

Intelligence Control Systems: Contemporary Problems in Theory and Implementation

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Abstract:

Problems of synthesis of modern control systems – intelligence systems were researched. The original concept of the synthesis of intelligence systems by the dynamic objects is presented which is based on the functional systems theory by Anokhin P.K.

Method of the synthesis of control systems using the intelligence components was developed. The various practical applications of the intelligence systems theory to the intelligence aircraft control systems were researched.

Introduction

The control systems development of the long-term dynamic objects for the aircrafts requires studying the new technologies of their construction, new concepts creating, modernization of the existing software, developing the new hardware components, implementation of the new information technologies.

Modern compound control systems of the dynamic objects were researched including consulting advising systems, dynamic expert systems and variously intelligence control systems. At present time the most attention is given to the researching of the intelligence control systems (IS) based on the functional systems theory of the Anokhin P.K. Practical applications of the intelligence systems have a great range [2,4,5,6,7].

Based on the detail examination of the ICS principle and the modern abilities of various realizations of dynamic objects control systems is developed a conceptual approach of the synthesis of the modern control systems. Based on the concept of the intelligence systems was developed the approach of the intellectual controls systems which used as an intelligence component such a functional system as an action acceptor. In the action acceptor of the ICS is used the self-organization algorithm for modeling the prognoses. The realization of the synthesis approach of the ICS is shown by example developing of the long-termed aircraft control systems.

In the article are presented the control systems structures which have a great practical implementation and can be used for the synthesis of various control systems, control complexes of different dynamic objects.

1. Analysis of the research and development state in the modern aircraft control systems

In the 80-s the interest in the artificial intelligence (AI) development has rapidly increased. Methods of AI are begun to use in theory and practice to control different dynamic objects. And

at the first line, to control variously aircrafts. Separate blocks, algorithms and systems which are included in the ICS often called as intelligent components of the control systems. At the present time, the most popular are following components: neural networks, evolutionary algorithms, systems based on knowledge.

Evolutionary algorithms and neural networks possess a high parallelization and consequently have a higher speed which is really important in control systems acting in the real time. These algorithms are widely used as separate parts of the algorithmic software and for creation of the long-termed multi-tired and multicriterion control system with AI an ICS elements.

At the present state of the AI development exists an opinion that the more corresponding components of control systems for high intelligence functions are intellectual components based on knowledge. These components are put into the basic prototype of the modern AI systems. The information processing is made with the help of logical tools. That helps to receive some preferences in the acceptable solutions set in order to find the most successful control. As the main mechanism of intellectualization in such systems is used the reasoning mechanism.

The most interesting are systems based on knowledge which use object-logic languages, frame-based logics and logic programming. These systems have a great popularity nowadays.

But the most popular practical application have now dynamic expert systems (DES) that could be reasonably called as prototypes of modern intelligence control [2].

Interpenetration of the control theory and AI methods turns to the appearance of the new direction which is called intelligence control. Intelligence control includes such parts as neural control, control based on knowledge, particularly control based on rules and logical models.

The most common determination of the intelligence control is: intellectual control system should have the possibility to perceive information about processes, disturbances and working conditions, make conclusions and learn. There are different types of architecture of the intelligence systems exist. We consider several types of intelligence control systems structure which are used in technical systems to control dynamic objects.

In the real time the most widespread intelligence systems are those which are based on fuzzy logic and other rules. Usually such systems are used to control various technological processes.

The main tasks while creating intelligence control system with fuzzy logic are: comparison of the object states descriptions with the truth product rules and determination of the strategy or algorithm of using these rules.

Intelligent control based on the method of the logical output is rarely used for the synthesis of the dynamic objects control systems. Methods of logical output are used for the theory proofs automation, for building consequences, generating hypothesis and etc.

The global problem of the development of the ICS in the present stage is the problem of increasing the level of the intellect in control systems.

With the increasing complexity of the systems which is estimated by the information size we should try to use, create and develop the most intelligence systems and control components. In [2] 4 classes of systems are selected sorted by the increasing intelligence:

- 1) systems of the identification control;
- 2) systems of the adoptable control (systems with self regulation);

- 3) systems of the intelligence control without goal settings;
- 4) systems of the intelligence control with goal settings.

The appearance of the goal setting function considerably distinguish intelligence control systems from intelligence systems without goal setting.

2. Intelligence Aircraft Systems

Modern aircrafts in the present time use consultative IS.

On-board operational advising expert systems (OOAES) are referred to consultative systems which operate in the real on-board environment and focus on real possible changes of the external conditions in order to increase the efficiency of the battle aircraft. OOAES in the upper and middle levels should tend to creation in the on-board algorithms operational procedures of the logical output and hypothesis generating. That correspond human's view about the reasoning correctness and the possibility of their realization in the current on-board information environment.

In the synthesis conception of the IS the modern compound control system is developed as a functional system with an adaptive effect. The distinctive mark of any outcome that contributes to the goal achievement is that he is based on the self regulation method and possesses the same node mechanisms. Namely, afferent goal synthesis, decision making for acting, efferent action program, action acceptor, reverse afferentation of result parameters and the comparison of obtained parameters with those which are predicted by action acceptor.

The universal architecture and perfected by evolution mechanisms of functional systems are the main advantages of the Anochin's theory of the functional systems for the IS.

The control law in the IS is represented not as fixed transformation of the incoming dates to the outcoming but as a some subsystem which makes decisions based on the incoming parameters and control signals based on saved in this subsystem knowledge.

Functional diagram of the intelligence system

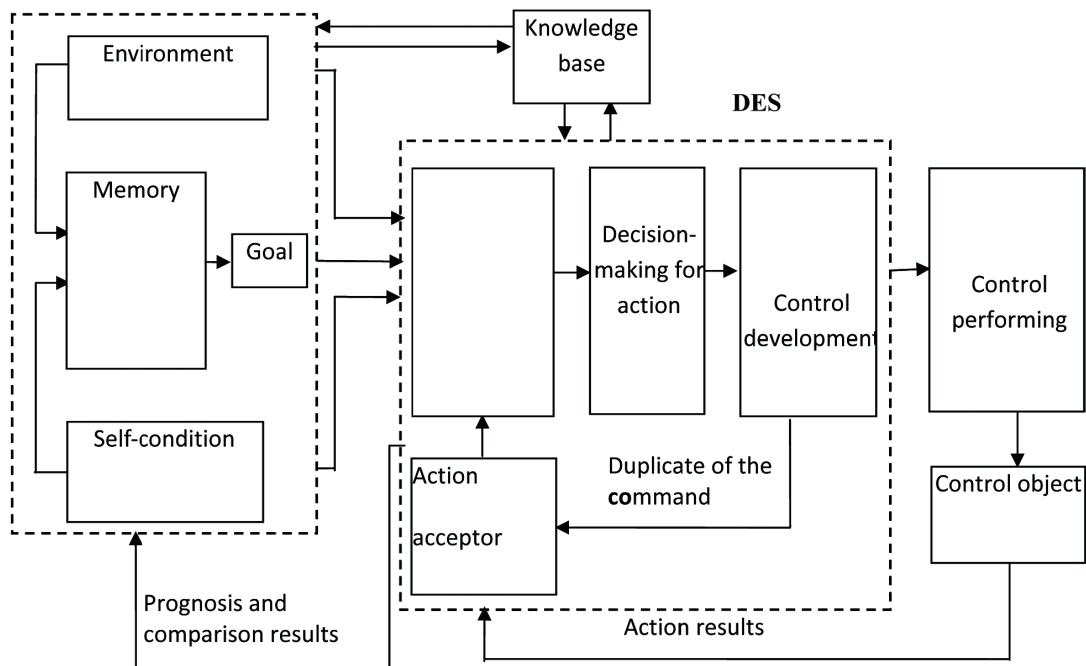
Intelligent systems are corresponded as complex functional systems consisting of the set of the more simple systems.

IS structure is presented on the fig.1.

The formation of the system goals is implemented in the synthesis block and is based on the memory, motivation and information about the environment and the object state. Than the goal enters dynamic expert systems (DES) and decision making system. The control law is made basing on this information.

The control results impact the object and then enter the action acceptor. The information about the correspondence of the action result and prognoses comes to dynamic expert systems and the goal synthesis block.

Fig. 1. Structure of the intelligence system

Block of the goal synthesis

In case of the results disparity new control action or new goal is chosen. If the action results are conformed to prognoses, that means that the goal is chosen right and control realized effectively.

The functioning reason of the IS is usually based on the permanent increasing of database and motivation mechanism. In practical application simple functional diagram is implemented as an ensemble of selection criterion and goal selection rules.

Usually the motion trajectory of the aircraft is realized by suggested functional structure of the IS adjusting the maximized self-preservation.

Thus the functional diagram is used for synthesis of the IS of the aircraft.

3. The ways of the development of the intelligence systems.

Synthesis of the modern intelligence systems is realized in different conceptions [2, 3, 4, 5, 6].

In the intelligence systems that possess compound multi-leveled architecture appear more and more possibilities for realizing the synergism effect. That increase the efficiency by using correlation and mutual intensification of the various kinds of activity, else responding effect in the control loop.

The next step in modernization and development process of the connections between functional systems is appearing and improvement of the mutualism. Symbiosis of subsystems should be mutual beneficial. Optimization of such functional systems interactions is a complex task.

Usually the following tasks are solved by the multicriterion optimization. The state parameters of the whole IS and of each subsystem and also the parameters that characterize the efficiency of the connections between these systems are optimized. The maximization of the positive interaction between all the subsystems of IS provides the establishment of mutual state.

It is desirable to consider the progress irregularity of the separate functional subsystems while the process of modernization of the intelligence systems is started. The evolution of intelligence systems is going in accordance to the principle of the minimum security of the function. Any functioning results of the intelligence system is achieved by the minimum of the funds, the minimum quantity of the subsystems is used whose complexity is corresponding the solving task. The increasing complexity of intelligence subsystems or the unification of their major part is occurred only for the reasons of the solving task.

The phenomenon of the minimum security of the function could be watched on an example of any motion act of the higher vertebrates.

The increasing complexity of the architecture and separate intelligence systems should correspond the real situation: the external functional conditions and tasks that must be solved in the course of the operation.

The development of intelligence systems is accompanied by the increasing amount of knowledge. The rising complexity of intelligence systems is proportional to the knowledge extension and this could mismatch the real tasks which system solved while the operation process.

For example, the knowledge amount is being increased at the expense of new incoming measurements while the real task remains invariable. In that case there is no need to complicate the subsystems, we can confine ourselves to existing level of the intelligence systems development: using the united subsystems and connections between them.

The choice of the universal starting device that determines the moment when the complexity of the intelligence system starts to increase is still the urgent problem.

Afferent synthesis is also realized by the principle of minimum security of the function. Formation of the functional systems that make up the loop of the inverse afferentation in the concerned intelligence systems occurs in the narrow afferentation conditions.

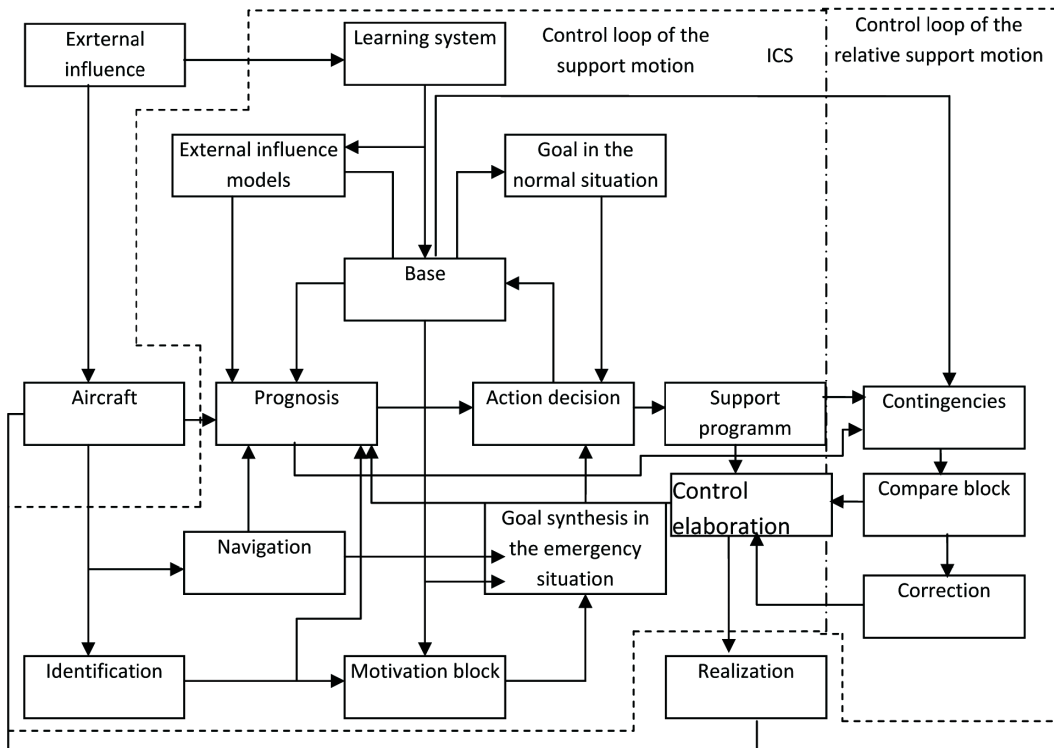
Functional system which is formed in the narrow afferentation conditions could not ensure the delicate suitability of the system to external conditions. That is why the afferent synthesis process problem of the IS is being paramount at the present stage.

Nowadays in the most of the practical applications of control systems the functioning reason is given a priori. Such systems are called Intelligence Control Systems (ICS) or the systems with the intellectual components. Considerable advantage of such systems is the ability of implementation on the serial computing aids base.

While the aircraft development as a basic control loop could be used the double-circuit scheme of the ICS with control loops of the reference motion of the center of gravity and relative to the reference trajectory.

The structure of functional groups for the basic algorithm of the considering intelligence control system is shown on the figure 2.

Fig.2. The structure of the intelligence control system with double-circuit control algorithm of the aircraft.



During the normal flight of the aircraft the functioning goal of the dynamic object is not being corrected in the network of the presented ICS. At the same time during the emergency situation could appear a need in changing the functioning goal which could require devices in the ICS that perform the functions of the motivation and goal synthesis blocks.

Methodology of the synthesis of the ICS for the advanced aircrafts provides for the mutual coordination of the decisions of the separate methodology problems and technical and economical valuation of the alternative variants of the ICS with further increasing of the performance characteristics.

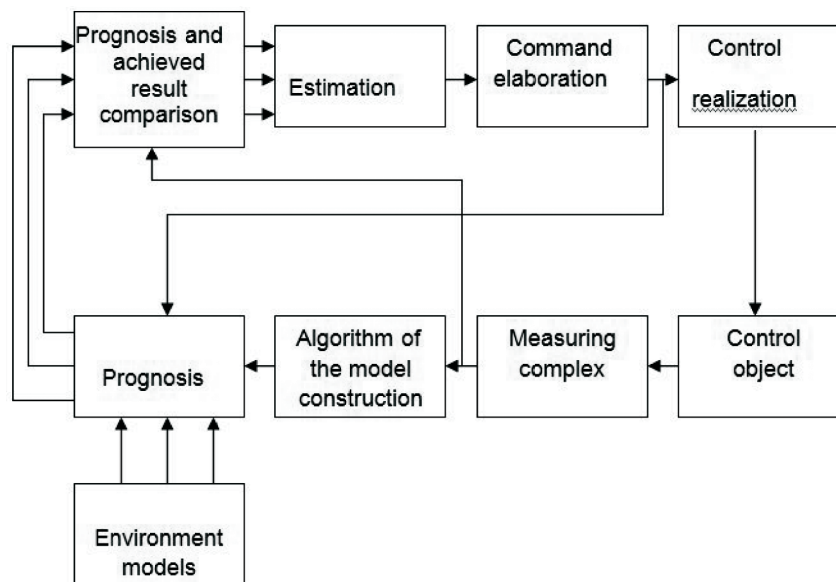
Control results and copies of commands are used for prognostication of the action results. Prognosis can be performed with the help of models which are appropriate to receive by the variety of methods, for example: with the help of neural networks, self-organization, etc. The ICS for the aircraft based on the presented scheme allows choosing in forehead the right scenario and confirming its correctness. In case of the false choice of control complex for the aircraft as soon as the first declination from the scheduled scenario appears the information about it from the comparison block is received by the block of the action decisions and then the elaboration of the new command complex is made.

For the development of the more lasting functioning scenarios of the aircraft is necessary to consider the inconstancy of the environment which could add essential changes during the huge time domains to the evolution of the aircrafts.

The models of the environment changes could be made empiric [7] or based on the known physical principles that influence the environment's state.

After the environment models of the aircraft functioning are made appears a possibility to develop control scenarios for longer periods of time. Functional scheme of the aircraft ICS with an account if variable models of environment changing is shown on the fig. 3.

Fig. 3. Functional scheme of the ICS with the accordance of the environment models.



In the shown on the fig.3 ICS the prognostication of the aircraft state into the prognosis block is made corrected for the various environment models. Some alternative prognoses are being compared with the real aircraft state and estimated according to the chosen criterion. The reason is to expose the most optimal state and consequently the best control strategy.

Using such ICS structures we should take into the account some peculiarities. For example, you should always have a satisfactory model. The model should be being rebuilt or you have to correct the existing model in case of the changing of the environment.

Thereby the ICS are examined which are now one of the most promising type of the aircraft control systems realized in the modern airborne computers.

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