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ASSESSMENT OF STUDENTS' KNOWLEDGE IN VIRTUAL REALITY ENVIRONMENTS

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Introduction

Modern ICTs allow to solve the problems that arise during the knowledge acquisition regardless of where this knowledge is stored, as well as financial, administrative and other constraints. Large volumes of information can be delivered digitally to any user through the global network. Access to various information sources enables to answer any query or obtain information related to it to one degree or another. Since it does not require any special knowledge from users (both in terms of hardware and software), it is available to every user.

Intensive use of modern computer technology causes new problems regarding human-computer interface, namely human-display interaction. In this regard, the study of human-computer interaction, especially analysis of system user activity, remains an actual problem. These problems occur when assessing students' knowledge of distance education, determining the ranking of websites, as well as using educational software, and so on.

In this case, the situation is complicated by the fact that knowledge acquisition takes place in a virtual environment, and it is impossible to directly monitor and evaluate user activity. One of the ways to solve the problem is to use the user`s unique psycho-physiological features to assess their activity while using the system.

Problem formulation

Summarizing the above mentioned, the problems can be formulated as follows: the user can freely use a sophisticated software system (source of information) any time without any restrictions. It is necessary to create a model to assess quality use of the software system.

Problem solving methods

Suppose that the user uses N KB of information to obtain the required information. For the necessary knowledge acquisition, the user arrives in the system K times, and depending on the provided information volume and the degree of complexity, the user in the system is for $t_j\, j=1, k$ thus, sojourn time equals $t_j\, j=1, k$.

Consider the following cases taking into account the time norms for obtaining information:

- normal duration of a user's sojourn time in the system;
- user's less than the norm sojourn time in the system;
- exceeding the user's sojourn time in the system.

Determining the time norms for obtaining information provokes interest in how a human perceives information, stores it in memory and turns it into knowledge, and how this knowledge affects human behavior. For example, the visual memory of the human operator plays an important role in perception of information from the display.

Psychologists have studied human memory for a long time [1]. [2] examines the possibility of rapid visual classification of many objects by humans. The article presents the information on the study of the perception of objects and ensembles and the accuracy of their visual memory [3].

[4] examines visual information presentation and influence on its storage in memory using Cowan's K formula.

The paper [5] deals with the problems of assessing the psychophysiological state of a human operator working in the dynamic object management system, based on experimental data. As an integrated assessment of the psychophysiological state, it is proposed to use the concept of operator`s perception delay. This total period, which consists of the time of visual perception, the time of assessment of the change in the situation based on the visual information as well as the time for making a decision, is called the latent period.

[6] presents a structural model of the work of a human operator in the information system “man-display”, implemented in the form of neural networks. Within the framework of the model subsystems of cognitive, decision-making, executive, as well as internal data sources are considered. Based on this model, a neural network in which the cognitive subsystem is clearly separated from the subsystem of decision-making was built. Self-organizing maps (Kohonen maps) are used as cognitive subsystems, and a hybrid neural network is used as a subsystem of decision-making.

The research has shown that the stages of information processing in human memory is as follows:

- Encoding (collecting and representing information);
- Storage (holding information) in short-term or long-term memory;
- Retrieval (obtaining the information when needed).

The processes of receiving, processing and storing information in human memory are characterized by the following indicators:

- The maximum speed of a person as an information transmitter is ~ 40 binary units, and the average speed of a person performing simple operations without prior training is 2 binary units / sec [7-9];
- The maximum speed of human memory information processing is 3 ... 4 words / second [10];
- In slow reading, leading to the understanding of the read, the speed is 2.5 words / sec. (~ 18 binary units / sec.) [11];
- The speed for flight crews during long flights is 1.41...8.3 bps. (with light stimulus), 0.44 ... 5.27 bit / sec. (with a sound stimulus) [11]. In [7,12] the rate of human perception of incoming signals is estimated at 18.2...24.4 bit/sec. or ~ 10 signals in 1 sec;
- The rate of human recognition of objects on a television screen in [12] is estimated at 30...40 bps. The human brain assimilates information at a speed of 0.2...1 bit/sec., and the maximum value of the speed of receiving and processing information is 50...70 bit/sec. [8].

Summarizing the above mentioned, we accept the following estimates of the processes of information reception, processing and storage in human memory:

- The minimum speed human information processing $v^{min} = 5\ bit/sec.$
- Average speed human information processing $v^{cp} = 20\ bit/sec.$
- Maximum speed human information processing $v^{max} = 40\ bit/sec.$
- Top speed human information processing $\bar{v}^{max} = 70\ bit/sec.$

Suppose that n user has an access to the same N KB information. Let`s assume that n user has an access to the same N KB information. To acquire the necessary knowledge, each user arrives in the system m_i, $i=1, n$, and sojourn time in the system is $t_j\, j=1, m_i$sec. depending on the provided volume of information and degree of its complexity.

In this case the following condition must be fulfilled:

$$\frac{N}{v^{\max}} \le t_{ij} \le \frac{N}{v^{\min}}\ . \qquad (1)$$

However, since the user has free access to the system, condition (1) may not be fulfilled. In this case, we get a discrete random t_{ji} – time series consisting of usage periods for each user. Assuming that the sequence is normally distributed (this assumption is based on the condition that the elements of the sequence are independent of each other), the confidence interval for each:

$$\left(\bar{t_i} - \frac{\sigma_i}{\sqrt{m_i}} \bar{t}_{\alpha,m_i-1},\quad \bar{t_i} + \frac{\sigma_i}{\sqrt{m_i}} \underline{t}_{\alpha,m_i-1},\right), \qquad i = 1,\ldots n\,. \qquad (2)$$

Here, $\overline{t_i}$ the user`s average duration of sojourn time in the system:

$$\overline{t_i} = \frac{1}{m_i}\sum_{j=1}^{m_i} t_{ij} \, , \qquad (3)$$

σ_j – variance of the user's sojourn time in the system:

$$\sigma_i = \sqrt{\frac{1}{m_i - 1}\sum_{j=1}^{m_i}\left(t_{ij} - \overline{t_i}\right)^2} \, , \qquad (4)$$

$\overline{t}_{\alpha,m_j-1}$, $\underline{t}_{\alpha,m_j-1}$ – the upper and lower levels of confidence interval $p = 1 - \alpha$ are the critical value of the t-distribution with degrees of freedom $m_j - 1$ (usually $p = 0.95$) and determined based on special tables [13].

The interval values determined by formula (2) can be taken as user`s minimum maximum critical sojourn time in the system:

$$\begin{cases} \overline{t_i} - \dfrac{\sigma_i}{\sqrt{m_i}} t_{\alpha,m_i-1} = \dfrac{N}{v^{\min}} \\ \overline{t_i} + \dfrac{\sigma_i}{\sqrt{m_i}} t_{\alpha,m_i-1} = \dfrac{N}{v^{\max}} \end{cases} , \qquad (5)$$

from here we define the critical value as the extreme points of the interval:

$$\begin{cases} t_i^{\max} = \dfrac{N}{v^{\min}} + \dfrac{\sigma_i}{\sqrt{m_i}} t_{\alpha,m_i-1} \\ t_i^{\min} = \dfrac{N}{v^{\max}} - \dfrac{\sigma_i}{\sqrt{m_i}} t_{\alpha,m_i-1} \end{cases} . \qquad (6)$$

If condition:

$$t_i^{\min} \le \overline{t_t} \le t_i^{\max} \qquad (7)$$

is fulfilled, we know that the user normally uses the system. Deviation from this condition is accepted as unusual user behavior.

To understand user behavior, we use the Saaty scale:

- If there is t_i^{min} or t_i^{max} 80% or more user behavior deviation during the use of the system, we consider that the user`s behavior is unusual. This means that the user has downloaded the text of the program and did not study the topics or just forgot to study them.
- If the user's deviation time from the system is t_i^{min} or t_i^{max}, from 60% to 80%, we consider that the user is not using the system resource effectively.
- If the $\overline{t_t}$ user's time has a deviation from t_i^{min} or t_i^{max} from 20% to 60%, we consider that the user is using the system resource satisfactorily.
- If the $\overline{t_t}$ user's time has a deviation from t_i^{min} or t_i^{max} 20% and less, we consider that the user normally uses the system resource.

Computational experiment

We have prepared 10 standard texts for the experiment. For simplicity, we choose texts with the same amount of 11-page information. In order to receive and process information in memory each letter or symbol of the text is taken as 1 bit. Moreover, gaps in the text when reading are not considered information and make up 30% of the total volume. In this case, for receiving and processing information in memory the 11-page data is only 0.7 * 11 * 29 * 61 = 13621 bits.

Based on the above mentioned, we determine the time norms for the reception, processing and storage of the information in human memory:

- maximum information processing time – $t^{max} = 45\ min$;
- average information processing time $t^{cp} = 11\ min$;
- minimum information processing time $t^{min} = 6\ min$.

Knowing, the time norms of receiving, processing, and storing information in memory, we assess students` behavior when reading a text (fig. 1):

- We consider that the student does not use the system resource properly if it takes him more than 81 min. or less than 1 min to read the text.
- We consider that the student does not use the system resource well if takes him a maximum of between 72 min and 81 min or minimum between 1 min. and 2 min.
- If the reading time of the text is between 54 min. and 72 min or between 2 min. and 4 min. we consider that the system resources is satisfactorily used by the student.

- If the time of using the system by a student is more than 4 minutes. and less than 54 min. then we accept that he normally uses the system resource.

For the experiment, we provided this information to 10 students of AzTU – Azerbaijan Technical University for checking comprehension skills. Students can read the text for as long as they want up to the point where they report that they have read and understood the information. Moreover, we assume that the student can read the text in parts, and it is not known which part of the text he is reading. After reading the text, students' knowledge was tested using test questions. Each student is given one question for each text, and the answer is scored on a 5-point scale.

The student can apply to the system as many times as he/she wants. The use of the text by students is recorded each time. The statistics is shown in fig. 2. The maximum number of applications is 10 times. The critical minimum, average and maximum time spent by a user in the system is shown in fig. 3.

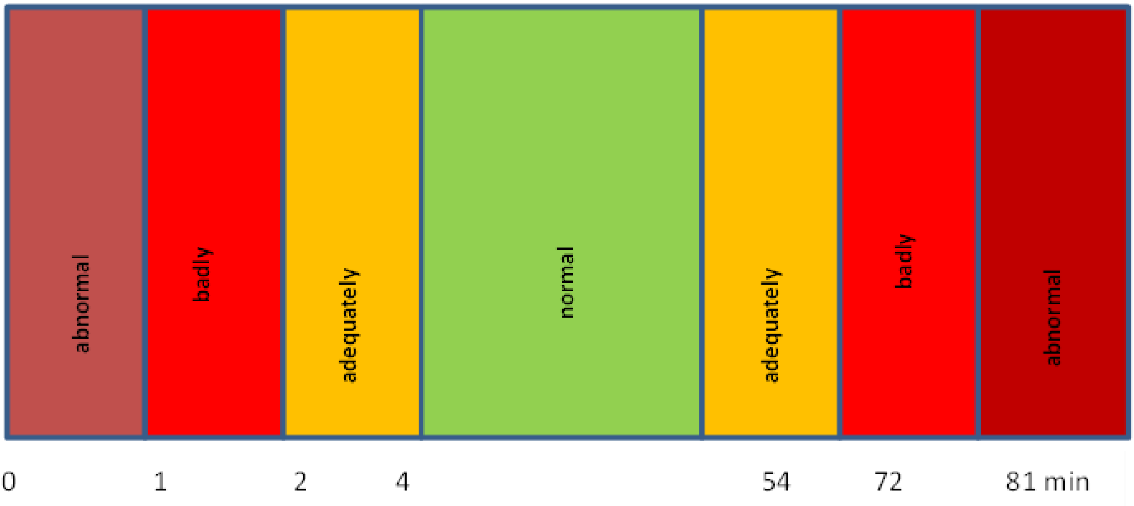

Fig. 1. Evaluation of user behavior when reading 11 pages of textual information

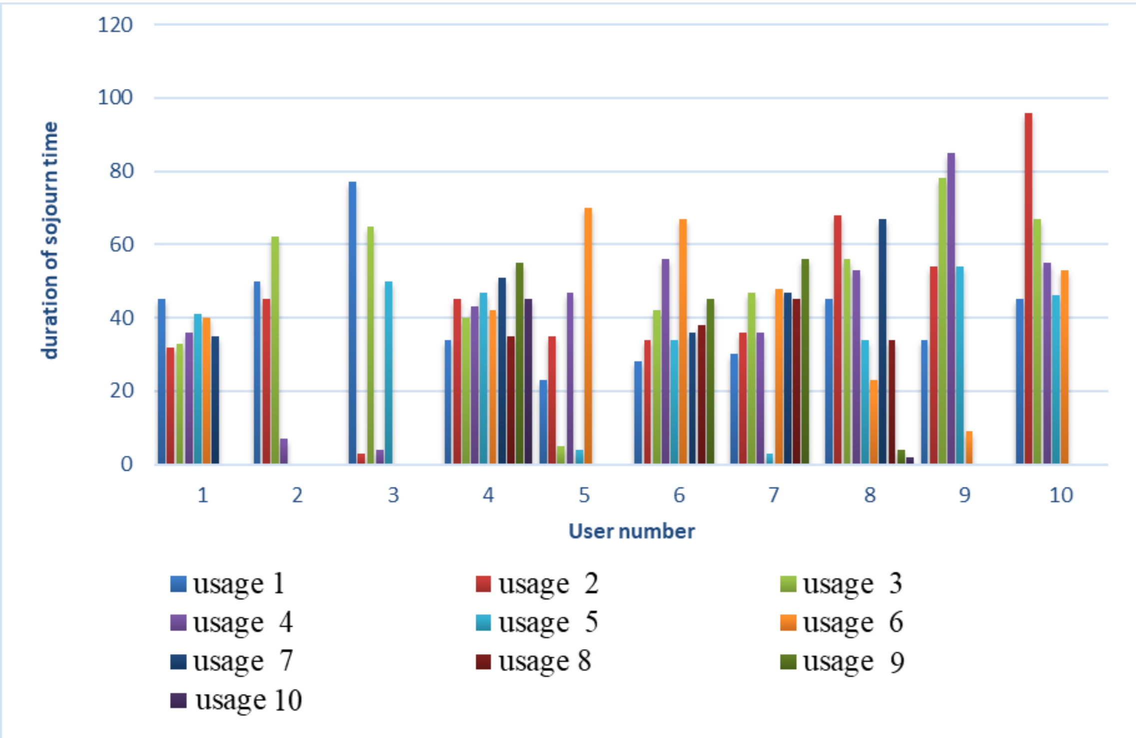

Fig. 2. Histogram of user access time

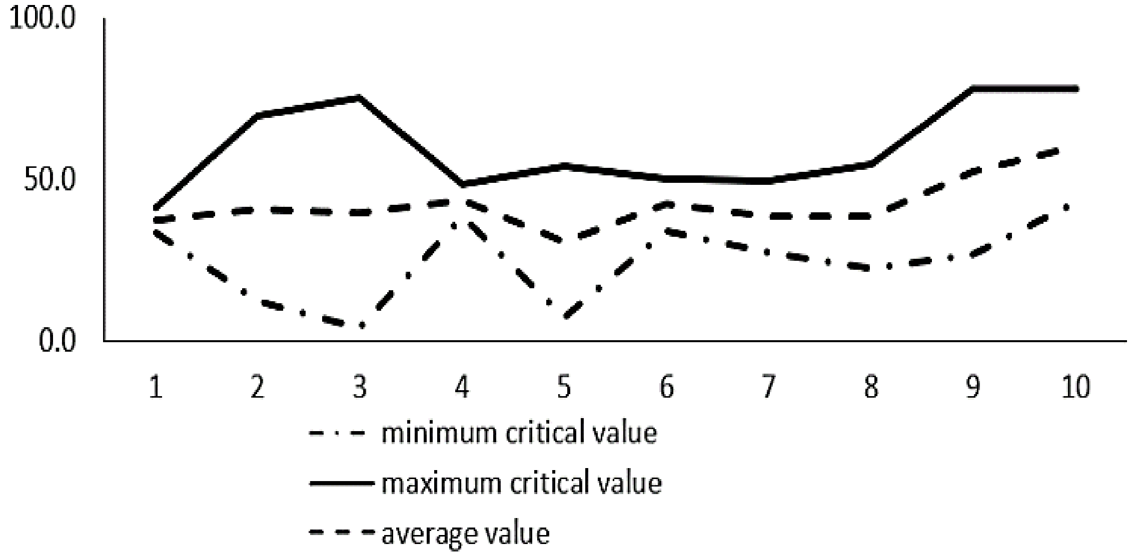

Fig. 3. Critical minimum and maximum user time spent in the system

Data analysis showed that if the student reads the text normally, he will normally answer the question. For example, students number 4, 6 and 7 answered all questions with an "excellent" rating. The worst result was shown by students numbered 2,3, 9 and 10. The rest showed average results.

Conclusion

The following results were obtained from research results:

- Research works on the process of obtaining, processing and storing information in human memory were analyzed.
- Based on the norms of time for receiving and processing a unit of visual and sound information, the extreme maximum and minimum values of the time of storage and processing of information in the human memory were determined.
- Based on the analysis and the results of the experiment a method of assessing user behavior when reading textual information depending on psychophysiological characteristics has been proposed.
- Analysis of the experimental results showed that students have difficulty answering test questions in case of any deviation (in this case, either because the student downloads the text on a computer screen and is busy with some other work, or simply wants to create a "learning" image by clicking on the text). The students who read the full text, usually get high marks.

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The article discusses the problem of studying the interaction of a person and a computer, in particular, the study and assessment of students' activities in the study of textual material. It is proposed to use the psychophysical characteristics of the user, including the characteristics of receiving, processing and storing information in a person's memory. The Saaty scale is used to assess user behavior.

Keywords*: psychophysical characteristics, standards of time to get information, minimum, average, and maximum speed of information processing, user's average time in the system, dispersion of user's time in the system, minimum and maximum user's time in the system, t-distribution function, user behavior.*

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ОЦІНЮВАННЯ ЗНАНЬ СТУДЕНТІВ У СЕРЕДОВИЩАХ ВІРТУАЛЬНОЇ РЕАЛЬНОСТІ

У статті розглядається проблема вивчення взаємодії людини та комп'ютера, зокрема вивчення та оцінювання діяльності учнів під час вивчення текстового матеріалу. Пропонується використовувати психофізичні характеристики користувача, в тому числі особливості отримання, обробки та збереження інформації в пам'яті людини. Шкала Saaty використовується для оцінки поведінки користувачів.

Ключові слова*: психофізичні характеристики, нормативи часу отримання інформації, мінімальна, середня та максимальна швидкість обробки інформації, середній час перебування користувача в системі, дисперсія часу користувача в системі, мінімальний та максимальний час перебування користувача в системі, функція t-розподілу, поведінка користувача.*