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SIMULATOR TRAINING OPTIMIZATION

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***Abstract*—*The process of helicopter pilots training by simulator is considered. It is analyzed the aviation accidents due to human factor. It is proposed the way of estimation of helicopter pilots training efficiency in the simulator.*

Index Terms—Training; simulator; pilots; helicopter; aviation accidents.

I. INTRODUCTION

Nowadays, accidents are mostly attributable to the human factor, 80–90 % from all accidents, and, unfortunately, existing methods have not led to improvement of safety.

Pilots work is the most difficult type of human activity, consequently training is difficult as well. The process of professional training includes a wide variety of instruments and devices. The level of training should mainly guarantee safety. Since graduate flight school immediately take jobs in the crew of the helicopter.

Accident analysis and preconditions shows that factors such as the mistakes in flight operations , omissions and deficiencies in the organization and management of flights and aircrew training methodology , errors in piloting technique and operation of aviation equipment determines the overall accident rate and the reasons for them, they are notorious for its repeatability[1] – [5]. This causes the need to improve the organization and methodology of flight training for flight crews [6]. For today the best way of pilot's training is to use simulators of different time. Unfortunately the training time is limited. So it is existed the important task of optimal redistribution the time of training.

II. STATEMENT OF THE TASK

It is known the whole time of training, and a number of pilot's skills that have different important in piloting processes. It's necessary to redistribute the time of training in such way that to improve the effectiveness of training.

III. REVIEW OF KNOWN METHODS

The disadvantage of the well-known approach to the creating of an educational plan (Fig. 1) and, in particular, in the planning of learning on the computer, is their reliance on the so-called term "average student". However, even at constant composition of subjects skills individualization, redistribution of time for their development is relevant, taking into account the ability of each student and the complexity of the skills. This ability depends primarily on the quality of training or "progress" in the early stages and the degree of degradation throughout time (the ability to remember or forget given material).

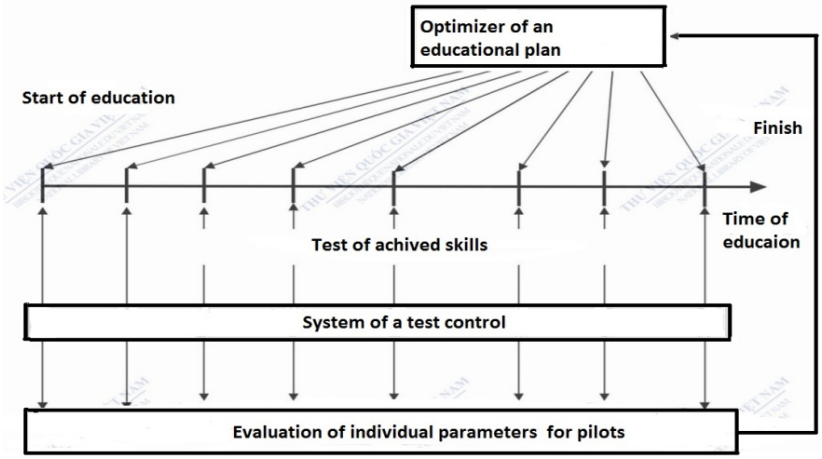

Fig. 1. Pilots training structure

Thus, it is necessary to study these abilities, which means to form a mathematical model of the quality of training and to estimate the parameters of the model for each individual group. Band which was obtained allows to formulate and to solve the direct problem of optimal scheduling of flexible learning, which should

provide a positive effect, and its implementation is available in the computer lab

It's necessary to take into account the disadvantage of the well-known approach. We take into account the most important factors affecting the development of one skill:

1. Coefficients which show the rate of influence of the human factor (significance coefficients).
2. Level of development of next skills, when current skill is based on previous.
3. Degree of degradation or "forgetting" previous skills, when next skill has to be developed.
4. Speed of skill development.

IV. ALGORITHM OF TRAINING OPTIMIZATION ON THE SIMULATOR

The algorithm of redistribution is based on the solution of the next tasks: the determination of coefficients which show the rate of influence of the human factor (significance coefficients), the estimation of level of development of next skills, when current skill is based on previous, the determination of the degree of degradation or "forgetting" previous skills, when next skill has to be developed, the estimation of the speed of skill development.

Construction of a graph to display optimization

The graphs consist of two axes:

– *X*-axis (time intervals) shows how much time you need to master a given skill based on the significance coefficients;

– *Y*-axis (performance measurement). We assigned a numeric value to a training, for example, the average loss if pilot makes error on a single helicopter flight training.

Move on to building graphics for the *x* axis, we determine the optimal time for training for each skill T_{max}, taking into account the factor of significance, the *Y* axis will be based on the efficiency of exercise (Fig. 2).

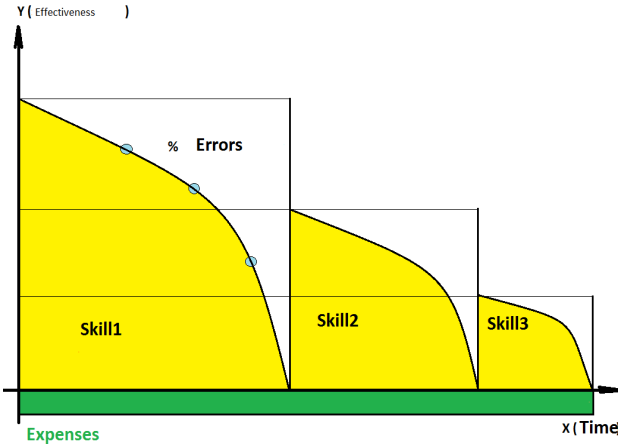

Fig. 2. Determination of optimal training time for each skill T_{max}

How the mark which estimates efficiency behaves with the increase of time dedicated for education? Obviously, trained pilot is safer than untrained. Training requires time. It is possible reasonably enough to suppose that exists some training time T_{max} for the gaining certain skill. At time of educating more than T_{max} gain of experience is absent.

At time of educating, insignificantly different from $t = 0$, admitting of specialist to the flight will bring the most major damage, thus the subsequent educating will result in reduction of this damage. Thus, time of educating is unequivalent on efficiency, and increase of efficiency certainly described by the function of decline of amount of errors from duration of training. It will be shown further, that reduction of training value T_{max} allows to increase a general size of prevented mistakes which cause damage (risk, fine).

We will enter the concept of functional of efficiency of the single training, qualitatively repeating the functional of errors, it's numeral values for time of completion of training of $t = t_{max}$ are set from a condition, that general area (or certain integral) is equal to the value of middle damage when a specialist makes an error on the topic of the single training on real helicopter.

V. THE FORMALIZATION OF THE EDUCATIONAL PROCESS WITH THE CONTROL AND FORGETTING OF TRAINING INFORMATION

In the work "personnel training" somehow control [7] characterized the process of forgetting information serving for some time as a model: $t = N$ (on the condition that at $t = 0$ he had skills):

$$p^{N+1} = 1 - (1 - p^N)\exp(-C^N \Delta t_{N+1}),$$

where C_N is speed of forgetting information. In the future we will use simpler models, considering that:

$$\sigma_N = \xi_{NK}\sigma_K,$$

where σ_K is the degree of knowledge at time t_K, ξ_{NK} is information loss for time $t_K - t_N$. To determine ξ_{NK} use the following expressions:

$$\left.\begin{aligned} \xi_{NK} &= \frac{\eta}{N-k+1}; \\ \xi_{NK} &= \eta\left(1 - \ln\frac{1}{N-k+1}\right). \end{aligned}\right\}$$

$$\left.\begin{aligned} \xi_{NK} &= \frac{\eta}{\eta(N-k)+1}; \\ \xi_{NK} &= 1 - \ln\frac{1}{\eta(N-k)+1}. \end{aligned}\right\}$$

These formulas are formed in the way when $K = N$, $\xi_{nk} = 1$ we can obtain trivial model

$$\sigma = \sigma_{\max} \frac{\Delta}{\sigma + \Delta}.$$

where Δ time for skill development.

Graphical explanation of the model (Fig. 3).

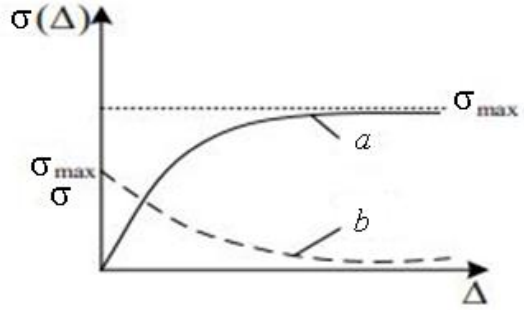

Fig. 3. Graphical explanation of the model

The main key point of this topic is that ability to digest information increases with the rise of time required for its learning

$$P_\sigma(\Delta) = \frac{d\sigma(\Delta)}{d\Delta} = \sigma_{\max} \frac{\sigma}{(\sigma + \Delta)^2}. \qquad (1)$$

Further simplification of formula (1) is connected with use σ in dimensionless form

$$\bar{\sigma} = \frac{\bar{\Delta}}{1 - \bar{\Delta}},$$

where $\bar{\sigma} = \frac{\sigma}{\sigma_{\max}}$; $\bar{\Delta} = \frac{\Delta}{\sigma}$.

Process of "forgetting" training information describe as simple dependence

$$\varphi(\tau) = \frac{\alpha}{\alpha + \tau}.$$

The symbol τ describes the "preservation" of information, and α is an "experimental" ratio. As a result we get the final formula for calculation.

$$\varphi(\tau) = \frac{1}{1 + \tau}, \qquad (2)$$

where $\bar{\tau} = \frac{\tau}{\alpha}$.

Eventually, formula (2) reflects the fact that the probability of saving in memory certain portions of information over time is reduced.

VI. Conclusions

In this work we figured out the disadvantage of the well-known approach to the creating of an educational plan and, in particular, in the planning of learning on the computer, is their reliance on the so-called term "average student". And, even at constant composition of subjects we performed skills individualization, redistribution of time for their development, taking into account the ability of each student and the complexity of the skills. This ability depends primarily on the quality of training or "progress" in the early stages and the degree of degradation throughout time (the ability to remember or forget given material).

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В. М. Синеглазов, Ю. М. Шмельов. Оптимізація тренажерної підготовки

Розглянуто процес навчання пілотів гелікоптерів на тренажері. Проаналізовано авіаційні пригоди як наслідок людського фактору. Запропоновано шлях покращення навчання пілотів гелікоптерів на тренажері завдяки перерозподілу часу навчання.

Ключові слова: навчання; симулятор; пілоти; гелікоптер; авіаційні події.

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В. М. Синеглазов, Ю. Н. Шмелев. Оптимизация тренажерной подготовки

Рассмотрен процесс обучения пилотов вертолетов на тренажере. Проанализированы авиационные происшествия как следствие человеческого фактора. Предложен путь улучшения обучения пилотов вертолетов на тренажере на основании перераспределения времени обучения.

Ключевые слова: обучение; симулятор; пилоты; вертолет; авиационные происшествия.

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