

Evaluation of portal sites for enterprises using normal cloud model

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Abstract

The existing schemes for evaluating the portal sites of enterprises suffer many problems. A novel evaluation scheme based on the normal cloud model is proposed, where two layers of indicators are created and their weights are specified. Cloud generators are used to enable transition of indicators between qualitative description and quantitative data. Three characteristic values of the cloud model are obtained through the use of the assigned weights. The final evaluation results are achieved using the cloud drop distribution. The real-data experiments show that the proposed scheme is simple, efficient and practical and can act a guide.

Keywords: cloud model, normal cloud model, cloud generator, performance evaluation

1 Introduction

With the rapid development of the Internet, the enterprise portal sites are competing fiercely to attract more viewers and resources. Thus, the quality of a portal site is essentially important. And it is urgent to find a solution to the accurate and objective evaluation of the enterprise portal sites.

Comprehensively evaluating the enterprise portal sites involve every aspect of the sites and is a multifactor multilayer problem of uncertainty. Typically, the chosen indicators are the qualitative natural-language descriptors, which are highly fuzzy and random. Hence, the traditional evaluation methods can neither measure user experience comprehensively, accurately and objectively, nor generate unbiased and accurate evaluation conclusions [1].

The current evaluation approaches are largely dependent on user satisfaction, weighted average or the theory of fuzzy sets. The weighted average method can provide the final evaluation results by taking into account the indicators of interest and their weights. But the final results are only the numerical values and lose the evaluation details. Therefore, it cannot show the performance of the evaluated objects in terms of the specific indicators. The user satisfaction strategy creates an evaluation system for websites by considering users' habits to feel the service quality. Although it can carry out in-depth evaluation of the websites, it is excessively subjective. The theory of fuzzy sets can lower data size but reducing properties causes loss of information.

2 Research status around the world and the generation of the normal cloud model-based method for evaluating the enterprise portals

Currently, the study on the evaluation of the website around the world is conducted in two ways. On the one hand, it focuses on the evaluation system, including the evaluation subjects, evaluation objects, evaluation metrics and the evaluation methods; On the other hand, it focuses on the evaluation methods, including the weighted average evaluation method [2], the user satisfaction-based method [3], the queuing model-based method [4], and the rough set-based relative property reduction method [3].

The weighted average method can provide the final evaluation results by taking into account the indicators of interest and their weights, but the final results are only the numerical values and lose the evaluation details. Therefore, it cannot show the performance of the evaluated objects in terms of the specific indicators. The user satisfaction strategy creates an evaluation system for websites by considering users' habits to feel the service quality, although it can carry out in-depth evaluation of the websites, it is excessively subjective. The queuing model-based website evaluation method is a quantified standard that introduces user experience as a metric, the concept of information entropy in the information theory is employed, and the relevant ideas in the queuing theory are used to compute the duration of a user group's access to the website, evaluating the website's efficiency from the user's perspective, but the queuing model-based evaluation method uses the duration of the user's access to the website as a measure of the user's interest in the website, but in fact, the duration of the user's access to the website is subject to many external factors, therefore, this method inevitably generates some errors, and is unable to

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show the user's real attitude to the website. The rough set-based relative property reduction method is an effective tool for data analysis, but in the rough set theory, there is no general approach to discretization of the continuous property values, the existing discretization methods are proposed according to practical applications or subject to specified constraints, hence, this algorithm's usage is limited. In addition, some information is lost due to property reduction.

In this context, we use the normal cloud model to propose a novel scheme for evaluating the quality of enterprise portal sites. By exploiting the advantage of the cloud model that it allows the transition between qualitative descriptions and quantitative data, the proposed method can deliver accurate details of the website's performance in every aspect, provide accurate conclusions, as well as fully and objectively responding to each and every concern of users. Therefore, the proposed method can allow the website administrators to detect problems rapidly for further improvement.

3 Cloud model

The notion of cloud is devised on the basis of the probability theory and the fuzzy mathematics [5]. For the concept that uses the natural language as its descriptor, cloud provides a model for making uncertainty transitions between the qualitative concept and the quantitative expression [6]. By combining the fuzzy and random natures, the cloud model is designed to represent two uncertainties in the substances of the universe and the notions of the human knowledge: fuzziness (ambiguity of bounds) and randomness (probability of occurrence). The cloud model can fully incorporate fuzziness into randomness, obtain the bounds and distribution of the quantitative data from the qualitative information, and properly convert the specific values into quantitative representation.

Currently, the cloud model has been widely applied to data mining, decision-making support and analysis and intelligent control. It has great potentials for being used in more applications.

A. Basic definitions.

By fully combining fuzziness with randomness, the cloud model provides a general approach to investigating the uncertainties hidden in the most basic language values of the natural language. On the one hand, it makes it possible to obtain the bounds and distribution of the quantitative data from the qualitative information expressed by the language values. On the other hand, it can properly convert the specific values into quantitative language values [1].

Let U denote the quantitative domain that are expressed as the exact values, T denote the qualitative concept spatially associated with U , and $X \in U$. If there exists a random number $Cr(x) \in [0,1]$ that shows a stable tendency for x , which is known as the membership of x with respect

to T , then the numeric field distribution of T 's mapping from the domain U to the interval $[0,1]$ is called the cloud.

Instead of emphasizing deterministic function representation, the cloud model uses three numerical characteristics to represent conceptual uncertainty and adopts specific algorithms to perform uncertainty conversion between qualitative concept and quantitative representation, as well as unveiling the correlation between fuzziness and randomness. By providing a profile of the uncertain concept, the cloud model delivers approximate and flexible conclusions. The forward and backward cloud generators [7] can be used to establish an interdependent mapping interrelation between qualitative concept and quantitative representation. Please note that the cloud method cannot be simply thought of as a random or fuzzy approach. The reason is that the cloud model-based conversion between qualitative concept and quantitative representation is performed via strict mathematical methods and thus the conversion is highly clear, definite, operable and expressive of conversion uncertainty [8].

B. Numerical characteristic of the cloud [18].

The cloud consists of many cloud drops, each of which is a mapping from qualitative description to quantitative data. The distribution of all drops forms a cloud [1].

A cloud can be basically shaped by the expectation E_x , entropy E_n and excess entropy H_e , because it performs the mapping between qualitative description and quantitative data.

Expectation E_x : In the domain X of the common cloud, the basic variable x that corresponds to the largest membership is defined as the cloud's expectation. It specifies the position of the cloud object in the domain, i.e. the median point of the cloud. In other words, E_x represents the information center of the corresponding fuzzy concept.

Entropy E_n : It is a measure of the concept's fuzziness. The value of entropy directly determines the extent at which the domain can be accepted by the fuzzy concept.

Excess entropy H_e : It is a measure of the cloud's discreteness. The value of excess entropy can indirectly determine the cloud's thickness.

The cloud model of the language value at the age of 20 or so is shown in Figure 1 [9,10]

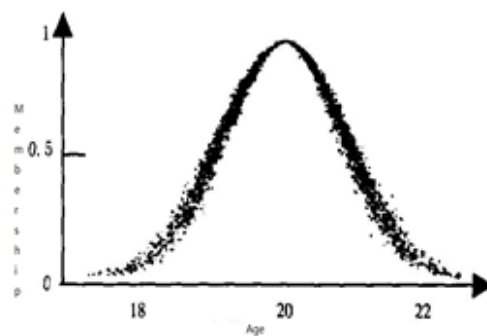


FIGURE 1 Cloud model of the language value at the age of 20 or so

For a cloud drop x , if it follows $x \sim N(E_x, E_n^2)$, $E_n' \sim N(E_n, H_e^2)$ and its certainty degree for the qualitative concept C satisfies

$$\mu_c(x) = \exp\left[-(x - E_x)^2 / (2E_n^2)\right],$$

then the distribution (E_x, E_n, H_e) of x in the domain U is called the one-dimensional normal cloud model. Where E_x is the cloud's expectation, describes the expected value of the cloud drops' distribution in the domain, represents the center of the qualitative concept, and indicates the basic measurement of the concept. E_n is the entropy of the cloud model, describe the cloud's span, represents the acceptance range of the qualitative concept, and indicates the concept's fuzziness and randomness. H_e is the excess entropy of the cloud model (i.e. the entropy of entropy), describes the cloud's thickness and represents the entropy's uncertainty.

C. Normal cloud.

Normal distribution is widely existent in social and natural phenomena as well as technical and production activities. Many random phenomena in practice follow or approximately follow normal distribution [11]. For example, the quality indicators of normally manufactured products, random measurement errors, a property of the colony, annual average of the temperature in a region, all follow normal distribution. The central limit theorem provides the theoretical condition for normal distribution [6]. According to the theorem, if a random variable is the sum of many tiny and independent random factors where the role of each factor is relatively small and uniform and no factor is dominant, then this variable approximately follow normal distribution. Consider mass production. If plant conditions (i.e. process, equipment, technology, operations, and raw materials) work normally, the quality indicators of the products should approximately follow normal distribution. Otherwise, it means that the plant conditions are either unstable or change and reduce product qualities. In practical scenarios, the above logic is typically used to check whether a random phenomenon follows normal distribution.

Normal distribution is the limiting distribution of many important probability distributions^[12]. A large number of non-normal random variable is a function of normal random variables. Both the density function and the distribution function of normal distribution have various desirable properties and simple mathematical forms, qualifying normal distribution for being widely used in practice.

The normal cloud model represents the uncertainty of a concept by using a set of independent parameters to express the numerical characteristics of the qualitative concept. Based on the normal function and the normal membership function, this set of parameters is denoted with the mean E_x , the entropy E_n and the super entropy H_e .

D. 3σ constraint of the normal cloud.

Because the one-dimensional normal cloud is universal [13, 14], it follows the 3σ rule of the normal distribution that a normal random number falls in the interval bounded by three times the standard deviation from the expectation at the probability of 99.73%. This means that in a complete cloud model that ignores the interval constraints, over 99.73% of cloud drops concentrate in the range $[E_x - 3E_n, E_x + 3E_n]$. The cloud drops outside this interval is viewed as events of small probability. Ignoring these drops will not affect the model's characteristics overall. Incorporating the 3σ constraints into the existing characteristic curve-based measuring method can centralize the cloud drops and reduce computational overheads.

E. Cloud generator.

The cloud generator is the algorithm for making transitions between the cloud's eigenvalues and the cloud images. It is also the implementation of the transitions between qualitative description and quantitative data, allowing for uncertainty derivation.

F. Forward cloud generator [15].

The forward cloud generator is the process of generating drops (xi, μ_i) based on the cloud's eigenvalues (E_x, E_n, H_e) . The given cloud's eigenvalues (E_x, E_n, H_e) represent a linguistic atom, the generated All the drops obey the properties described previously. This kind of generator is called forward cloud generator, it implements the transitions between qualitative description and quantitative data and extracts quantitative data, range and distribution from the qualitative information. This is a forward process that depicts the randomness in the human knowledge. Figure 2 to Figure 4 shows the total shapes with 100, 1000, and 5000 drops generated respectively with the same parameters $E_x=2.0$, $E_n=1.0$, and $D=0.04$.

The algorithm of the forward cloud generator is how to produce the details of the forward membership cloud generator.

Input: values of the three numerical characteristics (E_x, E_n, H_e) representing the qualitative concept A and the number of n cloud drops N .

Output: Quantitative values of the N cloud drops, and the degree of certainty that each cloud drop represents the concept A .

1) Generate a normal random number E_n' whose mean is E_n and standard deviation is H_e .

2) Generate a normal random number x whose mean is E_x and standard deviation is E_n' .

3) Assume $y = e^{-\frac{(x-E_x)^2}{2(E_n')^2}}$, then (x,y) is the cloud drop.

4) Generate the required N cloud drops by repeating steps (1)-(3).

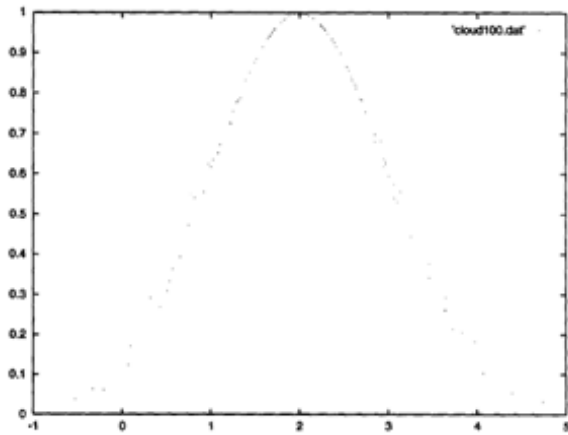


FIGURE 2 Clouds with 100 drops generated by $E_x=2.0$, $E_n=1.0$, and $D=0.04$

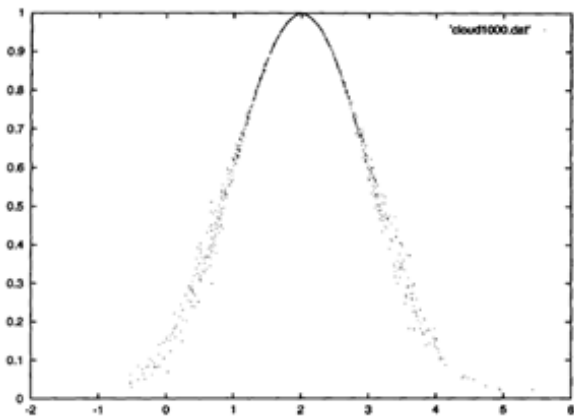


FIGURE 3 Clouds with 1000 drops generated by $E_x=2.0$, $E_n=1.0$, and $D=0.04$

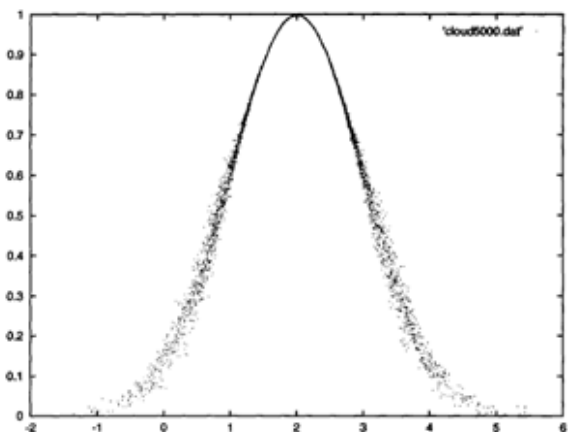


FIGURE 4 Clouds with 5000 drops generated by $E_x=2.0$, $E_n=1.0$, and $D=0.04$

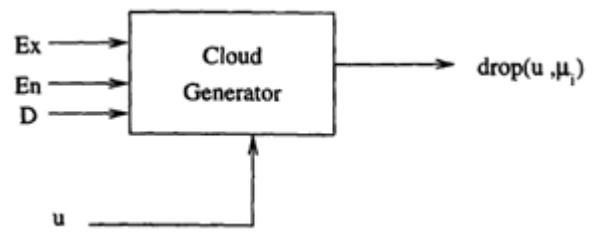


FIGURE 5 Generators on condition

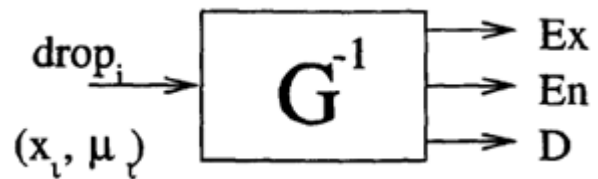


FIGURE 6 A backward cloud generator

G. Backward cloud generator

The backward cloud generator is responsible for effectively converting a number of exact numbers into proper qualitative language values (E_x, E_n, H_e) [15]. It is a quantitative-to-qualitative mapping and a backward and indirect process. It is designed to restore the three numerical characteristics E_x, E_n, H_e of the one-dimensional cloud from the given number of cloud drops in order to convert the quantitative values to the qualitative language values A.

It is in an inverse way to the forward cloud generator, the three digital characteristics (E_x, E_n, H_e) could be produced to represent the corresponding linguistic atom by the given a limited set of drops, drops (x_i, μ_i) , as samples of a membership cloud, the backward cloud generator is the process of restoring the eigenvalues (E_x, E_n, H_e) of the one-dimensional cloud based on the given number of drops. It implements the transitions from quantitative data to qualitative description. Obviously the more drops, the more accurate to the generated.

Figure 5 to Figure 6 shows the total shapes of a backward cloud generator.

Details of the backward membership cloud generator as following.

Input: Quantitative values of N cloud drops and the certainty degree of each cloud drop representing the concept (x, y)

Output: Quantitative values of N cloud drops and the certainty degree of each cloud drop representing the concept (x, y) .

1) Use $E_x = \frac{1}{n} \sum_{i=1}^n x_i$ as the estimate of E_x .

2) Remove drops that have $y > 0.999$ and remain m drops.

3) Obtain E'_n via $E'_n = \frac{x - E_x}{-\sqrt{2 \ln y}}$.

4) Obtain the estimate of E_n via $E_n = \frac{1}{m} \sum_{i=1}^m E_{n_i}$.

5) Compute the estimate of H_e via

$$H_e = \sqrt{\frac{1}{m-1} \sum_{i=1}^m (E'_{n_i} - E_n)^2}$$

H. Synthesized Cloud Construction [17]

Suppose there are two different cloud models, $C_1 (E_{x1}, E_{n1}, H_{e1}), C_2 (E_{x2}, E_{n2}, H_{e2})$, which are all from the same universe of discourse U . A Synthesized Cloud $C (E_x, E_n, H_e)$ may be created by the following Equation:

$$E_x = \frac{E_{x1} \cdot E_{n1} + E_{x2} \cdot E_{n2}}{E_{n1} + E_{n2}}$$

$$E_n = E_{n1} + E_{n2}$$

$$H_e = \frac{H_{e1} \cdot E_{n1} + H_{e2} \cdot E_{n2}}{E_{n1} + E_{n2}}$$

It is easy to see that this formula can be further extended to the synthesis of many cloud models.

4 Models for evaluating enterprise portal sites using normal cloud model

A. Disadvantages of the traditional methods.

Results of the traditional approach to website evaluation are typically the final ranks, qualitative description (e.g. good, mediocre), or the specific scores (e.g. 85, 60) [3]. These ranks are provided at the neglect of the informative details. As a result, the evaluation results are incomplete and ineffective.

B. Model for evaluating enterprise portal sites using normal cloud model.

The core of our ideas is to use the forward and backward cloud generators to make the transitions between quantitative data and qualitative description [16]. The resulting cloud images represent the prevailing opinions among users and can deliver qualitative conclusions. Through the use of the distribution of cloud drops, we can obtain in-depth details and quantitative data. Summing them up can eliminate randomness in the scores from users and thus offers complete, detailed, accurate and unbiased results.

Basic steps of the evaluation model are as follows:

1) Design evaluation indicators.

A proper and complete set of indicators is critical to the evaluation system. For an excellent website evaluation system, the indicators should be adequate enough to involve every aspect of the website. Furthermore, every indicator should be described concisely so that website viewers can express their opinions accurately.

The indicator system consists of the indicator set U , the weight set W and the comment set C .

For collection of the viewer opinions, the indicator set has two layers. The first layer includes the general indicators, while the second-layer indicators are specific to a particular aspect of the website.

The weight set is $W = \{w_1, w_2, \dots, w_n\}$, where $w_i > 0, w_1 + w_2 + \dots + w_n = 1$.

According to the requirements of the evaluation strategy, the indicators are scored using five ranks in the hundred mark system. That is, the comment set is $C = \{c_1, c_2, c_3, c_4, c_5\} = \{\text{very good, good, mediocre, disappointing, very disappointing}\}$. And each comment is bounded, where the mark 90-100 is for very good, 80-99 for good, 70-79 for mediocre, 60-69 for disappointing, and 59 and below for very disappointing.

After careful investigation and analysis, the most essential indicators to the website quality are specified, and their weights are assigned according to their importance. The indicator system is developed as shown in Table 1.

TABLE 1 Indicators and their weights

First layer indicators	Weights	Second layer indicators	Weights
Information delivery	0.4	Information contents are satisfactory and diverse	0.1
		Steadily deliver real-time messages	0.1
		Information is well organized	0.1
		Query tools are available to help users find what they want	0.1
Webpage design	0.15	The overall structure is impressive, elegant and matched with proper colors and fonts.	0.05
		Webpages are layered properly and give a sense of hierarchy.	0.05
		The interface is user friendly and developed to users' preferences	0.05
User-friendliness	0.3	Provide sufficient links, including those to other important websites.	0.1
		Link conditions and access speed are satisfactory.	0.1
		Easy to use and access.	0.1
Additional functions	0.15	Offer services in ticket booking, weather forecast, tourism information, etc.	0.05
		Highly interactive	0.05
		Deliver necessary bulletins or other advertisement messages	0.05

2) Obtain the numerical characteristics of the cloud models of each second-layer indicator using the backward cloud model

The collected scores (in the hundred mark system) from all users for the second-layer indicators are used as the source of evaluation data. For each of the second-layer indicator, the backward cloud generator can be employed to convert qualitative description into quantitative eigenvalues of the cloud, and to generate the three eigenvalues (i.e. E_x, E_n, H_e) of the cloud model corresponding to this second-layer indicator.

The backward cloud model algorithm based on n drops is used in this paper.

Inputs: $drop(t', u_i)$ for n drops, where u_i denotes the numerical value that corresponds to the users' scores for the website.

Outputs: three eigenvalues (i.e. E_x, E_n, H_e) of the cloud image that consists of the n drops.

Algorithm:

1) The average value

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n u_i,$$

b. $\sqrt{S^2 - E_n^2},$

c. $S^2 = \frac{1}{n-1} \sum_{i=1}^n (u_i - \bar{X})^2,$

2) $E_x = \bar{X}.$

3) $E_n = \sqrt{\frac{\pi}{2}} \cdot \frac{1}{n} \sum_{i=1}^n |u_i - E_x|.$

4) $H_e = \sqrt{S^2 - E_n^2}.$

3) Use the composite cloud algorithm to process the numerical characteristics of all second-layer indicators according to their weights, obtain the eigenvalues of the first-layer indicators and the three eigenvalues (i.e. E_x, E_n, H_e) of the final cloud model.

The composite cloud is obtained by mixing multiple basic clouds. For the resulting cloud, the numerical characteristics of all basic clouds can be calculated to get the numerical characteristics of the composite cloud.

The calculation of the composite cloud is as follows:

$$E_x = \frac{E_{x1}w_1 + E_{x2}w_2 + \dots + E_{xn}w_n}{w_1 + w_2 + \dots + w_n}, \tag{1}$$

$$E_n = \frac{E_{n1}w_1 + E_{n2}w_2 + \dots + E_{nn}w_n}{w_1 + w_2 + \dots + w_n}, \tag{2}$$

$$H_e = \frac{H_{e1}w_1 + H_{e2}w_2 + \dots + H_{en}w_n}{w_1 + w_2 + \dots + w_n}, \tag{3}$$

where w_i is the weight of the i^{th} indicator, (E_x, E_n, H_e) is the cloud model parameters of the i^{th} indicator, and n is the number of sub-indicators.

4) Use the three eigenvalues of the final cloud model to obtain the cloud model image and reach the final conclusions.

C. Example application.

Aggregating the evaluation data should start with the second-layer indicators and then the first layer, because the indicator system has two layers.

The actually collected scores from users for the second-layer indicators of a particular website are used as the source of evaluation data. Next, the backward cloud generator is used to process the data and the three eigenvalues (in the hundred mark system) of the cloud models for each second-layer indicator, as shown in Table 2.

TABLE 2 Numerical characteristics of cloud models for second-layer indicators

Second-layer indicators	(E_x, E_n, H_e)
Information contents are satisfactory and diverse	(96.67,9.01,5.37)
Steadily deliver real-time messages	(97.45,10.12,5.26)
Information is well organized	(95.30,10.25,5.78)
Query tools are available to help users find what they want	(95.21,11.19,4.97)
The overall structure is impressive, elegant and matched with proper colors and fonts.	(94.58,10.63,4.88)
Webpages are layered properly and give a sense of hierarchy.	(87.08,10.65,5.24)
The interface is user friendly and developed to users' preferences	(97.10, 9.34,5.34)
Provide sufficient links, including those to other important websites.	(93.26,10.04,4.79)
Link conditions and access speed are satisfactory.	(92.44, 9.74,5.11)
Easy to use and access.	(92.48,10.62,4.05)
Offer services in ticket booking, weather forecast, tourism information, etc.	(95.52,11.76,4.08)
Highly interactive	(90.38, 8.57,4.26)
Deliver necessary bulletins or other advertisement messages	(96.35,11.84,5.51)

The numerical characteristics of all second-layer indicators in Table 2 are processed using the composite cloud algorithm. In this way, the eigenvalues of the first-layer indicators are shown in Table 3.

TABLE 3 Numerical characteristics of cloud models for first-layer indicator

First-layer indicators	(E_x, E_n, H_e)
Information delivery	(96.16,10.14,5.35)
Webpage design	(92.92,10.21,5.15)
User-friendliness	(92.73,10.13,4.65)
Additional functions	(94.08,10.72,4.62)

By applying the composite cloud algorithm to the three eigenvalues of the first-layer indicators in Table 3, we obtain the three eigenvalues of the cloud model as $E_x=94.33, E_n=10.23, H_e=5.01$. This is the evaluation of users on this website.

By processing the first-layer indicators using the forward cloud generator, we obtain the cloud image as in Figure 7.

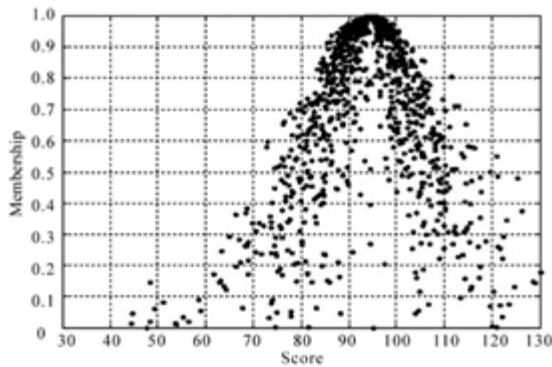


FIGURE 7 The evaluation of the website

D. Result analysis.

From Figure 7, it can be seen that the points are distributed most densely near 94.33 and the further from 94.33, the sparser the points are. That is, 94.33 have the highest probability of belonging to the evaluation result. The resulting cloud follows normal distribution, i.e. it is neither a deterministic probability density function nor a clear curve of membership function, but a one-to-many pan normal mathematical mapping image that stems from normal generators and consists of many cloud drops. It is also a flexible and elastic cloud image without deterministic edges to perform qualitative and quantitative conversion. The membership that is close to or distant from the concept center has a low degree of randomness while the membership that is neither too close nor too distant from the concept center has a high degree of randomness. This is consistent with features of expectation and entropy. The cloud that is thick in the middle and thin in the edge is consistent with features of super entropy.

To verify our algorithm, the above steps are followed for the example and produce the three eigenvalues of the cloud model as $E_x=94.33$, $E_n=10.23$, $H_e=5.01$.

From the results based on weighted aggregation, we can see that the expectation E_x is 94.33 in the range (90-100). We also observe that this interval has the highest

drop density. According to the bound limit of the comments, we know that the overall evaluation is very good.

Table 3 shows that of the four first-layer indicators, information delivery has the highest value of E_x , meaning that the users are most content with the website's information delivery. User-friendliness has the lowest value of E_x , meaning that there is scope for further improvement.

As for the values of E_n , User-friendliness is smallest, meaning that the examiners are most agreed on this indicator. Additional functions are highest, meaning that the examiners are divided on this indicator.

In terms of the values of H_e , information delivery is highest, meaning that users are highly uncertain about this and their comments are subjective. Additional functions are smallest, meaning that the users are highly certain about the scores they give.

From above, we can see that the proposed algorithm can provide accurate evaluation process. Instead of only determining it is good or not, the evaluation results of our algorithm are adequate enough to depict every aspect of the website. This is immensely informative to website developers.

5 Conclusions

Inspired by the advantage of the cloud model that it can make transitions between qualitative description and quantitative data, the normal cloud model is introduced to the evaluation of the websites. The shapes of the cloud images are used to analyse the evaluation of each indicator. Compared with the traditional approaches, the proposed method delivers more complete and diverse evaluation messages and improves the evaluation accuracy.

Furthermore, the proposed method can extract more nuggets of information. Hence, it is useful to improve the quality of the Internet and can serve as a reference point for other evaluation systems.

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