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A SURVEY ON NUMEROUS DEVELOPMENTS IN MULTI-TOUCH TECHNOLOGY

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ABSTRACT

Although multi-touch technology is currently a research focus in the field of Human-Computer Interaction, its relative research, however, is still comparatively few in China. In this paper, several foreign multi-touch technologies based on sensor and computer vision are introduced and the advantages and disadvantages of these technologies are analyzed briefly. It is important for studying the technology of detection and tracking touch-point in multi-touch. Furthermore the FTIR (Frustrated Total Internal Reflection) and DI (Diffused Illumination) which are based on computer vision multi-touch technology are highlighted. Finally, several crucial techniques in the field of multi-touch technology are also discussed.

Index terms: Multi-touch, Sensor, Computer Vision, FTIR, DI.

I INTRODUCTION

Traditional Graphical User Interface (GUI) WIMP (windows, icons, menus, pointing device) is the current main human-computer interaction mode. In this interactive mode, the mouse is the primary means of computer operations. But the mouse is only an input device with only 2 degrees of freedom input device, therefore it is hard for people to fully apply the hand operating skills learned in their natural life to human-computer interaction to reduce cognitive burden of the interaction, and improve the efficiency of computer operations. Multi-touch equipments allow one or more than one user to use multiple fingers interact with computers through graphical user interfaces. Our fingers are of a very high degree of freedom, and can touch directly without any media, which greatly enhances the efficiency of our interaction with computers. Although as early as 1982, Nimish Mehta of Toronto University, has designed the first Multi-

Touch display based on the pressure of fingers. However, its widespread use has been limited by its availability and extremely high price. This situation has been changed with the introduction of Apple's iPhone; more people are beginning to know and get access to multi-point touch technology. In 2005 Jefferson Y. Han, New York University, proposed a FTIR-based low-cost Multi-Touch equipment, which has greatly reduced the research cost of Multi-Touch technology, so that its research has been launched in all over the world, and many new Multi-Touch technologies have been presented. Moreover, some products have been successfully commercialized. Compared with the traditional input devices, one of the biggest advantages of multi-touch capable devices is that it allows for multiple users to operate simultaneously.

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CLASSIFICATION OF MULTI-TOUCH TECHNOLOGY.

TABLE

Sensor-Based		FMTSID(Fast Multiple-Touch-Sensitive Input Device)
		DiamondTouch
		SmartSkin
		iPhone
Computer	Purely	Everywhere Display
	Vision-Based	PlayAnywhere
Vision-Based	Vision-And	FTIR(Frustrated Total Internal Reflection)
	Optical-Based	Microsoft Surface

Various technologies have been introduced to develop multi-touch capable devices. They are of respective characteristics. These technologies are diverse in terms of their approach to the problem of recognizing and interpreting multiple simultaneous touches. We can put these techniques into two categories. This paper will give a brief overview of recent approaches to implementing multi-touch capable devices and discusses the advantages and disadvantages that come with each approach. For a more complete history of multi-touch devices see Bill Buxton's Multi-touch systems I have known & loved.

II PROBLEM AND ANALYSIS

Many Multi-Touch Devices based on sensor technology, can simultaneously detect multiple touch points to identify the multiple points of input. Unlike some of the computer-vision-based systems, sensor based systems are almost impossible to build from off-the-shelf components. The cost is prohibitively

high, and the environment temperature and humidity will affect the system performance. However, because the sensor can be integrated in the surface, it can be used for mobile phones, PDAs and other small-screen handheld devices.

In 1985, Lee et al. made FMTSID (Fast Multiple-Touch-Sensitive Input Device), one of the first multi-point touch sensor-based devices. The system

consists of a sensor matrix panel, the ranks of select register, A / D converter and a control CPU component. It can detect finger touch points by measuring the changes in capacitance. FMTSID can accurately detect multiple finger touch position, and finger contact pressure.

The Diamond Touch developed at Mitsubishi Electric Research Laboratories (MERL) in 2001 is a multi-user touch-sensitive surface. The Dietz et al. proposed Diamond Touch, is multi-touch system which allows multiple users and a front multi-touch camera. The desktop is a projection screen and a touch-screen as well. A large number of antennae are set below the touch screen, each antenna transmits a specific signal, and each user has a separate receiver, using the user's conductivity to transmit the signal through his or her seat. When the user touch the panel, the antenna around the touch point transmits weak signals between the user's body and the receiver. This unique not only allows multiple contacts of single user (for example bimanual interaction), but also distinguishes between the simultaneous inputs of different users (up to 4) without interfering with each other. The system also can detect the pressure of touch point and allow rich gestures without the interference of foreign objects. Diamond Touch cannot, like other multi-touch technologies, identify multiple touch locations by the same user. Diamond Touch has the following disadvantages: we can only detect "touch" movement, but can not recognize the objects placed on the surface [18]; Diamond Touch projects images from above the desk, so

when used, the human body would shadow the display, which hinders the operation.

On the basis of the FMTSID principle proposed by Lee et al, Rekimoto et al. developed Smart Skin at Sony Computer Science Laboratory in 2002. Smart Skin is a Multi-touch system of higher resolution ratio. The system consists of grid-shaped transmitter/receiver/. It can not only identify the number of hand contact position and their shape, but also calculate the distance between the hands and contact surfaces through capacitive sensing and grid antennas. Compared with Diamond Touch, Smart Skin is able to return more abundant contact information (such as the finger contact shape). This has inspired Cao et al who have designed novel interactions by using the shape of contact fingers.

The Apple iPhone released in 2007 is the first mobile device with access to multi-touch technology. iPhone uses capacitive coupling to sense multiple touch points. iPhone can achieve multi-touch with limited dimensions, allow people to operate by mere hands, and allow typing through a virtual keyboard, the dial of telephone numbers and the "pinching" technique introduced by Krueger (with the thumb and index finger of the same hand to zoom the map and photos). These cannot be achieved by these traditional input methods like a mouse, and a keyboard. Those features of .iPhone refresh the common people. iPhone SDK scheduled to be released in 2008 would attract much interest of researchers in the applied research of multi-touch technology in handheld devices.

III MECHANISM AND SOLUTION

COMPUTER-VISION-BASED SYSTEM

Due to the decreasing cost and improved performance of computers, computer vision technology has been greatly improved, which enables us to process real-time, and high-speed video signals, and is sufficient to meet the real-time interaction and human-computer interaction requirements. Thus researchers have put forward a number of Multi-Touch systems based on computer vision.

Purely-Vision-Based System

Purely-vision-based multi-touch systems rely solely on image processing techniques to identify touches and their positions. Multi-touch systems which employ this technique can be used on any flat surface without the need for a dedicated display device and are of very high portability. However, the flexibility of pure vision systems comes at the cost of precision. Pinhanes et al. have created a computer-vision-based system called the Everywhere Display. The system uses a camera and projector to turn a common touch screen into an interactive display screen through image processing

technology. While Pinhanes et al. did not provide any data about the accuracy of the detection algorithm in their paper, it is clear that they have chosen portability at the expense of choice accuracy. Compared with other Multi-touch technologies, Everywhere Display is difficult to accurately determine the time and finger touch-screen duration.

Microsoft's Play Anywhere is a relatively compact and well mobile desktop interactive system with a front camera. Wilson has contributed many image processing techniques for the desktop interactive system with a front camera based on computer vision. Most notably is the shadow-based touch detection algorithm, which can accurately and reliably detect touch events and their contact position. However, Agarwal et al. pointed out that the algorithm could achieve the best result only when the point of finger is vertical, which limits the system in a collaborative environment application. Agarwal et al. has developed a computer vision algorithm to improve computer vision-based multi-point interactive desktop choice accuracy (accuracy 2~3mm) according to the three-dimensional imaging and machine learning technology, which can accurately detect the fingertips touch. The precision, which is up to 98.48%, compared with previous technical-level (the choice of precision is generally cm level), has been greatly improved.

Computer Vision- and Optical-Based System

Devices based on computer vision and optical Multi-touch technology has good scalability, and a low cost relatively, but they have a larger volume. Here are two kinds of computer vision and optical-based Multi-touch systems.

Frustrated Total Internal Reflection (FTIR)

Frustrated Total Internal Reflection is a kind of optical phenomenon. Beams of LED (light-emitting diode) reach the surface of the screen from the touch-screen cross-section will reflect. However, if there is a relatively high refractive index material (such as a finger) suppressing the acrylic materials, the panels, the conditions of total reflection will be broken. Some of the beams would project onto the surface of fingers through the screen surface. The tough finger surfaces cause scattering (diffuse reflection), and the scattered light would be read by the infrared camera set under the acrylic board through the touch screen. The corresponding touch information can be detected through corresponding software (Touchlib). Touchlib is a set of software library developed by NUI Group for the multi-touch system development, which implements the majority of computer vision algorithms. This technique can detect multiple touch points and the location of exposure by using only a simple Blob detection algorithm.

In fact, FTIR principle has long been used to produce a number of input devices, such as a fingerprint

reader. Jefferson first used FTIR principle to build a low-cost multi-point touch screen, which greatly reduced the Multi-touch technology research cost.

Diffused Illumination (DI)

DI (Diffused Illumination) multi-touch technology refers to infrared radiation which reaches the touch screen from the bottom of, and places the diffuse reflection surface on or unearth touch screen. When objects touch the screen, the screen will reflect more infrared light than the diffuse reflectance do, and then the camera would read and the corresponding touch information would be detected through the Touchlib. With this diffuse reflection screen objects hovering and on the surface can also be detected.

Compared with FTIR, DI technology has certain advantages. DI system can detect objects' hovering state (the system can recognize hand or fingers moving across the screen, or closer to the screen, without having to actually touch). In addition, the DI-based systems rely on "see" what is on the screen, rather than detect touch, and so, DI is able to identify and detect objects and object tags. But, compared with the simple use of Blob tracking and detection algorithm of FTIR, DI uses more complex image processing technology. In addition, DI system is vulnerable to external light effect.

Microsoft's Surface is the multi-touch system based on the back of the DI (Diffuse Illumination) technology. Surface built-in camera can not only sense input of users such as the touch and gestures (finger moving across the screen), but also be able to identify and capture the required information of objects placed on the above. This information is sent to the common type of Windows PC for processing, and the results from the digital light processing (DLP) projector are sent back to the Surface. Microsoft Surface is able to sense multiple fingers and hands, and can identify a variety of objects and their location on the surface.

There are other computer vision-and-optics-based Multi-touch systems, such as: laser plane multi-touch technology proposed by Alex (LLP); light-emitting diodes planar multi-touch technology (LED-LP) made by Nima; the scattered light plane multi-touch technology (DSI) presented by Tim Roth. These technologies can be used to build Multi-touch devices. For more information, one can visit the Natural User Interface Group (NUI Group) open-source community website. NUI Group was founded in 2006, and is the world's largest online open source community on natural user interface. NUI Group provides an environment for mutual exchange for developers interested in human-computer interaction and its members have collected and shared a lot of information and valuable experience about the building of multi-point Touch system.

THE KEY TECHNOLOGY OF MULTI- TOUCH

Multi-touch technology can be simply divided into two parts: hardware and software. Hardware serves to complete the information collection and software to complete the analysis of information which are finally converted into specific user commands. It is believed that the Multi-touch key technology should include the following major components:

Multi-touch Hardware Platform

As described earlier in this article the hardware platform, these platforms have their own advantages and disadvantages. The knowledge of these platforms helps to understand how to build interaction platforms of lower cost, more convenient installation and more preciser target selection and to study a number of other interactive technology unrelated to the platforms.

The Accuracy of Selection for Multi-touch Device

Precision choice technology, in fact is the detection of contact tracing, and it has great significance on how to accurately track and locate contacts to achieve the freedom of gesture interaction. In particular, when the target size is very small, how our fingers could accurately locate the goal we want, is the content worth deep study.

Identification Technology

Existing Multi-touch technology detects the contact without carrying information of users. The technology that can now identify the user's identity is Diamond Touch technology (which can identify up to four users). Literature has proposed a lightweight user identification technology through the use of finger pointing in the FTIR platform. To study which user the identified contact is from and, further, from which hand of the user, and which contacts respond to a specific user, and son on is of great value to the interactive multi-user collaboration work on the large-sized interactive area.

Bimanual Interactive Technology

Hands operation is the most commonly used mode of operation in daily life. The applications of these natural and man-machine interaction process can greatly reduce the operator's cognitive load, form a natural "consciousness ~ Action" and increase the efficiency of interaction, which is believe to be a future research priority.

IV CONCLUSION

In the paper, several foreign multi-touch technologies based on sensor and computer vision are introduced and the advantages and disadvantages of these technologies are analyzed briefly. It is very meaningful for us to build the interactive platforms, which are cheaper, more convenient and portable to install and have more precise target selection. Finally a number of key technologies of the multi-touch technology are introduced. Although the Multi-touch technology

provides a more natural and efficient way of interaction, and has broad application prospects in many areas, there are still many problems to be solved. Only by solving these problems can the true widespread use of this interactive way be realized.

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