Virtual Concept of a Symbiotic Environment for CBL and CBT Methods Based Education in Aircraft System

Virtualan koncept simbiotičkog okruženja CBL i CBT metoda obrazovanja u sustavu zrakoplovstva

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Summary

The contribution is informing the reader on the current potentials of improving efficiency in aviation education based on the use of available means of simulation and computer-assisted methods of teaching such as the Computer Based Training a Computer Based Learning, which also enable realization of integrated systems assisted by modern educational methods and potentials for them to be implemented into the aircrew training systems. The authors are introducing a virtual concept of a symbiotic environment for education in aircraft systems. The concept makes use the mutual interrelation of three-dimensional dynamic models of aircraft instruments developed, which can be used for electronic training using simulation interface based on open standards in a virtual environment within a country and later with real onboard complex featuring the Instruments themselves. Attention is drawn to both the advantages and disadvantages of using such dynamic models of aircraft Instruments in aircrew training as well as the practical implementation of such a virtual concept into practice employing computer assisted progressive methods of teaching. The need of improving the quality of education in aviation is a reaction to the requirements coming from actual practice calling for the implementation of intelligent systems into the complex and dynamic systems of aircraft. At the present time, it is the very reason that requires shifting towards learning new ways and acquiring skills in applying progressive technologies to education exercising direct influence on the safety of air transportation.

KEY WORDS

Computer Based Training
Computer Based Learning
symbiotic education
3D model of instruments
symbiotic education model

Sažetak

Članak obavještava čitatelja o tekućim potencijalima poboljšanja djelotvornosti obrazovanja u zrakoplovstvu, temeljenom na korištenju dostupnih sredstava simulacije i metoda potpomognutih računalom kao što su Obuka temeljena na računalu i Učenje temeljeno na računalu, koje također omogućuje ostvarenje integriranih sustava potpomognutima modernima edukativnim metodama i potencijalima koji se trebaju implementirati u obrazovanje posade zrakoplova. Autori uvode virtualan koncept simbiotičkog okruženja za obrazovanje u zrakoplovnim sustavima. Koncept rabi uzajamnu interrelaciju trodimenzionalnih dinamičkih modela zrakoplovnih instrumenata, koja se može upotrijebiti za elektroničko obrazovanje koristeći sučelje temeljeno na otvorenim standardima u virtualnom okruženju unutar zemlje i kasnije sa stvarnim zrakoplovnim kompleksom koji označava same instrumente. Pažnja se usmjerava i na prednosti i nedostatke korištenja takvih dinamičkih modela zrakoplovnih instrumenata kod obuke posada zrakoplova, kao i kod implementacije takvog virtualnog koncepta prakse koja koristi računalno potpomognute progresivne metode poučavanja. Potreba poboljšanja kakvoće obrazovanja u zrakoplovstvu je reakcija na zahtjeve koji proizlaze iz stvarne prakse, koja zahtijeva implementaciju inteligentnih sustava u kompleksne i dinamičke sustave zrakoplova. U sadašnjem trenutku, to je pravi razlog koji zahtijeva pomicanje prema učenju novih načina i stjecanju vještina u primjeni progresivnih tehnologija u obrazovanju, koja se izravno odražava na sigurnost zračnog transporta.

KLJUČNE RIJEČI

obrazovanje temeljeno na računalu
učenje temeljeno na računalu
simbiotičko obrazovanje
3D model instrumenata
model simbiotičnog obrazovanja

1. INTRODUCTION

High level of current technology enables us to integrate modern simulation technology into the educational process in aviation, at which the absence of direct contact with real systems for students taking part in the educational process can to a certain extent be replaced by way of a simulated interface. The complex methodology of education, at which one of the real, technical, technological or physical conditions is replaced by simulation, in terms of sensing, is more efficient than providing information by standard ways of projection. The reason behind is in the memory skills of human beings, where the quantitatively largest portion of retained information are those resulting from understanding the logical relations existing among them.

2. INTEGRATED SYSTEM SUPPORT TO EDUCATION BASED ON CBT AND CBL

Educating complex aviation systems involves a set of principles, methods and tools arranged in a way so as to provide guaranty the required results required of education in terms of making safe use of the aviation equipment and ensuring efficient level of educating students the would be professionals of aviation. In bringing them closer to real processes involving complex technical systems, the packet of the aviation education is to contain, apart from classical methods of teaching, new, progressive ways of education represented by a set of simulation tools and computer assisted methods of education. When choosing among the methods of educating students scheduled to work in complex systems, the basic goal is to develop functional units, which are closest to real life, i.e. applying theoretical knowledge to real processes. All that with the use of information technology, which provides in via computers a synthetic environment, perceived as an artificially developed intelligent environment that enables performing various operational tasks without using real technology. The synthetic environment is by way of employing applications of information- and audio-visual technologies, adding greater momentum to the entire process of education. The process involves IT functioning on the basis of simulation mathematical descriptions of situations. There are lots of advantages that the synthetic environment can offer (e.g. elimination of the problem of dualism in the process of education), all that with amplified economic effect.

Systems used aboard of flying vehicles belong to the group of assistance systems, in which, by concept, each block ensuring the operation of the airborne complex is in feed-back relation with its output presented as control or information systems of the aircraft. The growing level of demandedness of the units and the related theoretical explanation results in the need for integrating and optimizing the processes for the students to be capable of receiving such an amount of information and selecting them by their level of importance. The best way of achieving this level is a process in which the student is able to exactly verify each theoretical phenomenon on a real mode. The diagram of action principle for the process mentioned can be seen in Figure 1. Efficiency of such education is unambiguously based on the use of dynamic models and simulation technologies.

Methods or mediums of education based on information technology termed as Computer Based Training (CBT) and Computer Based Learning (CBL) enable in via modern education technology realization of such integration systems. The represent a professional tool of rapidly achieving the required level of students ‘skills with the full-scale understanding of operation of airborne information systems. Integration of these systems forms the basis of education, which establishes a direct link between the technical condition of the laboratory and the condition of real aviation systems, i.e. the presentational part and the simulation environment making up a new, complex and synthetic educational environment. Such a concept is termed as a symbiotic environment, which enables aircraft technicians to attend technical preparation lead by a lecturer tasked to professionally and instrumentally lead the process of education as a controlled „symbiosis" of students capabilities of learning from intelligent presentations of aircraft features and its airborne information systems. When designing a new CBT built on the basis of a symbiosis, it is important that its contents clearly define tasks and the achieved levels of education in compliance with the EASA with reference to adherence to the theoretical bases stipulated in in PART 147 [1].

Consequently, the basis of the symbiotic aviation integrated system is made up of working environments in which there comes to a simultaneous realization of teaching from each area and level concentrated into units termed as technical modules. By their contents, the modules copy the events and phenomena defined by an exact methodology laid down in an exact thematically plan, so that the student having undergone it could be in position to set up such an aviation system and provide a comprehensive explanation from various aspect s at a level as required. The concept designed is focused on a specific variant of realizing education involving complex systems and real airborne integrated complexes and is concentrated into the existing need defined by the actual practice to improve education and preparation of students, who in practice come into contact with aviation equipment and systems of an air and ground operation. Its conceptual structure consists in setting up units in which the system is defined and technologically realized as a complex made up of a system of special-purpose aviation systems, information technology, audio-visual elements and technical instrumentation [1].

3. SYMBIOTIC EDUCATIONAL ENVIRONMENT OF AN AIRCRAFT SYSTEM

Modern aircraft are equipped with board systems capable of receiving and processing a huge amount of information, which are important for safe flight. Pilot cockpits stand for workplaces that can be characterized as a „symbiosis" of realization of aircrew operations related to learning the behaviour of the aircraft. This mutual relation is enabled by airborne information systems as outputs of between the individual complexes and aircraft systems. The suggested concept of symbiotically method of education enables the student fulfilment of tasks

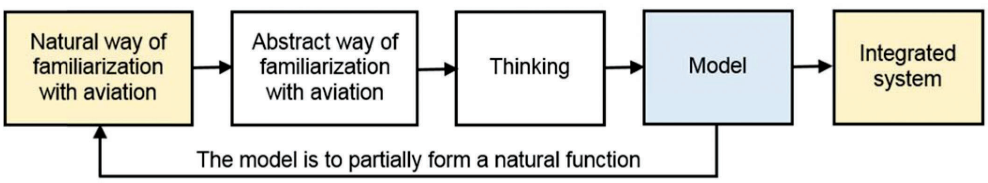

Figure 1 Integrated system of aviation education

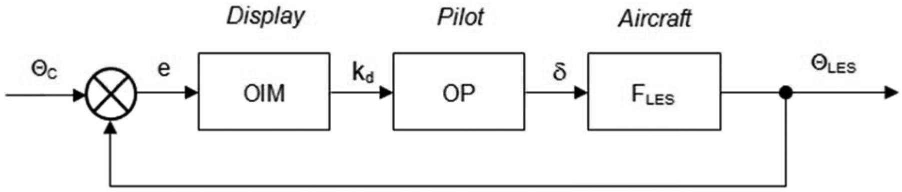

Figure 2 Block diagram of the transfer function of aircraft movement

during flight in a real environment and display output values from a program environment in which the airborne system have been developed and simultaneously measured by other group of students using real devices when performing physical monitoring of events or processes selected at their discretion [5]. Such a symbiosis of an aviation ergatic system as a system controlled by man and technical equipment represents an equality in partnership subjected to the staff´s decision-making capability while cooperating with the technological background formed by board systems serving the purpose of science, research and practice.

May the notion of symbiotic result in improved quality of aircrew skill, pilots or technicians. Let us assume that the visual information display (VID) is solving the problem related to the monitoring of an object. The diagram in Figure 2 represents a model of a general symbiotically structure of a moving airborne system described by a transfer function of the aircraft movement.

Where $\boldsymbol{F_{LS}}$ – object of control, ***OP*** – operator, $\boldsymbol{\Theta_c}$ – required position of the object, $\boldsymbol{\Theta_{LES}}$ – information of the sensor, ***e*** – control deviation/variance developed due to different values Θ_c and actual value Θ_{LS}, $\boldsymbol{k_d}$ – feedback outlet signal of the VID and $\boldsymbol{\delta}$ – output signal of control.

Solving the task of object monitoring is associated with the need of generating control commands of the operator in advance, on the basis of feed-back characteristics of the object monitored. By applying Pontryagin maximum principle for parametrical identification of mathematical aircraft model which is described in [4], we can in real time to predict the parameters to control upcoming aircraft maneuvers. -The potentials of realizing the symbiotic structure of object monitoring (monitoring understood as a comprehensive approach to education related to a complex aircraft system) can be fully realized under laboratory conditions, which unambiguously form the basis of teaching in schools for aviation professionals.

The entire integrated system for aviation education is made up of three parts:

1. Methodology of technical aviation education.
2. Skills of handling and making use of the information systems designed for education.
3. Ways of efficient assessment of the system and its errors when in operation.

This simple model of acquiring information, with the interpretation as presented above, is representing a concrete integrated system [4]. Functional realization of part of the system and its illustrational integration into the presentation part can be applied to any arbitrary system of the airborne complex. Our aim was to focus on such an item within the entire integrated system and ways of all-round realization of introducing the mentioned integrated system. As a follow-up to the work that had already been started [2], we have focused on developing a graphical presentation of the operation of concretely available board instruments as by the instrument panel of AugustaWestland A109K2 helicopter, to be subsequently implemented into the FlightGear simulator with the chosen informational-command elements of indication and the possibility of interconnecting the real instrument with those of the simulation so as to ensure integrity with the education system mentioned.

4. DEVELOPING A 3D MODEL OF THE INSTRUMENTS OF THE AIRBORNE COMPLEX

With the purpose of suggesting a specific variant of communication between the virtual presentation of the board systems and the real board system, as model, let us present the VOR/LOC/GS indicator of navigation Bendix King KI 206 product of the Honeywell. The device is visualizing several indicating elements such as the VOR radio navigation aid and those of the landing system termed as the ILS, superimposed to the LOC indicator (course indicator to display deviation from the present heading of the aircraft) as well as the GS indicator (glide-slope indicator), making it suitable for all-round applicational verifications of the suggested communication variant and also for transparency of visual presentation of the three-dimensional dynamic model. Developing the 3D model of the indicator, the parts of which can be assigned dynamical characteristics enables the student to obtain a comprehensive idea regarding the functionality of the modelled equipment without having it physically available. Logically, this feature can be used backward, namely when demonstrating the principles of operation for the given instruments [6]. Assumptions regarding regressive use of the 3D CAD models leads us to the idea of implementing it into the educational process. By logical sequence, we have developed all fifty-seven parts of the KI206 indicator in the Creo Parametric environment in compliance with the technical documentation, and subsequently came to define the motions of the individual parts of the instrument [7]. Thus, we have developed a three-dimensional dynamic model, which is capable of demonstrating the operation of the modelled indicator both efficiently and in a transparent manner.

Figure 3 The three-dimensional dynamic model of the KI206 indicator developed in Creo Parametric

The three-dimensional dynamic model of the equipment illustrated in Figure 3 serves as a first level of obtaining knowledge within the concept of virtual education, enabling simple and transparent communication of information about a concrete instrument as well as insight into the internal structure of the device without the need to handle a real equipment. Another level of obtaining information about a device forming part of the board instrumentation system is offered by direct access to a real device under concrete flight conditions, where demonstration of its behaviour would be almost impossible to realize. Applying a simulation tool to generate certain flight conditions and interlinking it with a real device could have been realized by us.

5. COMMMUNICATION BETWEEN THE SIMULATION ENVIRONMENT AND THE EXTERNAL INTERFACE AND DATA VISUALIZATION

If considering the concept of possible communication between virtual presentation of the board system environment and a real board system, one has to find out what kind of communication interface is available for the virtual visualization environment to be applied. As a basis for the virtual environment, we have made use of a simulation tool known as the FlightGear [3]. Primarily, it is designed for academic research, education and entertainment, featuring a relatively flexible general Input/output sub-system, which enables communication in via any supported protocol and arbitrary media enjoying support. Implemented into the simulator are several protocols, which regulate communication with the majority of external interfaces currently in use. For our purposes, the generic protocol was used, thus demonstrating a simple and efficient way of establishing rules of communication of our own. Communication is based on real-time transfer of packets containing arbitrary data in the form of ASCII or binary records among the so-called sockets, defined simply as terminal points or end-point serving communication with other program interfaces in via the computer network.

Defining input or output data is made possible by way of the XML configuration file. When suggesting the communication interface, we assumed communication to be carried out in real time and communication through sockets is not limited by the length of the conductor/cable length an provides several options of linking to client interfaces, and this alternative became fundamental to our work. Subsequently, after having studied the operational principles of the KI 206 indicator, it turned out to be necessary to define the indicated parameters of flight characteristics presented by this indicator and also which data are to be transferred in via the communication interface and last but not least to match the individual parameters with equivalent status variables of the simulation model in the virtual interface, the FlightGear, which can be directly converted and categorized by the individual characteristics of each indicator. Searching for the individual equivalent parameters, developing configuration protocols and configuring the internal communication subsystem of the FligtGear simulator, we have established a fundamental basis for the second phase of realization of communication, developing an application for realization of the socket-based contact with an the communication end-point of the FlightGear, based on TCP/IP protocol, of which the required information are taken, followed by decoding the input flow of data and storing them into the buffer memory of the computer. The information obtained are implemented into the visualization algorithm, which activates the individual „mechanical„parts of the 3D model of the indicator [8]. The final realization of visualization of cooperating indicator can be seen in Figure 4.

Similar way of application is used when visualizing the complete board of instruments of an Agusta Westland A109K2 helicopter and its implementation of the FlightGear simulator with the selected indication elements of the information – command related elements of indication.

Figure 4 Visualization of the 3D model movements of the indicator on the left, and the actual event during flight as by the FlightGear on the right

Figure 5 Instrument panel of the AgustaWestland 109 K2 helicopter and as seen in FlightGear

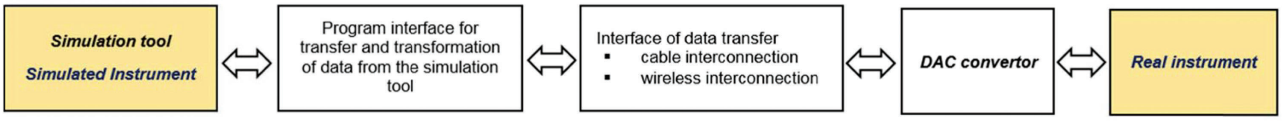

Figure 6 Principle block diagram of interconnecting the simulation tool with a real instrument

Visualization of the modelled indication movements have enabled functional verification of the suggested communication between the simulation tool and the external interface. The issue of interlinking with a real instrument device has thus been limited to making a device to ensure conversion of the digital form of data extracted from the simulator into analogue form of data presentation.

6. INTERCONNECTION OF THE VIRTUAL AND REAL AIRBORNE COMPLEX

The problem arising from interconnecting real instruments with a simulation tool presented in the principle-based diagram, see Figure 6, made it necessary to find solutions at two levels. At level one it is about developing a program interface, which ensures transformation of the required format and transfer of the required data information from the simulation program to be transformed on the required output interface, to which the real devices will be connected separately. The second part of interconnecting the simulator and the real system of board Instruments is facilitated by a DAC converter, which will transform digital data information into analogue form, into signals at values required for the individual Instruments. For example, for a situation where the position of heading indicator of the 3D model interpreted by digital values from showing declination from heading falling between -10, as far as 10, on the input of the real Bendix King KI 206 instrument will be converted into a voltage value from -150 mV as much as 150 mV fed onto the pair of connector pins. Interconnection with a real instrument for the concrete case a DAC (Digital to Analog Convertor) convertor is to be manufactured, which would transform the digital information, or the binary record of number 10 into a voltage of 150 mV in magnitude, the binary record of number 5 to be transformed into voltage of 75 mV in magnitude etc. Currently, we are developing testing solution based on the micro-controller termed as Arduino, which is capable of cooperation with the suggested prototype of and eight-bit DAC convertor operating by the voltage principle, using combination of referential voltage to generate voltage on the output, wherein on the basis of the output binary word, each bit of the digital information is switching on or off the appropriate parts of the referential voltage and the resulting outlet voltage is given by the sum of voltages of parts „switched ON". For a fully functional interconnection to be realized a DAC convertor featuring adequate number of outputs is to be manufactured.

Applying the given diagram, using the developed program interface for communication with the FlightGear simulation tool and interconnecting it to the complex DAC convertor made and tailored to concrete types of instruments, we are able to set up parts of a symbiotic educational environment, the priority of which is to inform students about the behaviour of instruments under concrete conditions of flight. The presented way of interpreting knowledge from the field of airborne information systems is intended to eliminate deficiencies in skills caused by the difference between theoretical knowledge related to airborne instruments systems and their application in practice.

7. CONCLUSION

The need to improve quality in the education of aviation professionals makes it necessary to adopt new ways and skills in utilizing progressive technology in education directly affecting safety of air transportation. One of the solutions focused on optimizing teaching such complex systems, hardly affordable neither to be purchased nor installed in their premises, consists in fostering the use of CBT and CBL methods, which facilitate, simplify and accelerate the process of education of the aviation staff. This is why we have made it our priority to apply modern methods based on information and simulation technology and models to develop a virtual concept of education matching the needs and requirements of modern aviation industry. Based on the potentials made available by modern technology, we have focused on a tool of education termed as a symbiotic concept using 3D dynamic models to visualize operation of aircraft Instruments including their internal functioning as well as offering interconnection between the core of simulation ensured by the FlightGear software and a current and real airborne complex. The ultimate purpose of the suggested concept is in establishing an efficient symbiosis between the theoretical interpretation of knowledge on the operation of sophisticated aviation systems and the potential in obtaining practical insight into the true functioning of those fairly complex airborne systems under affordable conditions.

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