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Research of Fire Classification Algorithm

Wen Shen
Hua Qing College, Xi'an University of Architecture and Technology, Xi'an, 710045, China

Abstract: According to the flame image characteristics cannot be selected with scene Adaptive techquestions, this paper put forward a new algorithm which is based on Concept lattice and rough set, support vector machine (SVM), Through the descretization of fire flame characterstic datas, built the concept lattice gackground, calculate the difference matrix of form background, and use inportance index of characteristics to calculate the inportance of defferent characteristics. Finally put the minimalist feature classification sets into SVM to test. Experiments show that recognition rate of this method was obviously higher than that of single application of rough set for feature selection and feature selection yes artificial identification recognition rate, the efficiency is raised, false alarm is reduced.

Keywords: Image fire detection; Concept lattice; Rough set; Support vector machine

1. Introduction

The basic principle of image-based fire detection is to collect video images from the scene by camera, segment and extract the collected video images, and send out fire alarm signals if the extracted regional features conform to the unique characteristics of flame or smoke.

In recent years, with the increasingly mature image fire detection technology, support vector machine and other technologies have been widely used in fire detection., the support vector machine (SVM) theory has been applied to image fire detection results emerge in endlessly, such as the image fire detection based on support vector machine proposed by Yang najuan [1], the image fire detection algorithm based on support vector machine proposed by ma zongfang [2], and the image fire detection based on independent component analysis and rough set proposed by hu yan [3].but these studies only selected the fixed features of the flame image manually, and did not make the image features adaptive selection according to different scenes.Hu yan et al. [4] proposed a fire detection algorithm based on rough set and support vector machine, which used the attribute reduction algorithm of rough set to select features, but did not consider the importance of attributes of individual features. To solve these problems, a new heuristic fire detection algorithm based on rough concept-support vector machine (SVM) is proposed. Concept lattice [5] is an effective tool for knowledge representation and knowledge discovery, a conceptual hierarchy based on the binary relationship between objects and attributes, and an effective tool for data analysis and rule extraction. One of its important aspects is knowledge reduction. While rough set [4] is a mathematical method to deal with fuzzy uncertainty, the core problem is attribute reduction. In this paper, the advantages of the two are combined for the classification and selection of fire features. The occurrence frequency of features is taken as the index of attribute importance to select the best combination of features from which the accuracy and efficiency of fire detection can be improved.

2. Conceptual Rough Heuristic Fire Feature Classification Algorithm

2.1. Basic theory

Definition 1: let (U, A, F) is the formal background, where $U = \{u1, u2, u3, u4, u5, u6, \cdots,\}$ is the finite object set, $A = \{a1, a2, a3, a4, a5, a6, \cdots,\}$ is the finite attribute set, $F \in U \times A$ is the binary relationship between U and A, if $(x, a) \in F$, is said x to a have attributes, is denoted as xFa, if $(x, a) \notin F$, x is said not to have attributes a .This dualistic relation becomes a conceptual lattices[6]

Definition 2: (U, R) is set as an approximate space, U is the set of objects, R is the equivalence relation on U, and $U/R = \left\{[x_i]_R \middle| x_j \notin R\right\}$. s generated by the equivalence class (U, R) [7] To: $[x_i]_R = \left\{x_j \middle| (x_i, x_j) \in R\right\}$

The formal background of the concept lattice is usually represented by a two-dimensional table. Horizontal represents the attribute, vertical represents the object, and the data in row I and column j is 1, indicating the existence of the attribute, and 0, indicating the absence of the attribute. This definition allows the knowledge of the object to be described as a data table, which becomes the formal background of the problem.

Definition 3: suppose the discernibility matrix $|U| = n$ of formal background D [6] Is a order matrix n, with any element $m_{i,j} = \{a \in C : f(x_i, a) \neq f(x_j, a)$ and $w(x_i, x_j) = 1\}$, where

$$w(x_i,x_j)=\begin{cases}1, x_i \in POS_C(D) \text{and } x_j \notin POS_C(D)\\ 1, x_i \notin POS_C(D) \text{and } x_j \in POS_C(D)\\ 1, (x_i,x_j) \in POS_C(D) \text{and}\\ (x_i,x_j) \notin IND(D)\\ 0, \text{other}\end{cases}$$

Obviously, D it's a symmetric matrix with empty diagonals.

Definition 4: suppose U is a domain, P is an equivalence relation cluster defined on U, and the set composed of all necessary relations in P is called the kernel of a cluster set P [8]And remember C_0.

Definition 5: set the kernel attribute set of the decision system (U,A,F) as (can be empty) C_0, and $a \in C - C_0$ define the mutual information after adding an attribute in the kernel attribute set divided by the self-information of the a attribute as the mutual information distribution rate about the attribute (attribute importance). [6]:

$$SGF(\alpha,C_0,D)=\frac{I(C_0 \cup \{a\},D)}{H(a)}$$

Where, $H(a)=-\sum_{i=1}^{l} p(a_i)\log p(a_i)$ is the proportion $p(a_i)$ of the number of objects a_i whose attribute value is to the total number of objects N. By definition $SGF(a,C_0,D)$, the larger the attribute $SGF(a,C_0,D)$, the more important it is a to the decision D.

2.2. Fire image attribute reduction algorithm

Firstly, video fire detection was conducted to detect different flame characteristics of different combustion materials, and the characteristic data of different combustion materials were counted to get the formal background of the fire detection system. Then, the classification table of characteristic quantity is established to classify and summarize the data of different flame characteristics and determine the classification table of characteristic quantity. The formal background of the fire detection system is simplified by classifying the combustion materials whose formal background attribute values are exactly the same through the characteristic quantity classification table. Calculate the differential matrix of simplified data. Find the elements in the discernibility matrix composed of single attributes, which constitute the relative kernel. C_0 Let $R=C_0$, eliminate the elements that contain the kernel attribute in the discernibility matrix D, and then remove the remaining attribute sets except the kernel attribute to find the attributes $SGF(a,C_0,D)$ that maximize the distribution rate of mutual information R and eliminate the element items that contain this attribute in the discernibility matrix. By repeating the above steps, when all the elements in the discernibility matrix are empty, a relatively optimal attribute reduction set R is obtained.

Input: a formal background (U,A,F), where U is the set of all fire data objects, A is the set of finite attributes, F is the binary relationship between U and A.

Output: a relative reduction set R.

Step1 By analyzing and studying the characteristics of the flame image, the classification table of the characteristic quantity is constructed, and the sample data obtained are discretized by the classification table of the characteristic quantity, and the formal background of the data is established.

Step2 the equivalence class algorithm in definition 2 above is used to delete objects with the same attribute values in the formal background and simplify the formal background.

Step3 use definition 3 to calculate the differential matrix.

Step4 find out the elements in the discriminating matrix whose combined elements only contain a single attribute ak, and make the kernel $C_0=\cup ak$, $R=C_0$.

Step5 empty the combination items containing kernel attributes in the difference matrix; D if empty, turn Step7.

Step6 for $ak \in C - C_0$, use the formula of definition 5 to calculate $SGF(ak,C_0,D)$ and repeat the following operations $SGF(ak,C_0,D)$ for each ak in descending order:

Step6.1 select ak, make $R=R\cup\{ak\}$, and empty the element ak items contained in the difference matrix;

Step6.2 if D empty, go Step7, otherwise go Step6.1.

Step7 output R.

3. Rough Concept - Heuristic Flame Feature Optimization and Classification Algorithm Flow of Support Vector Machine

Support Vector Machine (SVM) has a significant effect on classification problems of small samples, high dimensions and nonlinear. However, only the application of support vector machine in flame feature recognition requires feature recognition one by one with high.

Redundancy and long recognition time. The feature of rough reduction of concept is input into support vector machine, and the classifier is trained, so as to reduce dimension, simplify classifier and improve the speed of fire identification. The block diagram of heuristic flame feature optimization and classification algorithm based on conceptual rough support vector machine is shown in figure 1.

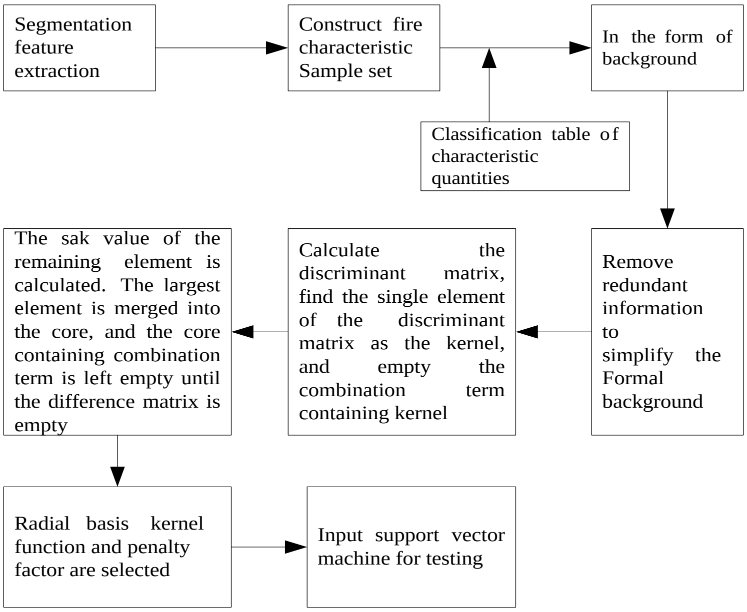

Figure 1. Flow chart of heuristic flame feature optimization and classification algorithm for conceptual rough support vector machine

4. Experimental Results and Analysis

Two groups of video were extracted in the laboratory building and the large factory building respectively. Both groups of video included a section of video with fire and a section of interfering video. They were segmented and feature extracted.

Table 1. Experimental data table of flame characteristics

Scenario	Average roundness	Number of sharp corners	Rate of area change	Mean density	The correlation coefficient	Both eccentricity	The average area change of the two adjacent frames	Red-green component area ratio	The number of dithering projections on the upper and lower edges
Alcohol [u1]	0.4639	9	0.1827	0.7	0.9812	0.2902	95	1.1464	8.2
The candle [u2]	0.822	2	0.0145	0.3604	0.9886	0.3454	162	2.2676	3.6
Annular lamp [u3]	0.8667	0	0.0023	0.1	0.9966	0	120	1.3635	1.25
The searchlight [u4]	0.3832	5	0.0017	0	0.991	0	90	1.2061	0.92
Gas [u5]	0.3374	12	0.18	0.19	0.96	0.3259	562	1.517	9.22
Diesel [u6]	0.3126	4	0.1915	0.2752	0.9808	0.4633	462	1.6737	6.82
Lighter [u7]	0.7842	1	0.13	0.7008	0.9965	0.91	73	1.3838	6
Fluorescent lamp [u8]	0.8703	0	0.0017	0	0.991	0.8405	95	1.5048	0

Can see from the experiment result above, video is like gasoline, diesel, alcohol lamp number of sharp Angle is relatively more, and lighter and fluorescent lamp number of sharp Angle is little, tend to 0 almost. Average roundness, the average roundness of video with fire is smaller, while the average roundness of lighter, fluorescent lamp and so on is larger, and these significant features are easy to find out whether there is fire.

Classification table of characteristic quantities

The characteristic quantity classification table is the standard for the discretization of the characteristic data measured above. With c1, c2, c3, c4, c5, c6, c7, c8, c9 and the number of 1, 0 indicates the circular degree, Angle, area rate of 9 kinds of features and decision making as A result, the attributes of A = {c1, c2, c3, c4, c5, c6, c7, c8, c9}, the attribute value Y = {0, 1} represent no fire and fire. Through a large number of fire image experiments and simulations, the classification table of characteristic quantities is shown in table 2.

Table 2 Classification table of characteristic variables

Characteristics of the	The scope of	Attribute values	
		1	0
Circular degree	c1 < 0.36	√	
	other		√
Number of sharp corners	c2 > 6	√	
	other		√
Rate of area change	0.2 < c3 < 0.5	√	
	other		√
Mean density	0 < c4 < 0.6	√	
	other		√
The correlation coefficient	0.96 < c5 < 1	√	
	other		√
Both eccentricity	c6 < 0.35	√	
	other		√
The average area change of the two adjacent frames	c7 > 200	√	
	other		√
Red-green component area ratio	1.2 < c8 < 3	√	
	other		√
The number of dithering projections on the upper and lower edges	6 < c9 < 12	√	
	other		√

4.1. Calculate the discrimination matrix

The differential matrix is calculated according to the simplified formal background $D=$

$$\begin{pmatrix} \{0\} & \{c2,c6\} & \{c1,c4,c7\} & \{c1,c2,c3,c7,c9\} & \{c1,c2,c4,c5,c6,c7,c9\} & \{c1,c2,c3,c4,c5,c6,c7,c9\} \\ \Phi & \Phi & \{c1,c2,c4,c6,c7\} & \{c1,c3,c6,c7,c9\} & \{c1,c4,c5,c7,c9\} & \{c1,c3,c4,c5,c7,c9\} \\ \Phi & \Phi & \Phi & \{c2,c3,c4,c4,c9\} & \{c2,c5,c6,c9\} & \{c2,c3,c5,c6,c9\} \\ \Phi & \Phi & \Phi & \Phi & \{c3,c4,c5,c6\} & \{c4,c5,c6\} \\ \Phi & \Phi & \Phi & \Phi & \Phi & \{c3\} \end{pmatrix}$$

4.2. Attribute importance is used to reduce features

According to the distinction matrix above, row 5 and column 6 of the matrix contain a single element a3, constituting the relative kernel. The SGF values of the remaining attributes c1,c2,c4,c5,c6,c7,c9 are calculated, and the SGF values of a1 are maximized. A1 is added to the relative core, and the element terms of a1 in the discernibility matrix are eliminated. Repeat the above steps until all elements in the discernibility matrix are empty, and then a relatively optimal attribute reduction set R={c1,c3, c6}={circularity, rate of area change, eccentricity} is obtained.

4.3. Input support vector machine for testing

According to experimental experience, radial basis kernel function sigma = 0.2 and penalty factor C =100 are selected for the fire classification model. Two groups of video were extracted from the laboratory building and the large factory building as the source of test data. 120 frames of images were extracted from each group of video as the test data. The algorithm in this paper was used to conduct comparative experiments with literature [1] and literature [2] respectively.

Table 3. Comparative test results of the three methods

Image sequence	Discrimination rate (%)		
	SVM algorithm	Rough-svm algorithm	This paper algorithm
1	92.6	93.3	95.4
2	93.2	93.6	95.6

According to the experimental data in table 3, in video sequence 1, the recognition accuracy of the algorithm in this paper is 95.4%, 2.8 percentage points higher than the 92.6% of the algorithm in SVM algorithm, and 1.1 percentage points higher than the 93.3% of the algorithm in rough svm algorithm .Similarly, in video sequence 2, the recognition accuracy of the algorithm in this paper is 95.6%, which is slightly higher than the 93.2% in SVM algorithm and 93.6% in Rough svm algorithm. This is because the concept lattice rough set heuristic algorithm, not only for the attribute reduction, and the importance of a single attribute measurement, choose the most can describe the properties of flame image characteristics as fire classification basis, to identify speed slightly higher than the SVM algorithm and Rough svm algorithm, greatly reduces the dimension of feature space and reduce the complexity of algorithm, the recognition system shortens the time fire detection and identification.

5. Conclusion

In this paper, the fire detection and improve efficiency and reduce misjudgment etc, for the purpose to study the new method of feature selection of fire image detection, namely in the heart of the feature selection process of the importance of attribute in rough set of metrics and the improved discernibility matrix used in attribute reduction in concept lattice, reduces the correlation between characteristics, reduces the dimension of feature space, through simulation experiment, reduces the dimension of feature space, through the simulation experiment proves the feasibility and effectiveness of the algorithm.

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