MouseField: A Simple and Versatile Input Device for Ubiquitous Computing

Toshiyuki Masui[1], Koji Tsukada[2], and Itiro Siio[3]

[1] National Institute of Advanced Industrial Science and Technology
Center Office 18F, Bunkyo Green Court
2-28-8 Honkomagome, Bunkyo, Tokyo 113-659, Japan
`masui@acm.org`,
[2] Graduate School of Media and Governance
Keio University
5322 Endo Fujisawa, Kanagawa 252-8520, Japan
`tsuka@sfc.keio.ac.jp`,
[3] Tamagawa University
6-1-1 Tamgawa Gakuen, Machida, Tokyo 194-8610, Japan
`siio@acm.org`

Abstract. Although various interaction technologies for handling information in the ubiquitous computing environment have been proposed, some techniques are too simple for performing rich interaction, and others require special expensive equipments to be installed everywhere, and cannot soon be available in our everyday environment. We propose a new simple and versatile input device called the MouseField that enables users to control various information appliances easily without huge amount of cost.

A MouseField consists of an ID recognizer and motion sensors that can detect an object and its movement after the object is placed on it. The system can interpret the user's action as a command to control the flow of information. In this paper, we show how this simple device can be used for handling information easily in ordinary environments like living rooms, kitchens, and toilets, and show the benefits of using it in the ubiquitous computing environment.

1 Introduction

Today, various Internet services are available and many people are using wireless networks at home. We now seem to have all the infrastructure for networked information appliances, but they are not yet available at every corner of the house, because standard computer input devices such as keyboards and mouses are not usable on the walls, on the kitchen table, and in the toilet.

To use computers in the ubiquitous computing environment, various interesting and useful technologies have been proposed. If input and output devices are equipped at many locations in a house, users can control information in a different way than conventional GUI techniques using keyboards and mouses. However, most of such techniques require many expensive and special sensors installed at all the places where interaction is performed.

For example, sophisticated interaction between human and a wall or a desk is possible if a precise position sensor and a projector is installed at the place of the interaction[1]. In this case, the user may be able to use his finger as a mouse and control menus and icons displayed on the wall or on the table. This kind of interaction is interesting and possibly useful, but it is unlikely that those devices will be widely used at home in the near future, since they are expensive, heavy, fragile, and difficult to install. Mirrors can be used to reduce the number of projectors[2], but installation and registration of these devices is not easy.

In addition, those devices cannot be used in rugged environments like kitchens and toilets where people may want to handle devices with wet hands. People like to have a computer in the kitchen, but they would not pay a lot of money to construct an IT kitchen just for watching TV programs and reading recipes on the Web. For enjoying real ubiquitous computing at home, robust and inexpensive input/output devices should be used at various corners of a house, and they should also be versatile enough so that they can accept various requirements from users.

RFID tags and printed barcodes have long been the candidate devices for controlling information appliances. Using the tags instead of keyboards and mouses is useful in many cases, since both the tags and readers are robust enough and can be put at almost any place. Also, the system is usually very easy to use, since the only thing a user can do with a tag or a barcode is to put the tag in front of the reader, and there's little chance of suffering from confusion. For example, you may be able to use a "weather forecast card" to check the weather at a nearby display, and you can use a "Yahoo stock tag" to check the stock status instantly without invoking a Web browser.

However, using these systems, a user can tell the system only one thing at a time, and cannot control complex things with one tag. For example, if a user wants to listen to various music using a tag-based music player, he should either use as many number of tags as the number of CDs he has, or use extra tags like "next", "rewind", and "volume up". Using a barcode-based presentation system[3], users have to prepare a number of cards for slide presentation. Tag-based systems are useful for small tasks, but it is difficult to perform complicated tasks with such systems.

2　MouseField

We introduce a robust and versatile input device called the MouseField that can be used at almost any place for controlling information appliances. MouseField is a device which combines an ID reader and motion sensing devices into one package.

Figure 1 shows an implementation of MouseField, which consists of two motion sensors (taken from standard optical mouses) and an RFID reader (Texas Instruments' S2000 Micro Reader) hidden under the surface.

The RFID reader and the two optical mouses are connected to a PC through a USB cable, and they can detect the ID and the motion of the object put on the device. When a user puts an object with an RFID on the MouseField, it first detects what was put on the RFID reader. When the user moves or rotates the object, the motion sensors detects the direction and rotation of the object. The amount of the rotation can be calculated by the difference of the amount of motions in the Y direction.
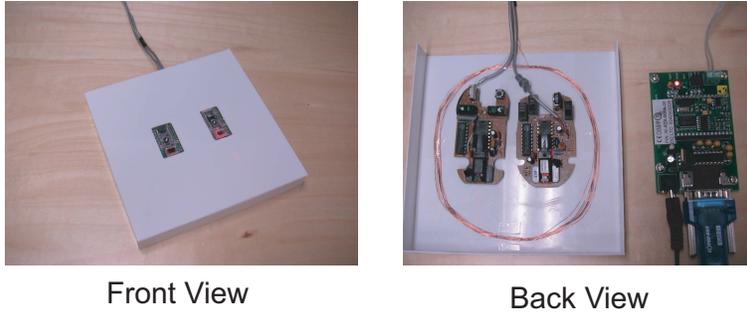
Front View   Back View

Fig. 1. An Implementation of a MouseField Device.

Table 1. Comparison of using the MouseField and using a mouse for controlling the sound volume.

Using a MouseField	Using a mouse in a computer display
Put an object on the the MouseField	Move the mouse cursor to the knob of a slider
(Wait until the RFID is recognized)	Click the mouse button
Rotate the object on the MouseField	Move the knob of the slider
Remove the object from the MouseField	Release the mouse button

These information are similar to the information we use when we control GUI widgets on PC screens. Just like we can control the sound volume by clicking the knob of a slider widget and move the slider up and down, we can do the same thing by putting a volume control object on a MouseField and moving or rotating the object. In this way, we can perform almost all kinds of GUI operations by putting an object on a Mouse-Field and moving it. For example, a user can put a "TV block" on a MouseField and rotate it to change programs, just like he can select a program using a pulldown menu. We can use a barcode reader instead of an RFID reader, just like our implementation of the FieldMouse[4]. Table 1 shows the comparison between using a MouseField and using a GUI slider for sound volume control.

Table 2. Comparison of using the MouseField and using a mouse for controlling the menu.

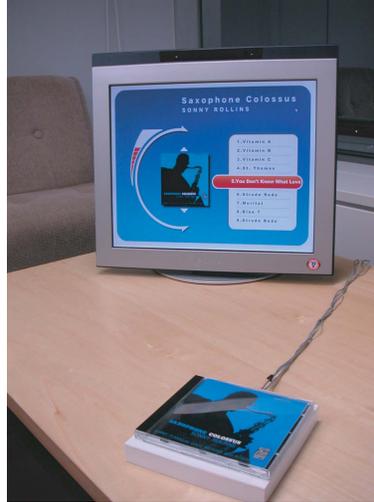| Using a MouseField	Using a mouse in a computer display
Put an object on the the MouseField	Move the mouse cursor to the menu title
(Wait until the RFID is recognized)	Click the mouse button
Move the object forward and backward	Drag the mouse cursor up and down
Remove the object from the MouseField	Release the mouse button

Fig. 2. PlayStand++: A Music Player with MouseField.

Similarly, Table 2 shows the comparison between using a MouseField and using a menu for selecting an item from a list. In this way, we can perform various kinds of GUI operations by putting an object on a MouseField and moving it. Nothing happens if the RFID was not recognized by the reader for some reason, just like nothing happens if people do not press the mouse button in standard GUI widgets.

The PlayStand++ system (Figure 2) shows how a user can enjoy music using a MouseField and CD jackets which represent the music in the CD. All the music in the CD are saved in a music server, and an RFID tag is attached to each CD jacket. When a user places a CD jacket on the MouseField, a music player is displayed on the screen, shows the contents of the CD, and starts playing songs. The user can change the sound volume by rotating the CD jacket, and move to the next or previous song by sliding the jacket to the front or to the back (Figure 3). When the user removes the jacket from the MouseField, the sound stops and a screen saver is displayed on the screen. The music player is not only very simple to use, but it allows users to control various parameters without using special controllers.

Just like a mouse can be used for various purposes, a MouseField can be used for whatever purpose you like in the ubiquitous computing applications. It can be used for invoking an application (just like a mouse-click can invoke an application), controlling parameters (just like using sliders and menus), selecting objects (just like dragging a mouse cursor), transferring data (just like mouse-based drag and drop), etc.

If we use multiple MouseField devices, we can utilize them for conveying information between locations. When we perform an operation on one MouseField and perform another operation on another MouseField, those series of operations can be interpreted as cooperative tasks. For example, a person can use one MouseField to tell the system that he wants to retrieve some information at the location, and use another MouseField
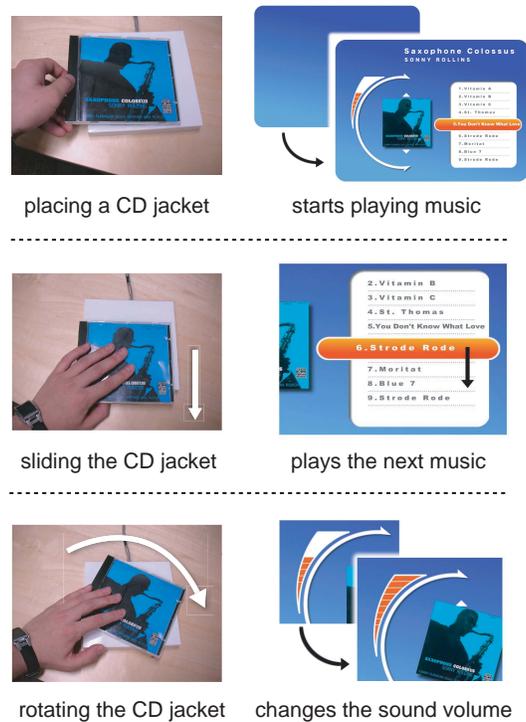
placing a CD jacket   starts playing music

sliding the CD jacket   plays the next music

rotating the CD jacket   changes the sound volume

Fig. 3. Controlling the Music Player.

to tell that he wants to convey the information to the new location. In this case, virtual Drag and Drop (or sometimes called "Pick and Drop"[5]) can be performed, just like other systems for using objects for carrying information[6][7]. If a person selects a TV program on a MouseField by using a TV block, he can bring the object to a different place with another MouseField and use the object to see the rest of the program there. In this way, MouseField can enable various interaction techniques which were only available with special and fragile input/output devices.

3 A Scenario of Using MouseFields

In this section, we show a scenario of a person's daily life where many MouseField devices are scattered at his house and at other places.

Hiro is a university student living alone in an apartment. In addition to his PC, he has a lot of hidden computers connected to MouseField devices installed in tables, walls, and doors. Those computers are used for various information appliances. Here begins his day:

– *Hiro gets up in the morning, goes to the living room and wants to awaken his brain by watching today's morning TV news. He puts a "TV block" on the MouseField*

equipped in the table of the living room. Then the TV is turned on, and a TV program is shown on the display.

– *Since the channel was not showing a news program, Hiro moves the TV block left and right to select a channel showing the morning news.*

– *He felt that the voice of the newscaster was too low, so he rotates the TV block and makes the sound a little louder.*

– *He then makes up his mind to make a morning coffee, and goes to the kitchen with the TV block. When he puts the block on the kitchen counter, the same TV news is displayed at the kitchen, since there's another MouseField equipped in the kitchen counter.*

– *He puts the TV block on the table and prepares to go to school. At the entrance door of his house, he puts his "Suica" card (a commutation ticket with an RFID) on the door, and check if there's something he has to do on that day. The display at the door tells him that a recycle car is coming to his neighborhood this morning, so he collects liquor bottles from his room and put them into a recycle box at the street corner near his house.*

We do not have to wait long before we can enjoy this kind of ubiquitous computing life. The only equipments required in this scenario are MouseField devices and displays connected via wireless network. There are so many services on the Internet, and wireless LANs and quiet PCs have been available in very low cost.

4 Discussions

4.1 Advantages of MouseField

The biggest advantage of using MouseField is that it can be inexpensive and robust. RFID tags are getting cheaper every day, and it costs less than $1 these days. Printed barcodes are almost priceless, and easily be replicated even when you lose it. Barcode readers, RFID readers, and motion sensors (optical mouses) are not as inexpensive as RFID tags, but they have been around for many years, and the prices are fairly low. You do not have to put MouseField devices everywhere, since people do not have to control information everywhere. In the house shown in the previous scenario, MouseField devices are equipped at only a small number of places including the living room and toilet. These are the locations where people sometimes stay for a while, and the number of those places are limited. If sufficient number of MouseField devices are installed, it would be more convenient than using remote controllers.

In spite of its simplicity, MouseField can be used for various purposes with only a few number of ID tags, owing to the motion sensors. Just like we don't have to use different mouses for different applications, we can use one RFID tag for various purposes. If we can't use the motion sensors, we have to use many RFID tags to do the same things described in the scenario.

4.2 Idioms of UbiComp

Many user interface idioms[8] are now widely accepted in the GUI on current PCs. Sliders and pulldown menus are examples of good GUI idioms. Although sliders and

pulldown menus are not found in the real world, people will remember how to use it, once they see it and understand how it works. Idioms like Drag and Drop, Click and Drag, and other operations are now considered to be basic operation for handling computers. On the other hand, good interaction idioms for ubiquitous computing have not been widely accepted yet. Some systems use gestures, and others use special objects like "phicons"[9], but none of the operations are widely accepted to control information in the ubiquitous computing environment.

Since moving something on a MouseField is so easy, we believe that "Place and Move" operation on a MouseField can be one of the basic interaction idioms used in the ubiquitous computing environment, just like Click and Drag is now one of the basic operations used in GUI. It is not clear what is the best mapping between application functions and available operations on the MouseField. Some people may prefer rotation for volume control, and others may prefer sliding operation. We cannot tell which is better at this moment, but one of the mapping would become dominant in the future, and everybody would accept it as a standard idiom.

4.3   Using Feedbacks

In most GUI systems based on direct manipulation, a user can see the effects of his actions as soon as he types the keyboard or moves the mouse. In the PlayStand++ system, users can look at the monitor display to see what happens when they move the CD jacket on the MouseField. Although visual feedback is very important on GUI systems based on direct manipulation, sound feedback or other simpler feedbacks can also be used in systems like PlayStand++. For example, even when a monitor is not present, simple click sound works fine for selecting songs.

4.4   Objects for Controlling MouseField

We can use almost any kind of object for controlling information using MouseField. If we put an RFID tag in an object which represents something, it can be used as a phicon. We can also use existing RFID-based cards like Suica for identifying a user and controlling information. If we use a MouseField with a barcode reader instead of an RFID reader, we can use printed barcode on any product for handling information related to the product. In this way, we can use whatever we like for controlling information, when a MouseField is installed at the place where we need information. We can use a CD/DVD jacket for enjoying a music or a movie. We can use a food package for getting information like its ingredients and the company. In this way, using a Mouse-Field is like using any objects as a standard mouse. In this sense, MouseField is a very universal input device.

5   Related Work

RFID tags have been used in various ubiquitous computing systems and projects[10][11]. For example, in the AwareHome project[11] at Georgia Tech, many RFID readers are placed at the floor and used for identifying people walking in the house. In the real

world, RFIDs are now widely used in many warehouses and libraries for identifying the status of packages and books. Many of the ubicomp systems use RFID tags mostly for identifying objects and people, but with MouseField, RFID tags are rather actively used for controlling the flow of information.

Since optical mouses are inexpensive and robust, they are used in various systems for detecting the motion of objects. For example, they are used in Navigational Blocks[12] for detecting the motion of blocks.

FieldMouse[4] is a device which has the same configuration as MouseField: a Field-Mouse consists of a motion sensing device and an ID recognizer. While MouseField is a device installed in tables and walls, FieldMouse is a device carried by people to control various information appliances. Advantages of using a FieldMouse is that people can operate real-world GUI[13] without installing many sensors everywhere. A disadvantage of using a FieldMouse is that a user always has to carry a FieldMouse to control information appliances. Since a FieldMouse consists of an ID recognizer and a motion sensor, it is always heavier than simple RFID tags. Also, it is not suitable to be used in kitchens and toilets.

"Phicons"[9], or physical icons, are sometimes useful for handling information in the ubiquitous computing environment. Using a MouseField, almost anything can be used as a phicon, if an RFID tag is put into it.

MediaBlocks[14] is a system for editing multimedia data like movie clips using multiple blocks. MediaBlocks has a special hardware which can detect the location of blocks, so the user can edit movie clips by changing the layout of the blocks. Mouse-Field can be used as a device to implement MediaBlocks and similar systems in wider range of environment.

DataTiles[15] enables users to perform various interesting operations using transparent square panels equipped with tags. The panels are laid out by the user on a LCD tablet, and the user can move the panel in a variety of way to perform various operations. The "Place and Move" idiom can be used on DataTiles. Since a LCD tablet should be used for DataTiles, it is less robust than the motion sensors used in MouseField.

Various techniques have been proposed for carrying information in the ubiquitous computing environment. In the WebStickers[7] system, users can attach URL bookmarks to barcodes, and carry the barcodes to use the bookmarks at other places. In the i-Land[16] system, a technique called Passage[6] is used for carrying information between different computers. Although people can carry data using a barcode or an RFID, complicated operations cannot be performed on these systems.

A technique called "Pick and Drop"[5] is proposed for picking up data from one computer and placing it to another computer. Using a FieldMouse[4], users can not only pick and drop data between objects, but they can perform arbitrary GUI operations like selecting menus. InfoStick[17] can also get data from one location for transferring it to another location, and PDAs are sometimes used for the same kind of purposes. In these systems, people should carry a special device like PDAs for carrying data.

There are also many ubicomp projects which use video cameras for identifying people and objects[1][18]. Using a camera with a pattern recognition system, we can detect the ID and the motion of the object at the same time, so in some cases using cameras is more appropriate than using RFID tags and readers. The advantage of using

RFID tags is that RFID tags can be hidden in almost any object, and no special pattern should be printed on the surface of the object. The same "Place and Move" idiom can be applied to camera-based systems.

Recently, various toolkits for ubiquitous computing is being proposed[19][20]. Since using a MouseField is almost the same as using a mouse in a GUI environment, adding features for handling MouseField to existing toolkits is easy.

6 Conclusion

We developed a simple, robust and flexible input device called the MouseField for controlling information in the ubiquitous computing environment. Despite its simplicity, MouseField is flexible enough for handling complex information at various places where conventional input devices like keyboards and mouses were not conveniently used. We have shown various possibilities of MouseField used everywhere in the ubiquitous computing environment. We hope MouseField will be one of the standard input devices used in the ubiquitous computing age.

References

1. Koike, H., Sato, Y., Kobayashi, Y., Tobita, H., Kobayashi, M.: Interctivetextbook and interactivevenndiagram: Natural and intuitive interface on augmented desk system. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI2000), Addison-Wesley (2000) 121–128
2. Pingali, G., Pinhanez, C., Levas, A., Kjeldsen, R., Podlaseck, M., Chen, H., Sukaviriya, N.: Steerable interfaces for pervasive computing spaces. In: First IEEE International Conference on Pervasive Computing and Communications (PerCom'03). (2003) 315–322
3. Nelson, L., Ichimura, S., Pedersen, E.R., Adams, L.: A paper interface for giving presentations. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'99), Addison-Wesley (1999) 354–361
4. Siio, I., Masui, T., Fukuchi, K.: Real-world interaction using the FieldMouse. In: Proceedings of the ACM Symposium on User Interface Software and Technology (UIST'99), ACM Press (1999) 113–119
5. 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), ACM Press (1997) 31–39
6. Konomi, S., Müller-Tomfelde, C., Streitz, N.A.: Passage: Physical transportation of digital information in cooperative buildings. In: Cooperative Buildings – Integrating Information, Organizations, and Architecture. Proceedings of the Second International Workshop (CoBuild'99). LNCS 1670, Heidelberg, Germany, Springer (1999) 45–54
7. Ljungstrand, P., Redström, J., Holmquist, L.E.: Webstickers: Using physical tokens to access, manage and share bookmarks to the web. In: Designing Augmented Reality Environments (DARE2000) Proceedings. (2000) 23–31
8. Cooper, A.: About Face – The Essentials of User Interface Design. IDG Books (1995)
9. Ishii, H., Ullmer, B.: Tangible Bits: Towards seamless interfaces between people, bits and atoms. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'97), Addison-Wesley (1997) 234–241

10. Want, R., Fishkin, K.P., Gujar, A., 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), Addison-Wesley (1999) 370–377

11. Abowd, G.D., Atkeson, C.G., Bobick, A.F., Essa, I.A., MacIntyre, B., Mynatt, E.D., Starner, T.E.: Living laboratories: The future computing environments group at the georgia institute of technology. In: Extended Abstracts of the ACM Conference on Human Factors in Computing Systems (CHI2000). (2000)

12. Camarata, K., Do, E.Y.L., Johnson, B.D., Gross., M.D.: Navigational blocks: Navigating information space with tangible media. In: Proceedings of the International Conference on Intelligent User Interfaces (IUI). (2002) 31–38

13. Masui, T., Siio, I.: Real-world graphical user interfaces. In Thomas, P., Gellersen, H.W., eds.: Proceedings of the First International Symposium on Handheld and Ubiquitous Computing. Number 1927 in Lecture Notes in Computer Science, Springer-Verlag (2000) 72–84

14. Ullmer, B., Ishii, H., Glas, D.: mediablocks: Physical containers, transports, and controls for online media. In: SIGGRAPH'98 Proceedings. (1998) 379–386

15. Rekimoto, J., Ullmer, B., Oba, H.: Datatiles: a modular platform for mixed physical and graphical interactions. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI2001), Addison-Wesley (2001) 269–276

16. Streitz, N.A., Geissler, J., Holmer, T., Konomi, S., Müller-Tomfelde, C., Reischl, W., Rexroth, P., Seitz, P., Steinmetz, R.: i-LAND: An interactive landscape for creativitiy and innovation. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'99), Addison-Wesley (1999) 120–127

17. Kohtake, N., Rekimoto, J., Anzai, Y.: Infostick: An interaction device for inter-appliance computing. In Gellersen, H.W., ed.: Proceedings of the First International Symposium on Handheld and Ubiquitous Computing. Number 1707 in Lecture Notes in Computer Science, Springer-Verlag (1999) 246–258

18. Wellner, P.: Interacting with paper on the DigitalDesk. Communications of the ACM **36** (1993) 87–96

19. Klemmer, S.R., Li, J., Lin, J., Landay, J.A.: Papier-mâché: Toolkit support for tangible input. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI2004). (2004) 399–406

20. Dey, A.K., Salber, D., Abowd, G.D.: A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. Human-Computer Interaction **16** (2001) 97–166