U \to [0,1]$ and can be represented as $= (\mu_A, \eta_A, \gamma_A)$. Obviously, any intuitionistic fuzzy set $A = \{(x, \mu_A(x), \gamma_A(x))\}$ may be identified with the picture fuzzy set in the form $A = \{(x, \mu_A(x), 0, \gamma_A(x)) | x \in U\}$.

The operator on PFS(U) was introduced [1]: $\forall A, B \in PFS(U)$,

- $A \subseteq B$ iff $\mu_A(x) \le \mu_B(x), \eta_A(x) \le \eta_B(x)$ and $\gamma_A(x) \ge \gamma_B(x)$ $\forall x \in U$.
- $A = B$ iff $A \subseteq B$ and $B \subseteq A$.
- $A \cup B = \{(x, \max(\mu_A(x), \mu_B(x)), \min(\eta_A(x), \eta_B(x), \min(\gamma_A(x), \gamma_B(x))) | x \in U\}$
- $A \cap B = \{(x, \min(\mu_A(x), \mu_B(x)), \min(\eta_A(x), \eta_B(x), \max(\gamma_A(x), \gamma_B(x)) | x \in U\}$

Now we define some special PF sets: a constant PF set is the PF set $(\widehat{\alpha, \beta, \theta}) = \{(x, \alpha, \beta, \theta) | x \in U\}$; the PF universe set is $U = 1_U = (\widehat{1,0,0}) = \{(x, 1,0,0) | x \in U\}$ and the PF empty set is $\emptyset = 0_U = (\widehat{0,1,0}) = \{(x, 0,1,0) | x \in U\}$.

For any $x \in U$, picture fuzzy sets 1_x and $1_{U-\{x\}}$ are, respectively, defined by: for all $y \in U$

$$\mu_{1_x}(y) = \begin{cases} 1, & \text{if } y = x \\ 0, & \text{if } y \neq x \end{cases}$$

$$\gamma_{1_x}(y) = \begin{cases} 0, & \text{if } y = x \\ 1, & \text{if } y \neq x \end{cases}$$

$$\eta_{1_x}(y) = \begin{cases} 0, & \text{if } y = x \\ 0, & \text{if } y \neq x \end{cases}$$

$$\mu_{1_{U-\{x\}}}(y) = \begin{cases} 0, & \text{if } y = x \\ 1, & \text{if } y \neq x \end{cases}$$

$$\gamma_{1_{U-\{x\}}}(y) = \begin{cases} 1, & \text{if } y = x \\ 0, & \text{if } y \neq x \end{cases}$$

$$\eta_{1_{U-\{x\}}}(y) = \begin{cases} 0, & \text{if } y = x \\ 0, & \text{if } y \neq x \end{cases}$$

***Definition 2**. Let U be a nonempty universe of discourse which many be infinite. A picture fuzzy relation from U to V is a picture fuzzy set of $U \times V$ and denote by $R(U \to V)$, i.e, is an expression given by*

$$R = \{((x,y), \mu_R(x,y), \eta_R(x,y), \gamma_R(x,y)) | (x,y) \in U \times V\},$$

where

μ_R, γ_R, η_R are functions from UxV to $[0,1]$ such that $\mu_R(x,y) + \eta_R(x,y) + \gamma_R(x,y) \le 1$ for all $(x,y) \in U \times V$.

When $U \equiv V$ then, $R(U \to U)$ is called a picture fuzzy relation on U.

***Definition 3**. Let $P(U \to V)$ and $Q(V \to W)$. Then, the max-min composition of the picture fuzzy relation P with the picture fuzzy relation Q is a picture fuzzy relation $P \circ Q$ on $U \times W$ which is defined by, for all $(x,z) \in U \times W$:*

$$\mu_{P \circ Q}(x,z) = max_{y \in V}\{min\{\mu_P(x,y), \mu_Q(y,z)\}\}$$

$$\eta_{P \circ Q}(x,z) = min_{y \in V}\{min\{\eta_P(x,y), \eta_Q(y,z)\}\}$$

$$\gamma_{P \circ Q}(x,z) = min_{y \in V}\{max\{\gamma_P(x,y), \gamma_Q(y,z)\}\}$$

***Definition 4.** The picture fuzzy relation R on U is referred to as:*

- *Reflexive: if for all $x \in U, \mu_R(x,x) = 1$,*
- *Symmetric: if for all $x, y \in U, \mu_R(x,y) = \mu_R(y,x), \gamma_R(x,y) = \gamma_R(y,x)$, and $\eta_R(x,y) = \eta_R(y,x)$,*
- *Transitive: If $R^2 \subset R$, where $R^2 = R \circ R$,*
- *Picture tolerance: if R is reflexive and symmetric,*
- *Picture preorder: if R is reflexive and transitive,*
- *Picture similarity (picture fuzzy equivalence): if R is reflexive and symmetric, transitive.*

***Example 1**.* Let $U = \{u_1, u_2, u_3\}$ be a universe set. We consider a relation R on U as follows (Table 1):

It is easily that R is reflexive, symmetric. But it is not transitive, because $R^2 \not\subseteq R$. The relation R^2 is computed in Table 2. Here, we see that $(\mu_{R \circ R}(u_1, u_2), \eta_{R \circ R}(u_1, u_2), \gamma_{R \circ R}(u_1, u_2)) = (0.4,0,0.1) > (\mu_R(u_1, u_2), \eta_R(u_1, u_2), \gamma_R(u_1, u_2)) = (0.3,0.4,0.2)$.

The transitive closure (proximity relation) of $R(U \to U)$ is $\widehat{R}$, defined by

$$\widehat{R} = R \cup R^2 \cup R^3 \cup ....$$

Table 1. The picture fuzzy relation *R*

R	u_1	u_2	u_3	u_4
u_1	(1,0,0)	(0.3,0.4,0.2)	(0.4,0.5,0.1)	(0.3,0.4,0.2)
u_2	(0.3,0.4,0.2)	(1,0,0)	(0.7,0.2,0.05)	(0.4,0.5,0.1)
u_3	(0.4,0.5,0.1)	(0.7,0.2,0.05)	(1,0,0)	(0.3,0.4,0.2)
u_4	(0.3,0.4,0.2)	(0.4,0.5,0.1)	(0.3,0.4,0.2)	(1,0,0)

Table 2. The picture fuzzy relation R^2

R^2	u_1	u_2	u_3	u_4
u_1	(1,0,0)	(0.4,0,0.1)	(0.4,0,0.1)	(0.3,0,0.2)
u_2	(0.3,0,0.1)	(1,0,0)	(0.7,0,0.05)	(0,4,0,0.2)
u_3	(0.4,0,0.1)	(0.7,0,0.05)	(1,0,0)	(0.7,0,0.1)
u_4	(0.4,0,0.1)	(0.4, 0,0.1)	(0.4,0,0.1)	(1,0,0)

Definition 5. *Let A be a picture fuzzy set of the set U. For $\alpha \in [0,1]$, the $\alpha -$cut of A (or level α of A) is the crisp set A_α defined by $A_\alpha = \{x \in U: \gamma_A(x) \leq 1 - \alpha\}$.*

Note that if $\mu_A(x) + \eta_A(x) \geq \alpha$ then $\gamma_A(x) \leq 1 - \alpha$.

Example 2. $A = \frac{(0.8,0.05,0.1)}{u_1} + \frac{(0.7,0.1,0.2)}{u_2} + \frac{(0.5,0.01,0.4)}{u_3}$ is a picture fuzzy set on the universe $U = \{u_1, u_2, u_3\}$. Then $0.2 -$cut of A is the crisp set $A_\alpha = \{u_1, u_2\}$.

3. ON PICTURE FUZZY RELATION

In this section, we study some properties of picture fuzzy relations.

Definition 6. *If $R(U \to U)$ is a picture fuzzy tolerance relation on U, then given an $\alpha \in [0,1]$, two elements $x, y \in U$ are $\alpha -$similar, denoted by $xR_\alpha y$, if only if $\gamma_R(x,y) \leq 1 - \alpha$.*

Definition 7.

If $R(U \to U)$ is a picture fuzzy tolerance relation on U, then two elements $x, z \in U$ are $\alpha -$

tolerance, denoted by $xR_\alpha^+ z$, if only if either $xR_\alpha y$ or there exists a sequence $y_1, y_2, \dots, y_r \in U$ such that $xR_\alpha y_1 R_\alpha y_2 \dots y_r R_\alpha z$.

Here, we show that R_α^+ is transitive. Then we have

Lemma 1. *If R is a picture fuzzy tolerance relation on U, then R_α^+ is an equivalence relation.. For any $\alpha \in [0,1]$, R_α^+ partitions U into disjoin equivalence classes.*

Lemma 2. *If R is a picture fuzzy similarity relation on U then R_α is an equivalence relation for any $\alpha \in [0,1]$.*

Lemma 3. *If R is a picture fuzzy similarity relation on U and $\alpha \in [0,1]$ be fixed. $Y \subset U$ is an equivalence class in the partition determined by R_α with respect to R if only if Y is a maximal subset obtained by merging elements from U that satisfies $max_{x,y \in U} \gamma_R(x,y) \leq 1 - \alpha$.*

Lemma 4. *If R is a picture fuzzy similarity relation on U then for any $\alpha \in [0,1]$, R_α and R_α^+ is generate identical equivalence classes.*

Lemma 5. *The transitive closure $\hat{R}$ of a picture fuzzy tolerance relation R on U is a minimal picture fuzzy similarity relation containing R.*

The proof of these results is obviously.

Example 3. Consider the picture fuzzy tolerance relation R on $U = \{u_1, u_2, u_3, u_4\}$ given by

Table 3. The tolerance picture fuzzy relation

R	u_1	u_2	u_3	u_4
u_1	(1,0,0)	(0.8,0.1,0.1)	(0.6,0.1,0.3)	(0,0.2,0.8)
u_2	(0.8,0.1, 0.1)	(1,0,0)	(0.5,0.1,0.4)	(0.6,0.1,0.3)
u_3	(0.6,0.1,0.3)	(0.5,0.1,0.4)	(1,0,0)	(0.3,0.4,0.2)
u_4	(0,0.2,0.8)	(0.6,0.1,0.3)	(0.3,0.4,0.2)	(1,0,0)

By Definition 7, it can be computed that: for $\alpha = 1$, then the partition of U determined by $R_1$is: $\{\{u_1\},\{u_2\},\{u_3\},\{u_4\}\}$,

for $\alpha = 0.9$, then the partition of U determined by $R_{0.9}$ is: $\{\{u_1,u_2\},\{u_3\},\{u_4\}\}$,

for $\alpha = 0.8$, then the partition of U determined by $R_{0.8}$ is: $\{\{u_1,u_2\},\{u_3,u_4\}\}$,

for $\alpha = 0.7$, here, although $\gamma_R(u_2,u_3) = 0.4 > 1 - 0.7 = 0.3$, but also we have $u_2R_{0.7}u_1$ and $u_1R_{0.7}u_3$ then $u_2R^{+}_{0.7}u_3$. Furthermore, we have $u_3R_{0.7}u_4$, so that partition of U determined by $R_{0.7}$ is: $\{\{u_1,u_2,u_3,u_4\}\}$.

Moreover, it is easily seen that:

for $0.9 < \alpha \le 1$, then the partition of U determined by R_1 given by

$\{\{u_1\},\{u_2\},\{u_3\},\{u_4\}\}$,

for $0.8 < \alpha \le 0.9$, then the partition of U determined by $R_{0.9}$ given by $\{\{u_1,u_2\},\{u_3\},\{u_4\}\}$,

for $0.7 < \alpha \le 0.8$, then the partition of U determined by $R_{0.8}$ given by $\{\{u_1,u_2\},\{u_3,u_4\}\}$,

for $\alpha \le 0.7$, then the partition of U determined by $R_{0.7}$ given by $\{\{u_1,u_2,u_3,u_4\}\}$.

4. PICTURE FUZZY DATABASE

In the section we introduce the concept of picture fuzzy database. First, we recall that the ordinary relation database represents data as a collection of relations containing tuples. The organization of relational databases is based on a set theory and relation theory. Essentially, relational databases consist of one or more relations in two-dimensional (row and column) format. Rows are called tuples and correspond to records; columns are called domains and correspond to fields. A tuple t_i having the form $t_i = (d_{i1}, d_{i2}, \ldots, d_{im})$, where $d_{ij} \in D_j$ is the domain value of a particular domain set D_j.

In the fuzzy relational database, $d_{ij} \subset D_j$ is the fuzzy subset of D_j. If $d_{ij} \subset D_j$ is the (fuzzy) subset of D_j and they have the intutionistic fuzzy tolerance relation for each other, themselves, i.e., the domain values of a particular domain set D_j have an intutionistic fuzzy tolerance relation. Then we obtain the intuitionistic fuzzy database. Also, if $d_{ij} \subset D_j$ is the (fuzzy) subset of D_j and they have the picture fuzzy tolerance relation for each other, themselves, i.e., the domain values of a particular domain set D_j have a picture fuzzy tolerance relation. In this case, we call this new concept is picture fuzzy database.

Now, for each the attribute D_j, we denote $P(D_j)$ as the collection of all subset of D_j and $2^{D_j} = P(D_j) - \emptyset$ as the collection of all nonempty subset of D_j. There exists at least an attribute D_j, in which, the picture fuzzy tolerance relation defines on it domain.

Definition 8. *A picture fuzzy database relation R is a subset of the cross product $2^{D_1} \times 2^{D_2} \times \ldots \times 2^{D_m}$.*

Definition 9. *Let $R \subset 2^{D_1} \times 2^{D_2} \times \ldots \times 2^{D_m}$ be a picture fuzzy database relation. A piture fuzzy tuple (with respect to R) is an element of R.*

An arbitrary picture fuzzy tuple is of the form $t_i = (d_{i1}, d_{i2}, \ldots, d_{im})$, where $d_{ij} \subset D_j$.

Definition 10. *An interpretation of $t_i = (d_{i1}, d_{i2}, \ldots, d_{im})$, is a tuple $\theta = (a_1, a_2, \ldots, a_m)$ where $a_i \in d_{ij}$ for each domain D_j.*

For each domain D_j, if R_j is the picture fuzzy tolerance relation then its membership functions are defined by:

- the degree of positive membership $\mu_{R_j}: D_j \times D_j \to [0,1]$,
- the degree of neutral membership $\eta_{R_j}: D_j \times D_j \to [0,1]$,
- the degree of negative membership $\gamma_{R_j}: D_j \times D_j \to [0,1]$,

where $\mu_{R_j}(x,y) + \eta_{R_j}(x,y) + \gamma_{R_j}(x,y) \leq 1$, $(x,y) \in D_j \times D_j$.

In summary, the space of interpretations is the set cross product $D_1 \times D_2 \times \ldots \times D_m$. However, for any particular relation, the space is limited by the set of valid tuples. Valid tuples are determined by an underlying semantics of the relation. Note that in an ordinary relational databases, a tuple is equivalent to its interpretation.

Example 4. Let us make a hypothetical case study for an application in the fight against crime. We consider a criminal data file. Supose that one murder has taken place at an area in a deep, dark line. The police suspects that the murderer is also from the same area.

Listening to the eye-witness, the police has discovered that the murderer has *more or less full big hair coverage, more or less curly hair texture* and he has *moderately large build*.

Police refers to the criminal data file of all the suspected criminals of that area, the short information table with attributes 'HAIR COVERAGE', HAIR TEXTURE' and 'BUILD' is given by Table 4. Then, we consider the picture fuzzy tolerance relation R_1 on the domain of attribute 'HAIR COVERAGE', which is given in Table 5.

Next, the picture fuzzy tolerance relation R_2

on the domain of attribute 'HAIR TEXTURE' which is given in Table 6. Finally, we consider the picture fuzzy tolerance relation R_3 on the *domain of attribute 'HAIR TEXTURE'*, which is given in Table 7.

Table 4. The short information table from the criminal data file (SHORT CRIMINAL DATA)

NAME	HAIR COVERAGE	HAIR TEXTURE	BUILD
Arup	Full Small (FS)	Stc.	Large
Boby	Rec.	Wavy	Very Small (VS)
Chandra	Full Small (FS)	Straight (Str.)	Small (S)
Dutta	Bald	Curly	Average (A)
Esita	Bald	Wavy	Average (A)
Faguni	Full Big (FB)	Stc.	Very Large (VL)
Gautom	Full Small (FS)	Straight (Str.)	Small (S)
Halder	Rec.	Curly	Average (A)

Table 5. The picture fuzzy tolerance relation R_1 on the domain of attribute 'HAIR COVERAGE'

R_1	FB	FS	Rec.	Bald
FB	(1,0,0)	(0.8,0.1,0.1)	(0.4,0.1,0.4)	(0,0,1)
FS	(0.8,0.1, 0.1)	(1,0,0)	(0.5,0.1,0.4)	(0,0.1,0.9)
Rec.	(0.4,0.1,0.4)	(0.5,0.1,0.4)	(1,0,0)	(0.4,0.1,0.4)
Bald	(0,0,1)	(0,0.1,0.9)	(0.4,0.1,0.4)	(1,0,0)

Table 6. the picture fuzzy tolerance relation R_2 on the domain of attribute 'HAIR TEXTURE'

R_2	Str.	Stc.	Wavy	Curly
Str.	(1, 0, 0)	(0.6, 0.1, 0.3)	(0.1, 0.1, 0.7)	(0.1, 0, 0.7)
Stc.	(0.6, 0.1, 0.3)	(1, 0, 0)	(0.3, 0.1, 0.4)	(0.5, 0.1, 0.2)
Wavy	(0.1, 0.1, 0.7)	(0.5, 0.1, 0.4)	(1, 0, 0)	(0.4, 0.1, 0.4)
Curly	(0.1, 0, 0.7)	(0.5, 0.1, 0.2)	(0.4, 0.1, 0.4)	(1, 0, 0)

Table 7. the picture fuzzy tolerance relation R_3 on the domain of attribute 'BUILD'

R_3	VL	L	A	S	VS
VL	(1, 0, 0)	(0.7, 0.1, 0.2)	(0.4, 0.1, 0.4)	(0.3, 0.1, 0.6)	(0, 0, 1)
L	(0.7, 0.1, 0.2)	(1, 0, 0)	(0.5, 0.1, 0.4)	(0.4, 0, 0.5)	(0, 1, 0.9)
A	(0.5, 0.1, 0.4)	(0.5, 0.1, 0.4)	(1, 0, 0)	(0.5, 0.1, 0.3)	(0.3, 0.1, 0.6)
S	(0.3, 0.1, 0.6)	(0.4, 0, 0.5)	(0.5, 0.1, 0.3)	(1, 0, 0)	(0.7, 0.1, 0.2)
VS	(0, 0, 1)	(0, 1, 0.9)	(0.3, 0.1, 0.6)	(0.7, 0.1, 0.2)	(1, 0, 0)

Table 8. Relation 'LIKELY MURDERER '

NAME	HAIR COVERAGE	HAIR TEXTURE	BUILD
{Arup, Faguni}	{Full Big, Full Small}	{Curly, Stc.}	{Large, Very Large}

Now, based on listening to the eye-witness, the job is to find out a list of the criminals who resemble with *more or less full big hair coverage, more or less curly hair texture and moderately large build.*

The job can be done with a query on the picture fuzzy database. It can be translated into relational algebra in the following form:

Select NAME, HAIR COVERAGE,
HAIR TEXTURE, BUILD
From SHORT CRIMINAL DATA
With Level(NAME) = 0,
Level(HAIR COVERAGE) = 0.8,
Level(HAIR TEXTURE) = 0.8,
Level (BUILD) = 0.7
Where HAIR COVERAGE = 'Full Big'
HAIR TEXTURE = 'Curly'
BUILD = 'Large'
Giving LIKELY MURDERER

It can be computed that the above query gives rise to the following relation (Table 8):

Therefore, according to the information obtained from the eye-witness, the police concludes that Arup or Faglguni are the likely murderers. And, further investigation now is to be done on them only, instead of dealing with a hugo list of criminals.

5. CONCLUSION

In this paper, we consider some properties of picture fuzzy relation and picture fuzzy tolerance relation on a universe. Finally, we introduced the new concept: picture fuzzy database (PFDB) and have shown by an example usefulness of picture fuzzy queries on a picture fuzzy database. In the next time, we will study about the functional dependence and practice the normalization in the picture fuzzy database.

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