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Image Mining Based on Concept Lattice Theory Using Texture Feature

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Abstract—Animportant part of our knowledge is in the form of images. Discovering knowledge from data stored in typical alphanumeric databases, such as relational databases, has been the focal point of most of the work in database mining. However, with advances in secondary and tertiary storage capacity more and more non standard data (in the form of images) is being accumulated. This vast collection of image data can also be mined to discover new and valuable knowledge. During the process of image mining, the concepts in different hierarchies and their relationships are extracted from different hierarchies and granularities, and association rule mining and concept clustering are consequently implemented. The generalization and specialization of concepts are realized in different hierarchies, lower layer concepts can be upgraded to upper layer concepts, and upper layer concepts guide the extraction of lower layer concepts. It is a process from image data to image information, from image information to image knowledge, from lower layer concepts to upper layer concepts. In this paper framework of image mining based on concept lattice is proposed. The methods of image mining from image texture features are introduced here, which include the following basic steps: firstly pre-process images secondly use cloud model to extract concepts, lastly use concept lattice to extract a series of image knowledge.

***Keywords*—image mining,concept lattice,texture feature, cloud model**

I. Introduction

Recent years have seen a rapid increase in the size of digital image collections.Advances in image acquisition and storage technology have led to tremendous growth in significantly large and detailed image databases [1]. This vast collection of image data can also be mined to discover new and valuable knowledge.Image mining deals with the extraction of implicit knowledge, image data relationship, or other patterns not explicitly stored in the image databases. It is an interdisciplinary endeavor that essentially draws upon expertise in computer vision, image processing, image retrieval, data mining, machine learning, database, and artificial intelligence [2].Concept is a kind of thinking form in mind which reflects the attributes ofobjects. The common essential attributes of the perceptual objects areabstracted andthen the concepts are formed. Concept is composed of intension and extension, and will be changed along with the development of subjective and objective worlds. Concept formation is an important character of brain learning, and it is considered as an effective approach of analogy between data mining and concept formation of brain. If a kind of mathematical formal data structure is created to express intension and extension of concepts, including the abstract relationships among concepts in different hierarchies, the process of data mining and knowledge discovery will be analyzed efficiently and formally.

The cloud model is an effective tool in transforming betweenqualitative concepts and their quantitative expressions. Cloudmodel is used to calculate support, confidence andrelationship in the field of association rules mining. Thehasse diagram of concept lattice reveals the concept hierarchyof the context. It also shows the generalization /specializationrelationship between the concepts corresponding to the subsetrelationship between the property and object sets. Thereforethe graph can be used to produce hierarchies and associationrules, which are consistent with specialization. Cloud modelis adopted to control the generalization of a set of qualitativeattributes, and a new constructing algorithm of concept latticebased on cloud models is presented for mining associationrules in large databases, which is integrating attributeoriented generalization and concept lattice. Mininginformation in high hierarchies will generate some rules thatare interesting and useful.

The remainder of this paper is organized as follows. The relationships between image mining and concept formation are described in section II, cloud model is described in section III, and image mining based on concept analysis is described in section IV, and software prototype and experiments analysis are described in section V. Finally, conclusions are drawn in the final section.

II. Formation of Concepts

A. *Image mining and concept formation*

Concept lattice is proposed by Wille R. [3]. It reflects theprocess of human's concept formationwith mathematicalformal language. Based on binary relationship, concept latticeembodies the unification of intension and extension ofconcepts, reflects the relationships between objects andcharacteristics and the relationships between generalizationand characterization among concepts. With correspondingHasse graph, concept lattice can implement the visualizationof the hierarchies of data concepts, and it is suit to find thelatent concepts from image data [4].

B. *Concept Lattice*

Given context which is a triple T= (O, D, R), where O is object set, D is attribute set, R is the binary relations between O and D, only one partial ordered set corresponds with R, a kind of lattice structure L will be created called concept lattice. Each node of lattice L is an ordered pair, which is called concept (X, Y); here X ε P (O) is the extension of the concept, Y ε P (D) is the intension of the concept, P (O) stands for power set of object, P (D) stands for power set of attribute set. Each ordered pair is self-contained on relation R.The partial ordered relationships could be built among thenodes of concept lattice. Given H1=(X1, Y1) and H2=(X2,Y2), if H1< H2 ↔ Y1Y2, it means that H1 is the directgeneralization of father node of H2. Concept lattice is therepresentation of concept hierarchy, the Hasse graph could beproduced from partial ordered relationships, if H1<H2 and noexisting H3 satisfying H1<H3<H2, there exists one edge fromH1 to H2. With corresponding Hasse graph, concept latticecan implement the visualization of the hierarchies of dataconcepts.
Definition1. A formal context is a triple: K= (O, A, R), where Oand A are two sets, and R is a relation between O and a.
O = {o1, om}, eachoi (i≤ n) is called an object. A = {a1, am),each aj (j ≤ m) is called an attribute. In a formal context K = (O, A, R), if (o,a) Є R, we say that the attribute a is an attributeof the object x, or that x verifies a.(o, a) Є R is denoted by 1 ,and (o,a) R is denoted by 0.Thus ,a formal context can berepresented by a matrix only with 0 and 1.

The set of all lower neighbors of a given concept is a subset of the set consisting of all sub concepts of it.

The algorithm for concept lattice is outlined as follows.

1. Create the top node and bottom node of concept lattice.
2. Scan dataset D, build concept lattice, and find the intensions of all frequent concepts.
3. Produce all frequent items with the intensions produced in Step2.
4. For each frequent item in Step3, generate association rules which confidence value is no less than min_conf.

Table 1. A Formal Context Of An Image

	a	b	c	d	e	f	g	h
1	1	1	1	0	0	0	0	0
2	1	1	0	1	0	0	1	0
3	0	1	1	0	1	0	0	0
4	1	0	0	1	1	0	1	0
5	0	0	1	0	0	1	0	0
6	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	0	1

The matrix of the Formal context represented in table 1 isgiven

	a	b	c	d	e	f	g	h
1	1	1	1	0	0	0	0	0
2	1	1	0	1	0	0	1	0
3	0	1	1	0	1	0	0	0
4	1	0	0	1	1	0	1	0
5	0	0	1	0	0	1	0	0
6	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	0	1

Fig.1.The Matrix of the Formal Context

The context in Table 1 has 16 concepts. The line diagram in fig 2 represents the concept lattice of fig.1 context

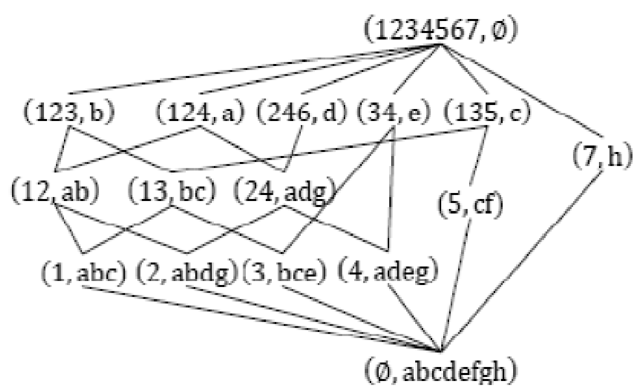


Fig.2 Concept Lattice Of Context

III. Cloud Model

Cloud model is a kind of uncertain transformation model between qualitative concepts and quantitative numerical values; it has been applied into the fields of digital watermark, network in break, data mining, and image segmentation etc. [5]. Cloud model depicts concepts' randomness, fuzziness, and their association. The methods of forward normal cloud model, cloud transformation, concept synthesis of cloud model theory can be used to implement concept ascending and induction in different granularity worlds.

Definition: If U is a quantity domain expressed with accurate numerical values, and C is a quality concept in U, if the quantity value x ε U, and x is a random realization of concept C, μ (x) is the membership degree of x to C,μ (x) ε [0,1] , it is a random number which has a steady tendency: μ :U→ [0,1] , V x ε U , x→μ (x) . The distribution of x in domain is called cloud; each x is called a cloud drop.

A. Numerical Characteristics

The numerical characteristics of cloud model are expressed with Expectation Ex, Entropy En and Super-entropy He, and they reflect the whole characteristics of the quality conception C. Expectation Ex of the Cloud drops' distribution in domain, is the point which can best represent the quality concept, reflect the cloud centre of gravity of cloud drops of the concept [6]. Entropy En is the uncertainty measurement of the quality concept, is decided by the random and fuzziness of the concept, it reflects the connection between the fuzziness and the random. Entropy En is a random measurement of the quality concept, reflects the discrete degree which can represent the quality concept; in another aspect, it is the measurement of fuzziness, and it reflects the value range which can be accepted by the concept of the cloud drop [6]. Use Entropy En the same numeric characteristic to reflect fuzziness and random, and it embodies the connection between each other. The super entropy He is the uncertain measurement of entropy, namely the entropy of the entropy. It reflects the coagulation of uncertainty of all points which representing the concept in the number domain, namely the coagulation degree of cloud drop.

The algorithm for uncertain concept ascending based on cloud model is outlined as follows.

1) Calculate the frequency distribution function f(x) of List
2) Set NULL as cloud concept, h(x) = f(x), While (peak value of h(x) > ε)
3) Set the peak value of h(x) as Expectation Exi of cloudconcept
4) Calculate Entropy Eni of cloud model which is fit to h(x)and its expectation value is equal to Exi
5) Calculate Hyper-entropy Hei
6) Find Clouds = Clouds_{C (Exi, Eni, Hei)}

B. Normal Cloud Model

Normal cloud model: Because of the realization methods of cloud model are different; several different kinds of cloud models can be created, such as symmetry cloud model, half cloud model, combination cloud model, normal cloud model etc.. The normal distribution has the characteristic of universality, the expectation curves of cloud of the quality knowledge about the social and natural sciences are all approximately similar to normal or half normal distribution. The normal cloud model is the most basic type of cloud models, and it is an efficient tool to express language atom. Given Ex=0, En=3, He=0.3, n=10000, the figure of normal cloud model is illustrated in Fig.3.

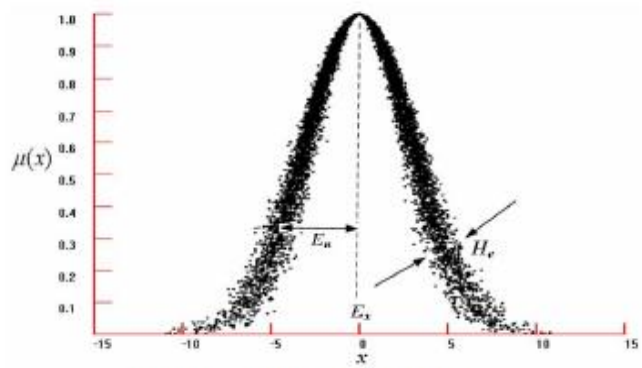


Fig.3 Cloud (0, 3, 0.3, 10000)

IV. Concept Analysis

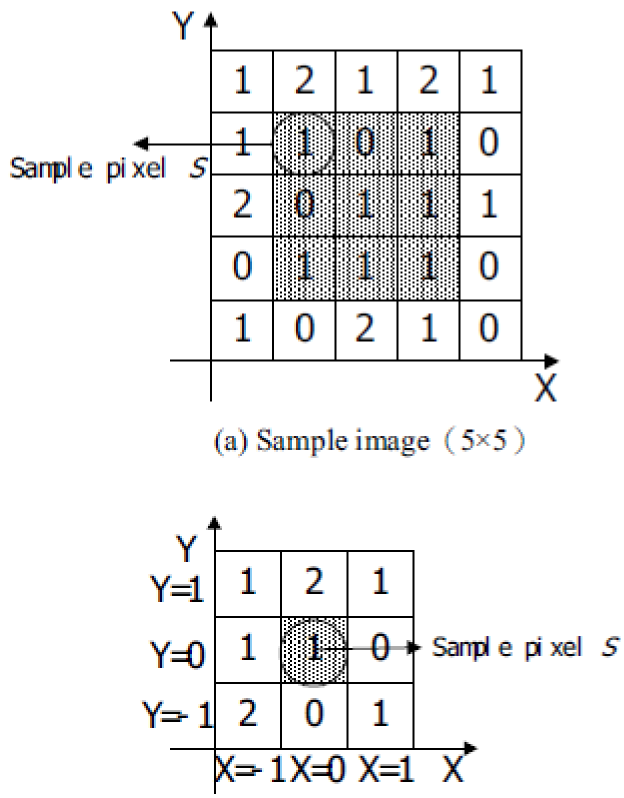
Both concept lattice and cloud model can be used to analyze concepts formally, and they can be combined together. Association rule mining is used to identify relationships among attributes in large data sets. Given a set of items and transactions, an association rule miner will determine which items frequently occur together in the same transactions.

A. Texture Feature

Texture refers to the visual patterns that have properties of homogeneity that do not resultfrom the presence of only a single color or intensity [7]. It is an innate property ofvirtually all surfaces, including clouds, trees, bricks, hair, and fabric. It contains importantinformation about the structural arrangement of surfaces and their relationship to the surroundingenvironment [8]. Because of its importance and usefulness in pattern recognitionand computer vision, there are rich research results from the past three decades. Now, itfurther finds its way into image retrieval.Some key definitions are introduced as follows.

*Root Pixel:*The root pixel of an nXn neighborhood is simply the pixel at the center of the neighborhood. Therefore, there exist $(N-n+1)^2$ root pixels in an image of size NXN. For a sample image of size 5×5, each grid stands for one pixel; every shading pixel is a root pixel, sothe total is 9.

*Item:*Each pixel in the neighborhood of a given root pixelcan map to an item. It is specified by a triple (X, Y, I), whereX is the column offset, Y is the row offset, and I is theintensity of the pixel. The offsets are measured from the rootpixel of the neighborhood. Therefore, the number of distinct



(a) Sample image（5×5）

(b) Item of Sample pixel S（3×3）

Fig. 4 An example of image texture

items is given by n^2G, where G is the number of possiblegray levels.When X = 0, Y = 0, triple (0, 0, i) specifies the items of root pixel in the neighborhood which is illustrated in Fig.4 (b).S is a sample root pixel, the items of S are:(–1, 1, 1), (–1, 0, 1), (–1, –1, 2), (0, 1, 2), (0, 0, 1), (0, –1, 0), (1, 1, 1), (1, 0, 0), (1, –1, 1).

Itemset: A set of items, the number of items in the item set is referred to the cardinality of the item set.

Transaction: A set of items associated with a root pixel.One transaction is only associated with one root pixel. AsFig.4 (b) shown, S is a sample root pixel, the transaction is{(–1, 1, 1), (–1, 0, 1), (–1, –1, 2), (0, 1, 2), (0, 0, 1), (0, –1, 0), (1, 1, 1), (1, 0, 0), (1, –1, 1)}.

The algorithm of image texture feature association rulemining is outlined as follows.

Input: texture images, which will be mined.

Output: texture feature association rules.

1. Read Image and pre-process it.
2. Use cloud model to extract a series of concepts from thepre-processed image.
3. If the number of concepts generated in Step2 is too large,implement cloud concept ascending; if not, go to Step4.
4. Create transaction database D.
5. Take D as source dataset, build concept lattice C, and drawHasse graph.
6. According to concept lattice C, generate texture featureassociation rules.
7. Choose some rules as texture feature knowledge.

The method of texture feature data mining is similar to the following methods of color feature data mining, shape feature data mining and spatial relationship feature mining.

V. Prototype and Experiment Analysis

A. *Design and Development of Software Prototype System*

Based on the framework of image mining for robot vision based on concept lattice and cloud model proposed in this paper, a software prototype system is designed and developed,and is illustrated in Fig.5.

The software prototype includes the following modules: image data management, texture feature data mining, color feature data mining, shape feature data mining, spatial relationship feature mining, storage and management of knowledge, and applications of image knowledge, namelyimage classification based on knowledge, image retrievalbased on knowledge, and object recognition based onknowledge.

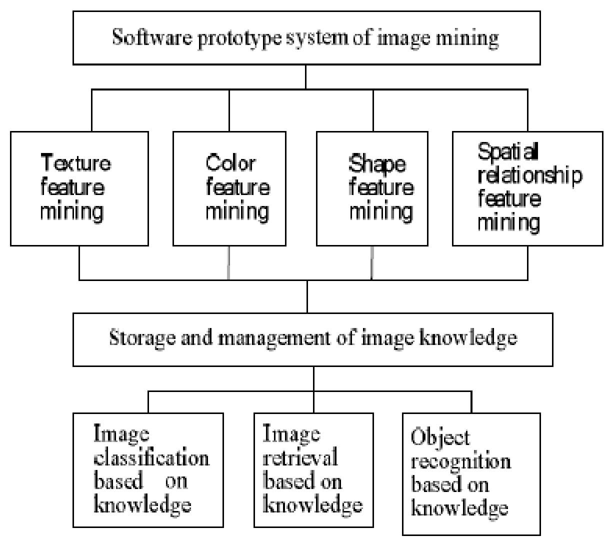
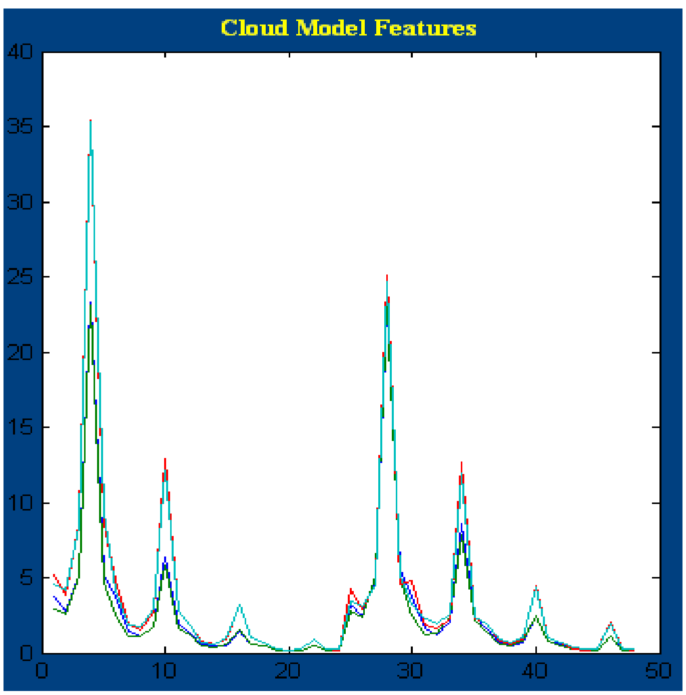


Fig. 5 System structure of software prototype system

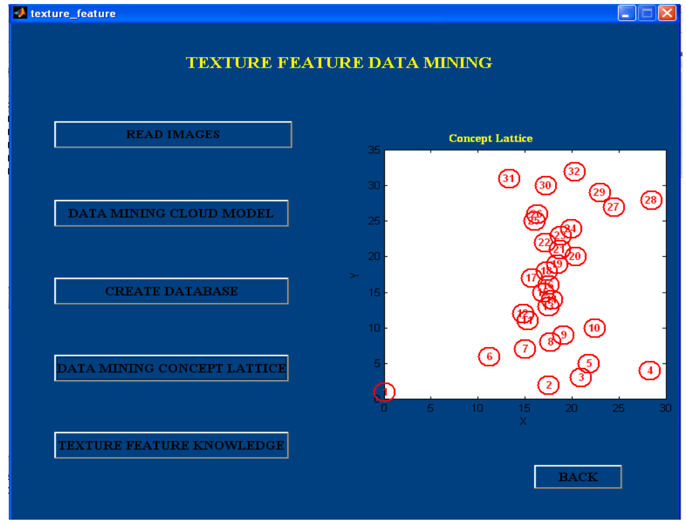
B. *Experiments Analysis*

1) Read the image for the Texture Feature data mining

2) Creating the cloud model of the image for texture features



3) Concept lattice of the image



4) Retrieval of image based on internal image.

5) Result of image retrieval based on knowledge

VI. Conclusion

Image mining is a new research direction, and there is a needto research the basic theories and methods. Both conceptlattice and cloud model provide the tools of formal conceptanalysis, which can be used to discover image knowledgefrom image data. Some experiment results confirm thevalidity of the methods of image mining, and show that theframework of concept driven image mining could preferablymine the knowledge rules of texture features.

The algorithm which is present in this paper has thefollowing advantages.

1) The cloud concept provides a means of both qualitativeand quantitative characterization of linguistic terms. Thismethod can reflect the distribution of data in that domainwhile keeping the soft boundaries.

2) We can find the association rule from thehasse diagram, and can also choose the concept hierarchy tofind the association rules.If user has the interesting of the relation between part objects,there are two methods to deal with it

A. Directly constructing concept lattice from part objectsusing above algorithm. The shortcoming of this method doesnot have the complete relation.

B. Constructing concept lattice from all objects using abovealgorithm, choose the relevance concept hierarchies for theanalysis of the relation between attributes.The methods of image mining based on concept lattice andcloud model offer a novelidea for the research of imagemining.

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