механизмом обратной связи, необходимой при переходе к цифровой трансформации и импортозамещению.

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Method of individual properties soft computing on the example of the civil aviation flight crew safety management

Abstract: Theory and methods of the characteristics of specialists remain uncertain. Statistical data and expertise may be piecewise defined, inaccurate and inconsistent. To calculate the dependability of flight crews based on workload and experience, it is necessary to establish indicators and values of acceptable accuracy, using fuzzy measures. It is proposed soft computing, statistical and expert methods for calculating the properties of a person and social groups in the management of dangerous professions. This makes it possible to calculate the dependability of the pilot properties with an assessment of flight safety risk levels for making management decisions. The results of the work are new standards for the workload of flight crews recommended for civil aviation.

Keywords: Soft Computing, Aviation, Accidents, Safety, Pilot, Crews, Workload

Introduction

Annual unpredictable aviation accidents (AA) have a huge international resonance, occur for decades and are a threatening reality of flight safety of the world civil aviation (CA) [1]. The commercial pressure of competition forces airlines to reduce the cost of purchasing, leasing, and maintenance of aircraft. The air carrier saves on professional training of personnel, on an arbitrary increase in the workload standards, on the use of flight crews with minimal and untenable experience in conditions of chronic fatigue. This paper explores the problem of existent standards of assessing human resource evaluation and regulatory approach for aviation safety management. The proposed method makes it possible to perform statistical analysis, expert assessments and calculations of the rationing of the work of flight specialists. The author presents his own approach to the theory of soft computing (SC) and mathematical definitions. Application of this approach makes it possible to analyze the existing statistics and obtain new quantitative data of dependability AA of CA pilot professional experience properties [2]. The result of the work is an example of development new standards recommended for CA flight crews.

Problem

Until now, the knowledge, theory and methods that could take into account the differences in the characteristics of any specialists remain uncertain, which leads to the use of untenable standards of professional training and labor rationing [3]. International regulatory standards constitute problematic content in security and safety terminology. To calculate the dependability of flight crews based on workload and experience, it is necessary to establish indicators and values of acceptable accuracy, using fuzzy measures. Probabilistic measures indicate relatively accurate and differentiated data. Thus, the relevance of the topic of this study is the lack of theory and methods for calculating the properties of objects for the purposes of effective, safe regulation and cockpit resource management (CRM) [4].

Soft computing method

The concept of SC was introduced by the founder of fuzzy set theory Lutfi A. Zadeh, 1994 [5]. In the understanding, SC is also revealed in the following directions: pseudo-physical logic, pseudo-quantitative calculus, and plausible reasoning. SC allows to define values by shifting the set object property towards strong scales. In the future, a new approach and interpretation of SC in fuzzy transitions of object states, calculations in combination with heatmaps, and examples of practical developments are presented.

The author does not know the formal definitions of SC in the scientific literature. To output the definitions of SC, let's accept the following justification for the observed (measured, estimated) boundaries values of object properties. Let the segment [a, b] contain subsets of the observed values of the value X belonging to the set R, figure 1.

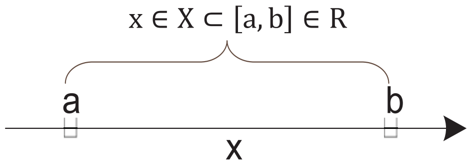

Figure 1 – SC definitions output

Enter the following conditions for calculating object values.

Condition A. The values of the observed quantities belong to any of the subsets, including the values a and b (A):

$$x \in [a, b] \text{ или } a \leq x \leq b. \qquad \{A\}$$

Def-1. Setting the values of the observed quantities in accordance with the condition {A} is called the method of hard estimation (evaluation) (HE).

The method HE calculates the exact (point) values of the values $x \in X$ of the two (both) boundaries of the segment [a, b] belonging to the set R.

Condition B. The values of the observed quantities at point [a] do not belong to any of the subsets (B):

$$x \in [a, b) = [a, b] \backslash \{b\} \text{ или } a < x \leq b. \qquad \{B\}$$

Condition C. The values of the observed quantities at point [b] do not belong to any of the subsets (C):

$$x \in (a, b] = [a, b] \backslash \{a\} \text{ или } a \leq x < b. \qquad \{C\}$$

Def-2. Setting the values of the observed quantities in accordance with the conditions {B and C} is called the soft measurement (SM).

The method SM sets the calculation of exact (point) values of values $x \in X$ for only one (any) of the boundaries of the segment [a, b] belonging to the set R.

Condition D. The values of the observed quantities in the region [a, b] do not belong to any of the subsets (D):

$$x \in (a, b) = [a, b] \backslash \{a, b\} \text{ или } a < x < b. \qquad \{D\}$$

Def-3. Setting the values of the observed quantities in accordance with the condition {D} is called the soft estimation (evaluation) method (SE).

The method SE calculates the exact (point) values of the values $x \in X$ of none of the boundaries of the segment [a, b] belonging to the set R.

Thus, let us do SC general formal definition output.

Def-4. Soft computing is a set of methods: hard estimation (HE), soft measurement (SM), soft estimation (SE) in metric and non-metric scales with the ability to simultaneously process quantitative numerical and qualitative linguistic data.

The presented interpretation of SC can be considered as the notion of the power of a finite universal set Ω, where fuzzy (soft) measures (1):

$$\Omega : \{\mu\_SM, \mu\_HE, \mu\_SE\} \qquad (1)$$

are indicators of data inaccuracy.

The powers of these measures are minimal for single-point sets. The most accurate values of the objects are measures μ_SM, less accurate μ_HE, and the greatest inaccuracy measures have μ_SE, in the limiting case $\mu\_SE \triangleq \Omega$.

The largest part of the values of the properties and states of organizations, social groups, and people is determined by the SC methods, which are used in conjunction with the heatmap model, the "traffic light model". The completed and presented theoretical work is a prerequisite for experimental and applied developments carried out by the author of this work.

Task statement

Further applied calculation work is aimed at establishing fuzzy intervals of pilot experience indicators that correspond to the rules of calculation by definition SC. Expert assessments performed in the work form the basis of the normative values of the experience of flight specialists which are the basis for flight standards. Enter the following symbols and numeric values for experience properties of an individual: [μ_SM] soft measurements have square brackets, (μ_HE] hard estimates can have a square bracket on one side, a round bracket on the other, (μ_SE) soft estimates have parentheses. Let's explain SC options in management decisions examples levels (table 1).

Table 1 – Example of management task

Pilot experience, flight ours values levels	Risk levels probability P: AA per million flight per year (heatmap, traffic lights)	SC options	Management decisions example
{1} big	P = AA 10^{-7} (green)	(μ_HE]	free, strong
{2} middle	P = AA 10^{-6} (yellow)	(μ_SE)	free, free
{3} small	P = AA 10^{-5} (red)	[μ_SM]	strong, strong

{1} Free decisions making are applying about increasing pilot flight ours values. Strong decisions concerns to control pilot age over 60 years.

{2} Free decisions space.

{3} Strong decisions about first admission to work of a pilot. Strong decisions about transition of the co-pilot to the position of the captain.

Thus, decisions depend of scientifically founded pilot experience values.

Expert assessments

The method of expert assessments includes: preliminary selection of experts, organized assessment procedures, development of a matrix of SC values, data processing, analysis and output of indicator values.

Expert assessments were carried out by the author over a long period in 1994-2014. The main criterion for selecting experts was professional work experience. The examination involved 42 professional pilots with extensive flight experience. Among the experts were both active pilots and those who retired from their flying careers. Characteristics of the experts' indicators: age: 34-75 years; flight experience: 16-47 years; total flight time: 8000-26000 hours: flight hours pilot in command (PIC): about half of the total flight time; number of mastered aircraft: 4-12 types; geography of experience: international. Expert assessments were carried out through questionnaires, surveys and final discussions of the results. These values are derived in organized procedures with the participation of professional pilots with extensive flight experience. The task includes the output of the values of the number of flight hours and the number of flights in the periods: monthly, annually, as well as the subsequent averaging of these values in three months and in half a year. The results are the final development of the CA standardization. The values of the pilot's operational dependability indicators are set:

[minimum (nominal) maximum]:
flight hours: monthly [20 (50] 80], annually [150 (400] 800];
number of flights: monthly [5 (10] 20], annually [30 (75] 200].

The novelty of the results is to establish the accounting of indicators for time periods: flight task (day), month, 90 days, six months, year. This structure and the established values of indicators allow for continuous monitoring and rationing of operational dependability of flight resources to ensure flight safety.

Conclusion

Some fragments and a detailed description of the developed theory, method, experiments and expert assessments is presented in the paper [7]. It should be noted that in the work performed, the most important are the new theoretical results of calculating the experience of professional pilots, corresponding to the established levels of accident risks. However, the work also confirms practical evidence of the implementation of the results in a large multi-year project with the participation of the author in 2011-2014 at Volga-Dnepr Airlines (Russian Federation) [7].

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Безопасное диспетчерское управление в условиях использования интеллектуальных беспилотных систем управления движением городского внеуличного транспорта

Аннотация: Рассмотрены принципы построения Интеллектуальной системы управления движением городским внеуличным рельсовым транспортом, приведены функции уровней иерархии системы, описаны задачи, решаемые в различных ситуациях функционирования линий внеуличного транспорта.