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Yuriy SKORIN, Iryna ZOLOTARYOVA
Simon Kuznets Kharkiv National University of Economics

ENHANCING THE EFFECTIVENESS OF USABILITY TESTING FOR USER INTERFACES

The paper analyses the problems of maintaining software quality, namely, usability testing as a direction of ensuring this quality, analyses publications that consider the methods of electro-oculography, electro-retinography, mouse-tracking, eye-tracking, etc. and proves that the issue of improving the quality of software products largely depends on the effectiveness of usability testing. The study is based on the analysis of traditional software testing methods and tools and the proposal of mouse-tracking and eye-tracking technologies as an alternative solution to the problem. Criteria and metrics for assessing the usability of web applications were identified, an analytical approach was used as a methodological basis, which involves a comprehensive consideration of the research object, methods of comparative analysis and classification were used to obtain data, the results were processed using standard statistical methods, and the necessity and importance of usability testing of websites was assessed. The article considers generally accepted rules and recommendations in the field of usability testing, analyses quantitative and qualitative methods of usability testing evaluation, for a more detailed study of the subject of research the ergonomic interaction of a user with an information system, namely with a web resource, studies the main categories of users depending on a number of indicators, and pays special attention to establishing quality assessment criteria based on existing standards of recommendations. the article reviews the process of usability testing of information system interfaces, its analysis and evaluation, analyses the methods of electro-oculography and electro-retinography, mouse-tracking and eye-tracking technologies, and concludes that the use of eye-tracking technology will allow collecting and systematising quantitative and qualitative data on user interaction with the system and will make it possible to optimise the process of usability testing by reducing the time of its implementation. The prerequisites for conducting an experimental study of theoretical results using eye-tracking technologies have been created.

Keywords: testing, usability, quality, website, method, electro-oculography, electroretinography, mouse-tracking, eye-tracking, system.

Юрій СКОРІН, Ірина ЗОЛОТАРЬОВА
Харківський національний економічний університет імені Семена Кузнеця

ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ USABILITY-ТЕСТУВАННЯ КОРИСТУВАЛЬНИЦЬКИХ ІНТЕРФЕЙСІВ

У статті проаналізовано проблеми підтримки якості програмного забезпечення, а саме, usability-тестування, як напрямку забезпечення цієї якості, був проведений аналіз публікацій, в якому були розглянуті методи електроокулографії, електроретинографії, mouse-tracking, eye-tracking тощо і який довів, що питання підвищення якості програмних продуктів, в значній мірі залежить від ефективності usability-тестування, проведене дослідження базується на проведеному аналізі традиційних, методів і засобів тестування програмного забезпечення і пропозиції в якості альтернативного вирішення проблеми, саме технологій mouse-tracking і eye-tracking, було визначено критерії і метрики для оцінки usability веб-додатків, в якості методологічної бази застосовувався аналітичний підхід, що передбачає комплексний розгляд об'єкта дослідження, для отримання даних використовувалися методи порівняльного аналізу, класифікації, обробка результатів проводилася за допомогою стандартних методів статистичної обробки, було проведено оцінювання необхідності і значення usability-тестування веб-сайтів, розглянуто загальноприйняті правила та рекомендації в області usability-тестування, проаналізовано кількісні та якісні методи оцінки usability-тестування, для більш детального вивчення предмета дослідження були розглянуті ергономічні взаємодії користувача з інформаційною системою, а саме з веб-ресурсом, вивчено основні категорії користувачів в залежності від цілої низки показників, особлива увага приділялася встановленню критеріїв оцінки якості виходячи з існуючих стандартів рекомендацій, було проведено огляд процесу usability-тестування інтерфейсів інформаційних систем, його аналіз та оцінку, проведено аналіз методів електроокулографії та електроретинографії, технології mouse-tracking та eye-tracking, зроблено висновок, що використання саме технології eye-tracking дозволить збирати і систематизує кількісні та якісні дані про взаємодії користувача з системою і дасть можливість оптимізувати процес usability-тестування скоротивши час його проведення, створені передумови щодо проведення експериментального дослідження теоретичних результатів за допомогою технологій eye-tracking.

Ключові слова: тестування, usability, якість, веб-сайт, метод, електроокулографія, електроретинографія, mouse-tracking, eye-tracking, система.

Introduction

Contemporary times are characterized by a notable shift within scientific and applied domains, wherein increasing emphasis is placed on the pivotal role played by the ergonomics of software products. This emphasis delineates the software's commercial allure, the extent of its market penetration, and the subjective gratification experienced by users in their interactions.

The practical import of this study is primarily intertwined with the dynamic evolution of the technological landscape, the burgeoning expanse of the Internet, and the imperative to fashion computer interfaces for a diverse user base. The burgeoning proliferation of tasks catering to a broad spectrum of users is propelled by the overarching trend of computerization and the progressive substitution of face-to-face interactions with information systems within select professional spheres.

The incorporation of standards governing software product ergonomics stands as a prerequisite to achieving a satisfactory level of accessibility within an information system. The orchestration of accessibility is seamlessly integrated into the broader spectrum of design and developmental processes, encompassing the methodical delineation of accessibility requisites, the quantitative assessment of accessibility metrics, and the formulation of a discernible criterion for verification within the purview of user engagement [5].

The endeavor to define accessibility assumes paramount significance due to the intricate interplay among users, tasks, and various other components constituting the user experience. Notably, a service, system, product, or apparatus can manifest varying degrees of accessibility across diverse use cases, an aspect that assumes heightened prominence particularly in scenarios involving distinct user segments characterized by specific disabilities [6].

To enhance the efficacy of usability testing, it is essential to perform a comparative analysis of usability testing techniques, particularly eye-tracking and mouse-tracking, and establish the necessary conditions to execute an experimental examination of theoretical outcomes utilizing these technologies.

Related works

An analysis of publications has shown that the issue of improving the quality of software products depends largely on the effectiveness of usability testing, which has been the subject of a number of studies [7-14].

The analysis and application of the electro-oculography (EOG) method is discussed in publications [15-16]. EOG records the electrical activity of the eyes at high speed using electrodes placed around the human eye. Vision control systems use this method to obtain EOG signals which, after processing, determine the direction of the user's gaze. This is particularly important for people with disabilities.

In this study [17], the measurement methods used in oculographic studies are analysed. The metrics used to quantify various psychophysiological states of the subjects are systematized by the authors. Through these metrics, it is possible to identify the elements of visual interest based on their size, brightness, colour, and location. The metrics can be divided into three groups: (1) those related to oculomotor activity, (2) technical indicators of eye-tracking performance, and (3) data tracking the actions of subjects as a result of keystrokes and mouse clicks. From the standpoint of practical tools for managing consumer attention in an information-saturated competitive environment, the paper discusses the capabilities, mechanisms of application, and possibilities for analysis of each group of metrics. The paper places particular attention on the overview of specialised paid and free software capabilities for oculographic research.

Publications [18-19] have described the use of the electroretinography (ERG) method. ERG is a method for objectively studying the functional state of the retina by recording biopotentials during light irritation. ERG enables an objective assessment of the functional state of different retinal layers and neurons. Electroretinography plays a crucial role in diagnosing retinal diseases and engages the attention of morphologists, ophthalmologists, physiologists, and electrophysiologists for scientific research beyond being a diagnostic method. Contemporary technological capabilities enable the identification of subtle disturbances in retinal bioelectrical activity, which forms the basis of initial and differential diagnosis. Electroretinography presents a characteristic diagnostic effect and opens up new aspects of the mechanisms of visual dysfunction by relying on our understanding of the neurophysiology of the visual system and molecular biology, which enables not only gene mapping and cloning but also comprehending the subtle changes in photoreception's structure, commonly causing hereditary retinal diseases. Moreover, it aids in the search for innovative initial diagnostic methods and pathogenetically-grounded treatments.

Several studies have addressed the modelling and geometry of vision [20-24]. The study has unveiled the unique features of visual perception, the understanding of which is essential in explaining many of the observed phenomena, given that 90% of information is processed by the brain through the eyes. The knowledge of the particularities of vision can aid in the analysis of the resulting image.

Publication [25] contains relevant information about the free software Mill Mouse, which uses oculography and Eye Tracker 4C to control the mouse and allow users to move the pointer to their line of sight. It can click when the user is looking at a fixed position or blinks. Additionally, Mill Mouse supports scrolling and compensates for involuntary eye movements.

The analysis and uses of the mouse-tracking method are described in reference [26]. Mouse-tracking is a method that employs software to collect data on the position of the user's mouse cursor on a computer. The objective is to automatically collect more detailed information about what users are doing, typically to enhance interface design. Reference [27] highlights that this technology enables the capture of all mouse movements of a website visitor. It is widely accepted that the mouse cursor always follows the visitor's gaze. This capability facilitates the identification of the content elements to which the user pays special attention, as well as the order in which the user studies them. The obtained data is represented on a map, highlighting the most visited areas with a bright colour. This mapping image is superimposed on a screenshot of the experimental page. This approach provides an accurate location for the most visited areas. If there is not any significant button, form or link among the hotspot areas, their design or location must be modified. According to [28], Mouse Tracking can be utilised to record every movement of the user's cursor on the site. This enables tracking of user's attention-focusing areas and their order of studying the whole page.

As per publication [29], eye-tracking is a type of technology that tracks gaze lines or points, also known as

eye-tracking technology. According to paper [30], eye-tracking has a wide range of applications such as marketing research, development of high-quality interfaces, improving usability, increasing conversion rate, determining advertising strategies, and studying user experience. Eye-tracking is considered impartial as it captures natural human reactions by studying the movements and reactions of the pupils, which cannot be imitated. This is another significant advantage of the method.

In article [31], ongoing research is described that aims to optimize human-computer interaction for emergency planning and decision support scenarios. The objective of this research is to explore the possibility of using low-cost eye tracking system with open source software in interpreting geospatial images. The project referred to in this article also includes an educational aspect.

Purpose and Task Statement

The aim of this article is to enhance software by improving the efficiency of usability testing. This study analyses conventional techniques and tools for assessing the usability of software such as 'testing in the corridor', remote usability testing, expert review, 'paper prototype testing' and automated usability testing [32]. Additionally, we propose alternative approaches to the matter. This article suggests alternative approaches such as the electro-oculography method, the electro-retinography method and technologies such as mouse-tracking and eye-tracking for further analysis. If we conclude that capturing quantitative and qualitative data on user interaction with the system via eye-tracking and mouse-tracking technologies helps systematise the data and streamline the usability testing process by reducing time, we can explore the theoretical outcomes by using these technologies. Subsequently, we can conduct an experimental study and compare the results against the other methods mentioned above.

The scope of this research aims to define a set of comprehensive research objectives that collectively lead to a deep understanding of the intricate interplay between software product ergonomics and user interfaces.

Careful exploration of ergonomic indicators in user interfaces will reveal the essential aspects of user experience in the digital realm.A comprehensive understanding of the intrinsic attributes that synergistically shape user interactions can be achieved by systematically dissecting and analyzing these indicators.Clarification of both qualitative and quantitative criteria for assessing usability. This research aims to establish a comprehensive framework that encompasses both qualitative and quantitative criteria for assessing usability testing.The dual-pronged approach aims to establish a nuanced methodology that captures both tangible metrics and intangible facets contributing to the holistic user experience. This study aims to meticulously identify and explain the key features inherent to the employed usability testing methods. The research seeks to explore the intricacies of these methodologies to understand the multifaceted layers underlying the efficacy and comprehensiveness of usability evaluations. As part of this research, software product usability will be analyzed using cutting-edge eye-tracking and mouse-tracking technologies, representing an innovative approach.

Usability testing will be executed through eye-tracking and mouse-tracking methods. In this research, a critical phase involves executing hands-on usability testing using the previously mentioned eye-tracking and mouse-tracking methods. The aim of this empirical endeavour is to bridge the gap between theoretical foundations and practical implementation. This will forge a visible link between conceptual frameworks and real-world applicability.

Comparison and analysis of usability testing results. The research will culminate in conducting a rigorous comparative analysis of usability testing results. The final phase aims to distill meaningful insights by meticulously scrutinizing and examining the data, thereby providing a conclusive panorama that highlights the efficacy and implications of the research.

The effectiveness of usability testing for user interfaces

Usability testing is a type of software testing that focuses on non-functional aspects. It is commonly classified into several categories including understandability, learnability, operability, attractiveness, and relevance. Usability testing is generally classified into three main categories: exploratory, evaluative, and comparative [32].

Modern models of software quality assessment frequently use the term "usability" to describe the ergonomics or usability of a software product.

The analysis indicated that including functions and properties that offer an additional ergonomic effect in certain usage conditions of the software product can enhance the usability indicator. In order to determine the level of ergonomics, assessing both user satisfaction and labour productivity when using the software is necessary.

The primary usability criteria are [1-4]: product effectiveness, which refers to the ratio of achieved results to resources used; productivity, which refers to the extent of resources that a user must expend to attain goals with accuracy and completeness; and satisfaction, which refers to the degree of comfort and ease of use.

To assess the quality of usability testing, it is necessary to establish testing objectives linked to the user's effectiveness, efficiency, and satisfaction, as well as the characteristics of the component's usage conditions. Figure 1 illustrates the components and dependencies between them in a schematic manner.

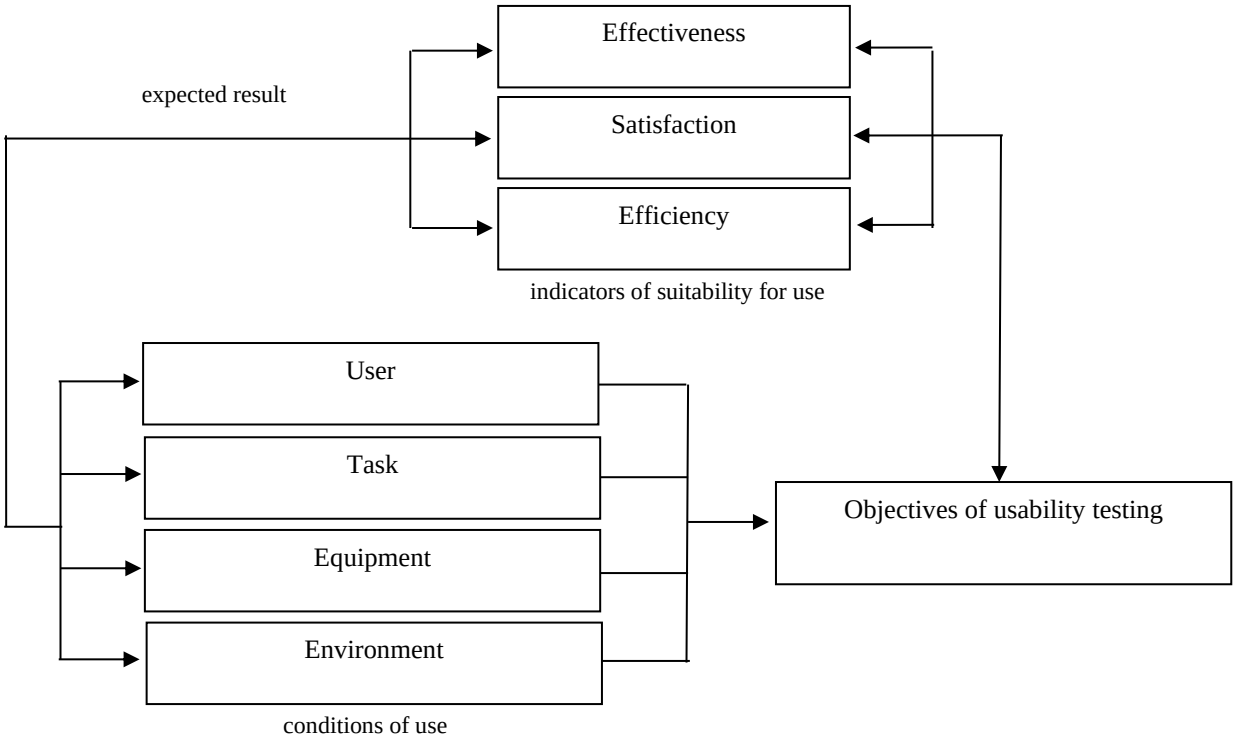

Fig. 1. Structure of suitability for usage

The design of software, services, equipment, and systems takes usability into consideration. Usability is the property that enables users to apply software products with the necessary efficiency, effectiveness, and satisfaction.

While developing a software product, it is necessary to identify usability requirements systematically. This includes usability indicators and software usage conditions. These conditions help to create project goals that are appropriate for verifying the finished software product.

When designing software products, systems, services, and equipment, it is important to consider the accessibility criterion. This criterion has an impact on the range of users who can easily utilise them. Accessibility is a characteristic of software that enables people with a wider range of abilities to achieve the set goals in specific conditions of use. Increasing accessibility can enhance the quality of usability and widen the range of users who can use a system, product, equipment, or service.

Compliance with software product ergonomics standards is necessary for achieving an acceptable level of accessibility in information systems. Planning for accessibility is an essential aspect of the design and development process, which involves systematically defining accessibility requirements, measuring accessibility, and specifying verification criteria for defined usage conditions. Defining accessibility is valuable due to the intricate interactions between users, tasks, and other elements of the use case. Different groups of users with disabilities may experience varying levels of accessibility when using a service, system, product or equipment in different use cases.

Standards in the field of usability testing for user interfaces contain guidelines for application and a description of the requirements for assessing the user interface of an information system. Such standards govern the quality of development and testing of user interfaces for software products.

The ergonomic principles for establishing a dialogue between users and an information system encompass suitability to the task, informativeness, fulfillment of user expectations, learning capacity, controllability, error tolerance, and individualization.

These principles facilitate the comprehension of software usability needs.

Human-centered design of interactive systems makes the existing research findings in ergonomics and usability accessible, enabling their application in testing the user interface. It also complements existing design methodologies and introduces the principle of a human-centered approach to designing information systems. This can be implemented in various software development and design processes.

Analysis and correct interpretation of the obtained data are important parts of carrying out usability testing. Quantitative data is suitable for identifying the most serious defects in an information system and for comparing different interfaces. Measurement results can be influenced by human factors, which leads to the need for a more detailed examination of the obtained information.

In the past, eye movements were studied using simple observations that required significant time to collect and process the information obtained. Initially, the primary field of application for eye reaction information processing

was the investigation of the psychological principles of human visual perception. Currently, the application of eye reaction information processing has been rapidly expanded, following the development of powerful software tools for processing various types of influences.

With regard to eye movement registration methods, two main groups can be distinguished: contact methods that register the impact directly around or on the cornea with the aid of sensors, such as electro-oculography, photo-optical, and electromagnetic methods; and non-contact methods, such as photoelectric, film, and video registration.

The electrooculography (EOG) method utilizes the inherent electrical properties of the eyeball. Due to the cornea's electrical positivity in relation to the retina, the eyeball is a dipole by its physical nature. As the electrical axis of the eyeball aligns with the optical axis, it provides a method of tracking gaze direction. Alterations in the potential difference between the cornea and the retina are identified through changes in the potential in the tissues bordering the eyeball. Electrodes placed horizontally around the ocular cavity detect movements of the eye. The method has the disadvantage of low resolution, but the advantage of low equipment cost. Eye movement recording does not disrupt the natural conditions of the subject's visual activity, and it can be performed in light or dark conditions, with eyes open or closed.

The photo-optical method involves directing a narrow beam of light at the eyeball, which is then reflected from a miniature mirror mounted on it. The reflected beam enters the input of the photo-registering device. This method's advantage is its high resolution. However, one disadvantage is the need to strictly fix the subject's head. Registration must be carried out exclusively in a darkened room when using the contact method.

The contact electromagnetic method has the same high resolution but is more convenient when registering the user's gaze. This method is based on the principle of changing the intensity of the electromagnetic field when the distance between the emitter and the receiver changes. The emitter is fixed to the eyeball using a contact lens, central suction cup or ring. The receiving coils are placed motionless around the subject's head. This method's advantage is its high resolution, but its contact nature is a significant disadvantage.

The photoelectric method converts a beam of infrared light reflected from the cornea into an electrical signal. This is a complicated and expensive method. It is worth noting that the last two methods are no longer in use.

The mouse-tracking method allows for the monitoring and recording of all user cursor movements on the website. This enables tracking of user attention on the site, including their preferences, and the sequence in which they engage with the page. Professionals can achieve impressive outcomes with this information [28]. The data is then compiled into a special map highlighting the most popular areas. A screenshot is captured of the page under study and superimposed with a map of mouse movements.

The mouse-tracking method offers several advantages, including a visual representation of user activity on the site, high-quality usability testing, identification of weaknesses in the areas of the site where users spend less time, low software cost, and increased conversion rates through targeted improvements based on reports. There are, however, some disadvantages to this method. These include a large margin of error due to a possible mismatch between the position of the mouse and the user's focus point. This can result from a delay between the user moving the mouse and them actually looking at the corresponding point on the screen. Furthermore, this method is not able to determine the emotions experienced by the user, as a visitor's attention may be attracted to something negative, even if the emotion is not explicitly negative. In addition, this method can only be used for pre-existing websites. Considering these limitations, the mouse-tracking method is recommended as one of several options for assessing website usability, but not as the main method. Furthermore, it should be noted that this method is not the primary means of evaluation. Rather, it is one of several evaluation methods that is most effective when used in conjunction with eye-tracking [27].

Eye recording is currently in active use, but due to its high labour intensity, it has not been widely promoted. Today, video motion recording has become popular as personal computers and digital video cameras are widely available. A point source of infrared radiation illuminates the subject's eye when high-speed pictures are taken by an infrared video camera. The position and size of the pupil, which appears as a dark oval in infrared rays, and the position of the corneal glare, a reflection of the infrared light source on the cornea, are determined by image software. The direction of the gaze is calculated by the system based on the vector connecting the corneal glare and the centre of the pupil. This technique's non-contact nature and ability to record the amount of opening are its advantages.

Currently, the most commonly used method is eye-tracking based on video recording of the direction of gaze. The primary components of such systems are one or more video cameras, appropriate software, and an infrared light source [27, 28].

The eye-tracker method captures a person during the usability testing process using cameras. The captured footage highlights the eyes and uses triangulation to determine each eye's position in space relative to the eye-tracker. Using high-resolution cameras ensures accurate gaze direction determination. The frame rate and delay of camera movements reveal how many images per second the camera captures and how long it takes for the images to be available for further processing [29]. Calibration is carried out before testing because each person has unique physiological eye characteristics. In order to obtain accurate and reproducible experimental data, it is necessary to use correct and reliable calibration. During calibration, the participant is instructed to consistently fixate their gaze on a series of calibration markers. Simultaneously, the eye-tracker records the pupil coordinates that correspond to the positions of each calibration marker [1].

Infrared light sources are directed towards the subject's eyes using projectors, enabling the determination of gaze direction across various conditions. Since the human eye is not sensitive to infrared light, the subject does not feel any discomfort. The cornea experiences glare or reflection due to the projector.

Two methods of infrared pupil illumination exist: the light pupil method and the dark pupil method. The distinction between these methods is their relative illumination source location in relation to the camera. When the infrared light is aligned parallel to the camera's optical axis, the eyes function as a secondary reflector of the light that is projected and reflected off the retina, resulting in a light pupil effect analogous to the red-eye effect encountered in photography. When the lighting source is not aligned with the camera's optical axis, the secondary reflection from the retina does not reach the camera, causing the pupil to appear black.

The gaze trajectory is determined by computing the vector between the pupil's center and the infrared light source's reflection from the corneal surface. By knowing the eye's position in relation to the screen and the gaze direction, the gaze point of the participant on the monitor screen is computed. The eye-tracker reads the gaze trajectory's coordinates several dozen times per second, and if unchanged, the time is accumulated. Once the threshold value, approximately 100 ms, is exceeded, the device registers a fixation. Because healthy people's eyes are consistently moving, even when looking at a specific point, the gaze coordinates include a threshold radius (30-50 pixels). If the coordinate values remain within the specified circle, fixation continues. However, if they go beyond it, a new fixation begins.

The heat map is the most commonly used type of eye-tracker data visualisation. Eye-tracker systems provide heat maps, which report the frequency of gaze movements by subjects in different parts of the software, presented as a page divided into colour-coded areas based on cursor movement statistics.

The above method enables calculating the gaze position with high accuracy, analyzing eye movement trajectory, and determining the gaze direction. Eye-tracking technology is vital for scientific research on visual perception processes or those employing visual stimulation. It is also useful for evaluating ergonomics and improving software product interfaces.

The advantages of the eye-tracking method are: the ability to identify areas of increased user attention, where the user's gaze was involuntarily delayed or returned several times, to reproduce the trajectory of gaze movement, the sequence of gaze fixations and the delay time, to select the most successful location of interface elements (buttons, images, etc.) in terms of user comfort, taking into account the user's needs, to set an algorithm that helps users navigate the site, which allows you to create a more effective site design, to process the data received and display several results. The disadvantages of eye tracking are Zones of increased attention can be formed for various reasons, eye-tracking forms zones without determining the principle on which they are formed (necessary information, design or location), misinterpretation of the received information can change the course of further development in the wrong direction, if the user's gaze repeatedly returns to a certain part of the screen or there is a long fixation, Taking into account the above-mentioned disadvantages of this method, it is proposed to combine usability testing methods with other methods in order to increase the efficiency of software quality evaluation.

The analysis showed that both mouse tracking and eye tracking are very convenient and useful tools, and it is rather pointless to oppose them. You just need to understand what you want to achieve and what parameters you want to measure [23].

The paper [23] states that if there was a cursor in a certain place on the page, the visitor looked there with a probability of 84%, and if he did not look at that place, there was no cursor there with a probability of 88%. However, this does not mean that the cursor was everywhere the visitor looked. In other words, the heatmap of mouse movements shows a part of what the user probably saw. Therefore, mouse movements cannot be used to estimate the temporal parameters of information perception, including the sequence of this perception. In other words, there is a certain correlation between cursor movement and gaze, but it is not entirely clear how significant it is and in which cases it is applicable.

Eye-tracking's primary drawback is its high cost. This includes expensive equipment, hiring highly qualified staff, and paying for respondents' recruitment and compensation. Yet, if we consider the type of data gathered and its potential cost-saving outcomes, the research price is not excessively high. When compared to other methods, eye-tracking offers a wider range of research possibilities. Mouse-tracking is limited to exploring websites and only allows restricted analysis of software interfaces. However, eye-tracking enables the study of additional materials such as design layouts and prototypes, printing, and commercials that don't require user interaction.

Testing layouts and prototypes is one of the most effective ways to employ eye-tracking. This method enables error detection at the early stages of development, thereby reducing the cost of fixing them. While mouse-tracking is limited to examining websites and application interfaces, eye-tracking can be utilised for examining design layouts, prototypes, printing, commercials, and other materials that do not require any user interaction.

Figure 2 illustrates the findings from a comparative analysis of traditional testing methods, mouse-tracking and eye-tracking.

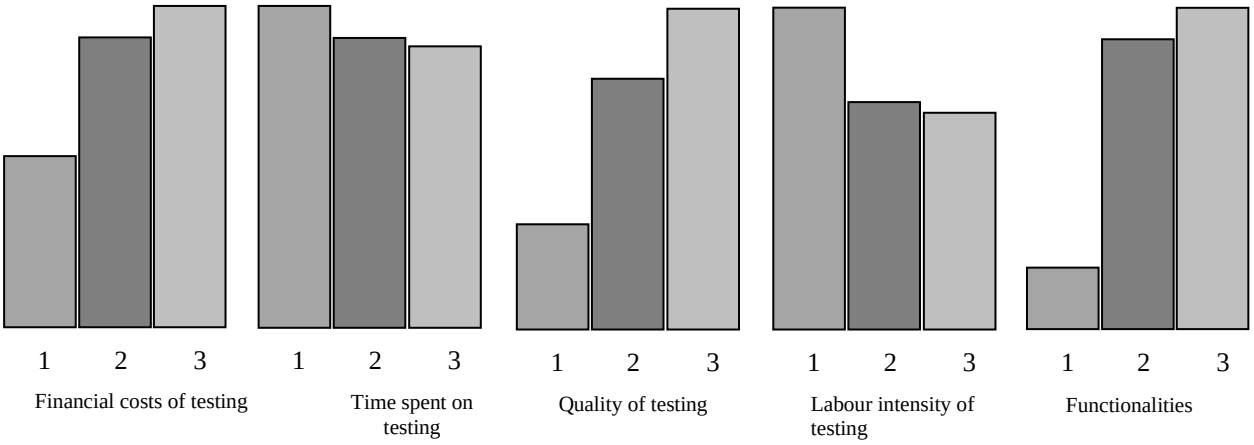

Fig. 2. Comparative analysis of software usability testing methods, where 1 - traditional testing methods; 2 - mouse-tracking technology; 3 - eye-tracking technology.

We formulated a sample usability testing task for the tax service website, based on the previously mentioned tasks:

1. Task. The task is to obtain personal information on the website. To access personal information, users must log in to the individual's account.

1.1. Find your individual tax number.

1.2. Find information about taxable objects and view information about accrued taxes.

1.3. Determine the current status of tax accounts.

1.4. Find the series and number of an identity document.

1.5. Find information about certificates.

1.6. Find information about income from the income tax return.

2. Task. The objective is to retrieve reference information from the website. To obtain more information, the user must download either a strengthened qualified electronic signature key or one of the two versions of a strengthened unqualified electronic signature to their personal account on their computer.

2.1. Send a request for information about the status of payments.

2.2. File a complaint against an act of a tax authority of an abnormal nature.

2.3. Send an application for clarification of information about the objects.

2.4. Submit an application for property tax relief.

2.5. Send a request for information about the status of tax accounts.

3. Task. Task description. Notification of changes in personal information should be provided for individuals. To report the presence of real estate or a vehicle, an unqualified electronic signature key must be created and a verification key certificate obtained.

3.1. Notification of the tax service of the change of place of registration.

3.2. Notify the tax authorities of the ownership of real estate or a vehicle.

3.3 Notify of opening an account in a bank located outside the country.

3.4. To notify the tax authorities of failure to file personal income tax returns.

4. Task. Preparation of standard documents of an individual. To fill out and send receipts/applications/declarations, the user needs to download a software program to fill them out on his/her computer. Also, the generated document must be signed with an enhanced qualified or unqualified electronic signature from the personal account before being sent to the tax authority.

4.1 Send a statement of receipt (non-receipt) of the social contribution.

4.2. Send/fill in the declaration online.

4.3. Send an application for confirmation of the right to receive property deductions.

4.4. Send an appeal to the tax authority.

5. Task. Payment of mandatory taxes by an individual. To pay bills, you are offered to download completed receipts or make electronic payment through the services of partner credit institutions.

5.1. Pay off tax arrears.

5.2. Pay real estate tax.

5.3. Pay income tax.

5.4. Pay the state fee for registration of an individual entrepreneur.

6. Task. Addressing a personal question to the employees of the tax service of an individual.

6.1. Submit a free-form request.

The developed test tasks cover some of the variations of the tasks set and show the main purposes of using the tax service website.

The following were chosen as fixed usability metrics:

the time taken to complete a test task is used to determine the system's learning curve;

the presence of user errors, such as selecting menu items, changing environment settings that are not required to solve the task, is used to determine the success of the task;

subjective user satisfaction will be assessed using a questionnaire, etc.

Additional questions asked to the test subject after completion of the test tasks form a subjective assessment and reflect the test subject's general attitude to the website under test. This score depends on the user's subsequent visits to the site. The formed test task allows to qualitatively and quantitatively evaluate the user interface of the tax service website and determine the degree of usability of this resource [33].

Conclusions

This study explores the concept and definition of user interface usability in line with the standards of ergonomics and human-system interaction. The study identifies three criteria, namely efficiency, productivity, and satisfaction, for assessing usability. Obtaining a sufficient level of usability requires the application of standards in this area.

Furthermore, the article analyses the principal standards of user interface usability, which describe the requirements for developing and testing an information system's user interface.

The study examines the characteristics of software quality assessment, namely functionality, reliability, practicality, efficiency, support, and mobility.

The standards and criteria that are considered are used to develop the user interface. The design process's primary stages and the significance of usability testing at each stage are analysed. The process comprises requirement identification for the future system, system specification, implementation, verification, and system implementation and support. Usability testing is a crucial feature of the technology being considered as it enables the direct identification of ergonomic issues during the development stage of the user interface. This, in turn, will help reduce resource costs during system design.

The article explores the criteria used to assess the usability of both qualitative and quantitative methods. In this study, we examine the quantitative method of tracking user actions, known as mouse-tracking. We identify the advantages and disadvantages of this method.

The article also examines the technology behind the pupil capture method in eye-tracking. Nowadays, the most commonly used technique relies on infrared light illumination to record a video of the gaze trajectory on the face. This technique allows the subject to remain as natural as possible when working with the system under assessment. The document covers the features of pupil capture, its quantitative indicators, the operating principle, and the technology's benefits. This study also considers different types of visualisations for eye-tracking results, including gaze graphs, heat maps, bee swarms, cluster analysis, and zones of interest. Although the method of eye-tracking has its limitations in usability testing, it is currently one of the most effective among existing methods.

This study analyses the technological aspects of the eye-tracking method. This study identifies the features and positive attributes of the eye-tracking method. The technology described enables the identification of weaknesses in the development of a user interface. Comparing the predetermined usability criteria with the test results exposes issues of usability in the design of the user interface. It has been established that it is highly important to conduct usability testing during the development process to achieve high-quality software products. Characteristics identified through quality assessment determine the final appearance of the product at the end of its development. Previously set tasks facilitated a fresh perspective on user interface usability testing process.

We employed an analytical approach as a methodological basis that involves thoroughly considering the research object. To obtain the data, we used comparative analysis and classification methods. Subsequently, we processed the results using standard statistical methods.

We examined the primary challenges that arise when evaluating usability qualities during various testing methods, including the survey, mouse-tracker, and eye-tracker methods. It was found that mouse-tracking technology enables the examination of websites and, to a certain extent, application interfaces. Eye-tracking technology, on the other hand, is useful in the study of design layouts, prototypes, printing, commercials, and other user-inactive materials.

To provide a detailed analysis of the research topic, we examined the user's ergonomic interactions with the information system, specifically with the web resource. The main user categories were analyzed according to gender, age, physical and psychological condition, and citizenship. Special attention was given to establishing quality assessment criteria based on existing standards.

According to domestic and foreign studies, the modern gaze-tracking based method for usability testing is more effective as it provides both significant quantitative and qualitative results in a single testing session.

The results of the usability testing demonstrate the qualitative differences between mouse and eye-tracking. In the usability testing, it was discovered that the use of eye-tracking method facilitates the acquisition of more qualitative and quantitative data about the software product than mouse tracking, revealing more detailed information about the test subject's attitude towards the website interface. Nonetheless, in situations where it is necessary to comprehend the intentions rather than the subconscious behaviour of customers, which can be subjective and deceitful, mouse-tracking can provide more valuable

information. The integrated eye-tracking testing method is highly efficient for software interface testing as it includes data obtained from other usability testing methods.

Empirically obtained data accurately and extensively described the eye-tracker assisted testing features, revealing the problem in the best possible way. Considering these characteristics in detail indicates that they are optimal and can be supplemented by other methods, depending on the usability testing goal. Eye-tracking technology has a high volume capacity for system usability analysis, making it relevant for designing and implementing software products.

To optimize and rationalize website development processes, it is crucial to employ modern usability technologies and tools. This research provides a comprehensive study on theoretical and practical aspects of improving software quality through the direction of usability testing. It presents a comparative analysis of the effectiveness of traditional manual approaches versus the latest advances in mouse-tracking and eye-tracking technologies in ensuring software quality.

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Yuriy Skorin **Юрій Скорін**	PhD, Associate Professor of Information Systems Department, Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine. e-mail: skorin.yuriy@gmail.com https://orcid.org/0000-0002-4613-3154	к.т.н., доц. кафедри інформаційних систем, Харківський національний економічний університет ім. С. Кузнеця, Харків, Україна.
Iryna Zolotaryova **Ірина Золотарьова**	PhD, Professor of Information Systems Department, Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine e-mail: iryna.zolotaryova@hneu.net https://orcid.org/0000-0002-1553-2849	к.е.н., проф. кафедри інформаційних систем, Харківський національний економічний університет ім. С. Кузнеця, Харків, Україна.