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Application of CREAM Algorithm in Navigation

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Abstract: The method for reliability analysis of the second generation of person's representative methods cognitive reliability and error analysis method (CREAM) were summarized, the developing course of CREAM method was introduced in detail, the main feature of CREAM method are summarized in the working principle and working characteristics, and the working process of the CREAM method was introduced in detail, the present situation of the application of CERAM method are analyzed and the future development of the CREAM methods is discussed.

Keywords: Human factor reliability analysis, CREAM, status analysis, Bayesian algorithm.

1. Introduction

Statistics from a variety of industries show that human error in nuclear power plants causes system failure events of about 50-70%, offshore oil drilling accidents caused by human error accounted for 70%, pilot misjudgment caused commercial airline crashes accounted for at least 50%.... Therefore, it is very important to conduct human factor reliability analysis (HRA) correctly in systematic probabilistic risk assessment (PSA). [1]

Human factor reliability analysis originated in 1950s, and three generations of human factor reliability analysis methods have been developed up to now:

The first-generation HRA method focuses on human behavior theory and error classification, and develops statistical analysis and prediction methods of human error probability based on operator experience and expert judgment. [2]

The second generation HRA method further studies the internal course of human behavior [3],focusing on the mechanism and probability of human error occurring in the whole behavioral process from human observation, diagnosis, decision-making and other cognitive activities to the execution of actions in a specific situation environment. Eric Hollnagel proposed the CREAM method in 1998, The Cognitive Reliability and Error Analysis Method is a representative Method in the second generation of human factor Reliability Analysis [4].

The third generation reliability analysis method emerged after the 1990s, The most representative and widely used method is IDAC (Information, Decision, Action in Crew Context) proposed by Chang and Mosleh et al from University of Maryland [5].in 1994. IDCA stands for "information-decision-behavior" response model, which is used to evaluate the ability of decision makers, operators and consultants to safely handle an event in a nuclear power plant control room. Its dynamic characteristics are mainly reflected in considering the dynamic interaction between system operators and the outside world (such as the system itself, the environment and other team members) [6], and such dynamic characteristics are integrated into the cognitive model IDAC, rather than analyzing a specific static scene like the second-generation HRA. [7]

Based on the research and summary of CREAM method, this paper introduces the basic concepts and core ideas of CREAM in detail, summarizes the application status of CREAM method, and prospects and analysis of the development of CREAM method.

2. Characteristics of CREAM Method

CREAM method is based on the situational dependent cognitive model (COCOM) [8] [9], which calculates the probability of human error in the corresponding scene by studying the relationship between situational environment and human behavior. The model divides human behavior into four categories according to cognitive functions, namely observation, explanation, planning and execution. In the environmental background, people's behavior is purpose-oriented and carried out according to the expected plan. During the process, it is adjusted according to the environmental background [10].

It has two main characteristics :(1) it emphasizes the important influence of situational environment on human behavior, summarizes environmental factors as co-performance condition (CPC), and gives the influence effect of CPC level on human reliability; (2) It proposes a unique cognitive model and framework with bi-directional analysis functions of traceability and prediction, that is, it can not only trace back the root cause of human error events, but also predict the probability of human error.

3. Analysis Steps of CREAM Method

CREAM classifies cognitive functions into four categories: observation, explanation, planning and execution. Each category has several failure modes [11] [12].

Extension method to predict the basic idea is to further analysis are in the process of completing the task of cognitive activities and possible cognitive function failure, first get cognitive function failure probability of the basic values, followed by the CPC scene environment factor levels to modify the basic values, when the person is to complete the task to predict the probability of failure may occur [13].

4. CREAM Application Development Status

CREAM, as the most important analysis method of human factor reliability analysis at present, is widely used in various fields and has a more mature development in each field, which is mainly reflected in the following aspects of

application scope and algorithm improvement:

4.1. Traditional Accident Analysis Field

CREAM as heavy research in a specific environment, in the observation, diagnosis, decision making and other cognitive activities to perform an action of the entire process of behavior, occur because of failure mechanism and the method of probability, especially widely used in the field of traditional, include aerospace, transportation, construction, nuclear power, coal and other traditional areas, And in its corresponding fields have a good performance, the typical performance is: in the construction industry for the quantitative analysis of human accidents, through the construction process to determine the factors, the use of basic law accident analysis; In the navigation field, CREAM method was used to analyze and predict the human factor reliability of pilots, triangular fuzzy number was used to improve the decision experiment and evaluation experiment method, and the weight of CPC factor was obtained. The fuzzy comprehensive evaluation theory is introduced into the EVALUATION of CPC factor performance effect, which reduces the influence of subjective factors of expert judgment on evaluation results [14]. By constructing the functional relationship between situational environment index and human factor error probability, accurate prediction of human factor reliability was achieved, and a comparison was made at the end, and the prediction result of CREAM was far higher than the traditional analysis method. In the field of aviation and aviation special algorithm to select the main factors affecting the aircraft positioning error communication navigation surveillance (CNS) performance, high altitude wind, human factors, in which the CNS performance and high altitude air performance were analyzed by random differential equation, human factors were studied by CREAM and IDAC combined comprehensive analysis [16] [17]. The corresponding collision risk model is established to evaluate the safety of aircraft flight safety spacing: the probability of driving error is calculated by the extended method of cognitive reliability and error analysis method in the prediction of intersection, and the external and internal factors affecting driving error are considered comprehensively. Establish signal intersection driving event sequence and identify the cognitive activities involved in each event; The common performance factors CPCs and the influence coefficients of each level factors on cognitive activities were determined. According to the CPCs level of the intersection, the influence coefficient of the corresponding level and the possible driving failure mode are determined, and the basic value of driving error probability is calculated and corrected to obtain the corrected value. According to the relationship between driving events, the driving error probability of the whole driving task is calculated and the final conclusion is drawn[18].

In the application of these fields, it is not difficult to find that most of the ideas of papers are carried out in accordance with the overall research ideas of CREAM. Firstly, basic law or extension method is determined, then CPC factor is determined, and the level of CPC factor and the influence coefficient of each level factor on cognitive activities are determined according to the environment and other factors. The influence coefficient and possible failure mode of the corresponding level are obtained, the basic value of error probability is calculated and corrected, and finally the idea of error probability interval is analyzed and calculated. Because the impact on the environment can be considered, it has a very in-depth application in various traditional fields and has a good analysis effect.

4.2. Human-computer Interaction Field

The human factor reliability analysis of human-machine interface mainly adopts some traditional human factor reliability analysis (HRA) methods, and the reliability analysis work and the optimization work of human-machine interface are not effectively combined. As for the human factor reliability analysis of human-machine interface, the existing methods have their own advantages and disadvantages, and some methods are more complicated to operate, and the relationship between the factors that affect the performance of the operator is not considered comprehensively. Therefore, using the CREAM method for analysis has become a good method to solve the above problems [19].

Human-computer interaction is mainly reflected in two aspects, one is digital human-computer interface, the other is uav interaction.

4.2.1. Digital MAN-machine Interface

The digital man-machine interface of nuclear power plant is illustrated as an example. For the digital interface of nuclear power plant, there are a lot of deficiencies in the traditional human factor reliability analysis, so the Bayesian CREAM method is adopted to analyze the accident. The evaluation and analysis steps are as follows:

(1) Situational environmental assessment. According to the description of the given operation control scenario and the evaluation rules of CPC performance factors, the CPC performance factors were scored, with the score range from 0 to 100.

(2) Fuzzy CPC score value. The triangular membership function of CPC factor fuzzy set was obtained by fuzzifying the score of CPC performance factor.

(3) Determine the membership degree according to the fuzzy function. According to the triangular function of each CPC performance factor, the membership value corresponding to the CPC factor level was obtained.

(4) Establish if-THEN rule library. After fuzzy CPC, multiple IF-THEN rules can be obtained by combining them according to membership values. If the CPC in the rule needs to be adjusted, it is adjusted according to the CPC performance factor adjustment rule.

(5) Calculate the confidence. According to the CPC weight factors and the principle of evidential reasoning, combined with the quantitative calculation method of confidence given in the design, the confidence degree in each rule was calculated.

(6) Construct Bayesian network to calculate the node probability of control mode. The bayesian network between CPC output factor and four control modes was constructed, the confidence degree in if-then rules was transformed into conditional probability in Bayesian inference, the membership degree in fuzzy function was transformed into node probability in each parent node, and the node probability of control mode was calculated according to The Bayesian model.

(7) Calculate the probability of human error. According to the human error probability calculation formula, the human error probability in a given scene is calculated.

The CREAM method of human factor reliability analysis and its improvement method are introduced into the field of

human-machine interface in the main control room of nuclear power plant

The detailed evaluation rules, which fully consider the weight relationship between each CPC factor, can be used to calculate the probability of human error, so as to identify the weakness and human engineering defects that are prone to human error in the human-machine interface. Compared with the traditional method has a great degree of improvement.

4.2.2. Application of UAV

CREAM, as the most popular cognitive reliability and error analysis method, has been applied in a variety of aspects. The most representative application field is the field of uav. CPC includes nine aspects: remote planning, operator, task, man-machine function allocation, working environment, operating time, situational awareness, organizational factors, and team collaboration.

The application of this model in the field of UAV was improved on the basis of traditional CREAM, that is, the weight difference of each CPC was taken into account on the basis of the original CPC, and the weight coefficient was introduced. HEP (failure probability) and continuous interval function of control mode were constructed, which made the CREAM more perfect and accurate. At last, human factor reliability was predicted [20].

4.3. Accident Tracing

The core idea of CREAM method is to emphasize the causal relationship between accident occurrence and human error. The basic idea of CREAM retrospective analysis is to start with the failure mode, select the corresponding failure mode, analyze and look for possible antecedents, and then continue to analyze and look for possible antecedents as the consequences, keep pushing forward, and finally find the root cause.

In the existing papers, most of the methods in CREAM are used to reverse trace accidents, so as to achieve the purpose of accident analysis. We take CREAM's application in coal mine accident analysis as an example to prove it.

For coal mine safety accidents in because of the complexity of the fault, randomness, fuzziness, using the CREAM principle to people by error model as a starting point back to coal mine accidents in by mistake before, to trace out the structure of the human factors because of the failure cause of the reason for the index system, establish fuzzy complementary matrix, and carries on the comprehensive evaluation index weight are obtained. After the event traceability table is established, the relevant sequence is weighted to establish the index table. The importance of each index is compared in pairs to determine the size, and then the average value is taken, and the fuzzy complementary matrix R is constructed. When the weight vector is used to figure out the cause of the accident, it is found that the violation of rules and regulations, lack of training and psychological quality are also the important root causes of the accident, among which the weight of the violation index ranks the third. It can be seen that the main cause of the accident is the failure of the leader of the production unit, so it can be seen that the failure of the personnel in charge of decision-making and command has the greatest harm to the safety of coal mine production [21].

4.4. Algorithm Improvement

Although the traditional CREAM method has been able to calculate the probability of human error in the scene, it mainly has the following shortcomings for evaluating the reliability of some specific human factors:

(1) The applicability of each CPC factor to the whole model is not strong enough, lacking detailed evaluation guidance.

(2) The differentiation degree of different evaluation levels of CPC is too small. Each CPC only has 3 to 4 levels of evaluation, and only one or the other situation can exist, so the differentiation degree is not enough.

(3) The weight of each CPC is not taken into account. Each CPC is considered to be equally important and should have different weights for different control room operation scenarios.

In view of the above problems, the existing papers have improved the algorithm, mainly focusing on the combination of other algorithms, the improvement of the existing algorithm, and the improvement of the basic law and extension method. In the article of aircraft collision risk assessment under free flight based on CREAM and IDAC comprehensive analysis method, CREAM and IDAC are combined to improve the function and overall structure of CREAM because of the needs in the aviation field. In CREAM model, fuzzy set and evidence inference based on CREAM are introduced, and bayesian algorithm is introduced to improve the determination of CPC factor. Most of the models are improved by adding Bayes algorithm to CPC algorithm. This is reflected in the human error of air management, because the characteristic of Bayesian algorithm is that it is a classification algorithm based on probabilistic and statistical knowledge. In many cases, naive Bayes classification algorithm can be comparable with decision tree and neural network classification algorithm, which can be applied to large database with simple method, high classification accuracy and fast speed. The Bayesian algorithm not only complements the feature of not being meticulous enough in classification, but also complements the problem that the algorithm does not involve weight. It is well reflected in the analysis of human error in air management. Firstly, a traditional CREAM model is established, and the quantitative relationship between COCOM (situational control mode) and PSF (behavior formation factor) given in CREAM Basic Law is used as the theoretical basis for constructing Bayesian network. The network was constructed with 9 PSFS as root nodes and the situational control mode as leaf nodes. The figure below is constructed by software, and the evaluation data of controllers on different PSF levels in various tasks are taken as the prior probability parameters of network root nodes. According to the formula, the probability distribution of scenario control mode for each general task.

The results show that the formation factor is given by the same judge behavior effect under the premise of the CREAM expansion prediction method and construct a bayesian network method to predict the most tasks people error probability in the form of different, from the view of the objectivity and rationality and applicability of methods analysis, bayesian networks in the study of the problem.

5. Conclusion

Through the review of the papers, it can be found that CREAM is widely used in various fields, involving various projects involving aviation, navigation, nuclear energy and so on. And can accurately assess, but with the increase of the amount of data, may be the CREAM of traditional impact factor is not accurate assessment of some projects, so for the improvement of the algorithm, focuses on the increase in the

number of impact factors, including the introduction of the bayesian algorithm, IDEC algorithm, etc., still can be in the future direction of further research, Combined with big data, it conforms to the development trend, makes the development of CPC factor more detailed and specific, and makes the human factor reliability analysis more comprehensive and accurate.

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