Acta Technica 62 (2017), No. 7A, 1151–1164

Performance evaluation model design for hospital staff based on fusion decision of grayscale topsis criterion

Min Guo[1], Wei Xiong[2*]

Abstract. To improve the efficiency of performance evaluation model design for hospital staff, a method for performance evaluation model design based on fusion decision of grayscale TOPSIS criterion has been proposed. First of all, the principle in combination with scientificity, completeness, practicality, qualitative index, and quantitative index is followed to construct performance evaluation model for hospital staff. Besides, subjective weight will be ensured in performance evaluation model index for hospital staff based on Analytic Hierarchy Process (AHP), and then comprehensive weight of index evaluation will be acquired with game compromise and the importance of performance evaluation model index for hospital staff based on fusion decision of grayscale TOPSIS criterion will be sequenced. Eventually, efficiency of the method has been verified through empirical analysis on 29 persons totally from medicine and surgery departments in a clinical medicine college of military clinical university.

Key words. Hospital staff, Performance evaluation, TOPSIS criterion, Fusion decision
.

1. Introduction

Performance evaluation refers to the course of identifying, observing, measuring and developing people's performance in an organization. Study on performance evaluation has a history of seventy to eighty years. As an important management tool, it is related to main management functions, such as decision, organization, leading, control, and innovation of the management and it is vital basis in organizing, determining, and establishing reward and punishment, promotion, training, and

[1]Affiliated Hospital of JIlin Medical University, Science and Education Department, Jilin City of Jilin Province, 132013, China
[2]Affiliated Hospital of JIlin Medical University, Administration Office, Jilin City of Jilin Province, 132013, China
*. Corresponding author

dismissal for staff and significant part in personnel selection and study. Therefore, leaders always pay attention to it.

In practice of human resource management, performance evaluation is also a key and difficult problems and it is always substituted by "performance management". As for working performance evaluation for professional technical leaders, from broad perspective, it is an integrated method system with comprehensive subject knowledge of psychology, management, statistics, educational estimation, compute technology and so on to measure and evaluate subject in morality, knowledge, ability, performance, and other factors so as to provide evidence for recruiting, selecting, training, and paying of talents. How to evaluate working performance for professional technical leaders scientifically and accurately is an important task and objective for management of professional technical leaders and it is a prominent problem for a solution at present. Hence, it is related not only to objective evaluation for performance of professional technical leader, but also directly to training and service directions for it. Scientific evaluation is a great guide direction. For many years, attentions have been paid to reducing evaluation errors and improving evaluation precision for study on performance evaluation. Researchers discussed the influences of evaluation tools, recognition processing course of evaluators, emotional factors in evaluation, and the role of evaluator on performance evaluation result so as to establish all kinds of causal models for overall individual performance evaluation. During the course of analyzing influence factor for overall evaluation of directors, contextual performance that is different from traditional task performance but can influence performance evaluation of the superiors independently has been proposed. As for division for performance component, it changes the thinking that factors impacting performance evaluation besides task performance are regarded as error traditionally and a large quantity of researches have been introduced to further discuss the structure of performance itself, determined factors and antecedent essentials of individual performance, and other problems.

A method for performance evaluation model design based on fusion decision of grayscale TOPSIS criterion to improve the efficiency of performance evaluation model design for hospital staff has been proposed in the Thesis. And scientific division and analysis for performance evaluation course of hospital staff have been realized and that has significant guiding meaning for improving performance level of hospital.

2. Establishment of Evaluation Index System

It is always known that evaluation is a behavior that can change object for evaluation into subjective utility according to its attribution with specific measured aim, and that means it is a course to define its value. Evaluation objects in the Research are clinically advanced professional technical leaders and there are more involved factors and higher complex degrees. Therefore, we shall design an evaluation model and evaluation method that fits objective reality, and eventually evaluation index system will be formed.

2.1. Basic principal for design of evaluation index system

The design of evaluation index system must abide by combination of scientificity, completeness, practicality, qualitative index, quantitative index, and it can be summarized into the following factors:

1. Comprehensive principle: from analysis on organization, individual, mass, and other angels, comprehensive situation of objective for evaluation shall be inflected in index system to guarantee comprehensive evaluation.
2. Scientific principle: the working performance of object for evaluation shall be reflected objectively, truly, and accurately.
3. Practicality principle: all evaluation indexes in evaluation system shall have specific meaning with practicality as basis.
4. Combination of qualitative index and quantitative index principle: in evaluation, "quality" in object for evaluation shall be emphasized for qualitative analysis, while "quantity" in object for evaluation shall be emphasized for quantitative analysis.
5. Incompatible principle: There are so many evaluation items; therefore, similar index or index with detailed meaning shall be avoided to be concise and summary.

2.2. Component of evaluation index system modules

Under the above principles, and in consideration of the actual working situation of clinical advanced professional technical leaders, designed evaluation system in the Research consists of four parts: quantified assessment and evaluation module (objective evaluation), departments and offices (mass) evaluation module, patient evaluation module, and index weighed module, as shown in Fig. 3.

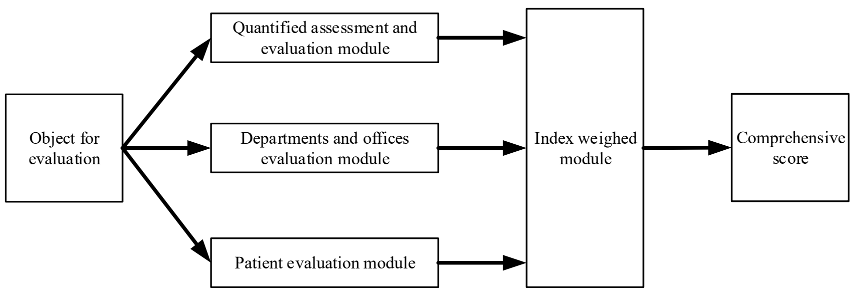

Fig. 1. Performance evaluation model for clinical advanced professional technical leaders

1. Quantified assessment and evaluation module: it is used for evaluating objective indexes of object for evaluation, including personal basic information, medical technical level, scientific research, and teaching and so on.
2. Departments and offices evaluation module: it is used for evaluating subjective indexes of object for evaluation that are not easy to quantify. According to evaluation indexes, it is subject to expert evaluation, departments and offices evaluation, or mass evaluation.

3. Patient evaluation module: it is also an important part in evaluation modules. Patient is direct beneficiary for working efficiency of doctor; therefore, it can reflect patient's evaluation for doctor in a profile. According to professional ethics, medical result, service attitude, and other factors, patient will evaluate the doctor.

4. Index weighed module: it indicates algorithm module. According to the requirement of all module indexes, standard score of all indexes will be calculated and comprehensive score of object for evaluation will be calculated according to the weight.

2.3. Index description

Indexes in the Thesis are shown in Fig. 1-2. Indexes 1-21 are quantified assessment and evaluation index, and its original score is calculated according to index requirement (descriptions for first six indexes are listed here).

1. Working time: accumulative working time (year). Scoring method: 2 points will be increase with tenure of one year each year.

2. Educational background:

First education background score: 0- below high school; 5- technical secondary school or junior college; 10- regular college; first degree score: 0. none; 5- bachelor; final educational background score: 0- below high school; 5- technical secondary school or junior college; 10- regular college; 15- master degree candidate; 20- doctoral candidate; final degree score: 0. none; 5- bachelor; 10- master degree; 15- doctor. Educational background score= first education background+ first degree score+ final educational background score+ final degree score

3. Tenure for current professional technical occupation: 5 points will be increase with tenure of one year each year. Note: disengagement of the occupation for over one year will not be accounted to statistics, and interpretation right for other situations is under verdict of review department.

4. Ability-level structure: tutor score: 30- doctor tutor; 20- master tutor; subject occupation score: 20- department and office director; 10- deputy department and office director; 5- business group leader; Ability-level score= tutor score+ subject occupation score. Note: only highest score will be selected for each item and deputy department and office director and business group leader will score with one year tenure.

5. Academic status: academic status score of the occupation including academic organizing occupation and academic status occupation= academic organizing occupation score+ academic status occupation score

6. Continuing education situation: learning situation that person participates in further education and continuing educational item that is confirmed by nation and army. Continuing professional development; 0- none; 20- yes: continuing education: 0- none: 10- once; 20- twice: 30: three times; score situation for continuing education= continuing professional development score+ continuing education score.

Table 1. Quantified assessment and evaluation indexes for expert weight

Grade I	Grade II	Grade III	Weight
Objective evaluation indexes	Personal basic information 0.25	Working time	0.12
		Educational background situation	0.1
		Tenure for current professional technical occupation	0.11
		Ability-level structure	0.1l
		Academic status	0, 12
		Continuing education	0.1
		Attendance	0.1
		Honors and awards	0.12
		Punishment of discipline violation	0.12
	Medical work 0.4	Clinical working time	0.17
		Business theory assessment	0.16
		Implementation of new technology and new business	0.18
		Medical results	0.19
		Publish medical article twice	0.15
		Medical safety	0.15
	Scientific research and teaching 0.35	Scientific research results	0.18
		Famous teaching material	0.18
		Thesis situation	0.16
		Subject of scientific research	0.16
		Teaching result	0.13
		Talent training	0.19

Table 2. Evaluation indexes of department and office (mass) and patient for expert weight

Grade I	Grade II	Weight value
Department and office (mass) evaluation	Professional dedication	0.09
	Working style	0.08
	Actual operational level in business	0.11
	Professional ethics level	0.07
	Diagnosis and treatment ability	0.11
	Comprehensive ability for handling problems	0.1l
	Ability for constant learning	0.07
	Dialectical thinking ability	0.06
	Strength and energy	0.06
	Psychological quality	0.08
	Coordinated ability	0.06
	Organization and management ability	0.1
Patient evaluation	Technical level	0.3
	Service attitude	0.25
	Professional ethic	0.22
	Professional dedication	0.23

3. Fusion Decision of Grayscale TOPSIS Criterion

3.1. Construction of reference number series and Comparative number series

Ideal scheme index set is selected to ensure reference number series $x_0 = \{x_0(k)| k = 1, 2, \cdots, n\}$, and comparative number series shall be $x_i = \{x_i(k)|k = 1, 2, \cdots, n\}$, $i = 1, 2, \cdots, m$. Then original data of comparative number series shall be handled with initial value transformation:

$$x_j = \frac{x_i(k)}{x_0(k)}(i = 1, 2, \cdots, m; k = 1, 2, \cdots, n)\,. \tag{1}$$

Where, value in comparative number series is obtained with normalized process of safety technology, environment, and economic index data in all schemes that are supported and protected by foundation trench. The correlation coefficient of comparative number series and reference number series is:

$$\xi_{0i}(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}\,. \tag{2}$$

Where, due to close relationship between dereference of ρ and integrality of correlative degree, difference value of entire correlative space for abnormal value in sequence is determined at the same time. Therefore, resolution ratio ρ shall be calculated according to dynamic change of index evaluation value in schemes:

$$\bar{\Delta} = \frac{1}{nm}\sum_{i=1}^{m}\sum_{k=1}^{n}|x_0(k) - x_i(k)|\,. \tag{3}$$

Let $\mu_\Delta = \bar{\Delta}/\Delta_{\max}$, where $\Delta_{\max}$ is the maximum value of $|x_0(k) - x_i(k)|$, and then the value range of P is $\mu_\Delta \le \rho \le 2\mu_\Delta$, and it must satisfy: when $\Delta_{\max} > 3\bar{\Delta}$, $\mu_\Delta \le \rho \le 1.5\mu_\Delta$. when $\Delta_{\max} \le 3\bar{\Delta}$, $1.5\mu_\Delta < \rho \le 2\mu_\Delta$.

Therefore, weight degree r_{0i} for evaluation of grey weight correlation degree:

$r_{0i} = \sum\limits_{i=1}^{n} [\omega_i(k) \cdot \xi_{0i}(k)]$ (4)Where, $\omega_i(k)$ is corresponding synthetic weight of correlation coefficient $\xi_{0i}(k)$.

Fluctuation for comparative number series and reference number series of correlation coefficient $\xi_{0i}(k)$ in all points compared with average weight value r_{0i} and influence of correlation degree on average value of correlation coefficient r_{0i} in all points are integrated. With Euclid theory, correlation degree of grey weight is revised and weight correlation degree $\bar{r}_{0i}$ compared with Euclid is concluded.

$$\bar{r}_{0i} = 1 - [(r_{0i} - 1)^2 + \sum_{k=1}^{n}\omega_j(k)\left(\xi_{0i}(k) - r_{0i}\right)^2]^{1/2}\,. \tag{4}$$

With relative Euclid weight correlation degree as basis, objects for evaluation are sequenced according to correlation degree. Large correlation degree shows good evaluation result. In next section, clid weight correlation degree is acquired for decision with fusion method of TOPSIS principle.

3.2. Multi-criteria decision algorithm flow

Currently, many scholars make researches on selecting algorithm for decision data [12∼13], but researches are almost concentrated on decision algorithm. Selecting ways for performance information of hospital staff are focusing on instant performance information of hospital staff or average handling and such a handling method ignores the influence for change of performance information of hospital staff on decision obviously. In fact, such a change for performance information of hospital staff is frequent and it can bring huge impact on rationality for choosing decision data. Time-varying weight algorithms are shown in Fig. 2.

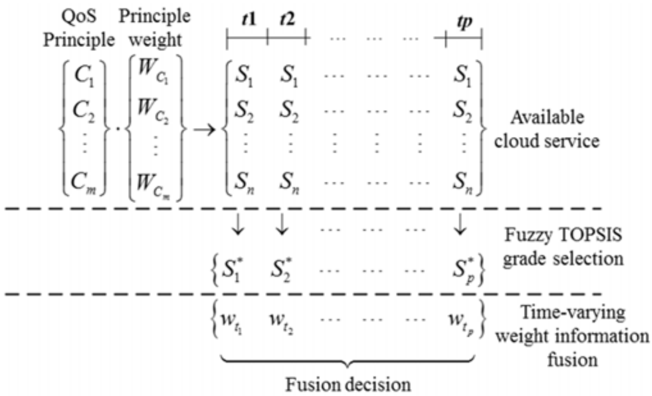

Fig. 2. Decision algorithm flow

It can be seen in Fig.2 that $C = \{C_1, C_2, \cdots, C_m\}$ is m-dimensional decision principle for performance of hospital staff and $W_C = \{W_{C_1}, W_{C_2}, \cdots, W_{C_m}\}$ is for its corresponding principle weight so as to differentiate relationships of different principles. With $w_t = \{w_{t_1}, w_{t_2}, \cdots, w_{t_m}\}$, time-varying weight based on time has been proposed in the Thesis for differentiate importance degree of performance information of hospital staff in different time buckets. Algorithm flow of fuzzy TOPSIS multi-criteria decision module shown in the Figure consists of three parts: Firstly, available decision data for performance information of hospital staff is extracted. Secondly, fuzzy TOPSIS grade is rated. Thirdly, information fusion of time-varying weight is extracted. In the following section 2.2, TOPSIS algorithm for ranking performance information of hospital staff is discussed.

3.3. Multi-criteria decision for fuzzy TOPSIS

In conventional multi-criteria decision algorithm, weight value W_C of decision principle is endowed with judgment and preference of decision maker, however, the weight cannot be calculated for an accurate value in actual application. Because resources for performance principles of hospital staff are abroad and they include: unquantifiable information, incomplete information, part unknown information and so on. Hence, recommended algorithm based on weight fuzzy TOPSIS of fussy fuzzy set theory for secondary quantitative decision data of time-varying is proposed as follows:

Step1: decision matrix is constructed. Suppose there m available decision data $S_i\,(i = 1, 2, \cdots, m)$, performance selection principle of hospital staff $C_j\,(j = 1, 2, \cdots, n)$, and then the following decision matrix of all decision data in each time point for performance value of hospital staff is constructed.

$$X = \begin{array}{c} \\ S_1 \\ S_2 \\ \vdots \\ S_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \left[\begin{array}{cccc} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{array} \right] \end{array} \tag{5}$$

Where, x_{ij} indicates quantization performance of decision data S_i in principle C_j.

Step2: Based on weight value assignment of entropy, normalization processing is subject to decision matrix in principle $C_j\,(j = 1, 2, \cdots, n)$ in order to ensuring objective weight value through entropy measure for acquiring projection value P_{ij} of each principle:

$$P_{ij} = x_{ij} \Big/ \sum\nolimits_{i=1}^{m} x_{ij}\,. \tag{6}$$

Then entropy value can be calculated as follows:

$$e_j = -\left(\ln m\right)^{-1} \cdot \sum_{j=1}^{n} p_{ij} \ln p_{ij}\,. \tag{7}$$

Therefore weight of each principle can be calculated as follows.

$$W_{C_j} = (1 - e_j) \Big/ \sum\nolimits_{k=1}^{n} (1 - e_k)\,. \tag{8}$$

Step3: Matrix form for normalized decision of fuzzy TOPSIS is constructed as follow:

$$\tilde{R} = [\tilde{r}_{ij}]_{m \times n} \tag{9}$$

Evaluation factors of decision data makes maximum variation is in different time, therefore, decision principles are divided into function correlation (F) and evaluation correlation (C). With triangular fuzzy principle, triangular fuzzy numbers are

(a_{ij}, b_{ij}, c_{ij}), and then:

$$\begin{cases} \tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+} \right), \quad if\ j \in F \\ \tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}, \right), \quad if\ j \in C \end{cases} \tag{10}$$

Where:

$$\begin{cases} c_j^+ = \max c_{ij}, \quad if\ j \in F \\ a_j^- = \min a_{ij}, \quad if\ j \in C \end{cases} \tag{11}$$

Step 4: Performance evaluation. With principle of weight calculated in Step2 and fuzzy decision matrix calculated in Step3, weight evaluation matrix can be calculated:

$$\tilde{V} = \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & \cdots & \tilde{v}_{1n} \\ \tilde{v}_{21} & \tilde{v}_{22} & \cdots & \tilde{v}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{v}_{n1} & \tilde{v}_{n2} & \cdots & \tilde{v}_{nn} \end{bmatrix} = \begin{bmatrix} \tilde{r}_{11} & \tilde{r}_{12} & \cdots & \tilde{r}_{1n} \\ \tilde{r}_{21} & \tilde{r}_{22} & \cdots & \tilde{r}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{r}_{m1} & \tilde{r}_{m2} & \cdots & \tilde{r}_{mn} \end{bmatrix} \cdot diag \left\{ W_{C_1}, \cdots W_{C_n} \right\} \tag{12}$$

Step5: With sequencing for multi-criteria weight evaluation matrix calculated in formula (16), positive ideal solution A^+ and negative ideal solution A^- are shown as follows:

$$\begin{cases} A^+ = \left(\tilde{v}_1^+, \tilde{v}_2^+, \cdots, \tilde{v}_n^+ \right) \\ A^- = \left(\tilde{v}_1^-, \tilde{v}_2^-, \cdots, \tilde{v}_n^- \right) \end{cases} \tag{13}$$

The distance between positive ideal solution and negative ideal solution is calculated. According to the distance calculation formula of two triangular fuzzy numbers proposed in literature [9]:

$$d\left(A_1, A_2\right) = \sqrt{\frac{1}{3}\left[\left(a_1 - a_2\right)^2 + \left(b_1 - b_2\right)^2 + \left(c_1 - c_2\right)^2 \right]}.$$

$$\begin{cases} d_i^+ = \sum_{j=1}^{k} d\left(\tilde{v}_{ij}, \tilde{v}_j^+\right), i = 1, 2, \cdots m \\ d_i^- = \sum_{j=1}^{k} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), i = 1, 2, \cdots m \end{cases} \tag{14}$$

According to above steps, star-ranted sequence of key factors for performance of hospital staff will be acquired.

4. Experimental Analyses

4.1. Data acquisition

In a clinical medicine college of military clinical university, 29 persons who have senior professional technician title in that year and need title appraisal and have intermediate professional technician title and prepare to promote to a sub-senior person will be evaluation objects and their data is from hospital information management system, basic archival data of hospital leaders. Other insufficient information shall be declared by individuals for acquisition through check of department of hospital leaders. There are 29 persons in total for evaluation, among others, 12 persons have senior professional technician title, and 17 have intermediate professional technician title. The detailed grouping is shown in Table 3.

Table 3. Member grouping

Department and office	Normal	Sub-senior	Intermediate
Medicine department	3	5	8
Surgery department	3	1	9

4.2. Data Calculation

Model design result of performance evaluation for 29 employees from a clinical medicine college of military clinical university calculated with grey TOPSIS algorithm based on fuzzy information is shown in Table4-5.

Table 4. Staff in medicine department

Class	Person No.	Quantitative score	Department and office score	Patient score	Integrated score
Senior	1	80	85	75	80.7
	2	85	75	80	80.5
	3	76	70	86	75.8
Sub-senior	4	60	70	50	61.5
	5	90	80	85	85.5
	6	80	75	86	79.4
	7	72	80	82	77.3
	8	73	90	90	83.2
Intermediate	9	52	65	60	58.1
	10	55	70	75	64.2
	11	88	85	78	84.9
	12	76	75	74	75.5
	13	87	82	93	86.9
	14	79	76	81	82.1
	15	85	77	82	81.2
	16	80	85	85	82.8

Table 5. Staff in surgery department

Class	Person No.	Quantitative score	Department and office score	Patient score	Integrated score
	1	60	70	50	61.5
Senior	2	90	80	85	85.5
	3	80	75	86	79.5
	9	80	68	75	74.8
	10	67	59	40	58.8
	11	70	79	70	73.2
	12	65	85	80	75.1
Intermediate	13	78	75	80	77.3
	14	81	90	95	86.9
	15	84	86	75	82.8
	16	75	76	70	74.3
		77	68	89	76.3

Compared with its actual assessment results, among others, people in first group have all passed the assessment. One person with basic qualification in sub-senior group of medicine department and senior group of surgery department respectively and they are No. 4 in medicine department and No. 5 in surgery department who need to be reassessed. That fits our calculated result: there are 5 persons in fifth group who have passed the professional title examination and acquired senior professional title, while No. 13, No.14, and No. 15 have not passed it and it fits our calculated result. What needs to clarify is that there are 5 persons who passed professional title examination and acquired senior professional title in the sixth group of 9 persons, and people who haven't passed it are No.22, No. 23, No.24, No.28. Except for No.23 with lower score, scores of No. 23, No.24, No.28 are close to score of No.21 that has passed the examination, and score of No. 22 is lower than that of No.24. In reference to risk coefficient, quantitative risk is 0.66, department and office evaluation risk is 0.45, and patient evaluation risk is 0.32. Hence, it can be seen that the higher risk for quantitative assessment can lead to uncertainty of evaluation result. Except for sub-senior group in surgery department, results are acquired in other groups according to evaluation calculation method in reference to risk coefficient during calculating process and they are all less than 0.6 and it fits the requirement of evaluation standard in Conclusion with small risk degree.

5. Conclusion

A method for performance evaluation model design based on fusion decision of grayscale TOPSIS criterion has been proposed in the Thesis. Performance evaluation model for hospital staff is constructed, besides, subjective weight will be ensured in performance evaluation model index for hospital staff based on Analytic Hierarchy Process (AHP), and then comprehensive weight of index evaluation will be acquired with game compromise and the importance of performance evaluation model index for hospital staff based on fusion decision of grayscale TOPSIS criterion will be sequenced. Eventually, efficiency of the method has been verified through empirical analysis on 29 persons totally from medicine and surgery departments in a clinical medicine college of military clinical university.

The forming of establishing index system and evaluation method is only the first step for us, and the ultimate aim for our scientific research is to transform research into practice. There are several problems to settle when the Research is applied to actual practice. The problems include software based research method, suggestion of reviewing website, and theoretical training for persons related to review and so on. These achievements can be put into practice in convenience of covering the shortage and strengthening real-time assessment, and they are beneficial to professional technical persons to know their disadvantages so as to make up for deficiency and improve working motivation. Besides, department of leader can discover problems in working and talent training of professional technical person and that will provide evidence for the revision of leader policy.

References

[1] Y. J. Zhao, Y. H. Hu, J. J. Liu: *Random Triggering-Based Sub-Nyquist Sampling System for Sparse Multiband Signal.* IEEE Transactions on Instrumentation and Measurement. *66* (2017), No. 7, 1789–1797.

[2] N. Arunkumar, K. R. Kumar, V. Venkataraman: *Automatic detection of epileptic seizures using permutation entropy, Tsallis entropy and Kolmogorov complexity*, Journal of Medical Imaging and Health Informatics, *6* (2016), No. 2, 526–531.

[3] Y. Y. Zhang, A. Algburi, N. Wang, V. Kholodovych, D. O. Oh, M. Chikindas, and K. E. Uhrich: *Self-assembled Cationic Amphiphiles as Antimicrobial Peptides Mimics: Role of Hydrophobicity, Linkage Type, and Assembly State*, Nanomedicine: Nanotechnology, Biology and Medicine, *13* (2017), No. 2, 343–352.

[4] N. Arunkumar, K. R. Kumar, V. Venkataraman: *Automatic detection of epileptic seizures using new entropy measures*, Journal of Medical Imaging and Health Informatics, *6* (2016), No. 3, 724–730.

[5] R. Hamza, K. Muhammad, N. Arunkumar, G. R. González: *Hash based Encryption for Keyframes of Diagnostic Hysteroscopy*, IEEE Access (2017), https://doi.org/10.1109/ACCESS.2017.2762405

[6] D. S. Abdelhamid, Y. Y. Zhang, D. R. Lewis, P. V. Moghe, W. J. Welsh, and K. E. Uhrich: *Tartaric Acid-based Amphiphilic Macromolecules with Ether Linkages Exhibit Enhanced Repression of Oxidized Low Density Lipoprotein Uptake*, Biomaterials, *53* (2015), 32–39.

[7] N. Arunkumar, K. Ramkumar, S. Hema, A. Nithya, P. Prakash, V. Kirthika: *Fuzzy Lyapunov exponent based onset detection of the epileptic seizures*, 2013 IEEE Conference on Information and Communication Technologies, ICT 2013, (2013), art. No. 6558185, 701–706.

[8] J. J. Faig, A. Moretti, L. B. Joseph, Y. Y. Zhang, M. J. Nova, K. Smith, and K. E. Uhrich: *Biodegradable Kojic Acid-Based Polymers: Controlled Delivery of Bioactives for Melanogenesis Inhibition*, Biomacromolecules, *18* (2017), No. 2, 363–373.

[9] Z. Lv, A. Halawani, S. Feng, H. Li, S. U. Réhman: *Multimodal hand and foot gesture interaction for handheld devices.* ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), *11* (2014), No. 1s, 10.

[10] Y. Z. Chen, F. J. Tang, Y. Bao, Y. Tang, G. D. Chen: *A Fe-C coated long period fiber grating sensor for corrosion induced mass loss measurement.* Optics letters, *41* (2016), 2306–2309.

[11] N. Arunkumar, S. Jayalalitha, S. Dinesh, A. Venugopal, D. Sekar: *Sample entropy based ayurvedic pulse diagnosis for diabetics*, IEEE-International Conference on Advances in Engineering, Science and Management, ICAESM-2012, (2012), art. No. 6215973, 61–62.

[12] 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.

[13] M. P. Malarkodi, N. Arunkumar, V. Venkataraman: *Gabor wavelet based approach for face recognition*,International Journal of Applied Engineering Research, *8* (2013), No. 14, 1831–1840.

[14] L. R. Stephygraph, N. Arunkumar: *Brain-actuated wireless mobile robot control through an adaptive human-machine interface*, Advances in Intelligent Systems and Computing, *397* (2016), 537–549.

Received May 7, 2017