

Minimalist and Intuitive User Interface Design Guidelines for Consumer Electronics Devices

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Abstract

People today come in contact with many consumer electronics (CE) devices in their daily lives. CE devices have become increasingly complex with added functionality; devices from different vendors provide different user interfaces for the same functionality; similar devices from the same vendor provide different user interfaces for common functionality. As a result, usability of CE devices has become a serious challenge for most users. In this paper, we put forth design guidelines for making user interfaces for CE devices easy to understand for most everyday users. To do this, we first present a taxonomy of user interface dimensions for CE devices. We then present our design guidelines against core elements of the taxonomy, and apply them against various popular CE devices. The designing guidelines, when applied consistently and diligently, can help bring some order to the current state of user interfaces for CE devices. The results of this paper should be applicable to a good extent to general digital systems

Keywords: User Interface, UI, Human Computer Interface, HCI, Usability, CE devices,

1 INTRODUCTION

People today use many types of consumer electronics (CE) products, including cellular phones, music players, DMB (digital multimedia broadcast) players, personal digital assistants, digital televisions, video recorders, digital cameras, smart refrigerators, video security systems, automobile navigators, digital clocks, calculators, etc., besides personal computers, laptops, and computer-based systems and equipment at home and work. All the functions these devices (and systems) provide, all the information they contain, and all the responses they make to user commands are exposed through the user interface (UI). Ideally, the UI should be designed so that most everyday users can, without having to consult the user manual, easily figure out how to use all of the primary functions of the devices and systems, easily comprehend all of the basic information they contain, and easily comprehend

most of the responses from them. Sadly, however, the state of UI for CE devices, and many of the general digital systems, today is well short of the ideal.

Many of the CE devices have become rather complex, as vendors have added new features and functions in order to differentiate from competitors and also to justify raising the price. CE devices of different types have some frequently used common functions, such as power on/off, channel up/down, date/time setting, etc; however, different vendors offer very different UIs for these functions. Even worse, vendors of the same family of CE devices offer different UIs for the devices. Further, the UIs are often inconsistent, and difficult or impossible to follow without consulting user manuals. For those features that are not often used, each time they are used, the manuals need to be consulted.

The UI may not be the most important factor that determines the commercial success of CE devices. For example, the commercial success of digital televisions is determined by the picture quality, price, design, functionality, and the brand name. However, once parity is established on these factors, UI becomes a key differentiator among competing products. Today, due to competitive pressures in the market, parity has been established on most of the important factors, and UI remains a factor that can help vendors differentiate from others.

As CE devices are used by everyday users, not just engineers or artists, their UIs must be designed for ease use and comprehension by everyday users. Various researchers have suggested guidelines for designing a UI. Shneiderman and Plaisant suggested “8 golden rules” [1]: A good UI should have consistency, provide universal usability, provide meaningful feedback, include an exit interface, prevent errors, make rollback easy, be always controllable, and reduce data which should be memorized to operate the device. Ferré et al. suggested 5 characteristics of determining usability [2]: learnability, efficiency, repeatability, error rate, and satisfaction. Norman suggested that basic principles of a good design for human are providing good a conceptual model and being visible [3]. Smith and Mosier offer guidelines for designing the UI for software in six functional areas: data entry, data display, sequence control, user guidance, data transmission, and data protection [4].

These are all valid guidelines. However, in our view, they have not been well-heeded by UI designers of CE devices on the market today, as evidenced by the sad state of the UI. As a result, we have decided to see if we can help to bring some order into the UI of CE devices by proposing a minimum set of very practical design guidelines. To do it, we first developed a taxonomy of user interface dimensions in CE devices. The taxonomy provides a framework for understanding more precisely how we apply our design guidelines.

For our research, we analyzed MP3 music players, digital TVs, DVD recorders, digital still cameras, DMB players, PMPs (Personal/Portable Multimedia Players), and cellular phones. The vendors included Samsung Electronics, LG Electronics, TiVO, and Apple Computers. By analyzing the UI of these devices, we arrived at a minimum set of design guidelines. (* Although we are not at liberty to divulge our findings with respect to Samsung Electronics products, suffice it to say here that we have reported our findings and recommendations to the top management for action, and the top management has accepted most of our recommendations. *)



The contribution of our research is the minimum practical set of guidelines for designing the UI of CE devices to substantially help everyday users to comprehend the functionality and information contents of the devices. We believe the set of guidelines can apply to a large extent to general digital systems, and should also be useful to technical users.

The remainder of this paper is organized as follows. In Section 2, we present a taxonomy of user interface dimensions for CE devices. In Section 3, we discuss a minimum practical set of design guidelines for CE devices. In Section 4, we make the design guidelines concrete, and illustrate the effectiveness of our guidelines by identifying how each of them is violated in CE devices. Section 5 concludes the paper.

2 A TAXONOMY OF USER INTERFACE DIMENSIONS

Before proceeding, let us see the reasons for the current sad state of the UI for CE devices.

1. There are many types, and many models for each type, of CE devices
2. Increasingly many functions are crammed into many of the devices.
3. The increasing number of functions leads to many types of information to store and display.
4. There are many methods to represent the information
5. There are many modes of interaction with the users
6. There are many ways to appeal to the user's sense of aesthetics and emotions.

Beyond these, the UI has not been a high-priority item for the vendors, as they have chosen to focus on the other, more pressing, items to survive in the market, such as cost reduction, pricing, distribution, marketing, design, hardware quality, features, and name branding. Further, as we will see shortly, the UI have several dimensions, in our view, user interface designers have devoted time on those dimensions that appeal to the emotions of the users, and devoted much less energy and thought on those dimensions that deal with how everyday users can comprehend the functions and information contents of the devices.

Some researchers proposed taxonomies of the UI and human-computer interaction systems. Chignell made an early attempt at a taxonomy of human-computer interaction and standardizing terminology [5]. Coomas and Timmermans proposed a taxonomy of physical media, representational modalities, and human-computer dialogue semantics [6]. Barr et al. considered a principled understanding of user-interface metaphors, and provided a taxonomy for discussing and analyzing them [7].

We developed our own taxonomy¹ as a framework for understanding all dimensions of the UI, and identifying more precisely where we should apply our design guidelines. The taxonomy, shown in Figure 1, consists of five parts, corresponding to five dimensions of the UI for CE devices; namely, physical vs. non-

¹ We note that an earlier version of this taxonomy was the subject of a very short paper by us in Korean that we presented in a domestic Korean conference [8]. We include an upgraded version here to provide a basis for presenting our design guidelines.

physical, aesthetics and emotion, convenience, operation mechanisms, information and information architecture. When designing a user interface, every dimension has to be accounted for.

2.1 Physical vs. Non-Physical

The first dimension is whether the user interface is physical or non-physical.

PUI (Physical User Interface)

- Physical user interface refers to the physical user interface elements on the CE device with which the users interact. This includes physical buttons, switches, wheels, knobs, stylus, touch screen, keypad, microphone, monitor, speaker, digital camera, video recorder, etc. on CE devices, including remote controls.

NPUI (Non-Physical User Interface)

- Non-physical user interface refers to logical user interface elements, such as alphanumeric information or images or video displayed on the monitor, voice or sound heard via the speaker, etc. Such information is the result of a command the user issues, an action (e.g., turning the power on/off) the user takes, or the occurrence of an abnormal condition. Often there are many categories of such information, and many of the categories may logically best be decomposed into sub-categories. As such, the information has to be organized in a hierarchical structure, known as information architecture. Information architecture refers to the organization of such information.

2.2 Aesthetics and Emotions

The next dimension in user interface refers to user interface elements that appeal to the aesthetics and emotions of the users. This dimension applies to both the physical and non-physical aspects of the user interface. This has five aspects, corresponding to the five sensory functions of the human. In practice, though, only three aspects are relevant.

Visual aspect

- color, brightness, contrast, etc.
- shape, size, arrangement of the PUI and NPUI user interface elements
- graphics, images, animation, video, symbols, etc.
- design and appearance of a device

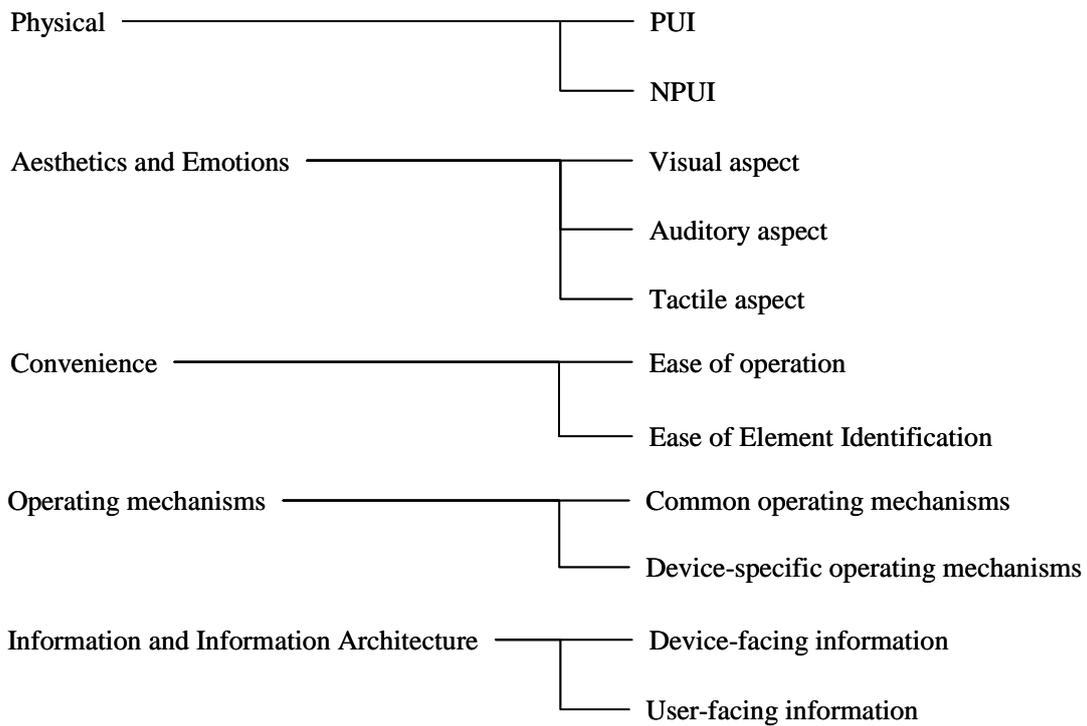


Figure 1. Taxonomy of CE User Interfaces

Auditory aspect

- tone, loudness of sound, intonation, accent, etc.
- sound effects (bell sound, animal sound, etc.)

Tactile aspect

- texture, weight, elasticity of a device, etc.

2.3 Convenience

The next dimension of the UI is convenience to the users. This refers to ease of use, and is certainly an important determinant of the usability of a device. In particular, there are two types of convenience. One is ease of operating a device, and applies to the physical aspect of the user interface. Another is ease of identifying user interface elements, and applies to both the physical and non-physical aspects of the user interface.

Ease of Operation

- shape, size, and layout of PUI elements,
- sound, flashing or blinking light,
- other characteristics of a device

that make it easier to see, understand, press, grasp, touch and feel a device, etc.

Ease of Identification

- shape, size, and color of PUI elements,
- font size, font style, font color, and background color of text, etc.,

- shape, size, color, and layout of NPUI elements, etc.,
- sound, flashing or blinking light, etc.
- other characteristics of PUI and NPUI elements

that make it easier to identify a user interface element.

2.4 Operating Mechanisms

The next dimension in user interface is the operating mechanisms for the devices. Broadly, this may be classified into those that are common to many types of devices, and those that are specific to a given type of device. The operating mechanisms apply to both the physical and non-physical aspects of the user interface. There are many mechanisms for operating devices physically, such as, moving a cursor, pressing a button, throwing a switch, touching a touch screen, typing on a keypad, gesture, motion, etc.

Common operating mechanisms

- power on/off
- menu operations: open/close, 4 way navigation, select/release, exit/back
- alphanumeric data input and manipulation of displayed alphanumeric data

Device-specific operating mechanisms

- TV: channel up/down, display modes, picture in picture mode, etc.
- digital still cameras: zoom in/out, shot mode, flash mode, etc.
- MP3 music players: media play control (play/pause, fast forward, etc.)
- other devices: tilting, shaking, touching,.....

Both types of mechanisms have a very important common sub-mechanism, namely, error-handling mechanisms. Error-handling mechanisms typically use visual or audio information. Sometimes, however, they involve a device lockout. There are two ways to handle error.

- Error prevention: ignoring input, requiring confirmation, circulative menu navigation, etc.
- Error warning: issuing of a warning message (and/or sound, blinking light, etc.)

2.5 Information and Information Architecture

The information and information architecture dimension refers to the information content and the organization of the information. In our taxonomy, this refers only to the non-physical aspect of the user interface, and does not include the aesthetics and emotions dimension. There are two types of information in terms of whether it is to be input by the user or to be viewed and manipulated by the user. The use of information may be for the installation and operation of a device, or for viewing by the user, as shown below.

Device-facing information

- installation: initial setting values, etc.



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- operation: input for menu navigation, control and data input, input for error handling, etc.

User-facing information

- installation: cable connection, help information for initial setting (including on-line manual), etc.
- operation: operating mechanisms for the menus, buttons, switches, etc.
- representation: labels, icons, symbols, buttons, etc., feedback on user input, device status information, error feedback, etc.

The information may also be classified in terms of the types of data to be input or output, as follows.

Device-facing information

- visual information
 - image: finger print, pupil, picture, etc.
 - text: title, name, description, etc.
 - numeric: channel, setting values, etc.
 - date and time: system time, reservation time
 - scalar: volume, play position, etc.
- audio information: voice, sound, etc.

User-facing information

- visual information
 - image: icon, image, graphic, animation, video, etc.
 - text: menu label, description, message, etc.
 - numeric: channel, setting values, etc.
 - date and time: system time, reservation information, program information, etc.
 - scalar: volume, play position, etc.
 - attributes: color, font size, font style, blinking, etc.
- audio information: voice, melody, sound effect, etc.
- other modalities: vibration (haptic information)

3 DESIGN GUIDELINES

We now present our minimal set of guidelines for designing the user interface of CE devices with the view to making it as easy as possible for everyday users to comprehend all primary functions and primary information contents of CE devices. The guidelines apply to all five dimensions in our taxonomy.

We start with a very simple premise, that is, the UI must be simple. To be simple, the types and number of UI elements must be minimal; all UI elements and their combinations must be intuitively comprehensible to everyday users with minimal exposure to some CE devices; and there must be consistency among all UI elements and their combinations. Further, the minimum and intuitiveness guidelines must be applied consistently throughout the UI design. Below we examine each of these three guidelines for making the UI simple.

3.1. Minimum

As the number and types of features keep increasing, it is easy for UI designers to increase the number and types of UI elements. The number and types of UI elements must be kept to a minimum. Specifically, the number of symbols, icons, labels, font styles, font sizes, text colors, background colors, modalities, the number of items and depth of the menu hierarchy, etc. should be kept to the minimum. If some redundancy is to be built in, it must be done in very careful consideration of the business requirements. The following explains what it means to minimize various UI elements.

- The number of physical UI elements, such as input buttons on a device, should be minimized to correspond to the most frequently used functions. Less frequently used functions should be manifested as non-physical UI elements, that is, as items on a menu. For example, there should not be buttons on a television remote control for functions such as “memorize or erase a channel”; the users should be directed to the menu to find items corresponding to such functions. In this way, UI designers should prevent the remote control from being crowded with buttons and labels for non-frequently used functions.
- When it is necessary to overlay several functions on one button, the number of overlaid functions should be limited to 2. The general public has been accustomed to toggle switches, and, for example, it is reasonable to overlay the “on” and “off” functions on the “power” button. However, it causes confusion if 3 or more functions are overlaid on a button, for example, the “open/close/back” functions on a single menu button.
- The use of icons, symbols, and labels for both physical and non-physical UI elements should be minimized. In other words, no icons, symbols, and labels should be used unless they are necessary. Icons, symbols, and labels that make no sense to the users or are difficult or impossible for them to easily comprehend and remember are regarded as “unnecessary,” and should be eliminated or modified.
- The number of font sizes, font styles, and colors used should be minimized. Mixing more than a few font sizes, font styles, and colors in general distracts the users.
- Labels, phrases and sentences on both the physical and non-physical UI elements should be brief (and clear).
- The number of items on a menu screen should be kept to fewer than 7 or 8 to avoid cluttering the screen.
- The depth of a menu hierarchy should be limited to 3 or fewer. It is difficult to trace the menu structure and be aware of the nodes and paths followed, if the depth is more than 3.

3.2. Intuitiveness

The labels, symbols, icons, words, phrases and sentences on many CE devices and on the menu are often difficult to comprehend intuitively. Sometimes, words, phrases, and sentences that only engineers can understand appear on the menu or even the devices. Further, icons are often not symbolic of the corresponding functions, and only their designers can appreciate their meanings. The users need to consult the user manuals to be able to operate the devices or navigate the menu. However, to



compound the matter, the manuals too are often difficult to understand or may have long been misplaced.

People in reasonably industrialized parts of the world today are exposed to everyday UI elements in their daily lives. These include a variety of doors (home, office, hotel, automobile,...), combination locks, public transportation systems, automobile dashboards, automobile and airplane seatbelts, road signs, traffic signals, signs in public places, elevators, toasters, washing machines, hair dryers, treadmills, etc. Beyond these, many use some of the many CE devices, personal computers, and the World Wide Web. Further, many are exposed to UI elements in performing their jobs, such as machine tools, heavy industrial and farming equipment, weapons, airplanes, trains, ships, etc. As such, everyday users may reasonably be expected to possess some common knowledge and experience-based intuition about the meanings and basic ways to operate various UI elements. This includes, for example, the fact that the red color or flashing light implies a warning; the power button on a CE device is an on/off toggle switch, the lines on a road sign near an exit ramp on the highway correspond to streets or other highways, etc.

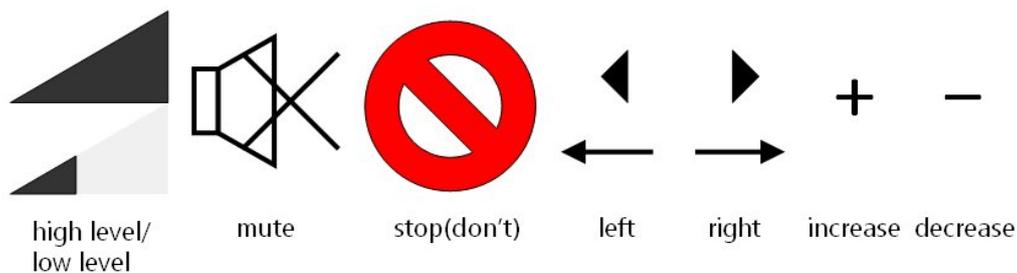


Figure 2. Intuitive Symbols

The meaning of each physical and non-physical UI element on a CE device must be intuitively clear to everyday users. Figure 2 shows some UI symbols whose meanings should be intuitively clear to everyday users. The sequence and combination of UI elements, too, must be intuitively clear. To design the UI for CE devices to be intuitively clear to everyday users, the designers must exploit the common knowledge and acquired intuition of the users, and must be very careful not to venture outside of the scope of such knowledge and intuition. The ultimate goal of the UI for CE devices should be to make it possible for most everyday users to be able to use the CE devices without having to consult the user manuals. The following further explains what it means for the UI to be intuitive.

- When it is necessary to overlay several functions on one button, there should be relationships among the functions that are intuitively clear. For example, the left and right navigation functions are overlaid on the message box button on some cellular phones, and the flash mode button on some digital still cameras. This is not intuitive, since there is no obvious relationship between the navigation function and the messaging function on cellular phones, or between the navigation function and the flashing function on digital still cameras. Even if the user is able to operate this function by first reading the manual, the user is likely to have to consult the manual again after not using the functions for a while.
- The icons and symbols must be symbolic of the functions they represent. For example, on a 4-way navigation button, there should be up/down/left/right

symbols; and on a volume up/down button, there should be corresponding symbols, such as +/-.

- The symbols, labels, icons, words, phrases, etc. should be easily comprehensible to everyday users. In other words, such technical phrases as “700 Mbytes of storage remaining” on a music player should be eliminated. Appropriate color should be used for warnings and emphasis.

3.3. Consistency

Consistency cuts across all aspects of every UI element in every CE device. Once a particular symbol is chosen for a particular function, it should be applied consistently throughout the UI. This should certainly be done within a particular device, and preferably also across devices of different types that happen to share the same function. We define inter-device consistency to be consistency between different types or models of CE devices, either from the same vendor or different vendors; for example, digital televisions and digital still cameras. We define intra-device consistency to be consistency among UI elements on one particular type and model of device.

In general, there should be inter-device and intra-device UI consistency. Today, as we will illustrate in the next section, both inter-consistency and intra-consistency are inadequate. As a result, everyday users have to learn to operate each device, separately, because each device has a different menu structure, different icons and symbols for the same or similar functions, different words and symbols even on the same device, etc. As CE devices of the same type, and even of different types, share common functions, the ultimate goal of consistency should be unification (i.e., standardization) of the UI elements for these common functions. The following explains further what it means for the UI elements to be consistent.

- The menu layout, and the navigation and selection of menu items should be consistent.
- The selection of the font style, font size, colors, etc. should be consistent.
- The selection of icons, symbols, and labels should be consistent for the same or similar functions. For example, if a left arrow is used for left navigation on the menu of a digital television, it should be used not only on all left navigations on the menu, but also on the remote control, and even on the music players from the same vendor.

4 APPLYING THE DESIGN GUIDELINES TO CE DEVICES

In this section, we apply the three design guidelines to the non-physical aspect of the UI of several representative CE products from leading vendors. The discussions serve two purposes: one is to illustrate each of the design guidelines in concrete contexts, and another is to demonstrate the merit of applying the design guidelines in identifying the problems and fundamental reasons for the problems with the UI in today’s CE devices. To protect the commercial interests of the vendors, we shall not name them.



Nested menu structure (violation of minimum)

It has long been established that the depth of a menu hierarchy should be limited to 3 or under. We have found, for example, that the external connection setting function on some digital TV menus is 4-level deep, as shown in Figure 3. Either the top or the second level of the menu hierarchy may be eliminated to fix this problem.

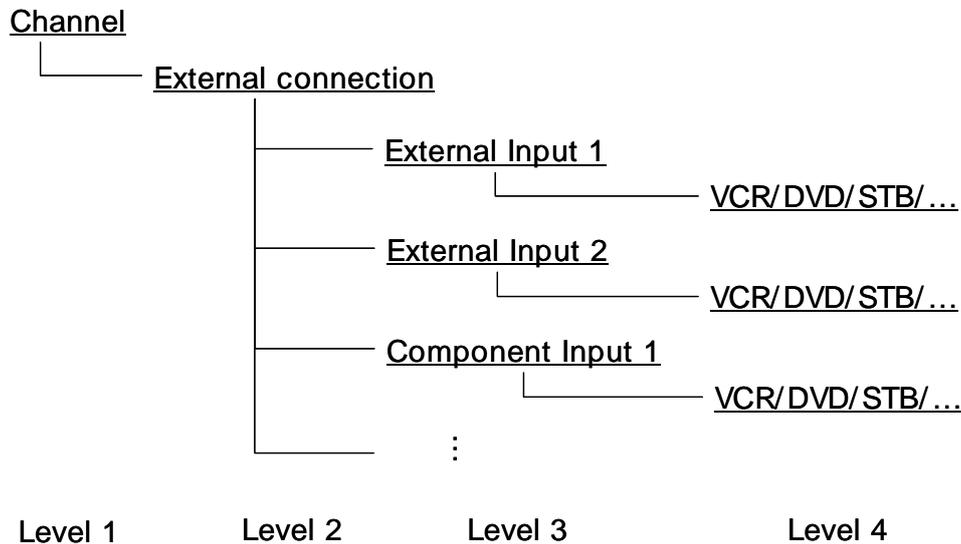


Figure 3. The menu structure for the external input connection setting function on a DTV

Overlaying of functions (violation of minimum and intuitiveness)

The “menu” button on some digital TV remote controls has three functions overlaid on it: open, close, and back. Only the open and close functions should be overlaid to make the button a toggle button that the ordinary users would expect. Either the back function should be removed from the remote control, or should be placed on the menu, or perhaps even overlaid with some other function on another button on the remote control.

Hidden functions (violation of intuitiveness)

The “program reservation” function on some digital TV does not exist on the remote control, and it is an item on the “Program Guide” menu screen. This presumes that the users will browse through the programs and, upon finding a desired program, will reserve a desired program. However, the label “Program Guide” would convey to ordinary users the notion that the menu screen would only provide program information, and does not convey the notion that the act of reserving programs would be a part of it. To fix this problem, either the label “Program Guide” should be changed to “Program Guide and Reservation,” or a separate menu screen should be created for “Program Reservation” at the same level as “Program Guide”

Use of difficult or non-helpful words or phrases (violation of intuitiveness)

Some digital TVs and DVD recorders are found to use technical terms or words and phrases whose meanings are not clear on the menu screens and help screens. These include such words and phrases as “display mode”, “audio mode”, “SRS”, “internal amplifier”, “v-mode”, “equalizer”, “free space remaining: 70Mbytes”, etc. These

would not mean much to a large segment of everyday users. Such technical term as “70Mbytes” should be translated to a term that would be both relevant and easily comprehensible to the ordinary users, such as “x number of additional songs may be recorded”, “x minutes of additional video may be recorded,” etc.

Mismatch of the PUI and NPUI elements (violation of consistency and minimum)

Figure 4 shows volume control interfaces of an MP3 music player. The “up and down” movement of the touch pad on the player (PUI) and the circular GUI feedback display (NPUI) do not match. The inconsistency between the two UI elements burdens the users with one extra UI element and paradigm to deal with.

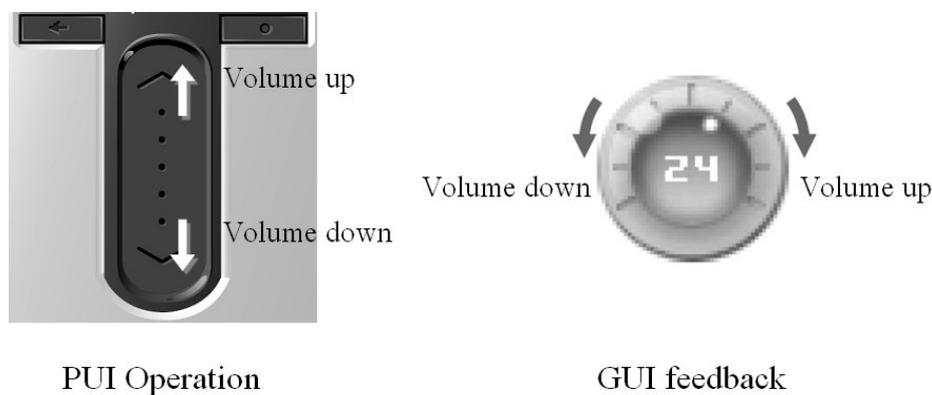


Figure 4. Inconsistent volume control interfaces (PUI and NPUI)

Use of different words, symbols and labels for the same functions within the same devices or across different devices (violation of consistency)

The selection button is labeled variously as “select,” “confirm,” or “OK” on different devices. Similarly, the “power on/off” button comes with different symbols on different devices, as shown in Figure 5.



Figure 5. Examples of the use of different symbols for the same function

Inconsistent operating mechanisms within a menu (violation of consistency)

The “back” button on digital TVs or DVD recorders is used either to exit the current menu or to return to the upper-level menu screen. However, in some devices it is used to exit all active menus.

Inconsistent operating mechanisms between similar devices (violation of consistency)

The “menu” button on digital TVs is used for the “menu open” and “menu back” functions, while the “menu” button on some of the DVD recorders is used for the “menu open” and “menu close” functions.



5 CONCLUSION

As the number of types and models, and the features and capabilities of consumer electronics (CE) devices have increased during the past decade, usability of the devices has become a major challenge to everyday users. Unfortunately, the vendors have not satisfactorily addressed this challenge. Although there have been a number of sensible guidelines for usability of digital systems in general, they appear not to have had sufficient impact on the design of the UI for CE devices.

In this paper, we started with the obvious notion that in order for the CE devices to be usable to everyday users, the UI must be simple. To be simple, we believe that the UI must diligently and consistently adhere to three principles: minimum, intuitiveness, and consistency. To make the discussions of the three principles concrete, we first described our taxonomy of UI elements for CE devices, and then applied the principles to various UI elements in a number of popular CE devices on the market. We believe that the set of principles, being minimal and intuitively obvious in themselves, should be able to serve as very practical guidelines for the designers of UI and CE product development executives in the vendors.

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