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The differences in Accessibility of TV and Desktop Web Applications from the Perspective of Automated Evaluation

Daniel Costa[a,*], Luís Carriço[a], Carlos Duarte[a]

[a]*LaSIGE, Universidade de Lisboa, Campo Grande, Lisboa 1749-016, Portugal*

Abstract

In today's culture, television is still a central part of everyone's life. Like everyone else, blind and partially sighted persons want to watch TV and be part of the trend. With the TV signal digitization and the current market growth of connected TVs, we envision the appearance of accessibility barriers for visually impaired persons. As a first step of a larger evaluation to understand the problems users with visual impairments face everyday, we decided to conduct an automated accessibility evaluation to compare TV and Desktop versions of the same Web application, and characterize their conformance with accessibility guidelines. From the results obtained with the automated accessibility evaluation we concluded that TV applications are in a significant better level of conformance with accessibility guidelines.

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1. Introduction

People with some kind of disability usually need some assistance when interacting with most electronic devices. This is even more pronounced when we consider blind people and devices strongly based on visual interfaces such as the TV.

In the past, the strategies used by the visually impaired to perceive what is happening on the TV screen consisted in the combination of residual sight, hearing and audio description (AD) to understand content. That was adequate, as the communication was mainly unidirectional. Nowadays, Connected TV platforms extend the reach of multimedia content by enabling access both to the broadcast of digital content and to Internet's multimedia content, including video-on-demand, games, social networks and much more. These platforms, together with the delivery of multimedia content to the home user via the Internet, are becoming increasingly frequent, with major brands such as Apple, Google and Samsung investing in this field. However, with the new plethora of on-screen information and interactivity they offer, TVs have become less accessible.

* Corresponding author. Tel.: +351-217500000; fax: +351-217500084.
E-mail address: dancosta@di.fc.ul.pt

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Audio description makes TV services more accessible to blind and visually impaired people by verbally explaining what is happening on screen. Audio descriptions of locations, actions, facial expressions, gestures and so on give the context and set the scene. They are fitted between dialog or commentary to avoid interrupting the flow of the TV show.

The fact is, the variety of on-screen information digital TV sets carry, both about shows and through which a viewer finds the show they want to watch, is making digital TV less accessible to blind people than its analogue predecessor. After all, if a blind person cannot find a show, no amount of AD will be of use to them. EBU's report[1] shows that, in order for a blind person to manage their digital receivers without any assistance, certain adaptations are needed, of which spoken rendering of the menus is the most important. These concerns extend to the, newly available, Web applications accessed through Connected TV.

In this work we give special attention to TV applications – Web based application software that is specifically designed for TV environments. Our goal is to evaluate the current state of accessibility of this kind of applications as we foresee an increase of the use of Connected TV platforms.

Applications such as Facebook, Twitter or AccuWeather, which have large numbers of users, are now also available via TV. Consequently, the TV versions of these Web applications will have to contend with users with a large diversity of capabilities and characteristics. Hence, our concern on the accessibility barriers they could face.

Our assumption is that TV applications, lacking specific accessibility guidelines for development when compared with their desktop counterparts, are less accessible than the desktop versions.

Our approach is to gather a sample of off-the-shelf TV applications that have a desktop version and perform an evaluation using a state of the art accessibility evaluation tool that follows the Web Content Accessibility Guidelines 2.0.

The main contribution of this work is an initial study of the current state of the accessibility of TV applications. The results of this study revealed that TV applications are more conformant with accessibility guidelines than their Desktop versions.

In the remainder of the paper we start by presenting a brief overview of current TV platforms, guidelines and recommendations. This is followed by a description of the experimental study, and the reporting and discussion of the results. Finally, we present the conclusions and planned future work.

2. Related Work

This section describes firstly some of the most known and used TV platforms as well as their characteristics in terms of running software. Secondly, a list of guidelines and recommendations for Digital TV applications is presented.

2.1. TV Platforms and Applications

Existing TV platform manufacturers usually have their own middleware, specifications, operating systems and programming languages for TV application's development. Nevertheless, some efforts are being made to implement neutral platforms that use standard technologies. The Hybrid Broadcast Broadband TV[2] established an open platform that uses standard Internet technologies such as HTML and JavaScript. The Smart TV Alliance[3] is committed to provide a platform to create interactive content on consumers' screens. Applications for this platform are developed using HTML5. These have the support of most of the top manufacturers and companies of this field, such as LG Electronics, Toshiba, Panasonic, Samsung and Sony Corporation.

The unifying feature of several existing TV platforms is that they use Web technologies such as HTML5 and JavaScript in their applications. As can be seen in Table 1, the majority of the listed platforms use a Browser as their runtime environment. Consequently, it can be expected that these platforms bring to the user the accessibility barriers and solutions that are currently found on classical desktop computers. Although these barriers have been extensively researched on regular Webpages, little has been done regarding Web applications directed to TV platforms.

We can group the applications we find on modern TV platforms into two classes: TV applications, which are usually simpler and well designed, taking in account the characteristics of TV sets but with less functionality and content than their Web counterparts; Web applications that can be accessed through the browser provided by the TV platform, which are more complex and suited to a Desktop view.

Table 1. List of TV platforms and their features

Platform	Programming language used	Runtime Environment
Hybrid Broadcast Broadband TV	HTML, JavaScript, CSS	Browser
Smart TV Alliance	HTML5, JavaScript, CSS	Browser
Web4CE (CEA-2014)	CE-HTML	Browser
Roku	BrightScript	BrightScript Virtual Machine
Google TV	Java	JRE
Opera TV	HTML5, JavaScript, CSS	Browser
Frog	HTML5, JavaScript, CSS	Browser
Open TV 5	HTML5, JavaScript, CSS	Browser
Yahoo! Smart TV	HTML, JavaScript, CSS	Yahoo! Widget engine

Similarly to what happens on mobile devices, there is the possibility of accessing an application via one or the other version. TV applications follow design guidelines that obviously are more adequate to the TV platform regarding the size of the interface, interaction and navigation.

2.2. Tools, Standards and Guidelines

Web accessibility has been the subject of interest of researchers since more than a decade ago, from the articulation of accessibility guidelines for development of Web pages such as the Web Content Accessibility Guidelines (WCAG) to the implementation of plugins for development environments.

The WCAG define a set of best practices for Web development and are the base for most evaluation tools. These tools are a good way to evaluate the conformity with the guidelines, but because they are automated they should serve as a complementary source to expert manual code verification and user studies. Some examples of evaluation tools include QualWeb[4], Web Accessibility Checker[5], Web Accessibility Evaluation tool[6] and WaaT[7] tool which provides personalized accessibility evaluation by selecting parameters such as impairments, assistive technologies and devices. An IBM's survey revealed that the most important features that these tools must have, from the developers' perspective, are a checklist of automatically detected problems and an explanation of each problem[8].

Although WCAG 2.0 is the standard for Web accessibility, its suitability for TV is yet to be evaluated. This section summarizes the several existing standards and guidelines for Digital TV and the development of TV applications. These comprise general TV standards from European-wide standardization bodies, TV accessibility guidelines and recommendations, access services standards and manufacturers development guides.

In 2009, INTECO (Instituto Nacional de Tecnologas de la Comunicacin) developed Digital Terrestrial Television (DTT) Accessibility Recommendations[9]. Primarily focused on the Spanish context, these recommendations begin with an overview of the Spanish legislation on Accessibility in television.

ITU (International Telecommunication Union) is the United Nations specialized agency for information and communication technologies (ICTs) and the world's most universally-recognized info communications standards organization. The ITU's Recommendation F.790[10] gives guidance on understanding the topic of accessibility and the ways that accessibility may be incorporated in ICT products and services.

The Irish Center for Excellence in Universal Design[11] guidelines aim to provide guidance on how to ensure that television services, equipment and programmes can be accessed, understood and used to the greatest extent possible by all people, regardless of their age, size, ability or disability.

The Digital TV Group (DTG) is the industry association for digital television in the UK. Relevant to DTV accessibility, DTG has published the following guidelines: UK Digital TV Usability and Accessibility Guidelines, including Text to Speech (U-Book)[12].

TV platforms also provide some guidelines on how to implement TV applications taking into account the technical specificities of connected TVs. Therefore, we also have to mention the Google TV Design guidelines[13], the Samsung UX recommendations[14] and the Smart TV Alliance Application requirements[15].

One problem about these guidelines is the lack of information they offer towards the new TV paradigm of connected TVs and the new technologies empowering them. Although the focus on Digital TV is still relevant, we believe that these documents should extend their recommendations taking in account the new advances on this field.

On the other hand, compared with WCAG 2.0, these guidelines do not offer a means to guide the development of TV applications by following some kind of checklist or techniques. This also prevents the support for an automated evaluation.

For an initial study of the current state of accessibility of TV applications, and given the reasons stated above, we decided to check the conformance of a sample of TV applications to the WCAG 2.0, instead of using Digital TV guidelines. The following section describes the study and its results.

3. Experimental Study

We performed an experimental study to understand the level of accessibility, measured by conformance to Web accessibility standards, of (Web based) applications on both platforms, TV and Desktop.

3.1. Methodology

The following hypothesis was defined: *TV applications are less conformant with accessibility guidelines than their Desktop counterparts.*

We considered this hypothesis as the research effort and developments in the last years towards the accessibility of Web pages and applications was greater than that for TV applications, which are quite recent when compared to their desktop counterparts.

To perform this evaluation we chose the QualWeb evaluator. This framework uses the WCAG 2.0 guidelines and it is capable of post-browsing processing evaluation[4], which increases the reliability of the results by evaluating code that approaches what an user perceives from the application.

After collecting the evaluation data from the QualWeb evaluator, a set of descriptive metrics proposed by Lopes et al.[16] were computed. We then assessed the results by applying the appropriate comparative statistical tests taking into account the normality of the data and the sample type of the test we conducted (two dependent samples).

3.2. Setup and Procedure

This section describes the design of the automated accessibility evaluation of TV and Web applications using the QualWeb tool as described on the evaluation methodology. The study comprised the following steps:

Selection of platform: Firstly we searched and installed different TV platforms that provided emulation and application support. All of them were based on the Linux operating system and the applications ran on browser based runtime environments. We chose the Opera TV platform mainly because it offered access to the applications' URL and therefore access to their rendered code in runtime, which is essential for taking advantage of the post-browsing processing capabilities of QualWeb.

Selection of applications: The Opera TV store provides access to a variety of off-the-shelf TV applications. The applications were organized on the store by categories such as Movies & TV, Music or Social. We analysed over 30 TV applications to verify if they had a Desktop version to proceed with the comparison study. We selected from 2 to 3 applications from each of 8 different categories (20 different applications in total).

Accessibility evaluations: we performed the evaluation of each version sequentially, thus minimizing the time gap between evaluations of the same application in order to assess similar data.

Structure analysis: We measured the complexity of the applications by counting their number of HTML elements, as defined in Lopes et al.[16]

Accessibility analysis: we applied three different metrics over the results gathered by the evaluator. These metrics will be explained further below.

Functionality analysis: by manually inspecting a subset of the applications we analysed some of the differences regarding the features and functions each version offers.

3.3. Structure Analysis

By observing the structure of the rendered TV applications we could identify the following distribution of the TV applications by template usage: 27% of the TV applications use the same template while we could not identify a

recurrent use of templates for the remaining 73%. Albeit the 27% used the same template, we could identify several different templates used by applications when we analyzed the Opera store. We decided to analyze accessibility differences between applications using a template and not using one. Results are presented in the following section.

Regarding the comparison of element count on the different delivery contexts, we can observe on table 2 that the TV version of the applications has, on average, about a fourth of the elements of the Desktop counterparts.

Table 2. Number of HTML elements by application on TV and Desktop versions.

Application	**TV**	**Desktop**
Roda Viva	173	921
WOWTV	350	858
Vimeo	215	501
WatchMojo	77	2186
Melynga	193	653
FreshMilk	339	728
Redbull TV	118	743
RantSports	226	1990
iG Moda	269	2354
AllTime10s	205	219
TechCrunch	219	1101
GameReactor	573	3177
AccuWeather	223	1801
Facebook	899	2477
Manga	77	1068
Bola.net	396	2715
Cocoric	173	434
CNBC	124	2572
AsianCrush	68	1917
CNNExpansion	185	2682
	255 (SD = 194)	1555 (SD = 923)

3.4. Accessibility Analysis

The QualWeb evaluator presents the accessibility results in terms of PASS, WARNING and FAIL. A PASS or a FAIL occurs if the technique is applicable to an HTML document and if the elements verified by the techniques are in agreement or disagreement with the W3C recommendations, respectively. A warning occurs if it is not possible to identify certain characteristic of an element as right or wrong, without the need of a human expert intervention. For this study we used three metrics defined by Lopes et al.[16] to verify the Accessibility quality of a given webpage (in this case a Web based application). Each criterion yields a percentage with the semantics from not accessible to fully accessible. Following the three metrics used are described.

Conservative rate: WARN results are considered failures. This metric interprets the results as the worst-case scenario on the accessibility evaluation:

$$Rate_{Conservative} = \frac{Passed}{Applicable} \tag{1}$$

Optimistic rate: WARN results are considered as passes. As the name indicates it is related with the best-case scenario where developers and experts dismiss warnings.

$$Rate_{Optimistic} = \frac{Passed + Warned}{Applicable} \tag{2}$$

Strict rate: WARN results are dismissed (only PASS and FAIL results are considered):

$$Rate_{Strict} = \frac{Passed}{Applicable - Warned} \tag{3}$$

Table 3. Evaluation scores for each application by platform and applied metric

Application	Conservative TV	Conservative Web	Optimistic TV	Optimistic Web	Strict TV	Strict Web
Roda Viva	0,93	0,27	0,95	0,73	0,95	0,50
WOWTV	0,70	0,48	0,97	0,71	0,96	0,62
Vimeo	0,96	0,47	0,98	0,78	0,98	0,68
WatchMojo	0,61	0,25	0,80	0,74	0,76	0,48
Melynga	0,59	0,58	0,87	0,82	0,83	0,77
FreshMilk	0,35	0,69	0,69	0,90	0,53	0,87
Redbull TV	0,54	0,37	0,82	0,76	0,75	0,61
RantSports	0,67	0,28	0,90	0,79	0,87	0,57
iG Moda	0,74	0,43	0,80	0,79	0,79	0,68
AllTime10s	0,63	0,74	0,88	0,89	0,84	0,87
TechCrunch	0,78	0,46	0,87	0,77	0,86	0,67
GameReactor	0,72	0,31	0,86	0,71	0,83	0,52
AccuWeather	0,66	0,51	0,79	0,81	0,76	0,73
Facebook	0,74	0,64	0,87	0,79	0,85	0,75
Manga	0,61	0,47	0,80	0,79	0,76	0,69
Bola.net	0,79	0,37	0,90	0,75	0,89	0,60
Cocoric	0,93	0,24	0,95	0,75	0,95	0,48
CNBC	0,85	0,49	0,89	0,83	0,88	0,74
AsianCrush	0,72	0,23	0,86	0,77	0,84	0,50
CNNExpansion	0,87	0,47	0,91	0,78	0,90	0,68
Average	0,72	0,44	0,87	0,78	0,84	0,65

Table 3 reports the scores (with 1 representing total conformance with the guidelines) for each metric for each application (and delivery context) and the respective average scores. From the average values we can already see the high score the TV versions have when compared to the Desktop versions, so we decided to check if these differences are statistically relevant.

To check for any significant differences between the conformance in the two platforms we began by assessing the normality of the data. The results for Conservative and Optimistic metrics showed data with a normal distribution. We conducted a paired t-test for each metric comparing the conformance of the same application in both platforms. We found that there was a significant effect on conformance of the application based on the platform ($t(19) = 5.09, p = 0.00006$) with TV versions ($M = 0.72, SD = 0.15$) being more conformant than desktop ($M = 0.44, SD = 0.15$) versions for the Conservative metric. The Optimistic rate ($t(19) = 3.68, p = 0.002$) also showed statistical differences between the TV ($M = 0.87, SD = 0.07$) and Desktop ($M = 0.78, SD = 0.05$) versions. The normal distribution of the data on the strict rate was not verified, therefore we used a non parametric test. We conducted a Wilcoxon test and found that there was a significant effect on conformance of the application based on the platform ($K = 3.21, p = 0.001$) with TV versions ($M = 0.84, SD = 0.1$) being more conformant than desktop ($M = 0.65, SD = 0.12$) versions.

3.5. Discussion

The results of this experiment reject our hypothesis. The outcome revealed that TV applications are more conformant with the WCAG 2.0 accessibility guidelines than their desktop versions.

One of the possible explanations for this is related with the correlation between the rate values and the page complexity. Lopes et al.[16] define the complexity as the number of HTML elements present in a Web page, encompassing both the breadth and depth of the HTML node tree. They found that, at least on the conservative and strict rates, there is an exponential decay between the node count and the metric. As the results show, the average of the element count of the TV applications is less than a fourth when compared with the desktop applications. By looking at figure 1 we can see that in the upper image the TV version is less complex in terms of elements per page than the desktop version (notice the scrollbar).

When faced with these results we came up with the question: *if TV applications are considerable more conformant with accessibility guidelines, why are they not recommended for and used by people with disabilities or special needs?*

By manually verifying the functionality of the TV applications and comparing with the desktop ones, we were able to find that the presented information on TV is mostly restricted to videos and that some of the features available on

Fig. 1. TV (top) and Desktop (bottom) versions of Rant Sports application

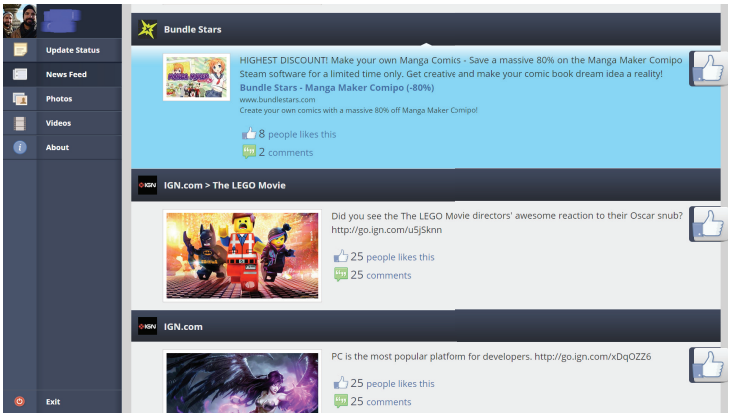

Fig. 2. Facebook application for Opera TV

the desktop version are removed. Figure 1 shows, for example, a TV application that is composed mostly by a list of videos while in the Desktop application (bottom image) it is possible to access richer information, such as text articles, images and videos. Additionally, it is composed by several sections unavailable on the TV version, it has connections to social networks and it is flooded with advertisements.

Another example of this trend is the Facebook application. It is not possible to see our list of friends, check their pages or chat with them in the TV version (see figure 2). This kind of restrictions can lead to the abandonment of these applications, and would certainly detract from the experience of its users.

Another contributing factor is the lack of support from assistive technologies for this new delivery context. User-friendly voice interfaces and voice guides are especially critical for individuals with special needs, such as the visually impaired, as mentioned in[1]. In addition, voice support is becoming an increasingly important part of staying productive and enjoying entertainment and multimedia.

The European project GUIDE (Gentle user interfaces for elderly people) created a software framework and design tools which allows developers to efficiently integrate accessibility and personalization features into their TV applications, minimizing intervention with existing development process and tools. GUIDE provides automatic integration and adaptation of various legacy and next-generation user interface technologies, such as gesture interaction, voice control, avatars, second screen multi-touch devices and gyroscopic remote controls[17]. Epelde et al. follow a similar approach by providing an implementation of a multimodal/multi-purpose natural human computer interface for elderly people, by creating adapted graphical user interfaces and navigation menus together with multimodal interaction (simplified TV remote control and voice interaction)[18]. Although a positive effort, these projects are not directed to severe impairments such as total blindness and their ideas were never picked up by the industry.

Recommendations state that TV networks broadcast should provide Audio Description (Video Description). Although the descriptive video services help describing a particular show or movie, leveling in some way the enjoyment and viewing experience, it is not prepared for TV applications. There are Text-to-Speech technologies developed for TV, similar to what blind users use on Desktop, such as IVONA[19] and TV Speak[20]. However they only read the programme guide and require an external source to run such as a computer or a Web enabled mobile device. Even if these technologies supported TV applications why would users use them if they need a computer? Users would simply use the computer to access the same (or more) information and with an extended assistive technology offer.

Following our study results, TV applications have a higher level of accessibility when compared to desktop Web applications (as measured by an automated evaluator). However, users are prevented from benefiting from it, as there is not a good support for assistive technologies for the TV environment

As we stated before, we found that on our sample there were applications that used the same template. We decided to analyse if the use of this template affected positively or negatively the accessibility scores. The Shapiro-Wilk Test of Normality showed that the data was normally distributed and with an independent samples t-test we could verify that there are no significant effects on the Conservative, Optimistic or Strict rates ($p > 0.05$). Therefore, we could not find any correlation between the accessibility results and the use of templates within the TV applications.

4. Conclusion and Future Work

This paper presented an experimental study of the current state of TV accessibility using off-the-shelf applications that can be found on the Opera TV store and makes a comparison between them and their versions on traditional desktop platforms. The results show that TV applications are more compliant with the WCAG 2.0 guidelines.

Evaluating the accessibility of a Web page for people with impairments requires a variety of expertise and perspectives. An effective and comprehensive evaluation of Web accessibility requires more than simply running an evaluation tool. Vigo et al.[21] confirm that relying on the automated tests alone can have negative effects and undesirable consequences. A good assessment requires evaluators with an understanding of Web technologies, automated evaluation tools, accessibility barriers, assistive technologies and strategies people with disabilities use. While conformance is important, evaluating with users with disabilities can identify usability and accessibility issues that would not be found other way. However, Aizpurua[22] alerts to the fact that a website with a significant number of guideline violations can be perceived as accessible, and on the contrary, some participants may not perceive a highly accessible website as accessible. Thus, in order to continue assessing the state of accessibility of TV platforms and their applications we are currently conducting an evaluation composed with a plethora of evaluation techniques: manual code inspections with accessibility experts, surveys and user studies with impaired users.

Additionally, we argue that the evaluation should consider TV focused techniques. With these, the results could be different as what is right for desktop can be wrong on TV platforms. For instance, some of the success criteria defined by WCAG must be adjusted according to the recommendations of the Digital and connected TV accessibility documents (e.g. contrast values, text size, etc.). Taking this into account, we are also characterizing and comparing the available recommendations and guidelines for TV environments as well as the adequacy of the WCAG 2.0 for TV applications for future implementation on the evaluator.

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