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Alexandr I. Tyshchenko[1], student of the System software department, E-mail: alexandrt1998@gmail.com, ORCID ID: 0000-0003-4309-3449
Tatyana V. Onishchenko[1], senior lecturer of the System software Department, E-mail: tonishenko@gmail.com, ORCID ID: 0000-0003-0717-6191
Katherine A. Pysarenko[1], candidate of technical sciences, senior lecturer of the System software Department, E-mail: katherine.gorodnichaya@ukr.net, ORCID ID: 0000-0001-9573-9315
[1]Odessa National Polytechnic University, Shevchenko Avenue, 1, Odessa, Ukraine, 65044

THE WEB-INTERFACE AVAILABILITY MODEL FOR PEOPLE WITH DISABILITIES

Abstract. *Today there is a situation in which customers reveal a great interest in ensuring the availability of the contents of the Website, as this allows expanding the target audience. The extension of the audience is supposed to be due to the possibility of interaction between groups of users with disabilities with a Web interface. At the same time, the quality of this interaction depends on the level of accessibility of the Website interface. The transition to Websites that have an average or even high level of accessibility is carried out through the implementation of solutions, most of which are clearly standardized. However, choosing a solution to move to a new level of accessibility of the Website's interface, developers are faced with the following problem: a lack of understanding of various types of violations related to the health of users leads to the fact that, as a result of development, a product is released onto the market that is still not available for certain user groups. This mainly concerns people who have cognitive impairment. To solve this problem, it was proposed to build a Web-based accessibility model that takes into account the main types of user health problems, and also follows the recommendations of the WCAG 2.0 standard. At the first stage, an accessibility model was formulated, called the classic. The components of the classic accessibility model were determined by analyzing existing Websites. To increase the level of accessibility, an expanded accessibility model was developed. The implementation of this model allows us to ensure, in addition to improving the quality of interaction between users with disabilities with the Web interface, also improving the user's perception of the information posted on the Website. The testing of the Website, implemented on the basis of the expanded accessibility model, was carried out at Odessa National Polytechnic University. For the experiment, a group of thirty students was formed. More than twenty-five percent of students were people with disabilities. As a result of the experiment, it was proved that the implementation of the expanded accessibility model allows to increase the quantitative indicators of the following parameters of the Website interface: the quality of user interaction with the web interface and the quality of user perception of the information presented on the Website. Based on the results obtained, a conclusion was made about increasing the level of accessibility of the Web interface by twenty percent.*

Keywords: *standard; Website; accessibility; Web-interface; health problems*

Introduction

The development of interfaces of most modern Websites, until recently, was aimed only at the audience that did not have health-related disorders. However, today people with limited abilities are trying to actively use the Internet, Websites and various Web applications. That is why the question of expanding the user audience of Websites comes to the fore. In this regard, the task of developing a Web interface that will be designed not only for ordinary users, but also for people with disabilities, becomes urgent.

A further increase in the accessibility level of Website interfaces is possible by implementing a model that takes into account all the main types of violations related to the health of users.

The purpose of writing this scientific publication is to increase the level of accessibility of a Website by developing an expanded accessibility model for people with disabilities.

According to this purpose, we can formulate next tasks:

– to build a model of accessibility of Web interfaces, based on the analysis of existing sites, which we will call the classic

– which we will call the classic;

– to describe the components of the classic accessibility model;

– to build an extended model for accessibility of Web interfaces;

– to describe the components of an extended accessibility model;

– to implement an extended accessibility model;

– to test the Web interface, developed on the basis of an extended model of accessibility.

Statistical methods were used to collect and process information as **main research methods**. When applying these methods, the following sequence of actions was observed: statistical observation, tabulation and grouping of data, calculation of general indicators (absolute and relative values).

Formulation of the problem

In this scientific publication, we propose one of the options for solving the problem of poor quality

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of interaction between users with disabilities with Websites as a consequence of the low level of accessibility of Web interfaces. The low level of accessibility allows you to receive information from Websites, as well as perform transitions between Web pages to users who have no health restrictions [1]. At the same time, a group of users who have a certain kind of health-related disabilities do not have the ability to interact with elements of the developed Web interfaces.

In addition, there is a situation in which the developers of Websites ensure availability of the interface at resolutions of 1440 * 900 or even more. However, with a decrease in the resolution of the browser window, there is no change in the location of the elements and their sizes [2].

Analysis of recent publications

A fairly large number of publications, which refer to the availability of Web-based interfaces have appeared recently. In this scientific publication we analyze nine publications on this topic.

Works [3-5] describe the characteristic of accessibility. The characteristic is considered for the time period from 2005 to 2018. The starting point is the formation of WCAG standards (Web Content Accessibility Guidelines) to ensure uniform accessibility requirements for Websites. The specification of the accessibility standard includes a listing of accessibility levels.

Publications [6-7] consider technological ways to ensure the possibility of user interaction with the Web interface by using specialized controllers.

The next groups are publications [8-11]. To increase the level of accessibility, they suggest structuring html elements, choosing a visual representation of elements and animations (styling elements), using element attributes when working with ScreenReader. ScreenReader is a technology that allows you to transform the text content of a Web-based interface into audio format.

In [12], the dependence of the number of sales on the level of availability of a Website is considered. The audience, which can interact with this interface, is expanding by providing a certain level of interface accessibility. If this site is an online store, then it expands the list of its users. However, this publication argues for the need for accessibility, but does not indicate a way to achieve the required level of accessibility.

The difference between all these publications from this work is that this scientific publication considers the accessibility model, which takes into account various types of user health problems and provides an improvement in both user interactions with the Web interface and their perception of the information provided on a Website.

1. Key Standards and Guidelines for Website Accessibility

The functioning of the software within the Internet requires standards. The W3C (World Wide Web Consortium) is responsible for the development and implementation of these standards. One such standard is WCAG. It is a set of recommendations, the implementation of which ensures the availability of Web content. Availability is a characteristic of the Web interface, which expresses the possibility of obtaining information when interacting with the interface by all user groups, including people with disabilities. First of all, accessibility is aimed at people with disabilities. WCAG 2.0 was published in December 2008 and became the standard ISO, ISO / IEC 40500: 2012 in October 2012. WCAG 2.1 became the W3C recommendation in June 2018 [13].

The WCAG 2.0 standard identifies 4 basic requirements for Websites: comprehensibility, reliability, perceptibility, manageability. Based on the compliance of the analyzed object with these criteria, 3 levels of site accessibility are distinguished: minimum (A), medium (AA), high (AAA) [14]. A transition from one level of accessibility to another is possible.

The above provisions of the standards and, as a result, accessibility levels were formed on the basis of the analysis of options for restricting a person's ability to interact with the content of a Web page. A comprehensive study of these restrictions will allow you to build a model of Website accessibility that will enable people with disabilities to be included as a target audience and increase the level of Website accessibility.

2. User's health disorders

The following main types of health disorders of website users were identified:

- ***Vision problems***

Taking into account the current state of the Internet, it can be determined that the most problems with accessibility occur in people who have visual impairments. The reason for this is the fact that 80% of information about the world around a person receives through a visual analyzer [15]. The information contained on the Web page is no exception. So, when it comes to color blindness, people suffering from this disease experience problem when the combinations of the background colors and the elements that are located on it are selected incorrectly [16];

- ***Hearing problems***

People who suffer from deafness or other auditory impairments are much less likely to encounter accessibility problems, compared to the first category of people. However, now we can observe a tendency to increase the number of multimedia ele-

ments on Websites. In most cases, video content is not accompanied by synchronized subtitles;

- ***Disorders of the musculoskeletal system***

A large number of users experience a certain kind of difficulty in those cases when it becomes necessary to make accurate and quick movements of the mouse cursor [17]. Also, people who have disorders in the functioning of the musculoskeletal system, quite often cannot simultaneously hold several keys on the keyboard;

- ***Cognitive problems***

Unfortunately, cognitive impairments of people who interact with the interfaces of Websites is taken into account much less often than other physical deficiencies. As a result, there is a situation in which people who experience problems with short-term memory, as well as problems, which refer to the spatial thinking, cannot navigate properly on the contents of a Web page. Users with dyslexia may have trouble reading long texts [18].

3. Hardware and software solutions to the problem

To improve the quality of user interaction with the Web interface, there are two different approaches, each of which has a number of advantages and disadvantages. The first such approach is the use of specialized equipment connected to a personal computer. Among such a technique, one can distinguish joysticks, programmable keyboards, remote computer buttons, and optical mice worn on the finger.

Users select technical solutions according to their needs. Special keyboards have been developed for the left or right hand for those who can use only one hand. The arrangement of keys on such a keyboard is more convenient than on a conventional keyboard.

A keyboard, keys on which are largest and located less frequently can help users, which have fine motor skills disorder. This keyboard is larger than usual. Mini-keyboards are suitable for those for whom the problem is not fine motor skills, but a limited range of movements, which does not allow the use of a keyboard of usual sizes.

There are mimic solutions to keyboard and computer mice, including scanning, Morse code, and eye tracking, for people with severe motor impairments. In addition, special switches can be connected to the computer, helping you to use the computer with the a single muscle, which a person is able to consciously control (for example, head, finger, knee, mouth).

However, this approach, in addition to the positive aspects, also has negative aspects. The main disadvantage in this case is the purchase price of a specialized device. The cost can range from eighty dollars (portable computer mouse) and up to two thousand eight hundred dollars (automated workstation for students with visual or hearing impairments) [19].

There is a second way to solve the previously mentioned problem. It includes the use of software aimed at an individual approach to each user. An individual approach is implemented by setting up this software and further use. Among such software, one can distinguish “ScreenReader”. It is a form of associative technology, which allows people with visual impairments to organize text work. The software reads the indicated passages and switches between them upon receipt of instructions from the user [20]. However, these associative technologies also have disadvantages. They do not ensure changing the interface for the convenience of the user. Using these technologies, user is forced to perform additional actions and, as a result, spend additional time.

However, there are ready-made software solutions specialized for certain programming languages, which allow to organize personal interaction with the Web interface. Some ready-made solutions are already actively used, while others are quite rare. The presence of these components determines the accessibility of Web interfaces. It is advisable to build an accessibility model to ensure accessibility by using ready-made software solutions in accordance with the WCAG 2.0 standard.

4. Classic availability model

Analysis of 100 different Websites made possible to determine the classic availability model (CAM). This model consists of components, the implementation of which is present on most Websites. CAM allows to simplify user interaction with the interface, as well as to improve the user's perception of information

$$\text{CAM} =< c, n, t, h, d >,$$

where:

c – the correct color decision;

n – the correct links naming;

t – dividing the text into thematic blocks;

h – the help to correct errors;

d – the absence of dangerous elements and animation.

The brief description of these components:

- ***The correct color decision***

Avoid the combination of bright colors, as well as the sharing of yellow, blue and green colors. This color combination will create serious difficulties for users with color blindness. It is also worth considering the color-contrast of text and background. Black text on a white background is the best solution, as most audiences perceive it well;

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- ***The correct links naming***

The sentence "To learn more about ONPU click here", which contains the link "here" is incorrect. Next link will be more correct: "Visit the ONPU Website for more detailed information." Also, you should highlight links against the rest of the text. This can be done by underlining and choosing a specific color scheme;

- ***Dividing the text into thematic blocks***

It is highly recommended to divide large text blocks of information into smaller ones (paragraphs). This will improve the perception and storage of read information by all categories of users. This will be especially useful for Websites that are mainly visited by aged users and people with limited learning abilities;

- ***The help to correct errors***

User can use this approach to fills a form. In case, when user filled out the field incorrectly, a text prompt should appear next to the field indicating the requirements for filling the field. If prompts are not displayed, and the indication of the incorrectness of the field is limited to changing the color of the borders of this field, we have a situation in which a person with visual impairment may not notice this. The time for filling out the form increases;

- ***The absence of dangerous elements and animations***

This paragraph refers to the frequent change of frames, unexpected flashes, and sharp sounds. All of the above is extremely harmful for people with mental disorders.

5. Extended availability model

Having identified main health disorders, we can determine the extended model of Website availability (EAM). This model extends the classic model. This means that all components of the classic model are included in the extended one. However, some components that take into account functional limitations of the user were added (disorders mentioned earlier).

$$\text{EAM} = CAM \mid <, a, m, r, s, mc, d, i >,$$

where:

$\mid$ – concatenation operation of two tuples;

a – the use of the alt and title attributes;

m – the keyboard control;

r – the time gaps creation;

s – acceptable elements sizes determination;

mc – providing subtitles for media content;

d – arranging separators in abbreviations;

i – providing information about accessibility methods.

Description of each of the components of the extended model:

- ***The use of the alt and title attributes***

A person with visual impairment and using a screen reader (software that reads text on a Website aloud) can hear the value of the alt and title attributes. This allows user to know what is displayed on the screen;

- ***The keyboard control***

Users who have disorders of the musculoskeletal system actively use the management of Web interface's elements by keyboard. Thanks to the focus on working with developers in advance, The convenient user's interaction with form elements, pop-up windows and navigation panel is providing by focus developing;

- ***The time gaps creation***

Reserving a certain amount of time is an increase of the amount of time that is allocated to a user for an action. It is applicable for online auctions, online tests. This introduction allows you to improve the quality of interaction between the elderly and people with visual problems with the Website;

- ***Acceptable elements sizes determination***

It may be difficult to users, who have problems with the musculoskeletal system, to click on small interface elements (for example, buttons) by conventional mouse. It is necessary to increase the size of the area with which the user will interact. It will also simplify the work with the Web interface to people who have visual impairments;

- ***Providing subtitles for media content***

In case, when Website contains a large number of video content, it is advisable to provide subtitles for this material. If the video material is your own production, then you can use the tools of such video hosting services as YouTube in order to add subtitles;

- ***Arranging separators in abbreviations***

If the text of the Web page contains abbreviations, it is recommended to put dots between the letters. For example, if there is a need to refer to the Institute of Computer Systems, then it would be more correct to write "I.C.S." rather than "ICS". The screen reader will not recognize the abbreviation without dots and will read it as a word (I-C-S will be read as "ics");

- ***Providing information about accessibility methods***

If developers of the Website are able to ensure accessibility at a certain level, a separate section should be created in which the main possibilities of Web interface will be described in detail. This will allow user to use the functionality of Website. You can, also, include in this section information on how to configure your personal computer and browser to

increase the user's capabilities when interacting with the content of Web pages.

The following statistical information was identified, based on the analysis of the links between the health problems of users and the components of the advanced model that offer a solution to the interaction problem:

1. If user has vision problems, 10 out of 12 components (83 % of the total) help, namely: the correct color decision, the correct links naming, dividing the text into thematic blocks, the help to correct errors, the absence of dangerous elements and animations, the use of the alt and title attributes, the time gaps enabling, acceptable elements sizes determination, arranging separators in abbreviations, and providing information about accessibility methods.

2. If user has problems with hearing, 4 out of 12 components (33 %) help, namely providing subtitles for media content, the time gaps creation, providing information about accessibility methods, and the absence of dangerous elements and animations.

3. If user has problems with the musculoskeletal system, 5 out of 12 components (42 %) help, namely: the keyboard control, the time gaps creation, acceptable elements sizes determination, the absence of dangerous elements and animations, providing information about accessibility methods.

4. If user has cognitive problems, 6 out of 12 components (50 %) help, namely: dividing the text into thematic blocks, the help to correct errors, the absence of dangerous elements and animations, the correct color decision, the time gaps creation, providing information about accessibility methods.

Compared to extended model, the classic model of accessibility of Websites allows you to achieve the following mark:

1. Five components help visually impaired users, namely: the correct color decision, the correct links naming, dividing the text into thematic blocks, the help to correct errors, the absence of dangerous elements and animations.

2. One component helps users with hearing impairments, namely: the absence of dangerous elements and animations.

3. One component helps users, which has problems with the musculoskeletal system, namely: the absence of dangerous elements and animations.

4. Three components help users with cognitive impairments, namely: the correct color decision, dividing the text into thematic blocks, the absence of dangerous elements and animations.

The results of the analysis can be seen in Table. 1. Grayed out cells highlight the benefits of an extended availability model.

Table 1. Use of the elements of accessibility model for users with health disorders

	Vision problems	**Hearing problems**	**Disorders of the musculoskeletal system**	**Cognitive problems**
The correct color decision	CAM / EAM	-	-	CAM / EAM
The use of the alt and title attributes	EAM	-	-	-
The correct links naming	CAM / EAM	-	-	-
The keyboard control	-	-	EAM	-
The time gaps creation	EAM	EAM	EAM	EAM
Dividing the text into thematic blocks	CAM / EAM	-	-	CAM / EAM
The help to correct errors	CAM / EAM	-	-	CAM / EAM
Acceptable elements sizes determination	EAM	-	EAM	-
Providing subtitles for media content	-	EAM	-	-
Arranging separators in abbreviations	EAM	-	-	-
The absence of the dangerous elements and animations	CAM / EAM	CAM / EAM	CAM / EAM	CAM / EAM
Providing information about accessibility methods	EAM	EAM	EAM	EAM

EAM – element of extended availability model, CAM / EAM – element of both availability models

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As can be seen from the above statistics, the expansion of the model allowed us to increase the number of involved components. In turn, this allows us to expand the functional capabilities of users who have a certain type of health-related disability. As a conclusion, we can determine the following: the absence of dangerous elements and animations has a beneficial effect for user with or without any health-related disorders while working with the user's interface.

6. Implementation and testing of the extended availability model

The Website https://socialprotectionhumanrights.org was created as implementation of the extended availability model. This site informs users about ways to protect human rights, as well as the specifics of social protection. To determine the level of the Website availability, an audience of 30 people was formed. Of these 30 people, 8 had impairments (4 people had visual impairments, 2 – hearing impairment, 1 – musculoskeletal disorders, 1 – cognitive impairment). At the first stage, the audience was provided with a version of the site for evaluation, which implements only the classic model of accessibility. After giving time to familiarize themselves with the Website (30 minutes), the audience was asked 2 questions: "Is it convenient for you to interact with the interface of the Website?", "Is the information on the Website presented in an easy-to-understand format or not?" Each question had to be answered "Yes" or "No". As a result, 20 people (67 %) gave a positive answer to the first question and 24 people (80 %) to the second. At the second stage, the audience was presented with an evaluation version of the site that implements an expanded accessibility model. The same questions were asked. As a result, 29 people (97 %) answered the first question "Yes", and 27 people (90 %) answered the second question. The results of the survey are shown in Fig. 1.

Implementation and testing of the developed accessibility model was carried out on the basis of Odessa National Polytechnic University. In the experiment, 30 people (I-IV year students) were involved, of which 27 % had health-related disorders. The results of the experiment showed that the level of accessibility of the Website was increased by 20 %, which confirmed the hypothesis formulated earlier.

This value was calculated as the average value between the following marks:

1. Improving the quality of user interaction with the Website interface – 30 %.

2. Improving user perception of information submitted on a Website – 10 %.

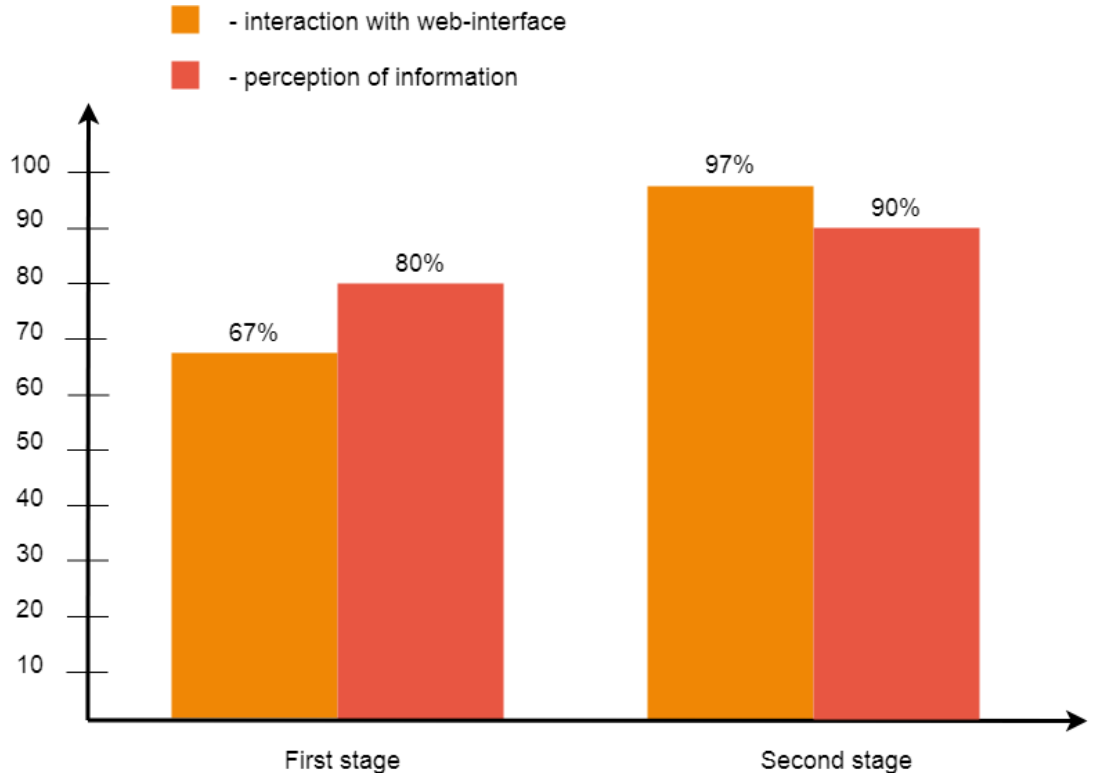

Fig. 1. Results of a sociological survey

Conclusion

Having analyzed the main types of health disorders among users who try to use Internet and various Websites quite actively, it was possible to develop an extended availability model of Website. The classic model was used as the basis for the extended model.

The classic model included components, which implemented by most modern Websites. By analyzing the structure of these Websites, the selected color schemes, as well as the size of text and media elements, fife main components were identified. Among them: dividing the text into thematic blocks, the help to correct errors (used when the user fills out registration and authorization forms), the absence of dangerous elements and animations.

An extended availability model of Web interface was obtained by adding seven more components. This model ensures possibility of interacting with the interface of a Website for users with health disorders of the following types: vision problems, hearing problems, disorders of the musculoskeletal system, cognitive problems. This hypothesis was formulated by comparing the number of components of the two described accessibility models, which help users with disabilities interact with the Web interface. For the identified types of health problems, have been managed to achieve the following results: the number of components that can be used when working with the Web interface for people with visual impairments increased from 5 to 10, for people with hearing impairments – from 1 component to 4, for people who have problems with the musculoskeletal system – from 1 to 5, and for people with cognitive impairment – from 4 to 6.

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[1]**Тищенко, Олександр Іванович,** студент кафедри системного програмного забезпечення інституту комп’ютерних систем, E-mail: alexandrt1998@gmail.com, ORCID ID: 0000-0003-4309-3449
[1]**Оніщенко, Тетяна Вікторівна ,** старший викладач кафедри системного програмного забезпечення інституту комп’ютерних систем, E-mail: tonishenko@gmail.com, ORCID ID: 0000-0003-0717-6191
[1]**Писаренко, Катерина Олександрівна,** кандидат технічних наук, старший викладач кафедри системного програмного забезпечення інституту комп’ютерних систем,
E-mail: katherine.gorodnichaya@ukr.net, ORCID ID: 0000-0001-9573-9315
[1]Одеський національний політехнічний університет, пр. Шевченка, 1, м. Одеса, Україна, 65044

МОДЕЛЬ ДОСТУПНОСТІ WEB-САЙТІВ ДЛЯ ЛЮДЕЙ С ОБМЕЖЕНИМИ МОЖЛИВОСТЯМИ

Анотація. *На сьогоднішній день ми маємо ситуацію, при якій замовник проявляє велику зацікавленість в забезпеченні доступності наповнення Web-сайту. Причиною цього є те, що забезпечення доступності дозволяє розширити цільову аудиторію. Розширення аудиторії передбачається за рахунок забезпечення можливості взаємодії груп користувачів із обмеженими можливостями з Web-інтерфейсом. При цьому, якість зазначеної взаємодії напряму залежить від рівня доступності інтерфейсу Web-сайту. Перехід до Web-сайтів, що мають середній або навіть високий рівень доступності виконується шляхом реалізації рішень, більшість із яких чітко стандартизована. Однак, при обранні рішення для переведення інтерфейсу Web-сайту на новий рівень доступності, розробники мають вирішити наступну проблему: відсутність розуміння різноманітних видів порушень здоров’я користувачів призводить до того, що в результаті розробки на ринок виходить продукт, який все ще є недоступним для певних груп користувачів. В основному це стосується людей, які мають когнітивні проблеми. Для вирішення даної проблеми було запропоновано виконати побудову моделі доступності Web-інтерфейсу, яка враховує основні типи порушень здоров’я користувачів, а також відповідає основним рекомендація стандарту WCAG 2.0. На першому етапі була сформульована модель доступності, яка була названа класичною. Визначення компонент класичної моделі доступності виконувалось шляхом аналізу існуючих Web-сайтів. Для покращення рівня доступності була виконана розробка розширеної моделі доступності. Реалізація даної моделі дозволяє забезпечити не лише покращення якості взаємодії користувача із обмеженими можливостями з Web-інтерфейсом, а і покращення сприйняття користувачем інформації, яка розміщена на Web-сайті. Апробація Web-сайту, реалізованого на основі розширеної моделі доступності, була виконана в Одеському національному політехнічному університеті. Для виконання експерименту була сформована група із тридцяти студентів. Люди із обмеженими можливостями складали більш ніж двадцять п’ять відсотків від загальної кількості студентів. В результаті виконання експерименту було доведено, що реалізація розширеної моделі доступності дозволяє покращити кількісні показники наступних параметрів інтерфейсу Web-сайту: якість взаємодії користувачів з Web-інтерфейсом і якість сприйняття користувачами інформації, яка подається на Web-сайті. На основі отриманих результатів було сформульовано висновок про покращення рівня доступності Web-інтерфейсу на двадцять відсотків.*

Ключові слова: *стандарт; Web-сайт; доступність; Web-інтерфейс; порушення здоров’я*

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[1]**Тищенко, Александр Иванович,** студент кафедры системного программного обеспечения института компьютерных систем, E-mail: alexandrt1998@gmail.com, ORCID ID: 0000-0003-4309-3449
[1]**Онищенко, Татьяна Викторовна,** старший преподаватель кафедры системного программного обеспечения института компьютерных систем, E-mail: tonishenko@gmail.com, ORCID ID: 0000-0003-0717-6191
[1]**Писаренко, Екатерина Александровна,** кандидат технических наук, старший преподаватель кафедры системного программного обеспечения института компьютерных систем, E-mail: katherine.gorodnichaya@ukr.net, ORCID ID: 0000-0001-9573-9315
[1]Одесский национальный политехнический университет, пр. Шевченко, 1, г. Одесса, Украина, 65044

МОДЕЛЬ ДОСТУПНОСТИ WEB-САЙТОВ ДЛЯ ЛЮДЕЙ С ОГРАНИЧЕННЫМИ ВОЗМОЖНОСТЯМИ

Аннотация. *На сегодняшний день сложилась ситуация, при которой заказчики выявляют большую заинтересованность в обеспечении доступности содержимого Web-сайта, так как это позволяет расширить целевую аудиторию. Расширение аудитории предполагается за счет обеспечения возможности взаимодействия групп пользователей с ограниченными возможностями с Web-интерфейсом. При этом, качество указанного взаимодействия зависит от уровня доступности интерфейса Web-сайта. Переход к Web-сайтам, которые имеют средний или даже высокий уровень доступности осуществляется путем реализации решений, большинство из которых четко стандартизированы. Однако, при выборе решения для перехода на новый уровень доступности интерфейса Web-сайта, разработчики сталкиваются со следующей проблемой: отсутствие понимания различных типов нарушений, связанных со здоровьем пользователей, приводит к тому, что в результате разработки на рынок выходит продукт, который по-прежнему не доступен для определенных групп пользователей. В основном это касается людей, которые имеют когнитивные нарушения. Для решения данной проблемы было предложено выполнить построение модели доступности Web-интерфейса, которая учитывает основные типы нарушений здоровья пользователей, а также соблюдает рекомендации стандарта WCAG 2.0. На первом этапе была сформулирована модель доступности, названная классической. Определение компонент классической модели доступности выполнялось посредством выполнения анализа существующих Web-сайтов. Для повышения уровня доступности была выполнена разработка расширенной модели доступности. Реализация данной модели позволяет обеспечить, помимо улучшения качества взаимодействия пользователей с ограниченными возможностями с Web-интерфейсом, также и улучшение восприятия пользователем информации, размещенной на Web-сайте. Апробация Web-сайта, реализованного на основе расширенной модели доступности, была выполнена в Одесском национальном политехническом университете. Для проведения эксперимента была сформирована группа, состоящая из тридцати студентов. Более двадцати пяти процентов от количества студентов составляли люди с ограниченными возможностями. В результате выполнения эксперимента было доказано, что реализация расширенной модели доступности позволяет повысить количественные показатели следующих параметров интерфейса Web-сайта: качества взаимодействия пользователя с Web-интерфейсом и качества восприятия пользователями информации, подаваемой на Web-сайте. Исходя, из полученных результатов был сформулирован вывод о повышении уровня доступности Web-интерфейса на двадцать процентов.*

Ключевые слова: *стандарт; Web-сайт; доступность; Web-интерфейс; нарушения здоровья*

Tyshchenko Alexandr Ivanovich,
Student
Scientific interest: development of flexible human machine interfaces

Onishchenko Tatyana Victorovna,
Senior Lecturer
Scientific interest: development of flexible human machine interfaces

Pysarenko Katherine Alexandrovna,
Candidate of Technical Sciences
Scientific interest: development of flexible human machine interfaces

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