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COMPARISON OF TWO CLUSTERING METHODS IN IMAGE SEGMENTATION

POROVNANIE DVOCH ZHLUKOVACÍCH METÓD V SEGMENTÁCII ČÍSLICOVÝCH OBRAZOV

Abstract

This contribution describes two clustering methods common for data analysis – the fuzzy c-means and the Gustafson – Kessel method, which were used in the image segmentation process in its pre-processing stage. The RGB and L*u*v* color space was used as the feature space for these clustering methods. Properties of these clustering methods were obtained from five color images. Images weren't of the same sizes; each image has its own vertical and horizontal resolution. An average count of pixels was about 157000 pixels. Images were originally defined in the RGB color space.

A segmentation method was based on a basic region growing method. Defuzzification of membership grades of pixels into clusters was necessary. Results were obtained in the RGB and L*u*v* color spaces, firstly with the fuzzy c-means, secondly with the Gustafson - Kessel method. A comparison of results given by both methods was done by experimental simulations in Matlab.

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Abstrakt

Tento príspevok popisuje dve zhlukovacie metódy bežné pri analýze dát – fuzzy c-means metódu a metódu Gustafsona – Kessela, ktoré boli použité v segmentácii číslicových obrazov vo fáze predspracovania obrazu. Ako príznakový priestor týchto metód boli zvolené RGB a L*u*v* farebné priestory. Vlastnosti týchto metód boli získané experimentmi nad piatimi farebnými obrázkami. Obrázky nemali rovnaké veľkosti, každý z nich mali rozdielnu šírku aj výšku. Priemerný počet pixelov bol zhruba 157000. Obrázky boli pôvodne zaznamenané v RGB farebnom priestore.

Metóda narastania segmentov tvorí hlavnú časť segmentačnej metódy. Pre jej prácu bola potrebná defuzzifikácia stupňov príslušností jednotlivých pixelov do zhlukov. Výsledky boli získané v RGB a L*u*v* farebných priestoroch, najprv s fuzzy c-means metódou, potom s metódou Gustafsona – Kessela. Porovnanie výsledkov dávaných týmito metódami bolo vykonané experimentálnymi simuláciami na testovacích obrázkoch v Matlabe.

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1 INTRODUCTION

Image segmentation was, is and will be a major research topic for many image processing researchers. The reasons are obvious and applications count endless. Most computer vision and image analysis problems require a segmentation stage in order to detect objects or divide the image into

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regions, which can be considered homogeneous according to a given criterion, such as color, motion, texture, etc [3, 4].

Sometime is necessary to adjust computer vision to human vision. Especially is it necessary, when we are segmenting images, which were segmented by people and we try to replace people with computers or when we want to help people in segmentation of images. Typical application is medicine, e.g. segmentation of MRI images or dermatological images [3, 4].

2 PARTIAL SEGMENTATION DEFINITION

For claim of methods is necessary to express more mathematically exactly partial segmentation, which is not exactly mathematically defined in [3].

Let I marks digital image of rectangular shape. Let image I has width w and height h. Let $\mathbf{a}_{ij} \in I, i = \{1,2,\dots,w\}, j = \{1,2,\dots,h\}$ marks pixel of image I (in general pixel can be a vector of values). Let R_i marks segment, let segment's count is M. Let H marks homogenous criterion, let homogenous criterion is binary (it can reach only two values) [4, 6]

$$H = \begin{cases} 1 \Leftrightarrow \text{argument accomplish criterion} \\ 0 \Leftrightarrow \text{argument not accomplish criterion} \end{cases} \tag{1}$$

Digital images segmentation is process of dividing image I to not overlapping segments R_i. Each segment R_i accomplish homogenous criterion H and at the same time for each neighboring segments R_j applies, that by homogenous criterion uniting neighboring segment R_i and segment R_j will be created not homogenous segment. Segment R_i is part of image I, which was created in process of segmentation. Digital image segmentation is process, which result accomplish next conditions [3, 4, 6]

$$\bigcup_{i=1}^{M} R_i = I= \tag{2}$$

$$\forall\, n,m \in \{1, 2, \dots, M\}, n \neq m : R_n \cap R_m = \varnothing \tag{3}$$

$$\forall\, n \in \{1, 2, \dots, M\} : H(R_n) = 1 \tag{4}$$

$$\begin{aligned} &\forall\, n,m \in \{1, 2, \dots, M\}, n \neq m, R_n \text{ and } R_m, \\ &\text{which are neighbours} : H(R_n \cup R_m) = 0 \end{aligned} \tag{5}$$

3 SEGMENTATION METHOD

Segmentation process consists of several steps. The first of all is input image conversion to chosen feature space, which may depends of used clustering method. In our case is input image converted from RGB color space to L*u*v* color space [4, 5, 6] and L*, u* and v* values are features respectively attributes for fuzzy c-means and Gustafson – Kessel clustering method.

Next step after input image conversion to feature space is applied clustering. In our case, we have chosen fuzzy c-means [1, 4, 6] and Gustafson – Kessel method [1], settings are in experiments section.

After these two steps (input image conversion to feature space of clustering method and accomplishing clustering method) is accomplished next segmentation method.

Method 1 (M1)

BEGIN OF M1

Assumptions: Image transformed into L*u*v* color space, number of clusters c, stop condition ε, fuzziness parameter m.

Step 1: Cluster image in feature space, with next conditions: number of clusters is c, fuzziness index is m and stop condition is ε.

Step 2: Repeat for each pixel $\mathbf{a}_{ij}$ of image I.

Step 2.1: Find out, into which cluster C_ℓ belongs pixel $\mathbf{a}_{ij}$ at most.

Step 2.2: Find out, whether in the closest surroundings of pixel $\mathbf{a}_{ij}$ exists segment R_k, which points belong to same cluster C_ℓ.

Step 2.3: If such segment R_k exists, than pixel $\mathbf{a}_{ij}$ add to segment R_k, else create new segment R_n and add pixel $\mathbf{a}_{ij}$ to new segment R_n.

Step 3: Merge all segments, which belong to one cluster and are neighbors.

Step 4: Arrange borders of all segments.

END OF M1

4 EXPERIMENTS AND RESULTS

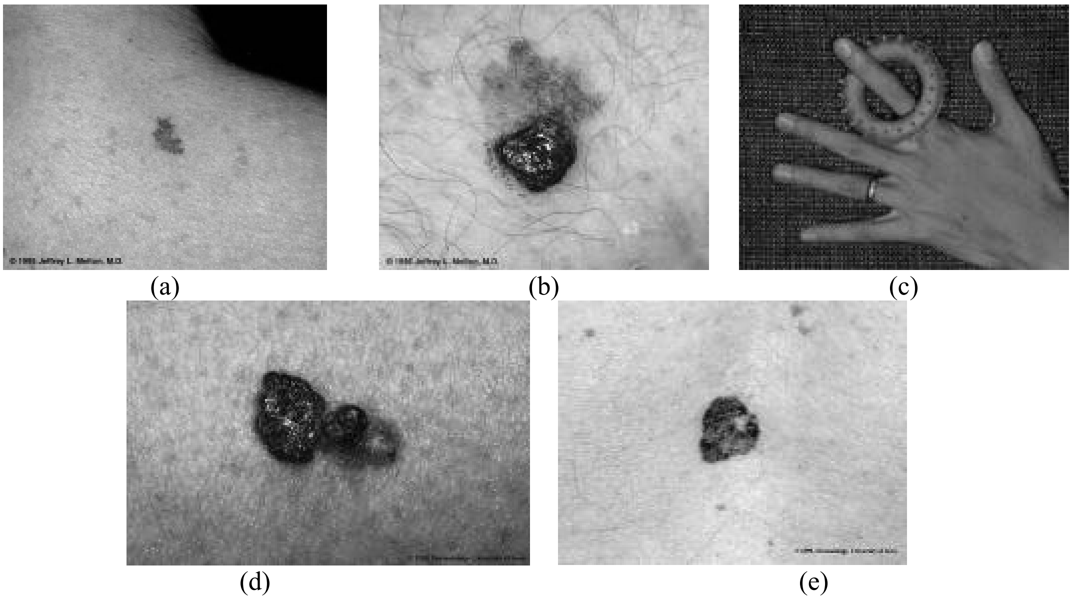

Fig. 1 Test images

Segmentation method M1 was applied to results of clustering method. Firstly were five testing color images clustered by fuzzy c-means method in RGB and L*u*v* color space. Consecutively were these images clustered with Gustafson – Kessel method in RGB and L*u*v* color space too. Conditions for clustering methods were: fuzziness index $m = 2$, stop condition $\varepsilon = 0.01$, number of clusters $c = 3$. Results for fuzzy c-means method can be seen in table 1 and in Fig. 2 and 3, results for Gustafson – Kessel method can be seen in table 2 and in Fig. 4 and 5.

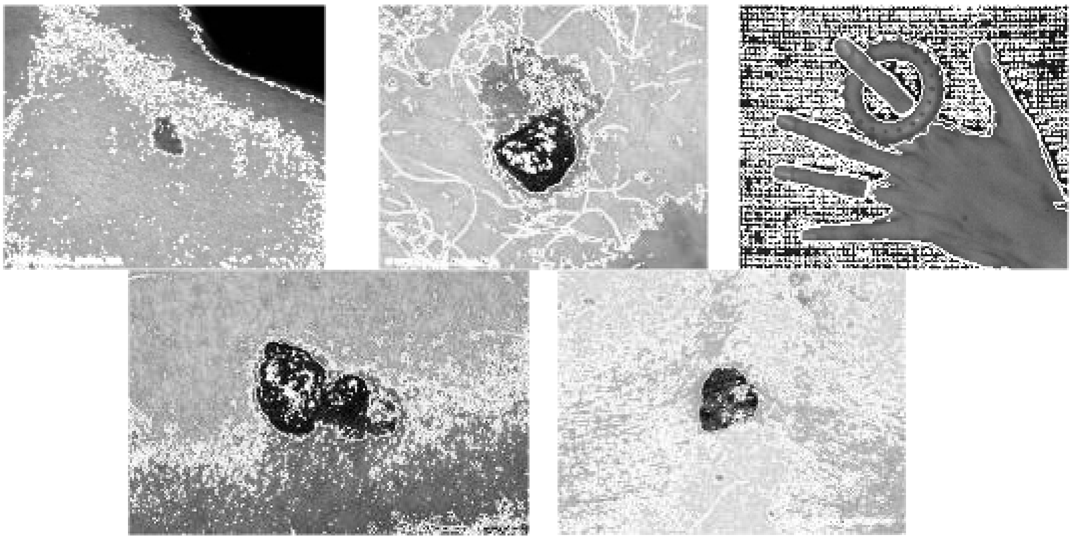

Fig. 2 Results of segmentation – fuzzy c-means method, RGB color space

Tab. 1 Results of segmentation – fuzzy c-means method

Image	(a)		(b)		(c)		(d)		(e)	
Color space	RGB	L*u*v*	RGB	L*u*v*	RGB	L*u*v*	RGB	L*u*v*	RGB	L*u*v*
Number of segments	976	454	850	516	1508	24	2292	1958	3459	1422

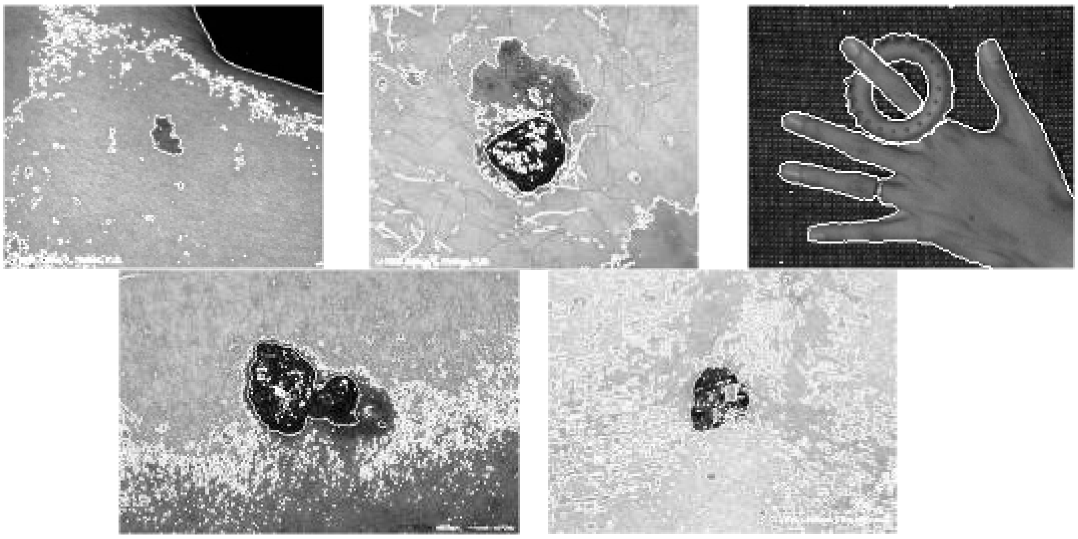

Fig. 3 Results of segmentation – fuzzy c-means method, L*u*v* color space

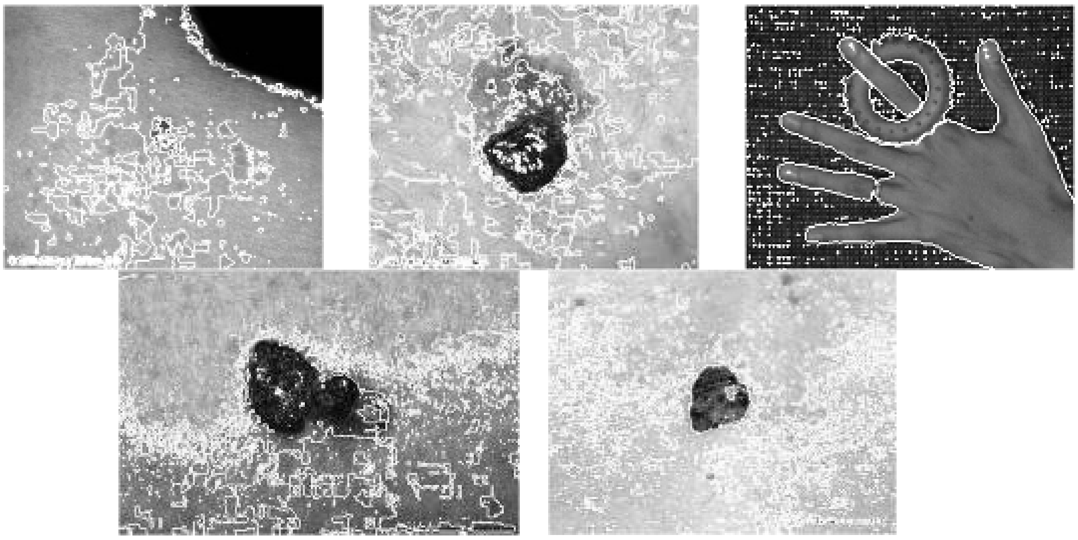

Fig. 4 Results of segmentation – Gustafson – Kessel method, RGB color space

Tab. 2 Results of segmentation – Gustafson – Kessel method

Image	(a)		(b)		(c)		(d)		(e)	
Color space	RGB	L*u*v*	RGB	L*u*v*	RGB	L*u*v*	RGB	L*u*v*	RGB	L*u*v*
Number of segments	402	325	839	522	428	1469	2111	2414	2996	1272

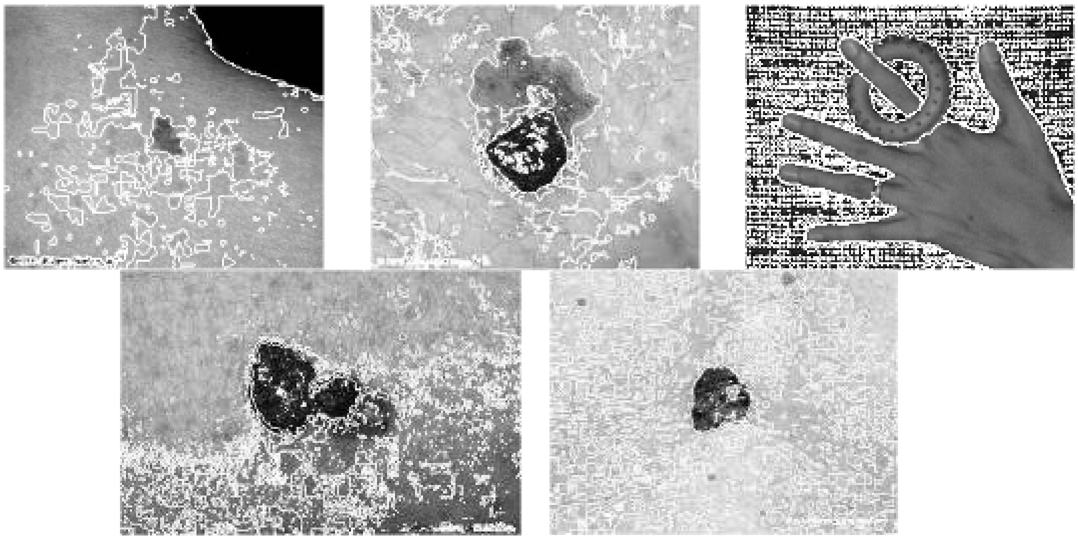

Fig. 5 Results of segmentation – Gustafson – Kessel method, L*u*v* color space

Method M1 makes a big number of segments independently of used clustering method (see in tables 1 and 2 or in figures 2, 3, 4 and 5). Fuzzy c-means method generates lower count of segments on test images in L*u*v* color space, Gustafson – Kessel method doesn't generate lower count of segments in some cases (cases of images (c) and (d)). Method M1 with fuzzy c-means method and independently of used color space generates better shapes borders of segments. M1 with Gustafson – Kessel method generates comparable count of segments, but shapes of borders were worse. Borders should be simple, not rugged, but Gustafson – Kessel method generates much more rugged borders of segments as fuzzy c-means method.

Method M1 with fuzzy c-means or Gustafson – Kessel method is appropriate for segmentation of digital images, which have large homogenous regions. For images with large number of small regions is this method inappropriate.

5 CONCLUSIONS

But one of demands wasn't reached in all experiments. It concerns demand on borders of segment. Border of segment may be simple and may not be rugged. For simplifying, respectively smoothing of segments' borders, may be used another methods, e.g. active contours. However simplifying borders wasn't objective of this work, but it grants impulses for next research.

REFERENCES

[1] BABUŠKA, R. *Fuzzy and neural control* [online]. 2002. Available from www: <URL: http://dutera.et.tudelft.nl/~discfuzz/transp/fncontrol.pdf>.

[2] BERNÁTOVÁ, R. & BERNÁT, M. Technika vizualizácie systému logickej štrultúry biologického a biofyzikálneho učiva na báze jeho kybernetickej podstaty. In: *Technológia vzdelávania*, 2004, pp. 12-14. ISSN 1335-003X.

[3] HLAVÁČ, V., ŠONKA, M. & BOYLE, R. *Image Processing, Analysis and Machine Vision*. 1999. ISBN 0-534-95393-X.

[4] HORVÁTH, J. 2003. *Image Segmentation Using Clustering*. Košice, 2003. 88 s. Master thesis.

[5] HORVÁTH, J. & ZOLOTOVÁ, I. L*u*v* Colour Transformation in Computer Vision. In: *Proceedings of 2nd Slovakian-Hungarian Joint Symposium on Applied Machine Intelligence*, Herľany, Slovakia, 2004, pp. 203-208. ISBN 963 7154 23 X.

[6] HORVÁTH, J., ZOLOTOVÁ, I. & MADARÁSZ, L. Contribution to Segmentation of Digital Images Based on Clustering. In: *IEEE International Conference on Computational Cybernetics ICCC 2004*, Wien, Austria, pp. 89-93. ISBN 3-902463-02-3.

[7] IEC. *Colour management in multimedia systems* [online]. 2002. Available from www: <URL: http://www.map.tu.chiba-u.ac.jp/IEC/100/TA2/kyoto/iec196621.pdf >.

[8] OCELÍKOVÁ, E., ZOLOTOVÁ, I. & LANDRYOVÁ, L. Risk Classes and Cluster Analysis. In: *Transactions of the VŠB - Technical University of Ostrava*, Ostrava, Czech Republic, 2003, pp. 17-20. ISSN 1210-0471.

[9] SKARBEK, W. & KOSCHAN, A. *Colour Image Segmentation – Survey* [online]. 2004. Available from www: <URL: http://iristown.engr.utk.edu/~koschan/paper/coseg.pdf>.

[10] STRAKA, M. & SOBOTA, B. Interactive Rendering on Clusters in Virtual Reality System Proland. In: *Proceedings of the 6-th international scientific conference - Electronic Computer and Informatics ECI 2004*, Herľany, Slovakia, 2004, pp. 457-462. ISBN 80-8073-150-0.

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