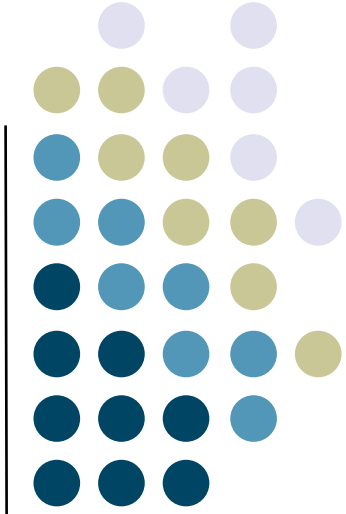
Touch Hardware: How Do Modern Touchscreens Work?



(Material originally from Craig Tashman)

Intro

- Why the focus on **touchscreen** hardware rather than **pens?**

- Unlike pens, can't rely in anything in the "stylus" (unless we get implants in our fingers)
  - Hardware must work with normal human touch, not assume anything fancy going on.
- Plus, at the hardware level, multitouch is very different than pen technology
  - And that's where the action is these days

Two kinds

Single Touch

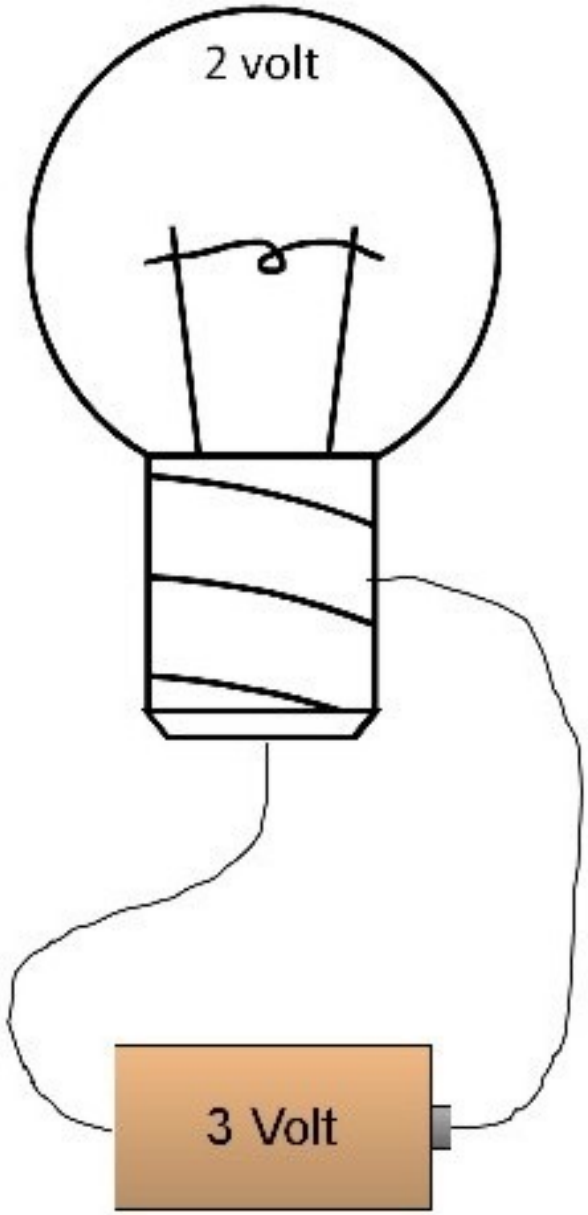
Multitouch

http://www.apple.com/iphone/
http://articles.businessinsider.com/2009-10-21/wall_street/30101529_1_citi-lowcards-com-default-rates

OLD SCHOOL

Single Touch

- Resistive
- Capacitive
- Ultrasonic
- IR Grid



- Resistive
- Capacitive
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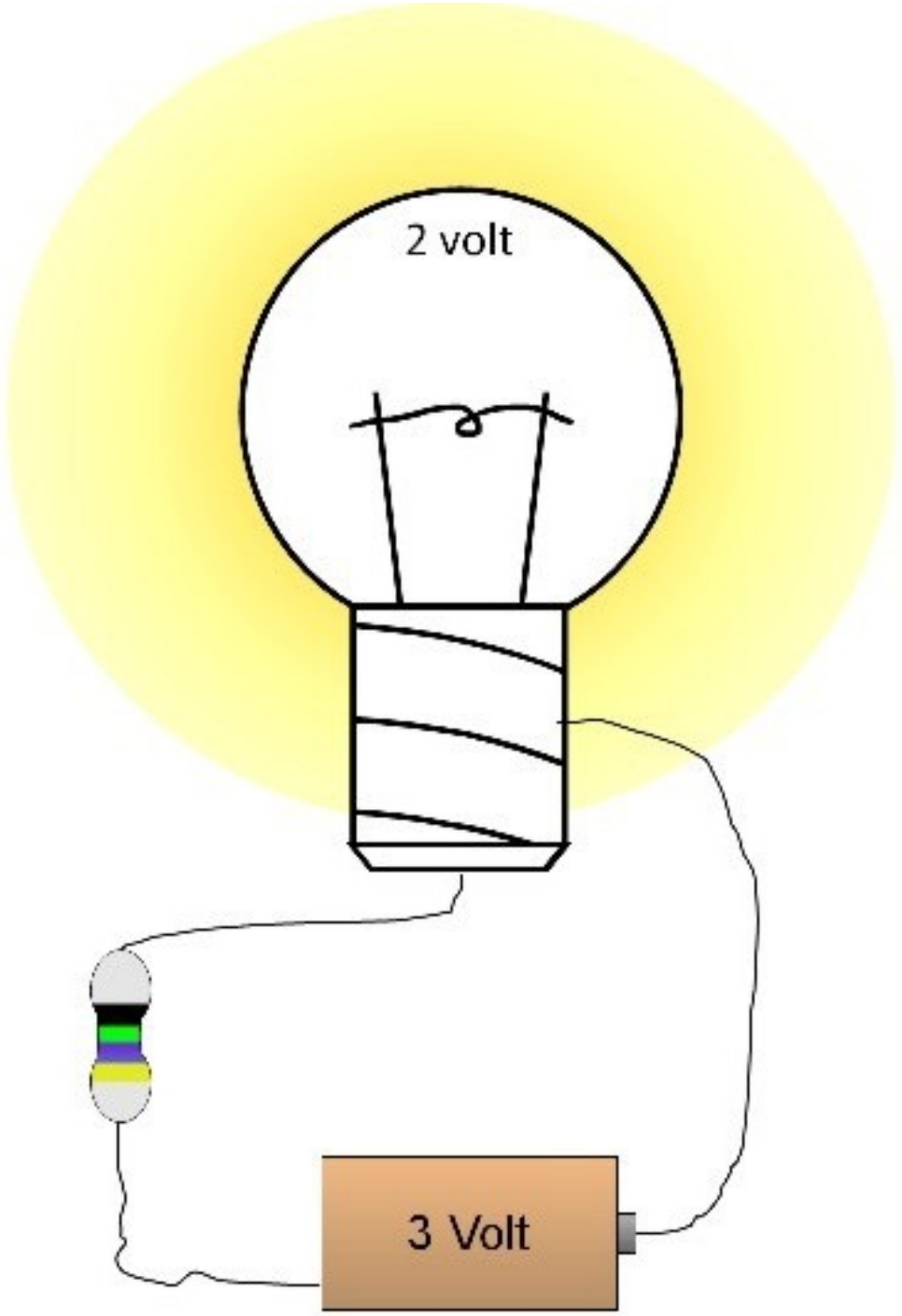

- Resistive
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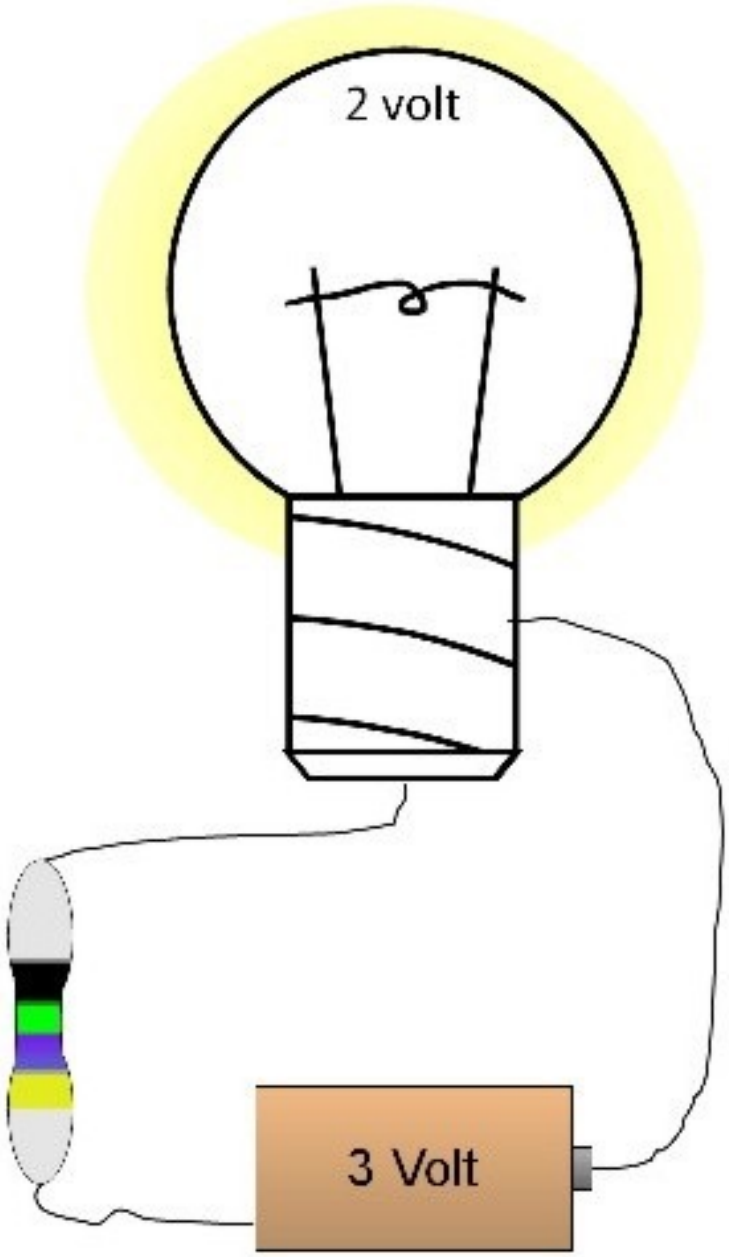


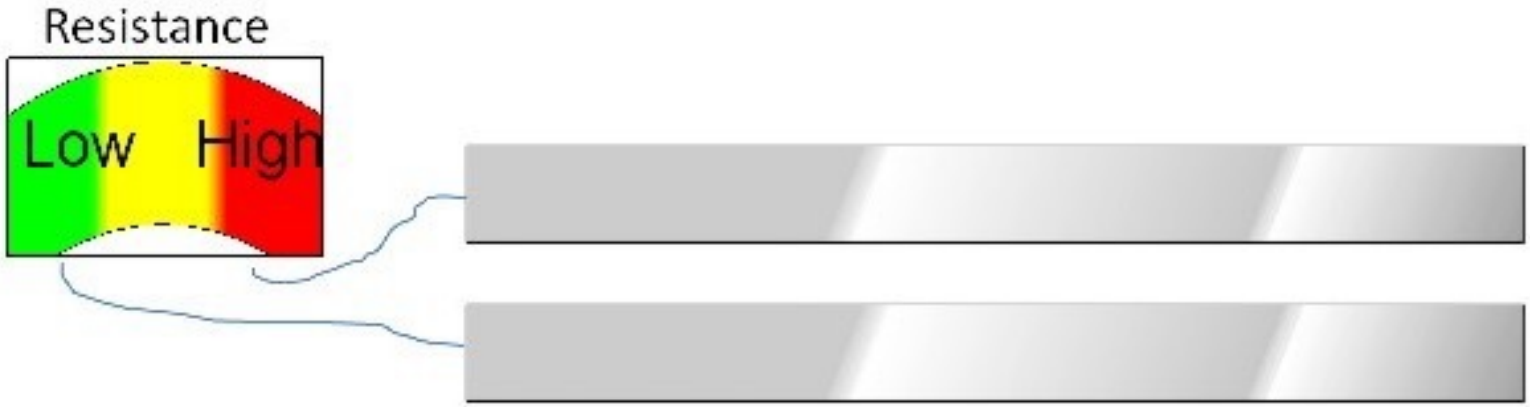
Resistive

Capacitive

Ultrasonic

IR Grid

1-D Touch Sensing



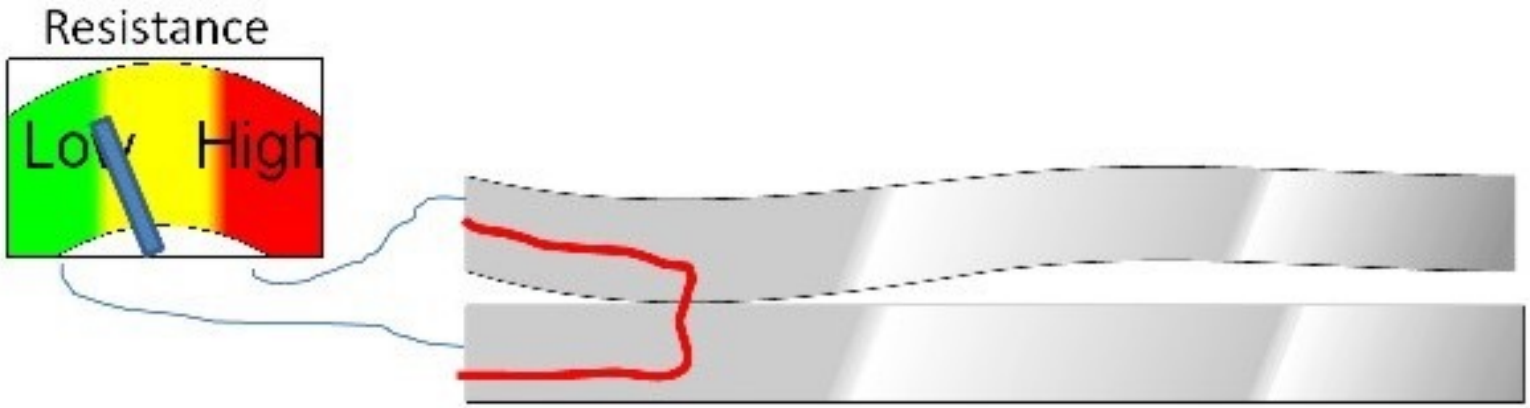
Resistive

Capacitive

Ultrasonic

IR Grid

1-D Touch Sensing



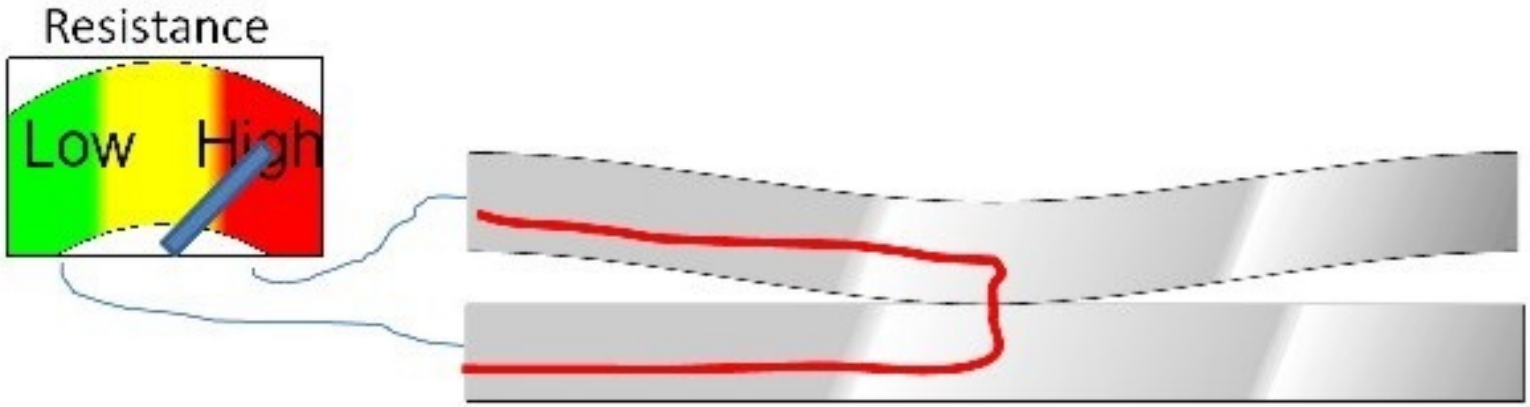
Resistive

Capacitive

Ultrasonic

IR Grid

1-D Touch Sensing



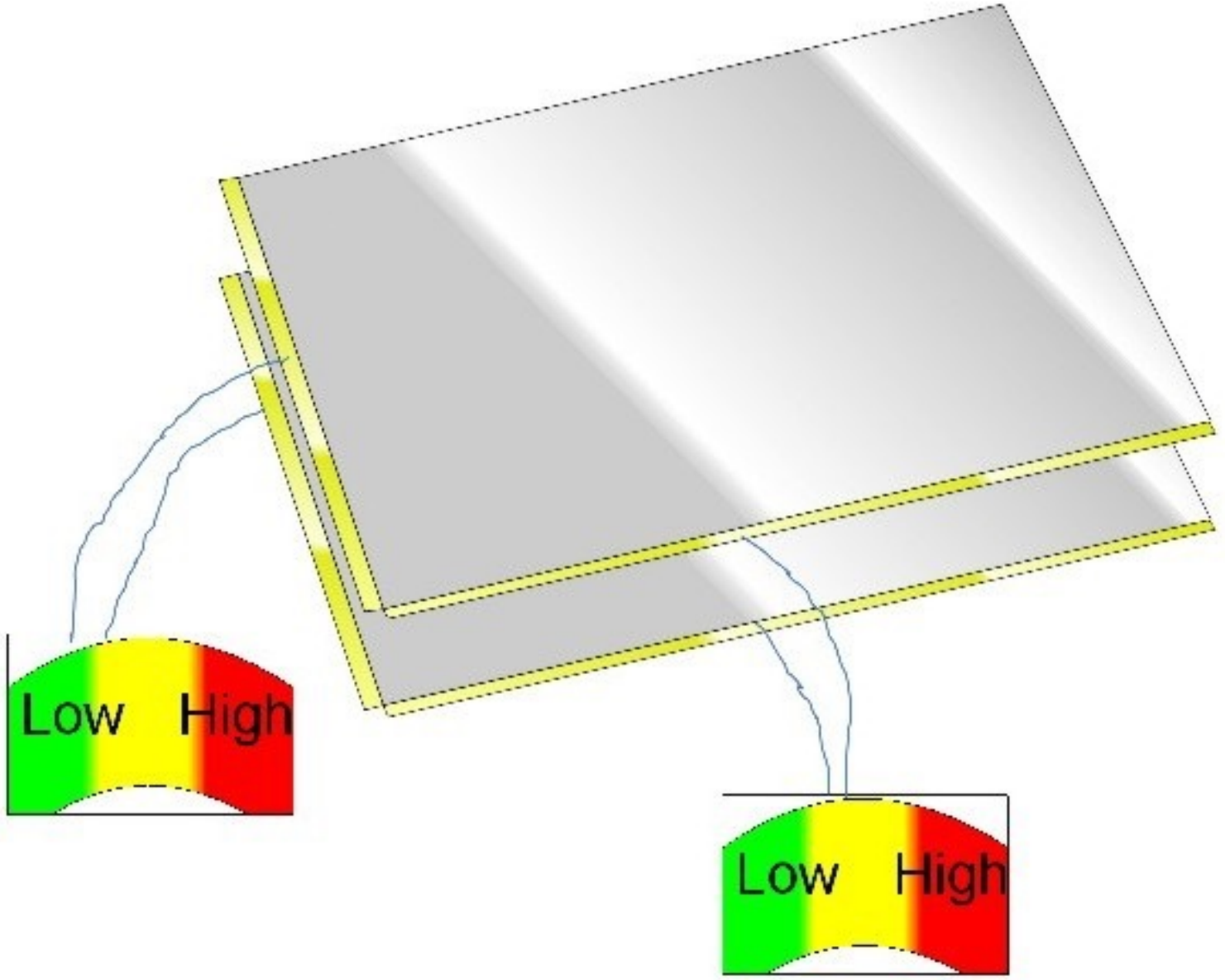
Resistive

Capacitive

Ultrasonic

IR Grid

2-D Touch Sensing



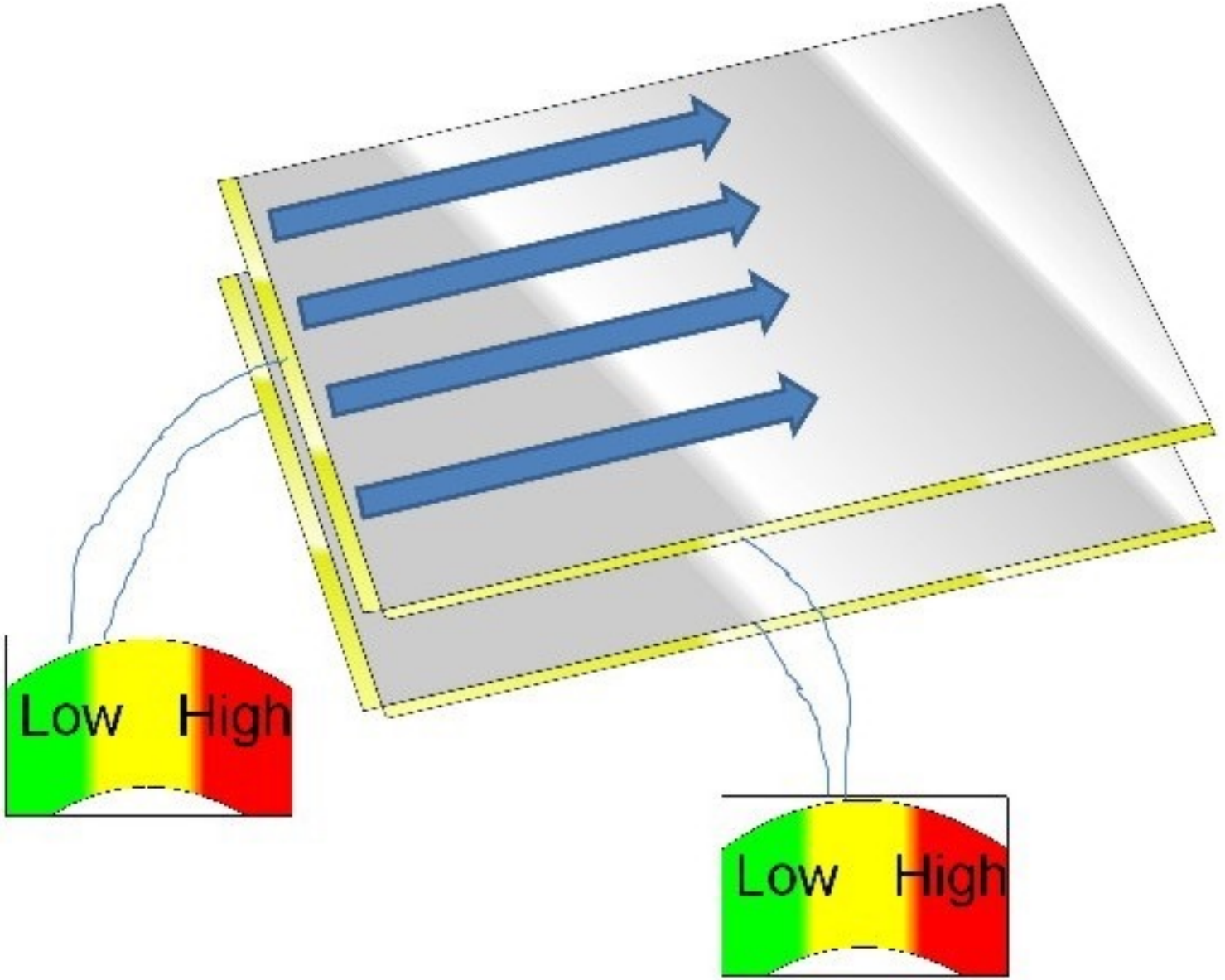
Resistive

Capacitive

Ultrasonic

IR Grid

2-D Touch Sensing



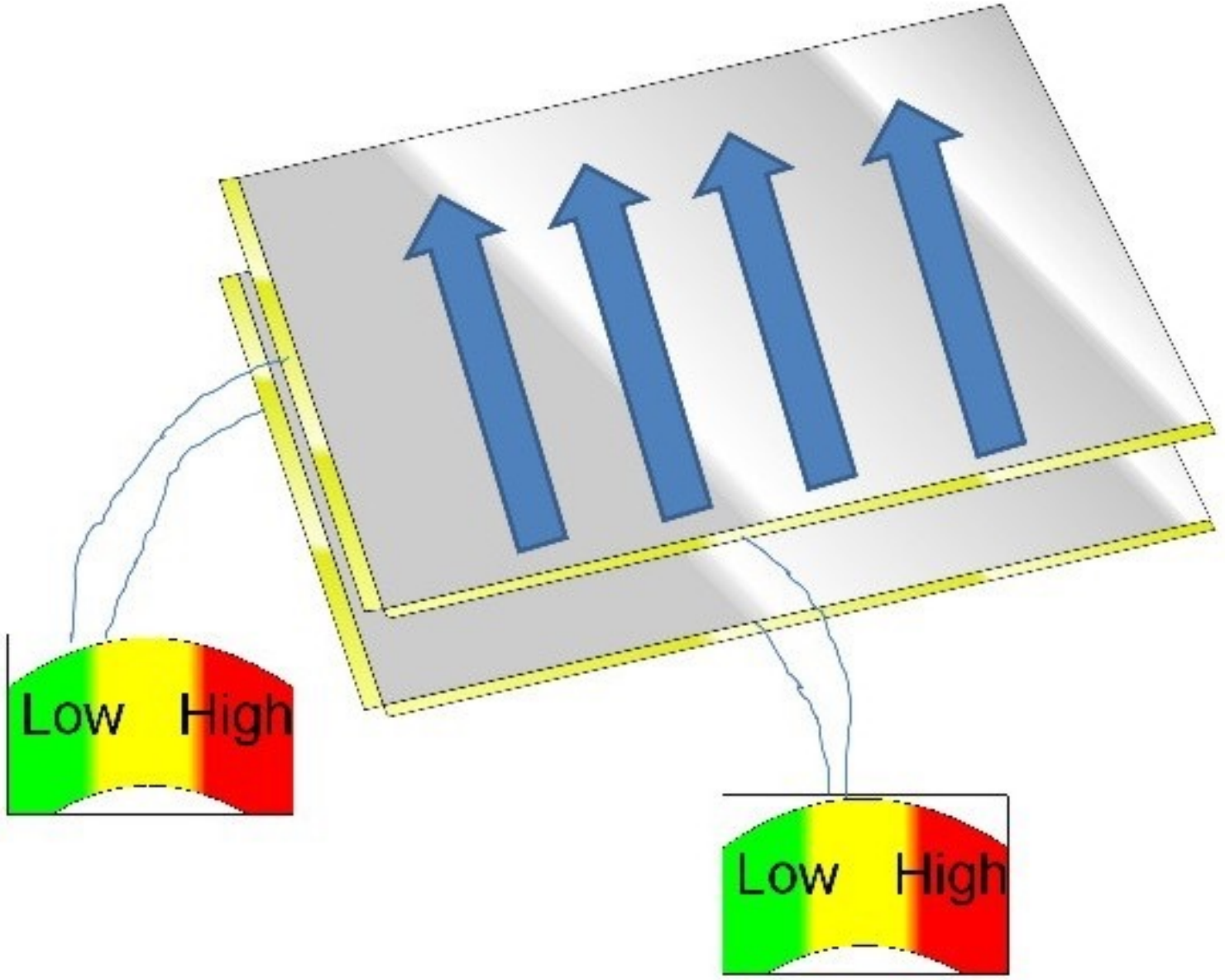
Resistive

Capacitive

Ultrasonic

IR Grid

2-D Touch Sensing



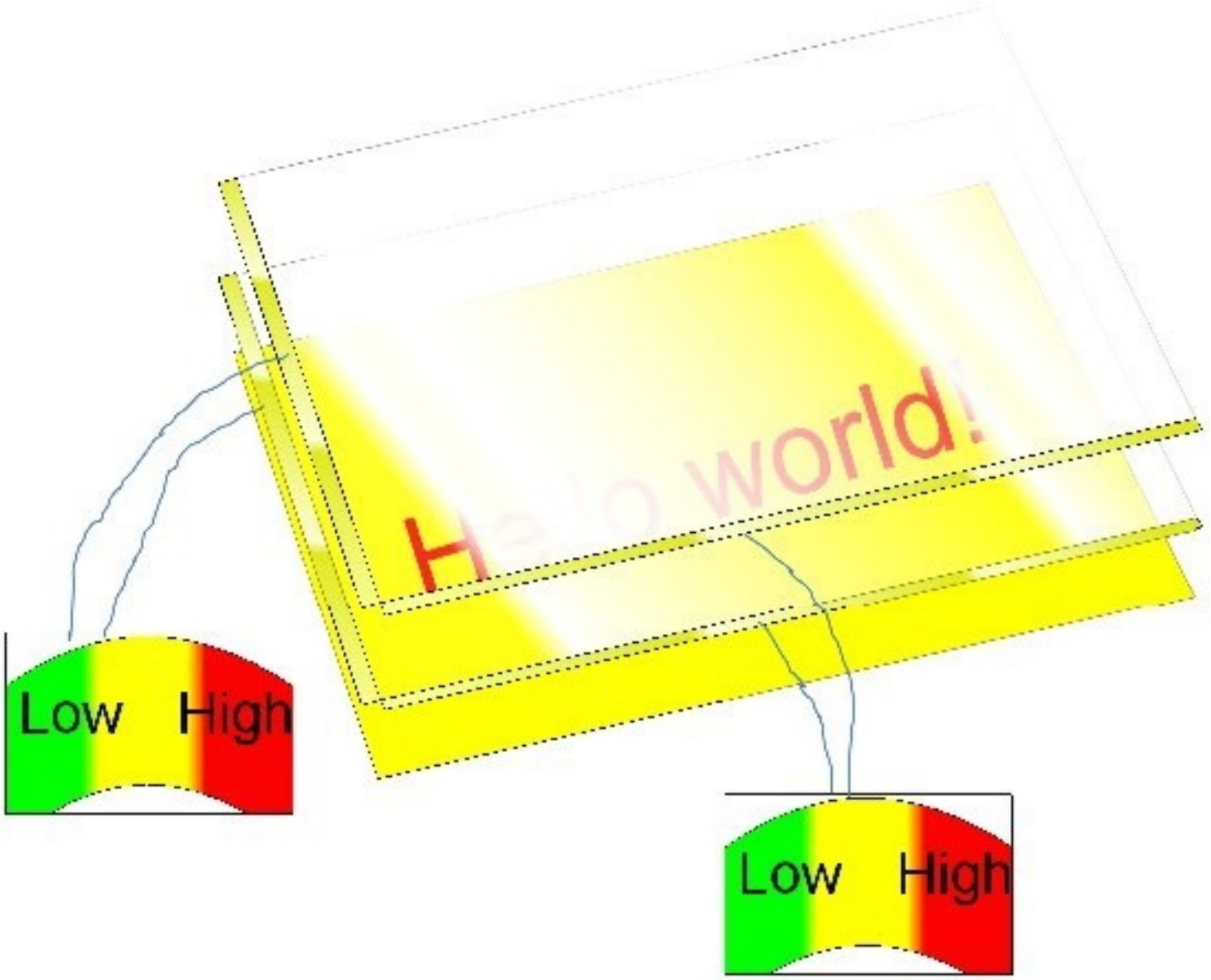
Resistive

Capacitive

Ultrasonic

IR Grid

2-D Touch Sensing



- Resistive
- Capacitive
- Ultrasonic
- IR Grid

The Good:

Reasonable precision.
Can sense any object!

The Bad:

Can sense any object!
Mechanical wear.
Drift.
Easy to scratch.
Blocks a lot of light (~25%)

Resistive

Capacitive

Ultrasonic

IR Grid

Surface Capacitive

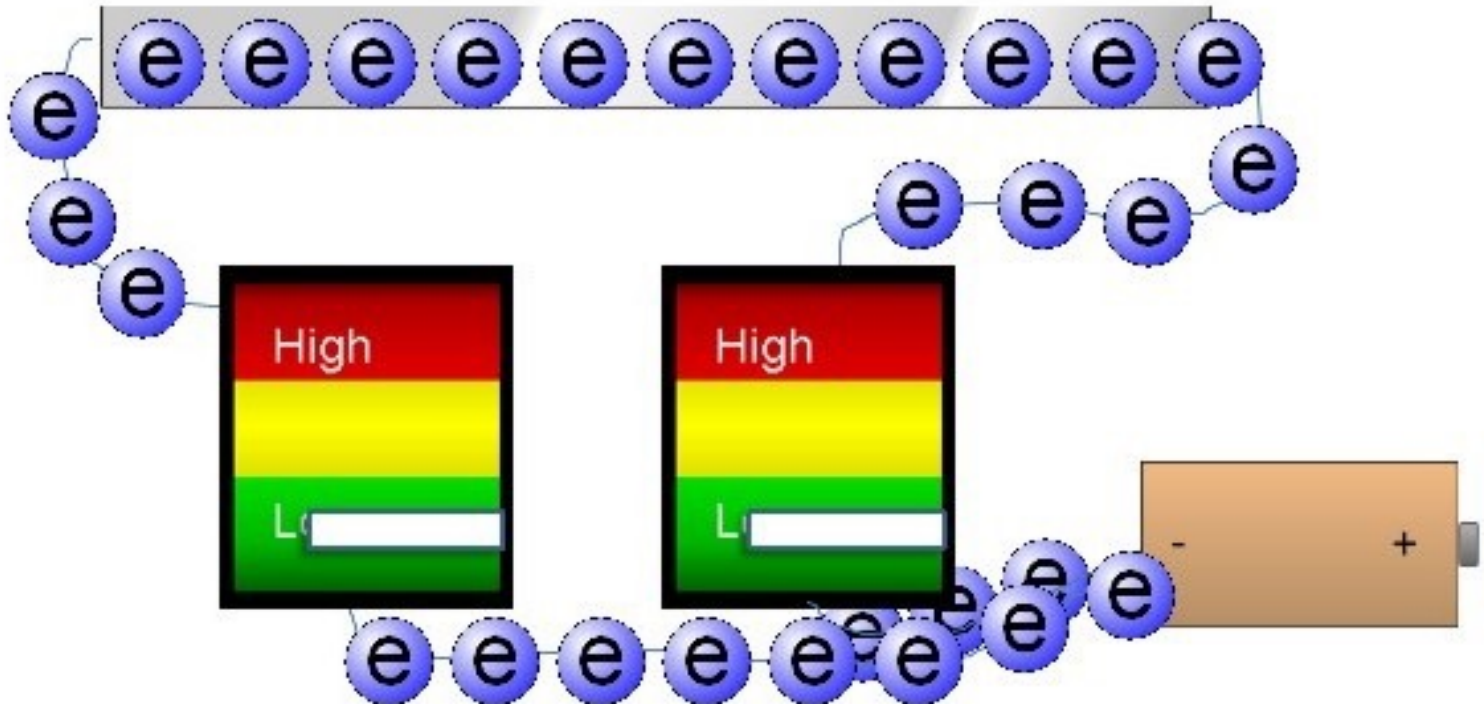
Resistive

Capacitive

Ultrasonic

IR Grid

Surface Capacitive



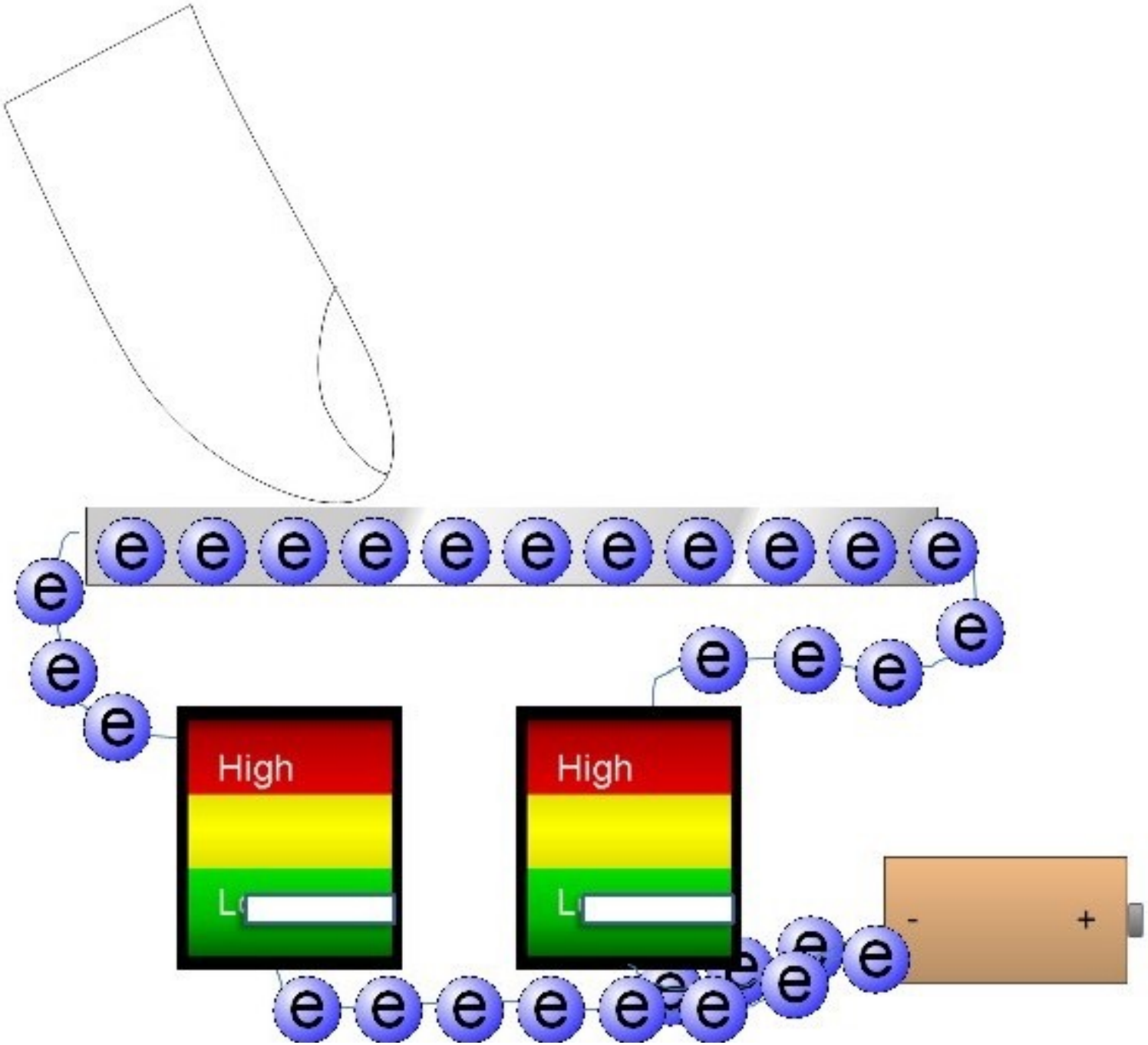
Resistive

Capacitive

Ultrasonic

IR Grid

Surface Capacitive



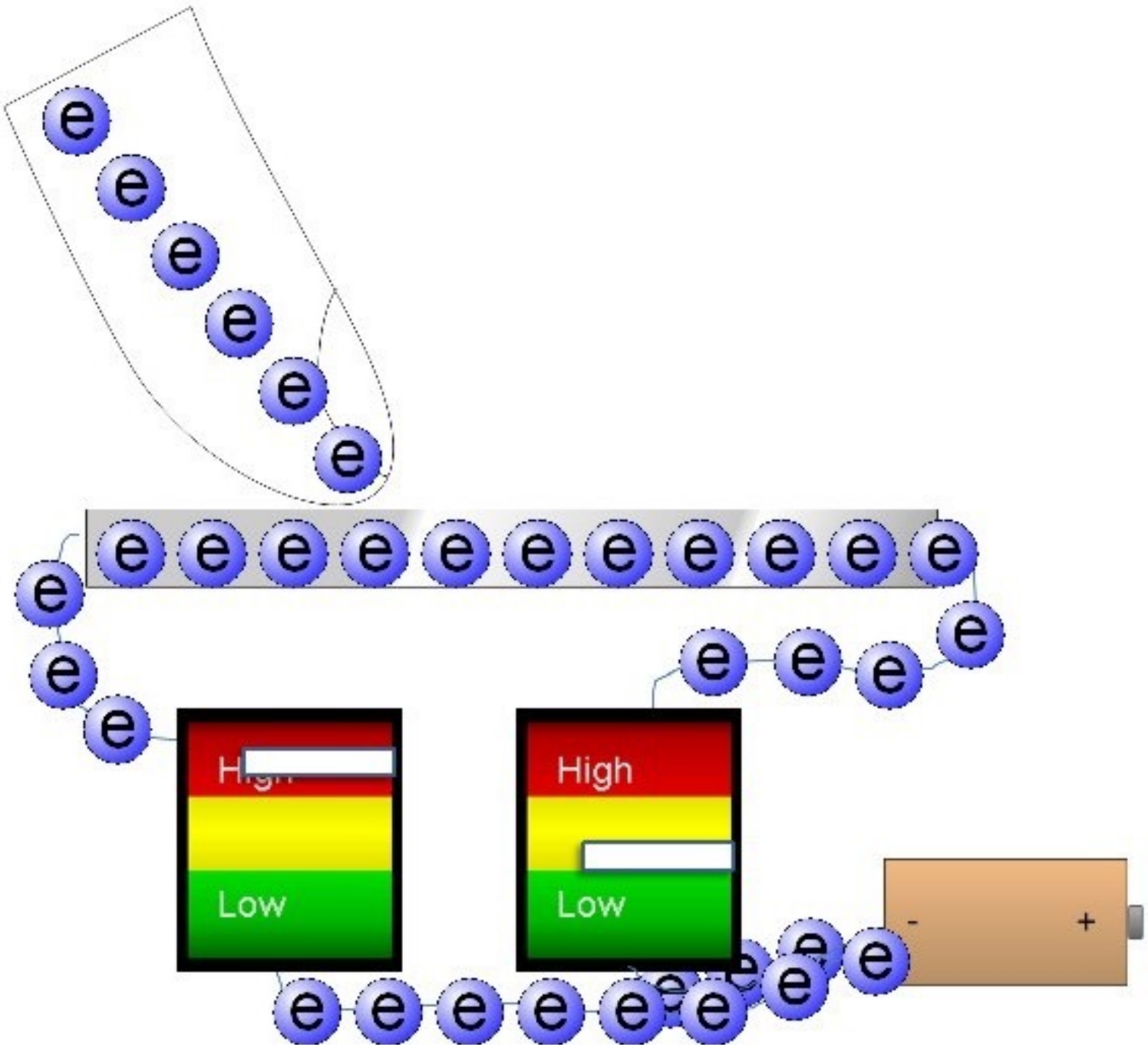
Resistive

Capacitive

Ultrasonic

IR Grid

Surface Capacitive



Resistive

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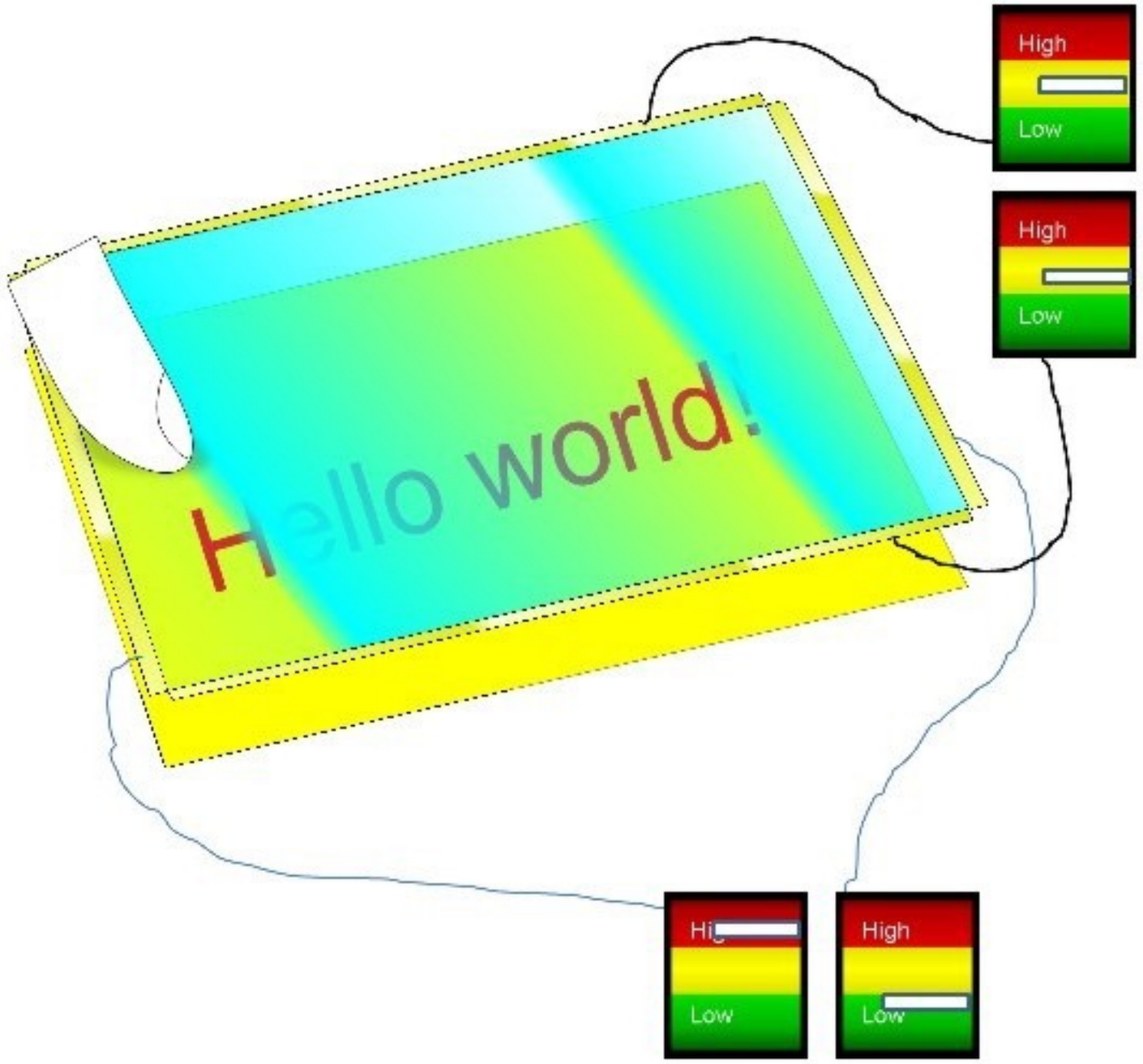
Surface Capacitive



Resistive

Capacitive

Ultrasonic

IR Grid

Surface Capacitive

The Good:

Transmits lots of light (85%-90%).
Very durable.

The Bad:

Can only sense certain (relatively conductive) objects.
Mediocre accuracy (~1.5%).
Must be really well shielded.

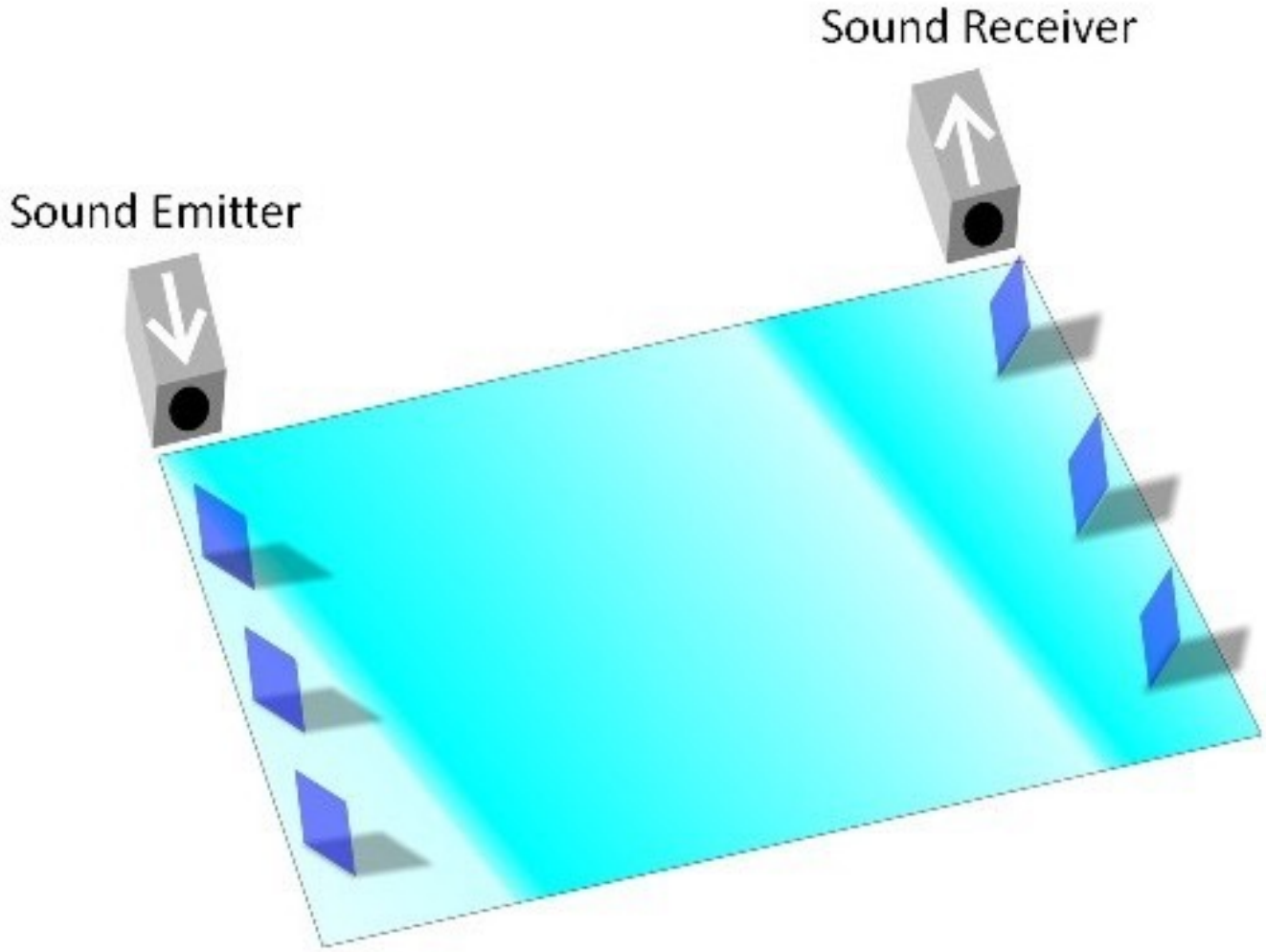
Resistive

Capacitive

Ultrasonic

IR Grid

Surface Acoustic Wave



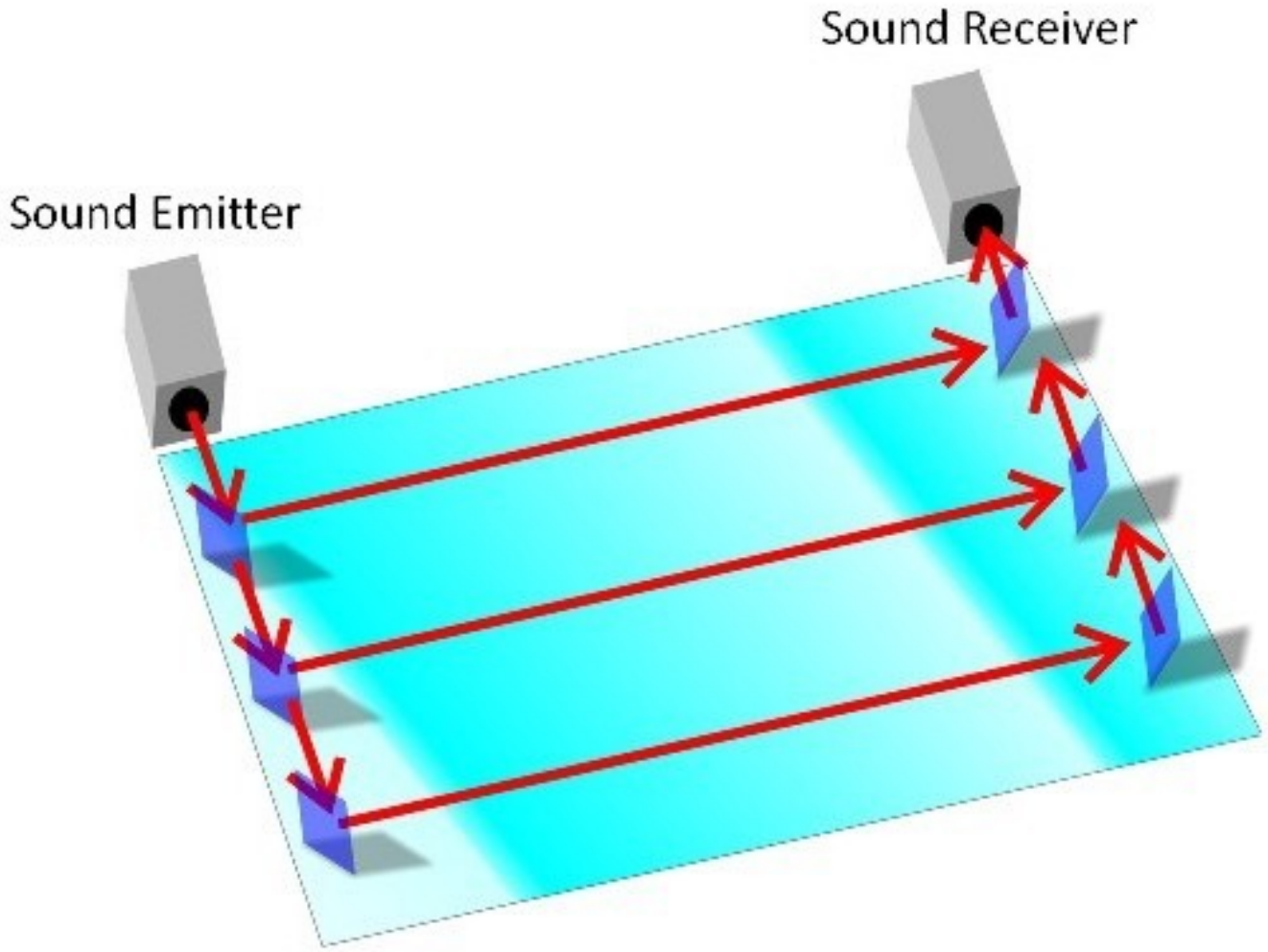
Resistive

Capacitive

Ultrasonic

IR Grid

Surface Acoustic Wave



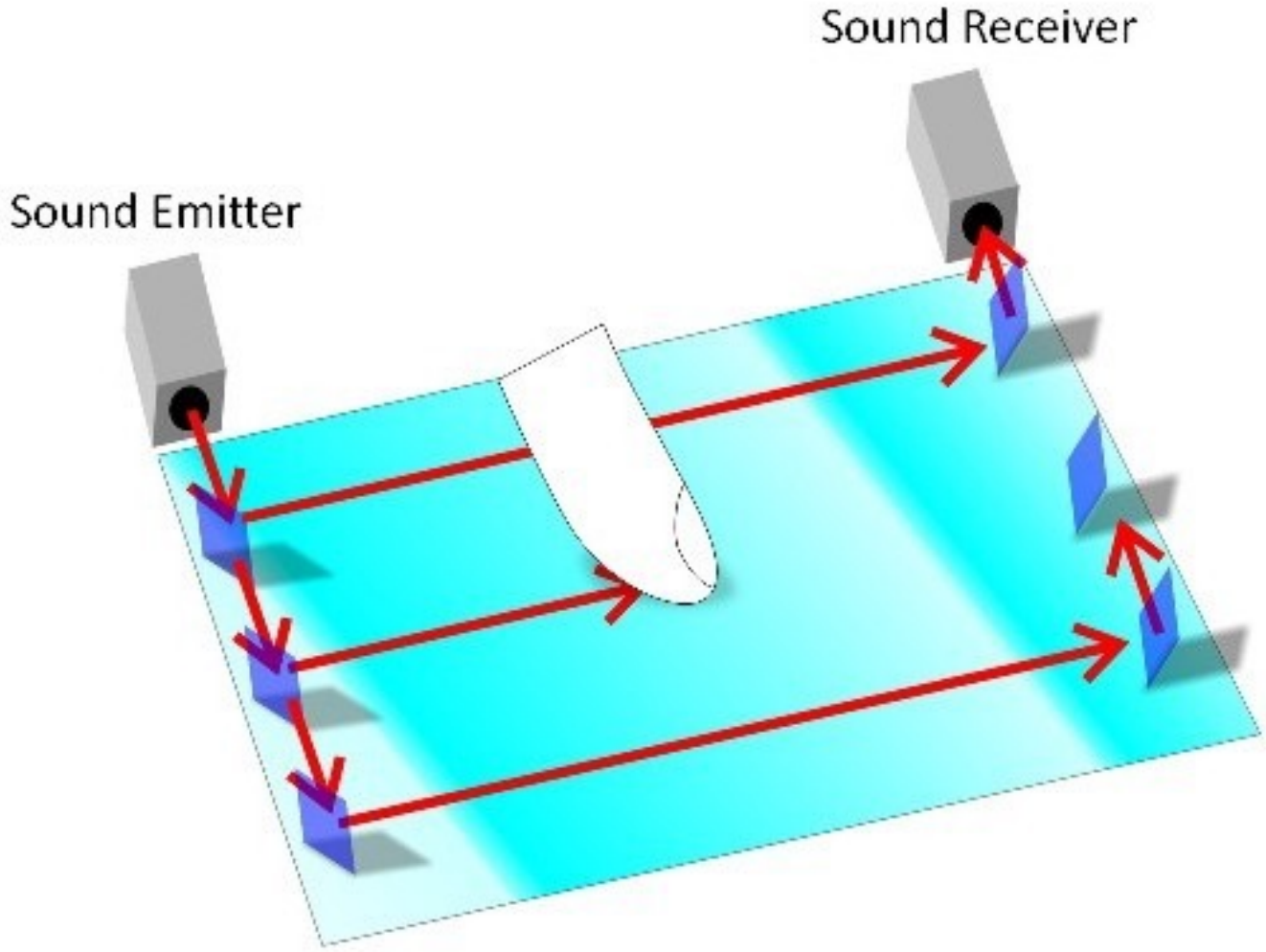
Resistive

Capacitive

Ultrasonic

IR Grid

Surface Acoustic Wave



Resistive

Capacitive

Ultrasonic

IR Grid

Surface Acoustic Wave

The Good:

Need not absorb any light!
Very durable—just a piece of glass!
Can sense any object!
Not sensitive to electrical noise.

The Bad:

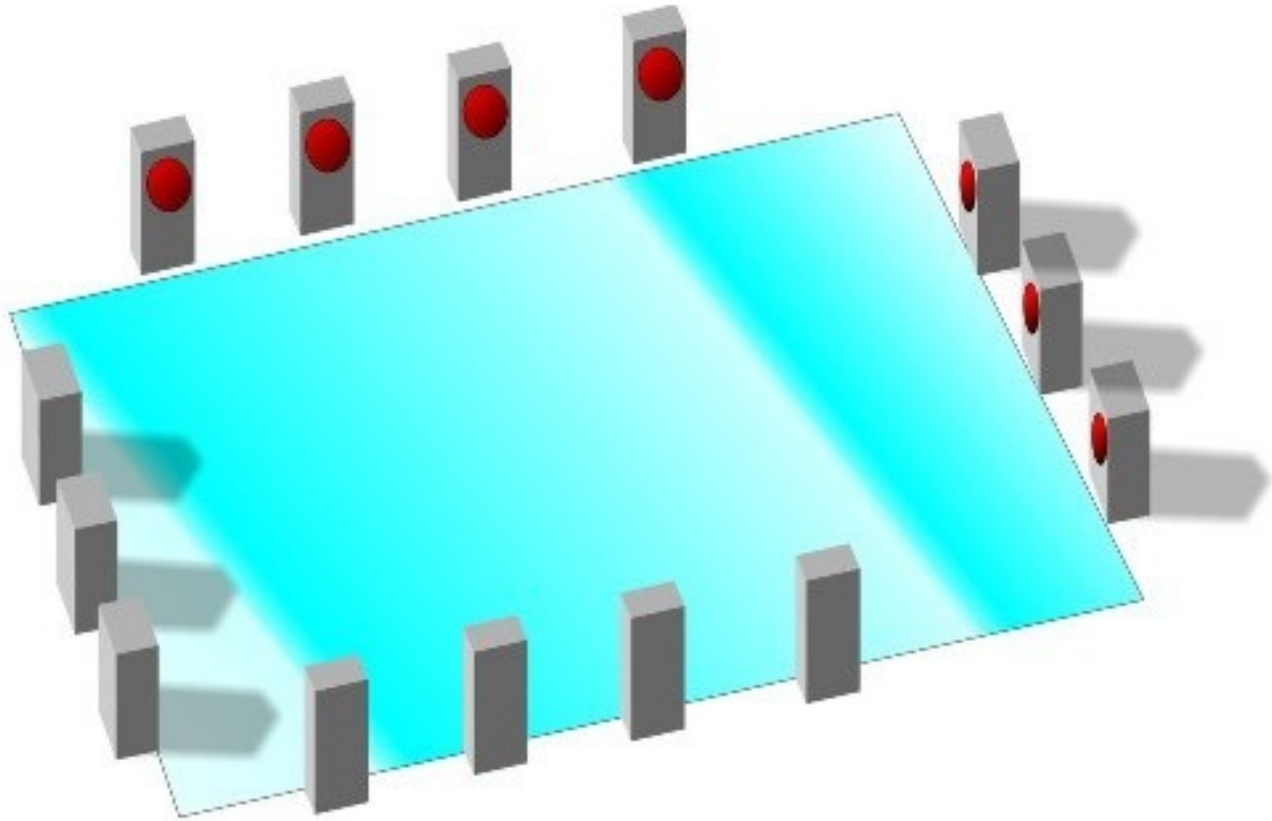
Dirt on screen can confuse it.
Can be hard to seal.
Mediocre accuracy (~1%).
Doesn't detect contact per se.

Resistive

Capacitive

Ultrasonic

IR Grid



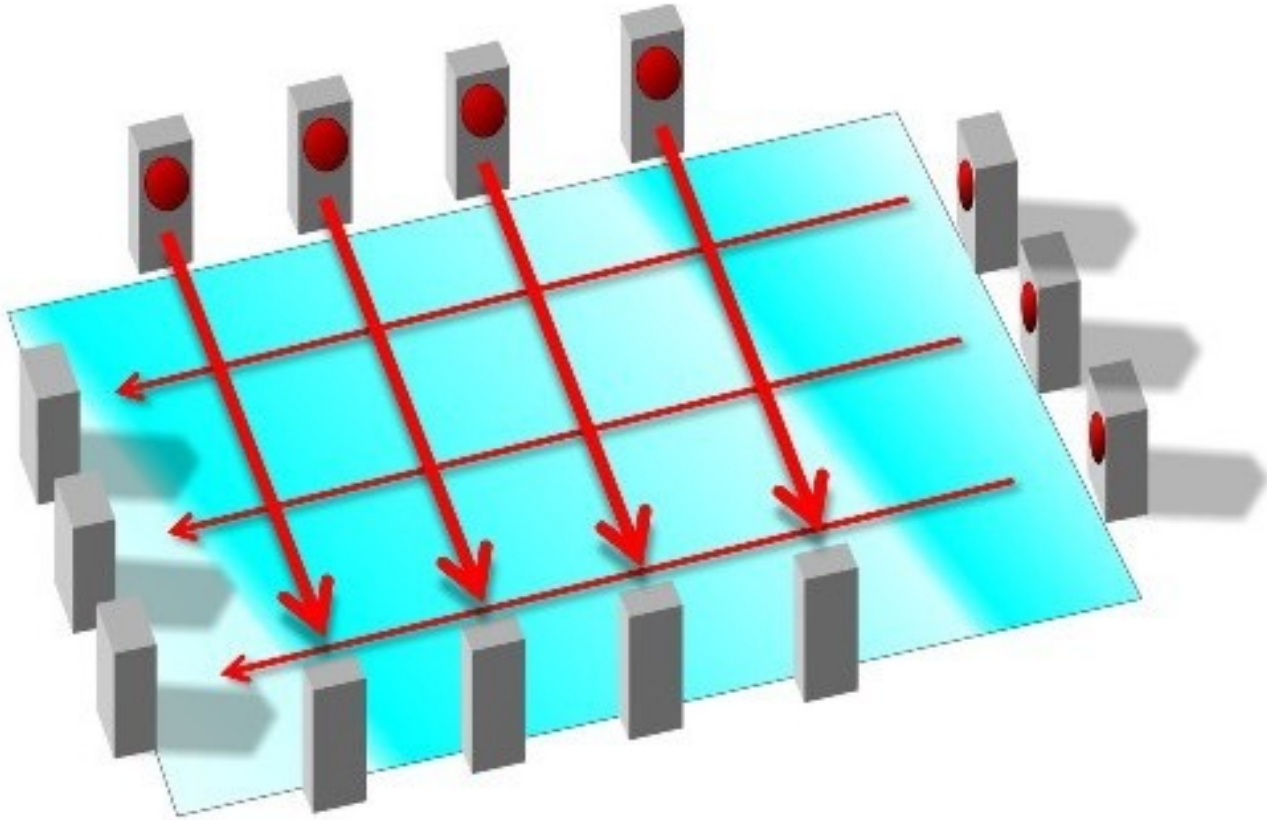
IR emitters on **top** and **right**, receivers on **bottom** and **left**

Resistive

Capacitive

Ultrasonic

IR Grid



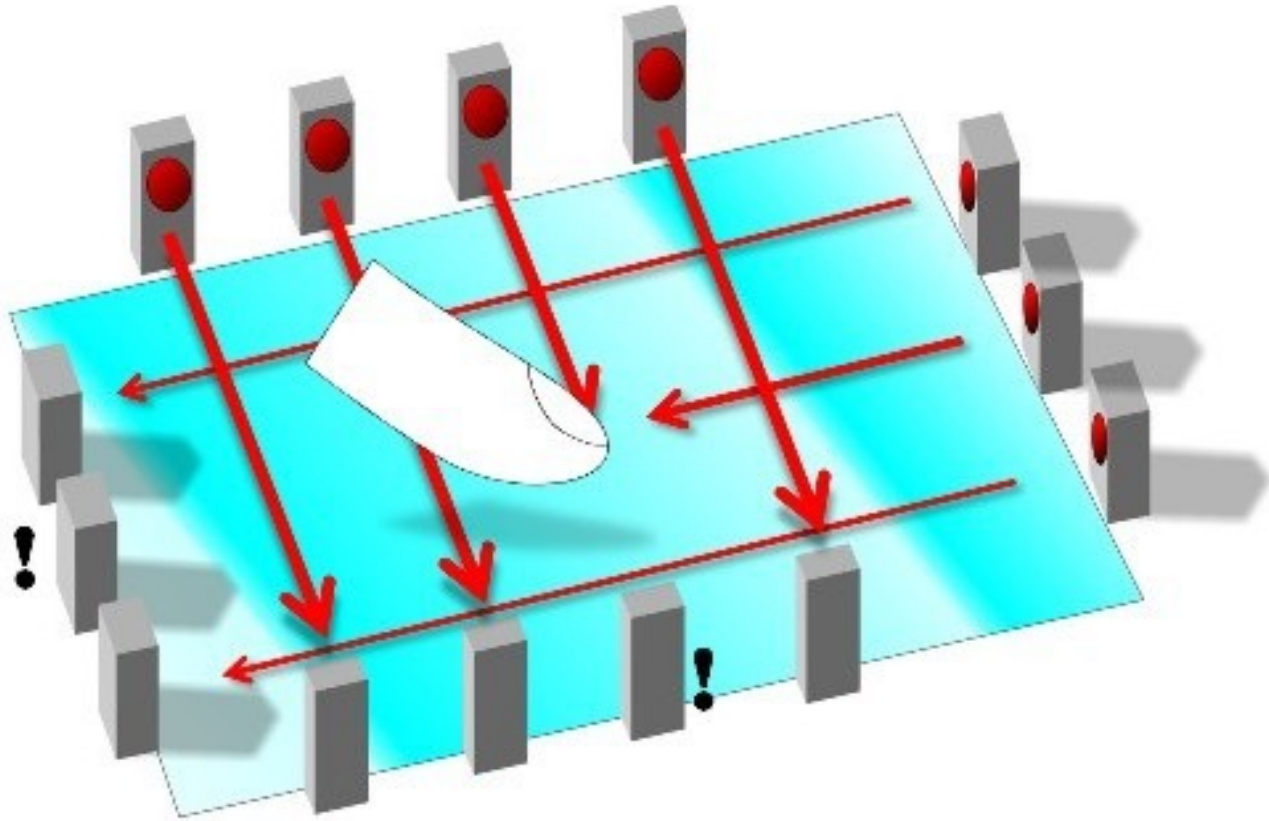
IR emitters on **top** and **right**, receivers on **bottom** and **left**

Resistive

Capacitive

Ultrasonic

IR Grid



IR emitters on **top** and **right**, receivers on **bottom** and **left**

Resistive

Capacitive

Ultrasonic

IR Grid

Corner IR

The Good:

Need not absorb any light!
Very durable—just a piece of glass!
Can sense any object!
Not sensitive to electrical noise.
Simple.

The Bad:

Very limited resolution.
Again, senses any object.
Doesn't sense contact per se.

Resistive

Capacitive

Ultrasonic

IR Grid

Corner IR

IR Emitters along the sides

Resistive

Capacitive

Ultrasonic

IR Grid

Corner IR

IR Emitters along the sides

IR cameras at the corners

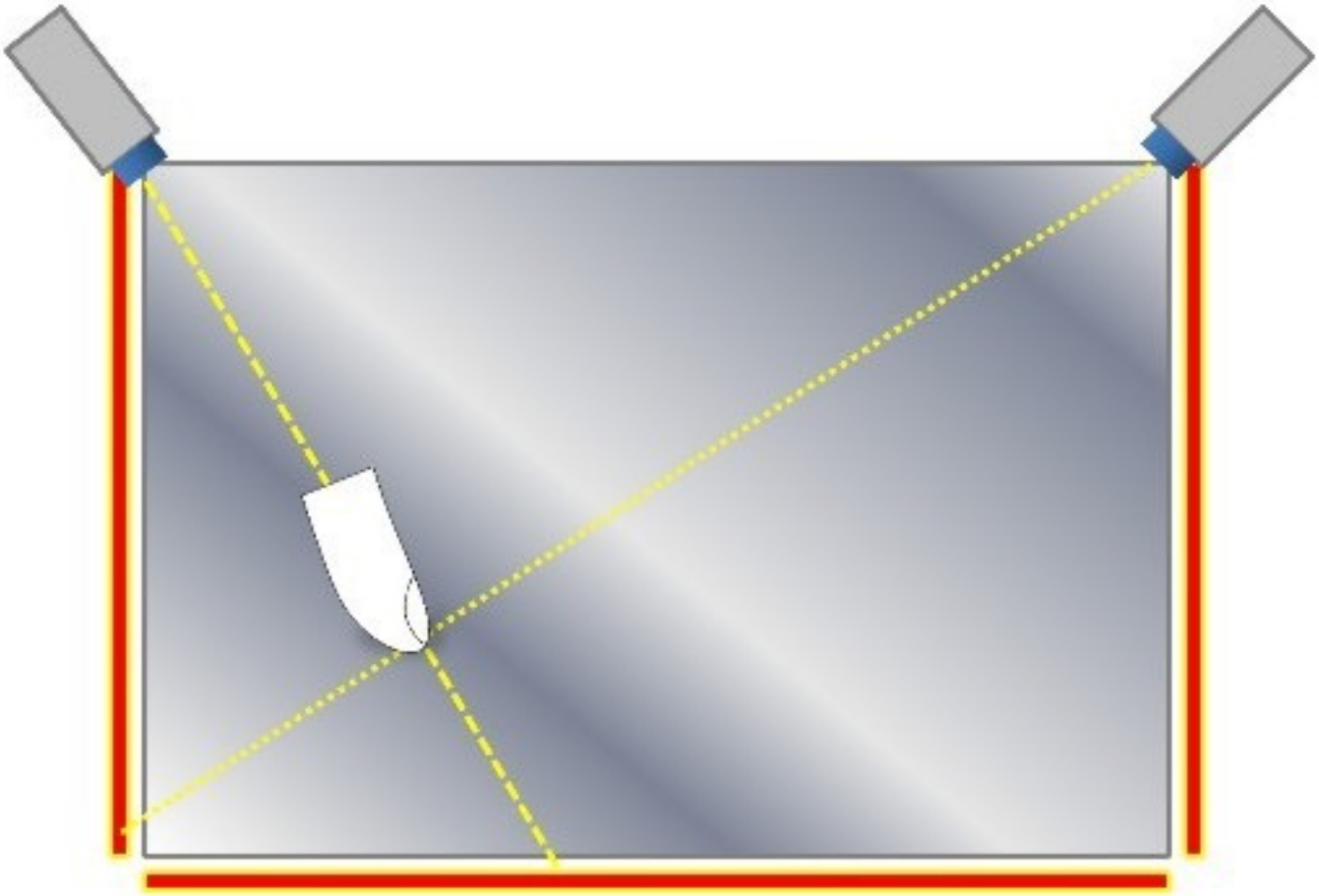
Resistive

Capacitive

Ultrasonic

IR Grid

Corner IR



IR Emitters along the sides

IR cameras at the corners

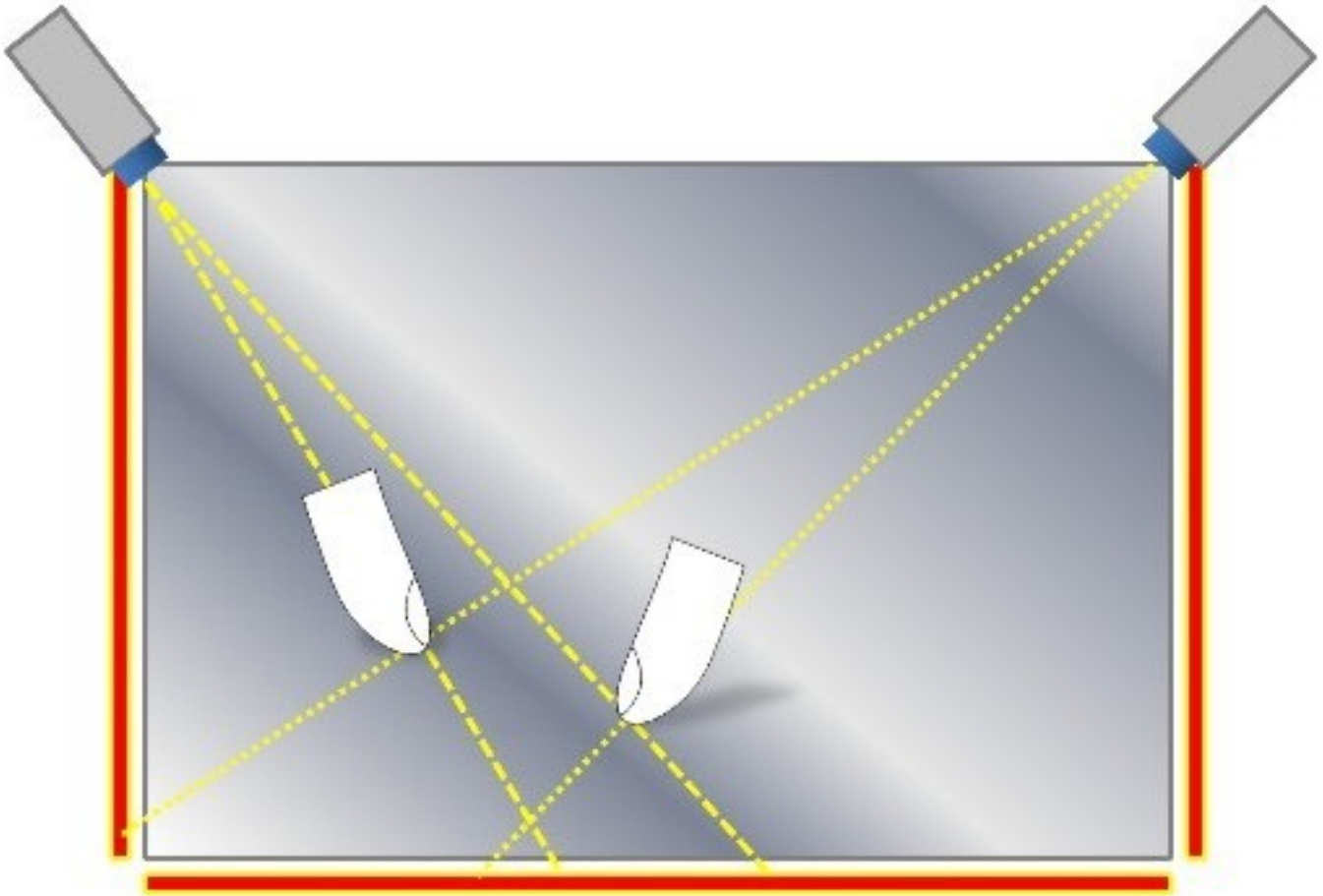
Resistive

Capacitive

Ultrasonic

IR Grid

Corner IR



IR Emitters along the sides

IR cameras at the corners

Supports multitouch, sort of.

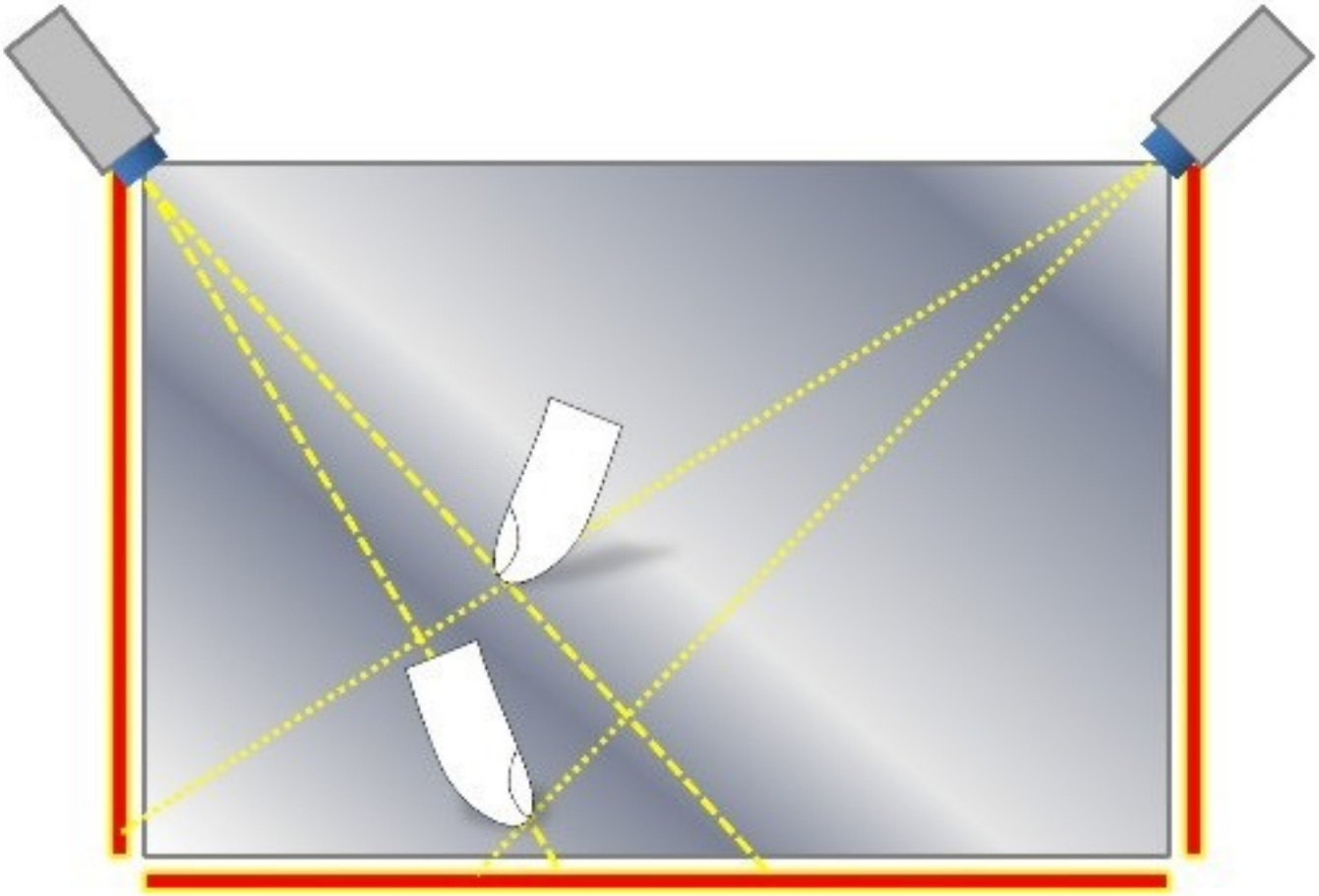
Resistive

Capacitive

Ultrasonic

IR Grid

Corner IR



IR Emitters along the sides

IR cameras at the corners

Supports multitouch, sort of.

- Resistive
- Capacitive
- Ultrasonic
- IR Grid
- Corner IR

The Good:

Need not absorb any light!
Very durable—just a piece of glass!
Can sense any object!
Not sensitive to electrical noise.
Good resolution.
Almost multitouch?

The Bad:

Again, senses any object.
Resolution varies over the display surface.
Doesn't detect contact per se.

Multitouch!

Capacitive

FTIR Optical

Diffuse Optical

Digital Resistive

Surface Capacitive

(what we talked about earlier)

vs

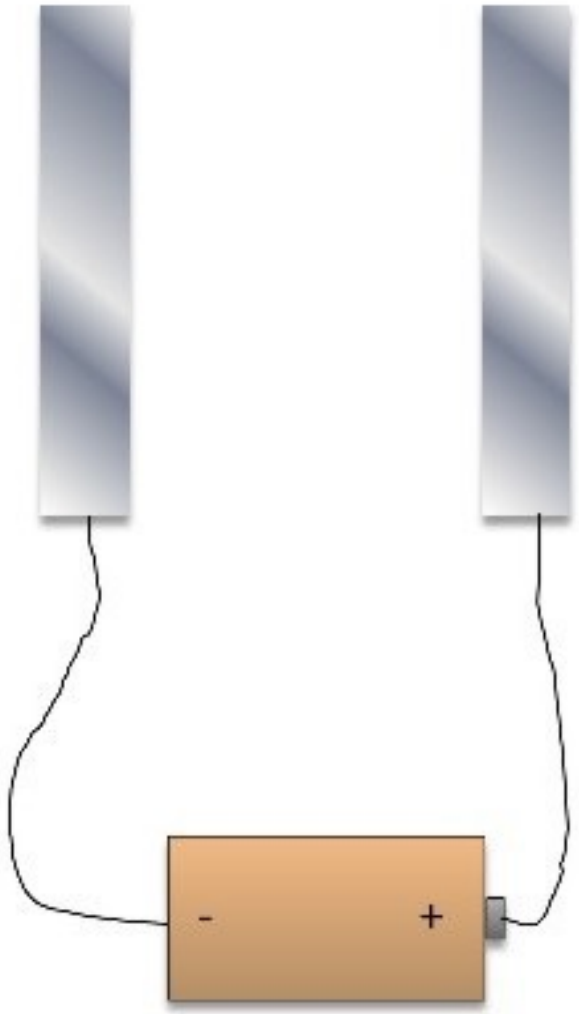
Projected Capacitive

Capacitive

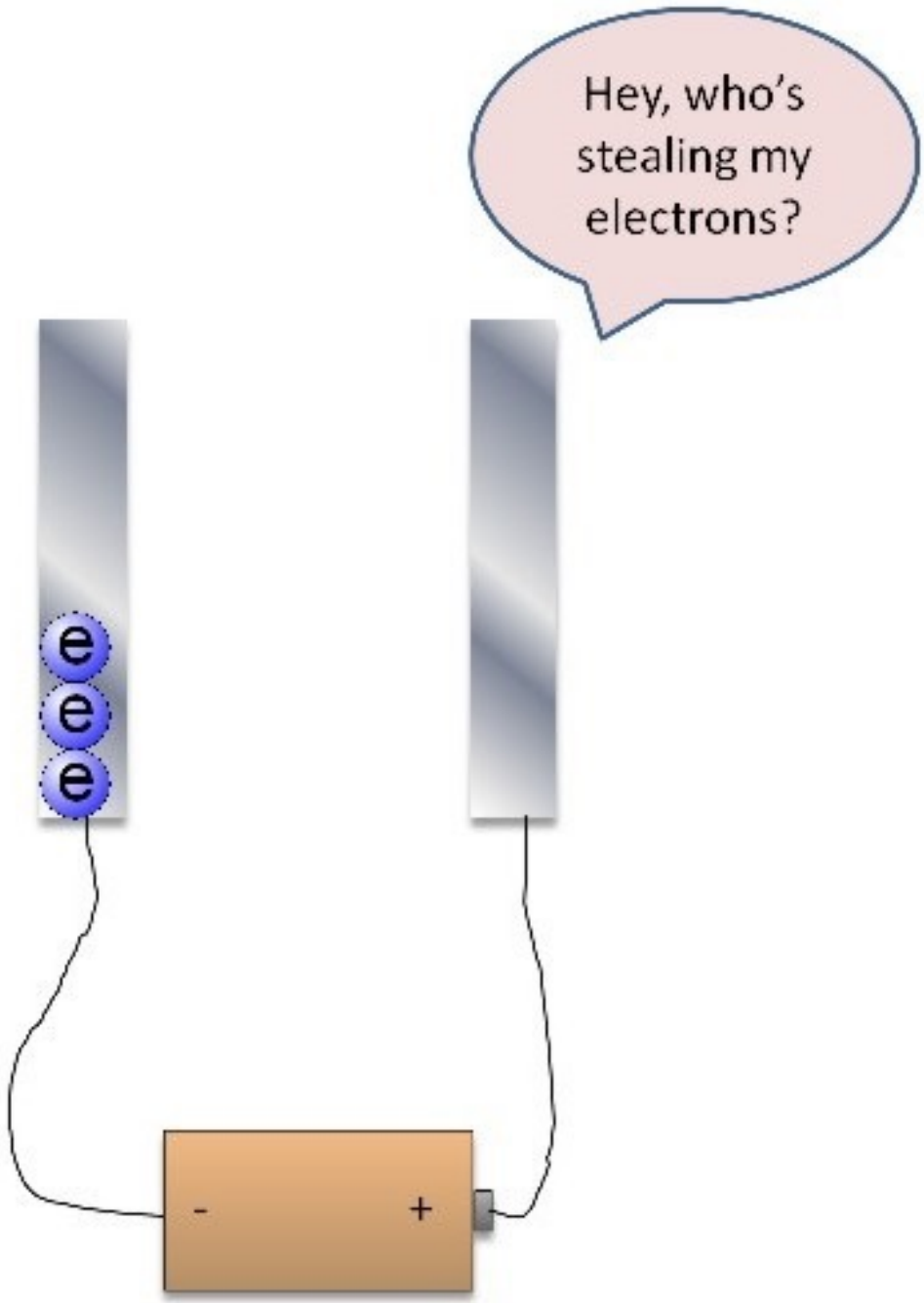
FTIR Optical

Diffuse Optical

Digital Resistive

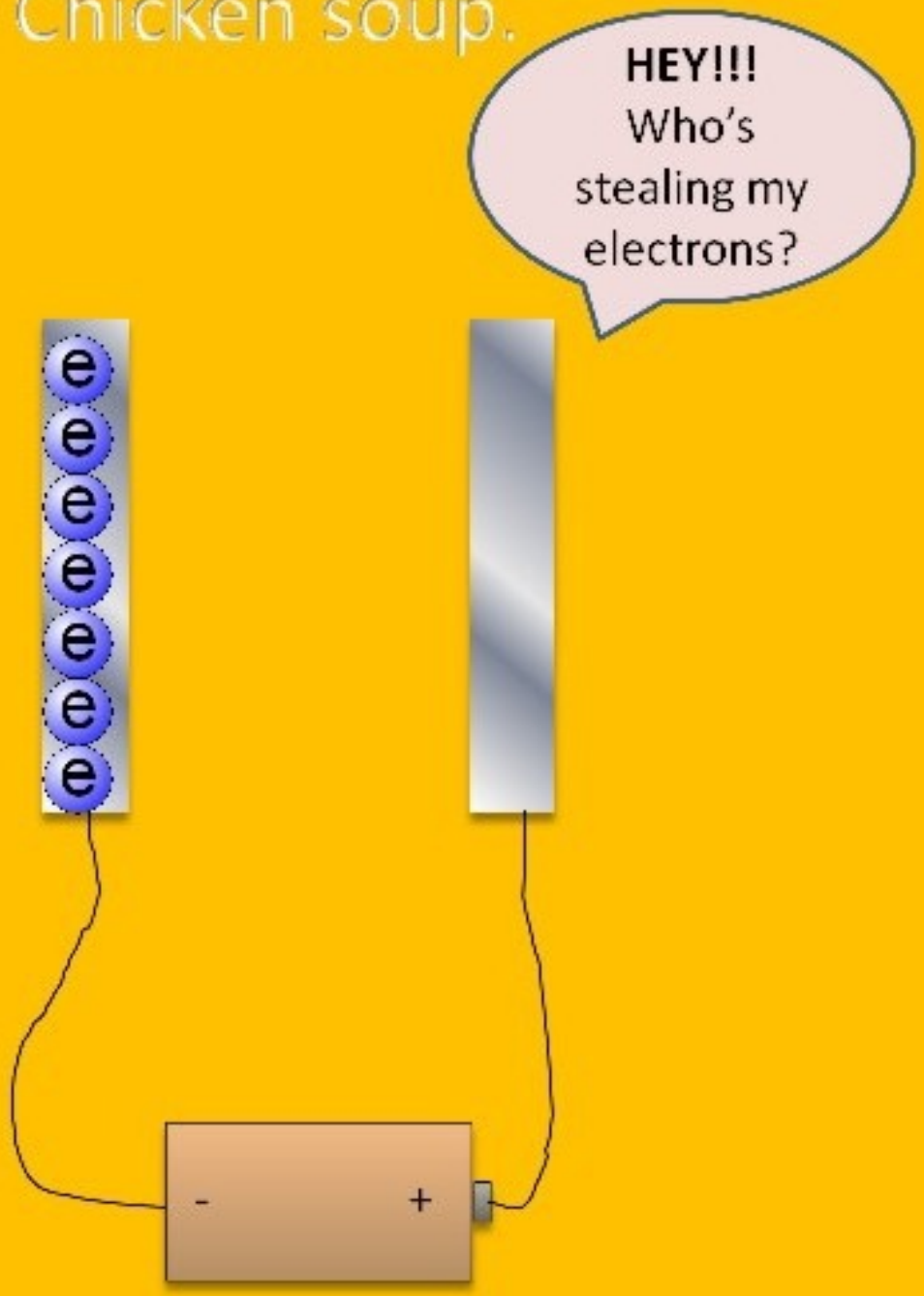


- Capacitive
- FTIR Optical
- Diffuse Optical
- Digital Resistive



- Capacitive
- FTIR Optical
- Diffuse Optical
- Digital Resistive

Chicken soup.

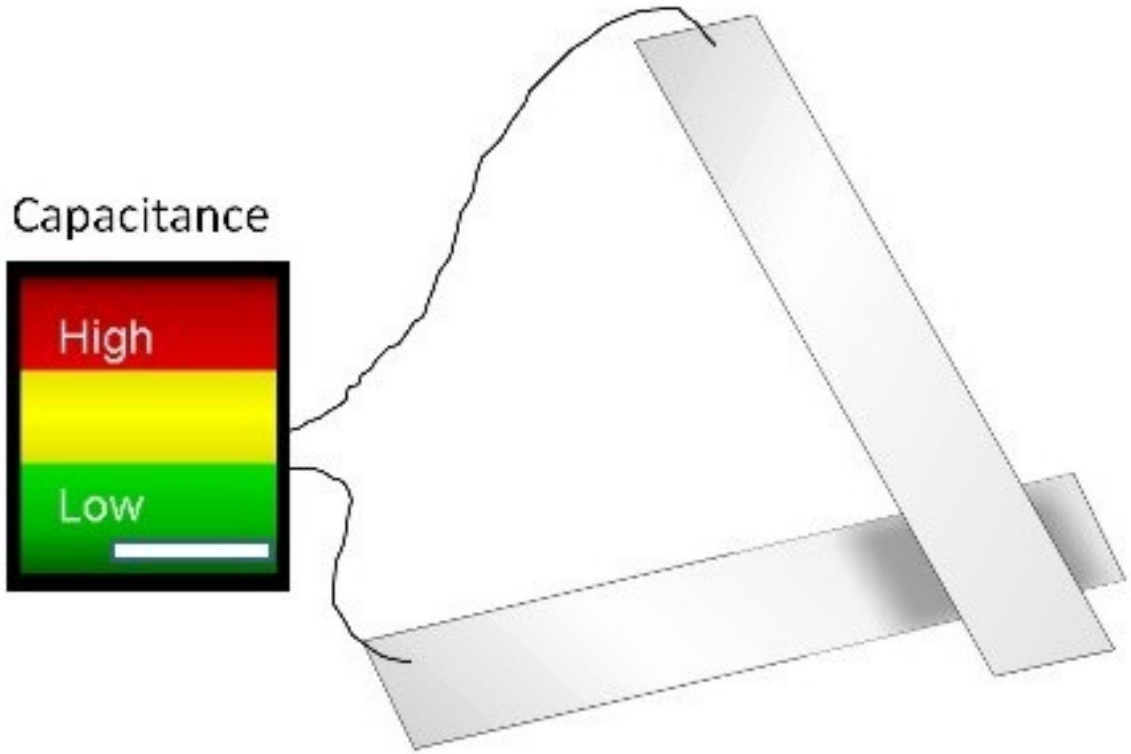


Capacitive

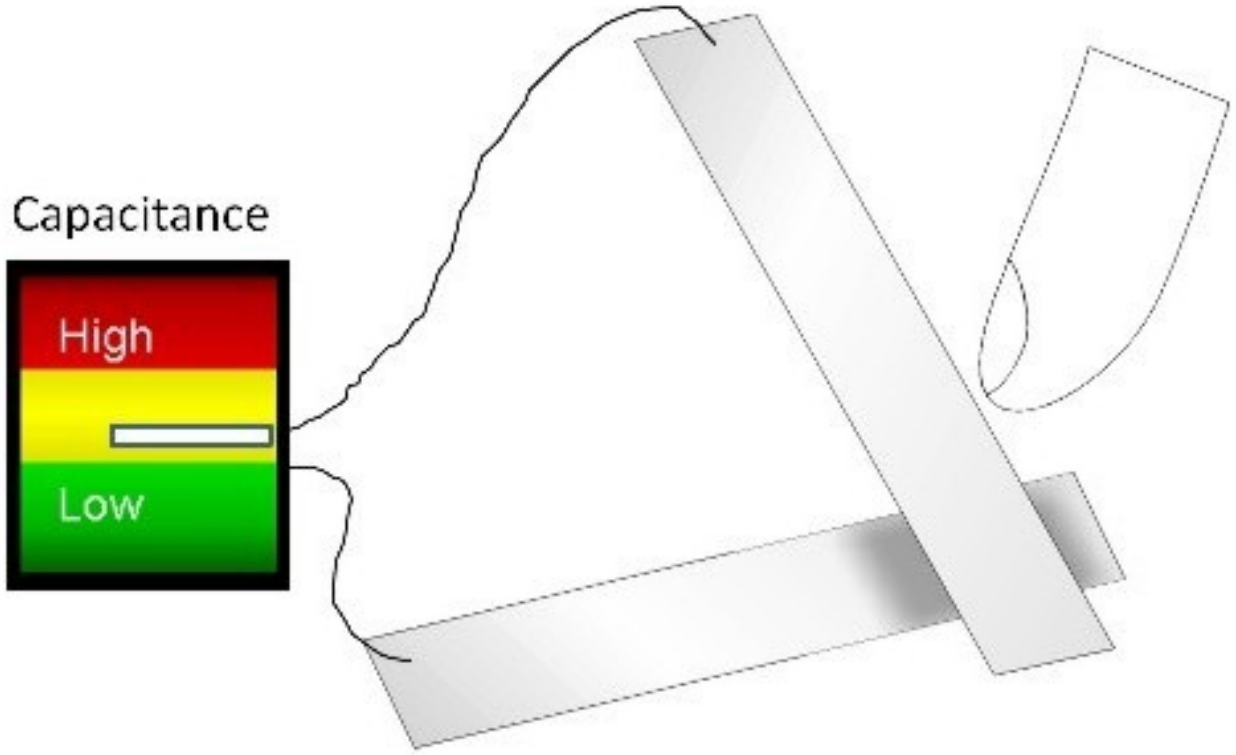
FTIR Optical

Diffuse Optical

Digital Resistive



- Capacitive
- FTIR Optical
- Diffuse Optical
- Digital Resistive

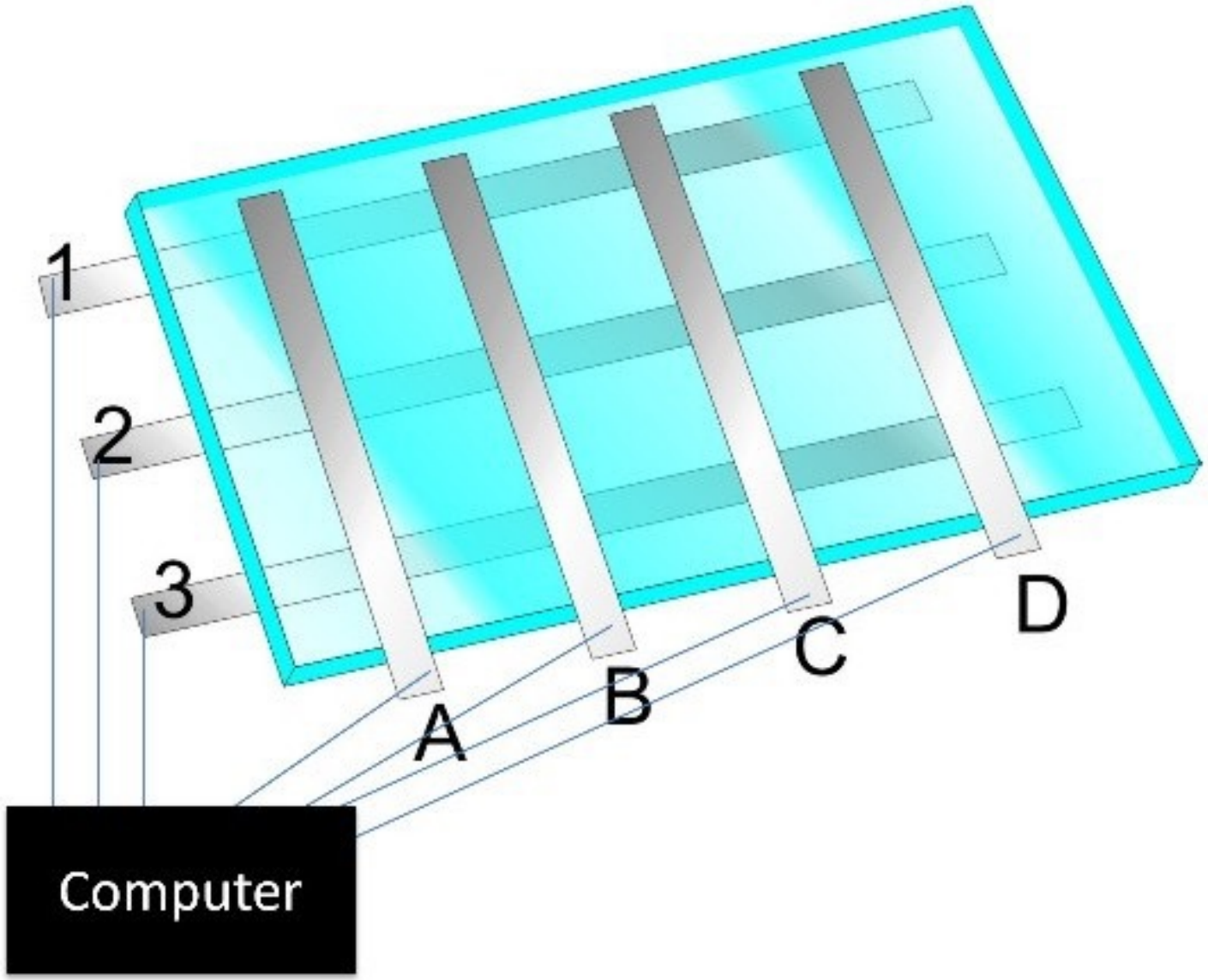


Capacitive

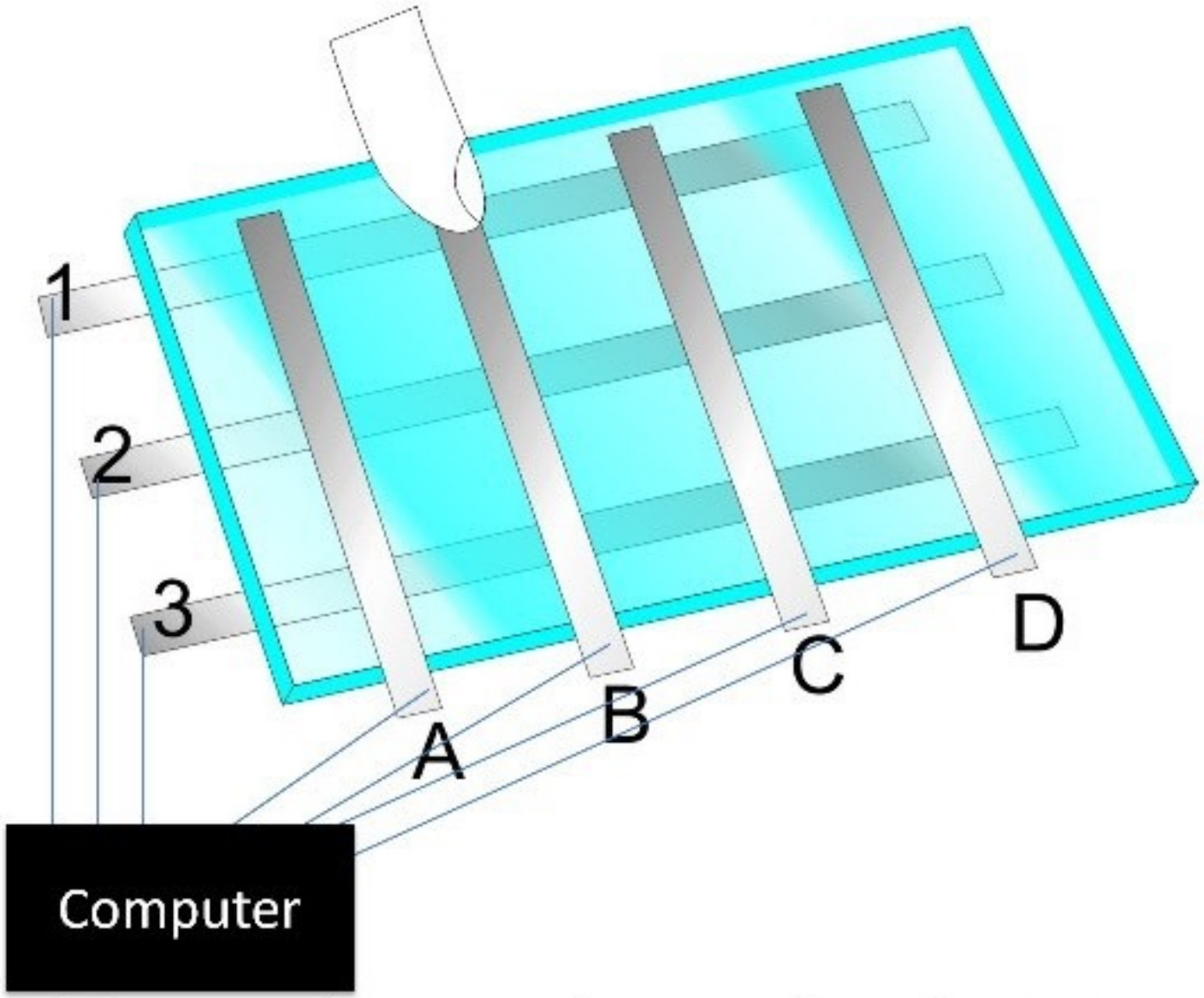
FTIR Optical

Diffuse Optical

Digital Resistive

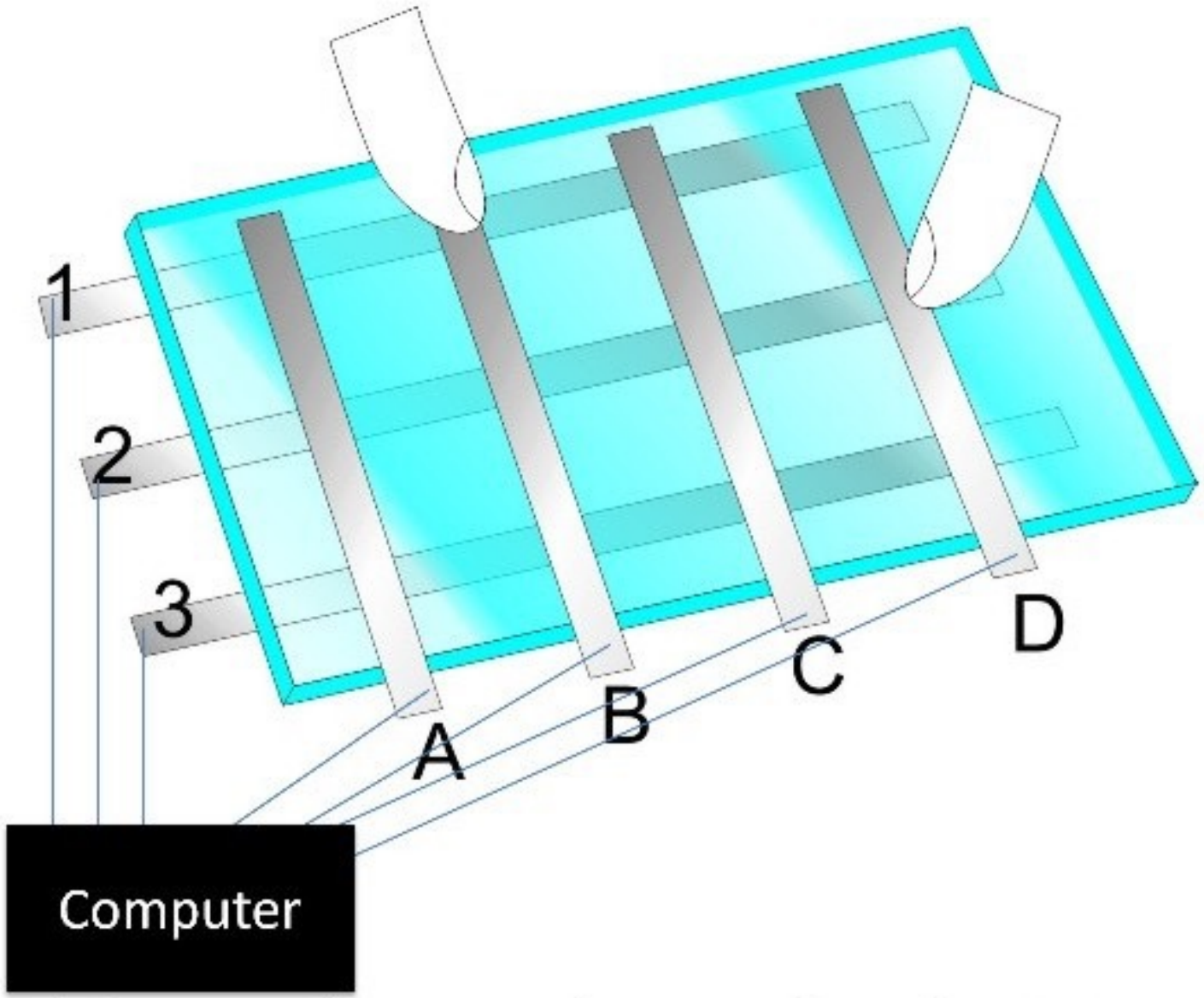


- Capacitive
- FTIR Optical
- Diffuse Optical
- Digital Resistive



Higher capacitance at intersection of 1 & B

- Capacitive
- FTIR Optical
- Diffuse Optical
- Digital Resistive



Higher capacitance at intersection of 1 & B
Higher capacitance at intersection of 2 & D

- Capacitive
- FTIR Optical
- Diffuse Optical
- Digital Resistive

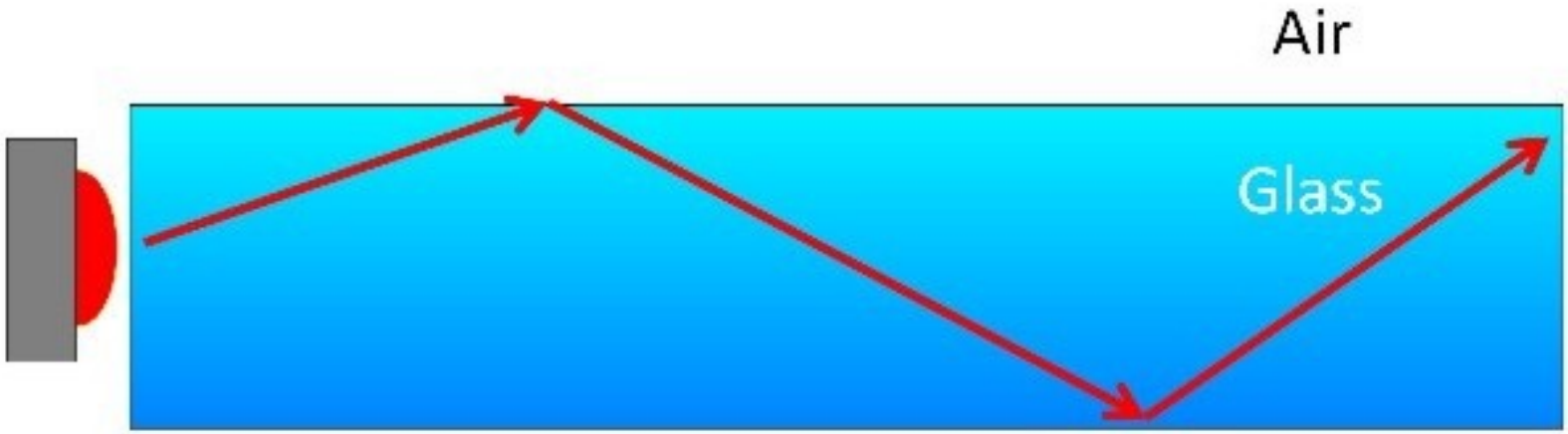
The Good:

Actually very good resolution.
Small, thin.
Doesn't need much energy.
Fairly transparent.

The Bad:

VERY sensitive to electrical noise.
Easily confused by water on the sensor.
Does block a bit of light.
Scales very badly.
Usually works with finite number of touches.

- Capacitive
- FTIR Optical
- Diffuse Optical
- Digital Resistive



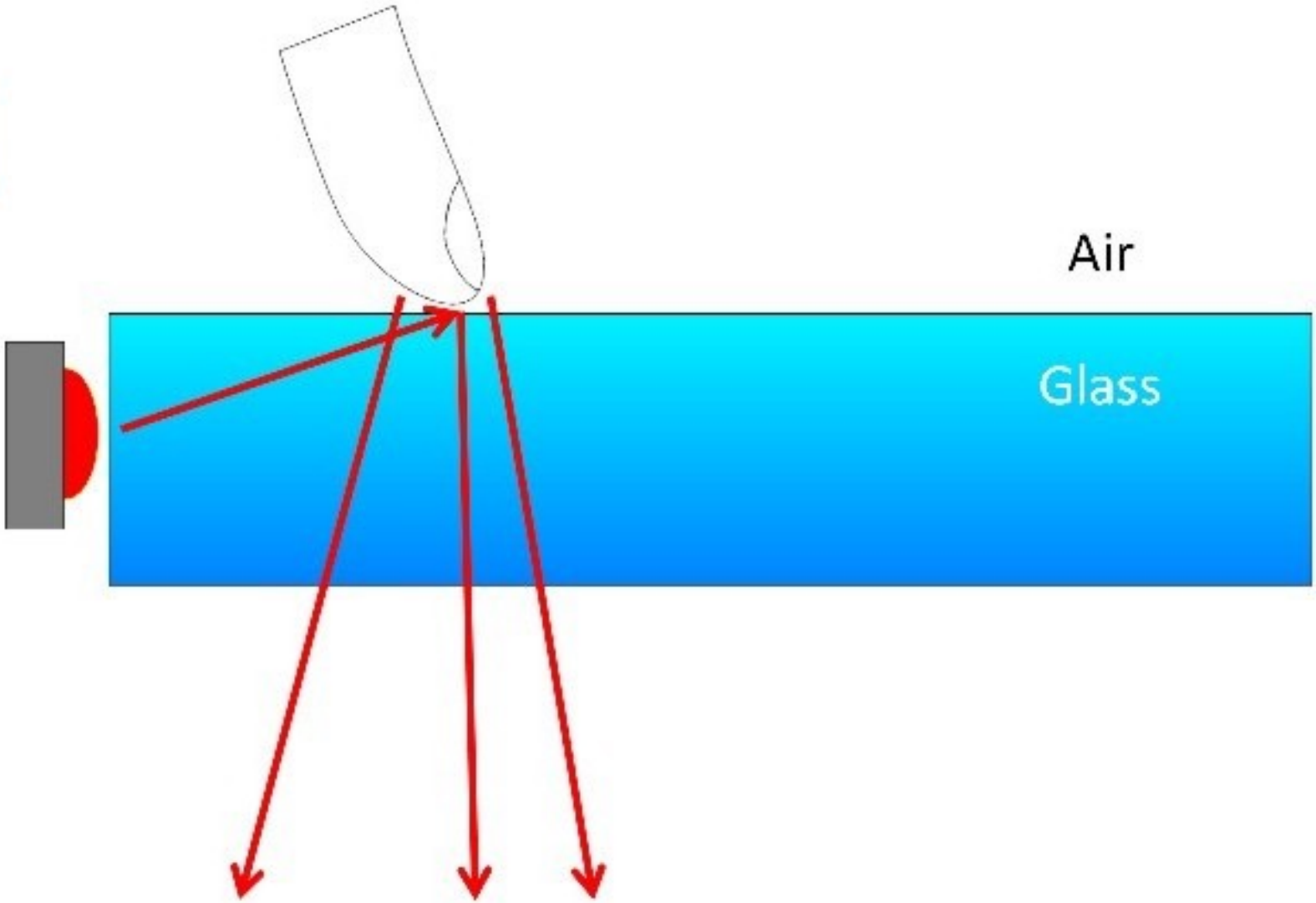
"Total Internal Reflection"

Capacitive

FTIR Optical

Diffuse Optical

Digital Resistive



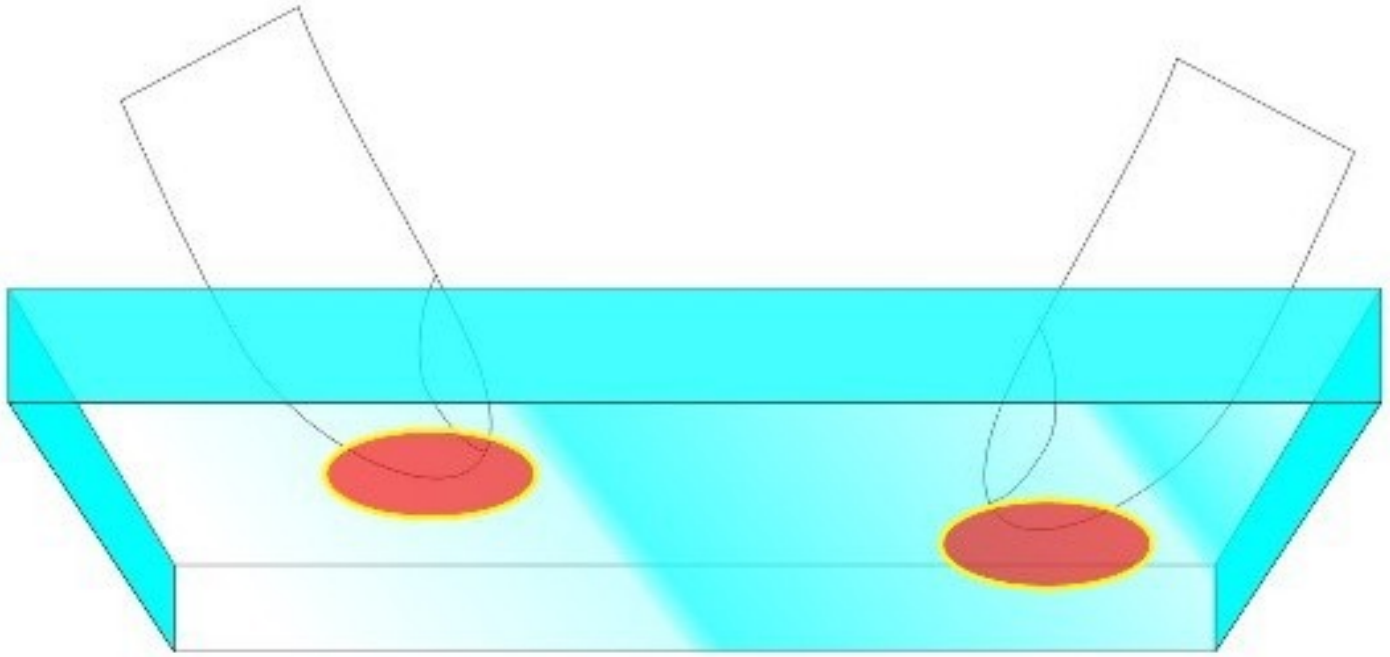
"Frustrated Total Internal Reflection"

Capacitive

FTIR Optical

Diffuse Optical

Digital Resistive

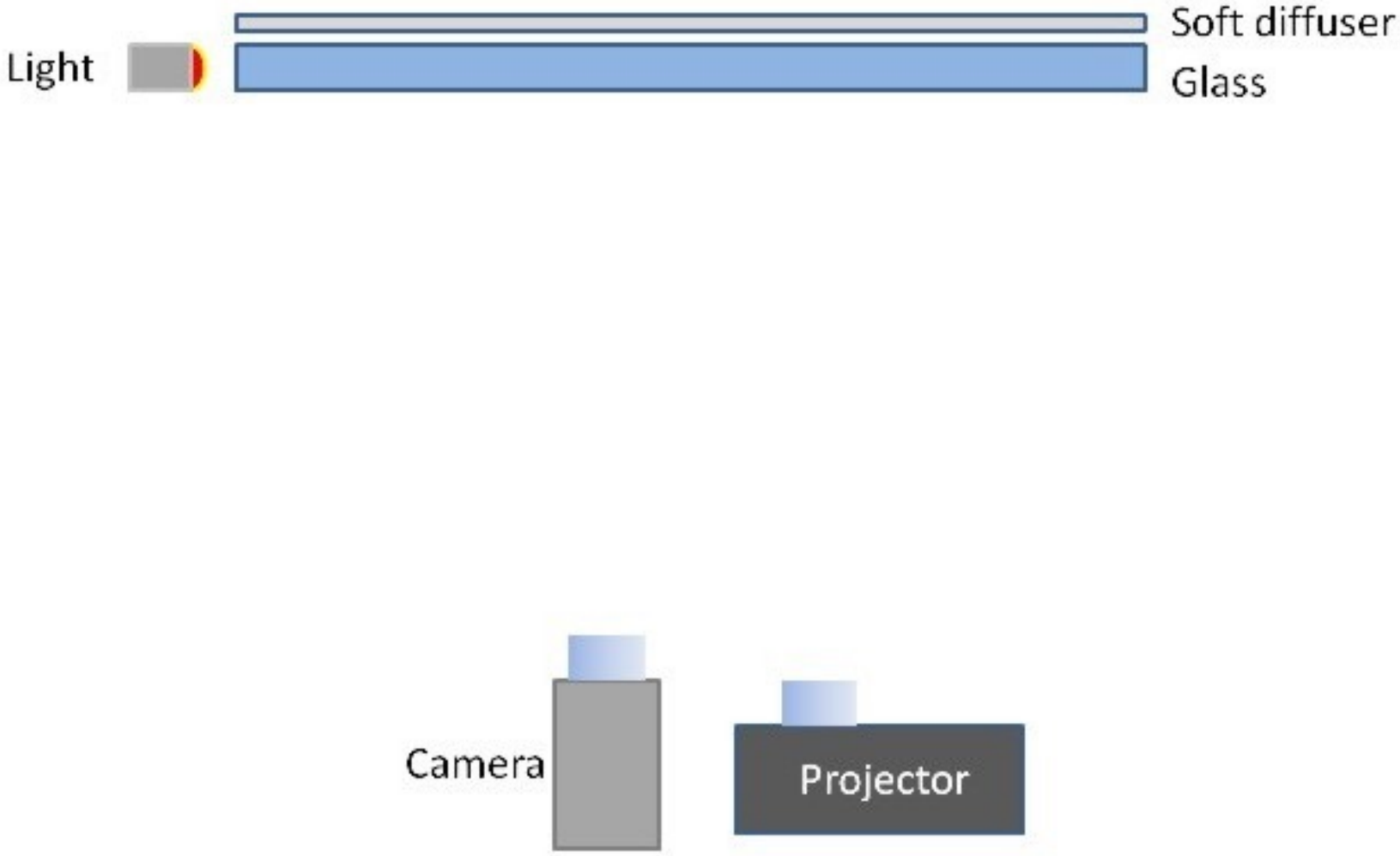


Capacitive

FTIR Optical

Diffuse Optical

Digital Resistive



Capacitive

FTIR Optical

Diffuse Optical

Digital Resistive

The Good:

Sense any number of objects!
Detects exact contact shape!
No parallax error in display.

The Bad:

Huge beast of a device.
Needs a lot of power (for projector).
Limited to projector display resolutions.
Can't sense anything not touching the surface.
Sensitive to ambient lighting.

Capacitive

FTIR Optical

Diffuse Optical

Digital Resistive

Often uses multiple cameras to calculate depth

Capacitive

FTIR Optical

Diffuse Optical

Digital Resistive

The Good:

Sense any number of objects!
Detects exact contact shape!
No parallax error in display.
Can sense objects BEFORE they touch screen!
Can see through screen to tell WHAT is contacting.

The Bad:

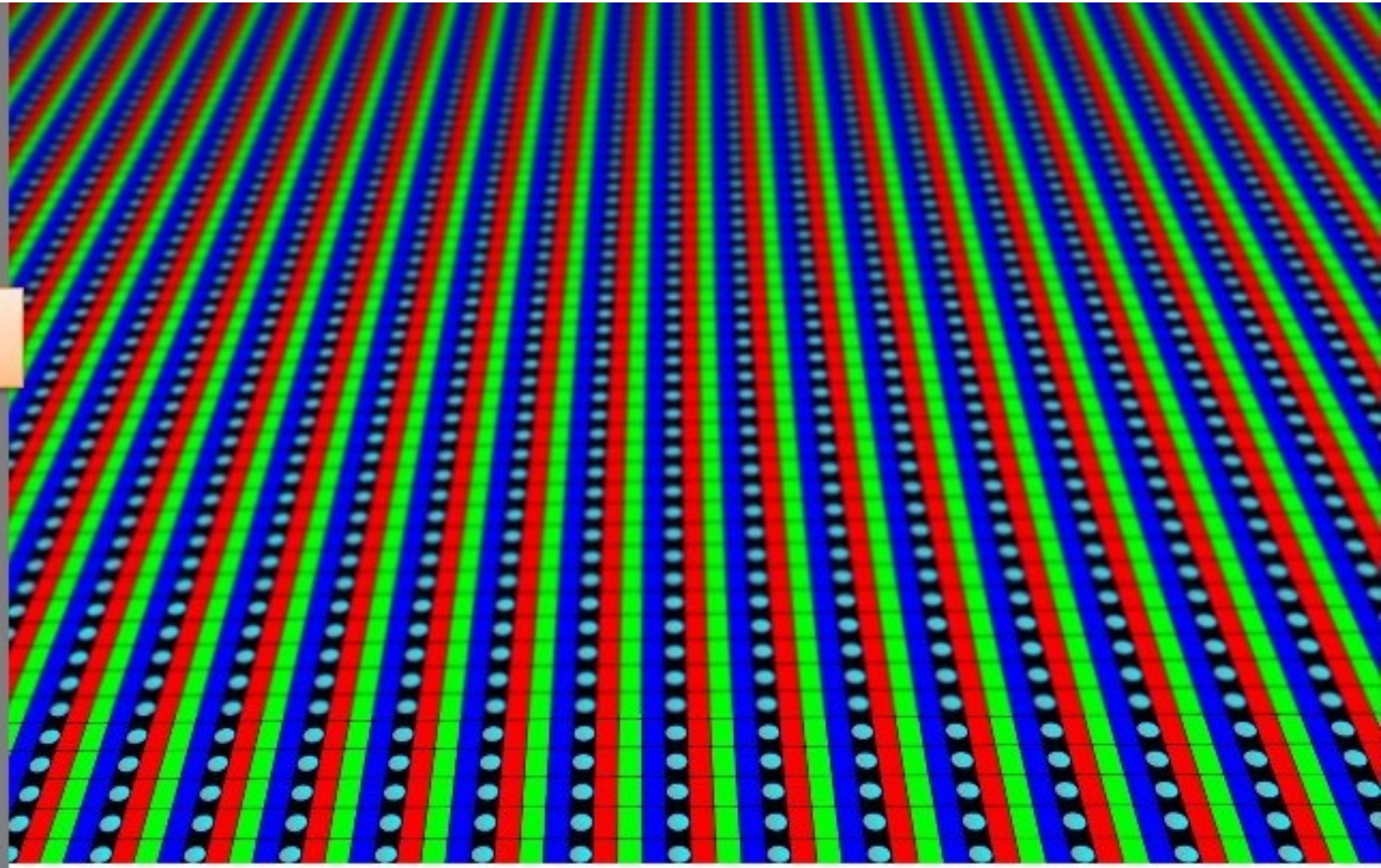
Detects objects before they touch screen.
Usually a huge beast of a device.
Needs a lot of power (for projector).
Limited to projector display resolutions.
Sensitive to ambient lighting.

Capacitive

FTIR Optical

Diffuse Optical

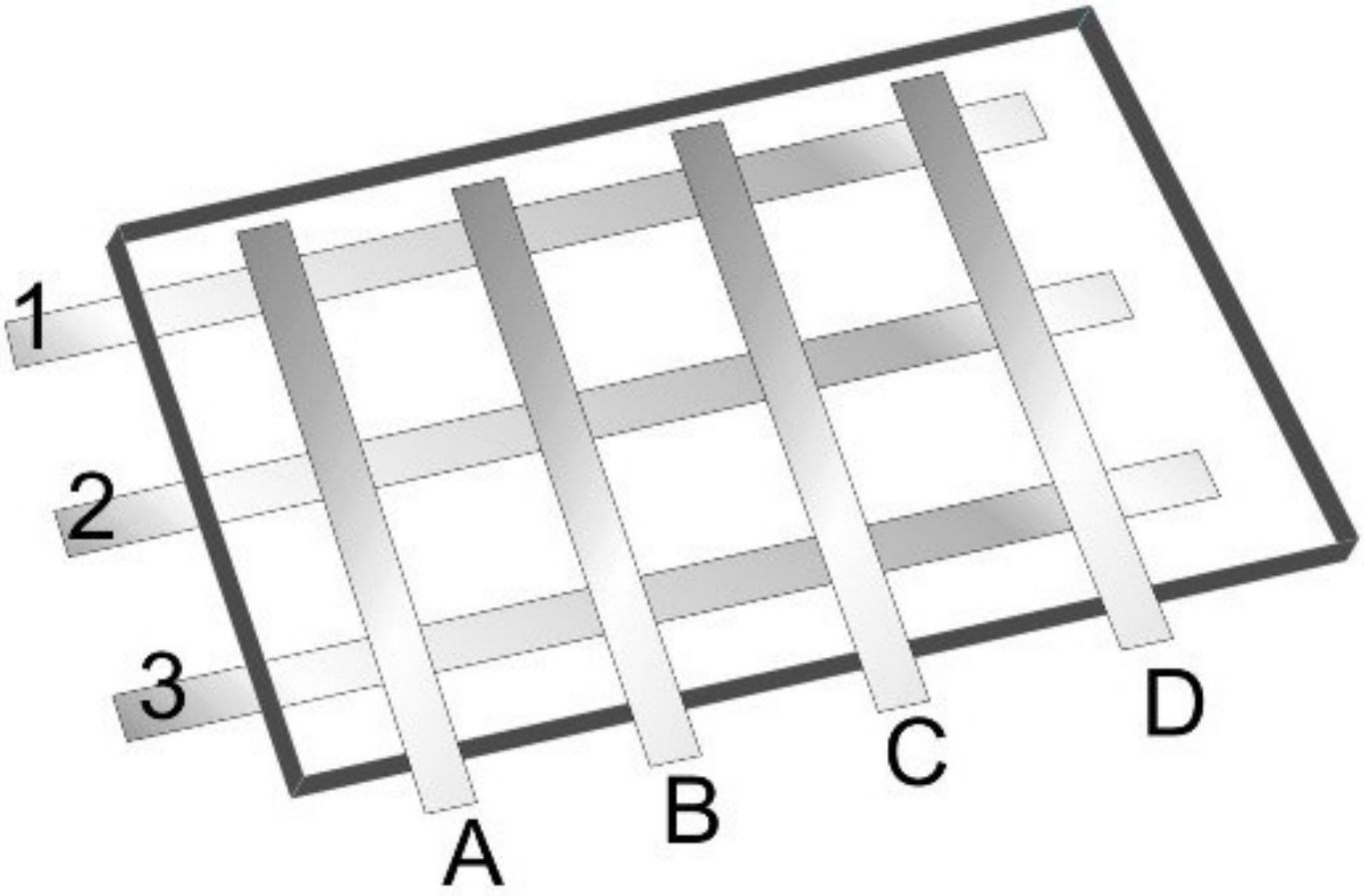
Digital Resistive



Diffuse optical may be the future:

Companies are already integrating optical sensors into LCD's

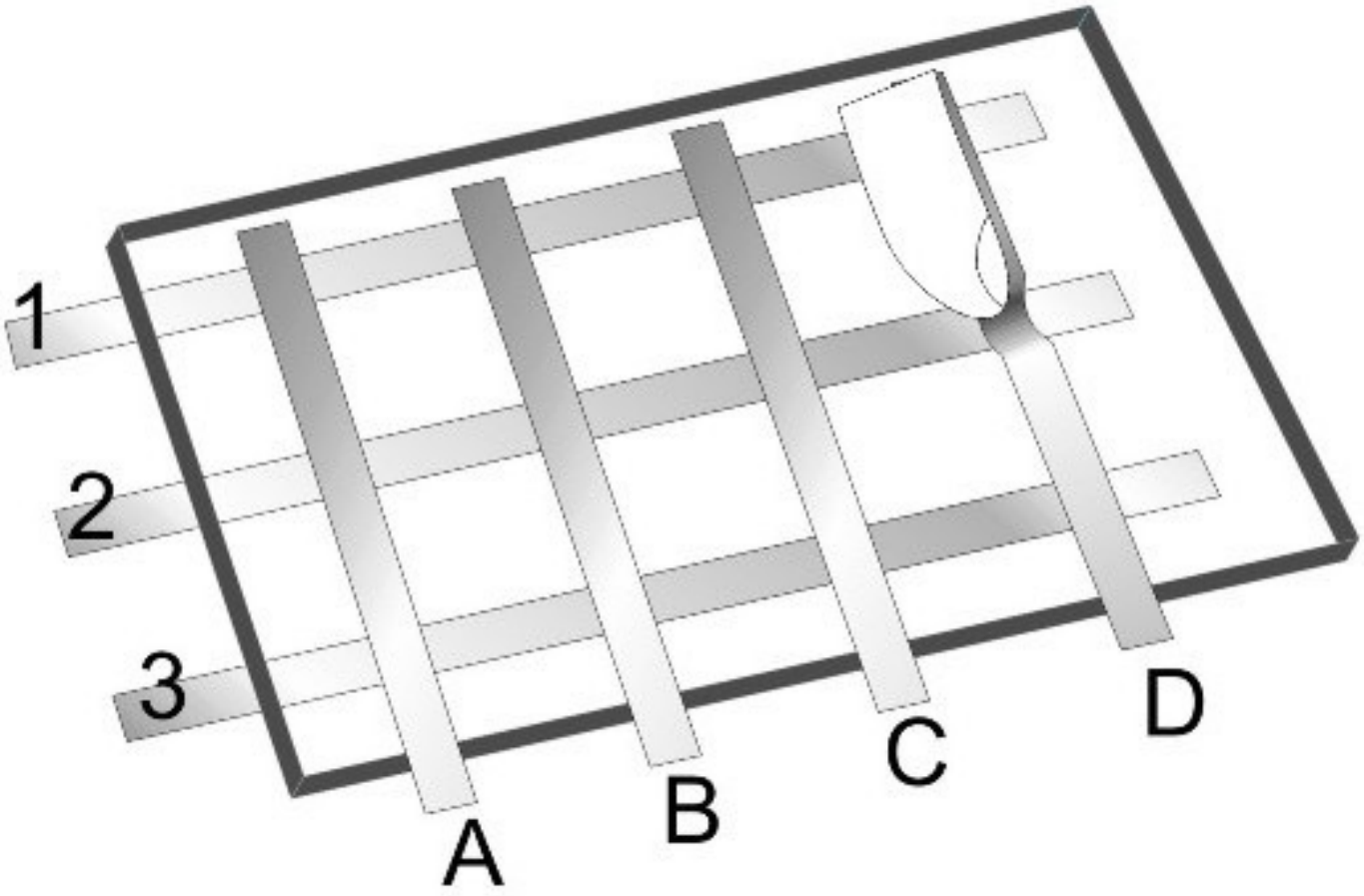
- Capacitive
- FTIR Optical
- Diffuse Optical
- **Digital Resistive**



Remember the Projected Capacitive approach?

Well, just take away the glass!

- Capacitive
- FTIR Optical
- Diffuse Optical
- **Digital Resistive**



Remember the Projected Capacitive approach?

Well, just take away the glass!

Only problem seems to be making those wires **clear**.

Capacitive

FTIR Optical

Diffuse Optical

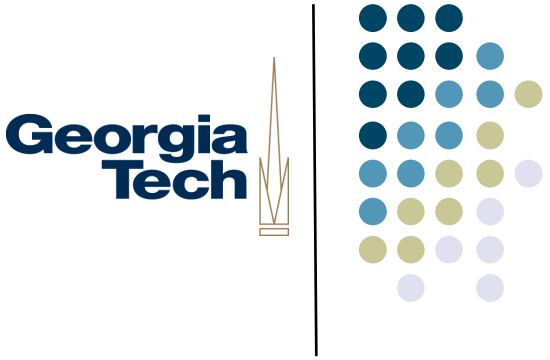
Digital Resistive

The Good:

Very high precision pressure calculation.
Not sensitive to electrical noise.
Very small and thin.

The Bad:

Not yet commercial—just in the R&D phase.
Haven't figured out how to get the wires clear!



Next Class: Touchscreen Software

Next time, we'll talk software

Any questions?