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Character art style for integration of traditional culture element into urban public art design

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Abstract. In order to realize research on character art style for integration of traditional culture element into urban pubic art design, a kind of public art design method based on hypergraph and convolutional neural network was proposed. Firstly, paper-cut pattern with traditional culture element was divided and was subject to normalized operation; noise interference of paper-cut pattern with traditional culture element was eliminated. Then, the optimal feature subset was identified through recursive fashion of features for hypergraph Helly; integration of traditional cultural element into urban public art based on convolutional neural network of residual error was designed; finally, effectiveness of above-mentioned method was verified through simulation experiment.

Key words. Public art, Traditional culture, Character art, Hypergraph, Convolutional neural network.

1. Introduction

Traditional culture element is a kind of folk handicraft with long history, extensive spread, and distinctive regional features. Although handicrafts with traditional culture element have different forms and styles, they have something in common in element composition of each image with traditional culture element in detail. Element structure of traditional culture element can be obtained through image decomposition of traditional culture element: embedded pattern decoration and main outline of pattern. Abundant and colorful works with traditional culture element is formed based on different art demonstration of pattern. Different demonstrations of art tastes can be obtained with different embedded pattern decoration for the same work with traditional culture element. Pattern can make traditional culture element

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have more vivid artistic image and have appreciation value, which is the specific artistic language expression load for traditional art element. Feature extraction and classification and recognition are made to pattern graph with traditional culture element through computer; then, artistic design for image with traditional culture element is made, which is a significant research job and has practical value [2].

General pattern with traditional culture element can be obtained through executing boundary extraction after image with traditional culture element is subject to the operation of two-value denoising. In case pattern with traditional culture element is directly extracted and identified in the way of looking for feature point on the edge of image with traditional culture element, there may be problem which is hard to be realized due to complexity of image. Meanwhile, it is hard to make classification and recognition with eyes through intuitive judgment due to hollow pattern, linear pattern, and other features of image with traditional culture element, because it is easy to make wrong recognition. What's more important is that in comparison with other image recognition, similarity between patterns with traditional culture element is hard to be reflected in mathematical manipulation expression. The artistic exaggeration method has great randomness, thus it has poor traditional recognition algorithm effect [3].

FM transformation [4] algorithm for image registration is a typical calculation method for non-feature image registration in image processing, which can realize similarity transformation registration for similar images. The algorithm can be used to make description for operator shape within the whole image field to be treated with invariant features at the time of rotation, stretching, and translation. FM transformation algorithm is improved in Literature [5] based on the filtering method; accurate match and strong noise-proof features are realized; descending of computational complexity is synchronously realized. FM transformation is used in the Literature [6] so as to realize accurate match of curve and image and to obtain satisfying obtain in the experiment, which realizes technical extension of image registration. Scale features of original image data is transformed into amplitude feature through executing Radon feature transformation to image to be treated and using typical FM image analysis. Defined scale and rotation invariant feature parameter are used so as to obtain corresponding 4 groups of feature invariants. In addition, classification effect of image is obtained based on nearest neighbor query of k. As there are lots of image processing algorithms based on FM transformation, they are not described.

Innovative method used in the thesis in the process of identifying pattern with traditional culture element is that pattern with traditional culture element is firstly subject to Fourier-Mellin transformation so as to obtain image binaryzation expression form. In addition, multiresolution wavelet feature extraction technology is used to obtain spectral decomposition of pattern signal with traditional culture element so as to obtain frequency component for spectrum mode with unique amplitude. Then, in terms of above-mentioned frequency component, convolutional neural network for hypergraph is used to construct multifrequency component for recognition model of pattern with traditional culture element.

2. Classification of pattern with traditional culture element

2.1. Pattern category

Traditional culture element is endowed with unique modeling by traditional Chinese culture; moreover, exaggerated image is used to conduct artistic decoration for traditional culture element. There is specific artistic expression form in image modeling and internal design of traditional culture element and, which is mainly use and beautification of decorative pattern. Beautification of decorative pattern with traditional culture element can be realized through stylized method. Common patterns with traditional culture element include: flower, crescent moon strip, sawtooth strip, specific pattern image (such as five sense organs), and etc. Pattern library based on traditional culture element in the research mainly includes: six kinds of common patterns with traditional culture element, such as single tooth strip, character shou-shaped strip, petal strip, long and twisted strip, sawtooth strip, and leaf strip, which is shown in Fig. 1. There is no pattern with fixed style due to exaggerated artistic expression method of image with traditional culture element. Although patterns with traditional culture element has the same name, they have great differences in vision.

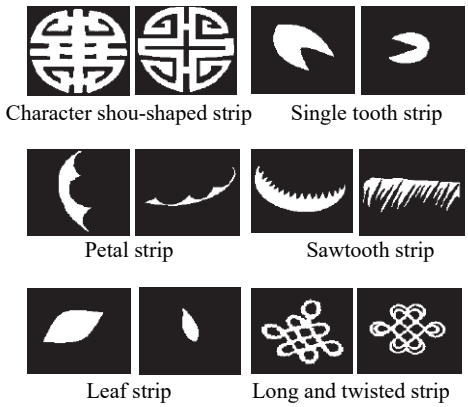

Fig. 1. Paper-cut patterns with traditional culture element

2.2. Recognition of pattern

Firstly, pattern with traditional culture element is subject to normalized operation; moreover, noise interference of pattern is eliminated. As great calculation amount will be generated after seven groups of feature vectors are used, follow-up calculation process is simplified through binaryzation operation so as to realize improvement of pattern recognition efficiency. Pattern feature of traditional culture element with the size of 128×128 can be obtained after being subject to binaryzation pretreatment. Then, 7 groups of invariant matrixes for pattern feature should be used to construct pattern vector feature with traditional culture element as input

training sample data of convolutional neural network for hypergraph so as to obtain classifier of sample with traditional culture element. Basic steps in the process are:

Step 1: (Pretreatment of pattern with traditional culture element) Pattern image should be scanned; smooth denoising operation should be executed; then, it should be subject to binaryzation operation so as to simplify data expression;

Step 2: (Construction of feature vector) Pattern with traditional culture element should be subject to feature extraction based on seven groups of invariant matrixes; in addition, extraction feature is used to construct training feature vector of convolutional neural network for hypergraph of pattern with traditional culture element;

Step 3: (Normalization of sample feature) Obtained feature vector should be subject to normalized operation so as to realize simplification of data; in addition, it should be used to train convolutional neural network of hypergraph;

Step 4: (Recognition of pattern with traditional culture element) Normalized feature vector of obtained tested sample with traditional culture element should be used as input; test for classification and recognition effect of pattern with traditional culture element should be conducted based on convolutional neural network of hypergraph obtained in the process of training.

It is known in steps of above-mentioned algorithm that algorithm process involved in recognition process of pattern with traditional culture element mainly includes: (1) feature extraction of pattern image with traditional culture element; (2) classification and recognition of pattern with traditional culture element.

3. Convolutional neural network of hypergraph

3.1. Convolutional neural network

Convolutional neural network (CNN) is a network of probability density estimation, which is designed by Specht. Core concept of CNN is to use multivariate probability estimation and "the strategy of winner-take-all" for learning and competition, which is the classifier edition combining Bayes strategy, Parzen window, probability density function (PDF(s)) method of non-parameter estimation. Different from radial basis function (RBF) network and multilayered feed-forward network, data processing can be conducted in the process of neural network training based on statistical principle. CNN is based on PDF estimation rather than iterated function approximation, thus it has higher training speed and good generalization ability.

According to classification of Bayes method, probability category classification of unknown input vector is based on historical data rather than parameter of mode, such as mean value and standard deviation. Bayes classifier can be prepared as follows:

$$P(C_i|x) = \frac{f(\chi|C_i) * P(C_i)}{f(x)}\,. \tag{1}$$

Where $P(C_i|x)$ is posterior probability, which indicates the probability for input x to belong to category i. In terms of any classification problems, posterior probability of category i should be calculated; moreover, input x with the largest $P(C_i|x)$ should

be divided into category i. Calculation of $P(C_i|x)$ is to obtain posterior probability $P(C_i)$ according to historical data. Category condition probability $f(\chi|C_i)$ can be evaluated based on training data approximation of Parzen window. Non-parametric estimator based on Gaussian probability-density function is obtained to be

$$f(x|C_i) = \frac{1}{(2\pi)^{n/2}} \left[\frac{1}{m} \sum_{j=1}^{m} e^{-\left(\frac{1}{2\sigma^2}\right)\left[\left(x-x_{c_{ij}}\right)^T\left(x-x_{c_{ij}}\right)\right]} \right]. \tag{2}$$

Where m indicates No. of mode in category C_i; $x_{c_{ij}}$ indicates No. of mode in the category C_i; σ indicate smooth parameter.

3.2. Structure and features of hypergraph

Hypergraph is promotion of traditional graph theory, which can be expressed as a more significant form through high order relation between entities in the real world. In mathematics, hypergraph is defined as $H = \{X, E\}$. Where $x = \{x_1, x_2, \cdots, x_n\}$ indicates nonempty finite vertex set; $E = \{E_1, E_2, \cdots, E_m\}$ indicates nonempty subset of X, which is called hypergraph and is shown in Fig. 2. Definition and features of hypergraph are analyzed in the section.

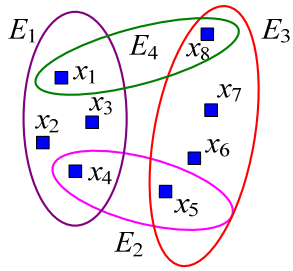

Fig. 2. Structure of hypergraph

Definition 1: As hypergraph $H = \{X, E\}$, in terms of each peak $y \in X$, there is a super frontier set, which is called lightspot of $H\left(H_y^*\right)$ and is shown in Fig. 3. Degree of D_y is equal to cardinal number of H_y^*:

$$D_y = \left|H_y^*\right|. \tag{3}$$

Peak set $x = \{x_1, x_2, \cdots, x_9\}$ and super frontier set $E = \{E_1, E_2, \cdots, E_5\}$ are included in the figure. x_2 is the centre-of-gravity position of $H_{y_2}^* = \{E_1, E_2\}$; degree of D_{y_2} is $D_{y_2} = 2$; x_5 is centre-of-gravity position of $H_{y_5}^* = \{E_2, E_4\}$; degree of D_{y_5} is $D_{y_5} = 2$.

Definition 2: In terms of given hypergraph $H = \{X, E\}$, an intersection cluster of H is the cluster of hypergraph $E \subseteq X$, which is the nonempty intersection.

Definition 3: In consideration of hypergraph H with super frontier set $\{E_1, E_2, \cdots, E_m\}$, in case intersection of E_i and E_j is nonempty, where $i, j \in k$ and $k = \{1, 2, \cdots, m\}$, intersecting edges of H can be divided into the following two cases:

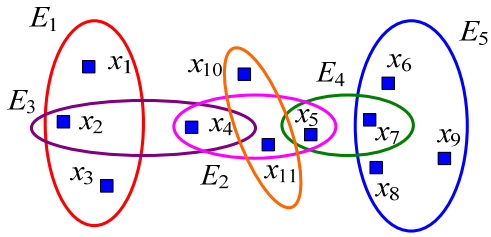

Fig. 3. Expression model for hypergraph

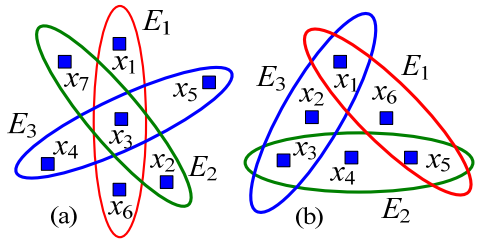

Fig. 4. Intersection classification ((a) with common intersection point (b) without common intersection point)

Case 1: It is intersected with normal intersection, which is shown in Fig. 4a. Intersecting edges $\{E_1, E_2, E_3\}$ makes x_3 be the common intersection point.

Case 2: There is no common intersection, which is shown in Fig. 4b. In the case, intersecting edge $\{E_1, E_2, E_3\}$ has no common intersection point.

3.3. Convolutional neural network based on hypergraph

Main purpose of all feature selection technology is to reduce dimension of data so as to make it have good classification accuracy. In terms of lots of mode recognition problems, text, spectrum, topology, geometry, statistical feature are used to realize training for learning model. Generalization error of learning mode is increased due to redundancy feature under the condition of unbalanced data set. In order to overcome above-mentioned defects, hypergraph data is used to express tool so as to obtain the optimal character subset recognition with the minimum time complexity.

Feature selection algorithm (algorithm 1) based on hypergraph proposed in the thesis is divided into two stages: (1) hypergraph expression; (2) Helly feature application. Edge of hypergraph can be obtained through topological and geometrical relation of samples in the initial phase. Edge and peak of hypergraph are in respectively corresponding to sample and feature of data set. In terms of supervised learning, Euclidean distance measurement based on the minimum distance algorithm is used to construct edge of each category:

$$E_d(x, y) = \|x - y\| . \tag{4}$$

Hypergraph feature is applied to recognition of optimal reduction and intersect-

ing edge in recursive fashion in the next stage. Non-intersecting is ignored in the processing procss in the next step. In terms of unsupervised learning, city block distance measurement is used to maximally improve distance between cluster and to maximally reduce distance within the cluster.

$$CB_d = \max(|x_1 - x_2|, |y_1 - y_2|)\,. \tag{5}$$

Helly feature of hypergraph is used; complexity generated through recognition of the optimal reduction for time is the smallest. Feature selection and recognition process of convolutional neural network based on hypergraph Helly feature are respectively shown in Algorithm 1 and Algorithm 2.

Algorithm 1: Feature selection based on hypergraph Helly feature

Input: $f \leftarrow \{f_1, f_2, \cdots, f_m\}$, // m features of given data set
$S = \{S_1, S_2, \cdots, S_n\}$, // n features of given data set
$C = \{C_1, C_2, \cdots, C_k\}$; // k features of given data set
Output: f_s $\leftarrow$ the optimal feature subset
$HG\,(f, s, c, f_s)$
1. for each $i \leftarrow 1{:}k$ do
2. $Hyperedge\,[i] \leftarrow \min\,[E_d\,(f_i, f_j)]$;
3. end
4. for each $i \leftarrow 1{:}k$ begin
5. $f_s \leftarrow \bigcap_{j \in i} Hyperedge\,[j]$;
6. end

Algorithm 2: Recognition process of convolutional neural network based on residual error

Input: total categories Tot_{class}, S_{Train}, f_s, and σ;
Output: $Classify \leftarrow$ classification accuracy of test vector;
CNN(Tot_{class}, S_{Train}, f_s, σ)
1. Initialization parameter value $Largest = 0$, $Sum = 0$, $Classify = -1$, and $\varepsilon = 0.1$;
2. Calculate residual error parameter of training:

$$Train_{Data}\,[i, j] \leftarrow \sum_{k=1}^{f_s} \left[\left(\frac{f_k}{\varepsilon}\right) - \left\lfloor \frac{f_k}{\varepsilon} \right\rfloor\right]$$

$$\forall i = \{1, \cdots, S_{Train}\}, j = \{1, 2, \cdots, f_s\}$$

3. Calculate residual error parameter of test

$$Test_{Data}\,[i] \leftarrow \sum_{k=1}^{f_s} \left[\left(\frac{f_k}{\varepsilon}\right) - \left\lfloor \frac{f_k}{\varepsilon} \right\rfloor\right]$$

$$\forall i = \{1, 2, \cdots, f_s\}$$

4. for each $k = 1 : Tot_{class}$ begin
5. $Sum\,[k] \leftarrow 0$;
6. for each $i \leftarrow 1{:}S_{Train}$ begin
7. $p \leftarrow 0$;
8. for each $j \leftarrow 1$ begin
9. $p \leftarrow p + (Test_{dataset}\,[j] \times Train_{dataset}\,[j]\,[j])$

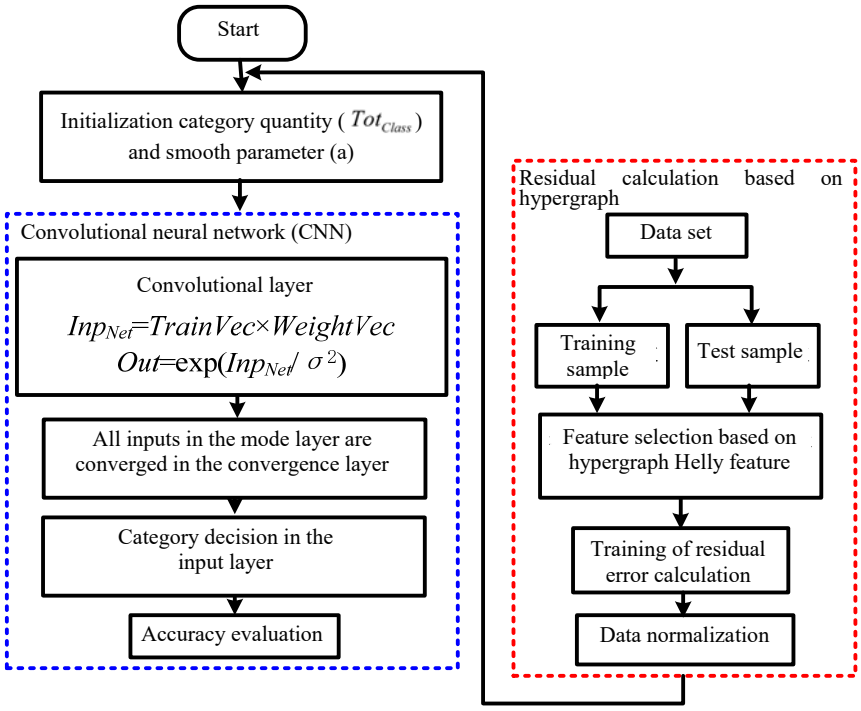

Fig. 5. Algorithm flow of convolutional neural network based on hypergraph

4. Experimental analysis

4.1. Feature construction experiment

8 standard pattern images for each pattern with traditional culture element are selected as input samples of CNN for hypergraph in experimental analysis of the section (which is shown in algorithm framework in Fig. 5 in detail). 54 standard input pattern images are required for 6 patterns with traditional culture element shown in Fig. 1. In fact, the 54 pattern images include the most common pattern style in artistic design of traditional culture element. (Part of) feature vectors of sawtooth strip, leaf strip, and long and twisted strip are described in the thesis due to limitation of the length, which is shown in feature data in Table 1 in detail.

It is shown in feature vector data in Table 1 that although some patterns with traditional culture element in similar category have great visual differences, obtained feature vector and its approximation has no great fluctuation in numerical value in the process of feature extraction. However, in terms of pattern with traditional culture element in different category, they have obvious differences in feature vectors, which indicates that use of above-mentioned 7 groups of invariant matrixes to substitute for frequency feature vector can effectively conduct feature recognition for

pattern with traditional culture element.

Original feature data and frequency component of the 54 patterns with traditional culture element should be considered as sample input of CNN for hypergraph; CNN for hypergraph should be subject to weight training; in terms of above-mentioned 6 kinds of pattern with traditional culture element in different types, single output expectation predication should be used; output result recognition of CNN for hypergraph respectively includes single tooth strip: 1; petal strip: 1; sawtooth strip: 2; leaf strip: 3; long and twisted strip: 4; character shou-shaped strip: 5. Training error threshold of convolutional neural model for hypergraph is set to be 0.001. Feature vector data of the rest 191 patterns for above-mentioned six kinds of different patterns with traditional culture element are used as test sample so as to be subject to algorithm verification.

Table 1. Parts of the feature vector

	e1	e2	e3	e4	e5	e6	e7
Sawtooth strip 1	1.464	3.491	2.283	3.225	7.835	6.782	6.295
Sawtooth strip 2	1.625	2.864	2.164	3.827	9.596	6.256	7.866
Sawtooth strip 3	1.614	3.249	2.166	3.406	8.313	5.045	6.218
Sawtooth strip 4	1.291	3.342	1.548	2.831	7.315	4.504	5.143
Leaf strip 1	0.650	0.274	1.950	4.066	8.847	5.262	8.288
Leaf strip 2	0.417	0.257	1.508	3.562	7.073	4.884	7.042
Leaf strip 3	0.496	0.291	1.486	3.529	7.697	4.911	7.469
Leaf strip 4	0.535	0.171	1.329	3.199	7.139	5.038	5.516
long and twisted strip 1	1.342	6.621	8.166	5.842	13.904	9.809	13.058
long and twisted strip 2	1.361	6.412	6.660	8.256	17.545	12.309	16.030
long and twisted strip 3	1.325	10.667	13.139	7.859	20.616	13.751	18.633
long and twisted strip 4	1.003	8.995	10.222	7.465	21.024	12.531	16.399

4.2. Instance analysis

Ancient art provides abundant elements for modern image design, such as dragon, phoenix, Tai Ji, and other basic images which express thoughts and emotions, such as removal of disaster, pursuit of happiness, longevity, and other wonderful wishes, of human beings. Chinese traditional image contains eternal times connotation, because ancient people and modern people are interlinked; modern people and future people are interlinked as well. They express fundamental demands of human beings, thus the designer can use these ancient images to shown times spirit. Integration of modern design into traditional image is not a simple bringism, because underlying culture features are required to be researched; quintessence of specific culture should be extracted; Chinese traditional elements should be unconsciously integrated into modern design works. Traditional image, and a series of elements should be changed and reconstructed so as to make it maintain form feature of traditional image and contain charm of modern design for further expressing certain emotion and thought. At present, extensive application of Chinese elements in the design field reflects

mighty rising of Chinese traditional culture.

A series of exquisite designs in 2008 Beijing Olympic Games perfectly interpret profound Chinese traditional culture to the world. Olympic medal is the application of traditional culture to olympic theme. Jade is embedded in the back of the medal, which originates from Chinese ancient dragon design jade. Metal image of Beijing Olympic emblem is embedded in the middle of the back medal. In general, the whole medal is noble and elegant with strong Chinese features, which has embodied praise to the winner, has visually interpreted noble value of Chinese nation in comparison with "jade" and "virtue" since in ancient times, and has indicates praise and respect of Chinese people to the Olympic spirit and sincere praise to fighting spirit of athletes. In addition, design of torch, symbol, and dress of volunteer and Miss Etiquette in different degrees have sense of fashion.

Fig. 6. Design example of the 2008 olympic games

Use of traditional image as design symbol contributes to forming visual image with cultural connotation under the condition of completion of them, which is the development result of Chinese traditional culture element in international big environment and indicates unique charm of Chinese culture.

5. Conclusion

A kinds of public artistic design method based on CNN of hypergraph is proposed in the thesis; patterns with traditional culture element are divided; integration of traditional culture element into urban public art is designed based on CNN of residue error. Effectiveness of above-mentioned method is verified through simulation experiment. Research on the subject is inheritance and development of Chinese traditional culture element in modern times; Chinese traditional culture is profound and extensive, thus it is the cultural heritage which cannot be abandoned. As there are various emerging design ideas and thoughts in modern times, original traditional design concepts seem to be gradually abandoned and replaced by new ones. Therefore, an equilibrium point is required to be found under the two kinds of design

concepts, which is to combine Chinese traditional culture element with modern design so as to make Chinese traditional culture element have new development and implied meaning in modern design. The thesis aims at innovative awareness, which is the center of the thesis. Traditional image, traditional typeface, and traditional colors are summarized; moreover, some opinions of the author are expressed. It is expected that we can accept shock of new things and cannot abandon traditional culture in modern society with rapid development. The effective method is to combine them so as to give birth to new design concept with Chinese features, which is definitely development tendency of future design!

References

[1] N. Arunkumar V. Venkataraman, T. Lavanya: *A moving window approximate entropy based neural network for detecting the onset of epileptic seizures*,International Journal of Applied Engineering Research, *8* (2013), No. 15, 1841–1847.

[2] J. W. Chan, Y. Y. Zhang, and K. E. Uhrich: *Amphiphilic Macromolecule Self-Assembled Monolayers Suppress Smooth Muscle Cell Proliferation*, Bioconjugate Chemistry, *26* (2015), No. 7, 1359–1369.

[3] Y. J. Zhao, L. Wang, H. J. Wang, and C. J. Liu: *Minimum Rate Sampling and Spectrum Blind Reconstruction in Random Equivalent Sampling.* Circuits Systems and Signal Processing, *34* (2015), No. 8, 2667–2680.

[4] S. L. Fernandes, V. P. Gurupur, N. R. Sunder, N. Arunkumar, S. Kadry: *A novel nonintrusive decision support approach for heart rate measurement*, (2017) Pattern Recognition Letters. https://doi.org/10.1016/j.patrec.2017.07.002

[5] N. Arunkumar, K. Ramkumar, V. Venkatraman, E. Abdulhay, S. L. Fernandes, S. Kadry, S. Segal: *Classification of focal and non focal EEG using entropies.* Pattern Recognition Letters, *94* (2017), 112–117

[6] W. S. Pan, S. Z. Chen, Z. Y. Feng: *Investigating the Collaborative Intention and Semantic Structure among Co-occurring Tags using Graph Theory.* International Enterprise Distributed Object Computing Conference, IEEE, Beijing, (2012), 190–195.

[7] Y. Y. Zhang, Q. Li, W. J. Welsh, P. V. Moghe, and K. E. Uhrich: *Micellar and Structural Stability of Nanoscale Amphiphilic Polymers: Implications for Anti-atherosclerotic Bioactivity*, Biomaterials, *84* (2016), 230–240.

[8] L. R. Stephygraph, N. Arunkumar, V V. enkatraman: *Wireless mobile robot control through human machine interface using brain signals*, 2015 International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials, ICSTM 2015 - Proceedings, (2015), art. No. 7225484, 596–603.

[9] N. Arunkumar, V. S. Balaji, S. Ramesh, S. Natarajan, V. R. Likhita, S. Sundari: *Automatic detection of epileptic seizures using independent component analysis algorithm*, IEEE-International Conference on Advances in Engineering, Science and Management, ICAESM-2012, (2012), art. No. 6215903, 542–544.

[10] Y. Du, Y. Z. Chen, Y. Y. Zhuang, C. Zhu, F. J. Tang, J. Huang: *Probing Nanostrain via a Mechanically Designed Optical Fiber Interferometer.* IEEE Photonics Technology Letters, *29* (2017), 1348–1351.

[11] W. S. Pan, S. Z. Chen, Z. Y. Feng: *Automatic Clustering of Social Tag using Community Detection.* Applied Mathematics & Information Sciences, *7* (2013), No. 2, 675–681.

[12] Y. Y. Zhang, E. Mintzer, and K. E. Uhrich: *Synthesis and Characterization of PEGylated Bolaamphiphiles with Enhanced Retention in Liposomes*, Journal of Colloid and Interface Science, *482* (2016), 19–26.

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