The Application of Rough Sets Theory in Video Information Processing and Analysis

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***Abstract*—Recent advances in technology have increased the availability of video information data, creating a strong requirement for high efficient systems to manage and process those larger materials. How to making efficient use of video information requires that data to be accessed in an intelligent and user-friendly method and techniques. based above consideration, Firstly, the paper illustrated the basic concepts of Rough Sets, a novel intelligent data analysis tool which have widely used in many fields, including the representation of knowledge and attributes reduction theory; secondly, the main research of Rough Sets application in video information processing researched in detailed, including shots detection and key frame extraction. Finally, the conclusion is given in the end and at the same time, the prospect is also proposed to Rough Sets in future.**

Keywords-video processing; rough sets; video analysis

I. INTRODUCTION

Advances in data compression, data storage, and data transmission have facilitated the way videos are created, stored, and distributed all over the world. The increase in the amount of video data has enabled the creation of large digital video libraries. This has spurred great interest for systems that are able to efficiently manage and analysis video information material [1, 2].

In video analysis and processing, the immediate and main question is what to do with all the large video information, one could store the digital video information on tapes, CD-ROM, DVD, or any such device but the level of access would be less than the well-known shoe boxes filled with tapes, old photographs, and letters[3]. We need to ensure that the techniques for organizing video stay in tune with the tremendous amounts of information [4, 5]. So, with video on demand about to arrive, there is an urgent need for effective video retrieval and summarization methods [6]. Data preprocessing is one of the first and critical step to data mining or data analysis. The results of data preprocessing is directly inputted to mining model and obtained the final results. A good data source can not only increase the accuracy of mining, but also raise the efficiency of algorithm dramatically [7, 8]. In general case, data preprocessing refers to as data cleaning, data integrate, data transition, data reduction, et al., processed before the implementation of data processing algorithm [9, 10]. Whereas, the technique of video data processing concern many comprehensive area such as mathematic, computer, statistic, artificial intelligent, computer visual, et al. different application domain need various function of data preprocessing. So we must explore novel and effective video data analysis tool and think to complete comprehensive computing. Aimed to solve this problem, the paper introduced the Rough Sets theory and applied to the video data analysis.

II. BASIC THEORY AND PRINCIPLE OF ROUGH SETS

In this section we will explore the most important theory and principle of Rough Sets used in this paper, especially the theory of Indiscernibility relation, Lower and Upper Approximations, Attributes Reduction and Core.

A. Indiscernibility Relation

Let $U \neq \phi$ be a universe of discourse and X be a subset of U. An equivalence relation, R, classifies U into a set of subsets $U/R = \{X1, X2, ..., X_n\}$ in which the following conditions are satisfied:

(1) $X_i \subseteq U, X_i \neq \phi$ For any i.

(2) $X_i \cap X_j \neq \phi$ For any i, j.

(3) $\bigcup_{i=1,2,...,n}, X_i = U$

Any subset X_i, which called a category, class or granule, represents an equivalence class of R. A category in R containing an object $x \in U$ is denoted by $[x]_R$. For a family of equivalence relations $P \subseteq R$, an indiscernibility relation over P is denoted by $IND(P)$ and is defined by equation (1).

$$IND(P) = \bigcap_{R \in P} IND(R) \qquad (1)$$

B. Lower and Upper Approximations

The set X can be divided according to the basic sets of R, namely a lower approximation set and upper approximation set. Approximation is used to represent the roughness of the knowledge. Suppose a set $X \subseteq U$ represents a vague concept, then the R-lower and R-upper approximations of X are defined by equation (2) and equation (3).

$$\underline{R}X = \{x \in U : [x]_R \subseteq X\} \qquad (2)$$

Equation (4) is the subset of X, such that X belongs to X in R, is the lower approximation of X.

$$\overline{R}X = \{x \in U : [x]_R \cap X \neq \phi\} \qquad (3)$$

Equation(5) is the subsets of all X that possibly belong to X in R, thereby meaning that X may or may not belong to X in R, and the upper approximation $\overline{R}$ contains sets that are possibly included in X. R-positive, R-negative, and R-boundary regions of X are defined respectively by equation(4), equation(5) and equation(6).

$$POS_R(X) = \underline{R}X \tag{4}$$

$$NEG_R(X) = U - \overline{R}X \tag{5}$$

$$BNR(X) = \overline{R}X - \underline{R}X \tag{6}$$

C. Attributes Reduction and Core

In RS theory, an Information Table is used for describing the object of universe, it consists of two dimensions, each row is an object, and each column is an attribute. RS classifies the attributes into two types according to their roles for Information Table: Core attributes and redundant attributes. Here, the minimum condition attribute set can be received, which is called reduction. One Information Table might have several different reductions simultaneously. The intersection of the reductions is the Core of the Information Table and the Core attribute are the important attribute that influences attribute classification.

A subset B of a set of attributes C is a reduction of C with respect to R if and only if

(1) $POS_B(R) = POS_C(R), and$

(2) $POS_{B-\{a\}}(R) \neq POS_C(R),$ for any $a \in B$

And, the Core can be defined by equation (7)

$$CORE_C(R) = \{c \in C \mid \forall c \in C, POS_{C-\{c\}}(R) \neq POS_C(R)\} \tag{7}$$

III. THE APPLICATION OF ROUGH SETS IN VIDEO INFORMATION PROCESSING AND ANALYSIS

A. The Application of Rough Sets In Video Shots Detection

The video is composed of many different video sequences frame, which is the most small units in video information. In shots detection, if we process every frame in video sequences, the efficiency of shots detection become very pool. So we must select the classic Representative frame to represent all video shots. In addition, as video exist many redundant data, before the analysis of video, we must determinate the impact of redundant data of video information. The novel data analysis tool RS can effective overcome the deficiency of above problem. The main think and steps can described as following.

Step1: extracting the DCT coefficients from original video sequences frame

Step2: extraction the DC coefficient from the DCT coefficients

Step3: constructing the information system using DC coefficients

Step4: divided the video shot using theory of Rough Sets attributes deduction.

We have made a lot of practical experiment use the method above to prove the feasibility and efficiency , figure 1 shows the final results of shots detection.

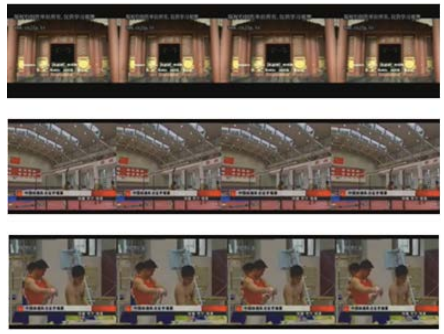

FIGURE I. THE FINAL RESULTS OF SHOTS DETECTION.

B. The Application of Rough Sets In Key Frame Extraction

Key frame is the Representative frame in video sequences, which is can represent the main video content produced from the original video sequences information, so in the video retrieval based on content, key frame is the first and crucial step in video retrieval and analysis. At present, the main problem in key frame extraction is large abundant video data, which can dramatically impact the whole system efficiency. While Rough Sets can effective omit the abundant data without need any pre-knowlege. based on above consideration, we can introduced the Rough Sets theory into key frame extraction techniques in video analysis. The main step can be described as following.

Step1: obtained the experience value of shots segmentation

Step2: extraction DCT coefficients and DC coefficients

Step3: constructing the information system using give DC coefficients

Step4: generating the core of information system

Step5: achieve the key frame of video

We also completed a serious of practical experiments used proposed algorithm to validated the feasibility and efficiency, the final results show that the developed algorithm can completed the object, figure 2 illustrate the results of key frame extraction.

FIGURE II. THE FINAL RESULTS OF KEY FRAME EXTRACTION.

IV. THE CONCLUSION AND PROSPECT

Rough Sets is a novel and powerful tool for data analysis, it has successfully been used in many application domain, such as machine learning, expert system, digital image processing and pattern classification. the main advantage of Rough Sets theory is that it is does not need any preliminary or additional information about original data, like probability in statistics, or basic probability assignment in Dempster-Shafer theory and grade of membership or the value of possibility in fuzzy sets, especially, the attributes reduction theory of Rough Sets has widely used in many application domain. In this paper, we considered the Rough Sets theory application in video processing and analysis, especially exploring the application of shots detection and key frame extraction based on Rough Sets in compressed domain.

With the development of high and new technologies, especially the computer network technologies, more and more data will generate every second, Rough Sets will become a more important and necessary tool to many practical data analysis, for instance, to the digital video analysis or surveillance data.

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