HIERARCHICAL CLASSIFICATION OF THE ELECTRONOGRAPHICAL IMAGES

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Abstract: To extract certain information from electronographical images, a variant of pattern recognition has been used. The paper refers to the hierarchical classification method, applied for establishing some classes that define some interest characteristics or medical tendencies in used images. This method shows the rapports existing between the patterns using a hierarchical structure (the patterns dendrogram), constructed by a similarity coefficient. The experimental results relieve the responses of the subjects having the same disability, at the color therapies and the comparative response of the subjects having different disabilities. This study presents the first employment of the hierarchical classification in the classification of the electronographical patterns.

Introduction

Pattern recognition (PR) provides the classifications information instruments, necessary for multidimensional research systems, such as the human body. The main problem in PR is to establish the appropriate classification algorithm.

The technological PR procedure intends to follow the human recognition procedure, which starts at cells level and finishes at the cerebral level. The structure of the informational pattern of the body is considered to be structured into a hierarchically layered model. Based on this idea, the current study tries to prove that the hierarchical structure of the electronographical discharges (ENG) contains information about human body. The main idea is to extract this information using the hierarchical classification algorithms.

The relation between the ENG patterns and the organic processes which generate them proves that both the cognitive and the recognition process are based on the self-organizing process within the body. The self-organizing is characteristic to the biological system and represents the ground of principle of the visual and auditory sense.

The application refers to the subjects with auditory and visual disabilities. The study is based on the reception of a syntactical message attached to the semantic message, in communication process. It is receipted on the sensorial level, which is the subject of this application. If only one analyzer is disabled, then another substitutes it. In this case its informational structures and the neuronal implied channels are modified. The study analyze if this is visible on the electronographical image. So the pattern recognition (PR) method is used to identify the interested shapes in a medical diagnosis.

The ENG discharges are correlated with the bioelectrical configuration of the organism areas, marked on the hand by the 14 sections. This configuration is based on a structural and functional tissues code, transferred at epidermis (cutaneous layer). The code-streamers describe the evolution of the electrical photo-luminescent and biogenesis processes. These variations are differentiated by the form of the luminescent channels.

The learning methods, respectively the self-regulation systems, apply the clustering techniques. This analysis is a typical unsupervised recognition problem, because predefine the patterns classes cannot be prior established. Only the number of the classes is approximated, based on the correlation with the anatomical structure within the corresponding area. The hierarchical classifications establish the connections among the patterns using a hierarchical structure called pattern’s dendrogram.

This structure, the dendrogram, contents the representation of a partition string having a variable cardinal between 1 and patterns number. It is the start point to division in M classes. The classification consists of running the tree beginning from the root and ending with the terminal nodes. In that way the M sub-trees having the root-nodes on the minim level, are determined [1].

The graphic of this tree represents the patterns on the abscissa (the terminal tree nodes), and the level of each node on the ordinate. Each node has attached a value that is inversely proportional with the similarity coefficient between the connected classes. The similarity degree decreases with the level of the nodes.

Materials and Methods

Electronography is the method of recording the electrical activity of the body. Electronographical images relieve the functionality of the body. In gas discharging mechanisms, a potential image is obtained by converting the energy of the particles to a brush light, depending on the electromagnetic field energy.

The electronographic device is a particles accelerator, having a condenser structure. The screen contents a metallic plate, which receipts the high voltage impulses, and the radiological film placed on it. The exposed object is the second capacitive electrode, and the dielectric is the air. It is the virtual space of the particles acceleration space. A high voltage impulse applied on the screen electrode produces an electronic ignition captured by the radiological film. The high voltage impulse generates an ordered movement of the electrons in the structure of the capacitor. The obtained image reproduces the electrical potential which distributes irregularity on the epidermal surface. The sources of these irregularities in the electrical potential are the distribution of the electromagnetic field into the living body, and the interactions between the biological electromagnetic field and the electrical content of the proximal medium.

The images analyzed in this study are scanned copies of the radiological film. Their content represents a complex electrical signal of the living body, recorded at its interface with the proximal medium. For extracting the pattern information, the hierarchical classification is used. This analysis is a typical unsupervised recognition problem, because it is not possible to predefine the patterns classes. The unsupervised classification is applied when the predefined classes aren't created and the learning samples do not exist. This classification is based on the type of the investigation samples and on their structure. The classes must verify two conditions: homogeneity (the entities having the similarly characteristics are included in the same class), and the separability (the entities which are not similar are assigned to the different classes).

The unsupervised classification construction needs a measure of similarity among the classes. This is usually a function defined on set of the possible partition of the samples set of test. This function associates a numeric value of same a partition [2]:

$$S : R^4 \to [0,1] \quad S(\bar{x},\bar{y}) = 1 - d(\bar{x},\bar{y}) / d_{\max} \tag{1}$$

A. Mathematical procedure

The Euclidean distance between two *n*-dimensionally vectors $X = (x_1, x_2, ..., x_n)^T, Y = (y_1, y_2, ..., y_n)^T$ are used:

$$\|X - Y\| = \left(\sum_{i=1}^{M} (x_i - y_i)^2 \right)^{1/2} \tag{2}$$

The distance between the vector X and a *n*-dimensionally vectors class ω is:

$$d(X,\omega) = \underbrace{\min}_{Y \in \omega} d(X,Y) \tag{3}$$

The distance between two classes' ω and ω' is:

$$d(\omega,\omega') = |\mu - \mu'| \tag{4}$$

B. The unsupervised classification algorithm

Let us consider *n* samples vectors $X_1, X_2, ..., X_N$ to be grouped in classes.
The first step considers each vector as a class:

$$C_1^1 = \{X_1\}, ..., C_N^1 = \{X_N\} \tag{5}$$

Next step computes $d(X_i X_j), i \prec j$, and if it minim is realized by the i_0 and j_0 , then the X_{i_0}, X_{j_0} samples are grouped in a single class $X_{i_0 - j_0}$. The other $N-2$ is unaltered. Then $N-1$ classes are obtained:

$$C_1^2 = \{X_{i_0}, X_{j_0}\} = X_{i_0 - j_0}, C_2^2, ..., C_{N-1}^2. \tag{6}$$

The high index 2 signifies the second grouping step.

The procedure is repeated until the distance does no decrease under the threshold, or the desired number of classes, is obtained [3].

Results

The database contains images of the subjects having a visual or an auditory handicap, recorded after the exposure at color therapy. In these images the hand is divided into 14 areas corresponding to different living body areas. Only one compartment is chosen for analyzing the characteristics of component streamers. In these cases, the same hand area is investigated and the three records are used: a blank test, a test after blue color exposure and a test after orange color exposure.

The first case of the study treats on the numbers of ramifications at dominant streamer resulting when the subjects are exposed to orange, respectively to the blue color, and to a blank test. The classification is based on the dates set recorded from visual disabled subjects (Table 1).

Table 1: The experimental dates for the visual disables set (by C. Guja, Fr. Rainer Anthropological Institute, 2002)

Subject		The steamer ramifications number
1	Orange	0
	Blue	0
	Blank Test	0
2	O	10
	B	5
	BT	7

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Subject		The steamer ramifications number
3	O	10
	B	4
	BT	4
4	O	0
	B	9
	BT	2
5	O	3
	B	1
	BT	11
6	O	14
	B	9
	BT	0
7	O	5
	B	9
	BT	2
8	O	0
	B	4
	BT	3

In the function of ramification number at dominant streamer, the subjects will be placed in two classes' ω_1 and ω_2 and the first level of the dendrogram is traced. The two classes show the degree of the chromatic influence in the chromatic therapy of the disables subjects. So, the first grouping is:

$$\{X_1\},\{X_2\},\{X_3\},\{X_4\},\{X_5\},\{X_6\},\{X_7\},\{X_8\}.$$

Using the above table dates, the distances between the experimental vectors are computed, in the two procedure cases (Table 2). The used distance is (4).

Table 2: The results which corresponding to the *2nd* grouping. The distances $d(X_i, X_j)$ are given at X_i and X_j lines intersection

X_j / X_i	2	3	4	5	6	7	8
1	16	13	8	16	20	10	7
2	0	4	20	14	18	14	15
3	4	0	16	18	16	12	11
4	20	16	0	21	26	14	5
5	14	18	21	0	26	11	15
6	18	16	26	26	0	14	25
7	14	12	14	11	14	0	11

The minimum distance is $d(X_2, X_3) = 4$, so that the second grouping will be:

$$\{X_{2-3}\},\{X_1\},\{X_4\},\{X_5\},\{X_6\},\{X_7\},\{X_8\}.$$

The second level of the dendrogram tree is traced.

Using the dates of the Table 2, the distances between the vectors of the second step are computed, in the third procedure case (Table 3).

Table 3: The results which corresponding to the third grouping. The distances $d(X_i, X_j)$ are given at X_i and X_j lines intersection

X_j / X_i	2-3	4	5	6	7	8
1	8	8	16	20	10	7
4	2	0	21	26	14	5
5	18	21	0	26	11	15
6	28	26	26	0	14	25
7	13	14	11	14	0	11
8	5	5	15	25	11	0

The minimum distance is $d(X_4, X_{2-3}) = 2$, so that the third grouping will be:

$$\{X_{2-3-4}\},\{X_1\},\{X_5\},\{X_6\},\{X_7\},\{X_8\}.$$

Using the dates of the Table 3, the distances between the vectors of the third step are computed, in the 4th procedure case (Table 4).

Table 4: The results which corresponding to the 4th grouping. The distances $d(X_i, X_j)$ are given at X_i and X_j lines intersection

X_j / X_i	2-3-4	5	6	7	8
1	5	16	20	10	7
5	30	0	26	11	15
6	26	26	0	14	25
7	13	11	14	0	11
8	5	15	25	11	0

The minimum distance is:

$$d(X_1, X_{2-3-4}) = d(X_8, X_{2-3-4}) = 5,$$

so the fourth grouping will be:

$$\{X_{1-2-3-4-8}\},\{X_5\},\{X_6\}\{X_7\}.$$

The computation process continues with the distances between the vectors resulted at the *4th* step (Table 5). The minimum distance is $d(X_7, X_{1-2-3-4-8}) = 5$, so the fifth grouping will be:

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$$\{X_{1-2-3-4-7-8}\},\{X_{5-6}\}.$$

Table 5: The results which corresponding to the *5th* grouping. The distances $d(X_i, X_j)$ are given at X_i and X_j lines intersection

X_i \ X_j	2-3-4-1-8	5	6	7
5	15	0	26	11
6	23	26	0	14
7	12	11	14	0

This result leads to the following classes:

$$\omega_1 = X_{1-2-3-4-7-8}$$
$$\omega_2 = X_{5-6}$$

The first class has a higher sensibility in color perception. The associate dendrogram is:

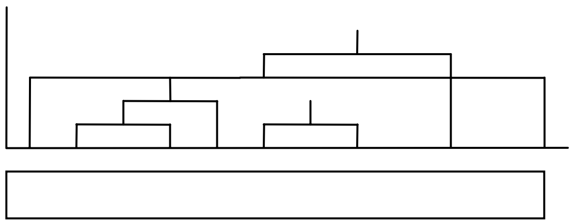

Figure 1: The diagram of classification according to the ramifications' number when the dominant streamer is considered.

Each class X_i has a level in the tree. The similarity between classes decreases of the level.

The second case of the study discuses on the variability of the resulting number of streamers in the above mentioned tests, considering two groups of patients with different deficiency. The classification is realized using the auditory and visual disables sets (Table 6).

Table 6: The experimental dates for the auditory disables set (by C. Guja, Fr. Rainer Anthropological Institute, 2002)

Subject		The streamer number
1.	Orange	11
	Blue	9
	Blank Test	6
2.	O	31
	B	25
	BT	28
3.	O	58
	B	54
	BT	40
4.	O	23
	B	25
	BT	19
Subject		The streamer number
5.	O	19
	B	21
	BT	17

The order number corresponds to that from Table 1 (in the visual disabled case) and Table 6 (in the auditory disabled case). The first grouping is:

$$\{X_{v_3}\},\{X_{v_4}\},\{X_{v_7}\},\{X_{a_1}\},\{X_{a_4}\},\{X_{a_5}\}.$$

Based on the correlation between the two sets, the distance between its vectors is computed (Table 7).

Table 7: The results which corresponding to the 2nd grouping. The distances $d(X_i, X_j)$ are given at v_i and a_i lines intersection

v_i \ a_i	1	4	5
3	8	39	29
4	4	40	29
7	17	34	24

The minimum distance is $d(X_{v_4}, X_{a_1}) = 4,$ so the second grouping will be:

$$\{X_{v_4-a_1}\},\{X_{v_3}\},\{X_{v_7}\},\{X_{a_4}\},\{X_{a_5}\}.$$

Using the dates of the Table 7, the distances between the vectors of the second step are computed, in the third procedure case (Table 8).

Table 8: The results which corresponding to the 3rd grouping. The distances $d(X_i, X_j)$ are given at v_i and a_i lines intersection

v_i \ a_i	$v_4 - a_1$	4	5
$v_4 - a_1$	0	45	52
3	23	39	29
7	28	34	

The minimum distance is $d(X_{v_4-a_1}, X_{v_3}) = 32,$ so the third grouping will be:

$$\{X_{v_3-v_4-a_1}\},\{X_{v_7}\},\{X_{a_4}\},\{X_{a_5}\}.$$

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Using the dates of the Table 8, the distances between the vectors of the third step are computed, in the 4th procedure case (Table 9).

Table 9: The results which corresponding to the 2nd grouping. The distances $d(X_i, X_j)$ are given at v_i and a_i lines intersection

v_i \ a_i	$v_3 - v_4 - a_1$	4	5
$v_3 - v_4 - a_1$	0	44	34
7	14	34	24

The minimum distance is $d\left(X_{v_4 - a_1}, X_{v_7}\right) = 14$, so the final grouping will be:

$$\left\{X_{v_3 - v_4 - v_7 - a_1}\right\}, \left\{X_{a_4 - a_5}\right\}.$$

This result establishes the two classes researched:

$$\omega_1 = X_{v_3 - v_4 - v_7 - a_1},$$
$$\omega_2 = X_{a_4 - a_5}$$

The associate dendrogram is showed in the Figure 2.

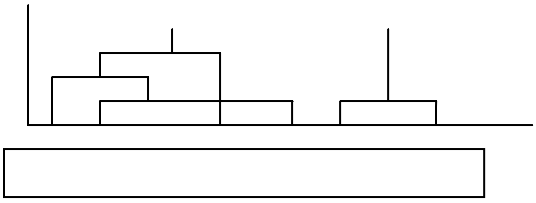

Figure 2: The diagram of classification by the number streamers

Discussion

The significance of the hierarchical classification (dendrogram) in the two analyzed cases is the progressive evolution of the similarity among subjects, when the human sensibility to colours is tested.

The classes obtained in the first steps of the classification are that more closed to Ox axis, and showing a good affinity among the subjects gradually implied in the classification tree, when considering the color therapy response. This result can be used as a manifold subject's group, to create a hierarchy of the subject's responses, or to conclude the different medical aspects. A similarly tree can be obtained using the second data set, namely the streamer number, inside of the same subjects set.

In the second case, the two classes reveal the increasingly influence of chromatic degree on the visual disabled subject. The graphical result of classification procedure shows the good response of the visual disabled subjects, at color therapy, and a slow correlation between the responses of two groups, namely with visual and auditory disabilities.

Conclusions

The hierarchical classification was used to extract the information from the electronographical images, recorded to a subjects group with visual and auditory disabilities, to establish the effect of color therapies. Other information is extracted from the streamers evolution, established according to the ramification types, into one of the 14 hand compartments.

All these tackling modalities of the streamers structure prove that the human organism contains the structures which perceive an energetic stimulus, even when an auditory or visual handicap obstructs the normal perception of the correspondent analyzer. The hierarchical classification shows the assimilation degree of this stimulus, and so the degree of energetic equilibration.

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