IMAGE PROCESSING BY DISTRIBUTED PATTERN STRUCTURE FEATURES

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An approach to determine distributed pattern structural features based on 3-stages clustering algorithm is considered. It is suggested to use these structural features for image classification and searching.

Key words – clustering, feature extraction, structure features, visual pattern.

1 INTRODUCTION

The existent universal content-based image retrieval systems (CBIR) attribute to one of three categories depending on approach of extracting features: a histogram, coloured location, and region-based. Such properties in particular, is: color [2 – 3], shape [4 – 5], structure [6] and location [7]. Extracted features are stored in a visual feature database. In the searching phase, when a user makes a query, a feature vector for the query is compared to the vectors in the feature database. The images most similar to the query are returned to the user.

A successful categorization of images will greatly enhance the performance of CBIR systems by filtering out images from irrelevant classes during matching [1].

Region-based image retrieval systems use local properties of regions (ideally objects) as opposed to the global properties of the entire image. Example of regions-based systems includes SIMPLIcity [8]. If objects within the image are segmented and each object feature is extracted automatically, these feature make possible object-based image retrieval [9]. However, representing of the images by adequate number of clusters (objects in the image) can better present the content of them but this approach is time consuming.

Other examples of semantic image classification includes comparison work of city and landscape [1] and finding of person [10]. Wang and Fischler [11] shows that exact semantic presentation is useful to the image comparison problem.

Presented article is devoted to investigation of distributed 4-D pattern features of image, got by the 3-stages clustering algorithm. As 4-D pattern features we consider two spatial coordinates, brightness level and space structure coefficients indicating characteristics of pattern decomposition. As a result it is suggested to use all types of properties to build the complex pattern key for merging criteria in image classification and searching systems.

2 IMAGE DECOMPOSITION

Visual pattern we decompose and consider as a set of objects which have its own complex structure presented by 3-stages hierarchical tree (Fig. 1). We call the objects in order from the highest to the lowest level as: integrated areas (its number we define as *IA*), closed regions (*CR*), clusters (rectangles, *C*), microclusters (*MC*) [12-13].

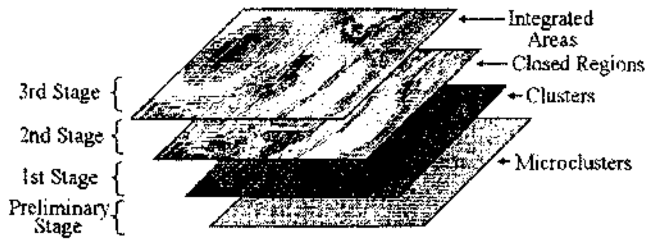


Fig.1. Objects of 3-stages hierarchical tree.

Fig.2 demonstrates for given pattern three surfaces, covered by clusters-rectangles, regions and integrated areas.

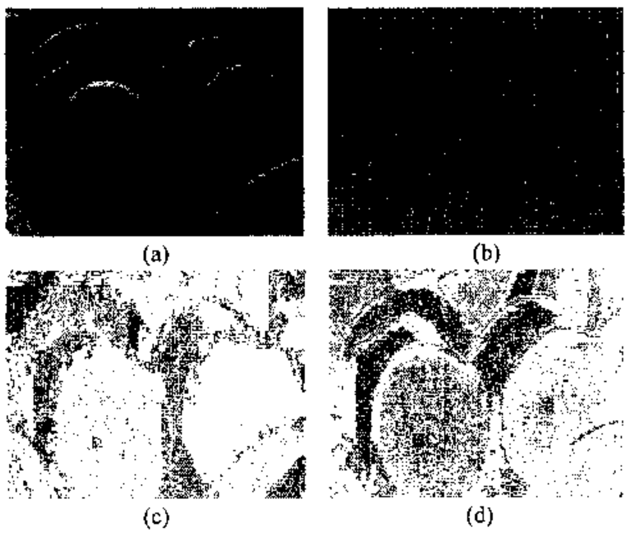


Fig.2. Image (a), clusters (b),
closed regions (c) and integrated areas (d).

The objects from different stages are characterized by dimension, brightness, topology and figure. Hierarchical structure is reached by description a pattern of a pattern by integrated areas, integrated areas by closed regions, closed regions by clusters-rectangles and rectangles by micro-clusters got by the 3-stages clustering algorithm.

3 DISTRIBUTED PATTERN FEATURES

Distributed structure coefficients. To formulate distributed 4-D pattern features we use the histogram model having 8 positions. First of all we present distributed structure number parameters CR_D and IA_D as dependence of its brightness (here also instead notation for structure objects and its number CR, IA we use a variable CL):

$$CL_D(BI_M) = \{CL_{d1}(BI_M), \ldots, CL_{d8}(BI_M)\}, \qquad (1)$$

where $\Delta CL(BI_M)$=256 / 8.

Eight intervals for integral brightness BI_M are: 0÷32, 33÷64, 65÷96, 97÷128, …, 222÷255.

Sometimes instead of full brightness interval 256 one could assign shorted more practical interval 50 ÷ 150.

The histogram model for structure object number dependence of its square is as follows:

$$CL_D(S) = \{CL_{d1}(S), CL_{d2}(S), \ldots, CL_{d8}(S)\}, \qquad (2)$$

where histogram interval is $\Delta = S(P)/8$.

The histogram model for structure coefficient dependence of its value and square is as follows:

$$K_{VD}(CL,S,v)=\{K_{Vd1}(CL, S, v),\ldots,K_{Vd8}(CL, S, v)\}, \qquad (3)$$

where first by square eight coefficients are taken part as determination values.

Spatially distributed features. To formulate the distributed pattern features by the histogram model we cover closed regions or integrated areas of a pattern by a grid for example with a step 4×2. On Fig.3 we have the pattern covered by eight rectangles.

For every rectangle we estimate number of closed regions or integrated areas covered by it. Thus we get spatially distributed structural object number:

$$CL_D(XY) = \{CL_{d1}(XY), \ldots, CL_{d8}(XY)\} \qquad (4)$$

Calculating point or integral brightness of every rectangles with related structural objects we get for a pattern its spatially distributed brightness characteristics:

$$BI_D(CL, XY) = \{BI_{d1}(CL,XY),\ldots, BI_{d8}(CL,XY)\} \qquad (5)$$

where: $\Delta XY = S(P)/8$, $BI_M(CL) = (1/CL)\cdot\sum w_i \cdot B_i(CL)$, $i \in I_p(CL)$, and $I_p(CL)$ – subset of structure cluster indexes.

Calculating structure coefficients for every rectangle from Fig.3 separately we get for a pattern its spatially distributed structure characteristics:

$$K_{VD}(P) = \{Kv_{d1}(CL, XY),\ldots, Kv_{d8}(CL, XY)\} \qquad (6)$$

where $\Delta XY = S(P)/8$, $K_{VD}(CL_p) = \sum w_i \cdot K_{Vi}(CL\text{-}1))$, $i \in I_p(CL_p - 1)$, $I_p(CL_p - 1)$ – subset of indexes of structure clusters forming the cluster CL_p.

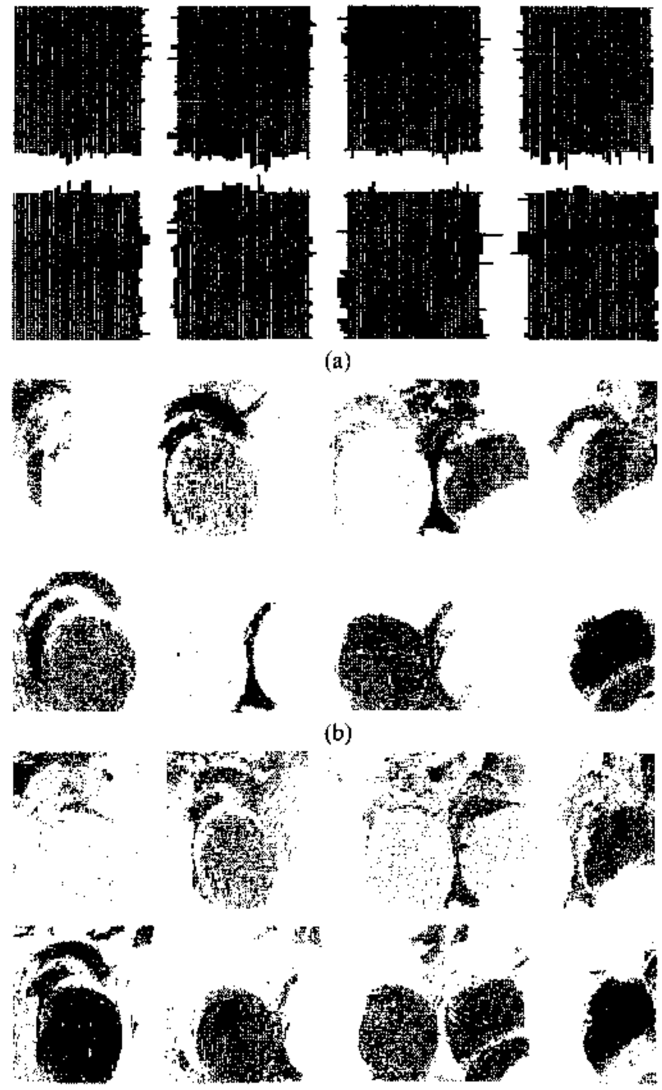
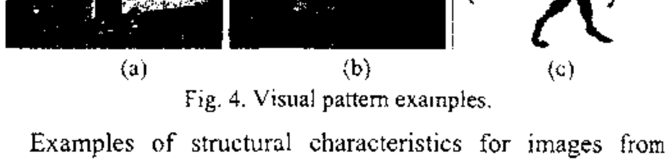


Fig.3. Image covered into 8 sections by clusters (a), regions (b) and areas (c).

4 STRUCTURAL FEATURES INVESTIGATION

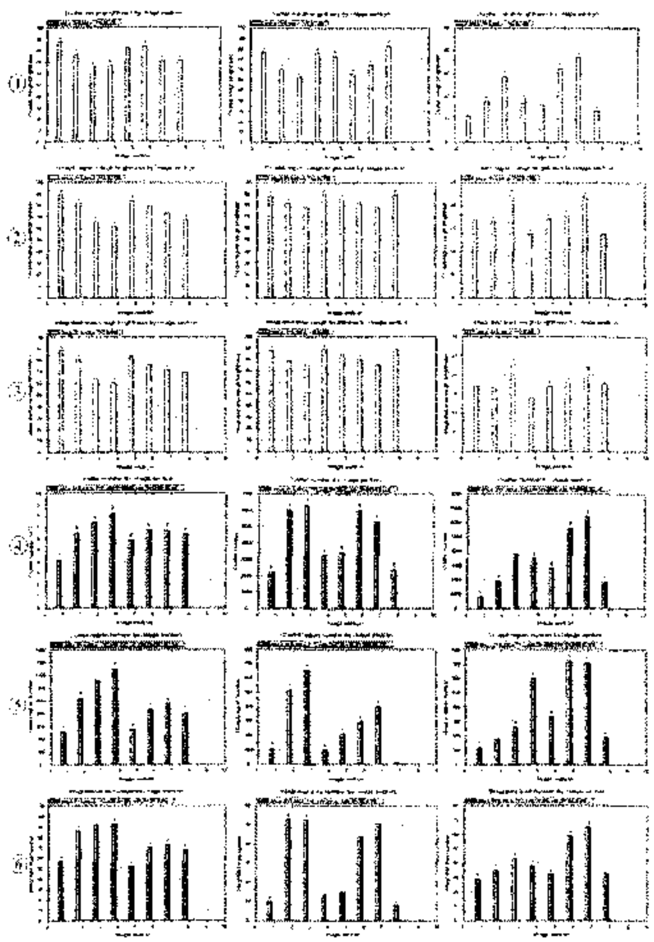
Investigation of algorithm and structural coefficients are conducted over database of 1000 visual patterns, collected into 10 semantic classes: lions, elephants, horse, flowers, meal, mountains, busses, design, texture image, medical patterns. Each class contains 100 images in the JPEG format with sizes 256×384 pixels. Examples of visual patterns are shown on Fig.4.



(a) (b) (c)

Fig. 4. Visual pattern examples.

Examples of structural characteristics for images from Fig.4 are presented on Fig.5.



(a) (b) (c)

Fig.5. Structural characteristics for images from Fig.4:
1 – cluster weighed brightness by image sections, $BI_D(C, XY)$;
2 – region weighed brightness by image sections, $BI_D(CR, XY)$;
3 – area weighed brightness by image sections, $BI_D(IA, XY)$;
4 – cluster number by image sections, $C_D(XY)$;
5 – region number by image sections, $CR_D(XY)$;
6 – integrated area number by image sections $IA_D(XY)$.

To collect images into semantic groups we suggest to use proposed distributed pattern features and next criterion: if features of image j creates curve which is in some tolerance area of image i features, than we assign the image j into image i class.

Fig.6 illustrates this criterion: curve which created from features of image i shown in blue color, and tolerance area is restricted by two red curves.

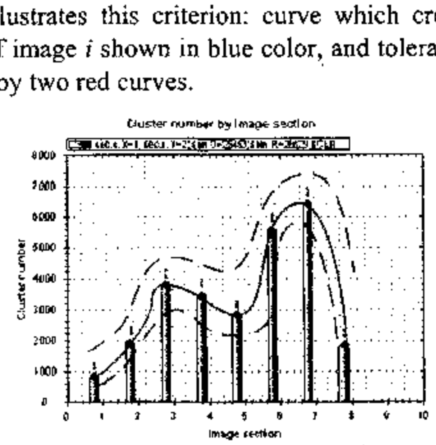


Fig.6. Image classification criterion.

For image indexing investigation a set A with 3×8=24 pattern features and set B with 3×8+2=26 pattern features were took:

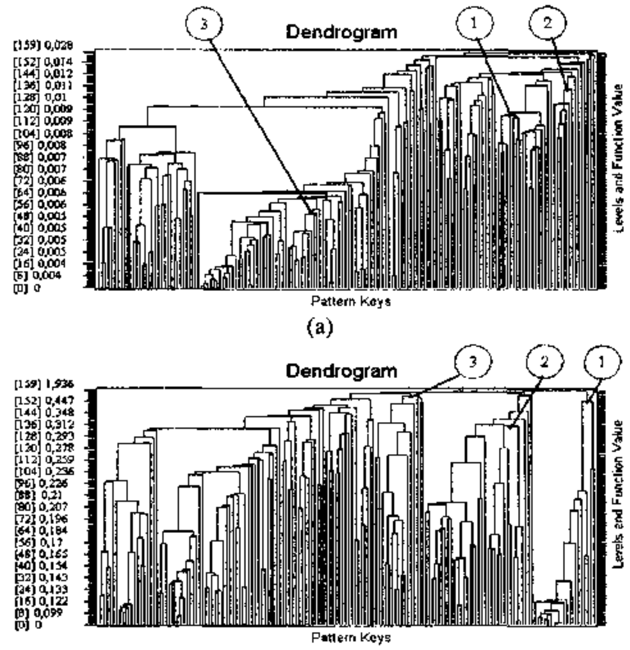
$$A=A\{BI_D(C, XY), BI_D(CR, XY), BI_D(IA, XY)\} \quad (7)$$

$$B=B\{CR, IA, C_D(XY), CR_D(XY), IA_D(XY)\} \quad (8)$$

As clustering result dendrograms were got. Every dendrogram node is connected with database of classified images. User can indicate the node and get full information about images placed on the concrete rolling-up tree level.

Examples of the indicated nodes 1, 2, 3 from dendrograms are presented on Fig.7.

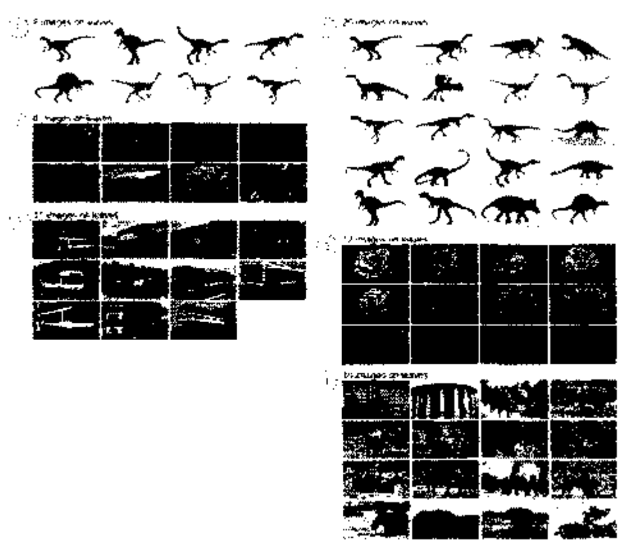
Fig.8 illustrates classification result for 3 semantic groups: dinosaurs, flowers, busses and animals (lions + elephants).



(a)

(b)

Fig.7. Dendrograms for clustering pattern feature set A (a) and B (b).



(a) (b)

Fig.8. Clustering results for pattern feature sets A (a) and B (b).

Fig.9 presents pattern examples from busses semantic group. Examples of distributed pattern features for images from Fig.9 are presented on Fig.5 and in a Table.

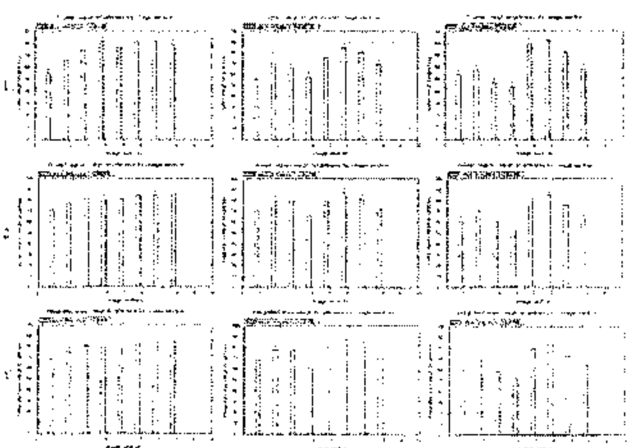
(a) (b) (c)

Fig.9. Visual pattern examples from busses semantic group.

TABLE

DISTRIBUTED PATTERN FEATURES

Feature	Section	Image (a)	Image (b)	Image (c)
$BI_D(C, XY)$	1	55,3870	56,1497	53,9556
	2	66,4136	70,3651	58,4315
	3	74,7831	66,4661	46,7596
	4	81,6099	57,7679	43,4452
	5	76,4207	75,9944	79,7779
	6	81,6133	85,0718	81,7986
	7	81,6186	80,9383	72,3188
	8	79,5002	69,9122	58,5714
$BI_D(CR, XY)$	1	71,0449	70,5835	62,0012
	2	77,0272	79,6805	70,4575
	3	81,5783	80,2204	60,1858
	4	80,4314	66,8075	52,9636
	5	81,1726	79,1122	81,7922
	6	84,3906	87,4511	84,6851
	7	84,5284	81,9393	75,9353
	8	85,3088	72,3918	62,9746
$BI_D(IA, XY)$	1	68,4058	68,5624	59,1051
	2	75,8741	78,2863	68,3680
	3	80,6082	77,6552	57,8259
	4	79,0194	61,6936	52,2132
	5	77,7906	76,5111	79,4991
	6	83,9854	83,5419	83,4974
	7	83,7397	81,1196	72,5386
	8	84,6743	80,6889	64,4064



(a) (b) (c)

Fig.10. Distributed characteristics for images from Fig.9:

1 – cluster weighed brightness by image sections, $BI_D(C, XY)$;
2 – region weighed brightness by image sections, $BI_D(CR, XY)$;
3 – area weighed brightness by image sections, $BI_D(IA, XY)$.

5 CONCLUSION

The 3-stages clustering algorithm for visual patterns allows to get a fragment quantitative and qualitative description and relations between them. Distributed pattern structure features are extracted from them.

Experiments confirmed usefulness of structural and fragment characteristics for image classification. Image keys formed by presented visual pattern features could be recommended for application in automated image processing systems.

REFERENCES

[1] On image classification: city vs. landscape / A. Vailaya, A.K. Jain, H.J. Zhang // Pattern Recognition. – 1998. – Vol. 31. – P. 1921-1935.

[2] Color indexing / M.J. Swain, D.H. Ballard // Intern. journal of Computer Vision. – 1991. – Vol. 7, n. 1. – P. 11-32.

[3] Image retrieval using histograms of unicolor and bicolor blocas and direccional changes in intensity gradient / H. Nezamabadi-pour, E. Kabir // Pattern Recognition Letters. – 2004. – Vol. 25, n. 14. – P. 1547-1557.

[4] Shape similatity retrieval under affine transforms / F. Mokhtarian, S. Abbasi // Pattern Recognition. – 2002. – Vol. 35. – P. 31-41.

[5] Image retrieval using color and shape / A.K. Jain, A. Vailaya // Pattern Recognition. – 1996. – Vol. 29, n. 8. – P. 1233-1244.

[6] Texture feature for browsing and retrieval of image data / B.S. Manjunath, W.Y. Ma // IEEE PAMI. – 1996. – Vol. 8, n. 18. – P. 837-842.

[7] Image classification and quering using composite region templates / J.R. Smith, C.S. Li // Academic Press, Computer Vision and Understanding. – 1999. – Vol. 75. – P. 165-174.

[8] SIMPLIcity: semantic sensitive integrated matching for picture libraries / J.Z. Wang, J. Li, G. Wiederhold // IEEE Trans. on Pattern Analysis and Machine Intelligence. – 2001. – Vol. 23, n. 9. – P. 947-963.

[9] Extraction of major object features using VQ clustering for content-based image retrieval / H.W. Yoo, S.H. Jung, D.H. Jang, Y.K. Na // Pattern Recognition. – 2002. – Vol. 35. – P. 1115-1126.

[10] A probabilistic approach to object recognition using local photometry and global geometry / M.C. Burl, M. Weber, P. Perona // Proc. European Conf. Computer Vision. 1998. – P. 628-641.

[11] Visual similarity, judgmental certainty and stereo correspondence / J.Z. Wang, M.A. Fishler // Proc. DARPA Image Understanding Workshop. – 1998.

[12] Decomposition of Visual Patterns / R. Melnyk, R. Tushnytskyy // Proc. of 9th Intern. Conf. CADSM. – 2007. – P. 278-279.

[13] Sensitivity Threshold and Brightness Control while Decomposing Grey Images by Clustering / R. Melnyk, R. Tushnytskyy // Proc. of Intern. Conf. CSIT. – 2007. – P. 133-136.