

Real-World Graphical User Interfaces

Toshiyuki Masui¹ and Itiro Siio²

¹ Sony Computer Science Laboratories, Inc.
3-14-13 Higashi-Gotanda, Shinagawa, Tokyo 141-0022, Japan
masui@acm.org

<http://www.csl.sony.co.jp/person/masui.html>

² Faculty of Engineering, Tamagawa University
6-1-1 Tamagawa-gakuen, Machida, Tokyo 194-8610, Japan
siio@acm.org

<http://www.edp.eng.tamagawa.ac.jp/siio/indexe.html>

Abstract. Although the age of information appliances is getting close, current remote control devices are too awkward, and we cannot control sophisticated equipments without using graphical computer terminals. We propose a new interaction technique called the *Real-world GUI*, where users can control real-world appliances just like performing GUI operations on graphical computer terminals, using a new input device called the *FieldMouse*. FieldMouse is a device which consists of an ID recognizer and a motion sensing device. Using a FieldMouse, various GUI tools like buttons, menus, sliders, and others can be used on any surface and objects, just like using a mouse on a desktop computer. Users can control or program various information appliances as easily as performing GUI operations on graphical computer terminals.

1 Introduction

People expect that more and more computers and information appliances are going to be used hidden in the background of our households [8]. In such an environment, all the audio devices, VCRs and computers will disappear from our living rooms, leaving more space for our life. This sounds like a promising future, but current limitations of remote controllers and input devices seem to prevent us from achieving this goal. Many of the control panels of current appliances are difficult to use, and most of the wireless remote controllers are filled with many obscure buttons, hard to find, and easily lost. People these days usually have to use many remote controllers, and it is hard to remember the mappings between buttons and their functions.

As appliances become invisible, controlling them may become more difficult. If wires are not visible, people may not be able to know easily how to send a video signal from a VCR to a screen. If all the VCRs are connected to a single network cable, people may have to give a name to each of them to distinguish them, just like we are giving names to network-connected computers and printers. If all the music CDs are stored in a hidden server, people may have problems remembering the name of a music and cannot retrieve it from the server. Without appropriate control devices, sophisticated information appliances and computers would be almost useless.



Fig. 1. FieldMouse#1: Combination of a barcode reader and a pen-mouse.



Fig. 2. FieldMouse#2: Combination of a barcode reader and a gyro-mouse.

Although current personal computers are still not very easy to use, the interaction environment is much better on computer desktops than doing jobs with remote controllers, owing to the improvements of various sophisticated graphical user interface (GUI) techniques. Icons are useful for remembering data and functions, and they can be copied and put to anywhere we need. Menus are useful for structuring hierarchical data and hiding unnecessary elements. Drag-and-drop is useful for specifying the flow of data without using symbols. Scroll bars and zooming interfaces are useful for handling large data. We cannot use these GUI techniques with remote controllers, and using many remote controllers is like using a computer with all its menu opened and spread on the desktop.

If techniques used in graphical user interface were available for handling VCRs and information appliances, and if GUI tools were available anywhere, people could control them much more easily. People can use a menu to specify the direction of a signal, use a scroll bar to select a CD, etc. We believe that various interface techniques invented for computer desktops are also useful for controlling appliances in the real world, so we are investigating hardware/software techniques to enable Real-World Graphical User Interfaces (RWGUI).

2 Real-World GUI

To realize RWGUI, we have developed a simple inexpensive control device called the *FieldMouse* that enables us to perform RWGUI without using computer screens or special sensing devices, which are often required for interaction in the real world. Using



Fig. 3. FieldMouse#3: PalmIII PDA including a laser scanner and a tilt sensor inside.

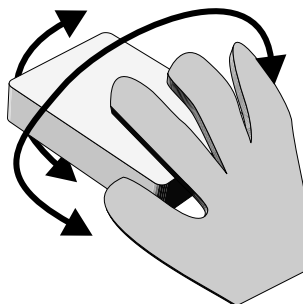


Fig. 4. Tilt detection using FieldMouse#3.

a FieldMouse for RWGUI, many of the problems of remote control devices are solved.

2.1 FieldMouse

A FieldMouse is a combination of an ID detection device and a motion detection device. The first device can be a barcode reader, RFID tag reader, etc., and the second device can be a mouse, a gyroscope, an accelerometer, etc. With the combination of these devices, various real-world interactions become possible [11].

We have been developing various combinations of the devices. Figure 1 (FieldMouse#1) is a pen-type FieldMouse which consists of a barcode scanner and a pen-mouse. Figure 2 (FieldMouse#2) is a combination of a pen-type barcode scanner and a mouse with a gyroscope.

Figure 3 (FieldMouse#3) is a combination of a PDA, a laser scanner, and a tilt sensor. FieldMouse#3 is constructed based on Symbol Technology's PDA SPT1500³,

Using a FieldMouse in the real world	Using a mouse in a computer display
Move the FieldMouse to a barcode	Move the mouse cursor to the menu title
Click a button to initiate recognition	Click the mouse button
Wait until the barcode is recognized	
Move the FieldMouse from the barcode	Drag the mouse cursor
Release the button	Release the mouse button

Table 1. Comparison of using a mouse and using a FieldMouse for selecting a menu item.

which is a combination of a small laser barcode module and 3Com's PalmIII PDA. At the back of the print board of SPT1500, we put a tilt sensor chip ADXL202 by Analog Devices⁴ and connected it to one of the unused pins of the CPU⁵, so that SPT1500 can detect its angle relative to the horizon. ADXL202 can detect 2 tilt directions, so the CPU on FieldMouse#3 can tell how much it is tilted from its horizontal position.

2.2 Using FieldMouse for RWGUI

A FieldMouse can use the barcode reader to tell what and where it is pointing at, and measure the relative movement of the device after detecting the barcode. Fortunately, many of the GUI widgets are based on point-and-drag operations and require only these information for interaction, and they can easily be simulated by the FieldMouse. For example, a barcode symbol can be used like a pulldown menu, by using the amount of the movement for selecting items. If the system interprets the amount of the relative movement as an analog value, it works just like a slider or a scroll bar.

RWGUI operations with a FieldMouse can be very close to the GUI operations using a mouse. Table 1 shows the correspondence between using a mouse and using a FieldMouse when manipulating a menu. To use a menu or a slider, a user first moves the FieldMouse to a barcode, clicks a button to initiate the scanner, waits until the barcode is recognized, moves the FieldMouse and releases the button. Since barcodes are usually recognized instantly, there is almost no time lag in the recognition step, and users feels little differences between using a mouse in a computer display and using a FieldMouse for using a menu or a slider in the real world.

Barcodes have been used for many years in industries, and small, reliable, and inexpensive barcode readers are widely available. Mouse and motion sensing devices are also widely available, so FieldMouse can be very easily constructed.

³ <http://www.symbol.com/palm/>

⁴ <http://products.analog.com/products/info.asp?product=ADXL202>

⁵ This technique and schematics are described in this page:
<http://www.ibr.cs.tu-bs.de/~harbaum/pilot/adxl202.html>

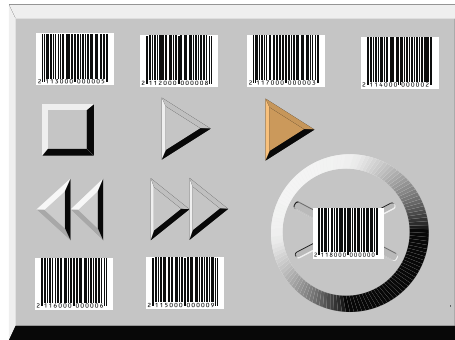


Fig. 5. A VCR control panel.

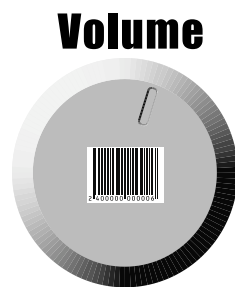


Fig. 6. A RWGUI symbol for controlling the volume.

3 Examples

With the technique shown in the previous section, we can use a variety of GUI widgets everywhere, just by putting barcodes on objects. We can put volume control widgets on TVs, speakers, and telephones. We can print barcodes on a paper card for selecting music and controlling the sound volume. All the remote controllers can be replaced by papers with barcodes, and we no longer have to worry about managing remote controllers as long as a FieldMouse is available. In this section, we show various examples of using a FieldMouse for RWGUI.

Buttons Any barcode symbol can be used as a GUI button, just by mapping the codes to different functions. Figure 5 shows an example of mapping VCR control buttons to barcode symbols printed on paper.

Although this is one of the most conventional usage of barcodes and this does not seem to be much different from using a control panel of a VCR, this method has an advantage, because the buttons can be printed or copied and pasted on anywhere, and users do not have to worry about the correspondence between remote controllers and appliances. Using papers like Figure 5, users don't have to suffer from the problems of having many remote controllers and worry about losing them. Users can lay out buttons as they like, or put them on anywhere the function is needed. The controlled device



Fig. 7. Controlling the volume at the speaker.



Fig. 8. A CD-Card.

does not have to be a real VCR; it can be a home video server, streaming video from the network, etc., but the interface can be the same.

Sliders and Rotators Using the FieldMouse, any barcode can be used as a scrollbar or a slider. By scanning a barcode and twisting the FieldMouse#3, the system can use the tilted angle for controlling the volume of an audio amplifier.

Figure 6 is an example of a RWGUI symbol for controlling the sound volume. The shape of the knob does not mean anything to the system, but like graphical symbols used in GUI, it helps the user understand that the barcode represents a RWGUI widgets for rotation.

Just like the RWGUI buttons, users can put the symbol anywhere they want. It can be pasted on a telephone, or it can be pasted on speakers to enable “direct manipulation”. Even when there are multiple speakers, users can control each of them without confusion. Using conventional control panels and remote controllers, it is often hard to remember which button corresponds to each speaker.

Menus Menus can be implemented in the same manner. Since FieldMouse#3 can detect the rotation of the device after detecting the barcode, pie-menu like shown in the lower-

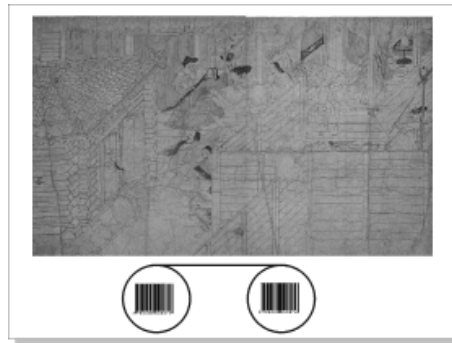


Fig. 9. A scroller panel.



Fig. 10. Using the scroll panel to browse a long scroll.

right corner of Figure 8 can be used.

Using the volume control widget and the music selection widget, a paper card like Figure 8 can be used to select music instead of using many barcodes for all the songs.



Fig. 11. An icon for specifying the signal direction.

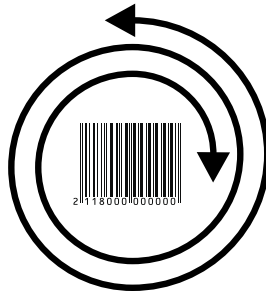


Fig. 12. A zooming icon.



Fig. 13. Searching music with zooming interface.

Scrollers Figure 9 shows an example of a scroller widget icon for FieldMouse. With the drawing around the icon, users can easily tell in which direction they should tilt the FieldMouse. In Figure 10, a user is using the card and browsing a very long scroll, by tilting the FieldMouse left and right.

Drag-and-Drop Drag-and-Drop can be performed if barcodes are printed both on the source and on the destination. In most drag-and-drop operations used in the GUI systems, users have to select the data object first and drag it to the destination. Using the FieldMouse, users can tell the system which is the destination and which is the source, by tilting gestures or by the moving direction. For example, using a symbol like Figure 11, users can tell VCR1 that data should be sent to it by tilting the FieldMouse#3 downwards, or tell VCR1 that it is the source of the data by tilting the FieldMouse#3 upwards.

Zooming Using a FieldMouse for zooming user interface is also possible. Zooming user interface (ZUI) is a new set of GUI paradigm suitable for handling huge amount of data [3]. Rotation of FieldMouse#3 after detecting a barcode like shown in Figure 12 can be used for controlling the zooming factor.

Figure 13 shows how a user can use the FieldMouse#3 to find a song from a huge

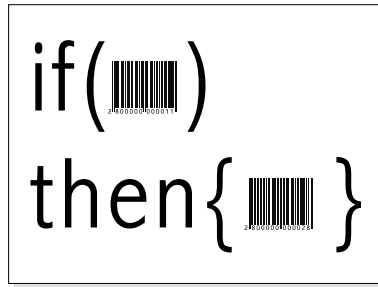


Fig. 14. A programming panel.

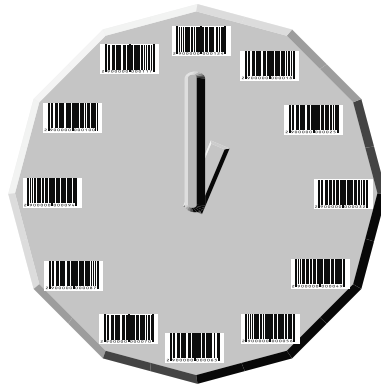


Fig. 15. Time panel.

MP3 database. The user can scroll the long list by tilting FieldMouse#3 up and down, and control the zooming factor by twisting it left and right, using the zooming mechanism described in [6].

Authoring Using a FieldMouse, users can pick up data from any barcode symbol in the world. They can go to grocery stores and pick up UPC/EAN data or go to book stores and pick up ISBN data of interesting books. By interpreting an ordinary ISBN code as a menu, users can give additional information to the data. Using the FieldMouse, users can intuitively pick up data from any barcode symbol and give it to other barcode symbols. This means that programming or authoring can also be performed intuitively.

Programming a VCR has long been believed to be a complicated task for ordinary people. On the other hand, everybody can easily set the wakeup time on a clock. The difference between these systems is that setting the wakeup time is much more concrete and direct than programming a VCR. Using a FieldMouse and appropriate barcode symbols, programming a VCR and other information appliances can become much more direct and easier. Figure 14 shows an example panel for programming VCRs and other appliances. Users can pick up the condition part directly from other barcode symbols and drop it to the programming panel. For example, a user can pick up a time



Fig. 16. Examples of the ID card.

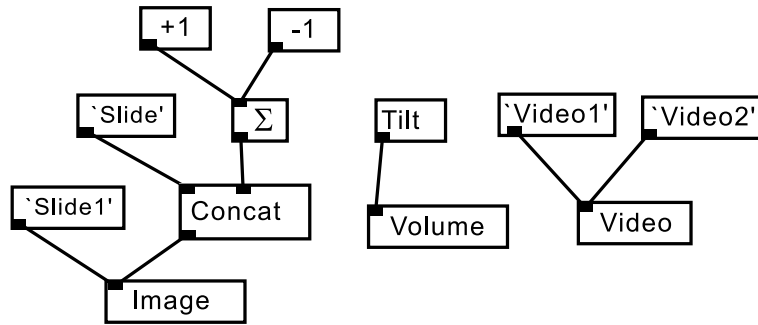


Fig. 17. A real-world program for slide presentation.

from the time panel shown in Figure 15 using the pick-up gesture, and give it to the “if” part. And the user can pick up the execution part from the VCR control panel shown in Figure 5 and give it to the “then” part.

4 Real-world Programming

Just like visual languages and 2D drawing tools are suitable for creating GUI programs, using RWGUI is suitable for creating RWGUI programs. Using the FieldMouse and RWGUI tools described in the previous section, simple RWGUI programs can be created without using computer terminals. Conventional techniques used in various visual programming languages can be used for general programming activities in the real world, which we call *Real-World Programming*(RWP) [7].

Figure 16 shows the “ID cards” which represent programming elements used in our example RWP system. By drawing virtual lines between elements like drawing lines in data-flow visual languages, RWGUI programs can easily be created only by using the FieldMouse.

Figure 17 shows an example real-world program for slide presentation. In this program, when a user scans the barcode printed on the “+1” card, the value is accumulated and serial slide number is generated. The number is then concatenated with a string “slide”, and the actual name of the slide file (e.g. “slide5”) is generated and sent to the display module. The whole program can be programmed only using the FieldMouse and ID cards.

5 Related Work

Many researchers have been trying to integrate the environment in the computer and the environment in the real world, and use real-world objects as GUI elements. Wellner's DigitalDesk [14] is an early example of this direction, and many systems based on similar ideas have been proposed [2][10]. In these systems, projectors are used to display computer-generated images on the desk or on the wall, and position sensing devices and cameras are used to get users' actions. Although this approach works well in a stable environment like a meeting room, the system can be used only in the fully-equipped room, and it is doubtful whether using many equipments just for mixing the environment is justified.

Some people are taking different approaches and trying to embed many small computers in the real world. This approach, called Ubiquitous Computing [13], is also promising, but it must still take long until everywhere is equipped with small computers.

Printed barcodes have long been widely used to identify objects, and various approaches have been investigated to use barcodes for augmented-reality applications. For example, Johnson proposed using a special 2D barcode for exchanging data between computers and printed papers [5]. Recently, RFID tags are becoming cheaper and popular, and methods for using them for linking real-world objects and computer is also proposed [12]. Using Arai's PaperLink system [1], any printed text can be used as a link or a command, by using a small camera for OCR. These approaches are promising because only small and inexpensive devices are required to realize real-world interactions, although there are more limitations than using equipped rooms or environments. Our approach is unique in that users can control real-world objects using gestures that are almost identical to GUI operations in computer display terminals.

Pick-and-Drop [9] is a system for exchanging data between different computers or between paper and computer, by a pick-up operation on a screen or on paper followed by a dropping operation on a computer screen. In this system, both the source and the destination computer should recognize the position of the electromagnetic pen, and the pick-up operation is not intuitive enough. Using a FieldMouse, special input devices are not required and intuitive paper icons for picking up and dropping data can be used for the same task.

6 Discussions

6.1 Evaluation

We have been using various versions of the FieldMouse only in the laboratories and we have not tested them in real households yet. However, one of the authors has hundreds of MP3 music data in his computer and using the FieldMouse for selecting it and controlling the volume in his office.

The impression of using it is quite promising. When a user want to control the volume using a conventional MP3 player program on a desktop computer, it usually takes several steps until being able to control the volume. Using the FieldMouse, controlling volume

is as easy as having an amplifier next to the computer and control the volume manually. Based on this experience, one of the authors is planning to set up a MP3 server in his home and put all the CDs and audio cassettes hidden in a closet.

6.2 Interaction Feedbacks

Unlike GUI operations on computer displays, printed barcodes do not change when users move the FieldMouse after recognizing the barcodes, and visual feedback is not shown to users. This is clearly an disadvantage, but this is not a serious problem, since the system can give various feedbacks to the user in different ways. For example, when controlling the sound volume, audio feedback is given back to the users and visual feedback is not necessary. Giving audio feedbacks to other operations like selecting a pie menu is also usually sufficient as feedbacks to users.

6.3 Using Invisible Tags

We are currently using printed barcodes for RWGUI, and printing barcodes everywhere would be not aesthetically pleasant for most users. However, various other invisible ID tags like RFID tags and invisible printed barcodes (with special ink) can be used for other types of FieldMouse, and we are planning to investigate on using other types of ID tags than printed barcodes.

6.4 Idioms for RWGUI

Some of the symbols and gestures introduced in this paper are new to conventional GUI users, since RWGUI is a new interface paradigm. Before people got used to graphical user interface, many of the symbols currently popular on computers meant nothing to them. However, people these days are having no trouble clicking the “X” icon to close a window and using menus to select an item from an item list. These symbols and interaction methods are like “idioms”, and good idioms are easy to remember and hard to forget [4]. Most of the current GUI elements like buttons and menu titles represent good idioms, since they have survived the selection step in the history of evolution. Currently there is no idiom for RWGUI yet, but there surely exist better idioms suitable for FieldMouse, and we hope we could design good idioms for RWGUI, as well as designing good hardware and software.

7 Conclusions

We have introduced a new interaction paradigm called the Real-World GUI (RWGUI), where users can use popular GUI widgets like menus and sliders in the real-world environment, only by using barcode symbols and a simple input device called the FieldMouse. Using our system, most of the appliances can be controlled by popular GUI operations, and all the awkward remote controllers can be thrown away. We are planning to use the system intensively both in the office and in the home, and get more evaluation results.

References

1. Arai, T., Aust, D., and Huson, S. E. PaperLink: A technique for hyperlinking from real paper to electronic content. In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'97)* (April 1997), Addison-Wesley, pp. 327–334.
2. Arai, T., Machii, K., Kuzunuki, S., and Shojima, H. Interactive desk: a computer-augmented desk which responds to operations on real objects. In *CHI'95 Conference Companion* (May 1995), Addison-Wesley, pp. 141–142.
3. Bederson, B. B., Hollan, J. D., Perlin, K., Meyer, J., Bacon, D., and Furnas, G. Pad++: A zoomable graphical sketchpad for exploring alternate interface physics. *Journal of Visual Languages and Computing* 7, 1 (March 1996), 3–31.
4. Cooper, A. *About Face – The Essentials of User Interface Design*. IDG Books, August 1995. ISBN4-88135-368-3.
5. Johnson, W., Jellinek, H., Jr., L. K., Rao, R., and Card, S. Bridging the paper and electronic worlds: The paper user interface. In *Proceedings of ACM INTERCHI'93 Conference on Human Factors in Computing Systems (CHI'93)* (April 1993), Addison-Wesley, pp. 507–512.
6. Masui, T. LensBar - visualization for browsing and filtering large lists of data. In *Proceedings of IEEE Symposium on Information Visualization (InfoVis'98)* (October 1998), pp. 113–120.
7. Masui, T. Real-world programming. In *Designing Augmented Reality Environments (DARE2000) Proceedings* (April 2000), pp. 115–120.
8. Norman, D. A. *The Invisible Computer: Why Good Products Can Fail, the Personal Computer Is So Complex, and Information Appliances Are the Solution*. The MIT Press, 1998.
9. Rekimoto, J. Pick-and-Drop: A direct manipulation technique for multiple computer environments. In *Proceedings of the ACM Symposium on User Interface Software and Technology (UIST'97)* (November 1997), ACM Press, pp. 31–39.
10. Rekimoto, J., and Saitoh, M. Augmented surfaces: a spatially continuous work space for hybrid computing environments. In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'99)* (May 1999), Addison-Wesley, pp. 378–385.
11. Siio, I., Masui, T., and Fukuchi, K. Real-world interaction using the FieldMouse. In *Proceedings of the ACM Symposium on User Interface Software and Technology (UIST'99)* (November 1999), ACM Press, p. to appear.
12. Want, R., Fishkin, K. P., Gujar, A., and Harrison, B. L. Bridging physical and virtual worlds with electronic tags. In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'99)* (May 1999), Addison-Wesley, pp. 370–377.
13. Weiser, M. Some computer science issues in ubiquitous computing. *Communications of the ACM* 36, 7 (July 1993), 75–84.
14. Wellner, P. Interacting with paper on the DigitalDesk. *Communications of the ACM* 36, 7 (July 1993), 87–96.