Seafarer's Competency Synthetic Assessment Based on Cloud Models

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***Abstract*—In order to process the uncertainty information in assessing human element, in this paper, a synthetic assessment method is proposed to seafarers' competency based on cloud models, where various uncertainties in the system are well kept and modeled by cloud theory. The presented approach focuses on effectively modeling the quantitative and qualitative variables of attribute factors of rules' antecedents and seccedents, and the optimal cloud models based on the relative cloud theory are found. Then the post-condition cloud of corresponding rule is fired by foregoing cloud models through 'logic and' or 'soft-and' operator. Furthermore, fuzzy comprehensive evaluation is utilized to build rule base. Finally, the output will be constructed by means of backward cloud. That is the final assessment result which is depicted by the cloud graph in the original synthetic evaluation cloud models. Since the post-condition' activated operators are different, experiments are conducted to analyze the different effects. Experiments are also conducted to compare the proposed paradigm with the fuzzy synthetic judgment in seafarers' competency assessment. Simulation research shows that the proposed algorithm is more intuitive, flexible, reliable and consistent with human thinking.**

***Index Terms*—cloud model, seafarers' competency; human element; marine traffic; soft-and; fuzzy comprehensive evaluation**

I. Introduction

Research has confirmed that human element is involved deeply in maritime accidents, which is drawn the attention from all relevant fields of international communities, especially from the International Maritime Organization (IMO). Nowadays, human element has been the hot topic in research field and seafarers' competency has developed accordingly. Since the abstractness and uncertainty in human element, how to depict the qualitative concepts in natural language and reflect the randomness and fuzziness and so on is the most important problem in scientific evaluation process. It is well known that the Delphi method, analytic hierarchy process (AHP) [1], probability and statistics method [2], grey system theory [3] and so on. To assess marine traffic safety, traditionally many researchers have studied in statistical method [4]-[5]. This is necessary to have a database of very large number of accidents information, whereas it is difficult to obtain sound data, and the standards for this field are not consistent with different countries. Grey relational analysis (GRA) [6]-[7] and fuzzy theory [8]-[9] have been comprehensively used in maritime safety assessment recently. Especially fuzzy comprehensive evaluation method is not appropriate to these cases, which different attribute factors are described by varied linguistic words and final result is expressed by different linguistic atoms. Hence, these methods mentioned above have been modeled by precise mathematical tools more or less. However, marine traffic safety assessment, known as a "Navigator-Ship-Environment" system, is a large-scale complex system with much uncertainty information inherently. Fortunately artificial intelligence with uncertainty would be effective to circumvent the difficulty of marine safety evaluation. Cloud model as a quality to quantity interchangeable model is presented. It combines the fuzzy mathematics, probability and statistics, which has made a great progress in assessing qualitative problem [10].

Cloud theory has succeeded in the fields of data mining [11], intelligent control and prediction [12]-[13], land price evaluation [14] and large-scale system evaluation [15], etc.

In this paper, the cloud model is introduced to develop a cloud evaluation algorithm for seafarers' competency assessment. The effect of human factors is highlighted and the cloud theory is used to model attributes of human element. The rule base is derived from fuzzy comprehensive evaluation. Then the corresponding rules are fired by optimal cloud models. Consequently, the final evaluation result based on the cloud graph is obtained. Finally, simulation results demonstrate the effectiveness and superiority of the proposed paradigm.

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doi:10.4304/jcp.6.2.263-270

II. Concept Of The Cloud Models And Description Of Factors Based On Cloud Models

A. *Concepts Of The Cloud Models*

Cloud is a model described by linguistic values for representation of the uncertain relationship between a specific qualitative concept and its quantitative expression. The cloud's global shape reflects the importance of the qualitative concept.

Let *U* be a universal set described by precise numbers, and *T* be the qualitative concept related to *U*. If there is a number $x(x \in U)$, which randomly realizes the concept T, and the certainty degree of *x* for *T*, *i.e.*, $C_T(x) \in [0, 1]$, is a random value with stabilization tendency $C_T(x): U \rightarrow [0,1]$, $\forall x \in U$, $x \rightarrow C_T(x)$. Then the distribution of *x* on *U* is defined as a membership cloud, and is denoted by N^3 (*Ex, En, He*), every *x* is defined as a cloud drop [16].

The beauty of cloud model is that the overall property of a concept can be represented only by the three numerical characters, which are *Ex*, *En*, and *He* to represent the concept as a whole. *Ex* is the mathematical expectation of the cloud drop distributed in the universal set. *En* is the uncertainty measurement of the qualitative concept, which is determined by both the randomness and the fuzziness of the concept. *He* is the uncertainty measurement of the entropy, which reflects the agglomerating extent of the uncertainty of drops in numerical domain.

B. *Cloud Generator and Uncertainty Reasoning Based on Cloud Model*

The algorithm of generative cloud drops or hardware is called cloud generator, which includes forward cloud generator, backward cloud generator, condition *X* cloud generator and condition *Y* cloud generator. When cloud's three digital characteristics (*Ex*, *En*, *He*) and the special value x_0 are given, the cloud generator is called condition *X* cloud generator, when cloud's three digital characteristics(*Ex*, *En*, *He*) and value μ_0 are given, the cloud generator is called condition *Y* cloud generator. Condition *X* cloud generator and condition *Y* cloud generator are the basis of doing uncertainty reasoning by cloud models [17].

If we combine one pre-condition cloud generator and one post-condition generator, as shown in Fig. 1, we can obtain a single-condition-single-rule generator. In this way, uncertainty is transited in the reasoning process by rule generator. As a result, we can easily construct the qualitative rules by cloud theory based on the relationships between linguistic atoms and cloud models. The cloud-based qualitative rule generator includes single-condition-single-rule, single-condition-multi-rule, multi-condition-single-rule and multi-condition-multi-rule.

The most pervasive cloud model is normal cloud model, which plays a significant role in academic research and practical applications. The algorithm is applicable to the one-dimensional universal space situation, and also applicable to the two or higher dimensional situation. The algorithm is as followed:

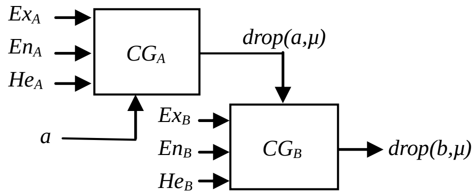

Figure 1. Single-condition-single-rule generator

Algorithm: Forward Normal Cloud Generator
Input: (*Ex*, *En*, *He*), and the number of cloud drops n
Output: *n* of cloud drops *drop*(x_i , μ_i), *i* =1, 2,…, *n*
Steps:
1) Generate a normally distributed random number $En_i^{'}$ with expectation *En* and variance He^2
2) Generate a normally distributed random number x_i with expectation *Ex* and variance $En_i^{'}$
3) Calculate $\mu_i = e^{-\frac{(x_i - Ex)^2}{2(En_i^{'})^2}}$
4) x_i with certainty degree of μ_i is a cloud drop in the definite domain
5) Repeat steps *1*) to *4*) until cloud drops are generated

C. *Description of Evaluation Factors with Cloud Models*

Different attribute factors in the set of standards are very often qualitative variables, which are described in natural language by experts in the field. Nevertheless there are still quantitative variables, for instance, the formalization like $V_{qa}[C_{\min}, C_{\max}]$, and its normal cloud model can be established as follows:

$$\begin{aligned} Ex &= (C_{\max} + C_{\min}) / 2 \\ En &= (C_{\max} - C_{\min}) / 6 \\ He &= k \end{aligned} \quad (1)$$

where *k* is a constant which can be adjusted by its own stability and experience. If the quantitative variables only have single limit, like $V[C_{min}, +\infty]$ and $V[-\infty, C_{max}]$, we must determine its expected value or default value, and then calculate the numerical characteristics by (1).

Take the attribute factor "average sailing age" as example, we can gain its numerical characteristics of the clouds as (*Exl*, *Enl*, *Hel*) = (15, 3.33, 0.08), (*Exm*, *Enm*, *Hem*) = (7.5, 3.33, 0.12), (*Exs*, *Ens*, *Hes*) = (3, 3, 0.08). The cloud graph is shown in Fig. 2.

III. Fuzzy Synthetic Judgment

Fuzzy comprehensive evaluation is a set of fuzzy decision of single-factor in system by way of the compound fuzzy operation defined.

Given the factors set which will be evaluated is *U*. Based on different attributes of the factors, *U* is divided

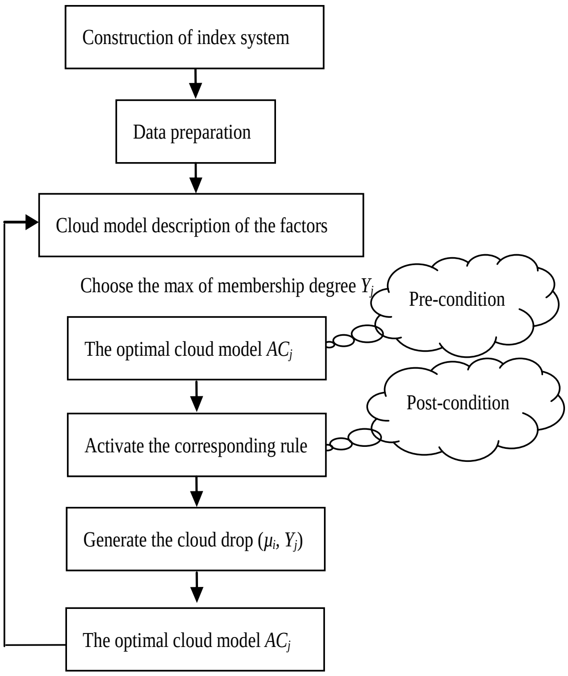

Figure 2. The evaluation flow chart

into $u_1, u_2, ..., u_n$, namely, there are n subsets, where $U = \{u_1, u_2, ..., u_n\}$, $u_i \cap u_j = \phi$, $i \neq j, i, j = 1, 2, ..., n$. In the index system, there are not only quantificational indexes, but also qualitative indexes.

When we evaluate, we should divide the quantitative indexes into different sections, divide the qualitative indexes into different levels, and give uniform degree by membership function. $B=(b_1, b_2,\ldots,b_m) \in P(V)$, $B(v_j)=b_j$ (j=1,2,…,m), b_j is the membership degree of v_j to fuzzy set B. So we can achieve comment set $V = \{v_1, v_2,\ldots,v_m\}$.

Given the weight set $A = (a_1,a_2,\ldots,a_n) \in P(U)$, where a_i is the weight of the factor u_i, and $\sum_{i=1}^{n} a_i = 1$, $0 < a_i < 1, i = 1, 2, ..., n$. If each factor is evaluated independently, we obtain the fuzzy mapping f: $U \rightarrow P(V)$, *i.e.* $u_i \mapsto f(u_i) \in P(V)$.

The fuzzy synthetic decision consists of three elements:

(1) Factor set $U = \{ u_1, u_2, ..., u_n \}$.

(2) Comment set $V = \{ v_1, v_2, ..., v_m \}$.

(3)Single factor fuzzy mapping f: $U \rightarrow P(V)$, $u_i \mapsto f(u_i) = (r_{i1}, r_{i2}, ..., r_{im}) \in P(V)$.

Fuzzy relationship $\underset{\sim}{R}_f \in P(U \times V)$, $\underset{\sim}{R}_f(u_i)(v_i) = r_{ij}$, we can obtain the single-factor evaluation matrix R $= \begin{pmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nm} \end{pmatrix}$, (U, V, R) is called mathematical model of fuzzy synthetic decision [18].

To avoid too many factors in the same level, we decompose the index system into multilevel since the weight of each factor would be too small if all of them are in the same layer of the original system. The new model evaluates the factors from the bottom to up. And the upper level will use the synthetic evaluation vector from the lower level. We call the new model as multilevel fuzzy synthetic judgment.

IV. THE COMPREHENSIVE EVALUATION ANALYSIS METHOD BASED ON CLOUD THEORY

A cloud evaluation method is proposed, to resolve the uncertainty in assessing a complex system. The randomness and fuzziness of object's attributes are both considered, where various uncertainties in the complex system are well kept and investigated by cloud theory. And the different attribute factors are depicted with different cloud models of varied linguistic words. And the final result also can be expressed by cloud models with different numbers or kinds of comment linguistic language. Finally, the evaluation results are a cloud graph which is more intuitive and understandable.

A. Data Preparation

The present paradigm's main idea is that by cloud modeling different attribute factors including qualitative and quantitative variables, the optimal cloud models of each factor are found, and through X-condition cloud, Y-condition cloud and backward cloud generators, the post-condition clouds of the corresponding rule are fired by soft-and operator. Consequently, the final evaluation result is obtained, which is described by the distribution of cloud drops. The flow chart is shown in Fig. 3.

Setting an index system is the most important premise for assessing scientifically. All the attributes concepts should belong to the same domain, which made the dimension unified by transmitting the attribute values into [0, 1] interval through cloud transfer. The continuous attributes should be discretized by cloud models and the granularity of concepts can be enhanced by climbing-up strategy and algorithms.

The evaluation object is determined, which is collected by asking experts the parameters and the comments. The factor set U is $\{u_1, u_2,\ldots,u_n\}$ and the comment set is $V = \{v_1, v_2,\ldots,v_{n+1}\}$ which is one more than factor set U .

B. Cloud models of attribute factors and formulation of the cloud clusters

After the evaluation object is determined, the three numerical characteristics of cloud models should be established. If the numerical characteristics of cloud model are given by N experts, the qualitative variables can be represented by a synthetic cloud, and the numerical characteristics of the synthetic cloud are calculated as follows:

$$Ex = \frac{Ex_1 \times En_1 + Ex_2 \times En_2 + ... + Ex_n \times En_n}{En_1 + En_2 + ... + En_n}$$
$$En = (En_1 + En_2 + ... + En_n) / n \qquad (2)$$
$$He = \frac{He_1 \times En_1 + He_2 \times En_2 + ... + He_n \times En_n}{En_1 + En_2 + ... + En_n}$$

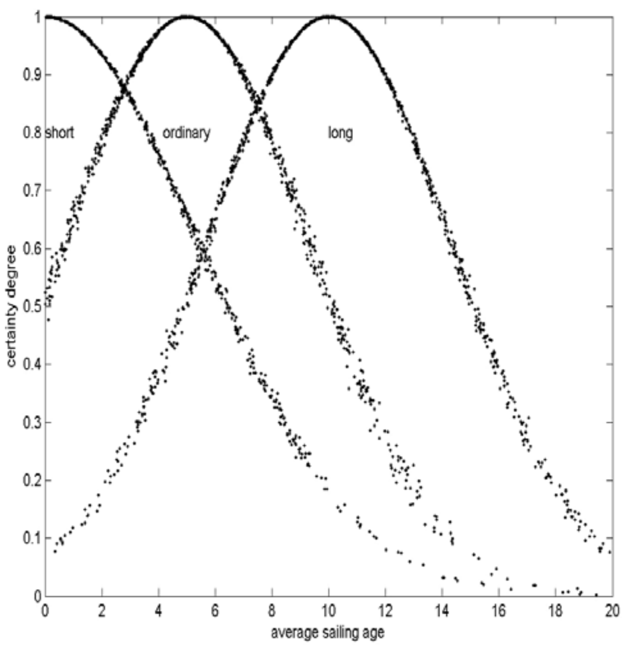

Figure 3. Cloud cluster of seafarers' the average sailing age

Take the variables of the factors in the same coordinate axis. Look at Fig.3. That is seafarers' average sailing age cloud models cluster in the same coordinate axis. When there is an input, the corresponding interval would be fired, the optimal cloud model should be chosen.

C. Construction of the rule base and cloud rules

According to the knowledge and experience of experts, k qualitative inference rules can be established based on the fuzzy synthetic judgment. They are presented by the priorities and frequencies. There is a rule database consisting of N qualitative rules.

Then antecedents and seccedents of the rules are both modeled by cloud theory, the singe-condition-single-rule can be expressed by If $A=C_j^i$, then $B=B_k^{i'}$, where A is the set of antecedents of rules, B is the set of seccedents of rules, C_j^i is the cloud model of antecedent comment factor v_j of attribute u_i, $B_k^{i'}$ is the cloud model of seccedent comment factor v_k of attribute $u_{i'}$.

D. Uncertainty reasonning based on cloud moedels

After the rules are modeled by cloud theory, the uncertainty reasoning structure is constructed. When there is an precise input (X_1, X_2,…, X_n), the certainty degrees of every single-rule generator are calculated to all concepts in the preconditions of each of the cloud rules. If there is more than one positive certainty degree, we choose the maximum Y_j, which is called activated strength. Through Y_i chooser and the forward cloud generator, the cloud drops (x_i, Y_i) are generated.

The output will be constructed by means of virtual cloud or backward cloud generator if there are large enough amount of cloud drops. Consume that there are more cloud drops (x_1, u_1), (x_2, u_2),…, (x_n, u_n), the backward cloud generator CG^{-1} can produce the expectation, entropy, as well as the hyper-entropy of the virtual cloud of final result.

For the multi-level index system, we should divide the index system into q levels. Then we evaluate the factors from the bottom to up. And the upper level should use the synthetic assessment vector from the lower level.

The process of evaluation can not stop repeating and optimizing itself in endless cycles until it satisfies the experts in the field. The expected value of the cloud can be considered as quantitative output value of the final result of the comprehensive evaluation if it is necessary.

V. The Synthetic Assessment Based on Cloud Models in Seafarers' Competency

A. Determine the assessment object

The above cloud evaluation paradigm is applied in assessing seafarers' competency of marine traffic safety assessment system, which is in the second class sub-index to evaluate the general quality of seafarers on board. The index system of human element is a noticeable part in assessing marine traffic safety system. In this paper, the index system is employed in [19] and the author of which has made a profound research into human element.

The evaluation object is determined, which is the general quality of seafarers in the second class sub-index of the total safety of all the seafarers on board. The factor set U is {language level of personnel on board u_1, educational background u_2, average sailing age u_3, level of management u_4}. Comment set is $V = \{v_1, v_2,…,v_5\}$, which is the evaluation language set of each factor and the general quality, where v_1 = {excellent C_1^1, ordinary C_2^1, worse C_3^1}, v_2 = {high C_1^2, middle C_2^2, low C_3^2}, v_3 = {long C_1^3, ordinary C_2^3, short C_3^3}, v_4 = {worse C_1^4, ordinary C_2^4, excellent C_3^4}, v_5 = {high C_1^5, ordinary C_2^5, low C_3^5}, and C_j^i is the comment factor v_j of attribute u_i.

B. Cloud model description of attribute factors

In this step, the different attribute factors are modeled by cloud theory. The three numeric characteristics of the cloud models' of the factor 'language level of personnel on board' are shown in Table I, which are investigated and modified by researchers in the field. And the cloud numerical characteristics of synthetic assessment of the seafarers' general quality are shown in Table II.

According to (2), we get the synthetic cloud models of factor 'language level' as follows: (Exh, Enh, Heh) = (0.8534, 0.1180, 0.0038), (Exc, Enc, Hec) = (0.5939, 0.0980, 0.0048), (Exl, Enl, Hel)=(0.2732, 0.0820, 0.0049). The synthetic cloud models of the second class sub-index 'seafarers' general quality' are as followed: (Exh, Enh, Heh) = (0.8533, 0.0900, 0.0032), (Exc, Enc, Hec) = (0.5712, 0.1040, 0.0035), (Exl, Enl, Hel) = (0.2500, 0.1020, 0.0041).

TABLE I.
CLOUD MODELS OF EVALUATION STANDARD OF THE FACTOR LANGUAGE LEVEL

	Excellent (*Exh*, *Heh*, *Heh*)	Ordinary (*Exm*, *Hem*, *Hem*)	Worse (*Exl*, *Enl*, *Hel*)
Expert 1	(0.9000, 0.1500, 0.0070)	(0.6000, 0.1000, 0.0090)	(0.3000, 0.0800, 0.0030)
Expert 2	(0.8000, 0.1000, 0.0030)	(0.6500, 0.1200, 0.0060)	(0.2000, 0.06, 0.002)
Expert 3	(0.9000, 0.1200, 0.0050)	(0.6000, 0.0800, 0.0040)	(0.2500, 0.1000, 0.0050)
Expert 4	(0.85000, 0.0900, 0.0020)	(0.5000, 0.0900, 0.001)	(0.3000, 0.1000, 0.0060)
Expert 5	(0.8000, 0.1300, 0.0010)	(0.6000, 0.1000, 0.0030)	(0.3000, 0.0700, 0.008)

TABLE II.
CLOUD CLOUD MODELS OF EVALUATION STANDARD OF SEAFARERS' GENERAL QUALITY

	High (*Exh*, *Heh*, *Heh*)	Ordinary (*Exc*, *Enc*, *Hec*)	Low (*Exl*, *Enl*, *Hel*)
Expert 1	(0.8500, 0.100, 0.0050)	(0.5000, 0.1000, 0.0040)	(0.2000, 0.1800, 0.0030)
Expert 2	(0.900, 0.0700, 0.0010)	(0.6000, 0.1000, 0.0050)	(0.2000, 0.0700, 0.0030)
Expert 3	(0.9000, 0.1200, 0.0050)	(0.6000, 0.0800, 0.0040)	(0.2500, 0.1000, 0.0050)
Expert 4	(0.8000, 0.0900, 0.0020)	(0.6000, 0.1400, 0.0030)	(0.3500, 0.0900, 0.0060)
Expert 5	(0.8000, 0.0700, 0.0010)	(0.5500, 0.1000, 0.0020)	(0.3000, 0.0700, 0.0040)

And the cloud cluster of 'language level of seafarers' is shown in Fig.4. When a quantitative value comes, the corresponding cloud model is fired and the corresponding optimal cloud models are found.

According to the knowledge and experience of experts, the rules are cleaned up and standardized. Totally, 93 qualitative inference rules can be established based on the fuzzy synthetic judgment.

The rules are presented by the priorities and frequencies. And the formulization like If $X_1=x_{i1}$, $X_2=x_{i2}$, $X_3=x_{i3}$, $X_4=x_{i4}$, then $Y=y_i$, i=1, 2,…93.

C. Uncertainty reasonning and the results

In this example, the uncertainty reasoning process is a four-condition-one-rule reasoning, which is shown as

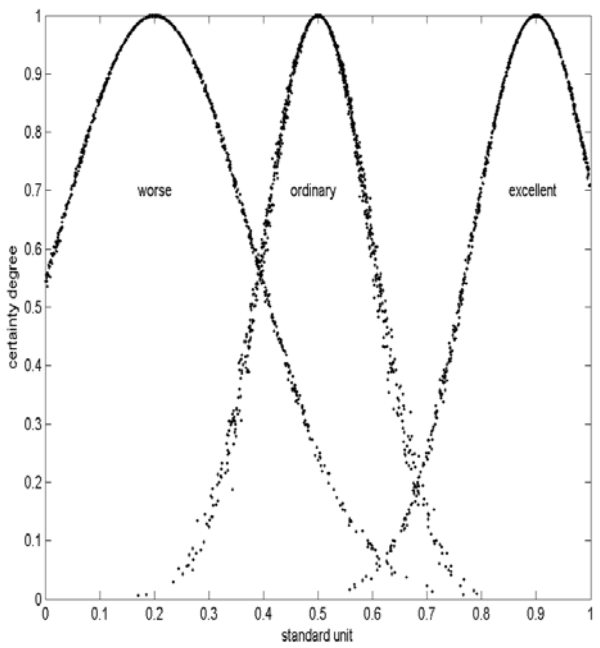

Figure 4. Cloud cluster of language level of seafarers

Fig.5. According to the knowledge and experience of experts in the area, the qualitative inference rules have been established based on cloud models and fuzzy comprehensive judgment.

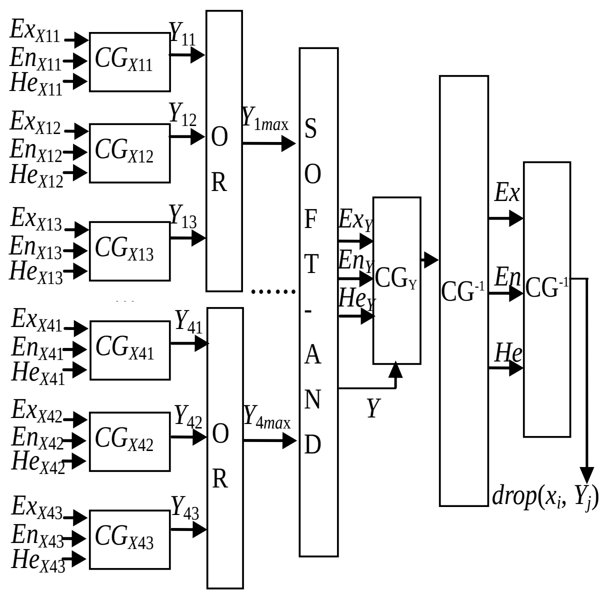

Figure 5. Structure of four-condition-single-rule reasoning

When there is an input (X_1, X_2, X_3, X_4) = (0.6, 0.4, 12, 0.8), the certainty degrees of every single-rule generator are calculated to all concepts in the preconditions of each of the cloud rules. In this case, there is more than one positive certainty degree, we choose the maximum Y_j, including Y_{1max} = 0.9977, Y_{2max} = 0.5952, Y_{3max} = 0.8998, Y_{4max} = 0.5415. Through the forward cloud generator and Y_i chooser, the corresponding optimal concept clouds are AC_1, AC_2, AC_3, and AC_4 *i.e.* language level ordinary, educational background middle, average sailing age long and level of management excellent.

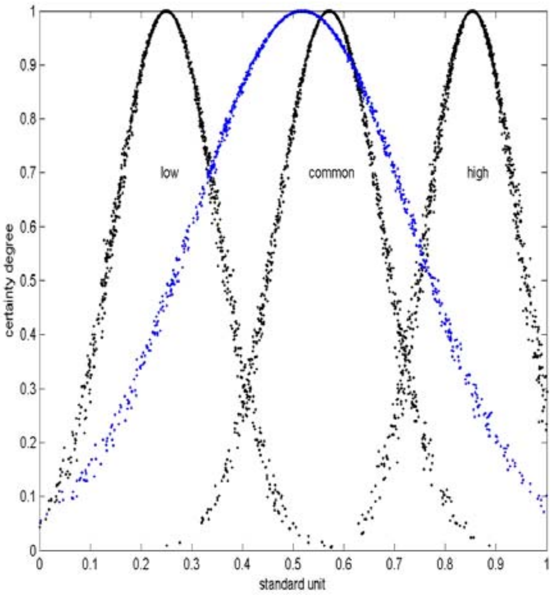

Figure 6. The cloud graph of final result in original synthetic cloud models with logic-and

In so for as mention the operator between the Yi chooser and the forward cloud generator, which can be used by the different operator ‘logic-and’ or ‘soft-and’. The ‘soft-and’ is realized by four-dimension cloud, and the logic-and is much easier than soft-and. We can see the difference between Fig. 6 and Fig. 7.

Comparing the two operators between the Yi chooser and the forward cloud generator, in Fig. 6, the final result is a little closer to ‘low’ cloud in the original comment set’s synthetic cloud model, and the ‘common’ cloud is covered by most of the drops of the final blue synthetic assessment cloud.

From the Fig. 7, the blue cloud model of the final result is a little far from the ‘common’ cloud model, but a large proportion is in the ‘common’ cloud. That is the difference between the different operators. The reason for the difference between them is that the activated strength is minimized by ‘logic-and’ of the four precondition of the rule corresponding the four concepts AC_1, AC_2, AC_3, and AC_4. The degrees of ‘logic-and’ between the four antecedents are not stated clearly in logic. Whereas the ‘soft- and’ which is introduced in is to implement the activated strength from the four antecedents. Hence, we come to the conclusion that the outcome of the two different operators is consistent with each other, i.e. the general quality of seafarers on board is common with the precise input to the system. However, in the latter one, the four antecedents of the rule are all considered by the ‘soft-and’, which makes the final result is more flexible and exact.

Consequently, the final comprehensive evaluation based on the cloud models is named as *BC* (*Ex*, *En*, *He*), which is depicted by blue cloud drops shown in the Fig 6. and Fig. 7.

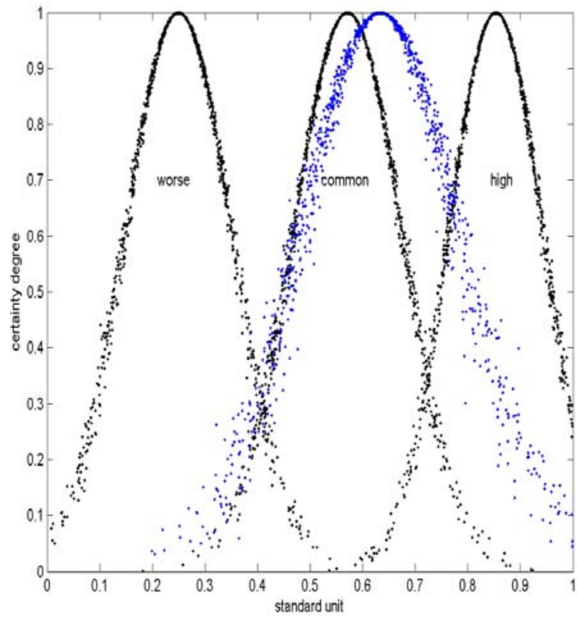

Figure 7. The cloud graph of final result in original synthetic cloud models with soft-and

Simulation research shows that it is feasible to describe the human elements of marine traffic safety system by using cloud theory.

Comparing the fuzzy comprehensive evaluation and the synthetic assessment method base on cloud models are used for personal factors’ analysis. We notice that there are fundamental differences between them.

- The former’s result in [19] is one concept of the comment set with a strong hand. To the contrary, the latter’s final result is a cloud graph, which is more intuitive, effective and understandable. The result is more exact by synthetic assessment method based on cloud model. And the description for these linguistic values is similar to the description for the attribute factor values of seafarers’ competency, e.g., ‘low’, ‘middle’, and ‘high’. They are expressed in terms of expectation, entropy and hyper-entropy, and are more understandable.
- The former’s output is constant for the same input. It requires a certain membership function, once the membership functions are defined, the fuzzy comprehensive evaluation is not any longer fuzzy to the concepts of factors. The latter utilizes the reasoning by qualitative knowledge rather than precise mathematical models, and evaluates the attribute factor with uncertainties based on cloud theory, where the uncertainty in the information is kept as much as possible. By contrast, in the cloud-based method the outputs are uncertain each time but, in the same overall variation trend as fuzzy comprehensive evaluation. That just reflect the way of human being’s thinking, they show the different opinions in different mood of the same time, but the overall arguments are consistent.

- In the synthetic assessment method based on cloud model, different attribute factors are depicted with different cloud models of varied linguistic words, and the final result also can be expressed by cloud models with different numbers or kinds of linguistic language, which makes the content of evaluation more enriched and suitable to practice. But the fuzzy comprehensive evaluation is not effective to these cases.
- Last but not the least, compared the two methods with the selection of min $\{Y_{1max}, Y_{2max}, Y_{3max}, Y_{4max}\}$ as the strength of post-condition activation, the latter is realized by the more scientific 'soft-and' operator. The uncertainty illation based on cloud models is more adaptable to adopt the quantitative transformation of 'soft-and' by cloud model.

VI. Conclusions And Futur Work

Human errors are the most important cause in the marine traffic safety system assessment, in which much uncertainty and abstract information are involved. It is not suitable to be modeled by precise mathematical tools. Hence, the synthetic assessment algorithm based on cloud modes is much more suitable to attribute factors are expressed by natural language values.

In this paper, a cloud model based assessment paradigm has been proposed to evaluate human element. Cloud models are utilized to extract uncertainty information and fuzzy comprehensive evaluation methods are introduced to build relationship rules. As a consequence, optimal cloud models are selected to activate the post-condition cloud of corresponding rules. Finally, the comprehensive evaluation result can be derived from the proposed assessment system. Experimental results show that the approach has higher reliability and better understanding for marine traffic safety assessment.

However, the numerical characteristics of cloud models are still determined by practical experience again and again. And the accuracy of the result is decided by the establishment of the factor evaluation standard model, which is expressed by natural linguistic words.

Our future work will study this problem and the qualitative and quantitative methods are mixed used in the process of assessment. And the study of 'soft-and' operator in uncertainty reasoning is also our main work in the future.

Acknowledgements

The authors gratefully thank the Ministry of Transport of the People's Republic of China and Liaoning Maritime Safety Administration. Specially thanks to all the seafarers who participated in the survey.

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