

Sensors

Scott Gilliland
zeroping@gmail.com

Connecting to sensors

- Connected to a PC
 - USB
 - Bluetooth
 - RS232 serial
 - Parallel
 - Analog adapters
- Connected to a microcontroller (ex: an Arduino)
 - I²C
 - SPI
 - Analog lines
 - Low-voltage RS232 serial

Properties of a Sensor

- Span – full range
- Transfer function – mapping from actual to measured value
 - May be neither linear or logarithmic
- Accuracy or Resolution – error on measured value
- Repeatability – stability of measured value
- Hysteresis – change in measured value based on direction of change
- Saturation – non-linearity at end of range

● Reference Data

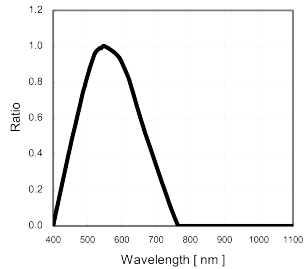


Fig.1 Spectral Response

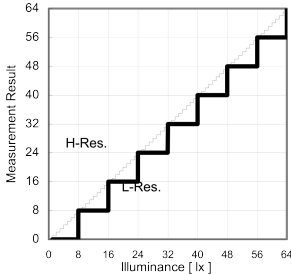


Fig.2 Illuminance - Measurement Result 1

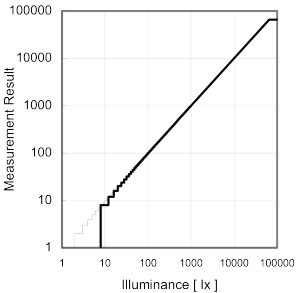


Fig.3 Illuminance - Measurement Result 2

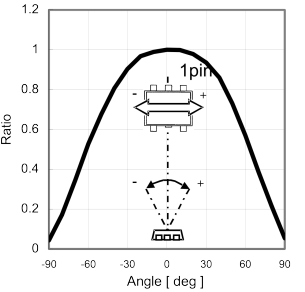


Fig.4 Directional Characteristics 1

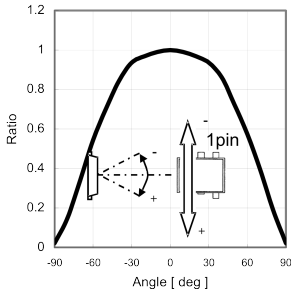


Fig.5 Directional Characteristics 2

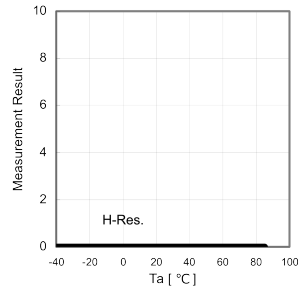


Fig.6 Dark Response

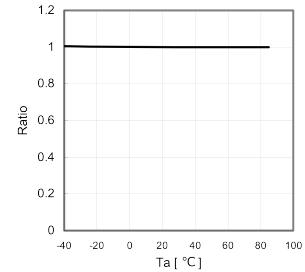


Fig.7 Measurement Result Temperature Dependency

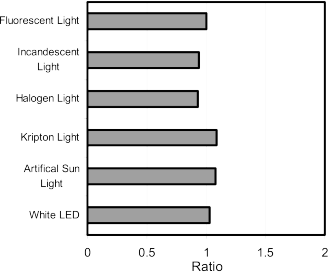


Fig.8 Light Source Dependency (Fluorescent Light is set to '1')

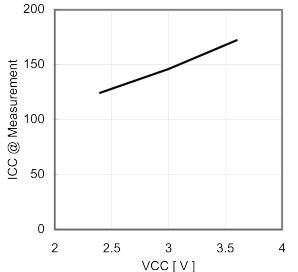


Fig.9 VCC - ICC (During measurement)

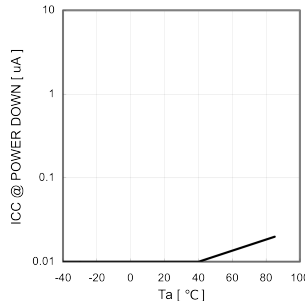


Fig.10 VCC - ICC@0 lx

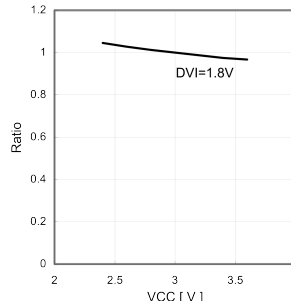


Fig.11 Measurement Result

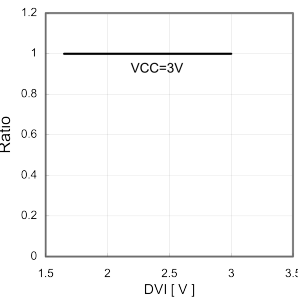


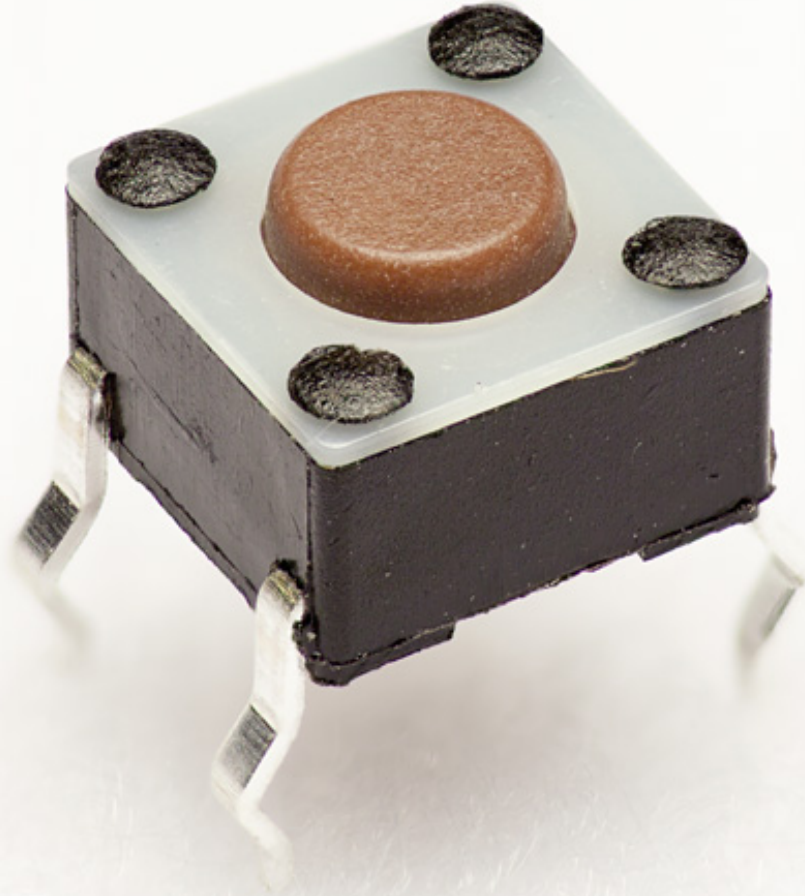
Fig.12 Measurement Result

Giant List of Sensors

Movement in Free Space

- Accelerometer
 - Acceleration, not velocity or position
 - Can be used to estimate 'down' due to gravity
- Magnetic compass
 - Estimate of “north”, but not when near magnets
- Gyroscope
 - Rotational acceleration
- GPS
 - Expect 2-100m accuracy outdoors

Tactile Switch



Microswitch

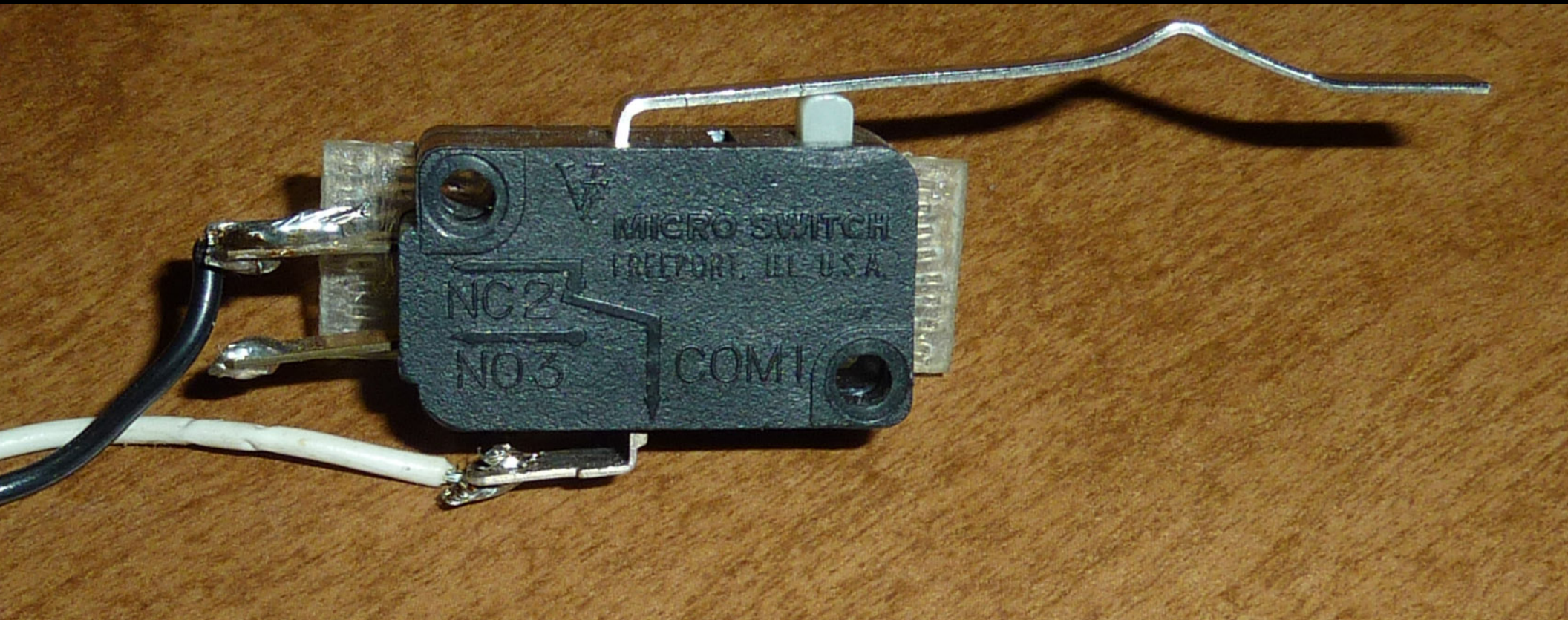
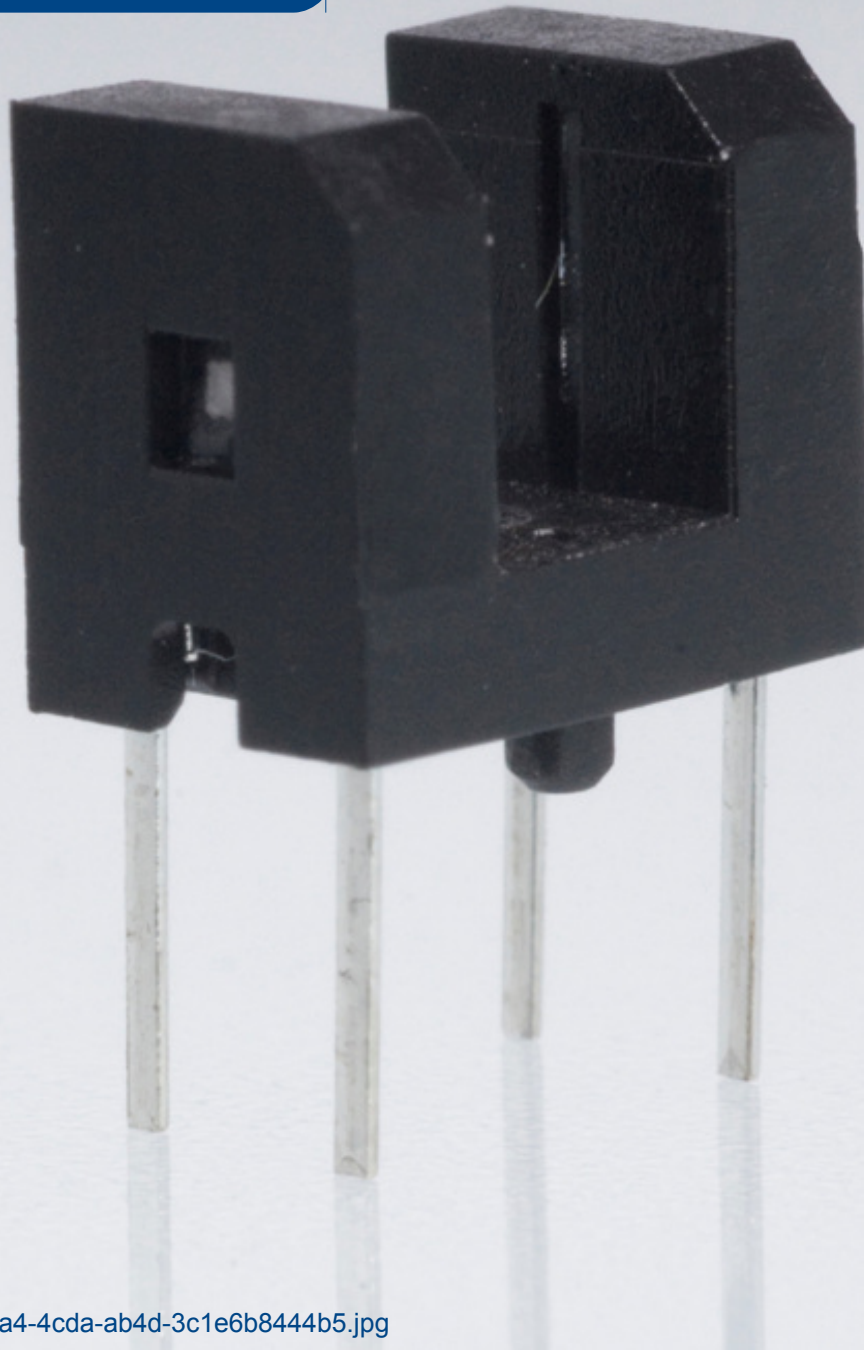
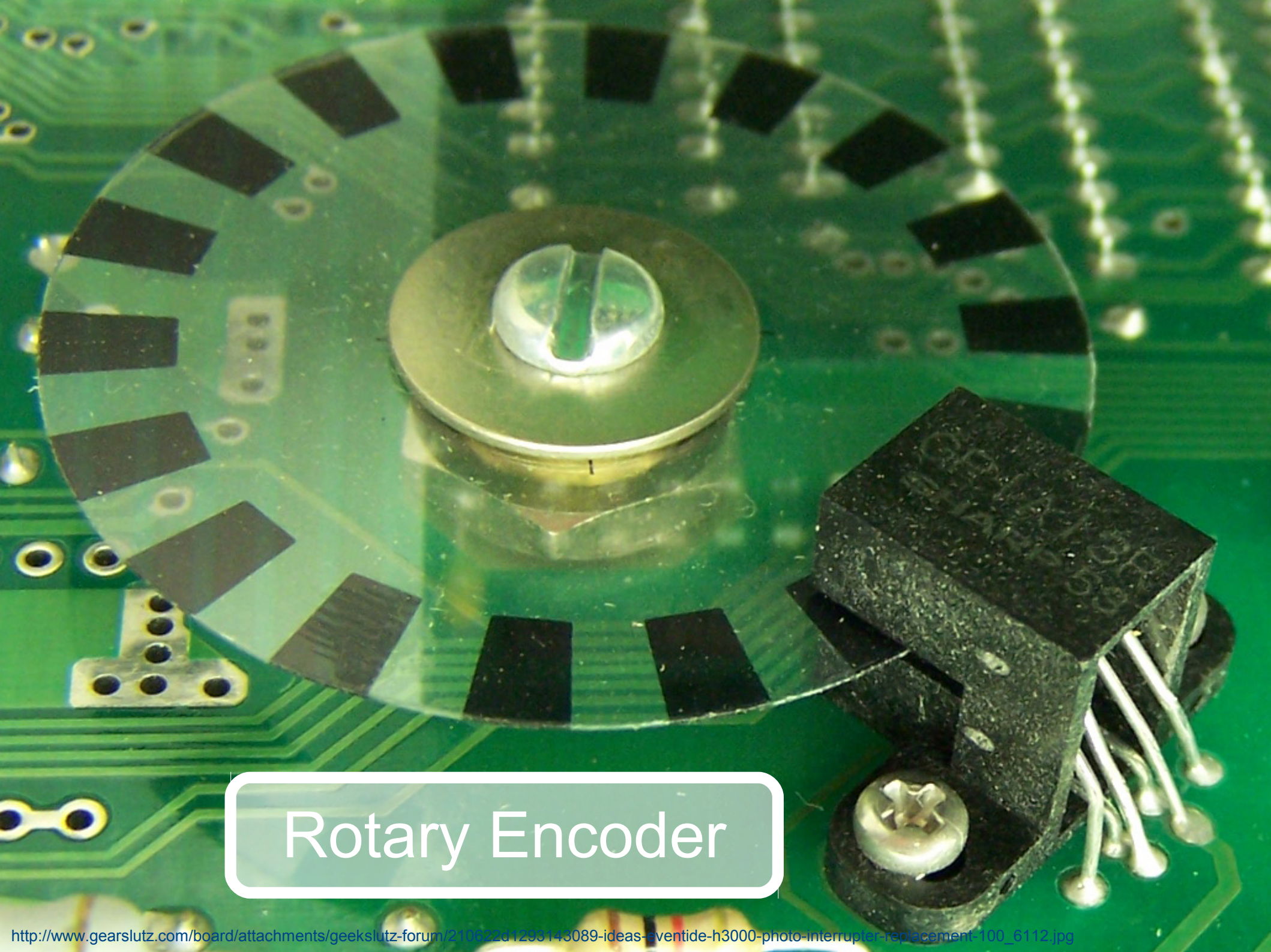


Photo Interrupter



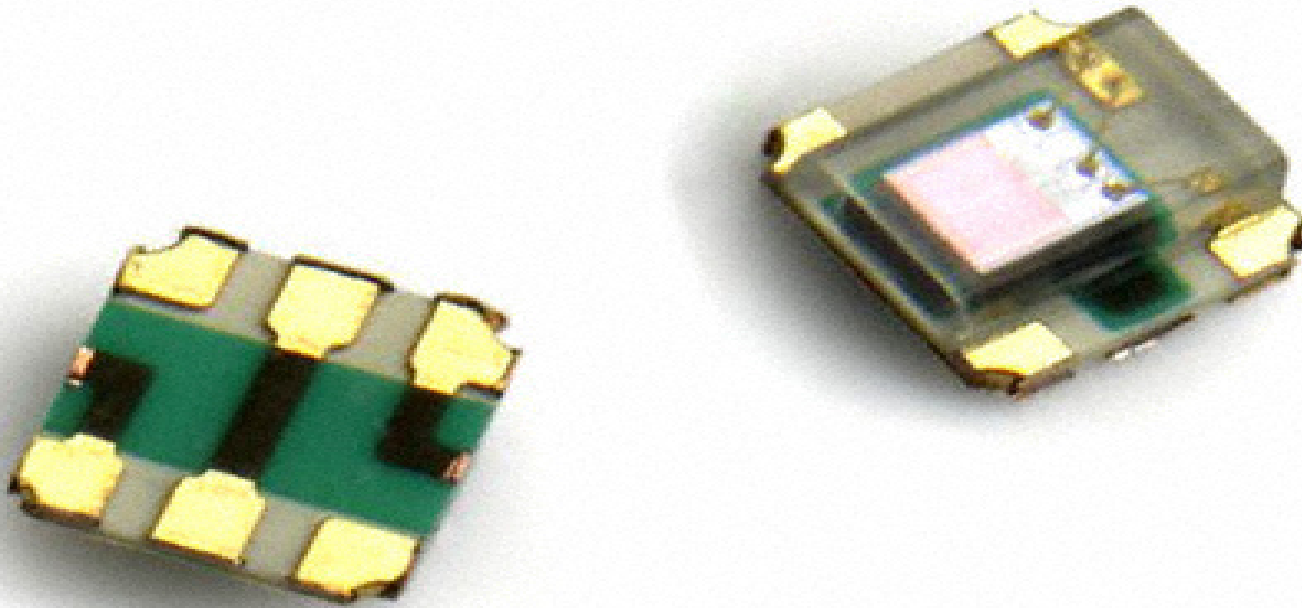


Rotary Encoder

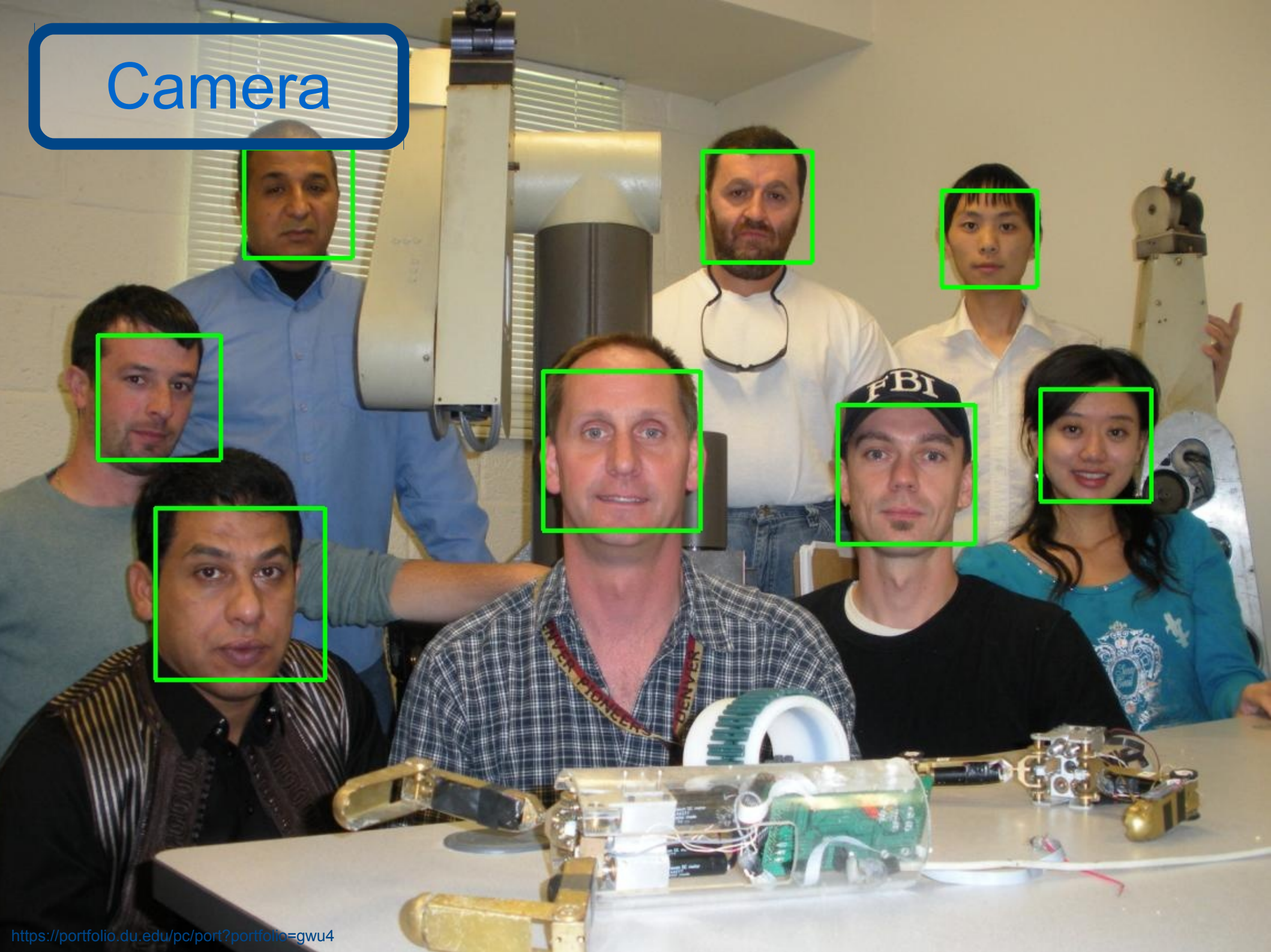
Reflective Proximity Detector

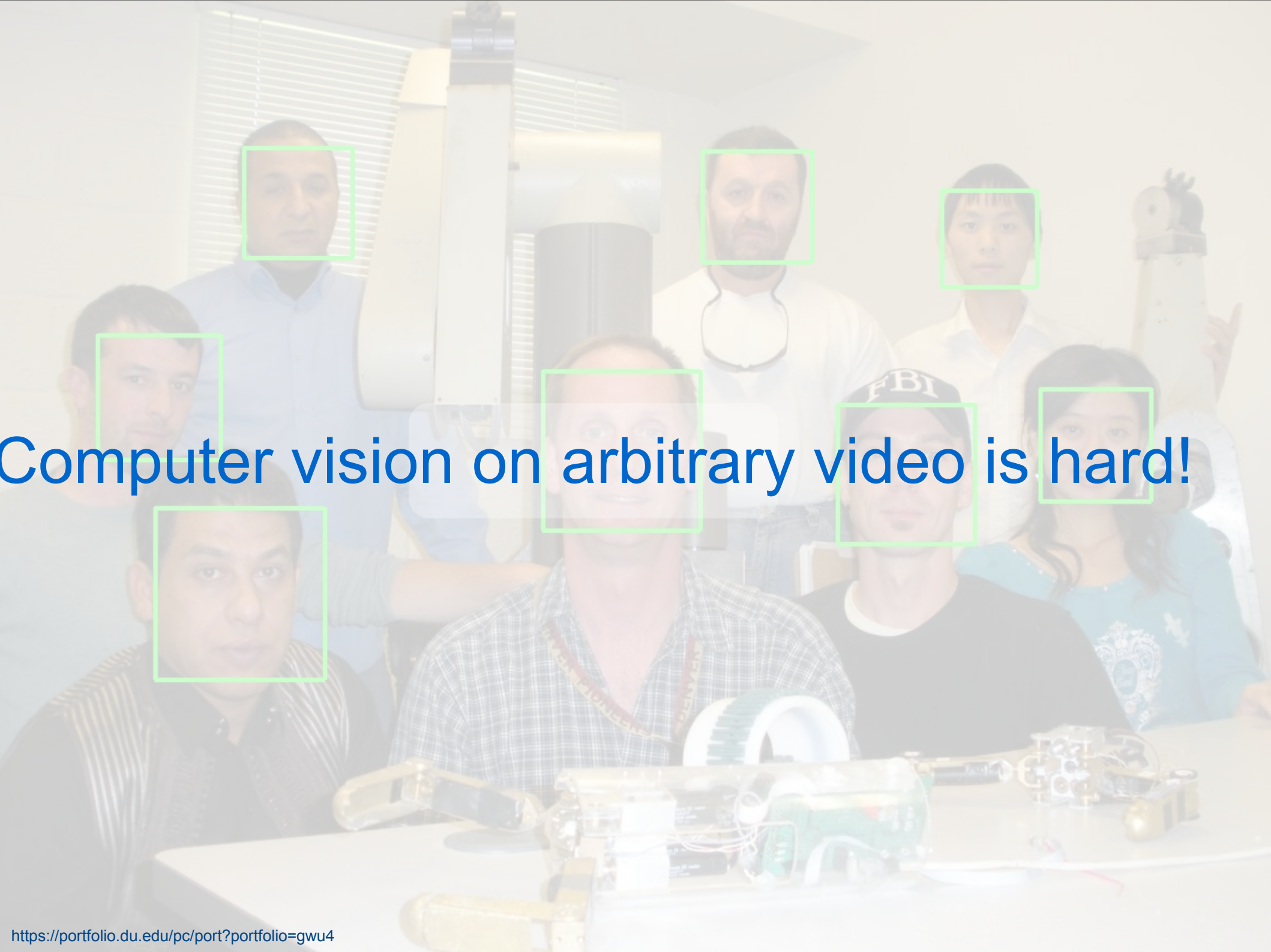


Light Sensor



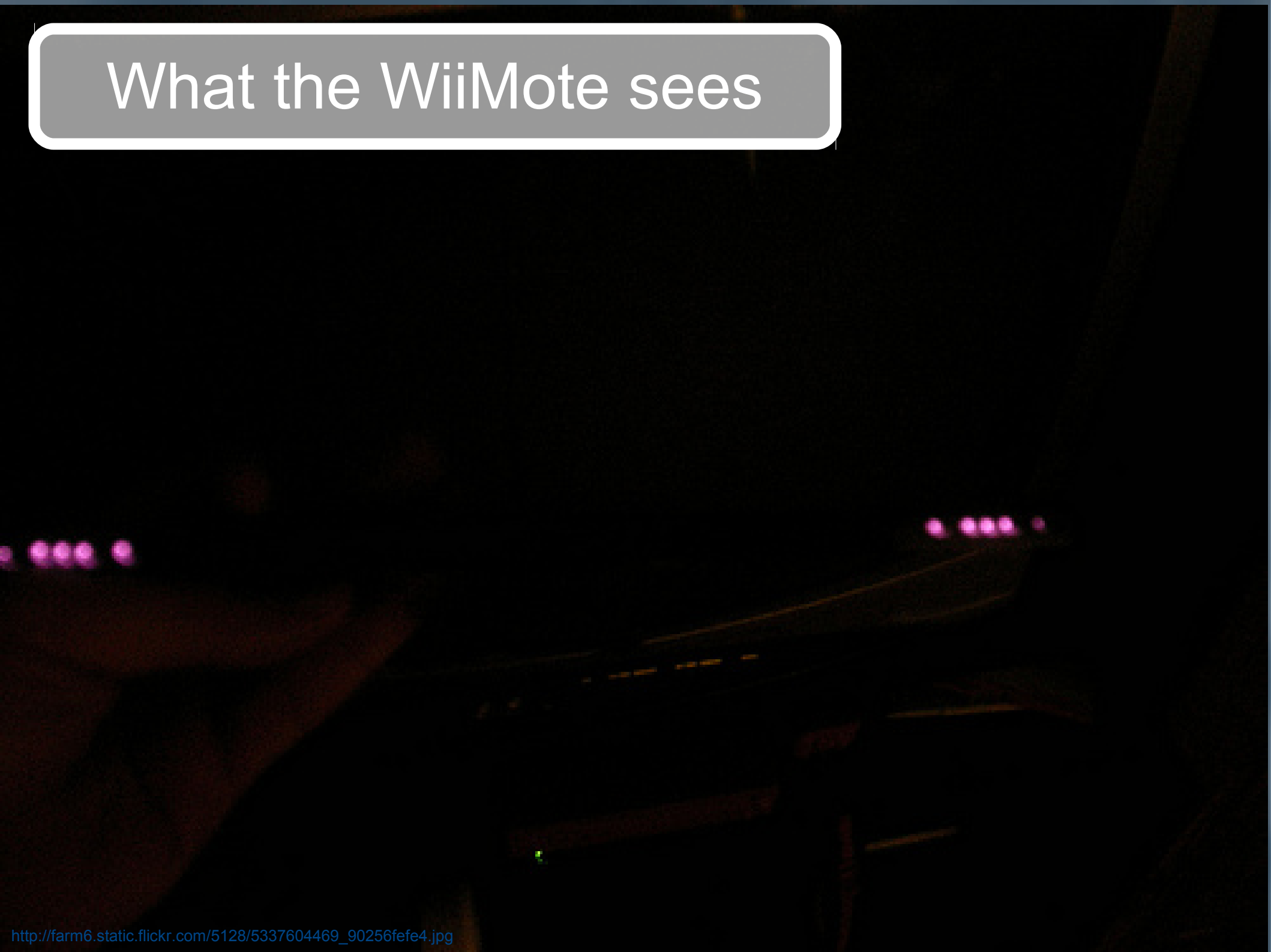
Camera



A group of seven people, four men and three women, are posed in a workshop or lab setting. They are wearing green rectangular bounding boxes around their faces, which are semi-transparent. The background shows various pieces of equipment, including a large vertical machine and a robotic arm. In the foreground, there is a table with electronic components, a breadboard, and a small robot. The text "Computer vision on arbitrary video is hard!" is overlaid in blue on a semi-transparent white background.

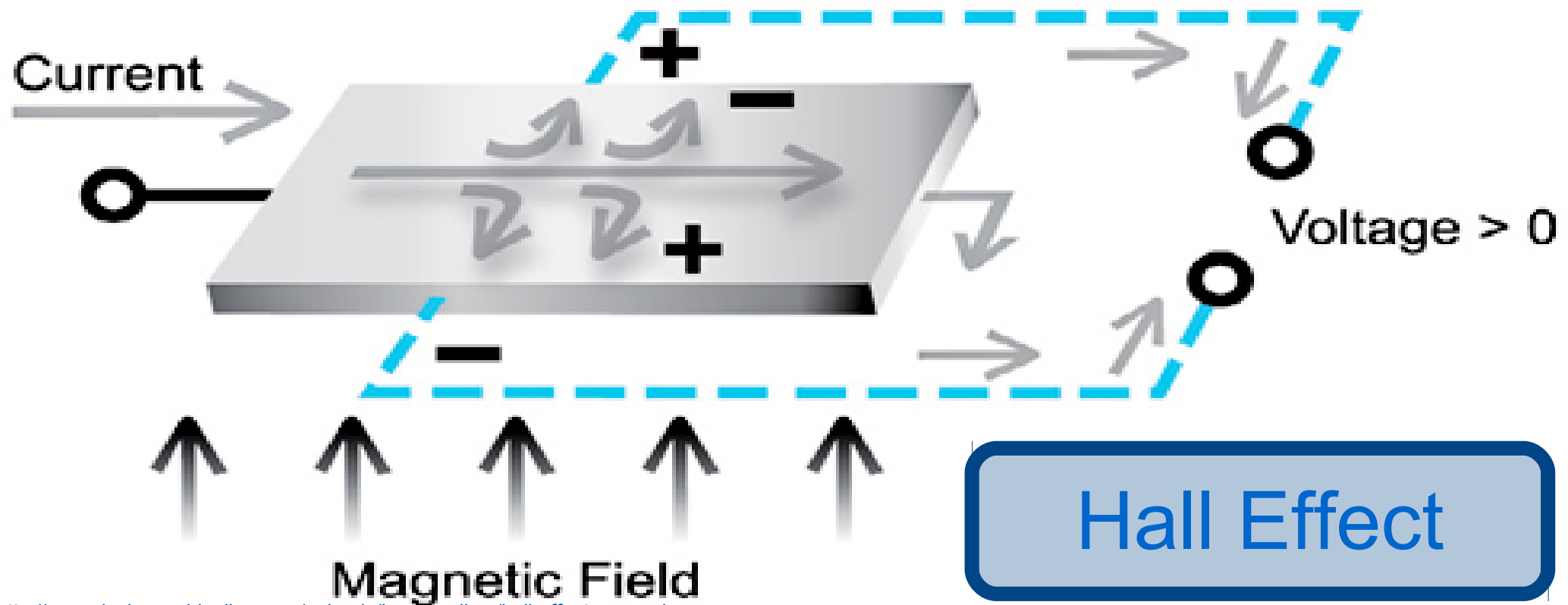
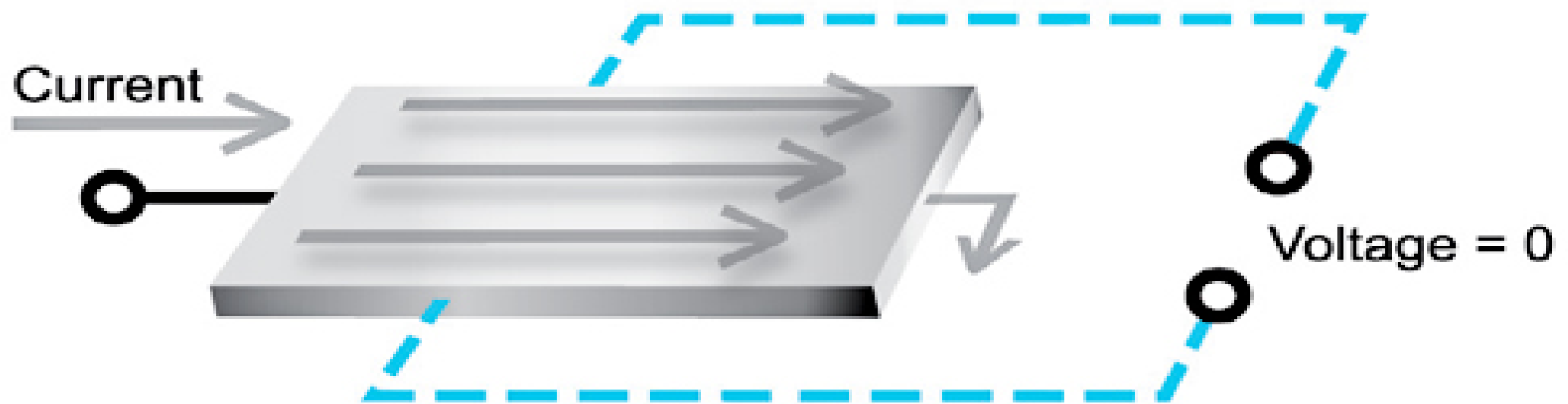
Computer vision on arbitrary video is hard!

What the WiiMote sees



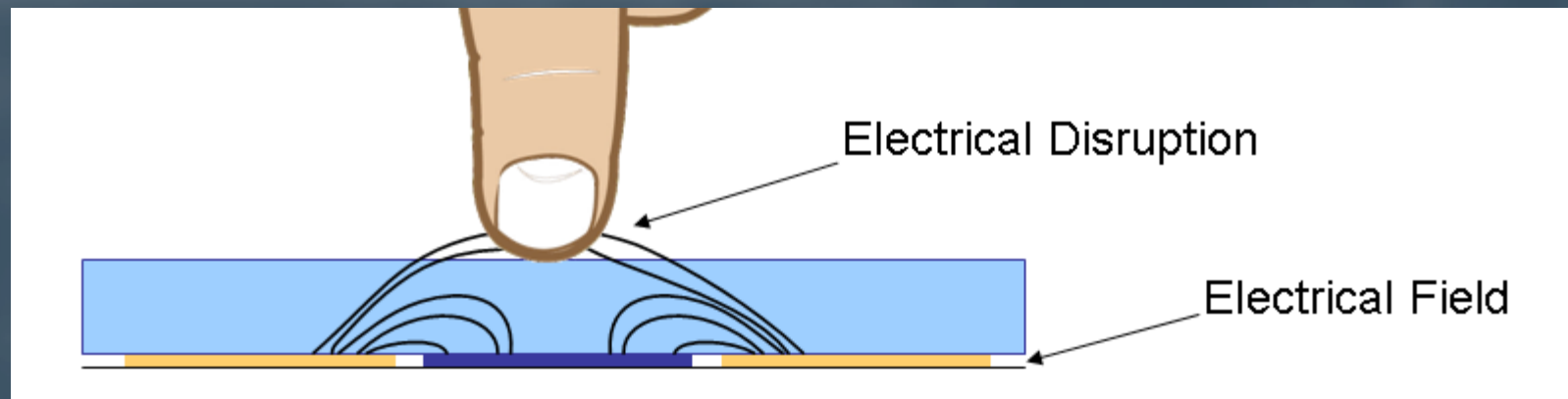
Pyroelectric





Capacitance

- Capacitance between two points is affected by:
 - Size of electrodes
 - Distance between electrodes
 - “Relative static permittivity” or “dielectric constant” of material between electrodes
- Proximity
- Touch
- Distance
- Fluids



Piezoelectric

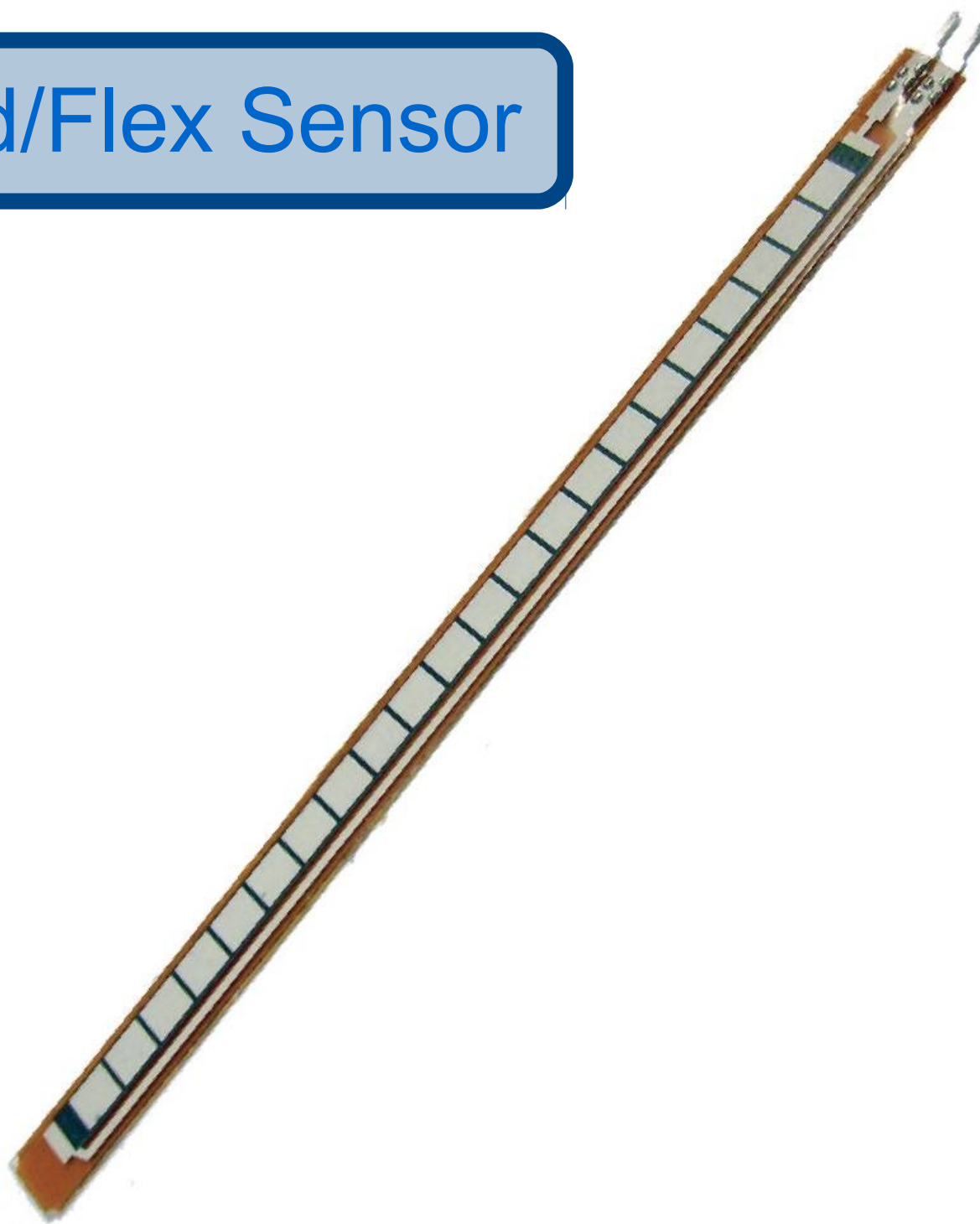


- Impact
- Change in force
- Vibration

Piezoresistive Strain Gage



Bend/Flex Sensor

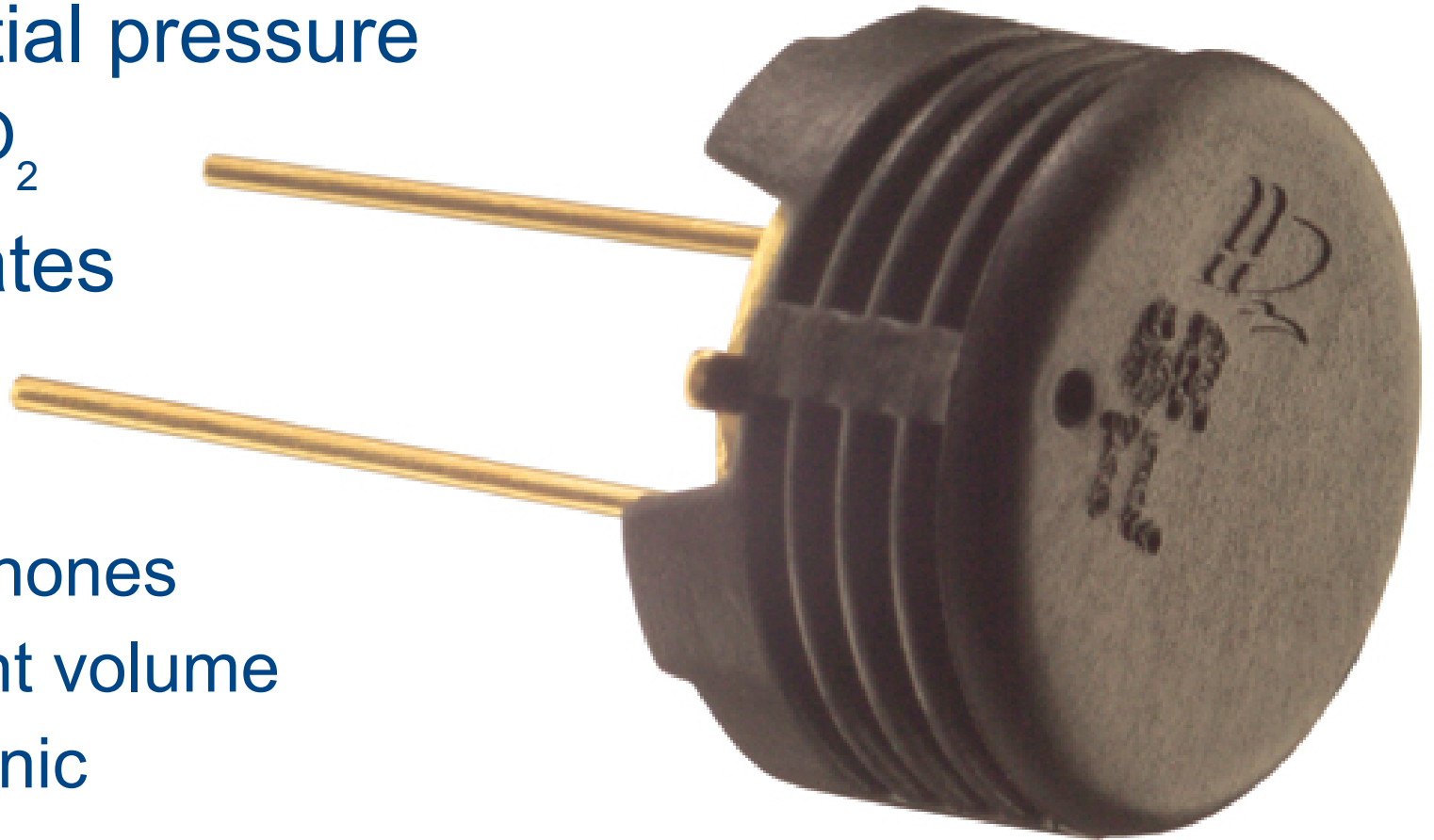


Load Cell



In-Air Sensors

- Humidity
- Ambient pressure
- Gas partial pressure
 - CO_2 or O_2
- Particulates
 - Smoke
- Acoustic
 - Microphones
 - Ambient volume
 - Ultrasonic





GSR

Other Sensors

- Temperature
- Sound or light time-of-flight
 - Good for measuring absolute distance
- pH sensors
- Force-sensitive resistors
- RF power measurements
- Integrated optical flow IC's for movement
- Fluid flow rate
- Fluid pressure
- RFID

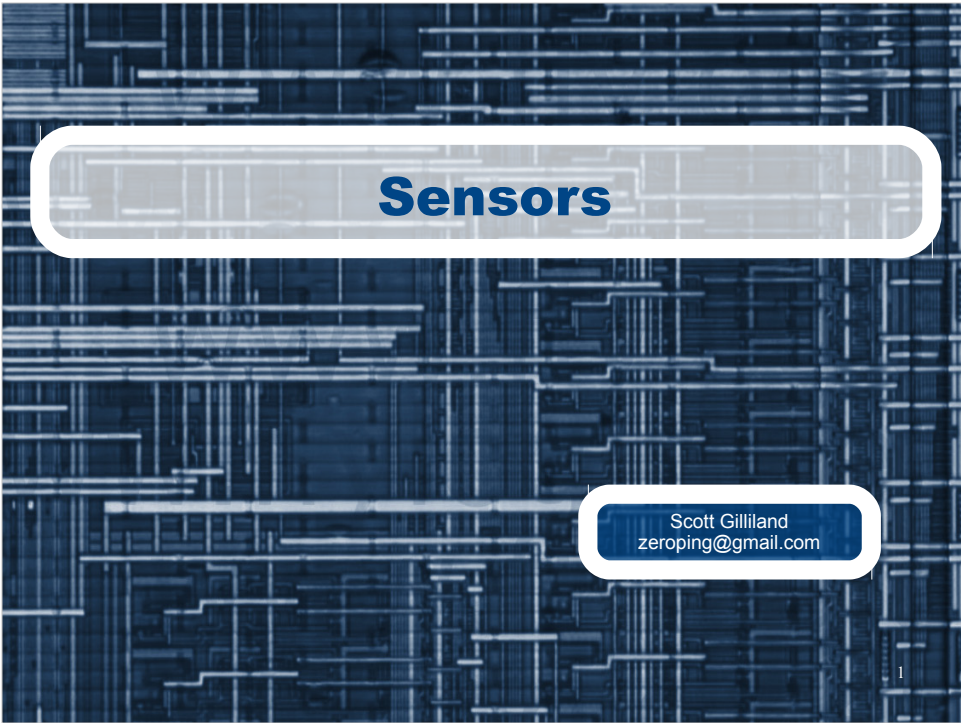
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 - False triggering or saturation (light sensor in sunlight)
- Constrain conditions if possible
- Use complex post-processing if needed

Suppliers

- [Mouser.com](https://www.mouser.com)
- [Digikey.com](https://www.digikey.com)
- [Sparkfun.com](https://www.sparkfun.com)

Chess Example

The background of the slide is a high-resolution, close-up photograph of a printed circuit board (PCB). The image shows a dense network of fine, light-colored traces and larger, more prominent conductive paths on a dark blue or black substrate. The perspective is slightly angled, giving a sense of depth to the intricate electronic layout.

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Transfer function – the human eye/ear/etc is weird.

Accuracy = close to truth

Precision = repeatable

● Reference Data

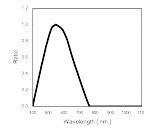


Fig 1 Spectral Response

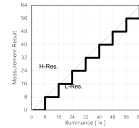


Fig 2 Illuminance - Measurement Result 1

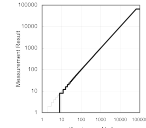


Fig 3 Illuminance - Measurement Result 2

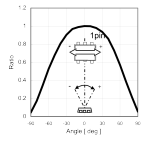


Fig 4 Directional Characteristics 1

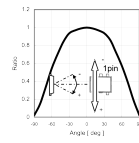


Fig 5 Directional Characteristics 2

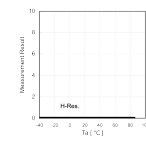


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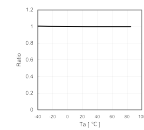


Fig 7 Measurement Result Temperature Dependency

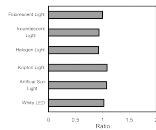


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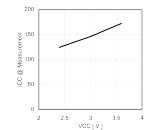


Fig 9 VCC - ICC (During measurement)

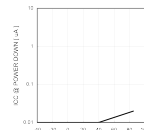


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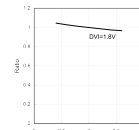


Fig 11 Measurement Result

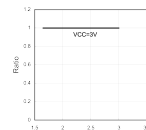


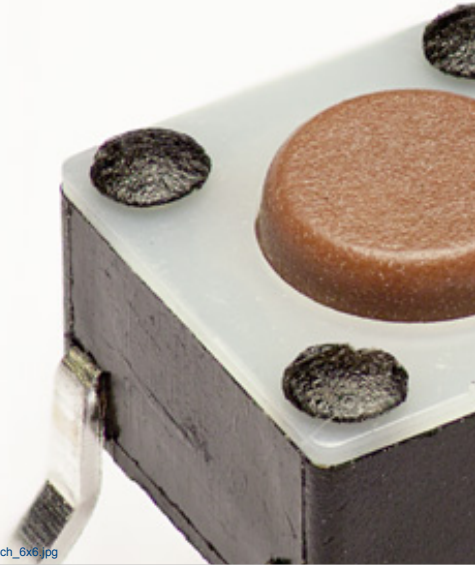
Fig 12 Measurement Result

Giant List of Sensors

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Tactile Switch



http://www.circuitsathome.com/wp-content/uploads/wp-content/uploads/wp-content/uploads/product_images/tactile_switch_6x6.jpg

Microswitch

- Click to add an outline

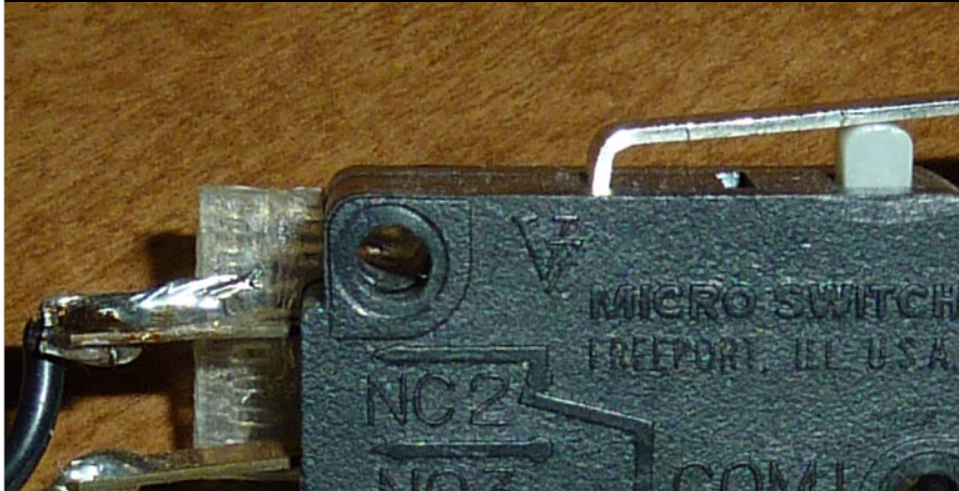
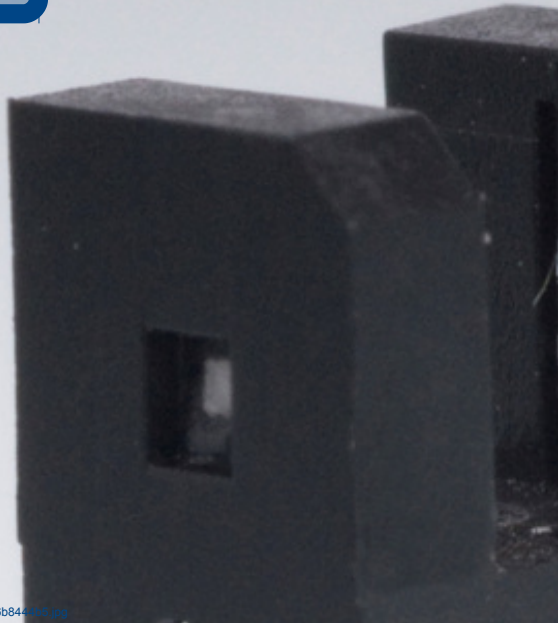
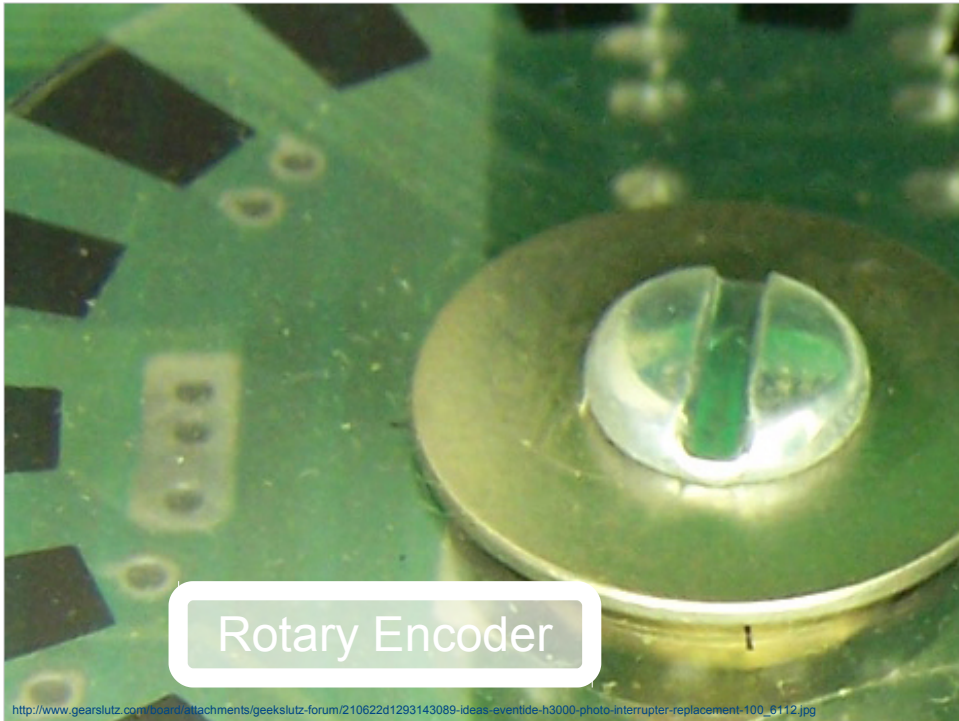


Photo Interrupter

<http://en.kodenshi.cn/imageRepository/03832042-03a4-4cda-ab4d-3c1e6b844a2d.jpg>





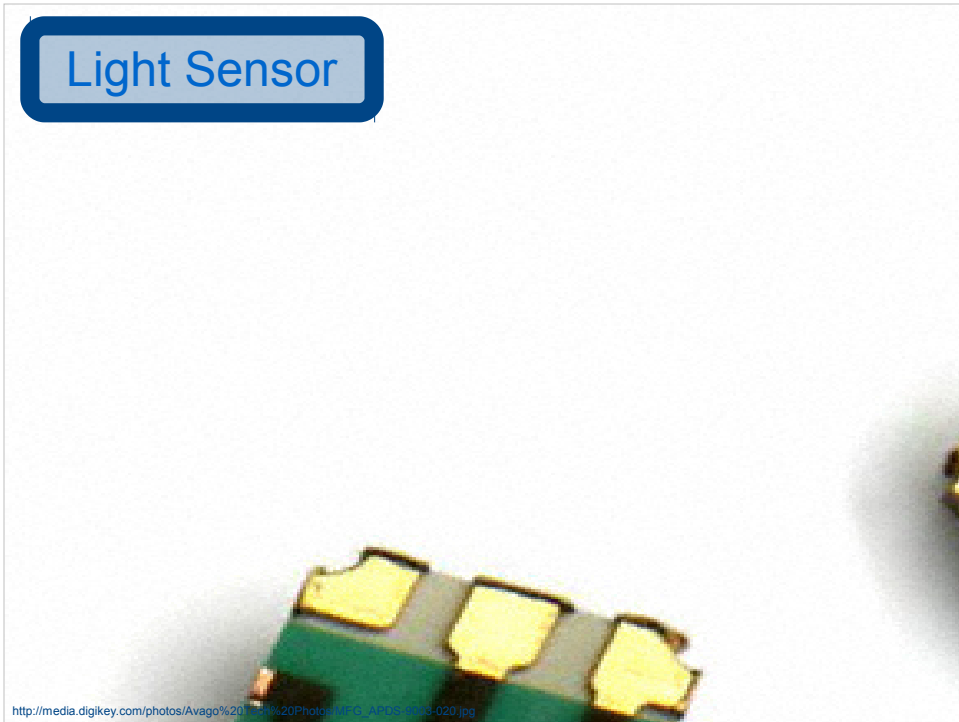
http://www.gearslutz.com/board/attachments/geekslutz-forum/210622d1293143089-ideas-eventide-h3000-photo-interrupter-replacement-100_6112.jpg

Reflective Proximity Detector



<http://media.digikey.com/photos/Avago%20Tech%20Photos/HSDL-9100-021%20MINISMD.jpg>

Light Sensor

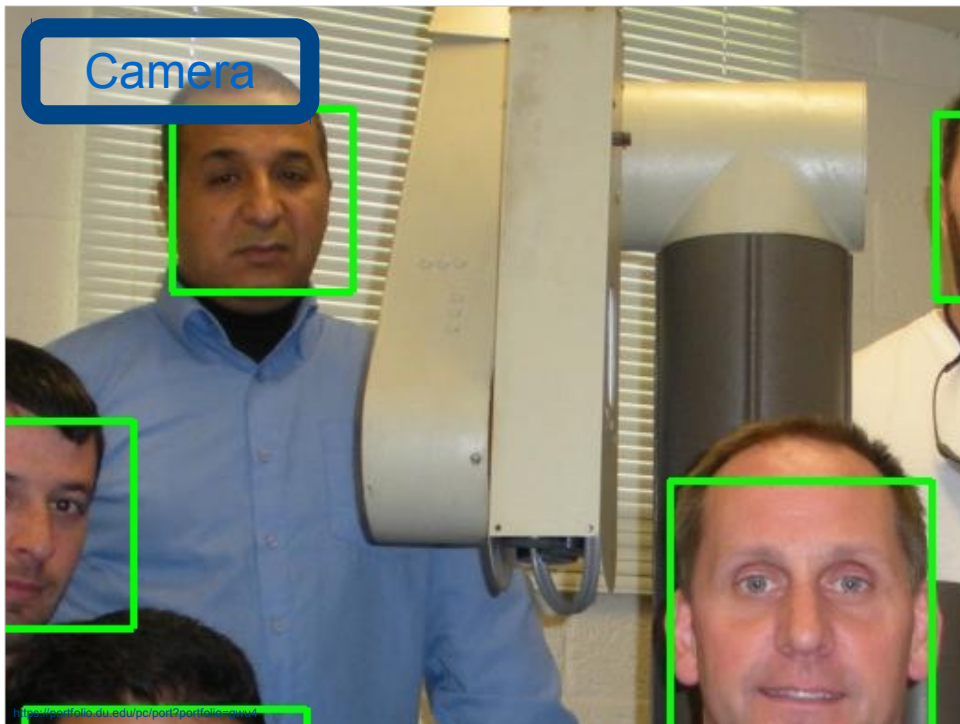


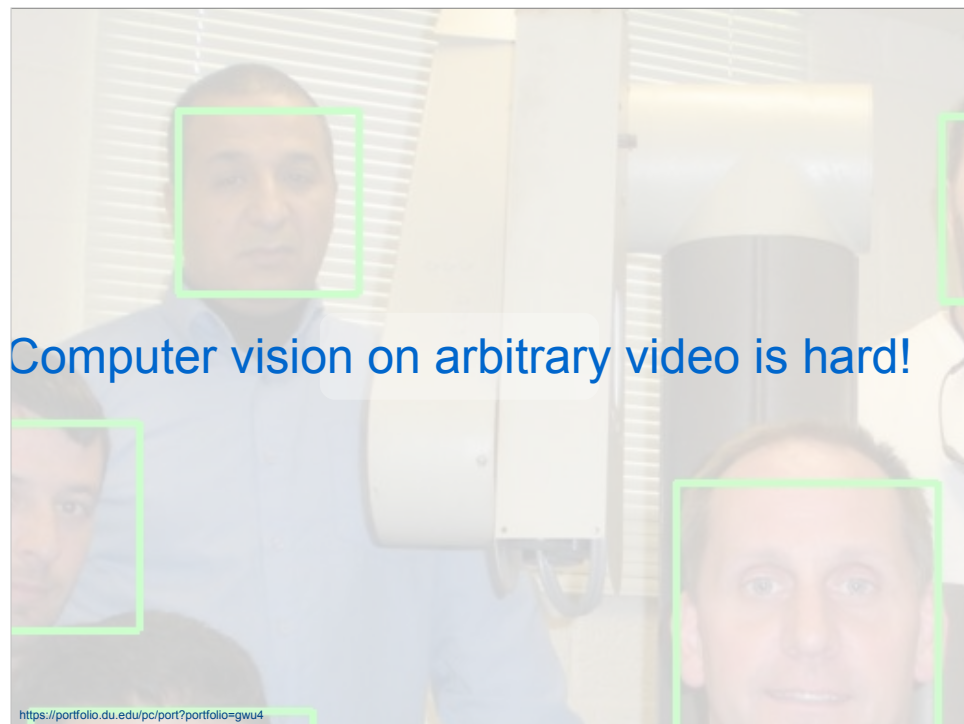
Photoresistors are slow

Photodiodes are hard to deal with

Phototransistors are better – can still be blinded

Smart ICs are best

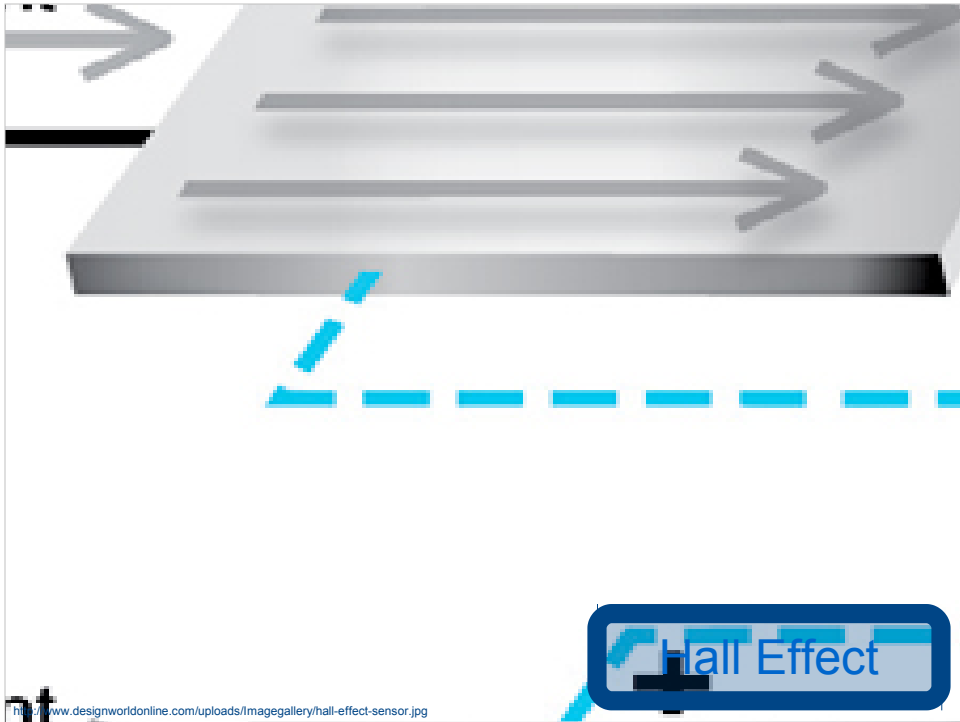




What the WiiMote sees

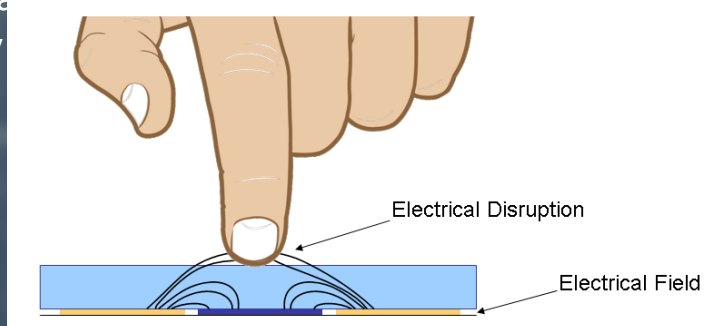
http://farm6.static.flickr.com/5128/5337604469_90256fefe4.jpg





Capacitance

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 - Size of electrodes
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- Proximity
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http://s.eeweb.com/members/jessica_shoemaker/blog/2011/08/17/image1-1313603666.png

Piezoelectric

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- Change in force
- Vibration

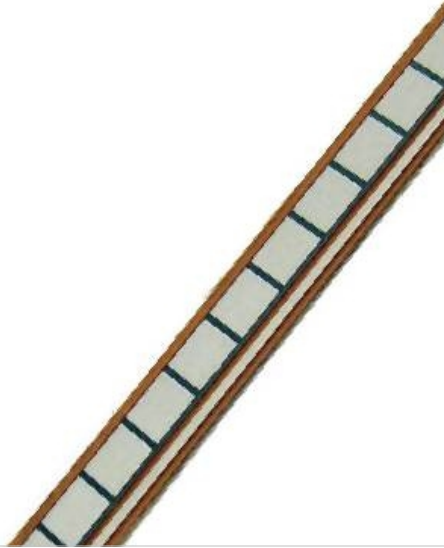
http://www.circuitsathome.com/wp-content/uploads/wpsolproduct_images/tactile_switch_6x6.jpg

Piezoresistive Strain Gage



http://www.astericconsulting.com/clients/Lambda/images/foil_fiber_strain_gages.JPG

Bend/Flex Sensor



<http://www.tacticalmarcomms.com/assets/1314722137.jpg>



In-Air Sensors

- Humidity
- Ambient pressure
- Gas partial pressure
 - CO_2 or O_2
- Particulates
 - Smoke
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 - Microphones
 - Ambient volume
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http://www.meas-spec.com/uploadedimages/Sensor_Types/Humidity/Products/IMG_HumiditySensor_HS1101LF.jpg



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Suppliers

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Chess Example

- Click to add an outline

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Say you wanted to make a chess board that tracks the game:

The general case is hard!

Unique pieces

Only one piece moves method

Easier!

Light