Evaluating the Usability for Interactive Digital Television Applications

line 1: 1st Given Name Surname   
line 2: *dept. name of organization   
(of Affiliation)*  
line 3: *name of organization   
(of Affiliation)*line 4: City, Country  
line 5: email address or ORCID

line 1: 4th Given Name Surname  
line 2: *dept. name of organization*  
*(of Affiliation)*  
line 3: *name of organization   
(of Affiliation)*line 4: City, Country  
line 5: email address or ORCIDline 1: 2nd Given Name Surname  
line 2: *dept. name of organization   
(of Affiliation)*  
line 3: *name of organization   
(of Affiliation)*line 4: City, Country  
line 5: email address or ORCID

line 1: 5th Given Name Surname  
line 2: *dept. name of organization   
(of Affiliation)*  
line 3: *name of organization   
(of Affiliation)*line 4: City, Country  
line 5: email address or ORCIDline 1: 3rd Given Name Surname  
line 2: *dept. name of organization   
(of Affiliation)*  
line 3: *name of organization   
(of Affiliation)*line 4: City, Country  
line 5: email address or ORCID

line 1: 6th Given Name Surname  
line 2: *dept. name of organization   
(of Affiliation)*  
line 3: *name of organization   
(of Affiliation)*line 4: City, Country  
line 5: email address or ORCID

***Abstract***—**Applications for Interactive Digital Television (IDTV) are becoming increasingly popular. Users no longer interact only with software applications on computers or smartphones, but also through a television set. Therefore, it is necessary to ensure the satisfaction, efficiency, and effectiveness that users may have when interacting with those applications. This paper presents an Application Usability Model for DTV based on two approaches: the quality of the product and the quality in the use of the software product. The model is based mainly on the ISO / IEC 25010 standard in which a set of usability characteristics are defined. These characteristics have been divided into sub characteristics, attributes, and metrics of the IDTV to quantify each attribute and identify the usability problems that might be present. Besides, to have a better idea of how the evaluation should be performed, an example of using the usability model for a weather application designed for IDTV is presented.**

Keywords—Evaluation, Usability, Interactive Digital Television, Feature, Metric.

# Introduction

Television is seen as a medium to communicate, inform, entertain, and educate [1]. This device is present in most homes in the world [2]; it allows interaction with various types of users. The transition from analog television to digital television (DTV) has been made in many countries [1][2][3][4]. Unlike analog TV, DTV increases the number of channels available, improves the quality of audio and video, and allows the incorporation of interactive applications [3].

Hence, interactive digital television (IDTV) enables a dialogue between the user and the device; that is, it is the active participation of the user with the content broadcast [2]. Thus, being able to determine the direction of the flow of the content, allowing viewers to participate and interact with the deployed applications [2][5]. IDTV allows interaction with various communication systems, mobile devices, among others [1].

An IDTV application provides three types of services: i) information services that are related to the transmitted programs, ii) transmitted programming services, and iii) transactional services that allow the sending and receiving of information [6]. These services require good interaction between IDTV applications and the user, So the question is, how do you ensure that IDTV application users get the best interaction satisfaction, efficiency, and effectiveness? Then, it is necessary to evaluate the usability considering characteristics, sub characteristics, attributes, and metrics that help to generate measurable values to have a clear perspective of the quality, always in terms of usability, of the different applications.

To evaluate the usability of applications for IDTV, a usability model based on the ISO / IEC 25010 standard is propose [7]. The model is important because it considers a set of characteristics of the IDTV applications, this model has attributes that can be measured through the definition of metrics. It is possible to evaluate each part of an application.

The method considers two approaches: the model of product quality and the model of quality in the use of the product. First, ISO / IEC 9126 refers to the usability of the product as the "*ability of software to be understood, learned, used and attractive to the user, under specific conditions of use*" [8]. Second, ISO / IEC 9241 refers to the quality in use as the "*effectiveness, efficiency and satisfaction with which a product allows specific objectives to be reached by specific users in a context of specific use*" [9]. Some aspects are considered here, such as the means available to the viewer to interact with the applications: remote control, second-screen devices, among others.

On the other hand, the development of interactive applications is required to improve the user experience. [4]. In the development of applications, it is essential to use different models, techniques, and principles focused on the user in IDTV [10]. Considering that users with little experience in the use of new technologies are perceived as difficult to use [10] and that the usability of an IDTV application is different from an application for a computer or mobile device [10]. Therefore, it is necessary to create a model for evaluating the usability of these applications so that they can provide development focused on improving the user experience.

This article has the following structure: Section 2 presents works related to usability evaluation methods for IDTV applications. In section 3, the proposed usability model is presented. Section 4 contains an application example of the usability evaluation model. Finally, section 5 presents the conclusions and future works.

# Related Work

There are studies [11] [12] [13] [14] that apply various techniques for evaluating usability, unlike related works, the ISO 25000 standard has not been used, these works are mentioned below.

The proposal presented in [11] is based on a proposal made of other usability evaluation methods (UEM) that integrate collaborative processes, which according to the authors, allow obtaining results richer in content than traditional UEMs. They propose three different paths, which depend on two factors: the objectives of the evaluation and the desired results. The tracks are explained below: i) global evaluation: analyzes an IDTV application in a complete way using heuristic evaluations, constructive interactions, and interrogation methods. ii) specific evaluation: analyzes specific functionalities of the IDTV application through heuristic evaluations, formal experiments, and interrogation methods and iii) complete evaluation: more in-depth analysis than the previous ones, making use of each of their techniques.

On the other hand, [12] proposes an evaluation of IDTV applications based on specific tasks that are broken down into generic tasks that must be executed by a user. The objective is to measure the effectiveness, efficiency, and satisfaction of the level of usability of an application in relation to the definition of specific tasks. Usability testing can be done on menu layouts, multiple video screens, content display areas, pagination, and scrolling, among others. The proposals mentioned above are different from the one presented in this work because they are based on the active collaboration of the user making use of experiments and methods of interrogation. The proposal of this article considers a set of characteristics of the IDTV applications represented in a quality model formed by sub-characteristics, attributes, and a set of metrics that provide a clear picture of what will be evaluated. The evaluation will help to determine if an application is usable or not; also, both, the developers and the users themselves can perform the evaluation.

In [13] the authors seek to examine universal access to IDTV applications by evaluating how accessible, usable, and compelling IDTV application user interfaces are within the television experience using a collection of constructs and quantitative measurement instruments obtained by combining research on affective Human-Computer Interaction (HCI) and media studies, considering: unique characteristics of the television medium, the television audience and the context of use. However, the evaluation focuses on the user interfaces obtaining general quantitative results of effectiveness and the affective capacity of the interface, unlike the model presented in this work which allows obtaining quantitative results of specific characteristics and attributes of both the quality of the product and the quality in the use of the product, taking into account the term "product" refers to IDTV applications in all its context.

To evaluate the usability of IDTV applications, [14] presents a set of heuristics divided into three groups: design and aesthetics, flexibility, navigation, and errors. To analyze each heuristic, it is necessary to fill out a template specifying information related to the heuristic such as identification, name and definition, examples, benefits, and problems. The evaluators evaluate the interface through the proposed heuristics, for this, it is necessary to establish usability problems, assign points to each problem according to its severity from 0 (less frequent) until 4 (more recurrent), sum the results and classify the problems according to their gravity.

# Usability Model for IDTV Applications

In this section, the usability model for IDTV applications is presented along with a brief description of the sub-characteristics, attributes, and metrics. For reasons of space, only the most relevant attributes of each sub characteristic will be presented. The complete model can be found at the following URL: "goo.gl/Nawpsh".

In the usability of the product, each of the sub-characteristics come from five of the six recommended features for usability in the ISO / IEC 25010 standard [7]: Intelligibility, learning, operability, protection against user errors, aesthetic. The feature not considered is accessibility because it focuses on the "ability of the product to be used by users with certain characteristics and disabilities" [7]. However, the proposed method focuses on the common user. Also, it is necessary to add the characteristic to evaluate the quality according to the level of user satisfaction. These characteristics are represented in figure 4.

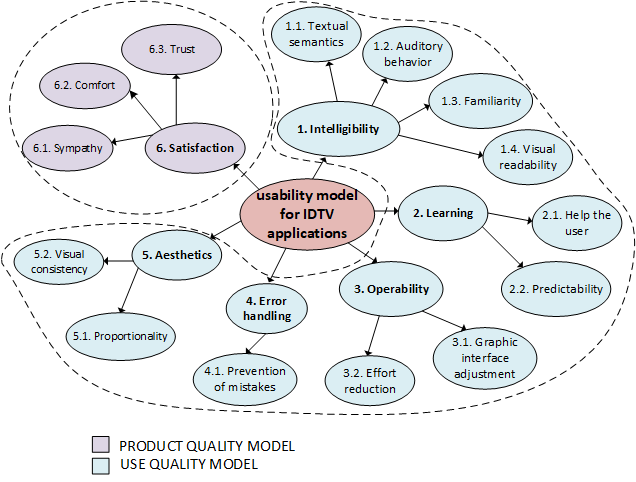


Fig 1. Characteristics and sub-characteristics of the usability model for IDTV applications

## Intelligibility

Table 1 shows the attributes related to intelligibility that allow the user to understand if the application is adequate to meet their needs [7]. The sub-characteristics are:

1. Textual semantics represents the level of understanding of the text being presented.
2. Auditory behavior is the presentation of images synchronized with the sound.
3. Familiarity is the interaction of the user with the graphic interface and its elements. It contains the following attributes: Internationalization and Component Popularity.
4. Visual readability that refers to the characteristics of visual components is suitable for the user. It contains the following attributes: density of the information presented, the layout of components on the screen, and the size of the elements.

The *layout of components* on the screen attribute refers to the strategic location of the components in the application interface so that they can be easily found and recognized. The associated metric consists of the division of the number of visible components among the total number of components. If the result is 0, there would be a greater usability problem, and if it is 1, then there is no usability problem.

TABLE 1. Sub-characteristics of Intelligibility

| Sub-characteristics | Attribute | Meaning |
| --- | --- | --- |
| 1.1 Textual semantics | 1.1.1 Understanding textual information | Is the textual information presented coherently and is it easy to find in the message that is desired to transmit? |
| 1.2 Auditory behavior | 1.2.1 Sound and images synchronization | Are the audio and video images synchronized (no lag)? |
| 1.3 Familiarity | 1.3.1 Internationalization | Are the available actions to navigate the application similar to the ones commonly used? |
| 1.3.2 Component Popularity | Are the components presented easily recognized because they have been accepted and commonly used? |
| 1.4 Visual readability | 1.4.1 Density of the information presented | Is the amount of information presented on the screen adequate? |
| 1.4.2 Layout of components on the screen | Are the components easy to find and recognize? |
| 1.4.3 Size of the components | Is the size of the components suitable for a viewing? |

The attribute *Size of the components* refers to the fact that the objects shown do not cause an overloaded presentation of objects that hinder visual understanding. The associated metric refers to the ratio of the number of components with the appropriate size among the total number of components. A result of 0 reflects a greater usability problem, while a result of 1 reflects the opposite.

## Learning

Another usability feature is learning, which allows the user to easily learn the content of the application [7]. This continent has two sub-characteristics, the same as those shown in Table 2 and described below.

1. Help the user: it is the one that represents the ability of the application to provide help to the user.
2. Predictability: this represents the expression level of the graphical interface to define the actions of each component.

The help on buttons uses attribute refers to the information of the functionalities associated with each button so that the user always has in mind what is allowed to do. The associated metric corresponds to the ratio of the number of buttons that have a description of the activities they perform among the total number of buttons available in the application. A response of 0 represents a greater usability problem; an answer of 1 indicates there is no problem.

The attribute Expressiveness of labels associated with the media refers to a label that defines the functionality of the associated medium to allow consistent navigation and rapid learning by the user [15]. The associated metric consists of the relationship between the number of expressive labels associated with the media and the total number of labels associated with the media. A response of 0 represents a greater usability problem, and a result of 1 indicates there is no problem.

The attribute *Predictability of component actions* refers to the ease of determining what action will be executed if a component shown on the TV screen is used. Its metric is associated with the relationship between the number of components with foreseeable actions and the total number of components. A response of 0 represents a greater usability problem, while 1 indicates there is no problem.

TABLE II. Sub-characteristics of Learning

| Sub-characteristics | Attribute | Meaning |
| --- | --- | --- |
| 2.1 Help the user | 2.1.1 Help on buttons use | Is there information provided to the users about the actions to be executed when using a button? (Red, yellow, green button) |
| 2.1.2 Information on activities to be performed | Is there information provided about the activities necessary to perform a task? |
| 2.2.1 Expressiveness of the labels associated with the media | Is it easy to foresee that a concept is associated with a label of an element of the interface? |
| 2.2 Predictability | 2.2.2 Predictability of component actions | Is it easy to predict the action a component performs? |
| 2.2.3 Determination of possible permitted actions | Is it easy to determine the actions allowed by the application? |

## Operability

This feature refers to the capacity of the product that allows the user to operate and control it easily [7]. Table 3 presents the sub-characteristics and attributes related to operability; the sub-characteristics are Graphic interface adjustment and Effort reduction.

1. Graphic interface adjustment is an automatic interface adjustment to any screen size or device.
2. Effort reduction: The user should make the least effort to complete a task.

TABLE III. Sub-characteristics of Operability

| Sub-characteristics | Attribute | Meaning |
| --- | --- | --- |
| 3.1  Graphic interface adjustment | 3.1.1 Auto-adjustment of the interface to various screens | Can the graphic interface be auto-adjusted to screens of different sizes without damaging the visualization of its components? |
| 3.2 Effort reduction | 3.2.1 Minimum actions | Are there mechanisms that allow carrying out a task where the user performs few actions? |

The attribute *minimum actions* refer to everything that facilitates the application, al-lowing to quick execution of certain actions, for example, the use of shortcuts that favor users to be able to operate the application quickly and easily [15]. The associated metric refers to the relationship between the number of actions required to complete a task using shortcuts with the number of actions without shortcuts. A result of 0 has a minor usability problem, 1 the opposite.

## Protection against user errors

The characteristic refers to the ability of the product to protect users from making mistakes [15]. Table 4 (a) shows sub characteristics and attributes related to protection against user errors. Sub-characteristics is the prevention of errors.

TABLE IV. Sub-Characteristics of Protection Against User Errors And Aesthetics

| Sub-characteristics | Attribute | Meaning |
| --- | --- | --- |
| **(a) Protection against user errors** | | |
| 4.1 Prevention of errors | 4.1.1 Validation of data entry | How much data entered into the application has any errors? |
| 4.1.2 Restriction of non-necessary functions of the remote control | Is there a small and limited number of functionalities available to interact with the application? |
| **(b) Aesthetics** | | |
| 5.1 Proportionality | 5.1.1 Ratio of Size between elements and screen size | Is the area occupied by a component correctly related to the total area of the application on the screen? |
| 5.2.1 Coherence in the grouping of components | Are the components grouped according to the purpose they must fulfill? |
| 5.2 Visual consistency | 5.2.2 Uniformity of colors | Are the background colors used consistently in all sections of the application? |
| 5.2.3 Contrast colors | Is the level of brightness and colors of the components ad-equate? |

In the *Restriction of non-necessary functions of the remote control,* it is necessary to consider that having a small and limited number of functionalities available to interact with the application improves usability because the user does not have to remember the operation of each button of the remote control.

## Aesthetics

Table 4 (b) presents the sub-characteristics and attributes related to Aesthetics. This feature refers to the ability of the user interface to please and satisfy the viewer [7].

The attribute *Coherence in the grouping of components* refers to the fact that the components must be grouped in contiguous zones of the screen according to the actions they execute (for example, those components with similar activities or those whose execution precedes the execution of another component). The associated metric corresponds to the relationship between the number of coherently grouped components and the total number of components. If the result is 0, there is a greater usability problem, if it is 1, there is no problem.

## Satisfaction

It is also necessary to establish a quality model to evaluate the quality in use of the applications for IDTV considering the devices through which the user can interact with said applications. It was considered to evaluate the quality in use in terms of the satisfaction achieved by the viewer.

Table 5 presents sub-characteristics and attributes of Satisfaction. This characteristic refers to the degree to which users feel satisfied with the experience of using a product in a context of specific use [9].

The *Results Waiting Time* attribute refers to the waiting time between the execution of an action and the presentation of results. The associated metric states that it will have a value of 0 if the response time is greater than or equal to 10 seconds, it is 0.2 if the response time is between 5 and 10 seconds, 0.4 if it is between 2 and 5, it will be 0.8 if the response time is between 0 and 1, and lastly, it will be 1 if it is less than or equal to 0. It is considered a metric of 0 as a major usability problem and 1 as the best result.

TABLE V. Sub-characteristics of Satisfaction

| Sub-characteristics | Attribute | Meaning |
| --- | --- | --- |
| 6.1 Sympathy | 6.1.1 Compliance on the behavior of the application | Does the user feel comfortable with the tasks that are al-lowed to perform in the IDTV application? |
| 6.2 Comfort | 6.2.1 Navigability between available functions | What is the level of compliance achieved when using the available navigation method to move from one functionality to another? |
| 6.2.2 Text input modes | How much time does it take for a user to enter text into the application? |
| 6.3 Trust | 6.3.1 Consistency of the result | Are the results presented adequate? |
| 6.3.2 Results waiting time | How long must a user wait for the results to be presented after having executed an action? |

# Application of the Usability Model

In this section, the usability assessment model applied to a randomly chosen IDTV application is presented. This application offers the visualization of the weather of a city or a place near the city selected by the user; the graphical interface of this application is shown in figure 1.



Fig 2. Weather display application for IDTV

To develop the evaluation, in the first instance, a set of sub-characteristics and attributes of the Usability Model for IDTV should be selected. Then, using the metrics of each attribute's sub-characteristic, the application is evaluated. This step is performed to obtain measurable values of usability to gather information and then generate a usability report. Said report will have the usability problems detected and will also provide suggestions to solve them.

Next, the usability evaluation of the application for weather visualization is presented, using four attributes with their respective metrics. Here, the objective is to generate a brief usability report. The sub-characteristics and attributes applied are:

## Visual readability: Size of the components (1.4.3)

Then, to apply this metric is necessary to know the number of components, or elements in the interface, with an appropriate size and the total number of components in general. There are 10 components with an appropriate size and 20 components in total. When calculating the metric obtained is 0.5.

## Help the user: Help on buttons use (2.1.1)

There is a total of 2 buttons that are associated with a description of the actions performed and 8 buttons available in the application. When calculating the metric, a value of 0.25 is obtained.

## Comfort: Navigability between available functions (6.2.1)

The metric is calculated by using a Likert scale with a range of 0 to 1 to indicate the level of conformity in the available navigation method. Here, 0 is the lowest level and 1 the highest to indicate the level of compliance in the available navigation method. The value obtained is 0.8.

## Trust: Results waiting time (6.3.1)

It is perceived that when applying for the weather of a city, the application takes 3 seconds to display the result, for which a value of 0.4 is assigned. With the results obtained, a usability report can be prepared.

Table 6 shows a summary of the before mentioned report together with the attributes, results, and degree of the usability issue.

TABLE VI. Summary of Usability Report

| Attribute | Metric Value | Usability Issue |
| --- | --- | --- |
| Size of the components | 0.5 | Medium |
| Help on buttons use | 0.25 | Major |
| Navigability be-tween available functions | 0.8 | Minor |
| Results waiting time | 0.4 | Medium |

As seen in the results report, attribute 6.3.1 has a minor usability problem because it has an adequate inter-function navigability. Attributes 1.4.8 and 6.3.2 present a medium usability problem because, in the first instance, there are large components that occupy an area too large of the screen and, second, the response time is relatively slow. The biggest usability problem is presented by attribute 2.1.1 because there are few buttons with information about their actions compared to the number of buttons that are used in the application, which can cause the user's lack of knowledge about what should and can be done.

# Conclusions and future work

This paper has presented an Application Usability Model for IDTV, which can be used to evaluate the usability of the applications that are deployed on TV. The model in question breaks down the usability characteristics proposed in the ISO / IEC 25010 standard into sub-characteristics and, at the same time, said sub-characteristics into at-tributes. It has also been defined a set of metrics associated with each attribute in order to quantify them and therefore be able to identify usability problems, whether these are major, medium, minor or none. The model is complemented with the satisfaction characteristic present in the quality of use of the product, which also considers the means of interaction with the application.

All the characteristics, sub-characteristics, attributes and metrics suggested in the Application Usability Model for IDTV refer to important elements that must be considered in applications of this field to achieve both an adequate product usability and a good quality in use.

As future work, it has been considered the design and develop of a method of evaluation of usability of applications for IDTV in which the process necessary to carry out this evolution is detailed and, at the same time, give guidelines of how the evaluators should apply the Application Usability Model for IDTV, both from the perspective of the developer or of the buyer.

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