

Survey overview

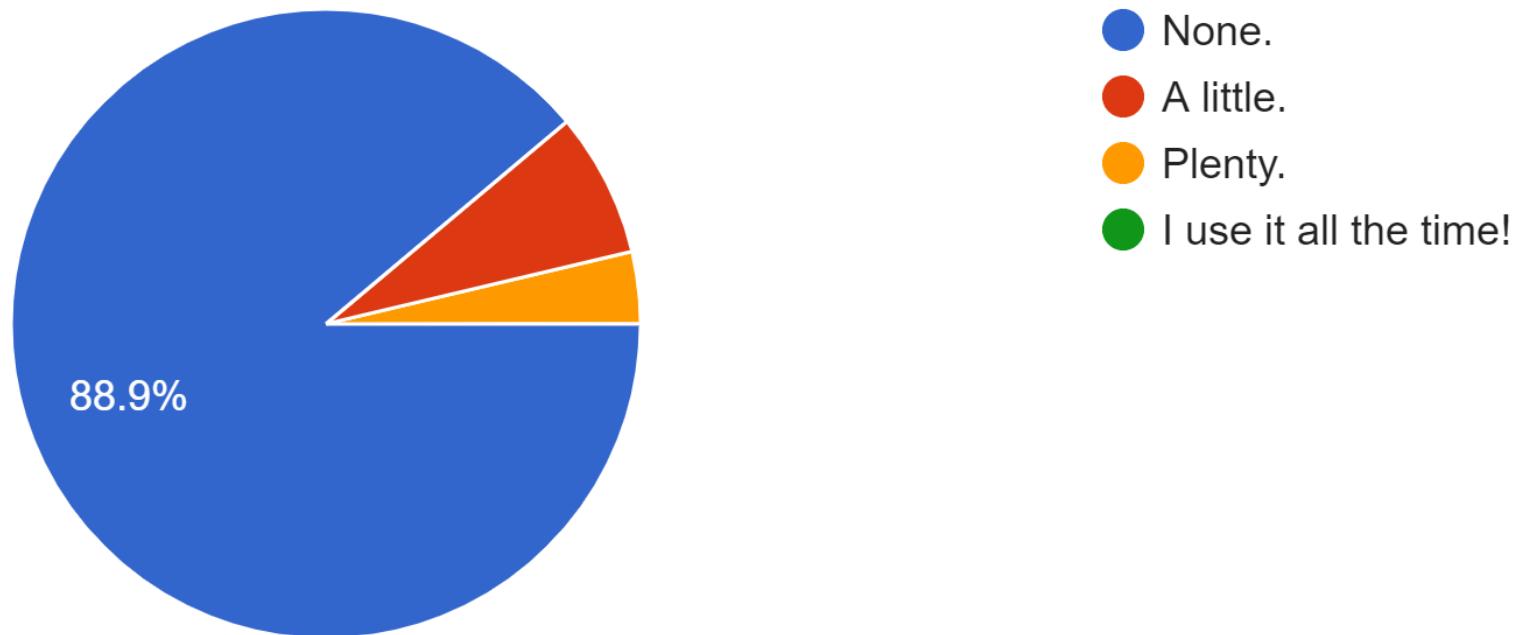
Microcontroller skills (say Arduino/Raspberry Pi)

27 responses



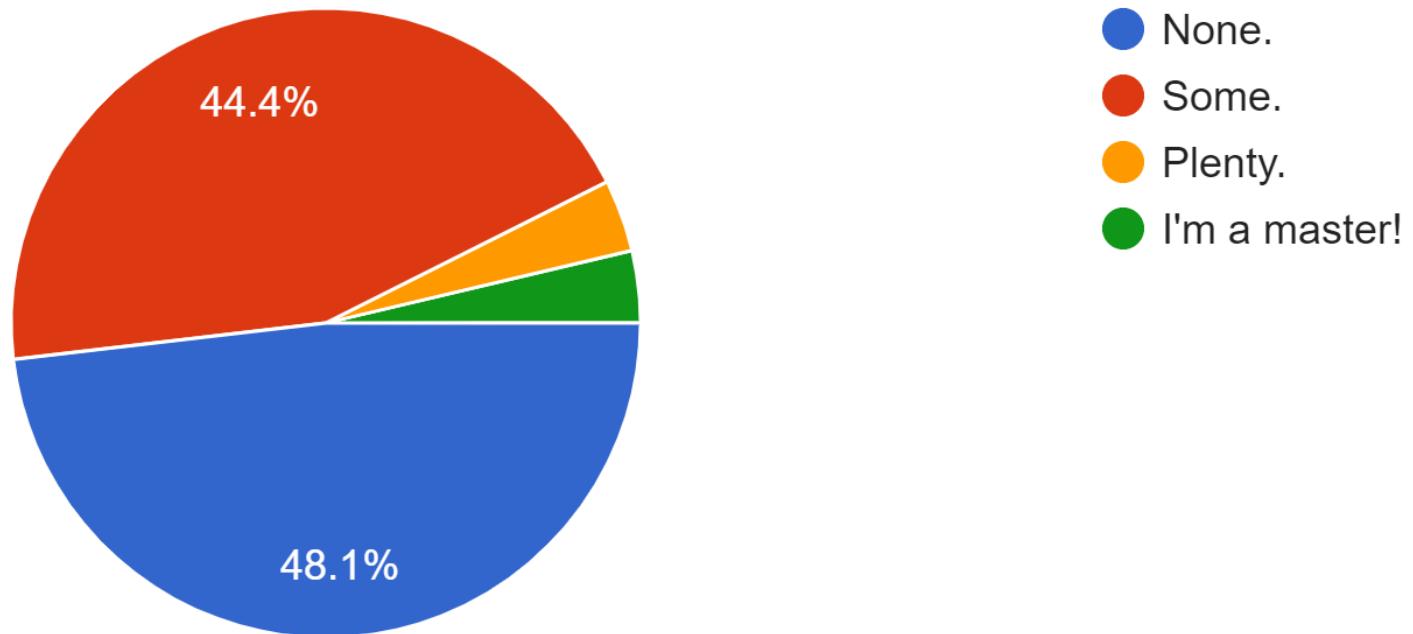
Laser cutter experience?

27 responses



3D modeling experience?

27 responses



What do you want to learn from this course?

This class seems to be fun.

How to combine different tools and technologies to build an end product.

How to run user study

Course requirement

Learn basics of HCI and understand if anyway I can incorporate with my area of research

I would like to learn how to use some new software packages (e.g. Unity) and learn about how I can apply these along with other new skills to HRI projects. The novel ideas of HCI applications in various fields.

Hopefully a low stress fun course req

How tech around me works and how I can apply them to software engineering concepts. And broaden my understanding in general.

Honestly, I am here to learn to build some cool (mostly useful) stuff.

I want use my learnings to add a physical design project to my portfolio.

I would like to have more hardware and robotics skills. I also have limited exposure to HCI but find it very interesting and generally want to be more exposed to the content area.

Concerns that you would like to share with me?

None

I am worried about getting an A

I don't have a background in HCI and relevant areas. Will that be a concern going forward in this course?

I do not have any experience with coding with hardware, so I am a bit worried about the projects and the mini robot climbing competition.

Time limit to complete a project

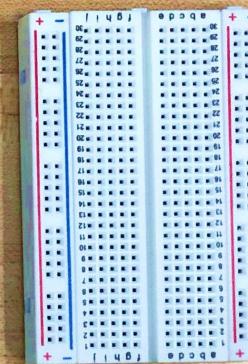
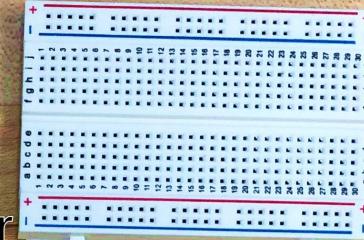
It looks like the workload of the course is heavy.

What's inside the 'tool box'

Jumper wire



Breadboards



Capacitor



ESP32

LEDs



Photoresistor



RGB LED



Resistors



IMU



Shift Register



Cables



USB Cable



Servo



Ultrasonic Sensor

A blurred background image of a person wearing glasses and a dark shirt, looking down at a multi-touch screen. The screen displays a grid of colored squares. The overall color palette is dark with red and orange highlights.

Multi-touch Technology

Huaishu Peng | UMD CS | Fall 2022

JEFFHAN

A medium shot of a man with glasses and a dark shirt, looking down at a multi-touch device he is holding. The background is dark and out of focus.

How would you **BUILD** a
multi-touch devices?

JEFF**HAN**

A man with glasses and a black t-shirt featuring a red logo on the shoulder is shown from the side, looking down at his hands. He appears to be working on something small and intricate. The background is dark and out of focus.

How will you **track** the finger?
With what **hardware**?

JEFF**HAN**

1 min brainstorming
Draw some sketches?

There are lots of different

Type of technologies

Camera-based

Resistive

Capacitive ...

Let's review the **history** again...

Steve Jobs, 2007:

“And we have invented
a new technology
called multi-touch,
which is phenomenal.
[0:33:33]





1986: Sensor Frame (McAvinney)

but there is **tech close to multi-touch**
that actually was invented even earlier...

THESIS AT M.I.T.

LINCOLN LABS

FEB. 1963

Ivan Sutherland Demos Sketchpad, **1963**

we have come a long way since then...

30 years later, multi-touch has reached the consumer market...



and then there's still stuff
that hasn't reached the consumer market yet

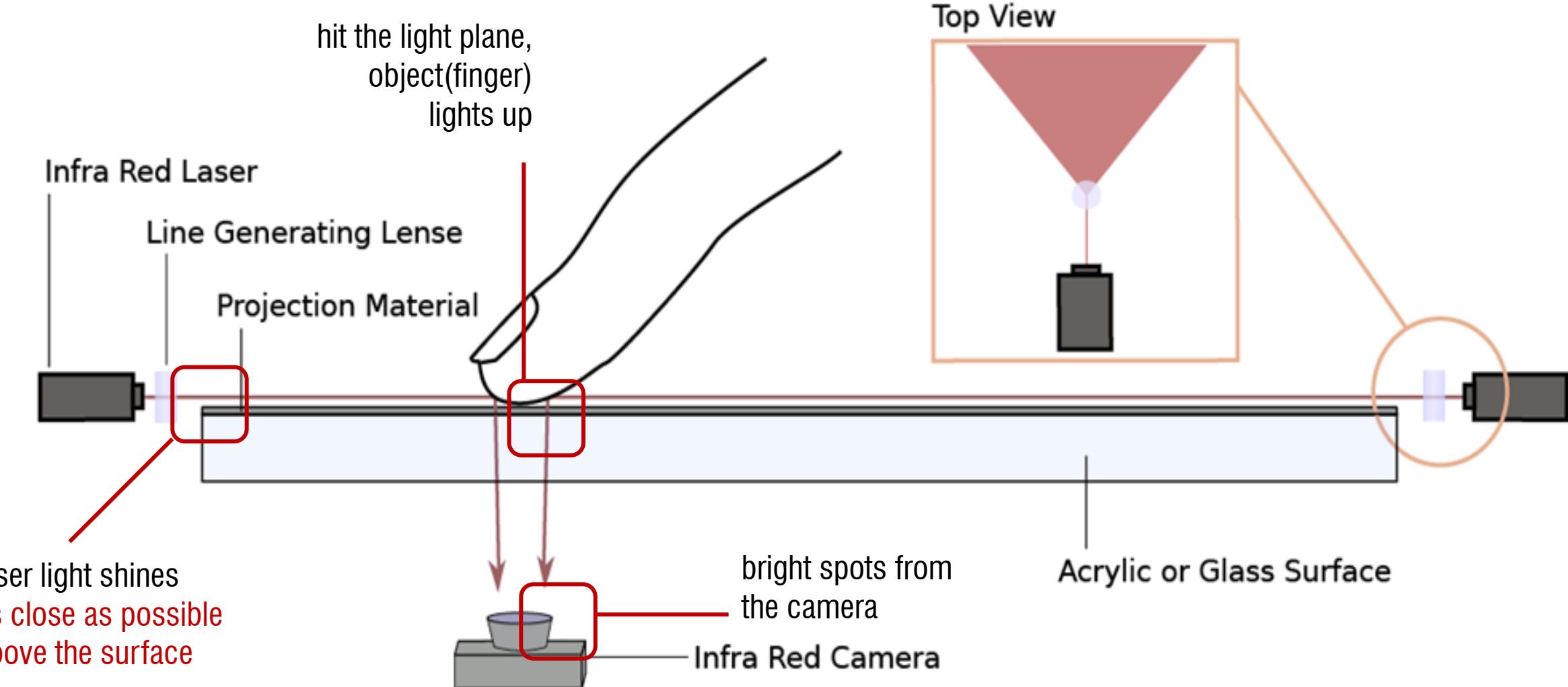


1991: Pierre Wellner, Digital Desk

**multi-touch:
engineering principles**

camera based multi-touch technology
#1 - Laser Light Plane (LLP)

LLP - Laser Light Plane



How does this recognize touch?

30s brainstorming

<http://sethsandler.com/multitouch/lip/>

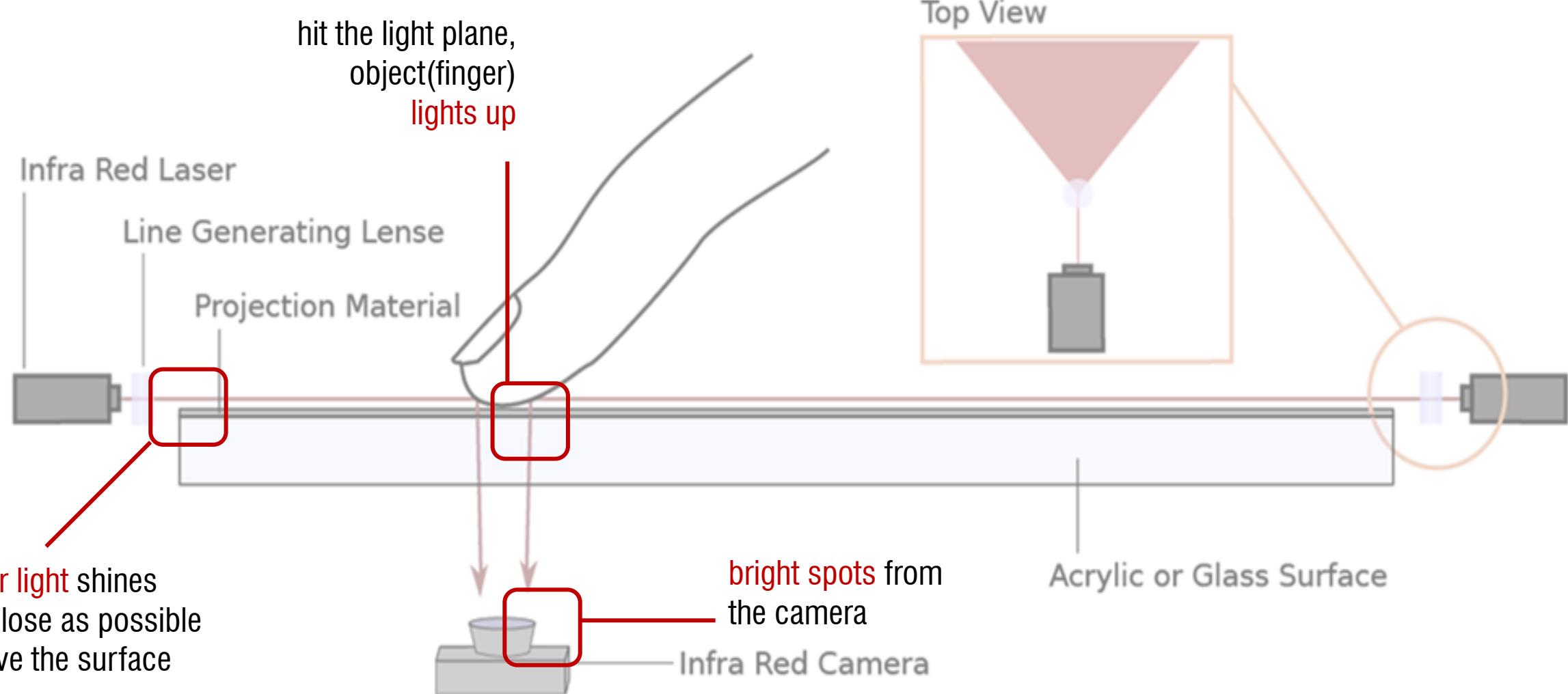


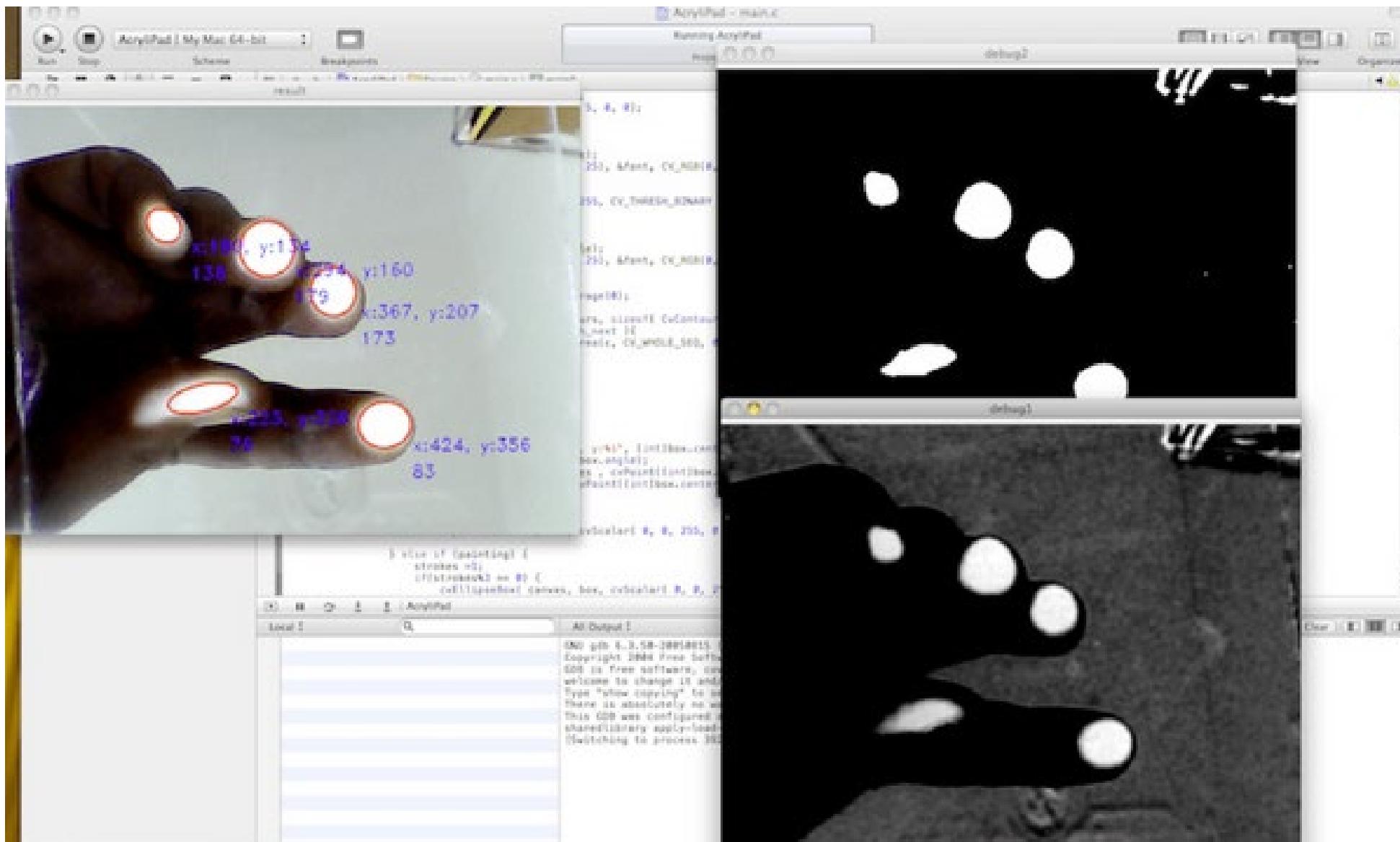
<http://www.youtube.com/watch?v=-GcmDOH8ebw>



<https://www.youtube.com/watch?v=mliHstoD4iU>

LLP - Laser Light Plane





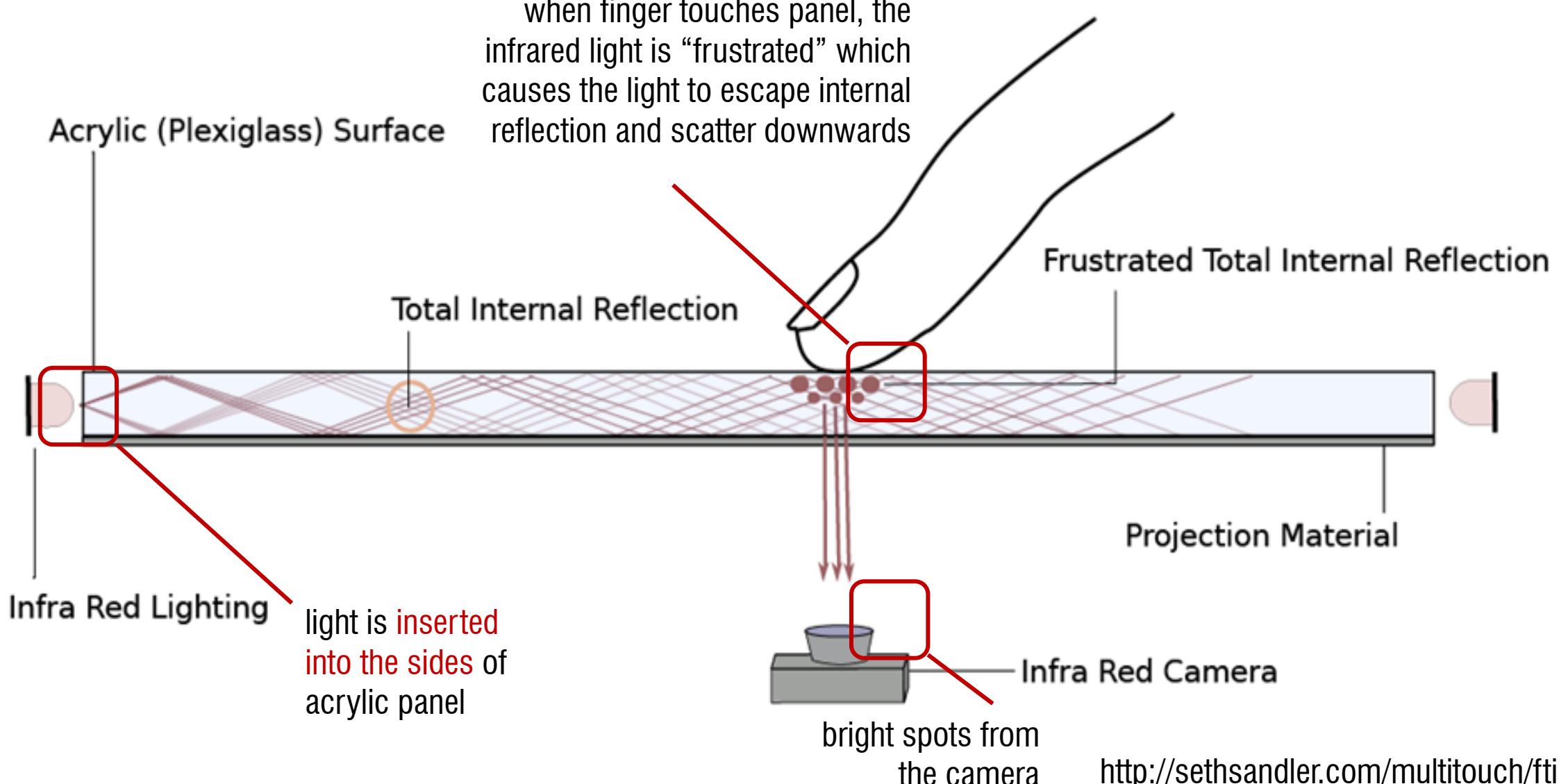
easy to do computer vision tracking based on this

camera based multi-touch technology
#2 - frustrated total internal reflection

total internal reflection



FTIR - Frustrated Total Internal Reflection

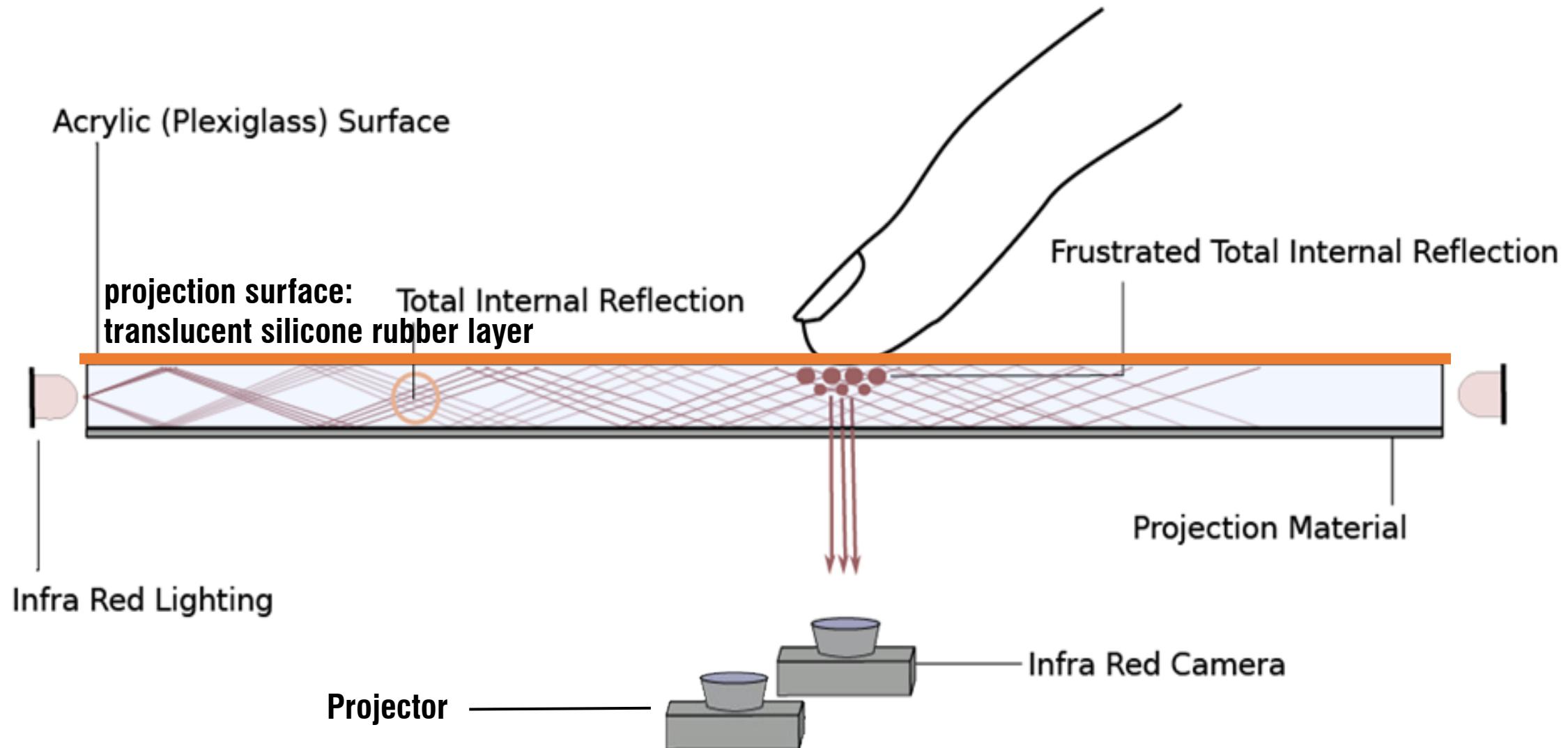


camera based multi-touch technology

#2 - frustrated total internal reflection - combine with projector

since acrylic is transparent, you cannot directly project on it
add a projection surface allows to display an image

FTIR - Frustrated Total Internal Reflection



A photograph of a man with glasses and a beard, wearing a black t-shirt, playing an acoustic guitar. He is positioned on the left side of the frame, looking down at his instrument. The background is dark and out of focus. The lighting is dramatic, highlighting his face and hands.

JEFFHAN

Low-Cost Multi-Touch Sensing through Frustrated Total Internal Reflection

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Figure 1: Simple examples of multi-touch interaction using our FTIR technique

ABSTRACT

This paper describes a simple, inexpensive, and scalable technique for enabling high-resolution multi-touch sensing on rear-projected interactive surfaces based on *frustrated total internal reflection*. We review previous applications of this phenomenon to sensing, provide implementation details, discuss results from our initial prototype, and outline future directions.

ACM Classification: H.5.2 [User Interfaces]: Input Devices and Strategies

General Terms: Human Factors

Keywords: multi-touch, touch, tactile, frustrated total internal reflection

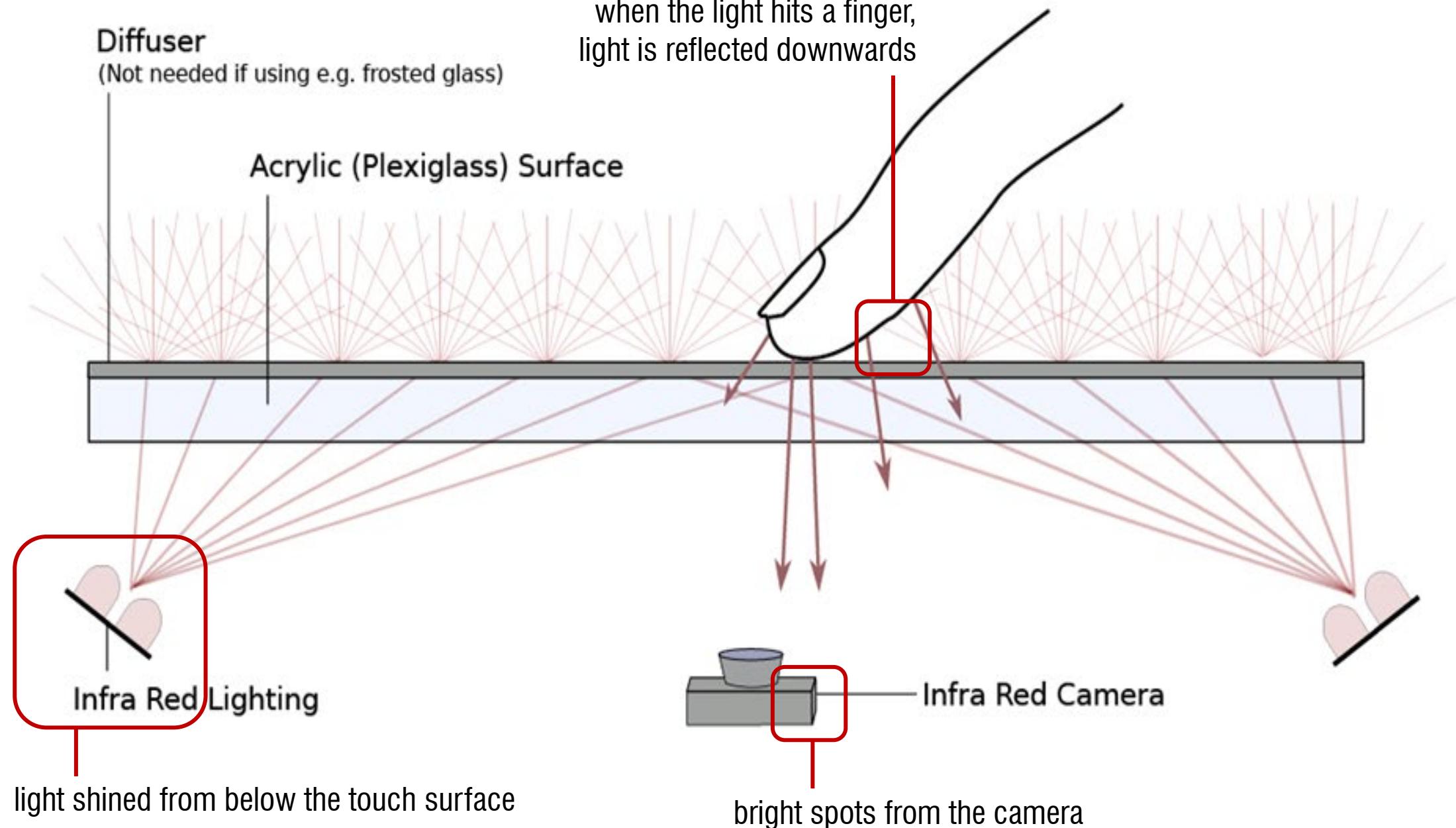
We present a simple technique for robust multi-touch sensing at a minimum of engineering effort and expense. It is based on *frustrated total internal reflection (FTIR)*, a phenomenon familiar to both the biometric and robot sensing communities. It acquires true touch image information at high spatial and temporal resolutions, is scalable to large installations, and is well suited for use with rear-projection. It is not the aim of this paper to explore the multi-touch interaction techniques that this system enables, but rather to make the technology readily available to those who wish to do so.

RELATED WORK

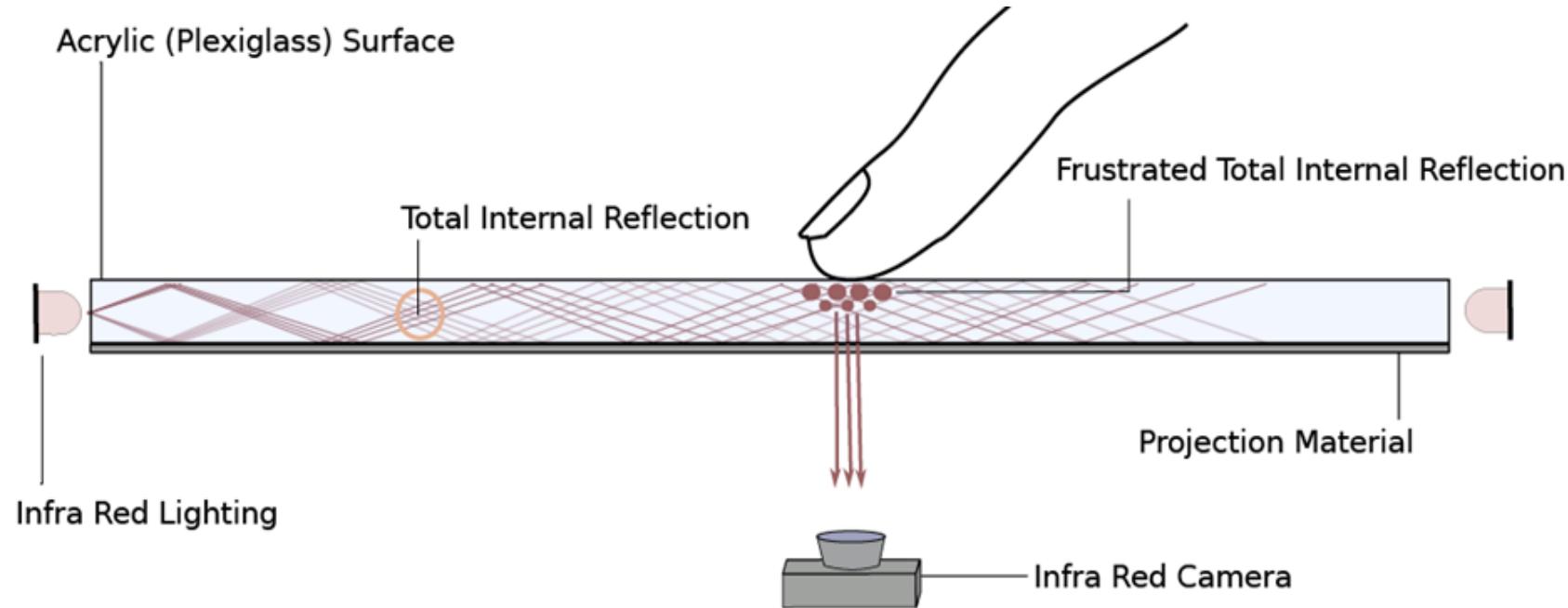
A straightforward approach to multi-touch sensing is to simply utilize a plurality of discrete sensors, making an individual connection to each sensor as in the *Tactex MTC Express* [20]. They can also be arranged in a matrix configuration with some active element (e.g., diode, transistor) at each node.

camera based multi-touch technology
#3 - rear diffused illumination (rear DI)

RDI - Rear Diffused Illumination

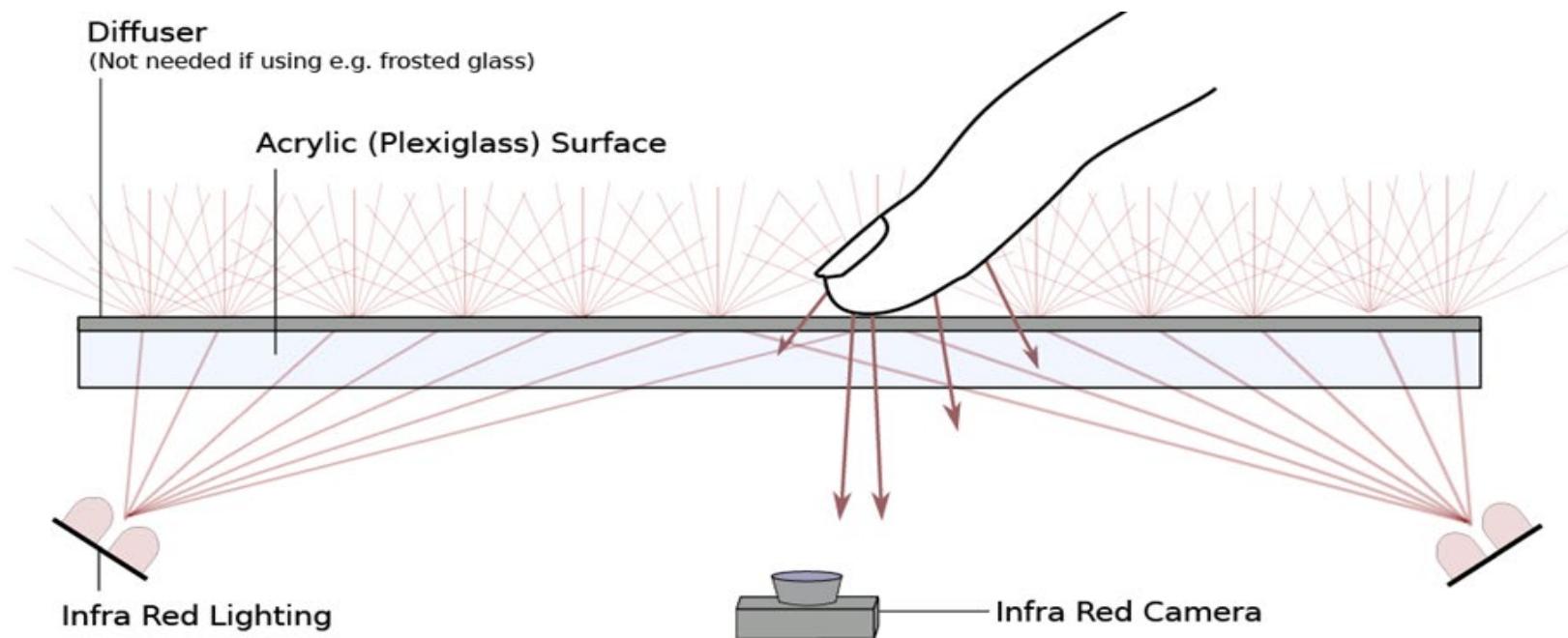


#2 - frustrated total internal reflection

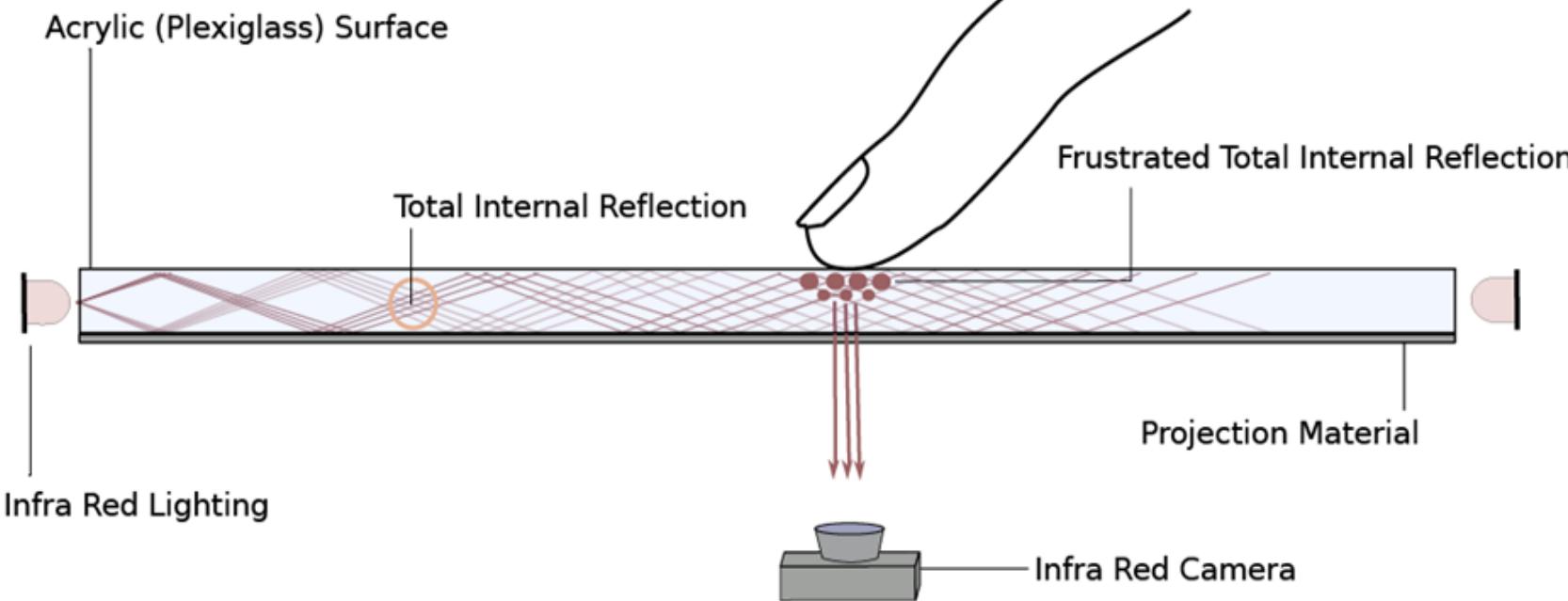
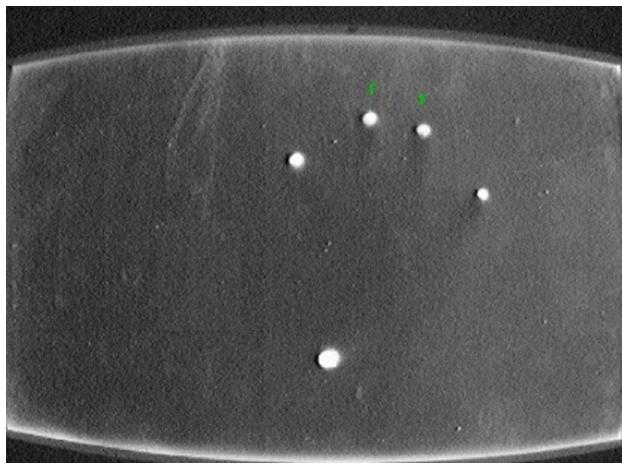


Any difference then?

#3 - rear diffused illumination (rear DI)

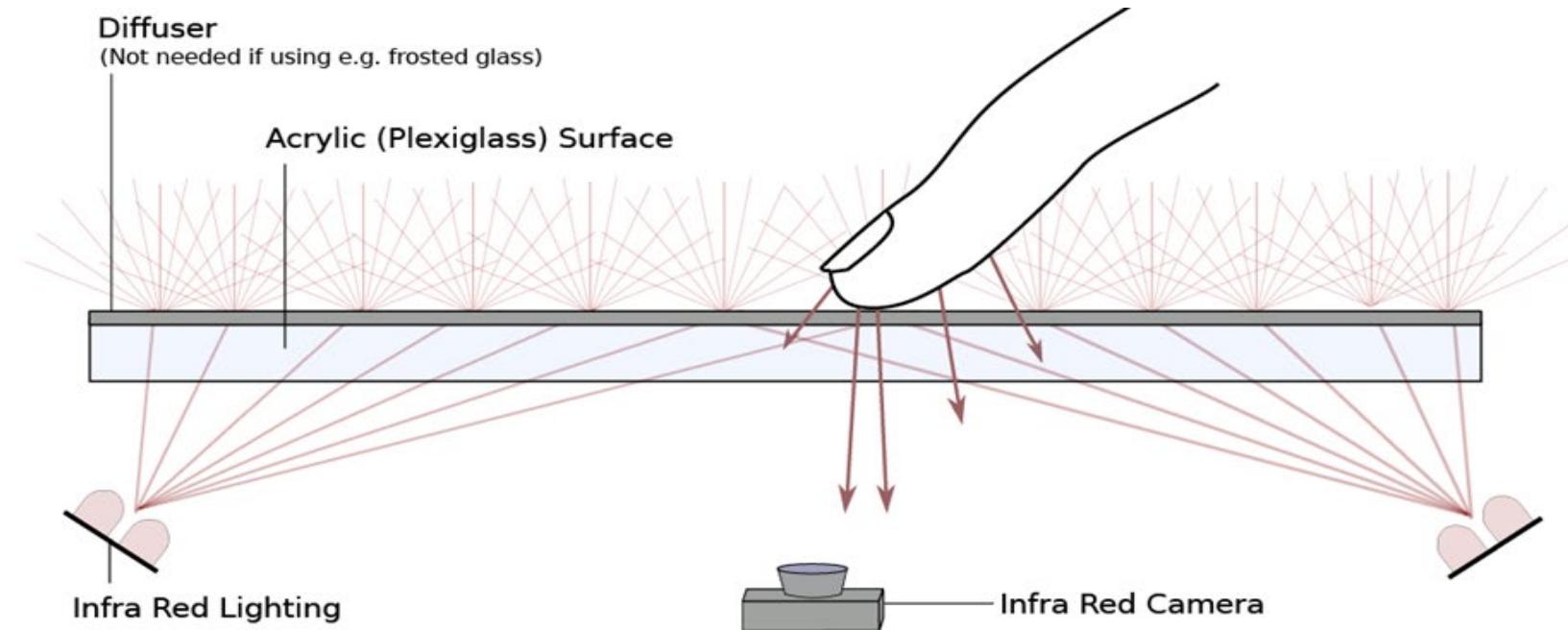


#2 - frustrated total internal reflection



Any difference then?

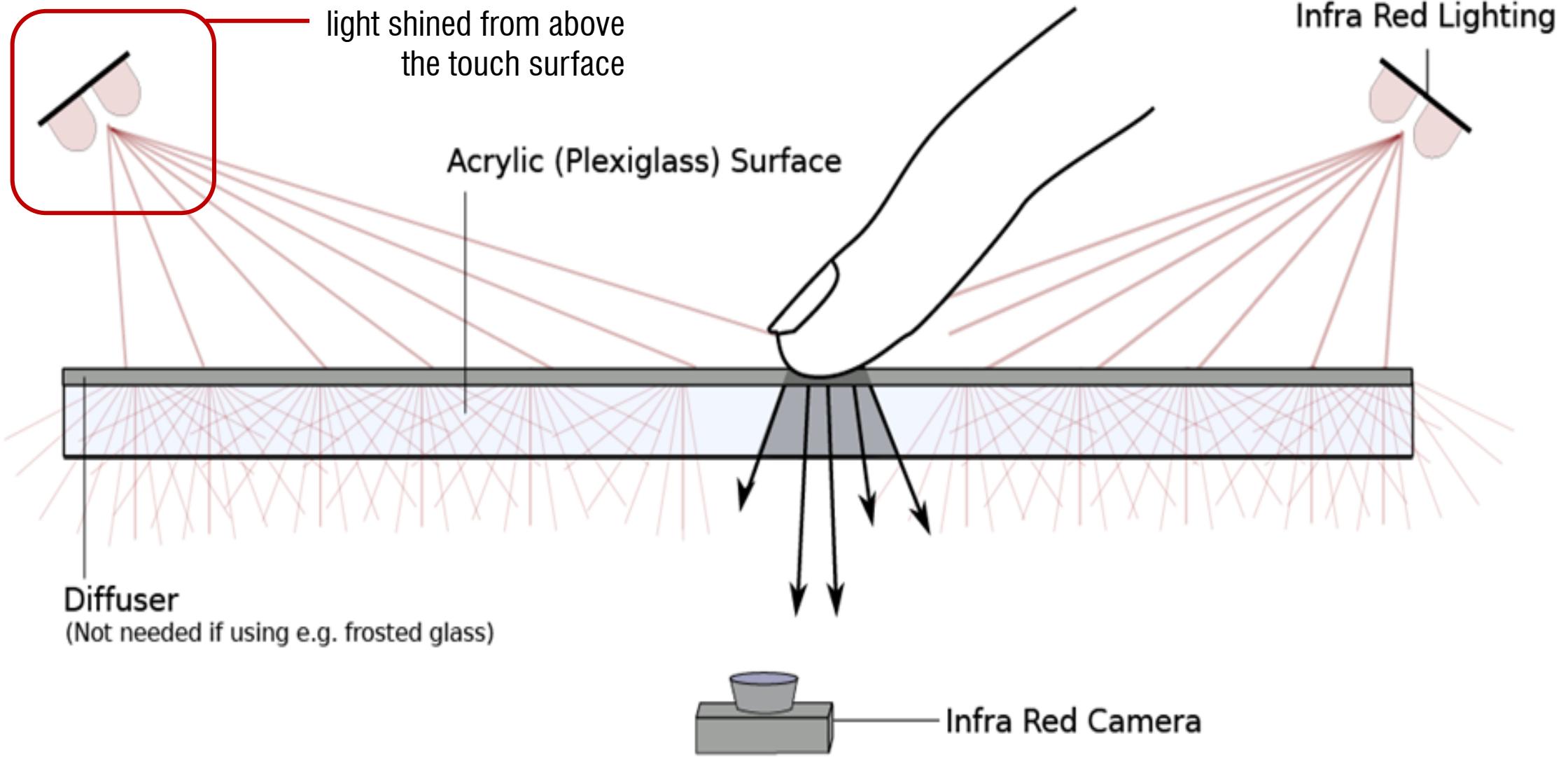
#3 - rear diffused illumination (rear DI)



camera based multi-touch technology
#3 - rear diffused illumination (rear DI)

camera based multi-touch technology
#4 - front diffused illumination (front DI)

FDI - Front Diffused Illumination

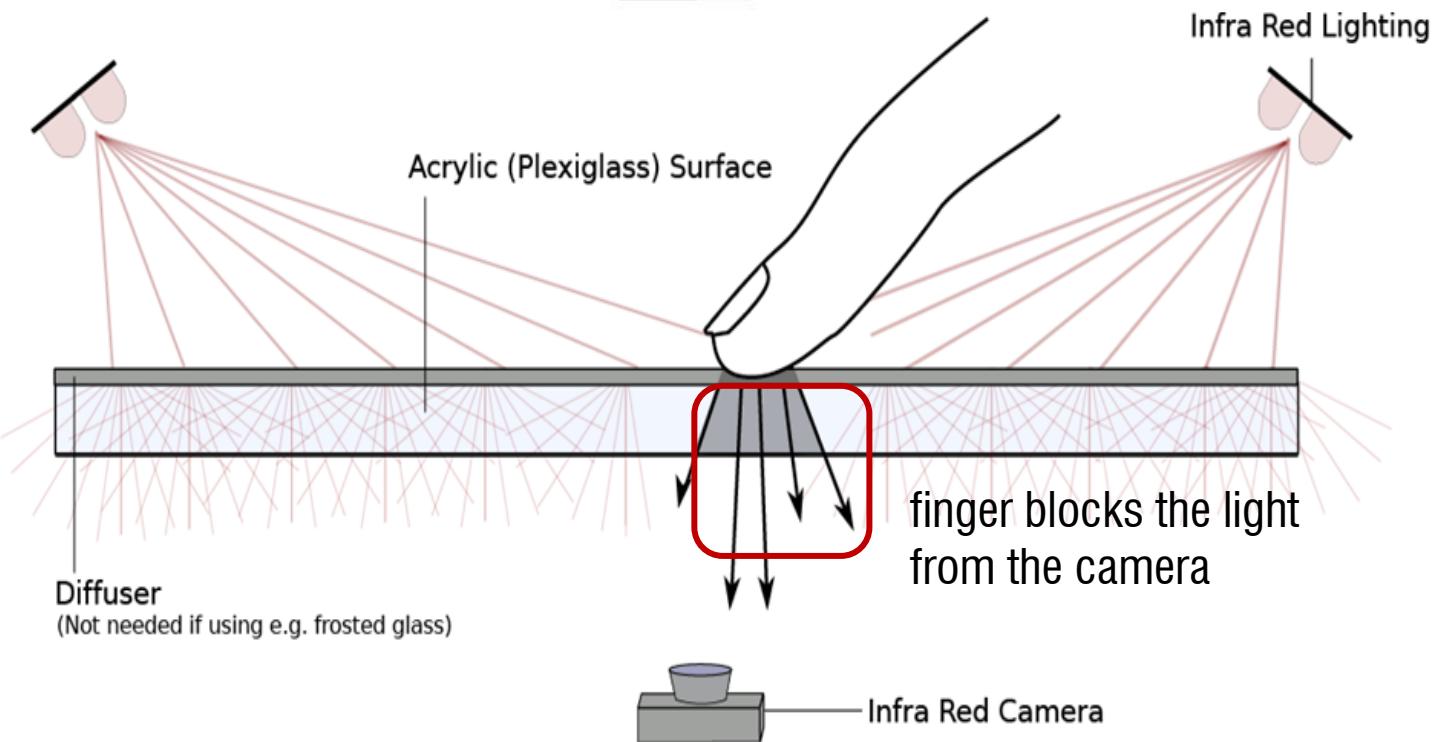
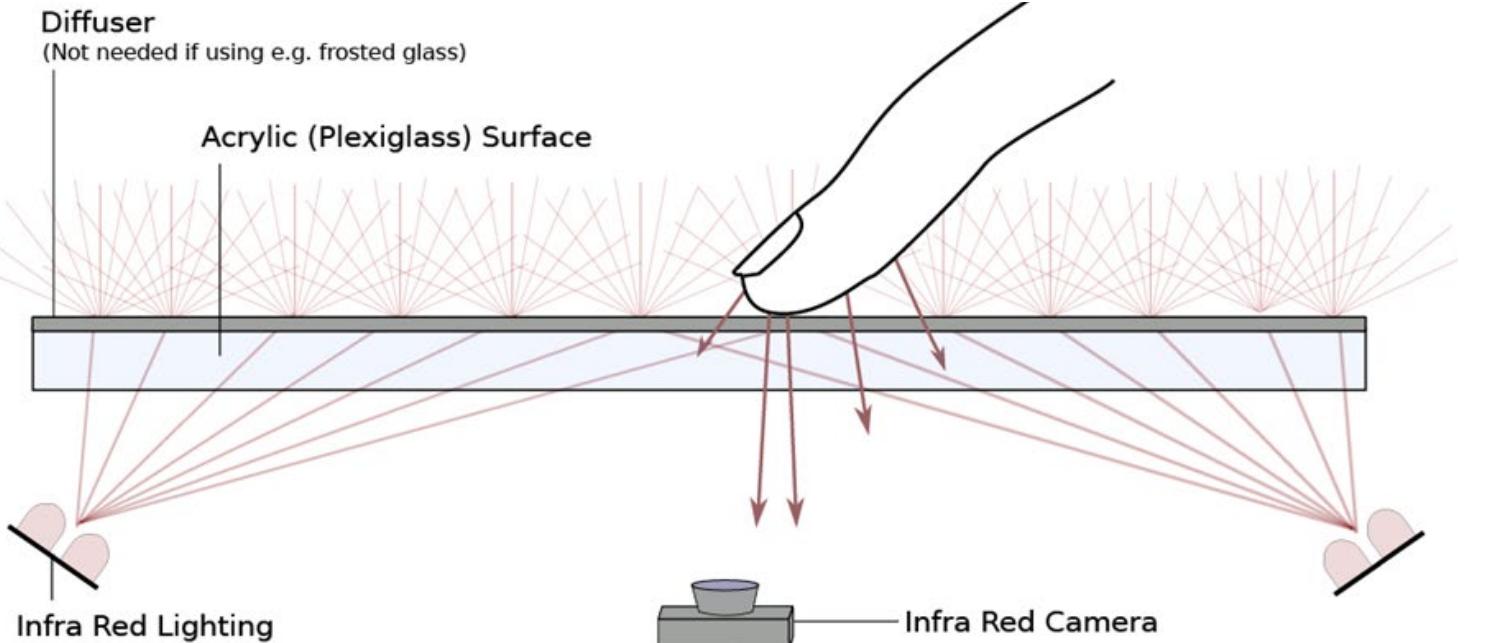
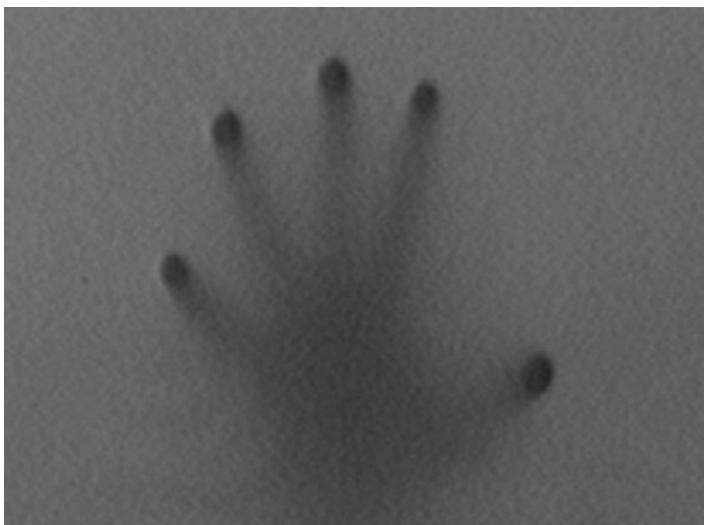


#3 - rear diffused illumination (rear DI)



Comparison?

#4 - front diffused illumination (front DI)





<http://www.youtube.com/watch?v=vLAzINB0QQY>

How to build one by yourself



MTBiggie by Seth Sandler, 2011

camera based multi-touch technology

#1 - laser Light Plane (LLP)

#2 - frustrated total internal reflection (FTIR)

#3 - rear diffused illumination (rear DI)

#4 - front diffused illumination (front DI)

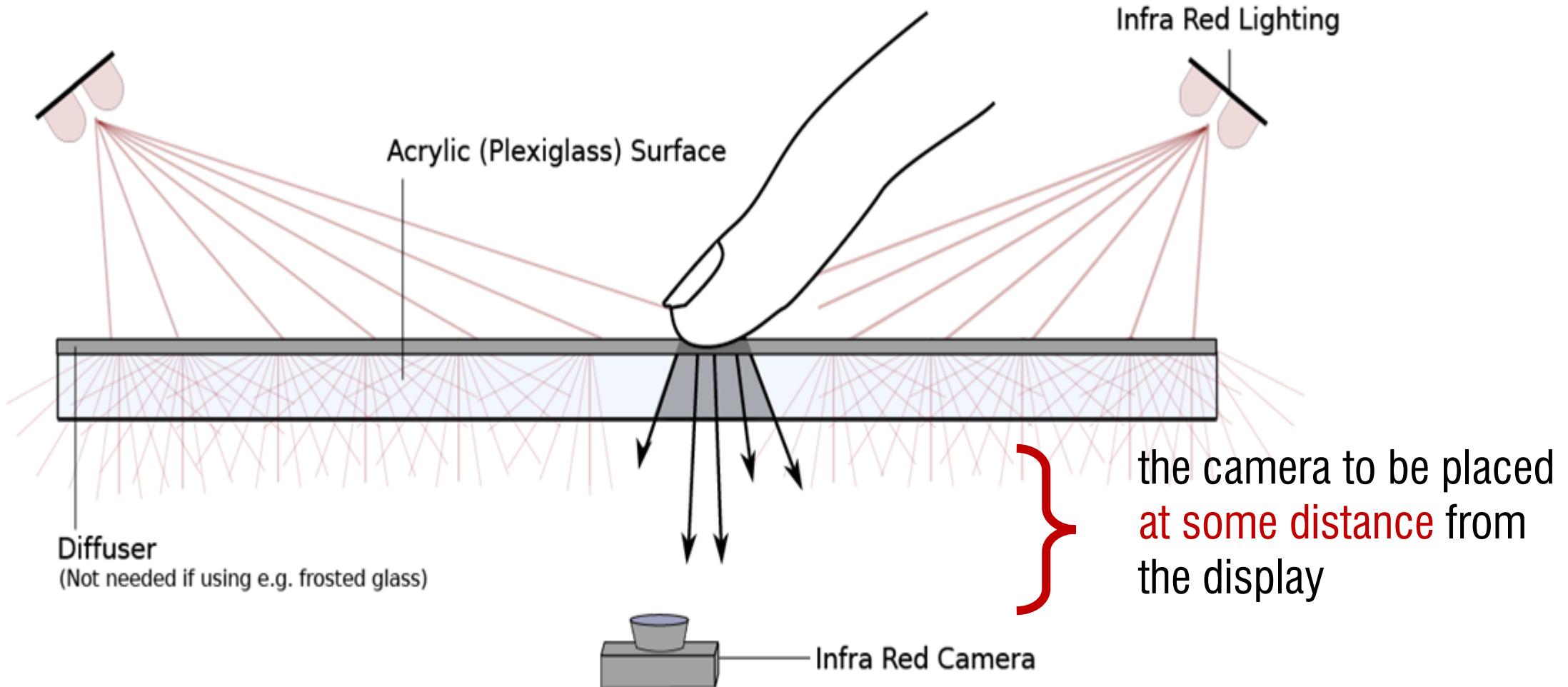
A light source

A way to break the light

A cam to capture the spot/shadow

What are the limitations of camera based multi-touch technique?

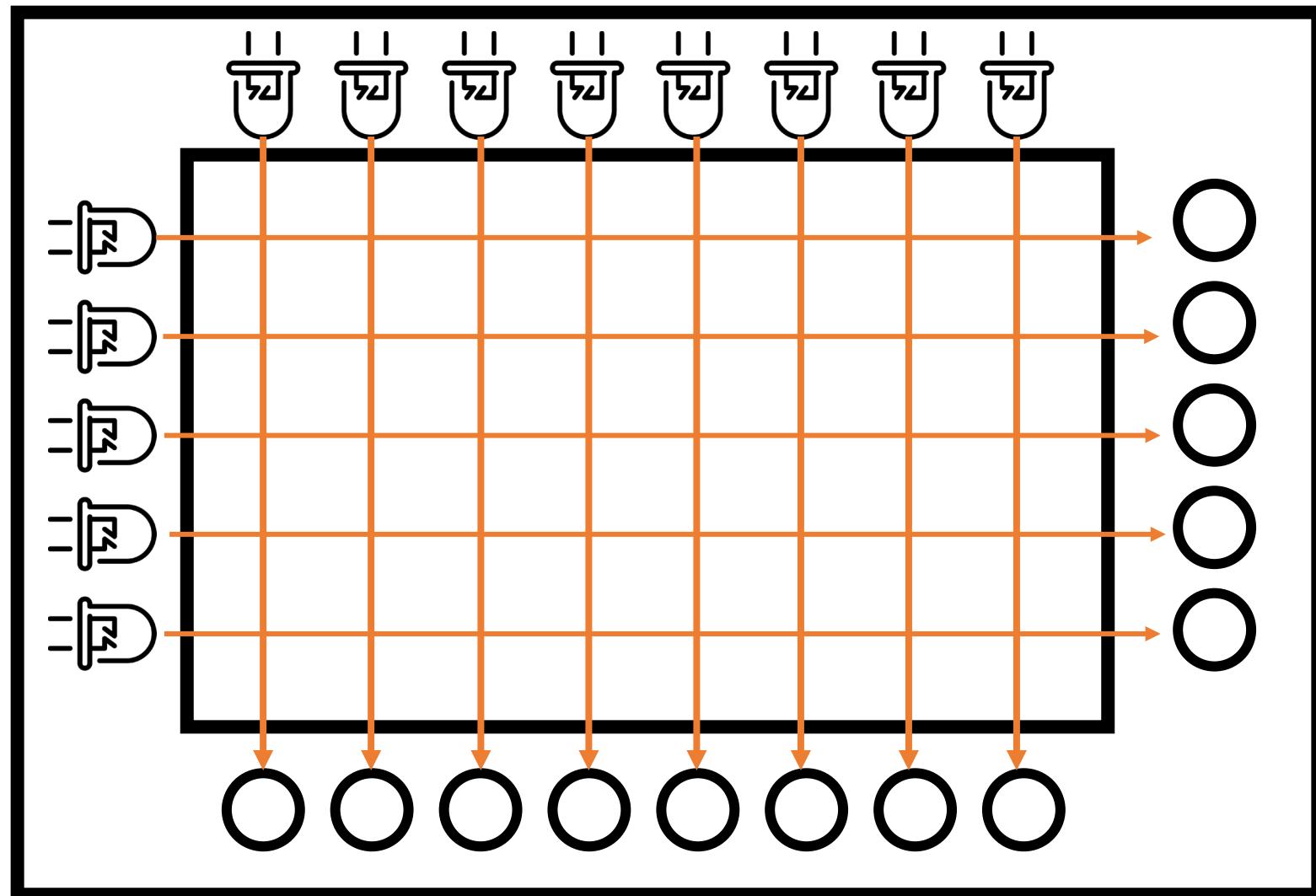
What are the limitations of camera based multi-touch technique?



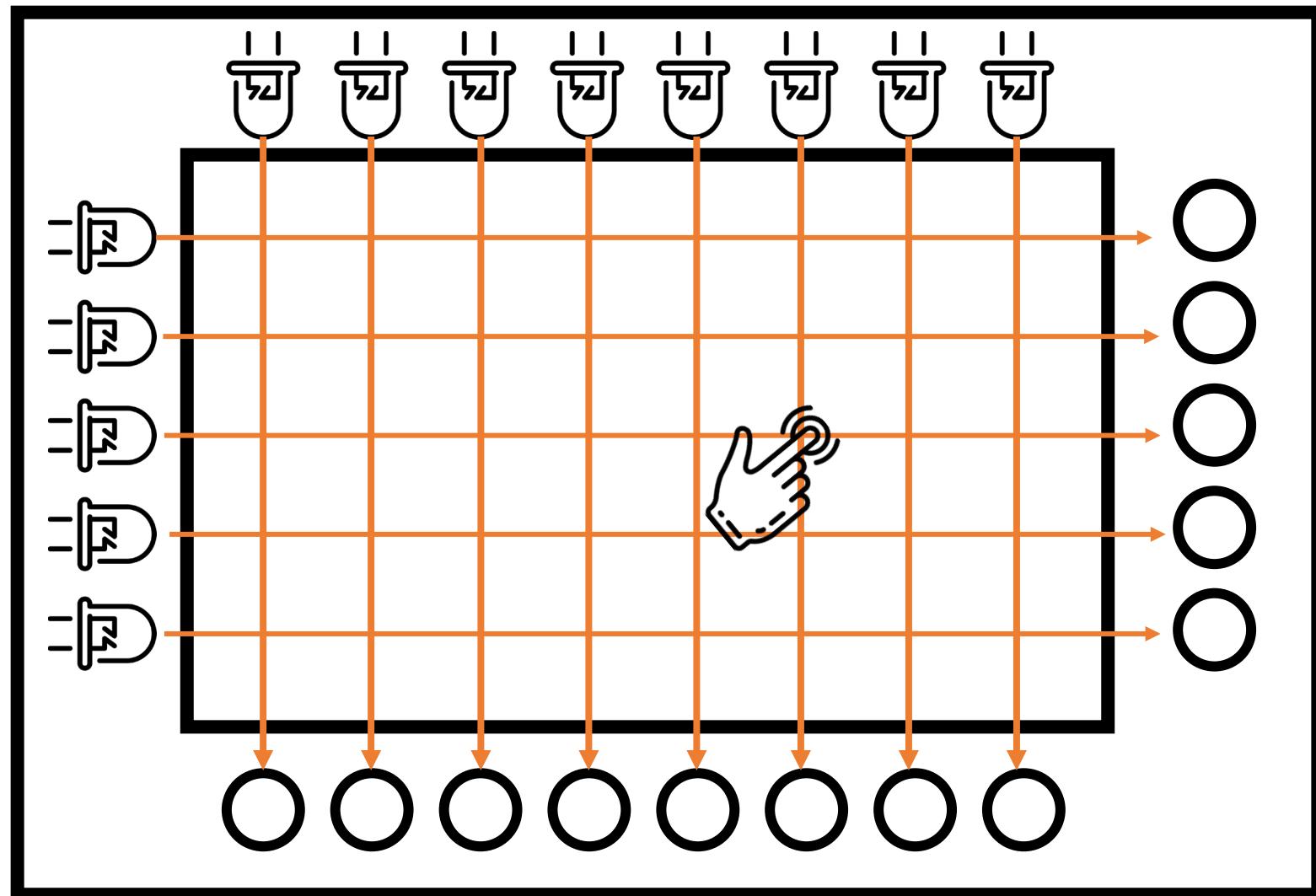
Put the sensor not to the bottom of the display
but to the side of it

infrared touch panels (ITP)

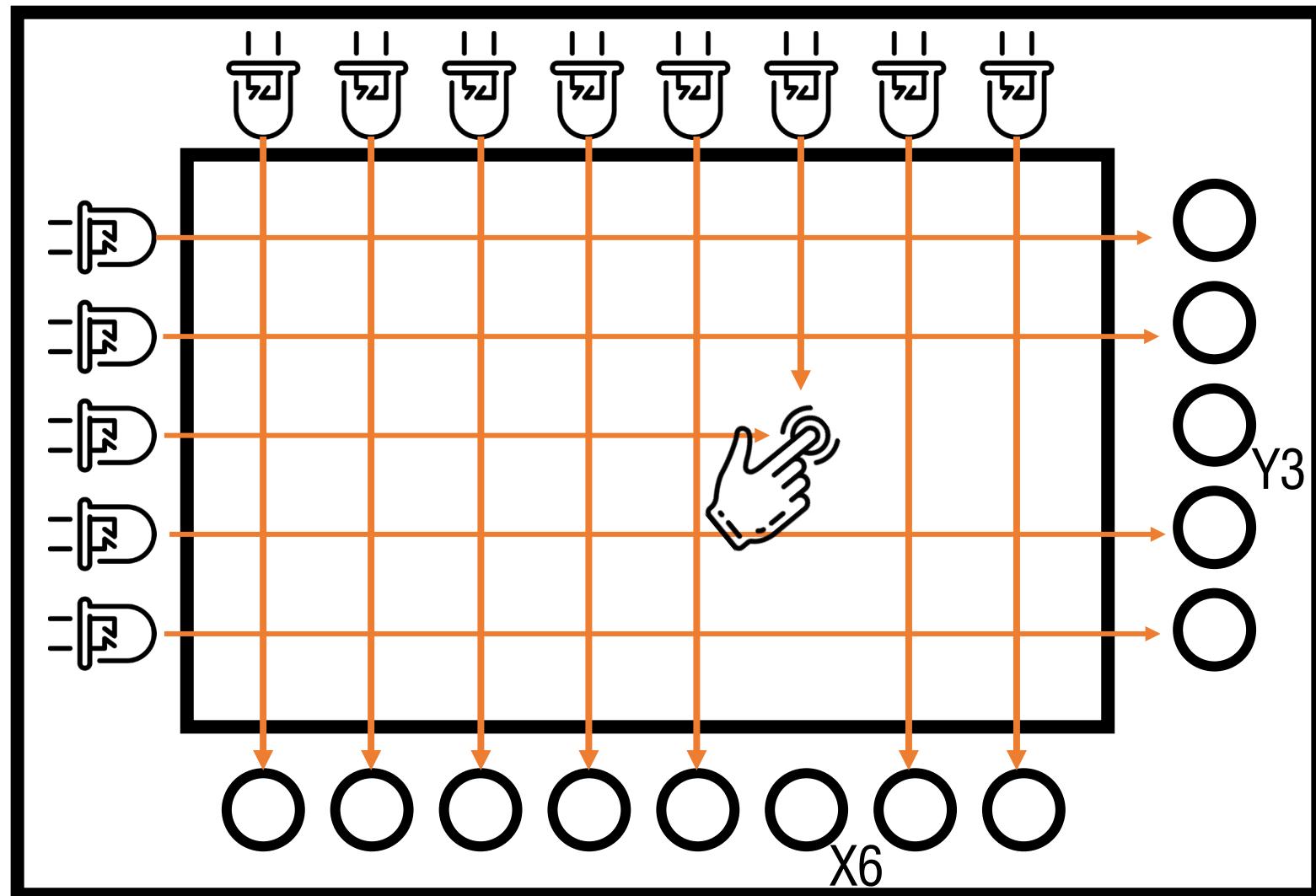
infrared touch panels (ITP)



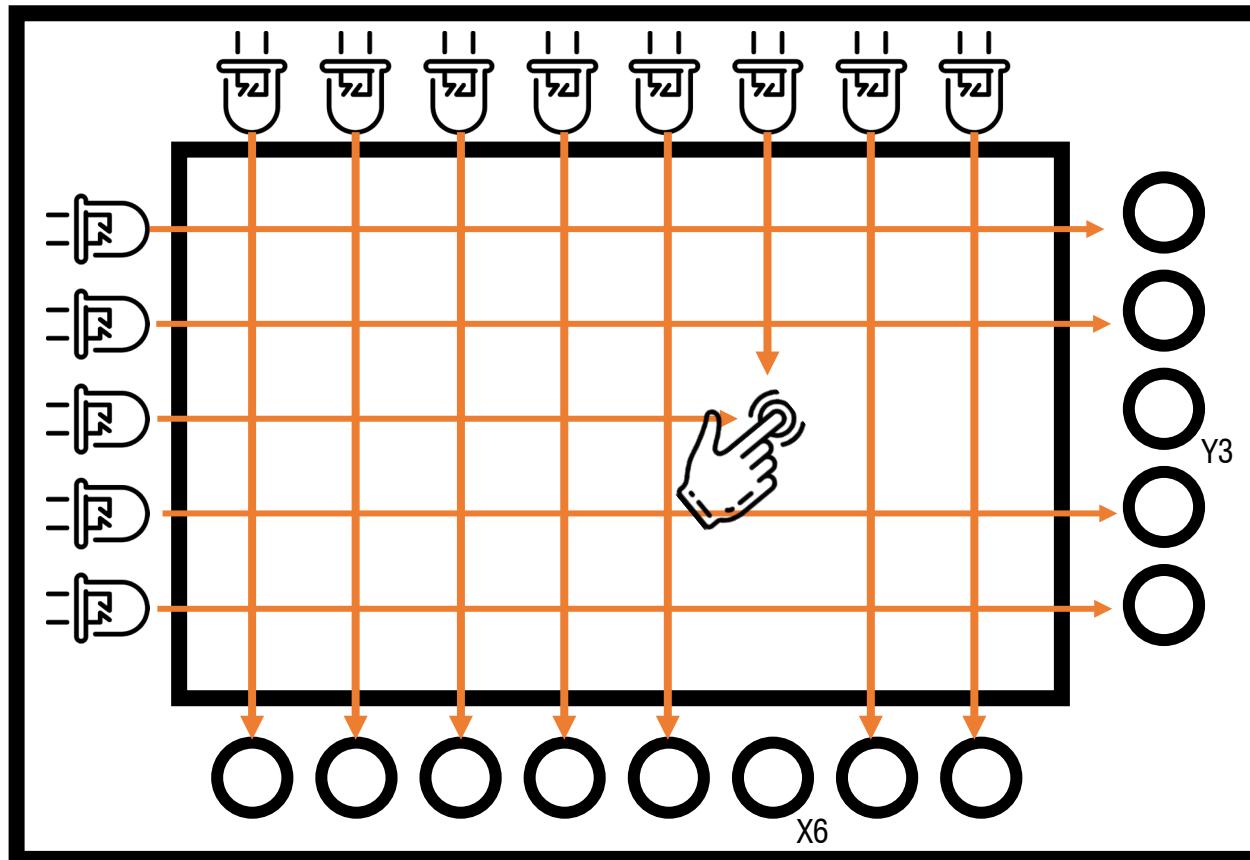
infrared touch panels (ITP)



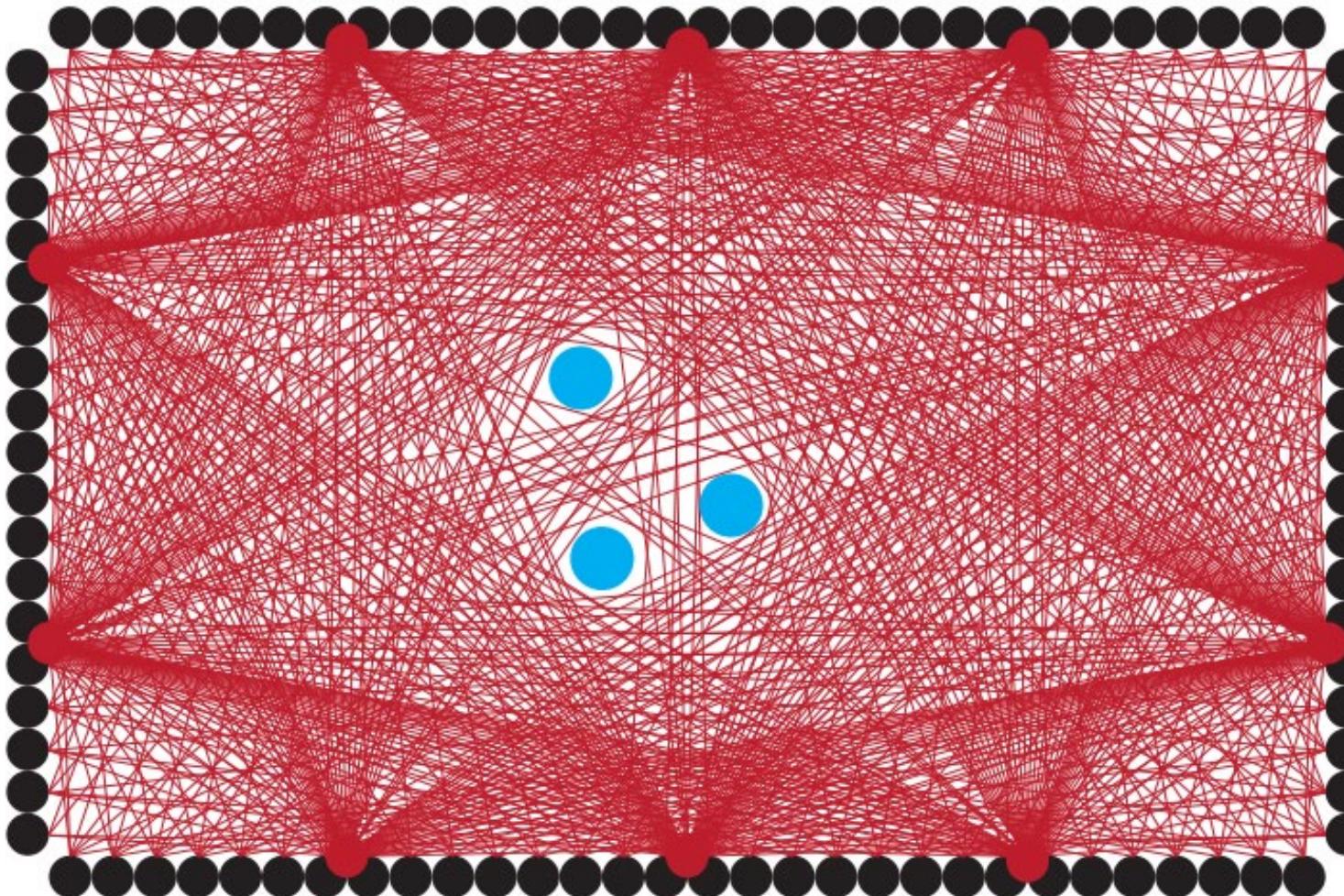
infrared touch panels (ITP)



infrared touch panels (ITP)



infrared LEDs and light sensors
placed in a grid on bezel
LEDs transmit light to light sensors on the other side
anything that disrupts light, will register as touch



ZeroTouch: An Optical Multi-Touch and Free-Air Interaction Architecture

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Interface Ecology Lab @ TAMU CSE
jmoeller@gmail.com, andruid@ecologylab.net

ABSTRACT

ZeroTouch (ZT) is a unique optical sensing technique and architecture that allows precision sensing of hands, fingers, and other objects within a constrained 2-dimensional plane. ZeroTouch provides tracking at 80 Hz, and up to 30 concurrent touch points. Integration with LCDs is trivial. While designed for multi-touch sensing, ZT enables other new modalities, such as pen+touch and free-air interaction. In this paper, we contextualize ZT innovations with a review of other flat-panel sensing technologies. We present the modular sensing architecture behind ZT, and examine early diverse uses of ZT sensing.

Author Keywords
Multi-touch; ZeroTouch; Free-Air; Interaction; Sensing

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces—Input Devices

General Terms
Design, Experimentation

INTRODUCTION
Flat-panel multi-touch technologies are slowly but surely scaling to larger and larger screen-sizes. What was once predominantly the domain of bulky vision-based camera/projector multi-touch systems is now being rapidly encroached upon by more space-efficient technologies, albeit at higher relative cost/screen area.

Recent developments in large-area flat-panel multi-touch sensing have used optical technologies. Whether by incorporation of optical sensors in the display itself, or by surrounding a display with optical sensors and transmitters, optical technologies are able to scale to large screen sizes.

Capacitive sensing technologies have recently scaled to large displays, enabling high-precision multi-touch at a scale once the sole realm of vision-based sensing. However, capacitive requires factory integration, and thus

is unsuitable for integration with the large contingent of non-multi-touch displays already in the world.

There are a number of technologies that enable multi-touch interaction on non-interactive displays in the market today, and the majority of these employ optical-based touch sensing. Some use cameras and computer vision techniques, and some use optical sensors and emitters to detect touch.

In this paper, we detail ZeroTouch (ZT), a hardware/software architecture for multi-touch sensing [16]. ZeroTouch is a flat-panel optical multitouch technology using a linear array of modulated light receivers which surround the periphery of a display to detect touch. It is designed with a modular architecture. A complete sensor is built from a number of smaller sensing modules, allowing a full sensor to be built at any practical size.

First, we present an overview of flat-panel optical multi-touch techniques, and position ZeroTouch amidst the multi-touch sensing landscape. Next, we go deeper into the technology of ZT, describing its modular architecture, sensing technique, and temporal and spatial resolution characteristics of the sensor. Finally, we develop application areas of ZT with case studies. We wrap up with a discussion and implications for the technology.

OPTICAL FLAT-PANEL SENSING TECHNOLOGIES
There are a few techniques for optical flat-panel sensing, some which sense from the sides, and some which sense directly behind or within the display itself. We will discuss some issues common to all forms of optoelectronic sensing, develop an overview of prior optoelectronic techniques, and situate ZT among them.

Common Issues in Optoelectronic Sensing
Among the wide variety of techniques for optoelectronic touch sensing, most suffer from a few common problems which can interfere with a system's success. Ambient light sensitivity is perhaps the most important noise factor in optoelectronic multi-touch systems, followed by active light interference.

CHI 2012

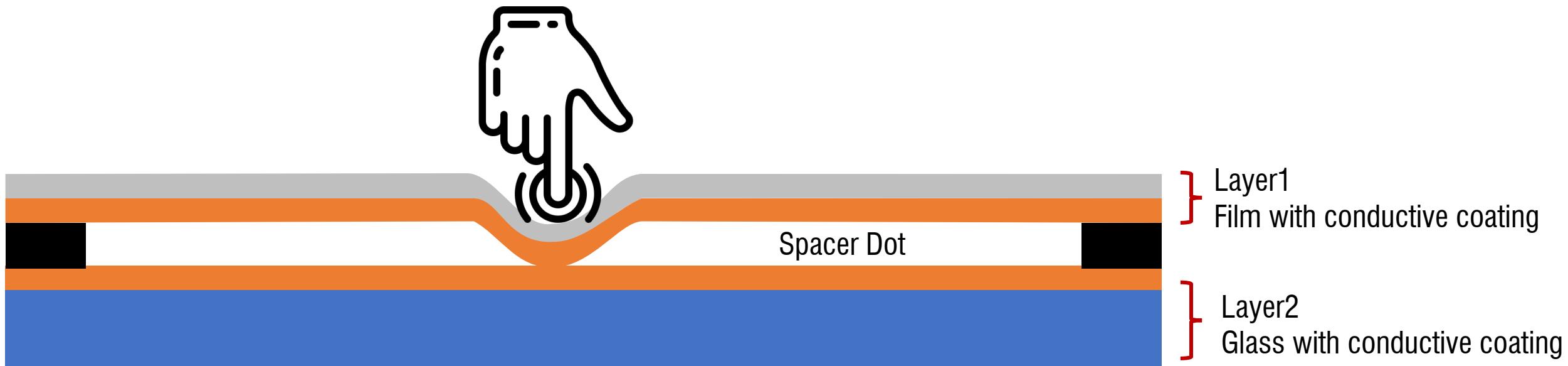
Moeller et.al. from TAMU

infrared touch panels (ITP)
resistive touch panels (RTP)

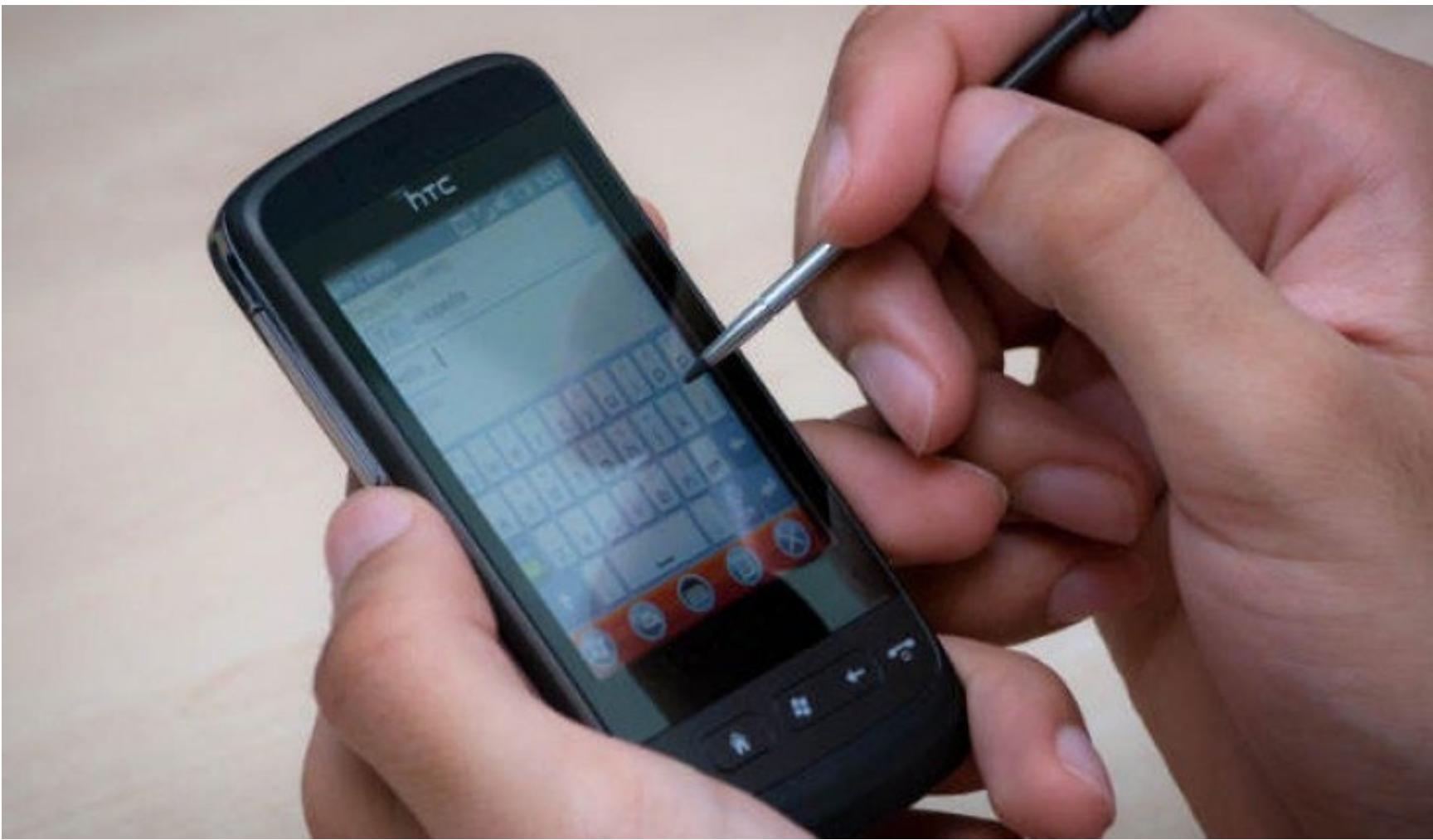
resistive touch panels (RTP)



resistive touch panels (RTP)

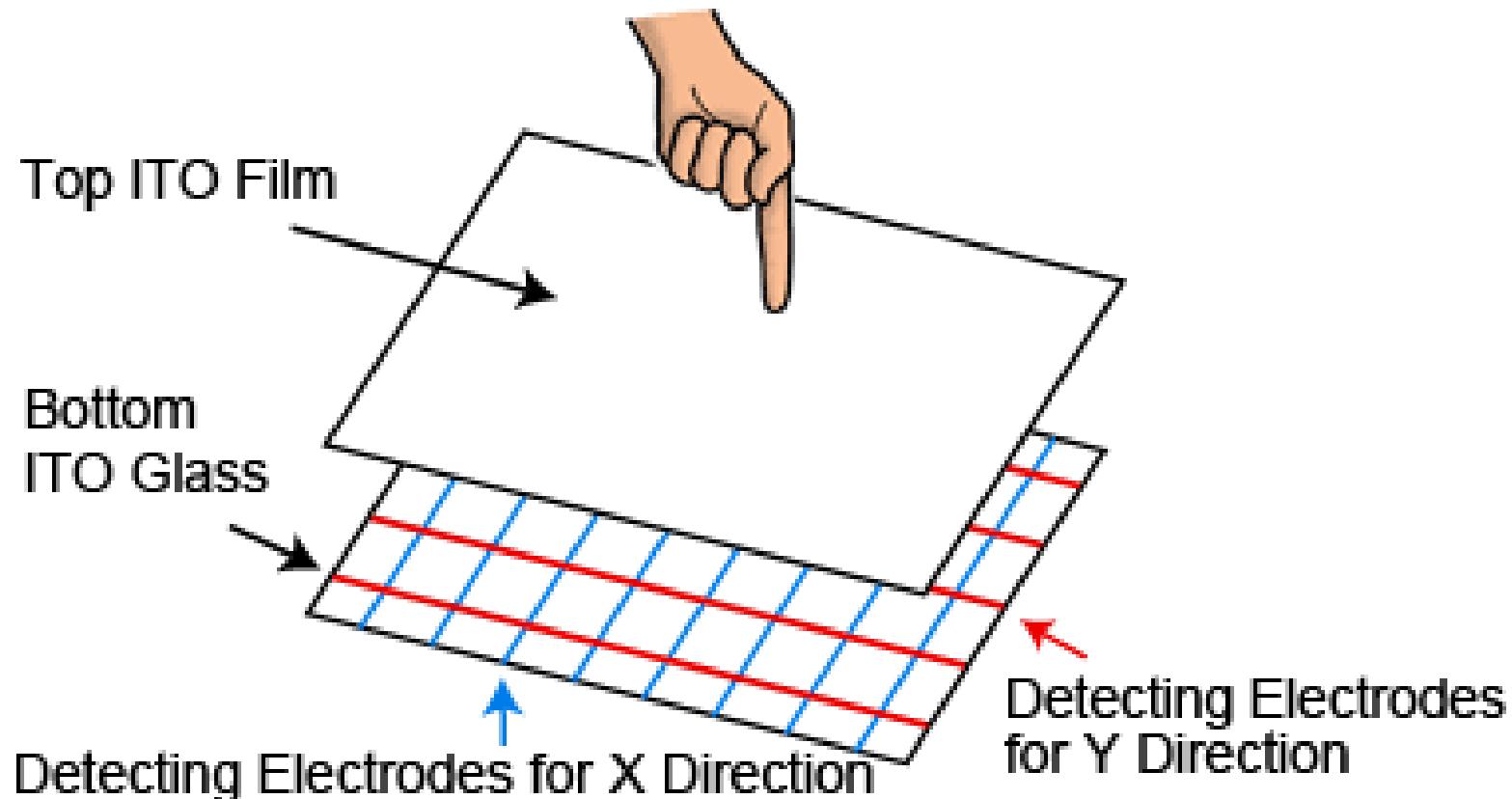


when the top sheet gets pressed by a finger, the pressed point
makes contact with the bottom sheet
electricity now get conducted at the contact point





Sensing principle?



infrared touch panels (ITP)
resistive touch panels (RTP)
capacitive touch screens

capacitive
touch screens

2007



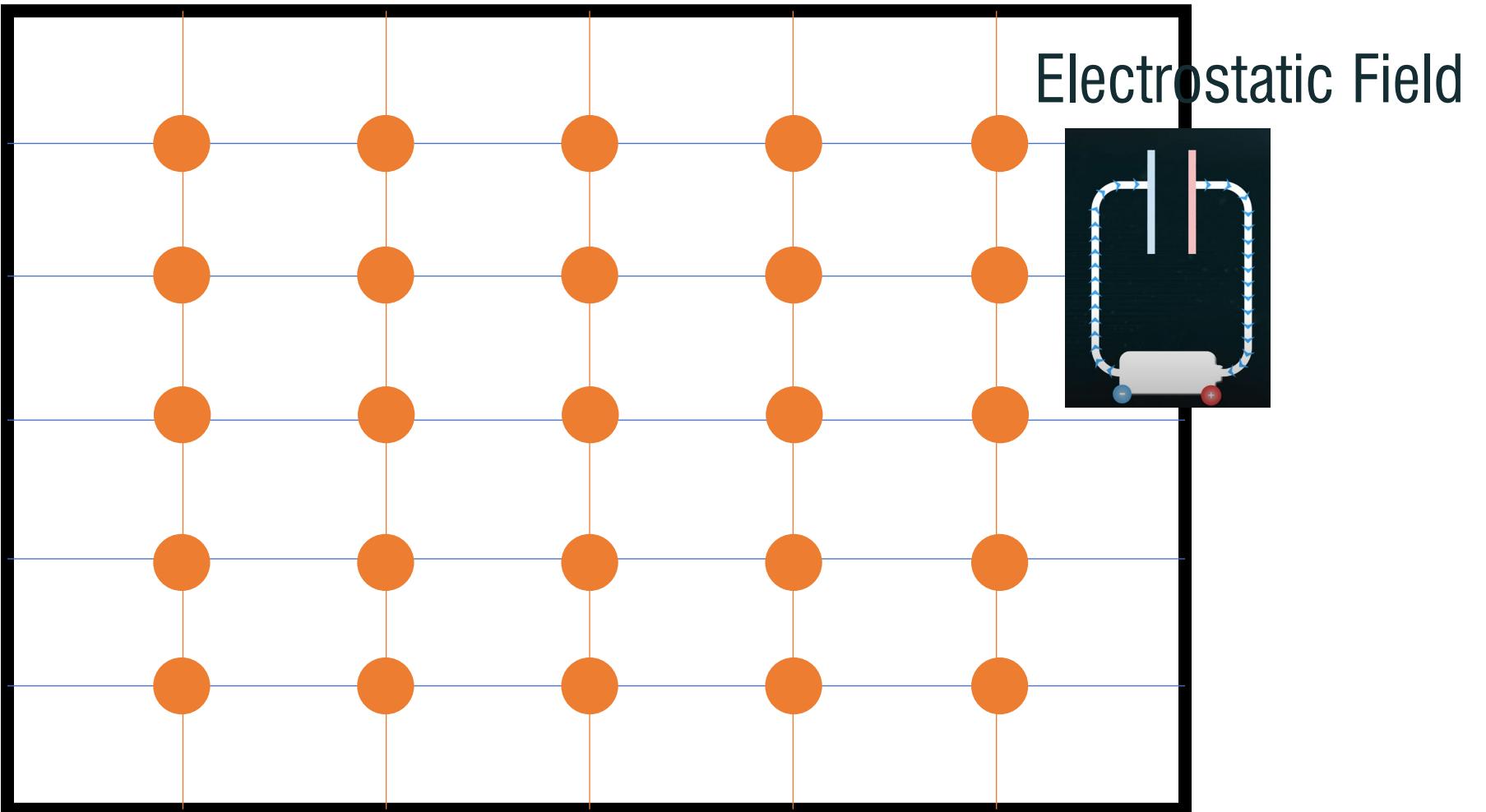
Sensing lines
to detect
electric current

Driving lines
with constant
electric current

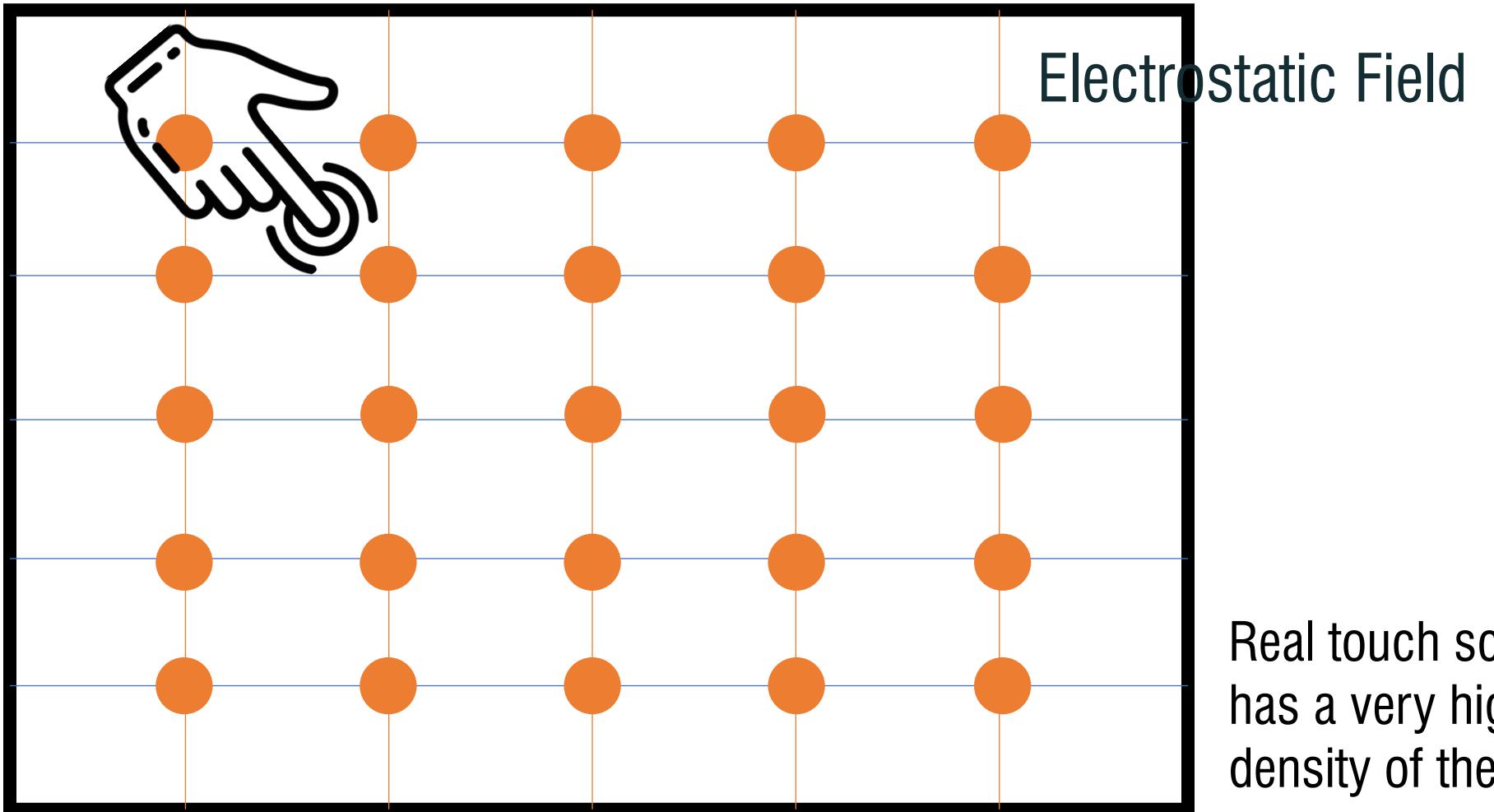


Sensing lines
to detect
electric current

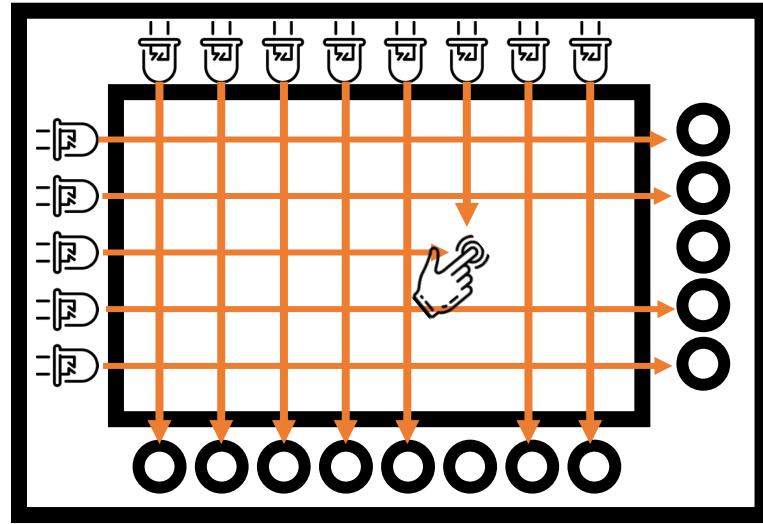
Driving lines
with constant
electric current



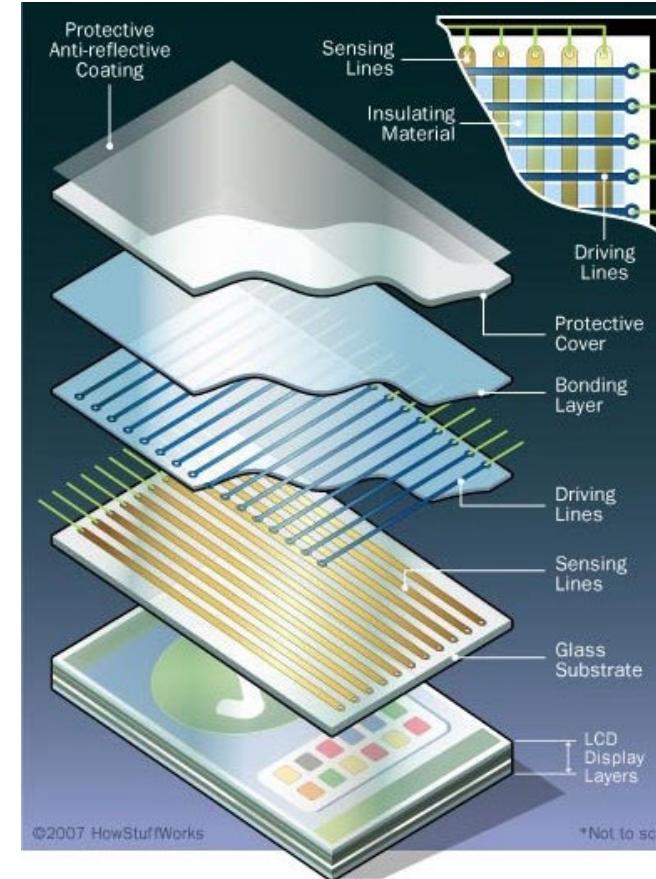
Human body has a natural capacitance
distorting the electrostatic field
at the contact point



infrared touch panels (ITP)

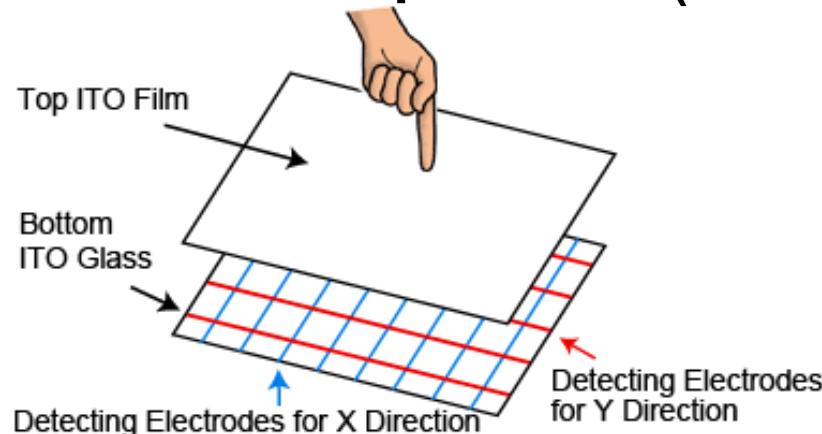


capacitive touch screens

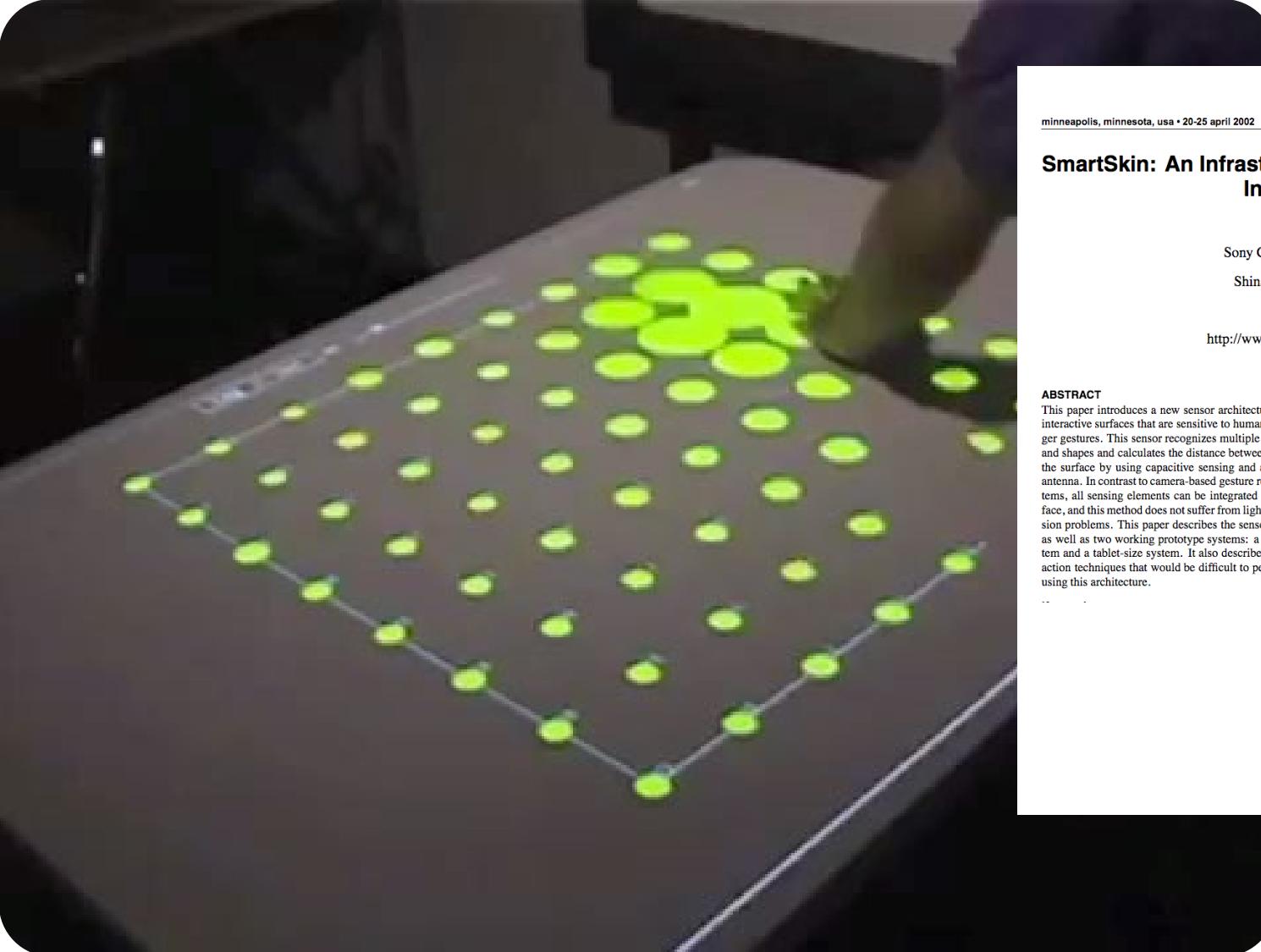


same principle

resistive touch panels (RTP)



<http://www.sky-technology.eu/en/displays/touch-screens/projected-capacitive-touch-screens-how-they-work.html>



minneapolis, minnesota, usa • 20-25 april 2002

Paper: Two-Handed Interaction

SmartSkin: An Infrastructure for Freehand Manipulation on Interactive Surfaces

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Fax: +81 3 5448 4273
Mail: rekimoto@acm.org
<http://www.csl.sony.co.jp/person/rekimoto.html>

ABSTRACT

This paper introduces a new sensor architecture for making interactive surfaces that are sensitive to human hand and finger gestures. This sensor recognizes multiple hand positions and shapes and calculates the distance between the hand and the surface by using capacitive sensing and a mesh-shaped antenna. In contrast to camera-based gesture recognition systems, all sensing elements can be integrated within the surface, and this method does not suffer from lighting and occlusion problems. This paper describes the sensor architecture, as well as two working prototype systems: a table-size system and a tablet-size system. It also describes several interaction techniques that would be difficult to perform without using this architecture.



Figure 1: An interactive surface system based on the

CHI 2002
Jun Rekimoto

DiamondTouch

A Multi-User Touch Technology

DiamondTouch: A Multi-User Touch Technology

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Cambridge, MA 02139 USA
+1-617-621-7500
{dietz,leigh}@merl.com

ABSTRACT

A technique for creating a touch-sensitive input device is proposed which allows multiple, simultaneous users to interact in an intuitive fashion. Touch location information is determined independently for each user, allowing each touch on a common surface to be associated with a particular user. The surface generates location dependent, modulated electric fields which are capacitively coupled through the users to receivers installed in the work environment. We describe the design of these systems and their applications. Finally, we present results we have obtained with a small prototype device.

KEYWORDS: DiamondTouch, multi-user, touch, collaborative input, single display groupware

INTRODUCTION

DiamondTouch is a multi-user touch technology for tabletop front-projected displays. It enables several different people to use the same touch-surface simultaneously without interfering with each other, or being affected by foreign objects. DiamondTouch allows the computer to identify which user is touching the screen.



Figure 1: The collaborative work environment for Human-Guided Simple Search.

ity. Keeping track of many mice is nearly impossible. This leaves users physically pointing at their virtual pointers to

UIST 2001
Dietz et.al.

Learn the technologies behind multi-touch screen

Camera-based | Resistive | Capacitive | ...

Recap

technologies behind multi-touch screen

Camera-based | Resistive | Capacitive | ...

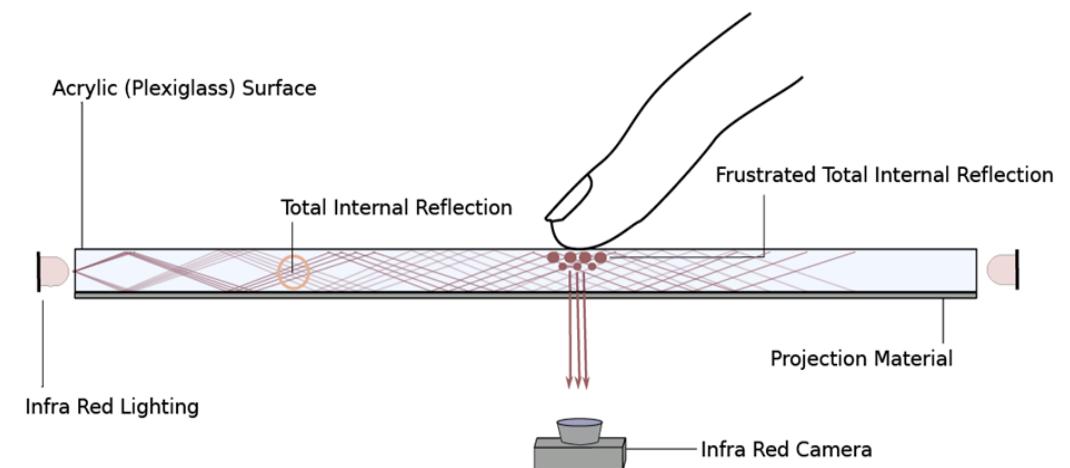
#1 - laser Light Plane (LLP)

#2 - frustrated total internal reflection (FTIR)

#3 - rear diffused illumination (rear DI)

#4 - front diffused illumination (front DI)

FTIR - Frustrated Total Internal Reflection



Recap

technologies behind multi-touch screen

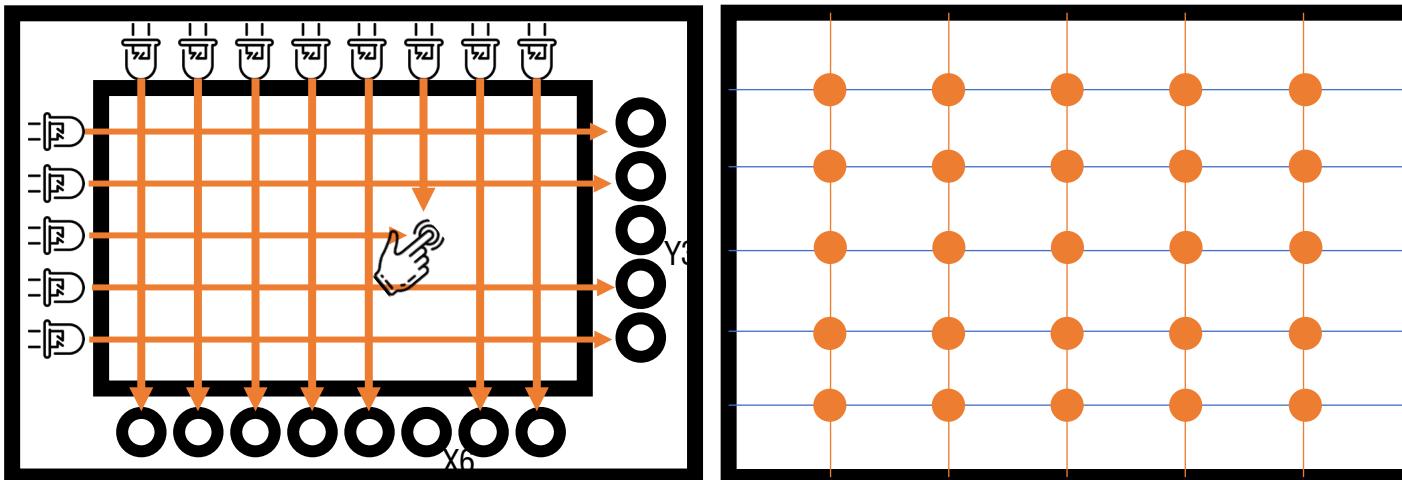
Camera-based | Resistive | Capacitive | ...



Recap

technologies behind multi-touch screen

Camera-based | Resistive | Capacitive | ...

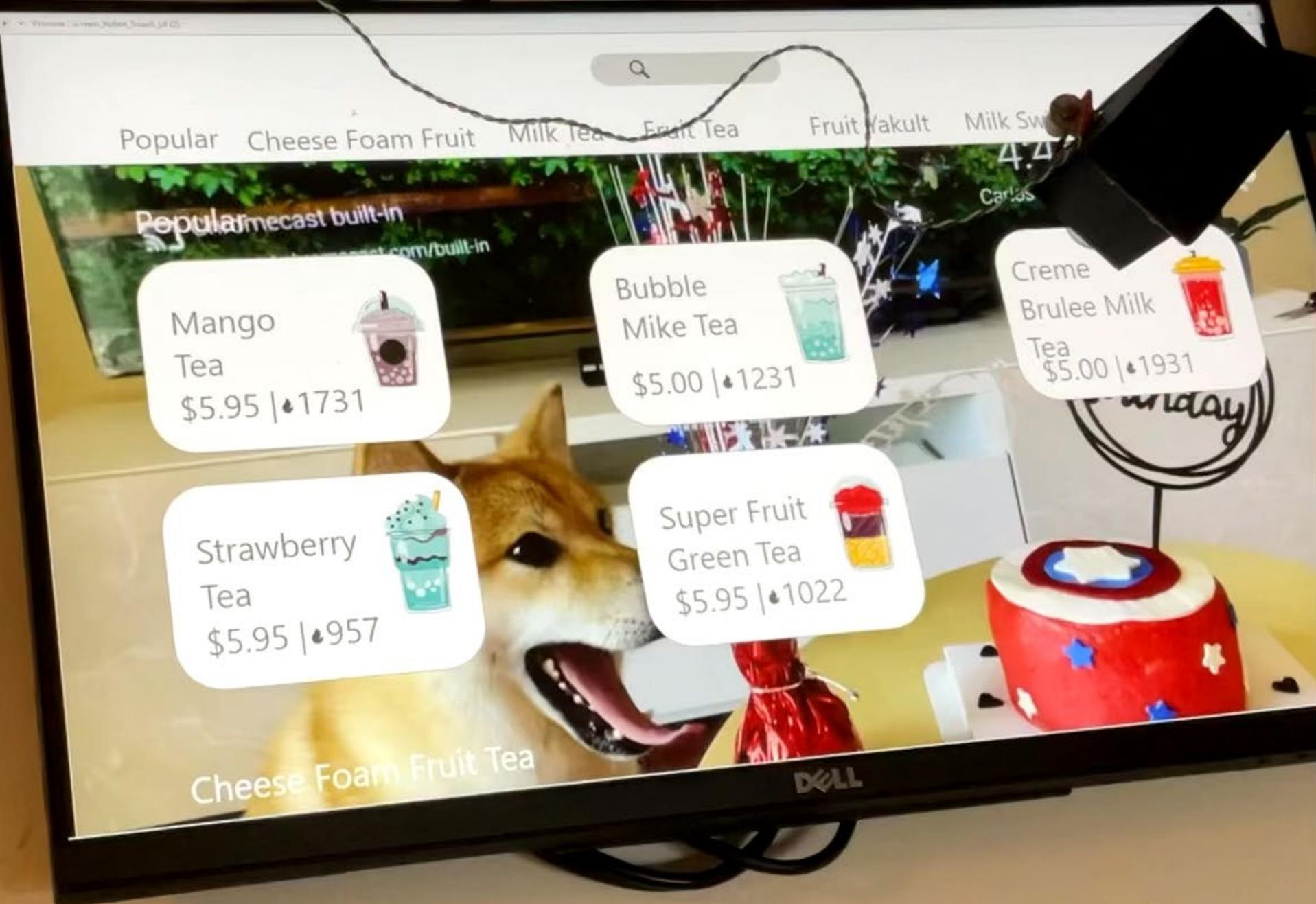


We have seen touchscreen devices almost everywhere nowadays replacing physical buttons



What can we do
for people who
cannot benefit
from it?

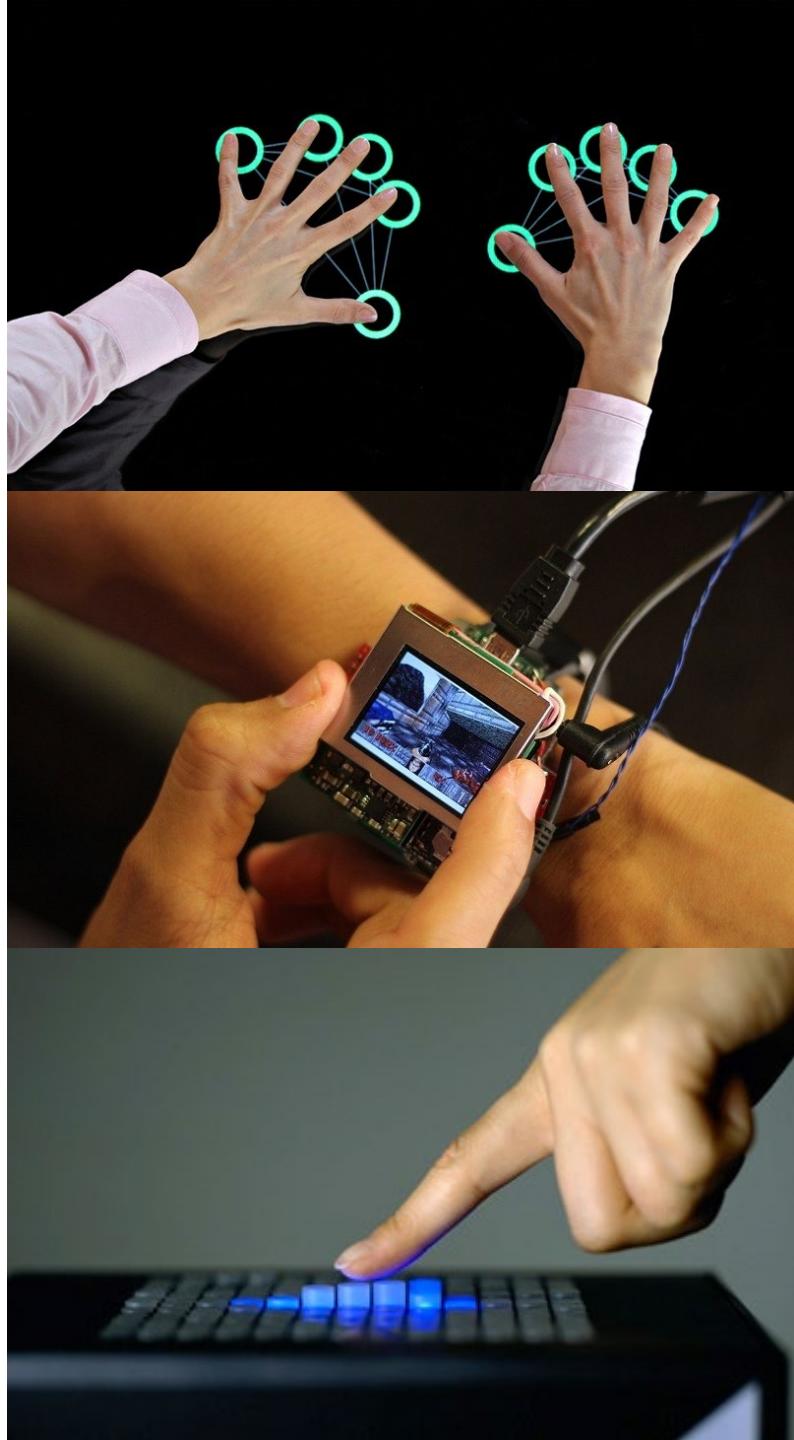




Learn

- Varies interactive technologies
- Technologies behind the scene

Wed: Milestone 1 presentation



Optional readings

DiamondTouch: A Multi-User Touch Technology

Paul Dietz and Darren Leigh
Mitsubishi Electric Research Laboratories
201 Broadway
Cambridge, MA 02139 USA
+1-617-621-7500
{dietz,leigh}@merl.com

ABSTRACT

A technique for creating a touch-sensitive input device is proposed which allows multiple, simultaneous users to interact in an intuitive fashion. Touch location information is determined independently for each user, allowing each touch on a common surface to be associated with a particular user. The surface generates location dependent, modulated electric fields which are capacitively coupled through the users to receivers installed in the work environment. We describe the design of these systems and their applications. Finally, we present results we have obtained with a small prototype device.

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INTRODUCTION

DiamondTouch is a multi-user touch technology for tabletop front-projected displays. It enables several different people to use the same touch-surface simultaneously without interfering with each other, or being affected by foreign objects. It also allows the computer to identify which person is touching where.

During the course of research on Human-Guided Simple Search [1] some of our colleagues have constructed a collaborative workspace in which multiple users work on the same data set. The environment consists of a ceiling-mounted video projector displaying onto a white table around which the users sit. A single wireless mouse is passed around as different users take the initiative. Our colleagues proposed that the collaboration would be improved if the users could independently and simultaneously interact with the table, and considered using multiple mice.

The use of multiple mice in a collaborative environment is particularly problematic. It can be challenging for users to keep track of one pointer on a large surface with lots of activity.

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UIST '01 Orlando FLA

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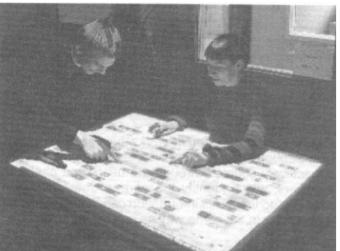


Figure 1: The collaborative work environment for Human-Guided Simple Search.

ity. Keeping track of many mice is nearly impossible. This leaves users physically pointing at their virtual pointers to tell other users where they are. Also, relying on a separate physical device keeps us from utilizing the natural human tendencies of reaching, touching and grasping.¹

Using a large touch-screen as the table surface would seem to be an answer, but existing touch technologies were inadequate. Most allow only a single touch and do not identify users. While schemes have been developed where users take turns [3], we wanted the interaction to be simultaneous and spontaneous.

Unlike electronic whiteboards or other vertical touch systems, the tabletop nature of our display creates a problem: people tend to put things on tables. With a pressure-sensitive surface, foreign objects create spurious touch-points causing single touch systems to malfunction.

Optimally, we would like a multi-user touch surface to have the following characteristics:

¹Plus see the discussion in [2] for advantages of touch interfaces.

UIST 2001

Dietz et.al.

StateLens: A Reverse Engineering Solution for Making Existing Dynamic Touchscreens Accessible

Anhong Guo, Junhan Kong, Michael Rivera, Frank F. Xu, Jeffrey P. Bigham
Human-Computer Interaction Institute, Carnegie Mellon University, Pittsburgh, PA, USA
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ABSTRACT

Blind people frequently encounter inaccessible dynamic touchscreens in their everyday lives that are difficult, frustrating, and often impossible to use independently. Touchscreens are often the only way to control everything from coffee machines and payment terminals, to subway ticket machines and in-flight entertainment systems. Interacting with dynamic touchscreens is difficult non-visually because the visual user interfaces change, interactions often occur over multiple different screens, and it is easy to accidentally trigger interface actions while exploring the screen. To solve these problems, we introduce *StateLens* — a three-part reverse engineering solution that makes existing dynamic touchscreens accessible. First, StateLens reverse engineers the underlying state diagrams of existing interfaces using point-of-view videos found online or taken by users using a hybrid crowd-computer vision pipeline. Second, using the state diagrams, StateLens automatically generates conversational agents to guide blind users through specifying the tasks that the interface can perform, allowing the StateLens iOS application to provide interactive guidance and feedback so that blind users can access the interface. Finally, a set of 3D-printed accessories enable blind people to explore capacitive touchscreens without the risk of triggering accidental touches on the interface. Our technical evaluation shows that StateLens can accurately reconstruct interfaces from stationary, hand-held, and web videos; and, a user study of the complete system demonstrates that StateLens successfully enables blind users to access otherwise inaccessible dynamic touchscreens.

Author Keywords

Reverse engineering; dynamic interfaces; touchscreen appliances; accessibility; crowdsourcing; computer vision; conversational agents.

CCS Concepts

•Human-centered computing → Interactive systems and tools; Accessibility technologies;

INTRODUCTION

Inaccessible touchscreen interfaces in the world represent a long-standing and frustrating problem for people who are

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Figure 1. StateLens is a system that enables blind users to interact with touchscreen devices in the real world by (i) reverse engineering a structured model of the underlying interface, and (ii) using the model to provide interactive conversational and audio guidance to the user about how to use it. A set of 3D-printed accessories enable capacitive touchscreens to be used non-visually by preventing accidental touches on the interface.

blind. Imagine sitting down for a 12-hour flight only to realize that the entertainment center on the seatback in front of you can only be controlled by its inaccessible touchscreen; imagine checking out at the grocery store and being required to tell the cashier your pin number out loud because the checkout kiosk is an inaccessible touchscreen; and, imagine not being able to independently make yourself a coffee at your workplace because the fancy new coffee machine is controlled only by an inaccessible touchscreen. Such frustrating accessibility problems are commonplace and pervasive.

Making touchscreen interfaces accessible has been a long-standing challenge in accessibility [14, 17, 30], and some current platforms are quite accessible (e.g., iOS). Solving all of the challenges represented by the combination of difficult issues for public touchscreen devices has remained elusive: (i) touchscreens are inherently visual so a blind person cannot read what they say or identify user interface components, (ii) a blind person cannot touch the touchscreen to explore without the risk of accidentally triggering something they did not intend, and, (iii) a blind person does not have the option to choose a different touchscreen platform that would be more accessible and cannot get access to the software or hardware to make it work better. This paper is about enabling blind people to use the touchscreens they encounter *in-the-wild*, despite the fact that nothing about how these systems are designed is intended for their use.

Most prior work on making touchscreens accessible has assumed access to change or add to the touchscreen hardware or software. For example, physical buttons were added to the

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5 Pong 3d
Project statement: you want to play little soccer ball and you have nobody to play with.
Solution: Pongbot, the robot that plays pong.

6 Main challenges/solutions

- Need force to project the ball back at the player
Use compression spring and electromagnet system on paddle
- Moving the paddle to hit the ball
Use two stepper motors to move each device in 90°

7 How

- Camera detects ball's position
- Simple image processing predicts trajectory
- Adjust paddle position based on trajectory

Since motor can only horizontal, movement of paddle through while code
is running is controlled by the pulses tells it what to do

Group 1

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Link can be found on Piazza