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TRAINING TIME OPTIMIZATION IN SIMULATOR

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Abstract—In general, the problem statement is formulated as the development of optimal distribution of time training on the simulator. The basic optimization algorithms a developed. The structure of software complex is proposed.

Index Terms—Training; simulator; pilots; helicopter.

I. INTRODUCTION

Nowadays, there is a well-known fact that the use of simulators in training of pilots is certainly useful. Moreover, training can be useful both for pilots and for specialist who provide a maintenance of this helicopters. It is proved fact that that six – eight weeks of computer training are equivalent to one year of training on real helicopter.

Efficiency of simulators use is considered to be effective, however practically, there are no reasonable methodologies for assessing the effectiveness of training in a form of reduction of accidents, not counting the numerous statistics on helicopter accidents. However, for the correct use of statistics we need a sufficient amount of information for the similar events, and accidents involving the human factor, usually they are unique, nature and the specific chain of events are rare [1] – [5].

II. ANALYSIS OF THE FUNCTIONING OF THE COMPUTER-BASED TRAINING

The learning process takes place in the course of the joint activities of the training and a trainer. For the improving of learning we have to study the activities of the training and identify those elements where automation is appropriate.

Analysis of the structure of pedagogical activities can highlight 5 main functional component of learning, closely interconnected:

– gnostic (an analysis of objectives, contents, teaching methods);

– projecting (long-term planning of the course);

– constructive (operational planning of lesson);

– organizational (organization of educational process);

– communicative (information interaction between student and teacher).

The learning process involves the assimilation of educational content (knowledge, skills, training material). Management can be performed either directly with the teacher and indirectly – through the handbook, hardware and software system of computer-based learning.

Since the learning process relies to the general principles of management, the structure of the system can be represented as shown in Fig. 1.
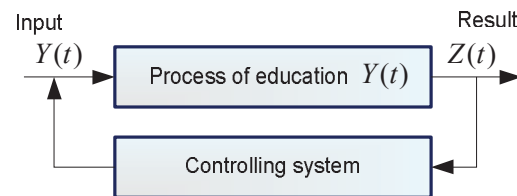

Fig. 1. System structure of education process

In a parallel realization of simple and complex skills total time t on the next stage of training is limited, so when you complete optimization, you may practice a lot one exercise while neglecting another one and in this situation everything depends on individual skills.

The main function of the teacher is to assess the quality of the current step and time allocation in the parallel development of skills for the future and the ability of trainees to split the group, often on three-strong, middle and weak (Fig. 2) [6].
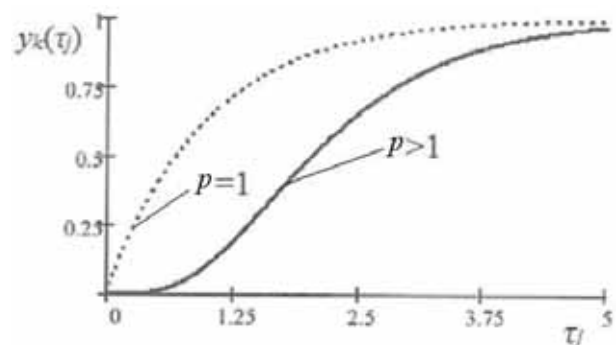

Fig. 2. The logistic function: $p_j > 1$ is exponent, which emphasizes logistical nature of learning (hastobeidentified); y_k is band which characterizes the quality of education; τ_j is time dedicated for education

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.

III. ALGORITHM OF TIME REDISTRIBUTION

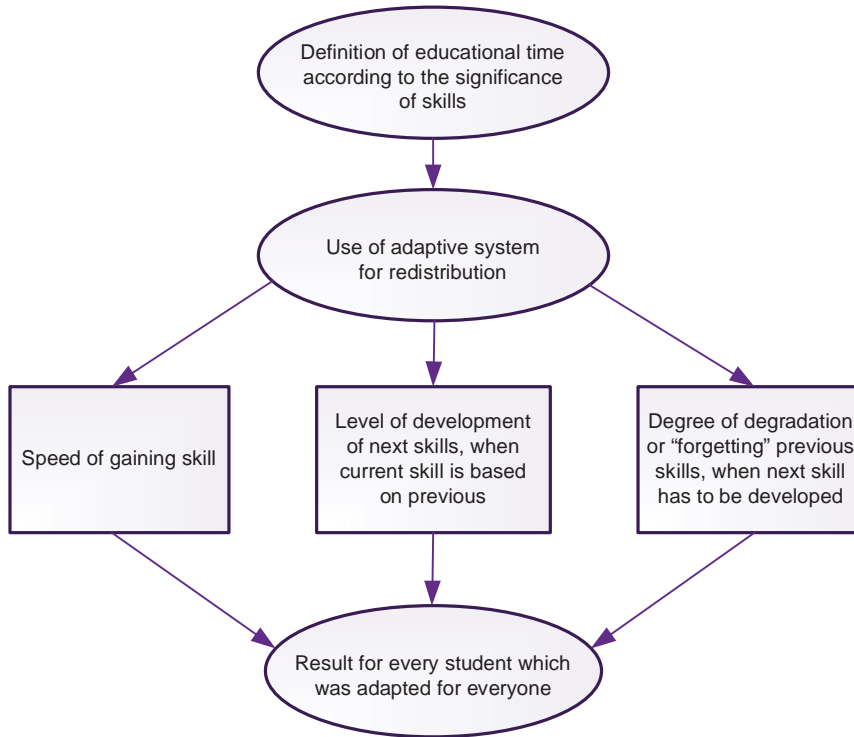Structure of algorithm is indicated below (Fig. 3).

Fig. 3. Structure of algorithm is indicated below

According to this figure the problem consist of two parts:

– definition of educational time according to the significance of skills;

– use of adaptive system for redistribution.

Definition of educational time according to the significance of skills.

Educational time according to the significance of skills includes the next steps.

1. The determination of a significant aspects of learning by comparing the causes of accidents and aspects of learning in terms of the current training.

2. Determination of the total time devoted to every aspect of the theoretical training.

$$T_{teor}^n = \sum_{i=1}^{n} T_{teor}^{exercise\ n},$$

n is the number of exercises; T_{teor}^n is the time needed to learn every theoretical aspect.

3. Determine the total time devoted to every exercise in training.

$$T_{pract}^n = \sum_{i=1}^{n} T_{pract}^{exercise\ n},$$

n is the number of exercises; T_{pract} is the time needed to learn every practical aspect.

4. Calculate the total amount of theoretical information perceived by students at the hearing, on every aspect (perceptual speed 50 bits/sec).

$$H_{teor}^n = T_{teor}^n \cdot 50,$$

T_{teor} is the time needed to learn every theoretical aspect; H_{teor}^n is the amount of theoretical information perceived by students.

5. Calculate the density of information perceived in the simulator.

$$P_n = H_{teor}^n / T_{pract}^n,$$

T_{pract}^n is the time needed to learn every practical aspect; H_{teor}^n is the amount of theoretical information perceived by students.

6. Accept coefficients of the human factor which influence on the avoiding of accidents (coefficients of significance).

$$K_1, K_2, ..., K_n.$$

7. Redistribute the amount of information respectively to a significant coefficients aspect of learning.

$$H_{\exp}^{n} = \sum_{i=1}^{n} H_{teor}^{n} K_{n}.$$

8. Having the initial density of the flow of information, we define time required to learn every particular aspect.

$$T_{\exp}^{n} = \frac{H_{\exp}^{n}}{P_{n}}.$$

9. Before the start of training we have to determine individual abilities of every student by testing the trained group.

Using an adaptive system of redistribution of skills taking into account the following factors:
  – speed of skill development;
  – level of development of next skills, when current skill is based on previous;
  – degree of degradation or "forgetting" previous skills, when next skill has to be developed.

10. Define a function $\sigma_n(t)$ for each discipline in the exercises.

11. Define a function $f(\sigma_n(t),\eta)$ for each discipline in the exercises, which will describe the level of assimilation of information depending on the studied aspect and level of individual abilities for each student (η is the level of the individual abilities).

12. Based on estimates obtained during the passage of the previous exercise, determine the difference between the permissible and the current level of knowledge $\Delta\sigma_n$. Before the beginning of the subsequent exercises perform "repeating of a previous material" for each student.

Use of adaptive system for redistribution.

Use of adaptive system for redistribution includes the next steps:
  1. Estimation of skill development speed.
  2. Estimation of development level of next skills, when current skill is based on previous.
  3. Estimation of degradation degree or "forgetting" previous skills, when next skill has to be developed.

Estimation of skill development speed.

As it is known, the level of initial knowledge and skills to learning are different in every student. It is worth considering that students that have less intellectual abilities need more time to get skill.

To improve the effectiveness of the training we should take into account the factor of individual abilities (Fig. 4). This will reduce resource-training costs of easily trained students. And also allows you to use the resources saved to train students with bad individual abilities. To determine this factor we must test the level of knowledge and abilities of the students before the start of the course.
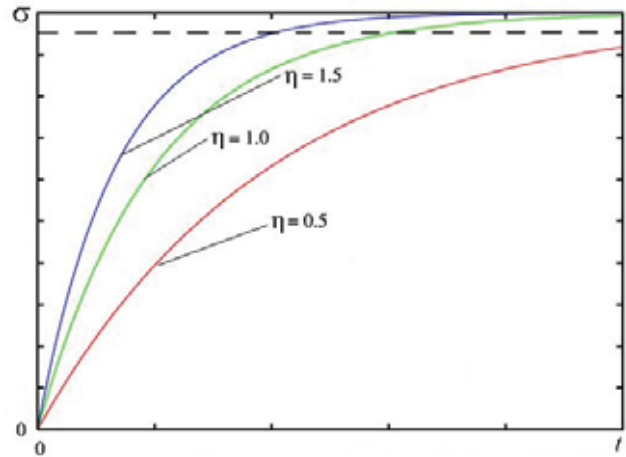

Fig. 4. Level of assimilation of information depending on the studied aspect and level of individual abilities for each student

Optimality criterion $F(\Delta)$, taking into account the different levels of abilities of subjects-η (Table). Therefore, respectively, have:

$$\xi_1 = \frac{\eta}{\Delta - 0.5\Delta + 1}.$$

Level of individual abilities

η_1	η_2	η_3	η_4
1.1	0.95	0.7	0.45

Figure 5 we have seen extreme curves, which depends on the level of the individual abilities is the η.
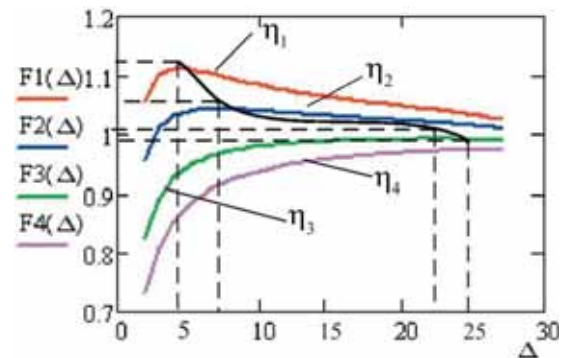

Fig. 5. Extreme curves, which depends on the level of the individual abilities is the η

The result of calculations suggests that the higher the η, the less time it takes to master portion of training information:

$\eta_1 = 1.1$ is time assimilation of information takes place within 5 hours;

$\eta_2 = 0.95$ is time assimilation of information is carried out within 8 hours;

$\eta_3 = 0.7$ is time assimilation of information is carried out within 23 hours;

$\eta_4 = 0.45$ is time assimilation of information is done within 25 hours.

Level of development of next skills, when current skill is based on previous.

We have a learning model, taking in to account the forgetting and individual abilities of subjects (Fig. 6).

This model describes a consistent method of training based on forgetting factor and individual abilities. Blocks of information are taught in series
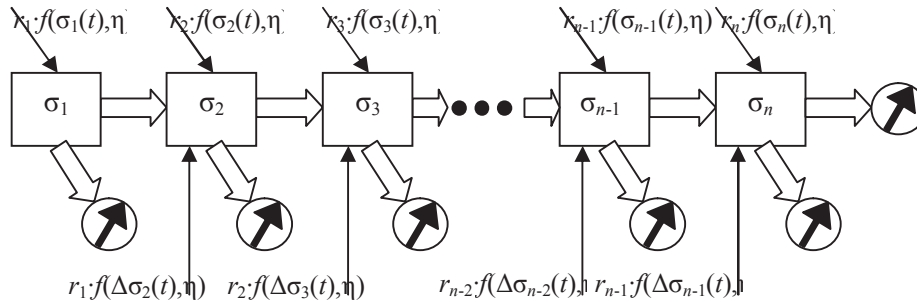
and exploring of the following pieces of information requires knowledge of the previous. Time resources spent on study of σ_n information are calculated depending on the function of $\sigma_n(t)$ and η, and also include previous topic on the basis of the assessment of the forgotten knowledge, before beginning study of σ_n.

Fig. 6. Model describes a consistent method of training based on forgetting factor and individual abilities

Degree of degradation or "forgetting" previous skills, when next skill has to be developed.

For more exact change training plan must be to introduce the notion of "forgetting". If you can't fit all the training the long practice sessions in a calendar day, you should research of forgotten material and plot a diagram of the number of forgotten information from time to time. To do this you need to spend a few tests and output dependence which is called Ebingaumem curve (forgetting curve) [7].

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

where σ_K is the degree of knowledge at a time t_K, ξ_{NK} is the coefficient of loss of information for the period $t_N - t_K$.

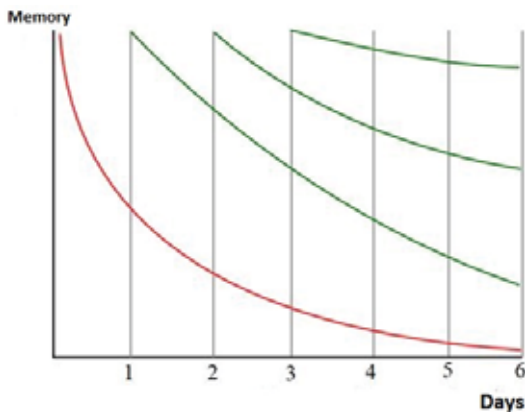In General, the curve of forgetting has the form (Fig. 7).

Fig. 7. The curve of forgetting

So before you explore the following pieces of information you need to repeat the forgotten information.

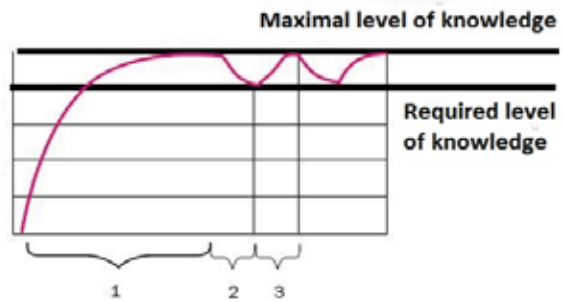The whole process of training with forgetting of information is shown on Fig. 8.

Fig. 8. Training with forgetting of information: period 1-study; period 2-forgetting; period 3-restoring the lost knowledge

$$\sigma_r = \sigma_N.$$

For every aspect of the course, you must define the function based on the number of learnt information σ from time t (Fig. 9). Here is the most common function of exponential distribution:

$$\sigma(t) = 1 - e^{-\eta t},$$

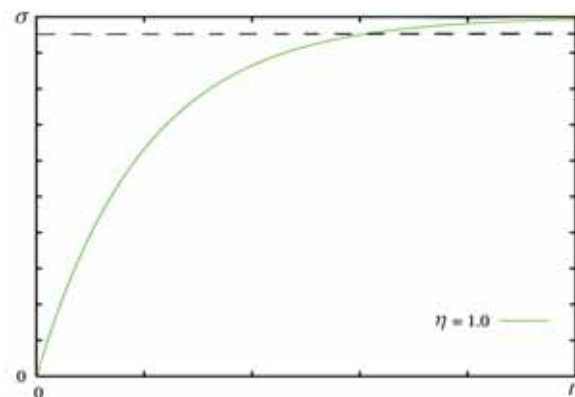where η is the level of individual abilities

Fig. 9. Function based on the number of learnt information σ from time t

In this case, consider the medium variant with $\eta = 1$. Restoration of the forgotten information before the next portion of the training will take a small amount of time, and t will significantly improve the efficiency of the educational process.

It's worth noting that when we change the educational plan we must take into account the order of disciplines and not to allow independent permutation (Fig. 10). Our original study plan complies with this requirement.
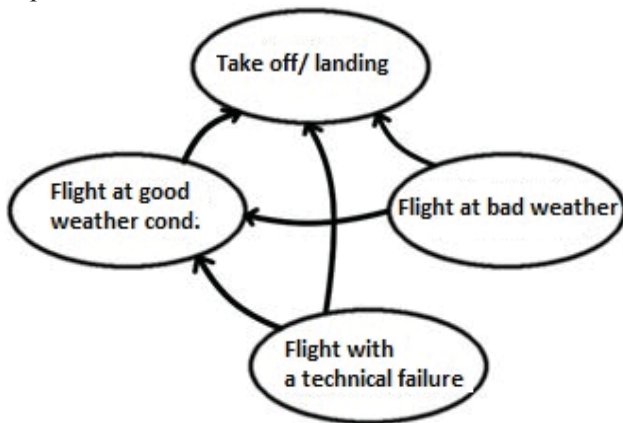

Fig. 10. Plan of training

It is worth considering that pilots which have less intellectual ability needed more time to study the course material.

IV. 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. Синєглазов, Ю. М. Шмельов. Оптимізація часу підготовки на тренажері
Розглянуто проблему оптимального розподілу часу навчання на тренажері. Розроблено основний оптимізаційний алгоритм. Запропоновано структуру програмного комплексу.
Ключові слова: навчання; тренажер; пілоти; гелікоптер.

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В. М. Синеглазов, Ю. Н. Шмелев. Оптимизация времени подготовки на тренажере
Рассмотрена проблема оптимального распределения времени обучения на тренажере. Разработан основной оптимизационный алгоритм. Предложена структура программного комплекса.
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