Real Eye Communicator:An Eye-mediated Real World Pointing Device

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Abstract. In this paper,we introduce a new pointing device for Ubiquitous computing environment.The user's eye is an integral part of the system. This relatively simple system makes it possible to realize novel features such as the "tele-click".

1 Introduction

In an ubiquitous computing environment[1],there are in general more than one information appliances[2] around the user. It is crucial for the user to have an intuitive and easy way to point to a device. To achieve that, we need to have a real-world pointing device. A real world pointing device must be able to have at least the following functionality:

- To select intended information appliances in real world
- To detect the network ID of intended information appliance in real world

In this paper, we present a new real world pointing device, the Real Eye Communicator (REC), which incorporates the user's eye as a medium. With this device, we can get several useful features to be used in the real world. We also describe the Interactive Sight Metaphor (ISM), which is an interactive computing environment using the REC.

2 Real Eye Communicator

Overview

Pointing to real world objects by finger is an easy and intuitive process. In designing a real world pointing device, we need to have a comparable ease of use on top of the basic features necessary in a real world information processing. The Real Eye Communicator (REC) is a simple optical communication system. The simplicity of the system comes from the fact that it bypasses the image processsing often used for object identification. The system consists of

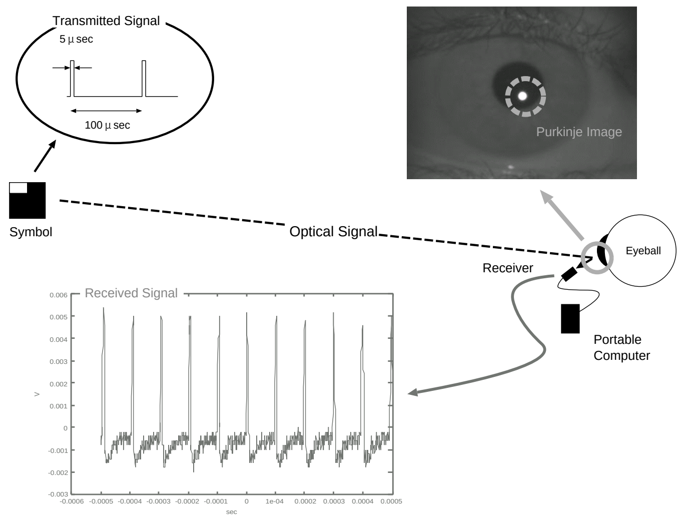

Fig. 1. Overview of REC

some transmitters (called "symbols") and a receiver. For instance, an infrared light transmitter can be used as a symbol, as we demonstrate here. see Figure1. The symbols are attached to the real world objects (typically an electronic device connected to the network), and the receiver is attached to the user.The optical signal is constantly transmitted from the symbols. The receiver picks the signal from the reflected image on user's eye. This particular setting has two useful advantages.

- Control of transmission coupled with user's sight
- Zero-parallax optical receiving system (here, "parallax" refers to the difference in receiving angle between the eye and the receiver)

We show later that the second feature is crucial for the user in manipulating the correct symbol.

Technological Background

In a natural environment, the visual information is fed into the user as the incoming light through the eyeball. A larger part of the light travels on to the retina, while the remaining light is reflected by the cornea, which is called the Purkinje image (Figure 1). The Purkinje image basically preserves the temporal dynamics of the incoming light. If the incoming light is modulated, the Purkinje image is modulated. Thus, we are able to obtain modulated signal from the "symbols" in the real world by observing the Purkinje image. Figure 1 shows the signal that arrives at REC receiver, when the transmitter transmits a signal of 10μsec duration and at the duty ratio of 1%.

The unique feature of REC

The REC system does not have a video-based object identification process. The REC identifies real objects in the environment by the information coded in the reflected light in the temporal domain. In this way, REC realizes the detection of the user's focus of attention in a very simple way, identifying the object at the same time. Bypassing the often difficult and not-so-robust image analysis process is a unique feature of REC. In addition, the REC "shares" the light coming into the eyeball with the user. Owing to this feature,we can obtain a zero-parallax receiving ability, which leads to several unique applications.

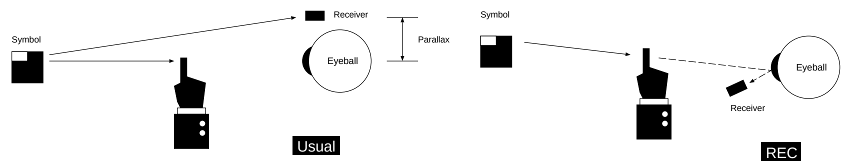

Fig. 2. zero-parallax-receiver

The zero-parallax setting enables us to construct an intuitive metaphor to use the REC: If the user can see the symbol, he or she can "access" the device and the process behind it represented by the symbol. This is an essential condition in implementing the Interactive Sight Metaphor (ISM), which we discuss in the next section.

Implementation

A photodiode is used to receive the optical signal. Using a photodiode has the following merits:

- High speed data transfer
- Simple architecture

The REC system we have constructed so far has an ability to receive the signal at the rate of more than 100kHz. This current limit is not inherent in the REC structure, but is due to the transmitter's chip set.

Receiver The REC system has a simple architecture to receive the reflected optical signal. We show the electrical circuit of REC in Figure 3.

Transmitter The transmitter has two LEDs to emit optical signal. The peak wave length is 870nm, which is invisible for a human. The optical signal is controlled by a microchip(See Figure 3).

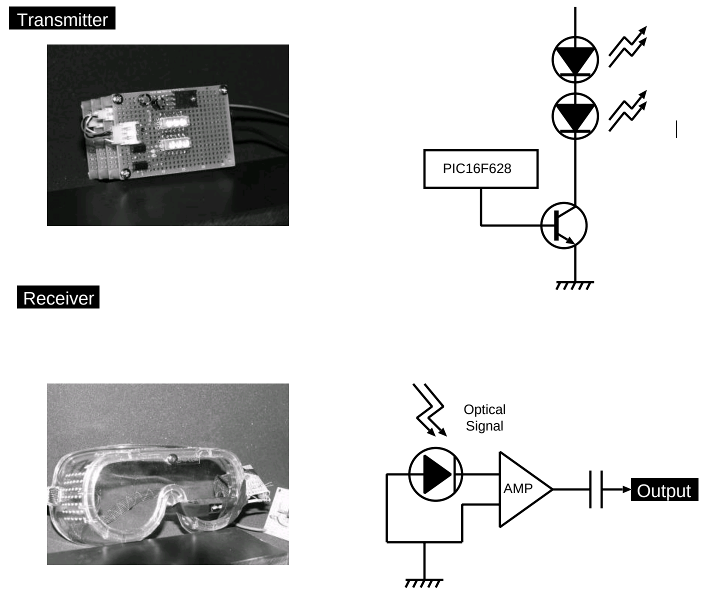

Fig. 3. Electric Circuit of REC receiver

3 Interactive Sight Metaphor

Now we describe the Interactive Sight Metaphor (ISM). In ISM, we employ the user's sight as a virtual display. The current mouse pointer system selects an object such as an icon by putting the cursor on them. In ISM, the user can select an object by temporally interrupting the sight of that object in his view. We need the REC optical receiver which has the zero-parallax receiving ability to detect such interruption with a high spatial precision.

Tele-click

Selecting an object in the ISM is simple: The user is asked to "point" to the symbol, hiding the target object with his finger (tele-click). The REC system can then detect the interruption, and invoke prescribed processes. This is a basic interaction technique in the ISM. Under a configuration where the "symbol" transmits its ID continuously or periodically (with a sufficiently short interval), we can use the tele-click to invoke processes related to the selected object. A potential problem is that the system might not be able to distinguish between an intentional tele-click and an unexpected interruption. To avoid such a confusion, we need to employ the characteristic temporal properties of a signal interruption by an intended tele-click (such as a threshold for hindrance duration) as compared to unintended ones. This is a theme for our ongoing research. On top of

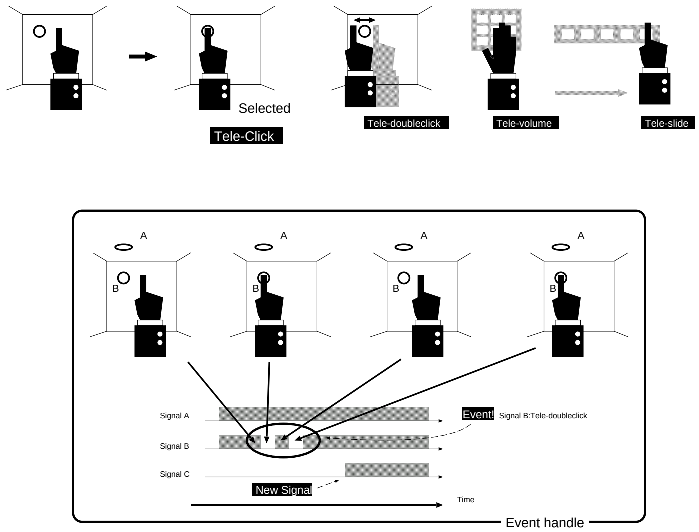

Fig. 4. Tele-click

such a detection, we can incorporate some characteristic code into the tele-click. We present some examples of coding by the tele-click in Fig.4.

4 Discussions

Owing to the recent improvements in digital and network technologies,we can now use small objects as accessible nodes. We can easily attach the network ID, for example, by using Electronic tagging system[4], Bluetooth[3], or Wireless LAN system, with a constant access to the internet. It is reasonable to expect that an ubiquitous computing[1] environment would be realizable in our daily life in the near future. In such an environment, an intuitive user interface system based on a natural metaphor will be of much value. The user would need to learn to manipulate several information devices concurrently in some cases, a situation which makes it necessary to rethink the interaction style. It would be unreasonable to expect the user to learn a complex command system. A natural and embodied manipulation metaphor is preferable (Figure 5.).

A good strategy is to replace the large amount of the user's task by effective addressing and network technologies. A lot of research has already gone into implementing a real- world pointer which is an essential element in such a ubiquitous computing environment . For example, Rekimoto's Pick-and-Drop[6] enables the user to transfer the data between multiple PCs without knowing the network IDs before accessing. Masui's Real World Graphical User Interface[9] enables the user to access the tagged real world objects, and to manipulate it

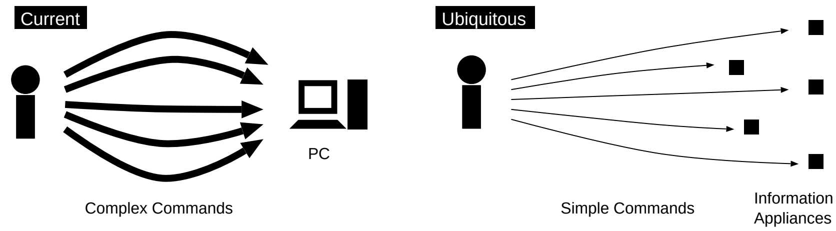

Fig. 5. The change of intaraction style

without knowing their IDs. In a Ubiquitous Computing Environment, a complex and precise input system is difficult to operate and carry. A naturally embodied operation system such as the tele-click is easy to use and robust, a philosophy shared by a lot of previous works:[5][7][8][10][11]

In order for a real world pointing device to be useful, it must have a high portability. Size and robustness are important requirements. To realize this, the pointer system should be as simple as possible. The Real Eye Communicator, which bypasses image processing, is exactly such a system.

5 Conclusion

In this paper, we described the Interactive Sight Metaphor (ISM) implemented by the Real Eye Communicator (REC). The REC uses the eyeball reflection for optical communication, and this characteristics gives its unique functionality: the zero-parallax receiver. With the REC, we can point to a device and detect its network ID in the real world. The REC has a simple architecture, can be manufactured at low cost, can be made small enough to be attached to conventional glasses. Under the ISM, the user can operate information appliances in the real world easily and intuitively. The tele-click is one way to implement the embodied operation. We have achieved so far a frequency of 100kHz as signal carrier. In the near future, we expect to achieve a faster data transmission, which will open the possibilities for further applications, such as a direct tele-clicked data transfer.

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