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Original scientific paper

HbbTV User Interface Usability

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Abstract: The goal of this paper is to explore how TV viewers perceive the HbbTV interactive service, which has been increasingly used to broadcast additional contents on TVs. If the volume of contents available to be provided to viewers is considered, the question is whether the developed user interfaces are up to the challenge. Are they easy to use and intuitive? All this considering the fact that the user interface is controlled by a simple TV remote control. For the purposes of this research, the EVOtv user application was used. The research was conducted by applying the User Eye Tracking and the User Opinion Survey through a Predefined Questionnaire testing methods. Based on the obtained results it was concluded that the HbbTV user interface is easy to use, that EVOtv's design has been tailored to the medium it is used on (the TV) and that the usage of HbbTV user interface is also affected by the age of users.

Keywords: HbbTV; usability; user interface; user experience

1 INTRODUCTION

Today, television is an integral part of everyday life. Numerous channels and contents find a way to their respective viewers on a big screen. However, TV has a huge disadvantage which decreases viewers' consumption of content. What once used to be an advantage, has today become a disadvantage if viewed from a certain perspective linearity, i.e. linear TV: different contents, one after the other, of which some are broadcast always at the same time, such as the news. Why has this become a problem? Reasons are several, and the most significant one is the Internet.

Modern lifestyle is fast and unpredictable, the viewers no longer adapt to the TV content, but rather expect to watch it whenever it suits them; this is what the Internet enables them to do. The viewers, younger generations in particular, increasingly consume video-on-demand (VOD), at the time when it suits them best and mostly on a platform which is not the TV. They consume it on PCs, tablets and smartphones, eliminating the TV from their common use, to the extent that the TV is not used in the same way it was used before. These users also use a PC or an auxiliary device to, simultaneously with watching a video contents, check the news, the weather forecast, text messages etc.

How to retain viewers to watch the big screen, i.e. the TV? This is easy, use the Internet. Connecting TV sets and various STBs to the Internet has provided the opportunity to present additional contents on a big screen, and the results were smart TVs which, with their additional applications, both successfully and unsuccessfully resolved the issue of consuming different types of contents on a TV. And then, a new technology emerged, the HbbTV combining the best of both worlds, the HTTP and video contents.

With HbbTV technology, the user's experience of consuming additional content improves, it does not require any additional devices or toggling from one application to the next and waiting for them to download, which was necessary on a typical smart television. HbbTV applications are uploaded via existing channels. These applications are based on web technologies: HTML, CSS and Java. They can be run quickly and easily, uploaded on full screen or part of the screen. On the other hand, they can be run and stay hidden to be viewed by hitting only one key. The applications are easy to administer, change and update, with no interaction necessary on the part of the user. All changes are made on the server, and the users can upload the updated content with no additional updates and waiting times, which is the case in classical smart TV applications. HbbTV applications can be exchanged according to the content the channel provides. As an example, during a cooking show or a commercial break, the application can be displayed, adding up to the linear content of the TV channel by providing additional content and information. For instance, by pressing the red button on your remote you open a recipe of the dish prepared in the cooking show. Our next question would be what such a user interface should look like?

2 THEORETICAL FRAMEWORK

2.1 HbbTV Technology

HbbTV (Hybrid Broadcast Broadband TV) is a platform which enables broadcasters to offer interactivity and new content to their viewers, within their existing terrestrial channel. This service is accessible to all users of the DVB-T/T2 terrestrial and DVB-S/S2 satellite television signal who have a TV receiver with integrated HbbTV function. HbbTV is a set of interactive and informative contents which are activated by pressing the red button on a TV remote control when the screen displays a tag indicating that it is possible to run the HbbTV application [1].

The HbbTV specification was developed by industry leaders to effectively manage the rapidly increasing amount of available content targeted at today's end consumer. It is based on elements of existing standards and web technologies including OIPF (Open IPTV Forum), CEA-2014 (CE-HTML), W3C (HTML etc.) and DVB Application Signalling Specification (ETSI TS 102 809) and DASH. The diagram below shows the relationship between HbbTV and other existing standards [2].

The HbbTV can work with either broadcast or an IP link, although it is most powerful when used in a connected environment with a combination of broadcast and broadband networking.

Fig. 1 shows the relationship among industry specifications.

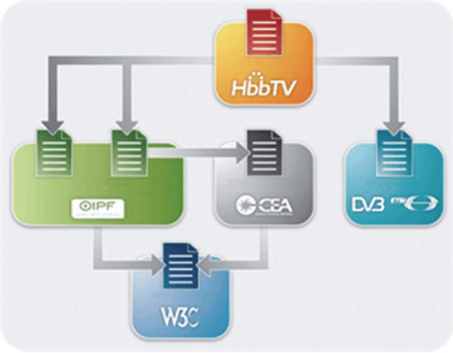

Figure 1 HbbTV - relationship among industry specifications [2]

As mentioned earlier, HbbTV uses the already existing broadcast and broadband technologies. To make the most of the HbbTV, a TV receiver (a TV set, STB etc.) which supports HbbTV has to be connected to the Internet using the existing antenna connector. HbbTV can also operate only through broadcast, but in such a case the two-way communication, which enables faster delivery of content, high quality and interactivity, which is why the technology was developed in the first place, gets lost. Fig. 2 shows the system general architecture.

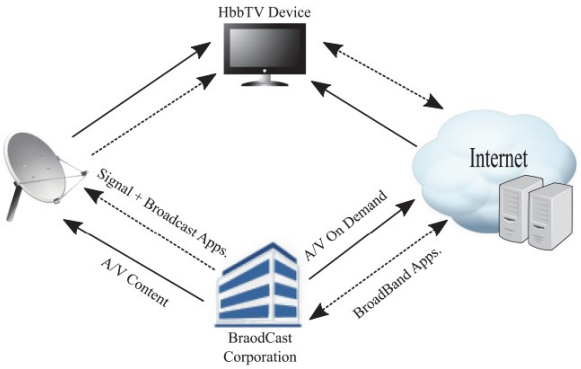

Figure 2 HbbTV general architecture [3]

User experience on TV sets has been defined by two key factors: the TV applications' user-friendliness and the TV remote control. Before the introduction of smart TVs interfaces were not considered a problem. The interface was simple and covered basic operations on a TV set.

Smart TVs made the situation much more complex. A smart TV can be connected to the Internet and as such can access numerous applications and information. The issue here is how to enable the user to navigate through huge volume of content using a common remote control. Manufacturers tried to overcome the problem by designing a new type of the remote control. This remote control has less functions (buttons) and can control the cursor on the screen (similar to a mouse function), which did not prove to be the best solution.

Navigation through the HbbTV application is primarily enabled by a common remote control, whilst the control of the cursor is not supported. If a smart controller has all the same function keys as the ones used by the HbbTV application, it can be used to successfully navigate through the user interface.

The development of a HbbTV user interface is not an easy task. Although the HbbTV application is based on HTML, CSS and JAVA web technologies, the development of a user interface cannot take the same direction as the development of websites. In order to develop an HbbTV application user interface the application has to be adapted to the display it is shown on, a TV screen, and a device it is controlled by, a remote control. When these two parameters have been defined (a TV screen and a remote control) it becomes obvious that navigation through a typical website using only a common remote control is impossible and the site's readability can also be questioned.

On the other hand, the user using the device itself (the TV set), with the HbbTV application running, must also be understood. Who exactly is the person using the TV set? PCs, tablets and mobile phones are personal items which individuals adapt to themselves, with content controlled in a different way. As opposed to them, a TV set is a device shared among all members of a household. These users are of different ages and levels of education, and this should be taken into consideration. When developing a user interface tailored to TV screens, the following criteria shall be taken into consideration: the size of the screen and the safety zone, colours, typography and font size, the remote control and limitations of the hardware.

From the research conducted in 2015 by Sven Pagel, Tobias Simon and Christian Seemann on the HbbTV usability analysis [4], the wireframe design of smart TV applications can be divided into five key wireframes shown in Fig. 3 below.

These wireframes are recommended and have obtained satisfactory results, i.e. none of the given interfaces tested negative. Ranking was performed according to the following criteria: clarity, user-friendliness, operative performance, video content search eligibility and orientation. Grades range from 1 to 5, where 1 is very good and 5 is bad (see Tab. 1 below).

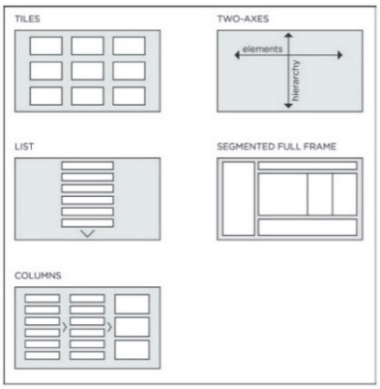

Figure 3 Wireframes for HbbTV application [4]

Table 1 Wireframes research results

2 directions	List	Thumbnails	SegmentedFullWireframe	Columns
2.1	2.3	1.7	2.0	1.6

The application used in this research was created according to the segmented full wireframe.

2.2 EVOtv Application

Research conducted for this paper used the EVOtv user application which is publicly available and signalled in Croatian DVB-T2 network. The application itself was created according to the creation guidelines for smart TV

and HbbTV applications described earlier. The purpose of the application is to provide the user of the EVOtv service (the viewer) additional, expanded content which can be easily adapted to the screen view, increase the value of the service itself and the level of user's satisfaction.

The content offered by EVOtv application has a link to the content actually expected by the viewer to be shown on TV, i.e. the type of content that viewers know they can access via certain services which might already exist on TV screens (e.g. the teletext). In addition to such natural television content, additional contents are offered, e.g. the weather forecast, games and webshops, since the HbbTV standard and technology enable them. Through additional interactive content, such as the survey questionnaires, the EVOtv team may learn about user satisfaction. By providing feedback, HbbTV has also enabled insight into channel ratings and can further improve its service.

EVOtvHbbTV application uses a combined segmented full wireframe design (see Fig. 4) and its graphic standard is adjusted with the HrvatskiTelekom brand. Additional content offered by the application includes:

- The weather forecast for all major Croatian cities.
- The TV channel guide (comprehensive).
- EvoTVWebshop device offerings.
- Additional offering of channel packages.
- Over 70 radio stations.
- Games.
- Assistance in using the application.

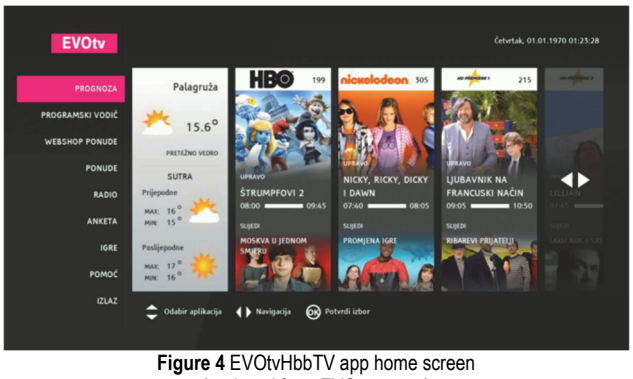

Figure 4 EVOtvHbbTV app home screen (retrieved from EVOtv server)

The application itself has two menus: a left-hand textual menu and a central, image menu. The textual menu provides all the content, whilst the image menu offers only the most commonly used content.

2.3 User Interface Usability

According to J. Nielsen, 'Usability is a quality attribute that assesses how easy user interfaces are to use. The word ‚usability' also refers to methods for improving ease-of-use during the design process. 'Usability is defined by 5 quality components [5]:

- Learnability - How easy it is for users to accomplish basic tasks the first time they encounter the design.
- Efficiency - Once users have learned the design, how quickly can they perform tasks.
- Memorability - When users return to the design after a period of not using it, how easily can they reestablish proficiency.
- Errors - How many errors do users make, how severe are these errors, and how easily can they recover from the errors
- Satisfaction - How pleasant is it to use the design

For usability, another key attribute is usefulness one of the most important qualities referring to usability of the application interface itself does the interface do what the users need?

The user interface usability is an important condition for user's connectivity with the interface itself users will abandon the interface in the following situations:

- The interface is difficult to use.
- The user gets lost within the interface.
- The user cannot find what he/she is looking for.
- The information is difficult to read.

Therefore, it is important to test the user interface usability. Testing the user interface usability can help in achieving its usefulness. The testing comprises 3 components: Representative users, representative tasks and monitoring what users do. Representative users are respondents who the designed interface is intended for, in this case the viewers, so that the HbbTV application would be acceptable to an average TV user (6). Representative tasks are actual tasks which respondents have to complete in a tested user interface. The tasks themselves are related to the assignment, i.e. the purpose of the application interface. By tracking what users do it can be seen whether the usability has been achieved or not. In the same way it is visible whether the respondents had completed the task successfully or not. If not, an analysis is made of items that caused issues which can then be rectified [5, 7].

2.4 Related Work

Synchronization of the TV content with applications, which offers viewers interactivity and new contents, a new dimension of user experience, has been a topic of various scientific research works in the recent years. As a hybrid TV standard, HbbTV synchronises video and sound broadcasting with different applications. These can be delivered to users via the broadcasting channel or a broadband network. Therefore, different HbbTV applications can be developed to provide contextual information within broadcasting TV shows and commercials, such as geographically interactive TV contents [3]. What is important is that commercials are broadcast in a less provocative interactive format of advertising, to generate higher level of acceptance by the viewers [8].

The methodology of researching user interface usability in order to improve the user experience when applying interactive HbbTV application commonly uses respondents' questioning through questionnaires and interviews [9, 10]. However, the assessment of user experience can be improved using sensors for users' eye tracking when interacting with the interface [11].

Numerous researches have concluded that the age of users affects navigation within user interfaces, especially due to vision issues, cognitive or motoric problems [12, 13]. It can be assumed that age also affects the use of a hybrid user interface, such as HbbTV applications.

Integration of new technologies into existing user interfaces makes them more innovative. For example, by

integrating AR into a web store, users can be given a near-real view of products, adding a dimension of interactivity that is missing from classic online experiences. Therefore, web stores that successfully implement augmented reality can significantly enrich the user experience, making it more attractive, interactive and informed [14].

3 RESEARCH METHODOLOGY

3.1 Goals of the Research

The purpose of this paper is to explore the usability of the HbbTVuser interface using the example of EVOtv application, and at the same time determine the user interface cognitive aspect, i.e. whether it is understandable to its users. Furthermore, the interactivity, and in particular the functionality of user interface, shall also be determined.

3.2 Hypotheses

Hypotheses of the research are given below:
H1: The HbbTV user interface is easy to use.
H2: The HbbTV application's design is adapted to the media it is used on (the TV).
H3: User's age affects the usage of the HbbTV user interface.

3.3 Methodology

During this research, when evaluating user interface usability the following two methods were used:
- Tracking method - user eye tracking method.
- Testing method - users' opinion polling through pre-defined questionnaires.

The research was conducted in the laboratory of University North in Varaždin. The respondents arrived individually to provide maximum comfort and to simulate natural environment of using the TV as much as possible (comfortable chair or armchair and relaxing atmosphere so that the user may concentrate on his/her work). They could not and need not have been familiar with the HbbTV technology. Every respondent took the test individually and received a set of 3 tasks which they had to complete. Once the assignment was finished, the respondents had 2 to 3 minutes to try the application. Then they would fill in the questionnaire where they answered questions mostly connected to the user experience they had when using the HbbTV application and questions about the application design.

Respondents received an explanation of what was being tested and what was expected from them. They were also explained how to complete the tasks and which set of keys on the remote control should be used. All respondents received the same set of input so that the testing conditions can be as precise as possible.

Fig. 5 shows the testing infrastructure diagram. In front of the respondent is an eye tracker, STB (supporting the HbbTV) and a TV set with a displayed image. At the side, the evaluator is running the test, controlling the eye tracker and recording the results.

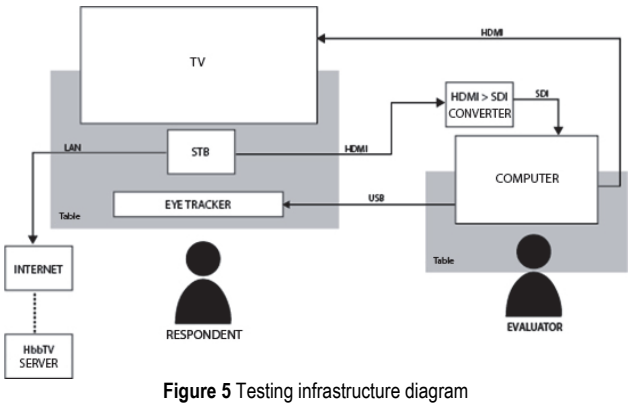

Figure 5 Testing infrastructure diagram

The respondents were people over 18 years of age who use TV content for at least 1 hour a week. The respondents were 16 women who had completed 4-year secondary education or university. They were employed on administrative position in offices. The age of the respondents was required to better classify the results and determine trends among observed population.

The equipment used in this research was the following:
- An STB set with the HbbTV technology, connected to the Internet.
- A TV set.
- An eye tracker (Gazepoint GP3).
- A PC with adequate software (Gazepoint Standard Edition v6.7.0).

Every respondent was briefed on the goal and purpose of research, what was expected of them and what the tasks would be. They were made familiar with the HbbTV application, the remote control and buttons, with special remark made for the attention to be paid on the menu which showed colours. Tasks which every respondent had to complete:
T1: Check the tomorrow's weather forecast for Varaždin.
T2: Using the HbbTVinterface, start Antena Zagreb radio station.
T3: Check what the next event (a film/TV series) on HBO channel is.

This was followed by a closed type survey questionnaire with open-choice answers and their appertaining grades. The grades were from one (1) to five (5), where 1 means a bad experience and grade 5 means a positive experience (modified Likert Scale questions).

By using the video recording created by the eye tracker it was possible to determine if the user interface was easy to use and understandable, regardless of age, gender and education.

Fig. 6 is an example of how Task 1 was analysed. The task was to check the weather forecast for Varaždin, for the following day. The respondent completed the first part of the task started the weather forecast from the menu. Fig. 5 shows the last 5 seconds of watching prior to the respondent returning to the home screen portal. The image clearly shows that the respondent successfully found the referring city, her eyes tracked the weather forecast for the following day and found the key to return to the application home screen (portal).

Figure 6 Respondent's eye tracking when completing task 1

Fig. 7 below shows completing of Task 3, where the respondent had to find the event (a film, a TV series, a documentary etc.) on HBO channel. The recorded part shows that the respondent managed to find the HBO channel, the event and searched for the information on how to return to home screen.

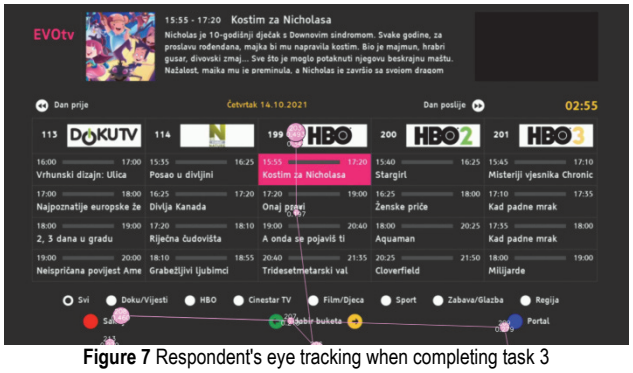

Figure 7 Respondent's eye tracking when completing task 3

Fig. 8 shows the respondent's focus on the frame listing the cities. The screenshot was made at the moment when the respondent was using a remote control to change city by city to reach Varaždin.

Figure 8 Respondent's focus when completing the task (listing of cities)

In addition to viewing the fixation (as shown in Fig. 6, Fig. 7 and Fig. 8), the software enables the overall view of a part or the whole recording using the view called the 'Heat Map'. This view enabled seeing how much the respondent was focused on a particular part of user interface in a certain period of time. Fig. 9 shows how focused the respondent was when completing the weather forecast tasks. It can also be seen that the respondent was the most focused on choosing the city, which is correct, because the respondent spent several seconds looking for Varaždin. The image then clearly shows that the respondent viewed all the important elements that provide feedback on the checked weather forecast, i.e. the task. Furthermore, the respondent managed to see the invitation message to check the EVOtv additional offer which, for this particular respondent, leads to a conclusion that the interface is clear and easy to use.

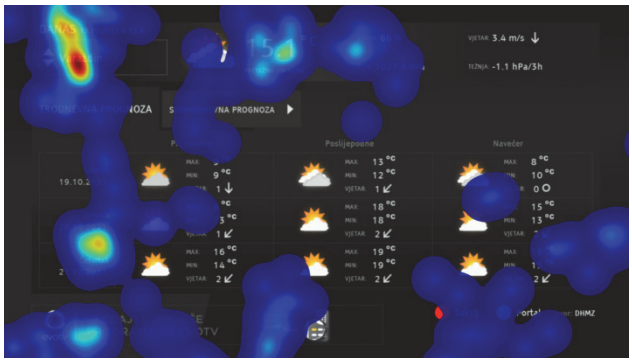

Figure 9 Respondent's heat map when completing task 1

4 RESULTS AND DISCUSSION

The evaluation of HbbTV user interface (using the example of the EVOtv HbbTV application) was conducted according to guidelines described in Section 2.3User Interface Usability. The results show that the users are satisfied with the user interface simplicity and intuitiveness, by grading it with 4.31 out of 5, which is a very good result, considering that the 'Segmented Full Wireframe' was used. In the research 'HbbTV Usability Analysis' [4] an average 2 (on a scale from 1 to 5, where 1 = excellent and 5 = bad). Better wireframes were graded 1.6 and 1.7, and worse 2.1 and 2.3 (as described in Section 1.6). The respondents graded the adjustment of the HbbTV application design to the medium it was used on, i.e. the TV, with an average grade of 4.24. The respondents were most satisfied with the text size and font choice, and less so with the element layout, consistency, design and content. The research itself resulted in a fact that the respondents/users also found the consistency of navigation very important. Adjusting controls, i.e. application control using a remote control was graded with high 4.6. The respondents unanimously consider that the remote control's commands were used in the best possible way. However, considering the application itself, there is still room for improvement regarding adjustment of the user interface to the remote control's buttons.

Based on the obtained results, with an average grade of 4.38 it can be concluded that the EVOtv HbbTV application's user interface is easy to use and intuitive.

Tab. 2 clearly shows that younger generations (age 18 to 30) perceive the HbbTV interface faster and better, 19.07% better than the next age group (age 30 to 40). Younger generations are 32.15% and 31.6% respectively better than age groups 40 to 50 and 50+.

Table 2 Questionnaires

Personal Information						
Total respondents: 16						
Gender: F = 16 M = 0						
Age: 18-29 = 4 30-39 = 4 40-49 = 4 50+ = 4						
Have you used HbbTV apps before? YES = 8 NO = 8						
Have you used smart TV apps before? YES = 13 NO = 3						
Question (number of responses)	Negative		Undecided		Positive	AVG
UI Usability						
How difficult was it to find the required answer to the task assigned to you?			2	7	7	4.31
Was every subsequent task easier to complete?			3	6	7	4.25
How would you evaluate your user experience with the HbbTV application?			2	5	9	4.44
Do you think the content was satisfactory?			1	10	5	4.25
Medium-adapted Design						
Was using of the HbbTV application easy?			5	5	6	4.00
How satisfied are you with the text size used in the HbbTV application?			1	7	8	4.44
How satisfied are you with the font used in the HbbTV application, is the font sufficiently readable?			1	7	8	4.44
How satisfied are you with the layout of elements used in the HbbTV application's user interface?			2	10	4	4.13
Do you think that the layout of elements was clear?			2	8	6	4.25
Do you think that the navigation was consistent?			1	10	5	4.25
How would you evaluate the HbbTV application's design?			2	6	8	4.19
Do you remember which button you used to return to home screen?		R	G	Y	B = 16	
Remote Control Usability						
Do you think that too many or not enough buttons are used for the HbbTV application?			16			3.00
How satisfied are you with remote control buttons?				9	7	4.44
Do you think that the remote control buttons are well adapted to the HbbTV application?			1	7	8	4.38
Task Solving Rate						
The average rate of task solving (in seconds), as per age of respondents	18-29	30-39	40 - 49	50+		
	124.5	148.5	183.5	181.5		
Image or textual menu (I or T)	18 - 29	30 - 39	40 - 49	50+		
	I = 75%	I = 100%	T = 75%	T = 50%		

In questioning whether the users preferred an image to a textual menu, the results slightly varied between testing methods themselves. In the survey questionnaire method the result obtained was pretty clear. The image menu was preferred by 68% of respondents and the remaining 32% preferred the textual one. This result was expected because image information is processed in the brain 60000 times faster than text [15]. The results of Eye Tracking method were slightly different. The results of solving Task 1 demonstrated a 43.75% to 56.25% ratio in favour of the textual menu, and in resolving Task 2 the ratio was 56.25% to 43.75% in favour of the image menu. After completing both tasks the ratio was 50% to 50%, i.e. the result was not clear. The third task was not evaluated here, because it could only be solved by using the textual menu. Since the number of users preferring the image menu increased in Task 2, it can be concluded that by every subsequent usage of this application the ratio would increase in favour of the image menu. What should not be forgotten is that the respondents were given the opportunity to independently use the application for a few minutes only after they had completed the tasks. Therefore, we can assume that in the end the ratio obtained by the eye tracking analysis should also match the ratio we obtained in the end of testing. However, this is a new hypothesis which could be confirmed if testing were repeated and the respondents recorded by the eye tracker once again, after they had independently used the HbbTV application for a few minutes. When percentages obtained by both methods are summed up (200%), the result is 118% for the image and 82% for the textual menu. Based on this ratio it can be concluded that the respondents preferred the image menu by 30.5%.

5 CONCLUSION

The user interface simplicity was tested according to usability components. The results show that the tested interface has a learning capability, graded with an average 4.31. The ease of solving the task was graded with 4.5 by the first three age groups (age 18 to 30, age 30 to 40 and age 40 to 50), whilst the age group 50+ graded this criterion with 3.75. Efficiency received an average grade of 4.25. Age groups 18 to 30 and 30 to 40 graded the efficiency with grade 4, age group 40 to 50 with 4.25 and age group 50+ with 4.75. Memorability was not part of this particular testing. All evaluated errors were less severe, and respondents recovered very quickly. In haste, they would most commonly open the wrong item on the menu. The respondents' satisfaction with using the application was graded with an average 4.4. The most critical was the age group 18 to 30, whilst all the other age groups graded satisfaction with 4.5. All respondents individually managed to complete their tasks, i.e. found information which was necessary to justify application usefulness. Considering an overall grade of 4.31 obtained in the third ranked wireframe out of five tested separately, it can be concluded that this interface is easy to use. Consequently, it can be concluded that the hypotheses 'The HbbTV user interface is easy to use' is confirmed.

The grade referring to design adaptation to the medium the HbbTV application is used on comprises two components: adaptation of the design to the interface and navigation across the interface using a remote control. The adaptation overall grade is 4.42, where the design adaptation to the interface was graded with 4.24 and control adaptation with 4.6. Based on the results obtained, it can be concluded that the hypothesis 'The HbbTV application's design is adapted to the media it is used on (the TV)", is confirmed.

The analysis of grades obtained for the user interface usability showed that age groups 40 to 50 and 50+ graded and perceived the HbbTV application in a slightly different way. Research results showed that these age groups needed on average 31.6% more time to complete the task than the age group 18 to 30. The results also showed that 60% of age group 40+ preferred the textual menu, whilst in the age group under 40 this menu was preferred by only 14%. Considering all of these facts it can be concluded that the hypothesis 'User's age affects the usage of the HbbTV user interface' is confirmed.

Related to the conducted research, usability and the overall user experience of an interactive HbbTV application may be a deciding factor for the user adoption of a solution. It is recommended that the HbbTV user interface usability is evaluated with consideration for the ordinary TV viewer.

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