Problem of virtual space modelling in aviation simulators

Vladimir Robertovich Roganov, Ekaterina Andreevna Asmolova, Alexander Nikolaevich Seredkin, Maria Vladimirovna Chetvergova, Nina Borisovna Andreeva, Valeria Olegovna Filippenko.

Penza State Technological University. Baydukova Travel / Gagarin Str.,1a/11, Penza, 440039, Russia

Abstract. A pilot training using aviation simulators is based on training in aircraft control in certain conditions. Particular units called imitators are developed for this purpose. The article contains quality estimation technique of models created by imitators during study task performance.
[Roganov V.R., Asmolova E.A., Seredkin A.N., Chetvergova M.V., Andreeva N.B., Filippenko V.O. **Problem of virtual space modelling in aviation simulators.** *Life Sci J* 2014;11(12s):371-373] (ISSN:1097-8135). http://www.lifesciencesite.com. 78

Keywords: simulator, training situation, training, probability of habituation of management professional skills.

Introduction

An aircraft pilot training using aviation simulators (AS) is based on habituation of aircraft management professional skills in certain situations [1], which are modelled in complex using key units of AS called imitators (Imitators are hard- and software complexes, simulating readings of cabin devices in real time. Visual surrounding imitator is opical hard- and software complex, simulating three-dimensional pictures of environment in pre-determined angles of view with the quality, which is sufficient for eye training.) [2]. In this case training pilots operate using models of aircraft controls, which moves in three-dimensional space model – recognizable copy of real space [1], and acquires essential professional skills of real aircraft handling in similar situation [3]. Sensation of aircraft model motion in virtual space is created for the training person by data reading from cabin instrumentation screens and by visual tracking of AS cabin motion in three-dimensional visually observable model of real three-dimensional space [4].

To impart professional skills in the aircraft control it is required to organize events for coordination of information which comes from certain device imitators and from visual surrounding imitator. The quality of the coordination model determines the possibility of imparting professional skill by the training person. The article proposes one of the variants how to estimate the quality of simulation.

The sense of the real aircraft flight control in real conditions originates in the trained person by complex and interconnected actions of information, coming from individual subsets of AS called imitators. Known results of theoretical studies, main of which is impossibility to create the complete model, can be applied to models realized in imitators [5]. Therefore simulators are unable fully replace the real aircraft for pilot training [6]. Any AS is designed and suitable for training in certain situations only.

The readings of simulator individual devices depend on the quality of the imitators, which collectively determine the equivalence of the simulated and real situation [7]. For estimation of the possible situation simulation quality we can represent AS as a system incorporating several models Ω_i.

Each model Ω_i, formed by *i*-th imitator of AS, shapes a part of the external environment picture for the trained [8]. Generally, the formation of the model Ω_i begins with processing of the database of certain *i*-th subset or realization of *j*-th mathematical model of corresponding aggregate and finishes with the information output in the form of $A_i = f_i(\Omega_i)$, similar to adopted in the real life (this can be deviation of corresponding device arrow, or visual scene formation [9], or on-board informer voice message etc.).

The assembly of data collected from individual AS imitators must give trained entire picture of environment S. It is possible under the condition of agreement of collected data model I_T from AS imitators with current trained data model of flight I_O, produced by his experience.

$$I_T = \sum_{i=1}^{N} f_t(A_i), \ M \in N \qquad (1)$$

$$I_O = \sum_{j=1}^{M} f_O(A_j), \ I_1 \neq I_2 \qquad (2)$$

where $I_T = f_i(A_i)$ – information, entering to trained by *i*-th subset of simulator during its performance (N – the number of imitators);

$f_O(A_i)$ - information, entering to trained by *j*-th subset of real aircraft during the flight or predicted by him on basis of his experience (M – the number of informational systems, forming trained

picture of environment and its interaction with AS, $N \subset M$).

At the moment t_k of simulated flight S must not deform the interaction of situated in its V models of passive elements S_p (models of the land surface with engineer constructions, which are always visible) and W models of active elements S_a (models of beacon stations, mobile objects etc.) with a model S_l, i.e.

$$S = \bigcup_{p=1}^{V} S_p \bigcup_{a=1}^{W} S_a \bigcup S_l \qquad (3)$$

when

$$f_t(S_l) \bigcap f_O(S) = 1. \qquad (4)$$

Bearing in mind that device readings in pilot cabin, as a rule, are duplicated at each moment t_i, models $\Omega t_i = \Omega_i(t_k)$, responsible for readings of corresponding *i*-th device, or indicator, or observed through cockpit windows part of visualization scene etc. must be coordinated, i.e.

$$\Omega_{ji} \bigcap \Omega_{iR} = 1, \qquad (5)$$

where $\Omega t_{ji} = f_i(\Omega t_i)$ – set, describing a legitimate field of detecting model of *j*-th object in environment model *S*, formed by one of the AS imitator, which forms model Ωt_i (it corresponds with readings of one of the cabin devices),

$\Omega_{Rj} = f_R(\Omega t_R)$ – set, describing a legitimate field of detecting model of the same *j*-th object in environment model S, but formed by another AS imitator, which forms model Ωt_R (it corresponds with readings of the another cabin device or imitator of visual surrounding).

Otherwise

$$Q_{ji} \bigcap Q_{iR} = 0. \qquad (6)$$

While completing (6) the simulator cannot be used for training. In actual practice there are certain moments t_k as well as periods Δt_k, when (6) is realized. It is rational to exclude situations, described by (6), out of list of practice ones, or to use other simulation methods. One can eliminate (6) by several ways:

- introducing the feedback in order to correct initial conditions of model Ωt_i formation;
- specifying correction time of all Ωt_i for adjust (6) to (5);
- limiting training time on the simulator, indicating calculated period Δt, while (5) is always realized;
- using mathematical tools for formation of models, which provide (5) satisfaction.

Hard requirements of real time (work cycle of data is from 60 to 120 μs) [2] usually do not allow to execute the conditions of (5) during "flight" on the simulator by the technique of complete recalculating of all necessary parameters.

It is significantly easier to assure filling of databases in unrealistic time scale combining with simultaneous coordination of entered information by all necessary parameters.

In this case there are a number of principles about preliminary information processing for basing. As a rule, they deal with necessary to take into account different capacities of technical equipment in imitators. We shall consider them in details.

Hard requirements of real time allow no one of existing AS imitators or imitators under development to simulate readings which pilot collects during the flight absolutely precisely. In other words, in real life aircraft pilot collects from ant *k*-th device if not more, but not the same information as from his imitator on the simulator. However, not all information, which comes to the aviator from *k*-th device $I(k)$ during the flight, is necessary for training. For example, it is not obligatory to imitate nearly invisible backlash of magnetic compass arrow etc. Taking into account moving of AS in virtual space, at the each moment each imitator simulates one of the possible models, which allows trained to manage AS, acquiring professional skills, necessary for managing real A.

As a rule, in the aggregate of models from one imitator $I(k)$ there is a subset $I_u(k)$, which is sufficient for training: $I_u(k) \subset I(k)$. If *k*-th imitator reproduces $I_u(k)$, they consider that it is sufficient for training. In the number of cases they can separate additional subset of desired information $Ig(k)$, $I_u(k) \subset I_g(k)$, which must be simulated as far as possible. The presence of $Ig(k)$ improves the quality of training by the fact of approximation of model $I_R(k)$ from concerned imitator to the native form $I(k)$;

$$I_R(k) = I_u(k) + I_g(k). \qquad (7)$$

At the same time, *k*-th imitator can provide false information $I_l(k)$ (which is absent in real conditions and obstruct to habituation of professional skills.

$$I_l(k) \cap I(k) = 0. \qquad (8)$$

The cause of $I_l(k)$ can be the imperfection of facilities in use as well as infraction of (4) while

corresponding models from all AS imitators, which is put into databases or mathematical models in use.

While observing strictly, every imitator always contains $I_l(k)$ and this fact impairs formation of aircraft management skills. For decreasing of $I_l(k)$ and realization of condition

$$I_l(k) << I(k), \qquad (9)$$

it is necessary to conduct the number of activities during development of each AS imitator as well as during their incorporation into single complex. Besides, while developing training techniques using AS it is also necessary to take into account the presence of $I_l(k)$.

In each individual case one can achieve the realization (9) by various ways. While developing databases, which contain information about outdoor environment of the visual situation imitator, they use the approach of ranking of data entering into base and subsequent filling of such bases by models of the objects, which have maximum information value. In other cases the limitation of the list of training situations is possible as well as modernization or replacement of certain imitators.

Corresponding Author:
Dr. Roganov Vladimir Robertovich
Penza State Technological University. Baydukova Travel / Gagarin Str.,1a/11, Penza, 440039, Russia.

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7/23/2014