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IMPROVING THE EFFICIENCY OF DEVELOPMENT PROCESS OF AUTOMATED HELICOPTER FLYING

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***Abstract*—*It is considered the efficiency improving of the automated process control of helicopter flying simulator training by means of the knowledge base of computer control system of helicopter flying mastering.*

Index Terms—Training; simulator; efficiency; helicopter flying mastering

I. INTRODUCTION

Today it is clear that simulator training is the effective approach for the pilot's quality. But this way demands the search of new methods of effectiveness increase. First of all it is information-cybernetic approach use, supposing the computer model of training the aim of this article is to improve the efficiency of helicopter flying (HF) simulator training by means of the knowledge base (KB) of computer control system of HF mastering [1]–[7].

II. PROBLEM STATEMENT

The problem of training effectiveness increase is enough complicated and supposes the solution of following tasks:

– analysis of human impact on the effectiveness of human-machine systems, methods of HF computer mastering and the implementing tools to identify the main disadvantages of HF mastering and ways to overcome them;

– development of algorithms for the acquisition and updating of knowledge in the specific knowledge base of helicopter flying;

– methods development of computer formation of educational training operation, providing high capacity of special KB of HF;

– formation of generalized structural model of computer-aided control system of helicopter flying (CACS HF);

– effectiveness evaluation of helicopter simulator mastering using CACS HF.

III. ANALYSIS OF HUMAN-MACHINE SYSTEMS

The existed man-machine systems in their structure represents themselves hierarchical structures in which each subsystem and each of its elements perform certain functions that can only be corrected by a higher subsystem (Fig. 1).

The analysis of subsystems use in the overall structure of human-machine systems has permitted executive and management subsystem, which are the central and most complex in the system, by that, and thus to determine the boundaries of the structure part of human-machine systems, which should be explored.

The most long-lasting and important stage of the life cycle of man-machine system is the use of it by purpose (Fig. 2).

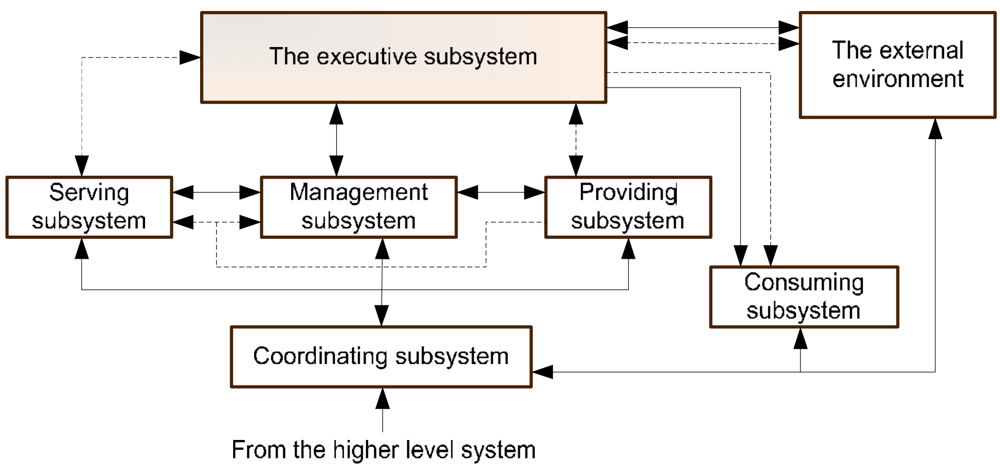

Fig. 1. The general structure of man-machine system

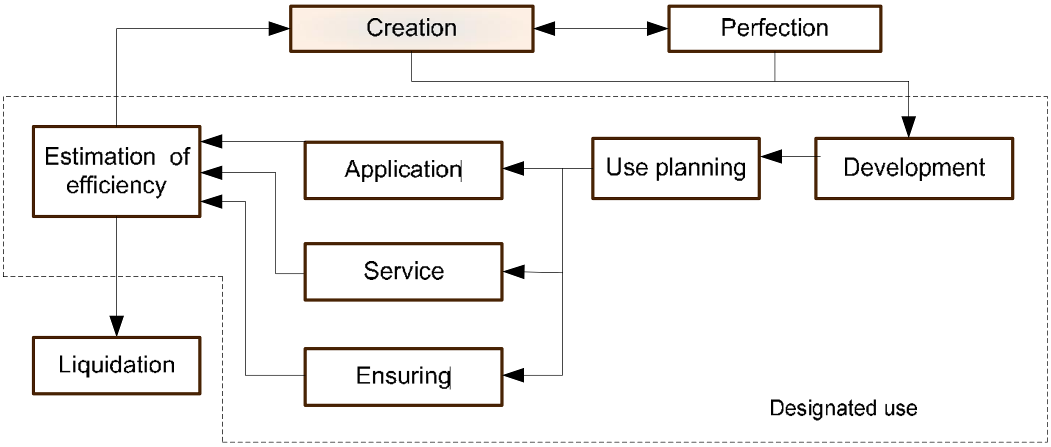

Fig. 2. Life cycle stages of human-machine systems

IV. Phases of the human-machine systems application

To apply the man-machine systems by purpose without human participation is impossible, at the same time the efficiency of human-machine systems is directly related of the level of human exploration of these systems.

Figure 3 shows the disadvantages analysis results of currently used technical means of training (TMT) for HF mastering.

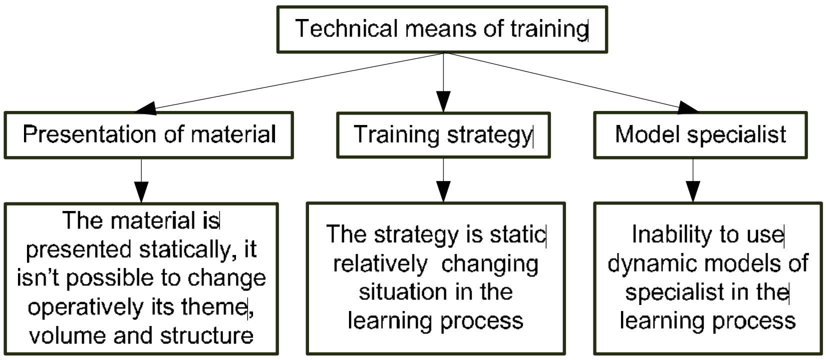

Fig. 3. Disadvantages of currently used technical means of training for HF mastering

Carried out researches allowed to justify the conclusion that the creation of computer systems of HF mastering based on special base of knowledge of the subject area will allow to overcome the main disadvantages of existing TMT and provide the realization of HF mastering taking into account the most important factors affecting the development of one skill, speed of skill development, level of previous skills development, when current skill is based on previous, degree of degradation or "forgetting" previous skills, when next skill has to be developed.

Computer-aided control system of helicopter flying training (CACS HFT) should be able to work effectively with the knowledge of the subject area. As the knowledge base occupies a central place in CACS HFT, then for its creation it necessary to solve important problems: to determine the algorithms of knowledge base forming and the methodic of its use during the process of computer HF mastering.

Then the structure of the research can be represented the following finite sequence

$$\langle M_k, A_{\text{acq}}, A_{\text{ak}}, M_{\text{lir}} \rangle,$$

where M_k is a model of knowledge representation in a special knowledge base CACS HF; A_{acq} is algorithm for acquiring knowledge; A_{ak} is an algorithm accumulating of knowledge; M_{lir} is a logical inference rules structuring model.

IV. Development of algorithms for the acquisition and accumulation of knowledge in the knowledge base CACS HF

Based on the results of domain it is made a general conclusion that for the formalization of the KB of CACS HF it is necessary to represent knowledge mainly in the form of frames networks. The feature of frames network in KB is relationship heterogeneity in the network [8].

To implement such a model KB it is applied the heterogeneous semantic networks, in which the vertices represent a set of ordered pairs of the "frame-the ratio" and the edges – communications between frames having different labels having different algebraic characteristics, different semantics and consequently various interpretation procedures.

The acquisition of knowledge is called an approach in which a mediator between the source of knowledge and KB is a computer system. This approach is implemented in the system using model of knowledge in the form of non-uniform semantic network. The developed algorithm of this process is shown in Fig. 4. In this algorithm Q is the number of elements in a set of properties of X_i; N is set of natural numbers.

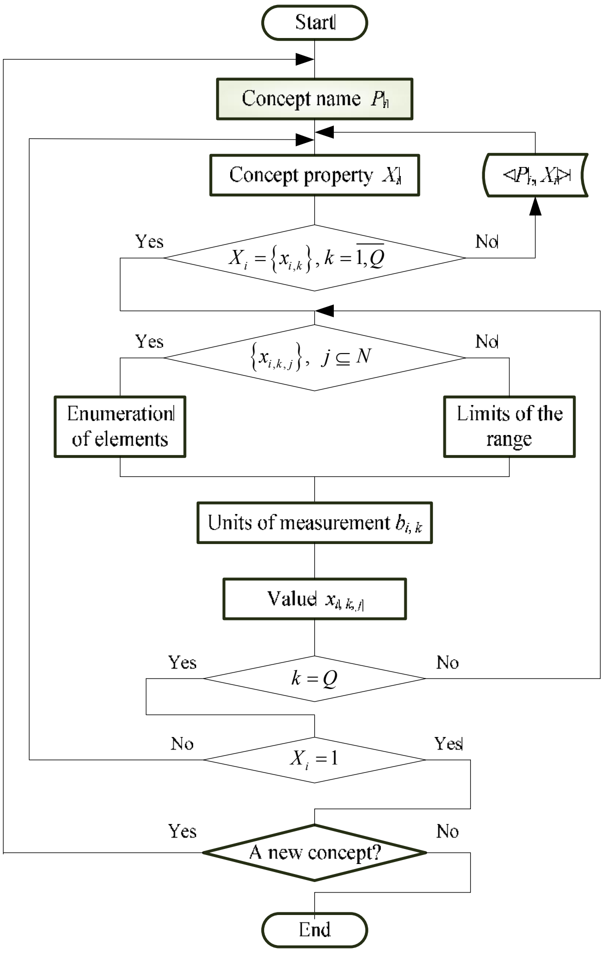

Fig. 4. The algorithm of knowledge acquisition in the KB CACS HFT

As a result of such interaction the KB is filled with concepts and their features in accordance with the subject area. After such filling it is made the identifying of semantic relationships between concepts (Fig. 5).

The links identification from references tree is based on the analysis of reflexive, symmetric, and transitive relations. Types of links and their properties are shown in Table 1. In the table the properties are marked: Rf – reflexivity, Nrf – nonreflexivity, Arf – antireflexivity, Sm – symmetry, Ns – nonsymmetry, Ans – antisymmetry, As – asymmetry (connection inversion gives other link) Tr – transitivity, Ntr – nontransitivity.

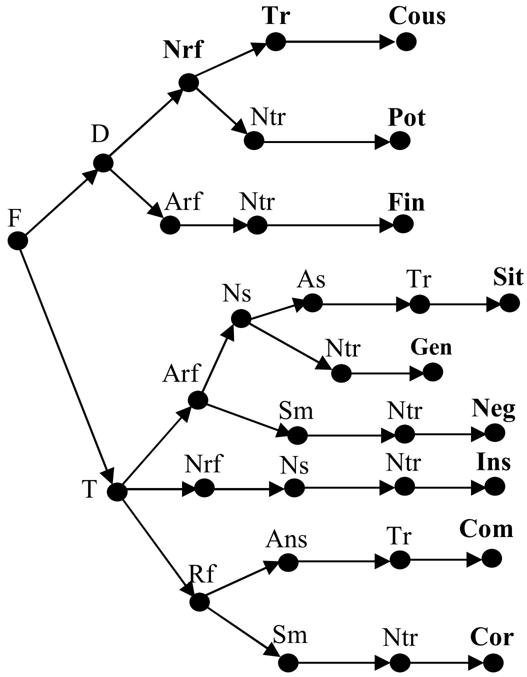

Fig. 5. Inferences tree of relations types

After the initial filling of KB in the operation of the system it is made its accumulation. Currently, the main method of increasing knowledge is a direct dialogue with the expert.

In the developed algorithm knowledge of accumulation (Fig. 6) T is a set of basic elements; S is a set of KB syntactic rules; S_p is a set of syntactic rules of P concept, and $S_p \subset S$.

New knowledge represents itself properly the concept as well as syntax rules and subject area of application defined by the truth table of its universally valid formula. In addition, the accumulation of knowledge is carried out by the system based on the existing rules of inference of new knowledge.

It is developed the procedure of inference rules structuring in the KB of CACS HFT, the use of which gives the possibility of knowledge accumulation organization in KB without the participation of an expert. The aim of structuring of relations and rules of inference (decision rules) should be considered as the construction of the morphological space containing the structured statements and rules of inference of the form

$$M = < F_{ri}, H^f >,$$

where F_{ri} is the set of all possible combinations of rules of inference; $H^f = < H_1^f,\ H_2^f,\ ...,\ H_5^f >$ are set of relations defined on the set F_{ri}.

TABLE 1

TYPES OF CONNECTIONS AND THEIR PROPERTIES

Number grade	Type of connection (*X*, *Y*)	The canonical form	Property
1	Gen – generative Sit – situational Neg – negative	*X* is an element of *Y* *X* is in the situation *Y* *X* denies *Y*	Arf, Ns, Ntr Arf, As, Tr Arf, Sm, Ntr
2	Ins – instrumental	*X* is a means of *Y*	Nrf, Ns, Ntr
3	Com – commutative Cor – correlative	*X* accompanied *Y* *X* sometimes increases the possibility of *Y*	Rf, Ans, Tr Rf, Sm, Ntr
4	Fin – finitary Cous – causal Pot – potential	*X* s the aim of *Y* *X* causes *Y* *X* may cause *Y*	Arf, Ns, Ntr Nrf, Ns, Tr Nrf, Ns, Ntr

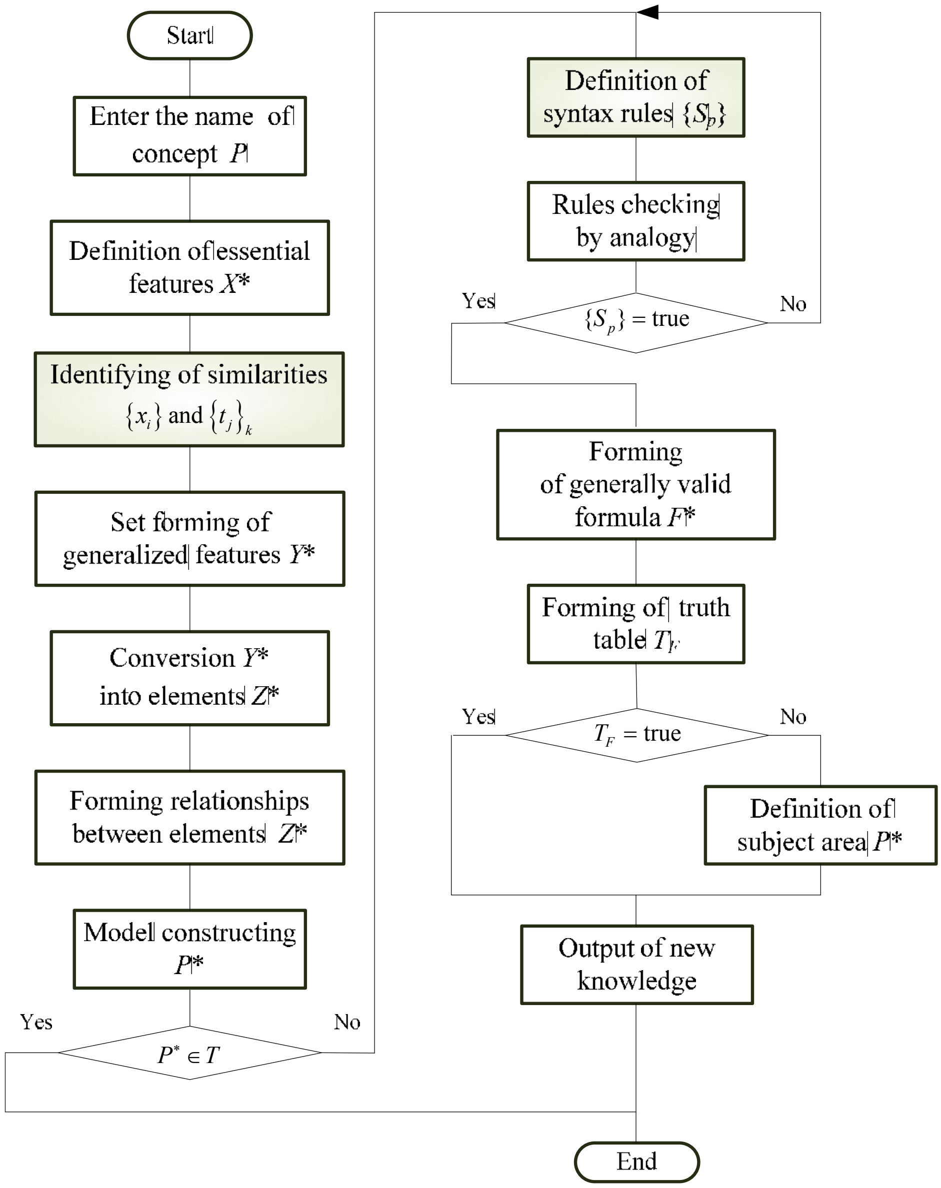

Fig. 6. Algorithm knowledge accumulation in the KB of CACS HFT

A set of relations $H_1^f - H_5^f$ consistently identifies on the set of existing rules of making decision a set of rules $\{f_i\}$ r_i, which is necessary to select the desired solution r_i. The obtained results give the possibility to conclude that the proposed procedure of relations and making decision rules structuring ensures the formation of a set of models of phased ordering of choice rules for each decision r_i.

Analysis of the literature showed that the presence of computer forming function of a training operation (TO) significantly extend the possibilities of CACS HFT by computer pilots HF mastering. The main reason for the limited use of computer forming TO functions is the lack of developed management tools of special KB, ensuring the implementation of the of computer forming TO functions without interference expert, or requiring his participation in a minimum volume.

Forming of TO is realized on base of their models. At a level that is invariant to the subject area and type of helicopter, the TO model M_t is a finite sequence:

$$M_t = < A, D, C, M_s, M_{su}, V, V_u, M_{as}, O_v, O_a >, \quad (1)$$

where A is the goal (that is required of the student, what activities you must perform); D is initial data; C are limitations that should be considered at the execution of TO; M_s is model of the situation (depending on the destination and type of CACS HFT, this component may correspond to the models of studied helicopter, professional work environment, etc.); M_{su} is an information model that describes the method of M_s representation and also the means of operation by it within the system; V are the results (answers); V_u is the description of the input method of result; M_{as} is reference model activity; O_v is evaluation result function; O_a is activity evaluation function.

The components A, D and C correspond to the problem statement to the TO perform. In the model of situation we distinguish three components:

$$M_s = (S(M_s), V(M_s), I(M_s)), \quad (2)$$

where $S(M_s)$ is M_s structure; $V(M_s)$ are M_s values; $I(M_s)$ is M_s interpretation.

Under the forming of TO describe by M_t model it is understood the formation of model variant gen (M_t) by values determining of its variable components. Many variants of gen (M_t), which may be formed, name by the closure of M^{c}_t operation model and the number of elements in it (m) is M_t capacity:

$$M_t = \{\text{gen}^{(1)}(M_t), \text{gen}^{(2)}(M_t), ..., \text{gen}^{(m)}(M_t)\}.$$

The capacity is one of the key characteristics of M_t. Another important characteristic is its degree of diversity, reflecting the extent to which formed TO options differ from each other. The types of formed TO are allocated based on the ratio of fixed and variable components in their models. The valid combinations corresponding to the types generated TO are listed in Table 2. Plus represents a variable value, minus – fixed.

Thus, for the formation of specific TO it is necessary to fill the model (1), (2) by the content of the subject area, to determine the types formed TO and then make a selection the most rational variant of TO.

TABLE 2

PERMITTED COMBINATIONS OF TRAINING OPERATIONS

Type formed TO	$S(M_s)$	$V(M_s)$	$I(M_s)$	A	C	M_{as}	V
1	+	+	+	+	+	+	+
2	–	+	+	+	+	+	+
3	–	+	–	+	+	+	+
4	–	+	–	+	–	+	+
5	–	+	–	–	+	+	+
6	–	+	–	–	–	+	+
7	–	–	+	+	+	+	+
8	–	–	–	+	+	+	+
9	–	–	–	+	–	+	+
10	–	–	–	–	+	+	+
11	–	–	–	–	–	+	+
12	–	–	–	–	–	+	–
13	–	–	–	–	–	–	+

Analysis of research results shows that in the learning materials stored in the special KB can be used variety formal presentations. Sophisticated KB contain formal representations expressed on artificial languages. Since such presentations of educational material have formal character, it is possible to describe the formal rules of their construction and processing. These rules are implemented as in algorithms of TO formation, and in the procedures for entering and evaluating of their results.

CONCLUSIONS

Carried out researches allowed to justify the conclusion that the creation of computer systems of HF mastering based on special base of knowledge of the subject area.

Based on the results of domain it is made a general conclusion that for the formalization of the KB of CACS HF it is necessary to represent knowledge mainly in the form of frames networks.

It is shown that new knowledge represents itself properly the concept as well as syntax rules and subject area of application defined by the truth table of its universally valid formula.

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В. М. Синєглазов, Ю. М. Шмельов. Підвищення ефективності управління процесом автоматизованого засвоєння гелікоптероводіння

Розглянуто підвищення ефективності управління процесом автоматизованого засвоєння гелікоптероводіння шляхом розробки алгоритмічного забезпечення спеціальної бази знань автоматизованої системи управління засвоєнням гелікоптера.

Ключові слова: навчання; тренажер; ефективність; засвоєння гелікоптероводіння.

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В. М. Синеглазов, Ю. Н. Шмелев. Повышение эффективности управления процессом автоматизированного освоения вертолетовождения

Рассмотрено повышение эффективности управления процессом автоматизированного освоения вертолетовождения путем разработки алгоритмического обеспечения специальной базы знаний автоматизированной системы управления освоением вертолета.

Ключевые слова: обучение; тренажер; эффективность; освоение вертолетовождения.

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