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COMPUTER SIMULATION OF MODERN AIRCRAFTS BY USING NETWORK TECHNOLOGIES OF REMOTE CONTROL

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Abstract. *The problem of a computer simulation of modern aircraft and the use of new models and remote aircraft control (through the networks) to improve safety, especially in difficult circumstances and in conflict situations is considered in the paper.*

Keywords: aircraft; computer modeling; remote control; safety; Web.

1. Introduction

Comprehensive implementation of virtual technology development and support is a prerequisite for performing a variety of important tasks such as maintenance of complex scientific and engineering calculations, updating production, reduce risks, improve the reliability of products.

The development and the use of aircraft are directly related to modeling in those areas where information systems are complex. In addition, the simulation is a major step in system analysis. So, of course, there are modern information technologies that provide automation of this process.

Computer simulation is the method of solving problems of analysis and synthesis of complex systems based on the use of its computer model.

The essence of computer simulation is to find qualitative and quantitative results using an existing model. Qualitative conclusions that are based on the analysis, enable to find previously unknown properties of a complex system: its structure and dynamics of development, stability, integrity and so on. Quantitative findings are predictive of future or past explaining variables that characterize the system.

A computer model of a complex system as far as possible should reflect all the main factors and interactions that characterize real situations, criteria and constraints. The model should be versatile enough where the purpose of similar objects is possible to describe, yet simple enough to make it possible to perform the necessary research at minimal cost.

Thus, the use of computer simulation is very important aspect of science, and especially in the aerospace industry.

Using this simulation there is a practical need for a network technology for remote processes. However, the use of these technologies faces many challenges, the resolution of which is necessary to ensure an appropriate level of research and results.

The main task of our research is the combination of professional 3D-modeling of aircraft (AC) with remote control networking technology model that transmits data over long distances, with great precision, small errors and compensation for delays.

2. Simulation

In modern 3D-modeling there is a use of many standardized software from different manufacturers that provides not only a graphical realism, but also fairly accurate reproduction of the physical and mathematical parameters of the aircraft, for example: MATLAB and Simulink for Technical Computing, 3D Studio Max, Autodesk Maya, ZBrush, AutoCAD, programming language C++, JavaScript and many other graphics and animation programs and programming languages.

Currently using the above listed programs, we have created a new, more quality, accurate and predictive 3D-model of the modern aircraft (Fig. 1) based on all of its geometrical and physical data, which later have to provide a number of priorities:

– compilation and optimization of virtual models of aircraft by using parameterized models of the engine, mechanical, chassis, steering, ready-functional units of hydraulic, electrical and electronic components of construction;

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– perform virtual testing of the aircraft, its components and assemblies by using virtual models of aircraft, runway, parameterized models and test benches modes planting, processing and systematization of the results of virtual testing;

– analysis of static and dynamic aeroelasticity at subsonic and supersonic flight conditions, balancing the aircraft in the stream, determining aerodynamic loads on the airframe, aerodynamic influence coefficients of determination, determination of dynamic loads during landing impact, run and run on uneven aerodrome flight in the atmosphere and outraged reactions to gust, integrated design optimization based on constraints aeroelasticity;

– calculation of stability and controllability, maneuverability of the aircraft, the design of handling equipment, folding mechanisms cabins and gangways fuselage, locks and hinges, modeling bailout and landing;

– design and assessment of the durability of aircraft gas turbine engines for civil and military aircraft;

– development of new control systems and flight mode.

Fig. 1. 3D-model of the modern aircraft

However, it should be noted that this is only a short list of the tasks that should be done by a modern 3D-model aircraft. Planned program of keyed kinematic and dynamic formulas aerodynamics of the aircraft that will fully program and simulate its flight (even with all atmospheric conditions):

$$m\frac{d\Delta V}{dt} = (P^V - X^V)\Delta V - (P^\alpha - X^\beta)\Delta\alpha - G\cos\Theta - X;$$

$$m\frac{d\Delta\Theta}{dt} = (P^V\alpha + Y^V)\Delta V + (P + Y^\alpha)\Delta\alpha + G\sin\Theta + Y - Z;$$

$$-mV\cos\Theta\frac{d\Delta\Psi}{dt} = (P + Z^\beta)\Delta\beta + (P^\alpha + Y)\Delta\gamma_a + Y + Z.$$

However, it should be noted that the specific main task that stands before us now is not normal flight simulation aircraft and its flight simulations under difficult circumstances, conflicts, threats to the collision at take-off and landing phases. That is, those flight conditions when the danger is at its highest level and taking into account the human factor may be a threat of disaster.

It is planned to use 3D-models for working towards upgrading of existing systems to prevent collisions in the air and on the ground and to develop new landing systems (Fig. 2) [Bogachuk, Melnikov 1993].

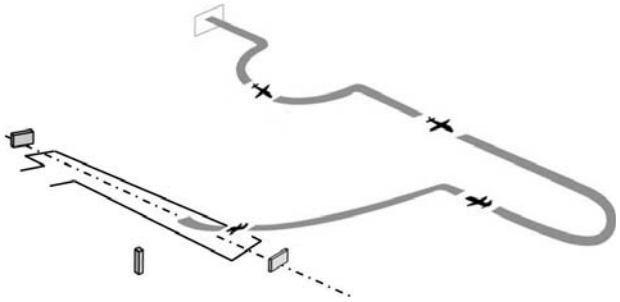

Fig. 2. Landing simulation on MLS technologies

The particular relevance is the question of solving conflict situations during landing and landing at airports with a high traffic air transport, in addition, the fact that the current system (eg, TSAS) does not solve the problem and does not meet modern safety requirements was given.

The aspect of the design and development of new planting that can increase the efficiency of operations is quite important.

Thus there is a fundamental problem to consider the dynamic properties of the model in a distributed environment.

The properties of the model significantly affect the quality of the settlement process and its use in continuous flight control aircraft. It manifests itself as an important systemic functional deficiency in the multidimensional delay of multi-control aircraft. Delay creates the model complexity driven process to evaluate which is useful as E. Sage and J. Mels [1976]:

$$N \geq n + n^*(n-1)/2,$$

where n – the dimension of the controlled process.

The growth of complexity of the mathematical model of the system leads to a polynomial growth of complexity control, which in turn leads to the so-called effect of “curse of dimensionality”,

uncontrollable delays, and consequently to poor coordination of control and even to the collapse of the whole system. Polynomial complexity of processes is calculated as follows:

$$(x_1+x_2+\ldots+x_k)^n=$$

$$=\sum_{n_1+n_2+\ldots+n_k=n}\frac{n!}{n_1!n_2!\ldots n_k!}x_1^{n_1}\ x_2^{n_2}\ldots x_k^{n_k}$$

Solving the problem of a quality of 3D-modeling of modern aircraft the aerodynamic characteristics are fundamentally important aspect, as they allow high-level model to develop methods and means of increasing safety in difficult and dangerous conditions.

3. Network technologies of remote control

Due to the modern development of communications networks, transmission systems and satellite communications it is necessary to use these technologies and systems in aircraft to ensure high safety, to improve data accuracy and ultra-fast backups and accurate data channels.

Given the complexity of the creation of such technologies theoretically corrects their initial test in the computer hardware, 3D-models of aircraft and the establishment of local networks for data transmission [Savinov 1987].

In this regard there is a problem of creating a remote control aircraft of any class from the ground through the control point. The use of such technologies will change the motion of an emergency aircraft to ensure safety in the following situations:

- terrorist threats and emergencies on board;
- severe weather flight conditions, the occurrence of catastrophic natural events;
- threat of collision with the ground;
- threat of collision with other aircraft;
- takeoff or approach in difficult circumstances;
- flight control during emergency situations;
- factor overlays including human factors, etc.

Based on current research local and extended local area networks to create a remote control of 3D-model of a modern aircraft will be built. Given the complexity and diversity of today's networks it should be noted that it is possible to use both internal LANs and external network (Fig. 3). The structure of the internal and external networks will be quite difficult to have a lot of relationships between elements. Their combination will provide a real opportunity to use network central systems that will identify errors delays in different systems, so choose appropriate algorithms for their compensation.

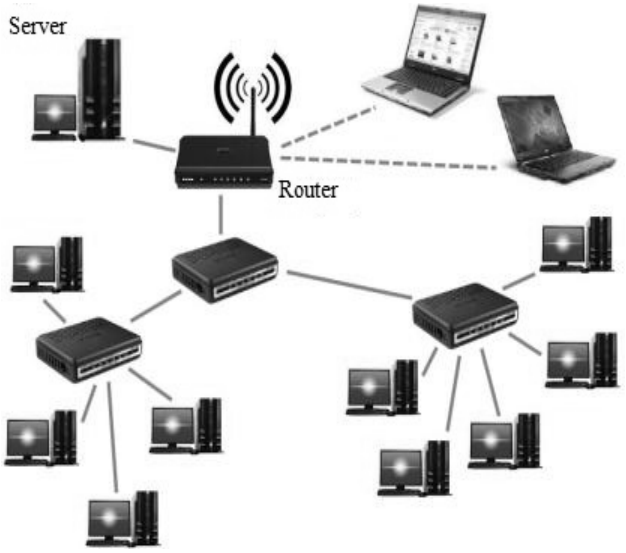

Fig. 3. Network structure

Based on these studies it is provided the definitions of thresholds delays in data transfer and inventing ways to reduce these delays by creating feedback, analyzing the possibility of introducing these technologies into the existing system of civil and military aviation.

At this time we have developed programs to determine network delays and compensation. It was possible to create a line of feedback that provides information about the delay and the number of packets lost (Fig. 4).

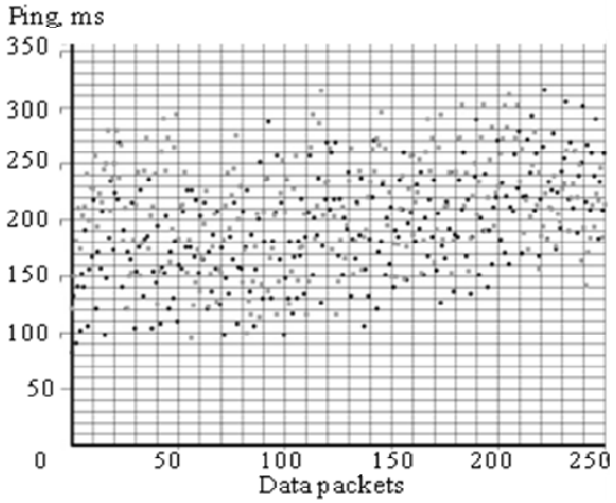

Fig. 4. Figure of network delays and packet loss

The received schedule delays also in the transmission of information via the image is divided into 3 levels of data packets (the lower curve shows the delays to aircraft tolerances data packets) (Fig. 5). The delay in the transfer of data is an average of about 200 ms and packet loss data of about 20% was found.

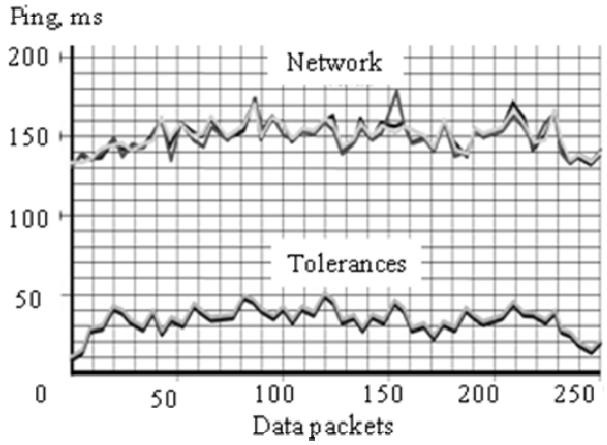

Fig. 5. Figure delays of the integral image transfer is divided into three packets

When creating local and extended local network to control a computer model of the aircraft technical base provides for the use of CNS/ATM [Pavlova et al. 2011]. Depending on the requirements to the control process it is planned to form flying control and correction streams with different temporal intensity [Melnikov 2012; Protopopov 1972].

The functional goal of the research is to provide a systematic and functionally-time compatibility aircraft as control object, with the ground (and others) integrated information and control systems.

4. Conclusions

We have managed to develop a computer model of a modern aircraft based on several factors, using a remote control model. It is based on the investigations failed to reduce errors and delays in data transmission in the network. Feedback system that will transfer control from one operator to another was developed. The research and the development of new economic landing systems and systems of conflict resolution are already begun. Particular attention is paid to such regimes as flight approach and landing.

Using 3D-modeling in modern aviation research is quite important aspect. The creation of a new modern model aircraft will be able to fully reproduce the dynamics and physics of flight of the aircraft, its behavior in complex emergency conditions and for the effects of terrain and atmosphere will be a major breakthrough in the field of aeronautics research.

The development of new or improvement of existing landing systems and collision warning with the land and conflict resolution in the air will quantitatively and qualitatively improve safety.

The author's actual ways in different areas of practical application of modern information management systems were considered. Further development of the proposed methods will enable more clearly consider the various components of the model aircraft and control processes, its parameters and characteristics of the environment etc.

Modern development of communication networks and network technologies data provides the opportunity to expand the range of problems to be solved technologies remote dynamic objects. Creating technologies that will conduct research on a modern integrated 3D-model aircraft which takes into account the dynamic characteristics and environmental variables, using remote control via network – that is the opportunity to make a "step forward" in the development of modern technologies in aviation science.

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В.В. Павлов[1], О.Є. Волков[2], Д.О. Волошенюк[3]. Комп'ютерне моделювання сучасних повітряних суден із використанням мережевих технологій віддаленого керування
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Досліджено актуальні питання комп'ютерного моделювання сучасних повітряних суден з використанням мережевих технологій віддаленого управління. Запропоновано використовувати комп'ютерну 3D-модель сучасного літака, що враховує багато фізично параметрів, для розробки нових систем віддаленого управління та підвищення безпеки польотів. Створено реально діючу модель літака, яка заснована на фізичних параметрах літака і його аеродинаміці. Розроблено систему віддаленого мережевого управління цією моделлю. Показано, що застосування таких технологій дозволяє проводити дослідження в галузі авіації. Зазначено, що, використовуючи дану модель повітряного судна і систему управління, виникає можливість вирішення питань щодо усунення конфліктних ситуацій у повітрі, особливо, під час зльоту і посадки. Передбачено розробку нових систем посадки літака на підставі технологій MLS (Microwave Landing System) для забезпечення найбільш економічного та екологічного режимів польоту. Розглянуто технології поліпшення мережевих зв'язків для зменшення тимчасових затримок і втрати цифрових пакетів.
Ключові слова: безпека польотів; віддалене управління; комп'ютерне моделювання; літальний апарат; мережі.

В.В. Павлов[1], А.Е. Волков[2], Д.А. Волошенюк[3]. Компьютерное моделирование современных воздушных судов с использованием сетевых технологий отдалённого управления
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Исследованы актуальные вопросы компьютерного моделирования современных воздушных судов с применением сетевых технологий отдалённого управления. Предложено использовать компьютерную 3D-модель современного самолёта, учитывающую многие физически параметры, для разработки новых систем отдалённого управления и повышения безопасности полётов. Создана реально действующая модель самолёта, которая основана на физических параметрах воздушного судна и его аэродинамике. Разработана система отдалённого сетевого управления этой моделью. Показано, что применение таких технологий позволяет проводить исследования в области авиации. Отмечено, что при использовании данной модели воздушного судна и системы управления возникает возможность решения вопросов по устранению конфликтных ситуаций в воздухе, особенно, во время взлёта и посадки. Предусмотрена разработка новых систем посадки самолёта на основании технологий MLS (Microwave Landing System) для обеспечения наиболее экономичного и экологического режимов полёта. Рассмотрены технологии улучшения сетевых связей для уменьшения временных задержек и потери цифровых пакетов.
Ключевые слова: безопасность полетов; компьютерное моделирование; летательный аппарат; сети; удаленное управление.

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