Assessment of Level of Professional Competence of Programmers

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Abstract

The objective assessment of the level of professional competence of programmers is an urgent task. In our research we try to find patterns in the behavioral aspect of programmer's work. Therefore we have conducted an experiment and collected gaze fixation data from professional programmers. During the analysis of the results we faced with different kinds of information representation for “back-end” and “front-end” developers. We assume that this factor may be an additional result of the experiment, namely, the programmers of varying specificity are formed of various behavioral situations. We showed that there is a general trend of the nature of the presence of sampling time gaze fixation under the supervision of the work of Web developers, suggesting the formation of a web developer similar behavioral aspects of the work. Finally we proposed the method to assessment of level professional competence of the programmers. As part of future research we propose to investigate the influence different factors(such as operational experience or IQ) to instrumental component of the competence of the programmer.

Keywords. Gaze fixation, eye-tracking, programmer, professional competence, SMI, information representation, Web developers, behavioral aspect of programmer's work.

Introduction

The quality level of the specialist is determined by its ability to solve problems of the real production. Employee's ability to solve actual problems in a rigidly fixed period of time (“here and now”) is what IT company are looking for. This ability is a combination of knowledge of personal and professional competencies. Professional competence as the facility and the ability to operate effectively within their profession, can be estimated by various methods: the biographical method, interviews, testing, and group methods for estimating staff, psycho-diagnostic technique. However, there is a problem to find the objective method of assessing the professional competence of a specialist in general and of a specialist in programming in particular. Competence, as the quality of the system can not be assessed on the basis of a simple summation of estimates of individual components, but there are integrating components of competence: instrumental (practical), communicational, axiological, knowledge-based.

The goal of this research is to identify patterns in the behavioral aspect of programmer's work in general and the assessment of the instrumental component of the competence of the programmer, in particular. A man meets a lot of problems for which solutions he has to use the conscious level of thinking in the profession. As soon as the employee will gain a positive experience of problem solving the process itself will be carried out automatically. It is assumed that the process of collecting information and to establish its compliance to problem will disappear from consciousness, such as the moments of doubt and hesitation. A chain of cognitive and motor operations will be run, instead of choosing process. Periods of doubt and hesitation will only occur in completely new and unexpected situations, during the user experience. Thus we can assume that professionalism can be estimated by the number of unexpected (extreme) situations throughout the working cycle. The question is how to objectively assess and hardware measure the amount of extreme situations in a person work. It could be the basis for the indirect estimation of instrumental (practical) component of competence.

Methodological study

Oculomotor activity is a necessary component of the mental processes which are associated with the procurement, conversion and use of visual information, as well as conditions and human activities. Therefore,

recording and analyzing eye movements, we have the possibility of indirect estimates of internal mental activity. The nature of eye movements could help us to identify: the state of consciousness, the effectiveness of the decision by the user tasks and performance of individual stages of practice. Gippenreyter and her co-workers suggested that saccades restrict any "quantum" processes of regulation, even if the man does not use visual information [1]. According to the concept of automaticity, saccades do not occur in response to a stimulus, and are generated in a certain rhythm, like similar rhythm of the heart and respiration. This is confirmed by the fact that there are saccades with the eyes closed, and there are saccades even for blind people, when seemingly they are not needed. But in the case of mental work saccades followed by much less, intervals between them sharply, increasing by several times. When the mental activity level increase, intervals between saccades also increase (or intervals between saccades) as an arbitrary or involuntary nature. Many experimental studies suggest that most adequately the properties of cycles of mental regulation should reflect the duration of intervals between saccades (IBS or duration of eye fixation), and it can be used as a parameter to assess the complexity of mental processes. The problem boils down to, to determine what ranges of IBS correspond to different levels of mental regulation of the programmers in their daily work.

The experiment

Hypothesis. The positive programmers experiences of solving problems forms the similar behavioral aspects of their work(or automatic behavior).

Metrics. The degree of complexity of human activities associated with the duration of gaze fixation. The duration of gaze fixation it can be used as a parameter to assess the complexity of mental processes. Time of duration of gaze fixation (intervals between saccades – IBS).

Construction. Construction of the experiment was carried out with the following features:

- Participants in the experiment should be a professional domain, in this case is a web development;
- The context of the experiment should not change the habitual user environment as emotional and interior.

Providing the first aspect has been achieved, the fact that the experiment involved 10 programmers from the company FotoStrana (http://fotostrana.ru/). FotoStrana is one of the largest Russian Internet projects with an audience of more than 30 million. The web site is visited monthly by more than 12 million people, and the FotoStrana team creates its own new services. There are more than 50 programmers in the company whose staff are about 100 people. All volunteers are professionals in the field of programming (web development) from the perspective of the employer.

The problem for the providing usual context of the programmer was resolved by field experiment directly in the FotoStrana office (not in the laboratory). In our study, we use the mobile software and hardware system of registration of eye movements - iView X™ HED (Figure 1) produced by the German company SensoMotoric Instruments (SMI), owned by the department of Information technology in the design of the Institute of International Educational Programs St. Petersburg State Polytechnical University. The equipment was placed on a person's head with a helmet. An employee wearing a helmet does not feel the discomfort and get used to it within a few minutes. During calibration the test person was requested to look at the five points which were in the activity field (in our case, the corners of the monitor or monitors, if the programmer is working on two screens). System setup time and calibration usually takes about 5-10 minutes, the experiment itself 25 minutes (of which 5 minutes were subtracted from the environmental situation from the beginning or from the end of the experiment, so the clear recording time was 20 minutes). The case that the test programmers should solve were their current challenges of development, the employee did not pull much of the work timeline.

Figure 1. Field experiment.

Analysis. Analysis of the results was performed using a programming language for statistical data processing and graphics – "R". So, were constructed an IBS distribution histogram for each of the participants (see Figure 2). Visual assessment of the distribution histogram shows a strong deviation from Gaussian shape distribution (distribution of IBS is seems not to be normal). We use the Shapiro-Wilk test with params p-value > 0.05 and indicate that all samples are different from normal. The next step was to compare all samples. We use non-parametric Kruskal-Wallis test. As a result of Kruskal-Wallis test is the fact that our distributions are significantly different (p-value = 6.14e-32). There is a diagram with 10 distributions in Figure 3.

In the construction of diagram uses stable (robust) estimate of central tendency (median) and dispersion (interquartile scale). Despite the fact that samples are statistically distinguishable the diagram shows that the boxes of interquartile ranges overlap by more than 1/3 of its length. Distribution number 8 (see Figure 3) has a different configuration from most others. The median value of this sample is maximal. Next was an analysis of the two extreme (at the median value) of samples - sample number 8 and number 10. It was found that in the experimental group of programmers three people had a specific situation (sample № 8, № 9, № 10). Professional activities of these three developers, is associated with the development of graphical user interface. The seven remaining men occupy positions of the server developer (backend), and the nature of their work is associated more with the processing of textual information, rather than graphical. We assume that this factor may be an additional result of the experiment, namely, the programmers of varying specificity are formed of various behavioral situations. Our assumption is consistent with the results of the University of Eastern Finland. In "Analyzing and Interpreting Quantitative Eye-Tracking Data in Studies of Programming: Phases of Debugging with Multiple Representations" research has shown that the changes in eye-tracking measures reflect both the

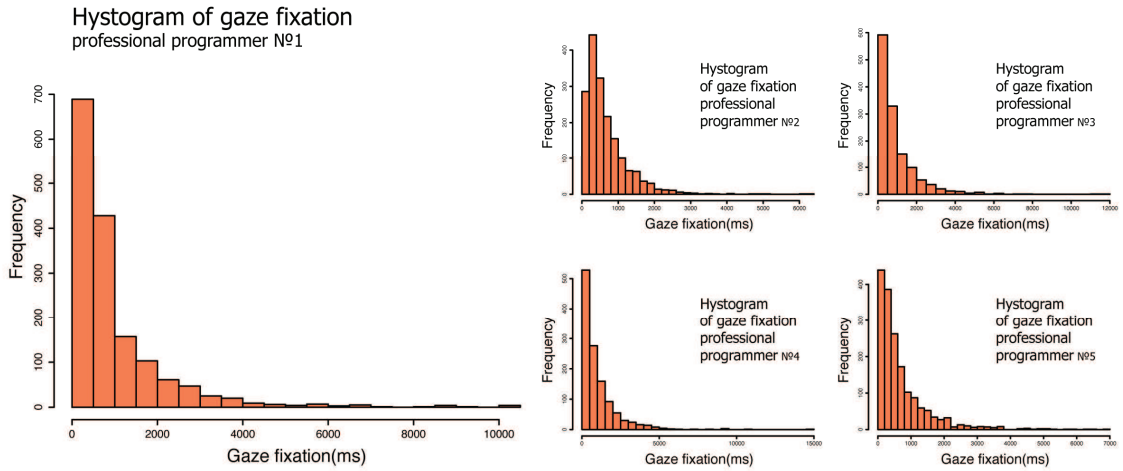

Figure 2. Hystogram of gaze fixation.

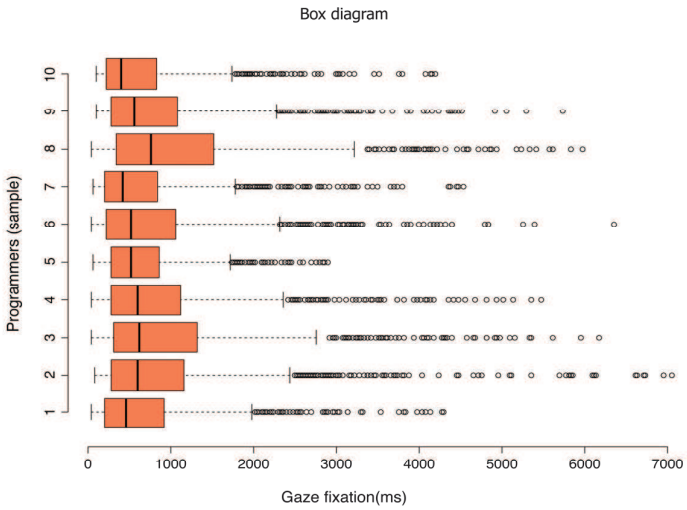

Figure 3. Box diagram.

importance of different representations(textual and graphical) during programming processes and differences in debugging strategies [2,3].

Thus, for further analysis we drop 3 samples. To clarify the statistical differences between the samples was carried out comparing trampled 7 remaining samples. As a result, the confidence level p = 0,05 were: 71,4% (15 out of 21) comparison of the samples showed statistically indistinguishable; 28,6% (6 out of 21) comparisons of samples showed a statistical difference. This suggests that there is a general trend of the nature of the presence of sampling time gaze fixation under the supervision of the work of Web developers, suggesting the formation of a web developer similar behavioral aspects of the work.

Results and Discussion

We use again the Shapiro-Wilk test with params p-value > 0.05 and indicate that the distribution of medians are normal (p-value = 0.39). On this basis were calculated by parametric features: mathematical expectation is 533.29; standard deviation is 76.35. We tend to believe that the obtained value of the mathematical expectation may be a reference, and the spread of it may be a criterion for deciding on the instrumental component of professional competence.

Next, similar experimental actions were carried out with four candidates for the programmer's position in company FotoStrana staff. All four men have already had one month training at the course of school web development Embria before the experiment. This school is a specialized unit, it main task is training in the field of programming for the company FotoStrana. Analysis of the results was constructed similar to the analysis of the gaze fixation of professional programmer. The results are presented in Table 1.

Table 1. Summary table.

Students id	Value of median from IBS sample, ms.	Reference value of IBS, ms.	Spread from reference, ms.	Reference spread, ms.	Correlation with inst. comp. of prof. comp.
Stud №1	480	533.29	53.29	76.35	true
Stud №2	439	533.29	94.29	76.35	false
Stud №3	499	533.29	34.29	76.35	true
Stud №4	699	533.29	165.71	76.35	false

The table shows that the two students (№ 1, № 3) deviation from the reference value of gaze fixation is placed in the reference, so we can talk about their high level of compliance instrumental component of professional competence. As a result, we tend to conclude that there is a general trend in the characters of the gaze fixation time of Web developers work. This fact confirms the assumption that web developers are formed similar behavioral aspects of the work. For an objective assessment of the behavioral aspects of the work could be applied the method of analysis taxonomy of eye movements, namely the value of the gaze fixation time. The main limitation of this study can be seen in the low number of participants (10 programmers and 4 students).

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