SELECTION OF INFORMATIVE COLOR FEATURES OF OBJECT AREAS OF PORK

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Abstract: *The purpose of the paper is to present selection of informative color features complexes of object areas of pork. The basic descriptive statistics related to 19 color features from six color models (RGB, HSV, Lab, LCH, XYZ, CMYK) measured by colorimeter are presented in the paper. Comparative analysis of methods for informative feature selection is done by 5 distance methods. The methods used for data analysis are Principal component analysis and Correspondence analysis. Complexes of informative color features are proposed for classification of object areas of pork.*

Key words: *Colorimeter, Pork color, Color features.*

1. INTRODUCTION

The grading of meat and meat products by their color characteristics necessitates the use of precise and faster procedures for obtaining, processing and interpretation of the most informative complex of features concerning the qualitative characteristics of the objects [1, 8, 10]. The task of assessing the quality of the features themselves, is closely related to reduction of the number of features used in the identification, thereby greatly reducing the required computational resources without loss of information [2, 6].

The first requirement in the ranking of the features is to find a minimal description of the feature space, and the second requirement is to find such features, which are as much as possible less dependent on each other [3, 9].

The main goal of this paper is to determine the value of color information features of color models for recognition of object areas on the surface of the pork.

2. MATERIAL AND METHODS

For the purpose of the study are used 25 samples pork chops purchased commercially. The color is measured at 5 points for object areas on the surface of meat with meat, fat and bone tissue.

The measurement of the color is realized with a colorimeter, developed at the Department "Electrical Engineering, Electronics and Automation" at the Faculty of "Technics and Technologies" – Yambol, Bulgaria [11]. To adjust the color has been used the methodology presented in [8] by reference Lovibond with serial number 12064.

In Figure 1 is presented a device for measurement of color (colorimeter). The parameters for determining the values of color components are for illumination D65 and observer 10° [1, 8, 11].

Figure 1. Device for measurement of color

In Table 1 is a description of the investigated functions of the distance between the color components.

Have been used Mahalanobis distance, Euclidean distance, a distance of Manhattan (Cityblock), Chebyshev distance and Fisher discriminant ratio.

Table 1. Distance functions used in the study

Function	Mathematical formula	Description
Mahalanobis	$d_{st}^2 = (x_s - y_t)C^{-1}(x_s - y_t)'$	C – covariance matrix
Euclidean	$d_{st}^2 = (x_s - y_t)(x_s - y_t)'$	x and y – the compared vectors
Cityblock	$d_{st} = \sum_{j=1}^n x_{sj} - y_{tj} $	
Chebyshev	$d_{st} = \max_j \{ x_{sj} - y_{tj} \}$	max – maximum
Fisher discriminant ratio	$d_{st} = \frac{(\bar{x} - \bar{y})^2}{SD_x^2 + SD_y^2}$	SD – standard deviation

The resulting distances are processed by methods: Principal Component Analysis (PCA) and Correspondence Analysis (CA) [4, 5, 7, 12]. With these methods are determined the informative color features.

3. RESULTS AND DISCUSSION

Table 2 shows the systematized results for averages of color components from six color models. Referred are average values and standard deviation of each color component for each of researches areas on the surface of the meat - fatty, meat and bone tissues.

Table 2. Mean values and standard deviation of the color features for object areas

Object area		Meat tissue	Fat tissue	Bone tissue
Color component	R	168,800±8,061	204,352±19,515	171,186±54,336
	G	104,142±10,861	153,598±25,178	107,406±57,372
	B	91,428±15,454	128,976±32,596	94,394±50,857
HSV	H	0,063±0,186	0,057±0,060	0,132±0,288
	S	0,459±0,083	0,373±0,125	0,464±0,206
	V	0,662±0,032	0,801±0,077	0,671±0,213
Lab	L	130,508±8,968	173,216±21,411	133,540±52,310
	a	153,654±3,684	145,464±6,080	152,762±12,839
	b	146,774±5,933	149,022±8,557	147,936±10,289
LCH	L	51,180±3,517	67,928±8,396	52,369±20,514
	C	32,047±5,688	27,438±10,211	32,137±15,762
	H	35,432±7,300	49,453±6,044	46,683±50,700
XYZ	X	7963,494±1053,160	14105,170±3669,728	9920,870±6169,843
	Y	6419,796±1056,172	12786,214±3819,021	8454,698±5910,425
	Z	3190,112±1043,706	6924,116±3389,517	4454,212±3583,852
CMYK	C	23,160±3,504	11,652±5,692	27,610±28,804
	M	142,196±16,514	91,170±26,519	138,888±61,399
	Y	117,164±24,637	96,288±35,864	119,738±53,405
	K	77,616±9,447	41,742±18,829	75,990±54,348

Table 3. Distances for object areas by color features

Color component distances	Mahalanobis			Euclidian			Cityblock			Chebychev			Fisher discriminant ratio		
	Meat-fat	Meat-bone	Fat-bone	Meat-fat	Meat-bone	Fat-bone	Meat-fat	Meat-bone	Fat-bone	Meat-fat	Meat-bone	Fat-bone	Meat-fat	Meat-bone	Fat-bone
R	1,78	1,77	1,78	25,57	61,69	67,65	31,26	68,86	81,92	23,92	60,36	63,57	2,84	0,00	0,33
G	1,75	1,75	1,78	33,17	67,36	76,03	40,37	75,83	92,99	31,05	65,73	71,16	3,25	0,00	0,54
B	1,76	1,76	1,77	43,74	62,88	74,73	54,46	74,61	94,65	40,53	60,11	67,82	1,08	0,00	0,33
H	0,70	1,07	0,90	0,10	0,27	0,21	0,10	0,28	0,21	0,10	0,26	0,20	0,00	0,04	0,07
S	1,79	1,75	1,73	0,19	0,26	0,28	0,24	0,32	0,36	0,17	0,24	0,25	0,33	0,00	0,14
V	1,78	1,77	1,78	0,10	0,24	0,27	0,12	0,27	0,32	0,09	0,24	0,25	2,84	0,00	0,33
L	1,76	1,75	1,79	28,21	61,47	68,23	34,13	68,87	83,80	26,48	60,08	63,70	3,38	0,00	0,49
a	1,76	1,76	1,73	8,69	15,42	16,31	10,73	17,99	20,59	8,03	14,78	14,97	1,33	0,00	0,26
b	1,79	1,78	1,73	12,80	14,47	16,00	16,37	18,45	21,20	11,47	13,03	13,72	0,05	0,01	0,01
L	1,76	1,75	1,79	11,06	24,11	26,76	13,38	27,01	32,86	10,39	23,56	24,98	3,38	0,00	0,49
C	1,78	1,77	1,72	14,24	19,76	21,92	17,79	23,94	28,72	13,10	18,59	19,21	0,16	0,00	0,06
H	1,74	1,47	1,36	11,63	30,62	29,39	14,55	34,87	32,70	10,61	29,23	28,40	2,19	0,05	0,00
X	1,75	1,74	1,80	4,56	7,31	8,89	5,32	8,19	11,28	4,37	7,15	8,05	2,59	0,10	0,34
Y	1,73	1,73	1,79	4,69	6,97	8,74	5,43	7,80	11,05	4,51	6,82	7,91	2,58	0,11	0,38
Z	1,73	1,74	1,77	4,16	4,42	6,17	4,89	5,14	7,82	3,99	4,26	5,49	1,11	0,11	0,25
C	1,77	1,72	1,72	8,24	28,90	30,05	10,36	31,85	34,24	7,49	28,28	29,02	2,96	0,02	0,30
M	1,77	1,75	1,75	38,55	73,23	78,58	48,63	85,36	97,65	34,92	70,33	72,85	2,67	0,00	0,51
Y	1,78	1,75	1,74	53,77	68,72	76,53	69,55	85,57	98,63	47,85	63,73	68,53	0,23	0,00	0,13
K	1,78	1,77	1,78	25,80	62,09	67,13	32,08	70,36	80,92	23,80	60,41	63,26	2,90	0,00	0,35

By the presented methods for measuring the distance are defined distances between vectors of each color component between the two areas - meat-fat, meat-bone and fat-bone. The obtained results are presented in Table 3. The resulting distances are processed by method Principal component analysis.

Using the distances - Euclidean, Manhattan, Fischer and Chebyshev according to the method PCA, the color features can not be ranked by informativeness. This ranking is possible by using the Mahalanobis distance.

Figure 2.

Results from Principal component analysis for Mahalanobis distance

Figure 2 presents the results of an Principal component analysis using Mahalanobis distance. From this figure it is apparent that H color component from HCL and HSV color model can not be used for the separation of object areas of pork, as apparently is remote from areas and the others color components.

The second method in which they are processed the results for the distances between vectors of color features is Correspondence analysis. In this case, the distance of Mahalanobis not relevant for the evaluation of the informative value of the color features.

Whichever method is used to measure the distance between two vectors as in PCA method H component from HCL and HSV color model is not applicable for the separation of object areas on the surface of the pork.

In Figures 3, 4, 5 and 6 are presented results of Correspondence analysis.

Figure 3. CA for Euclidean distance

Figure 4. CA for Cityblock distance

Figure 5. CA for Chebichev distance

Figure 6. CA for Fisher discriminant ratio

Table 4 summarizes the results of the selection of color features by methods Principal components analysis and Correspondence analysis. For baseline data were used distances determined by established appropriate methods – Mahalanobis, Euclidean, Manhattan, Chebyshev and Fisher distances. The data are grouped according to the method of valuation of distances and object areas such specified obtained informative color components.

Table 4. Summary analysis of research results

Method for data analysis	Object area	Meat-fat	Meat-bone	Fat-bone
	Distance			
Principal component analysis (PCA)	Mahalanobis	$C_{CMYK}; Y_{CMYK}; K_{CMYK}; R_{RGB}; Y_{CMYK}; M_{CMYK}; B_{RGB}$	-	$L_{Lab}; G_{RGB}; Z_{XYZ}$
Correspondence analysis (CA)	Euclidean	$Y_{CMYK}; b_{Lab}; S_{HSV}; C_{CMYK}$	H_{HCL}	$Y_{XYZ}; L_{LCH}; R_{RGB}; K_{CMYK}; G_{RGB}$
	CityBlock	$Y_{CMYK}; b_{Lab}; R_{RGB}; K_{CMYK}; G_{RGB}$	-	$L_{LCH}; G_{RGB}; V_{HSV}; R_{RGB}; K_{CMYK}$
	Chebichev	$Y_{CMYK}; S_{HSV}; L_{Lab}; b_{Lab}$	H_{HCL}	$V_{HSV}; R_{RGB}; K_{CMYK}; L_{LCH}; G_{RGB}$
	Fisher discriminant ratio	$C_{CMYK}; X_{XYZ}; Y_{XYZ}; M_{CMYK}; L_{LCH}$	-	$B_{RGB}; C_{LCH}; S_{HSV}$

4. CONCLUSION

The report provides a comparative analysis of several criteria to determine the information value of each color features separately.

Is assessed informativeness of 19 color features that represent average values of the color components of 6 color models (RGB, HSV, Lab, LCH, XYZ, CMYK) in relation to the object areas of pork – meat, fat and bone tissues.

From the analysis of the results, the authors consider that:

- It is established the possibility of reducing the number of the color features. Practically it may be reduced, depending on the method of selection;
- It have been used five distance functions at which it is established that the PCA method can be used for the results of the Mahalanobis distance;
- In the method of Corrspondence analysis can be used other 4 ways to measure the distance without Mahalanobis one;
- Distinguishability of object areas is allowed in meat-fat by 5 color components (Y, S, b, C, and L), meat-bone tissue by 1 component H, fatty-bone tissue by 5 components (L, R, G, K, V).

5. REFERENCES

- [1] Dankov D. P. Prodanov, Investigation of driver for LED lamp, International scientific conference UNITECH 2015, Gabrovo, ISSN 1313-230X, pp.I-333-I-338 (in Bulgarian).
- [2] Georgiev, G., N. Georgieva, Investigation possibilities for the use of free software for data processing used for accurate measurement details through photogrammetry. ARTTE Vol. 2, No. 3, 2014, ISSN 1314-8796, pp. 202-210.
- [3] Georgieva K., E. Kirilova, Ts. Georgieva, P. Daskalov, Selection of informative color features complexes from digital images of healthy and diseased vine leaves, ARTTE Vol. 3, No. 4, 2015, ISSN 1314-8796, pp.289-295.

- [4] Kazlacheva Z., J.Ilieva, M. Zhekova, P. Dineva, Fashion design on the base of connection between colors and lines, ARTTE Vol. 2, No. 1, 2014, ISSN 1314-8796, pp.54-64.
- [5] Kazlacheva, Z., Use of the correspondence analysis in fashion design. Textile and apparel, vol.7, 2011, ISSN 1310-912X, pp.191-196 (in Bulgarian).
- [6] Kirilova E., P. Daskalov, R. Tsonev, Ts. Draganova, Selection of colour features for recognition of Fusarium damaged corn seeds, Proceedings of Ruse university, vol.49, iss.3.1, 2009, pp.125-130.
- [7] Lorenzo-Seva, U., M. van de Velden, H. Kiers. Simple & multiple correspondence analysis. <http://psico.fcep.urv.cat/utilitats/CorrespondenceAnalysis/index.html> (available on 02.07.2015).
- [8] Mladenov M., St. Penchev, M. Dejanov, Complex assessment of food products quality using analysis of visual images, spectrophotometric and hyperspectral characteristics.// International Journal of Engineering and Innovative Technology (IJEIT), No Vol. 4, 2015, ISSN 2277-3754, pp.23-32.
- [9] Prodanov P., D. Dankov, M. Simeonov, Analysis of reliability on the electronic ballast for compact fluorescent lamp, Proceedings of XVII-th International Symposium on Electrical Apparatus and Technologies SIELA 2012, Sofia 28-30 May 2012, ISSN 1314-6297, pp.254-261.
- [10] Ribarski S., A. Genchev, S. Atanasova, Effect of cold storage terms on physicochemical characteristics of Japanese quail (*Coturnix coturnix japonica*) meat, Agricultural Science and Technology, vol.5, No.1, 2013, pp.126-133.
- [11] Zlatev Z., A. Dimitrova, S. Baycheva, Colorimeter based on single-board microcomputer and color sensor, AUTOMATICS AND INFORMATICS'2016, October 4-5, 2016, Sofia, Bulgaria, ISSN 1313-1869, pp.29-32 (in Bulgarian).
- [12] Zlatev, Z., G. Shivacheva, A. Dimitrova, M. Vasilev, Analysis of data from sensory evaluation of yogurt. Collection of scientific works of XXIV International conference "Management and quality" for young scientists, 15-16 october 2015, ISSN 1314-4669, pp.128-136 (in Bulgarian).