Implementation of image processing techniques as a tool for form analysis of Romanian folk elements

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ABSTRACT – REZUMAT

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The present paper proposes a method for an effective analysis of Romanian folk motifs using two basic algorithms – Radius-Vector function (RV) and Principal Component Analysis (PCA). For a better accuracy of the analysis, a combination of these methods has been proposed. The authors selected few Romanian folk motifs (embroidered on blouses, skirts called "poale", front aprons called "zadii", sleeveless vest) from Bihor, Arad, and Maramures Counties. The vectorization of traditional motifs was made by GIS software.

Keywords: *traditional folk costumes, folk motives, Radius-Vector function, Principal Component Analysis (PCA)*

Implementarea tehnicilor de procesare a imaginilor ca instrument pentru analiza formei elementelor tradiționale românești

Lucrarea de față propune o metodă pentru analiza eficientă a motivelor populare românești folosind doi algoritmi de bază – funcția Radius-Vector (RV) și Analiza componentelor principale (PCA). Pentru o mai bună precizie a analizei, a fost propusă o combinație a acestor metode. Autorii au selectat câteva motive tradiționale românești (brodate pe cămăși, poale, zadii, veste) din județele Bihor, Arad și Maramureș. Vectorizarea motivelor tradiționale a fost realizată folosind Software-ul GIS.

Cuvinte-cheie: *costume populare tradiționale, motive populare, funcția Radius-Vector, Analiza componentelor principale (PCA)*

INTRODUCTION

By its beauty and remarkable artistic value, the folk costumes can be transformed into the best ambassador of Romania. Unfortunately, today's authenticity is increasingly replaced by kitsch, the interest in preserving, putting to good use and transmitting the material of cultural treasure is fading away. Therefore, much of our cultural dowry is disappearing. Although they have a great variety of shapes and ornaments, the traditional costumes from Crisana (Bihor, Arad County) and Maramures have not been studied enough and exploited thoroughly. That is why we believe that we should do everything in our power to preserve the traditional motifs found in the costumes of these ethnographic areas, in order to preserve and promote them, thus saving them from being extinct. This approach is seen as a symbol for redeeming the past for a sustainable future of the traditional motives and a way to convey the love for the inherited beauty of the past, finally yet very important to develop the feeling of local pride.

The digitization of cultural heritage and Romanian traditional motifs is an activity that has gained great momentum over the past two decades together with the development of computing technology. Today it is very common to obtain vector information through digitization. Along with vectors and associated databases, the digital images have become the core component of GIS [1–3]. In recent years, GIS software has been used to map historical objects, restore artefacts and map folklore areas.

In the present paper, were analysed the traditional motifs (embroidered on shirts underskirts, apron, embroidered sheepskin vest or traditional pouches) from Bihor, Arad, and Maramures Counties, Romania. GIS software was used for vectorization of traditional motifs. This software is able to create vector features from raster interactively or with the help of automated tools, comparable to the quality of the results obtained with the more common software products used for this purpose, Inkscape, Adobe Illustrator, Corel Draw.

The main aim of this paper is to propose a method for effective analysis of Romanian traditional motifs. In the analysis of the folk elements, two basic algorithms – radius-vector function (RV) and principal component analysis (PCA) were used. In order to improve the accuracy of the analysis of these elements, a combination of these methods has been proposed.

MATERIAL AND METHODS

Material

From Maramureș to Oltenia, from Banat to Dobrogea, from the Crișurilor county to Muntenia and Moldova, the Romanian costume unity manifests itself in all domains of its essential aspects. From the raw materials used, from the tailoring and the structure of the various pieces, up to the ornament used, the symbols sewn on Romanian folk costumes are classified into: vegetal symbols (fruits, flowers, leaves, plants); abstract symbols (anthropomorphic, zoomorphic or cosmic); geometric symbols (points, straight lines, interrupted lines, or zigzag lines, crossed lines, the rhombs, squares and triangles), and the chromatics is characterized by freshness and harmony [4, 5]. With regard to the folk costumes from the western part of Romania, the line and the composition of the costume show some deviations from the authentic type of Romanian clothing by the white cotton skirt that is wide and creased, the apron that is only worn in front and with the short shirt worn without a girdle, and large men tights (long peasant trousers) [4]. However, the ornamentation of Romanian traditional motifs and technical systems of seams and fabrics is preserved [4, 6–10].

The motifs of the folk costumes from Crisana (Bihor and Arad) and Maramures were vectorized, motives that were found embroidered on blouses, skirts called „poale", front aprons called „zadii", sleeveless vest (30 traditional motifs/region or a total of 90 elements). Figures 2, 3 and 4 represent the folk elements that were used. The GIS system was used for vectorization of folk elements.

Fig. 1. Map of the studied folk costumes from (Bihor, Arad and Maramureș) [9]

Folk elements from Bihor County are presented in figure 2.
Folk elements from Arad County are presented in figure 3.
Folk elements from Maramures County are presented in figure 4.

Methods

In the present work, a survey was conducted on consumer opinion. In order to assess the forms of Romanian folklore elements 180 respondents from Romania filled in the survey. They were arbitrarily chosen no matter of their age, work, gender, education, employment. All respondents know the reason for the survey and the motivation behind using the information that was obtained. The study was led through a Google Forms survey, since it is a free Google
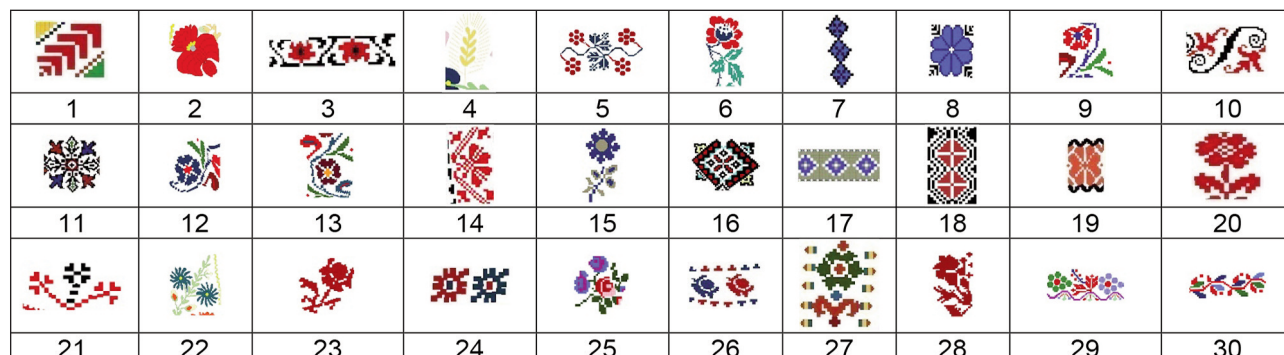

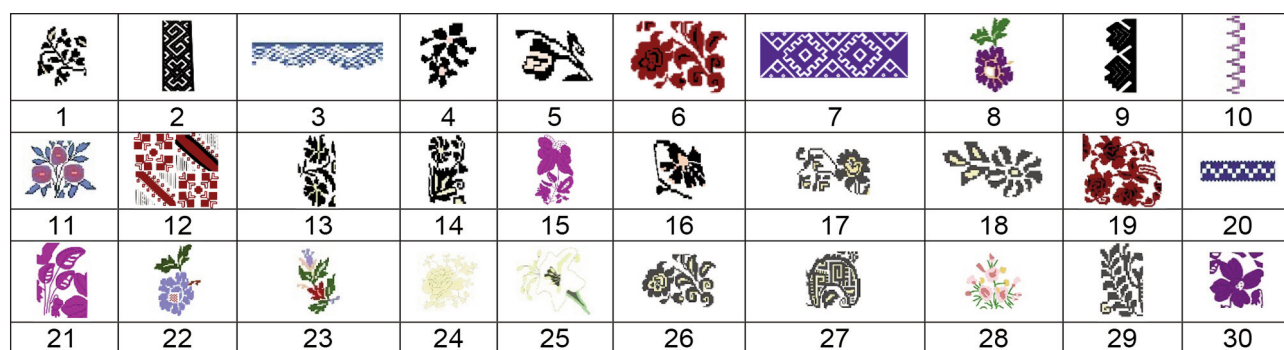Fig. 2. Folk elements from Bihor County

Fig. 3. Folk elements from Arad County

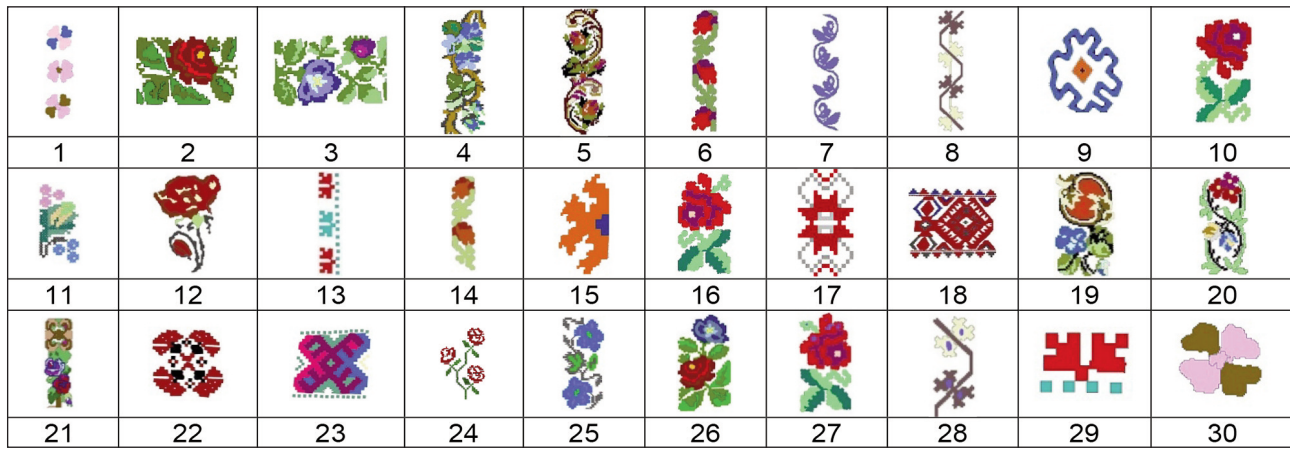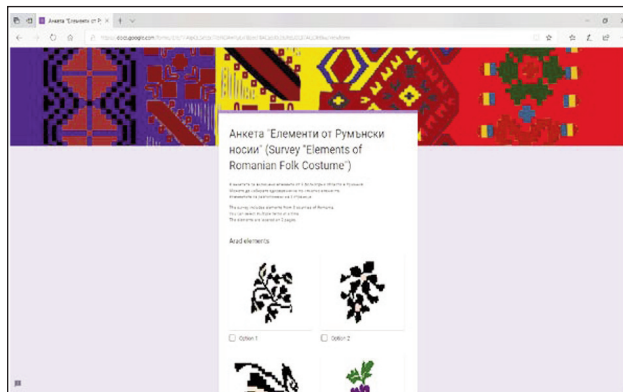|									
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30

Fig. 4. Folk elements from Maramures County

Fig. 5. Survey in Google Forms

online tool application that can be conducted on the Internet by a cell phone, tablet or a desktop computer. The results are processed by the ABC investigation technique [11]. The information is gathered into three classes A, B and C. In class A fall 0–75% of the data, 75–95% in class B and 95–100% in class C. The elements that fall into class A have the highest percentage of choice by respondents. In the analysis of the folk elements, two basic algorithms are used: radius vector function (RV) and principal component analysis (PCA). A combination of these methods is proposed in order to improve the accuracy of the analysis of this element's analysis.

Descriptions by radius – vector function

A radius vector function is used that reflects the vector's magnitude dependence from a particular point in the interior of the object at any point of the boundary to its slope relative to the positive axis X of the coordinate system [12]. The radius vector function is typically assumed to be the distance from a reference point that is the center of mass to the contour [12,13]. When the slope θ varies from 0º to 360º, then the vector fully traverses the boundary of the contour, and the resulting function $R = f(\theta)$, where R is the vector size and it can be used as a description of the shape of the object [13].

The radii of the center of mass are calculated for each individual point in the contour of the object:

$$r_i(\theta) = \sqrt{(x_1 - x_i)^2 + (y_1 - y_i)^2} , \ i = 1 \dots 360 \quad (1)$$

where r_i is the radius at a given angle θ, x_1, y_1 – coordinates of the object's center of gravity, x_i, y_i – coordinates of a point on the outline of the object.

The actions on this phase are repeated, with the slope θ changing from 0º to 360º. From each value of θ, the found value of r and the coordinates (x_i, y_i) of the relevant point of the boundary of the object are remembered. Thus, the radius vector function $R = f(\theta)$ for the particular object is obtained in tabular form.

Stages of an algorithm for radius-vector function are presented in figure 6. From the original image B (RGB) component is extracted. Then it is converted
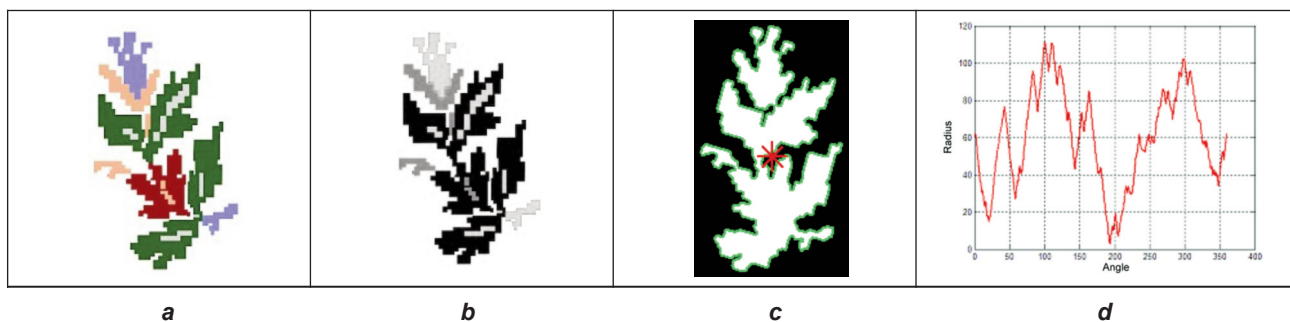

a	*b*	*c*	*d*

Fig. 6. An algorithm for extraction of Radius-vector function: *a* – original image; *b* – B(RGB) colour component; *c* – image re-orientation, contour and centroid; *d* – radius-vector function

to a binary image with threshold 0.9. Filter with type "disk" is used with radius 2. Radius-vector function is calculated according to methodology, presented in [14]. Parameters that describe folk elements are calculated according to formulas in table 1, where: d-short axis; D – long axis; A_e – element area; P_e– perimeter; A_{ideal} – ideal area of an ellipse, calculated by short and long axis; A_{mr}– area of a minimum rectangle, calculated by long and short axes.

The principal component analysis uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components [15].

The principal component analysis creates an orthogonal coordinate system where the axes are arranged according to the dispersion in the original data to which the relevant major component and the dispersions in the principal values refer. In the data covariance matrix K:

$$K = E[(x - \bar{x})^T [(x - \bar{x})] \qquad (2)$$

The simple variant of PCA has some disadvantages if data is highly overlapped.

PCA method is used to reduce the amount of data and analysis of the radius-vector functions and for the selection of informative coefficients that describe the form of folklore elements [15].

All of the analysis was made with a level of significance alpha = 0.05.

RESULTS AND DISCUSSION

The results for calculated parameters of the elements are presented in table 2. Coefficient of variation (CV) is calculated as a ratio between standard deviation (SD) and mean value of the elements (CV = SD/mean). If it is under 30% then the values of parameters are close to one another. It is clearly seen that areas ratios have coefficient of variation under 30%, which means that the folk elements from these three Romanian regions have the same area ratios. The analysed elements significantly differ in their coefficients as form, eccentricity, ovality. PCA analysis of the coefficients that describe folk elements show that Kf (coefficient of form) and $K1$ (eccentricity) describe 99% of the variance of the data. These coefficients are significant for analysis of consumer choices

Table 1

PARAMETERS OF FOLK ELEMENTS [16]			
Parameter	**Formula**	**Parameter**	**Formula**
Coefficient of form, K_f	$K_f = \dfrac{P_e^2}{A_e}$	Roundness, R	$R = \dfrac{1}{c}$
Eccentricity, K_1	$K_1 = \dfrac{D}{d} \times 100$	Area ratio, K_A	$K_A = \dfrac{A_e}{A_{ideal}}$
Ovality, c	$c = \dfrac{P_e^2}{4\pi A_e}$	Area ratio, K_{AM}	$K_{AM} = \dfrac{A_e}{A_{mr}}$

Table 2

	PARAMETERS OF FOLK ELEMENTS						
County	**Descriptive statistics** \ **Parameter**	**Kf**	**K1**	**c**	**R**	**KA**	**KAM**
Arad	min	86.85	105.13	6.91	0.02	0.50	0.39
	max	618.65	252.24	49.23	0.14	0.96	0.75
	mean	**266.77**	**158.20**	**21.23**	**0.06**	**0.70**	**0.55**
	SD	133.24	40.07	10.60	0.03	0.10	0.08
	CV	0.50	0.25	0.50	0.54	0.15	0.15
Bihor	min	38.91	105.38	3.10	0.01	0.37	0.29
	max	860.41	685.24	68.47	0.32	0.94	0.74
	mean	**300.35**	**188.55**	**23.90**	**0.08**	**0.65**	**0.51**
	SD	218.58	124.59	17.39	0.08	0.16	0.12
	CV	0.73	0.66	0.73	0.97	0.24	0.24
Maramures	min	35.23	109.75	2.80	0.03	0.37	0.29
	max	492.93	557.75	39.23	0.36	0.94	0.74
	mean	**138.86**	**255.67**	**11.05**	**0.14**	**0.78**	**0.61**
	SD	102.49	149.47	8.16	0.09	0.14	0.11
	CV	0.74	0.58	0.74	0.63	0.18	0.18

Note: Kf – coefficient of form; K1 – eccentricity; c – ovality; R – roundness; KA – area ratio; KAM – area ratio; min – minimum; max – maximum; SD – standard deviation; CV – coefficient of variation.
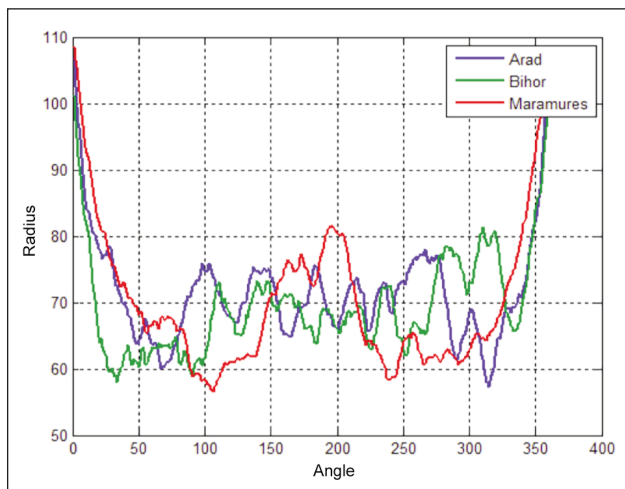
Fig. 7. Mean values of radius-vector functions
of elements from three Romanian Counties

of elements. According to the results obtained by ABC analysis, Arad elements with $Kf = 245.77\pm133.96$ and $K1 = 164.62\pm42.59$ (mean ± standard deviation) are most selected by respondents from the survey. $Kf = 418.72\pm239.96$ and $K1 = 238.82\pm174.84$ for Bihor elements, $Kf = 173.93\pm124.32$ and $K1 = 210.09\pm \pm63.23$ for Maramures. These results correspond to those obtained in other Balkan countries, presented in [16] where authors have found that consumers in Bulgaria prefer folklore elements with a high value of coefficient of form.

Mean values of radius vector functions of elements from three Romanian counties are presented in figure 7. The radius-vector functions differ just like the other parameters that describe folklore elements. The elements of Arad and Bihor have close radius vector functions, whereas those from Maramures differ from the other two areas. Arad and Bihor are near on the map, and their form descriptions have visually the same character of change. It is hard to distinguish the elements from these three regions directly by their RVs.

To reduce the amount of data of the RVs, principal components – simple (PCA) was used. First three principal components describe 97.4% of the variance of radius-vector functions that is why the first three components are chosen. Figure 8 presents the results from principal component analysis of radius-vector

functions. When using a simple variant of PCA in the separation of folk elements classes – their region of origin, the obtained results prove the statement of Haenlein [17] that the simple PCA variables are strongly dependent and directly correspond to raw data.

The folklore elements most selected by respondents in the survey, with a higher percentage of choice, are presented in the material and methods part.

The method proposed here for the analysis of consumer opinion by reduced data of radius-vector functions of folklore elements improves the methods of analysis proposed by [16] and [18], where the authors use forms and radius-vector functions only as descriptors of folklore elements that can be used for their storage in specialised databases. The method proposed here uses less amount of data – only three principal components for every folklore element and it is also a suitable tool for analyzing the consumer opinion needing less processing time, for example 10 seconds in direct implementation of radius-vector functions, compared to 3 seconds with 3 principal components for every element.

CONCLUSION

The results obtained represent a key feature in the use of PCA. Its effectiveness depends mainly on the object being studied and the methods used to reduce the amount of data.

A combination between radius-vector function and PCA has been proposed in the analysis of folk elements and consumer preferences. This combination is a new tool for the analysis of these elements considering the reduction of the amount of data. The practical implementation of the results obtained in this paper is going to solve the problem that most of the results presented in the articles published so far could not solve, meaning that they only contain theoretical aspects and do not aim to analyse the traditional motifs. Vectorization of folklore elements from raster images will improve the analysis of the external aspect of the traditional motifs analysed according to their size, shape, color, condition and lack of visual defects.

In order to reduce the amount of data and accelerate the computational process, in the future, the method
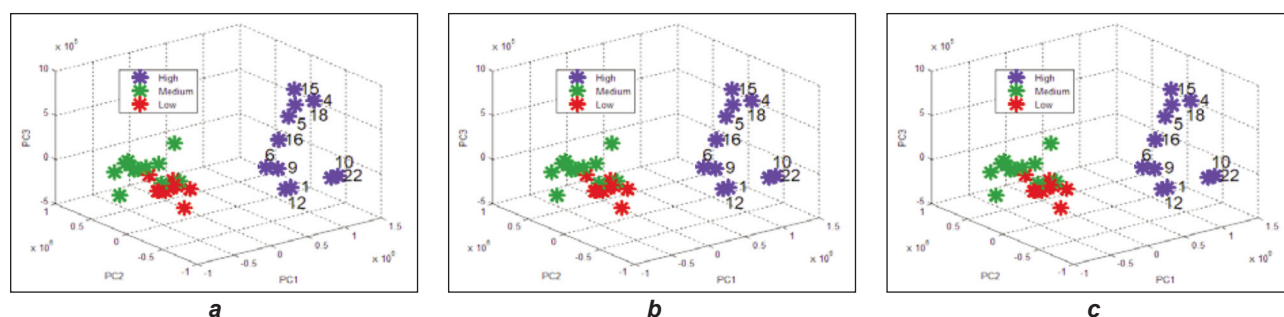

| a | b | c |

Fig. 8. Principal component analysis of radius-vector functions: *a* – Arad; *b* – Bihor; *c* – Maramures

can be used in digital databases containing a collection of Romanian folk elements.

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