

Object Tracking in the IR Domain for Multi-Touch Surfaces

Ritesh Lala

Media Arts and Technology
University of California Santa Barbara
ritesh@mat.ucsb.edu

Abstract

The concept of Natural User Interfaces is becoming more and more widespread from applications in user appliances to research instruments. In this domain of technology where user experiences range from simple touch screens to fluid interfaces, multi-touch surfaces have an important role to play. For some they might promise of a more integrated, interactive and intuitive multi-user solution, while for others they might pose a situation of unwanted change. This paper takes a positive approach towards adapting to this technology and investigates to a certain extent in the mechanics of it. It also presents a brief overview of certain applications for such an interface and how they can be expanded.

Keywords: Multi-touch surfaces, Natural User Interfaces, Object Tracking, Finger Tracking, Collaborative Software.

1. Introduction

Most present day multi-touch surfaces depend on either finger or object tracking by detection in the infrared region. Several techniques and setups exist for this but all have certain pros and cons, and a certain amount of detailing is necessary before the user can decide the one to be implemented. These IR based setups include a) FTIR (Frustrated Total Internal Reflection) b) DI (Diffused Illumination) c) DSI

(Diffused Screen Illumination) and d) LLP (Light Laser Plane Illumination). Each of these techniques, their advantages and disadvantages are described in the following sections followed by a brief explanation of camera setup and application development.

1.1 IR Based Setups

Frustrated Total Internal Reflection

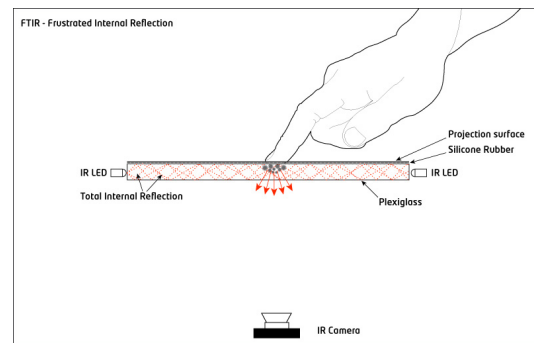


Fig 1. FTIR Setup^[1]

FTIR is one of the most widespread used setups for multitouch interfaces comparable only with DI setups. Both of these normally present solutions for contrasting situations and hence it is obvious for a user to choose between one of them. As shown in figure 1, FTIR comprises of a frame of Infrared LEDs surrounding a transparent sheet of acrylic, which normally has a complaint surface on top of it for smooth finger tracking. As the LEDs cast infrared light inside the acrylic, a phenomenon known as Total Internal Reflection occurs, causing the light to remain inside the

sheet. When a finger is placed on the surface the light is reflected at an angle less than the critical angle of the material causing it to pass through the sheet and fall on the camera situated below the sheet. This collected light is treated as a blob and assigned an ID to track it till it disappears completely.

FTIR requires certain amount of effort to setup initially due to the requirement of an LED frame and a compliant surface, but it performs with a higher accuracy for finger tracking. The blobs are much smoother than other setups and it does not require a box setup as is the case in DI. This makes it a portable and robust setup for touch detection and tracking.

1.2 Diffused Illumination

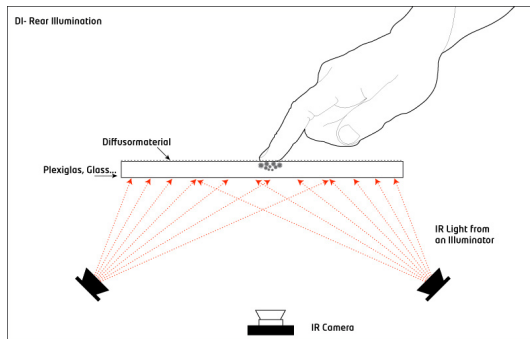


Fig 2. DI Setup

DI setups are commonly used for fiducial object tracking and arranged as shown in figure 2. A bulb of infrared light illuminates the surface from either above or below it, and a finger or an object creates either a shadow or a more illuminated image respectively based on the setup. DI setups are easier to arrange since they do not require an LED frame or a compliant surface. Although this results in less sharper and less clearer blobs due to nonuniform illumination of the surface. They also have to be contained in a box to constraint the IR

illumination which might make a more robust but a less portable structure.

1.3 Diffused Surface Illumination

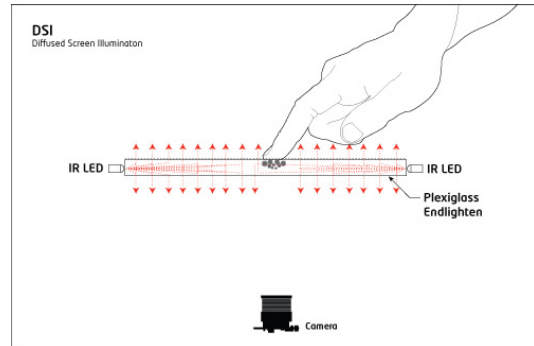


Fig 3. DSI Setup

DSI poses a solution that can overcome the disadvantages of both FTIR and DI and thereby it is being increasingly used. It can be easily transformed from an FTIR setup simply by replacing the normal acrylic by a more advanced one that distributes the luminance evenly throughout the surface, known as "EndLighten Acrylic". It basically contains small particles that act as thousands of small mirrors and spread the light evenly. This makes it usable without a compliant surface and makes it possible to track both fingers as well as objects accurately. Figure 3 shows an outline of the setup as described above.

1.4 Light Laser Plane Illumination

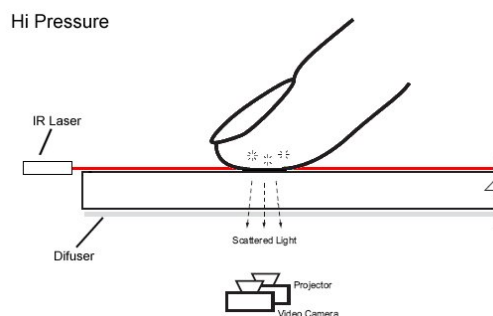


Fig 4. LLP Setup

LLP contains an IR laser that shines the IR just above the surface and creates a laser plane of about 1 mm thickness ^[2]. When a finger touches the surface it reflects the laser and creates a blob in the registered image.

2. Camera Setup

The infrared framework described above has to be used in conjunction with an IR detectable camera to process the images and track the changes. A normal webcam can be used for this purpose by replacing its lens by one that allows IR light to pass through, or by simply removing the IR blocking filter in front of it if it is present separately ^[3]. For accurate blob detection it is necessary to use a visible light blocking filter, which can be a layer or two of exposed film negatives. The camera should have a proper frame-rate to support fast processing of the images for a smoother and more intuitive touch tracking. For our purposes a Unibrain Fire-i Camera was used with a resolution of 640 x 480 (VGA) and a frame-rate of 30 fps ^[4]. The lens contained a coating of IR blocking material and hence had to be replaced by an IR-passing lens of the same focal length (4.3 mm).

3. Sample Applications for Multi-Touch Interfaces

The infrared framework with an IR detecting camera outputs a series of images that can be easily processed to track touches in form of changes of the white blobs. While for most cases it is advisable to use libraries that assign attributes to blobs that can be manipulated to create user applications, it is also possible to directly process

these images for simpler applications. "Touch Synth" is one such application that works on the following algorithm.

1. Input image from the camera
2. Store it and subtract from the next image
3. Threshold to control smoothness and accuracy of tracking
4. Process detected blobs to identify regions of changes
5. Play different synth frequencies for different regions that have been touched

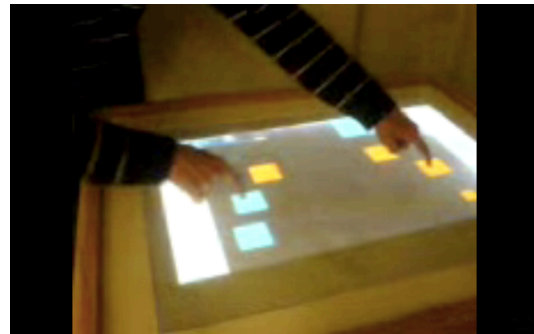


Fig 5. Touch Synth- Audio Application for MultiTouch Surface

Yet another application that generalizes this one, maps each surface pixel to a distance frequency (the lowest one being one corner of the diagonal of the frame, while the highest one being its other corner) to create chirp like tones responding to touch detections. As can be seen these applications can be easily extended for visual domain by processing detected regions through various image processing filters to generate various effects.

4. Conclusions

The experience of using a multi-touch surface conforms to the notion of it being a natural user interface, as the user starts to explore its limits by making all kinds of movements that do not confine

to the restrictions of more traditional ones like mouse and trackpads. Also touch interfaces provide a sense of instant feedback and a feeling of prompt reaction from the instrument, which makes it a richer and faster experience. Further investigations and user feedbacks would lead to more streamlined applications that could take multi-user collaborative software to the next level.

References

- [1] Natural User Interface Group, 27 April 2010. [online: wiki] <http://wiki.nuigroup.com/FTIR>

- [2] Multitouch Dev Blog, 27 April 2010. [online:] <http://wiki.nuigroup.com/FTIR>

- [3] “Build your own multi-touch surface computer”, Maximum PC, 7 April, 2009. [online: http://www.maximumpc.com/article/features/maximum_pc_builds_a_multitouch_surface_computer]

- [4] “Fire-I Digital Camera”, Unibrain 2010. [online: http://www.unibrain.com/products/visioning/fire_i_dc.htm]