# CSE 190: Virtual Reality Technologies

LECTURE #12: 3D TRACKING TECHNOLOGIES PART 2

# Announcements

Project 2 due Sunday May 10th at 11:59pm

Project 3 to be released Monday at 1pm during discussion

Today's VR app presentations:

- Brandon Foey: Gravity Pull
- Kwok Ming Leung
- Brandon Chau

# Overview

Position/Orientation Tracking
- Mechanical Tracking
- Electromagnetic Tracking
- Ultrasonic Tracking
- Inertial Tracking
- Optical Tracking
- Tracking with Radar

Outside-in/Inside-out Tracking

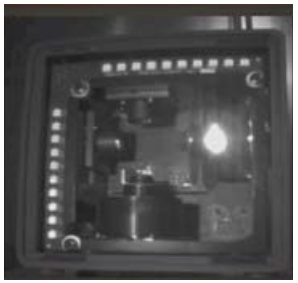
Hand/Finger Tracking

Eye Tracking

Application-specific Input Devices

# Optical Tracking Continued

# HTC Vive Lighthouse



- Runs at 60 Hz
    - i.e. horizontal & vertical update combined 60 Hz
    - broadband sync pulses in between each laser sweep (i.e. at 120 Hz)
- Each laser rotates at 60 Hz, but offset in time
- Usable field of view: 120 degrees
- Sync pulse emitted 120 times per second (Hz)
- Each sync pulse indicates beginning of new sweep

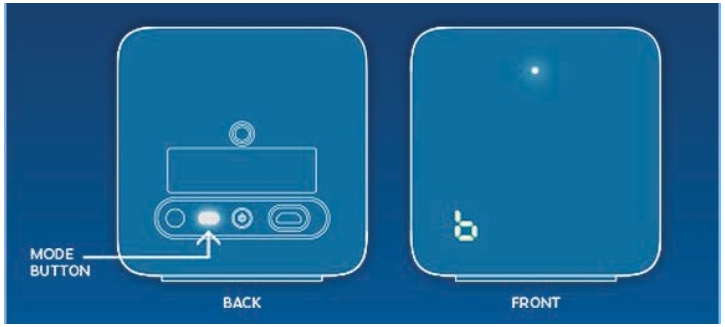
# HTC Lighthouse – Base Station

- Can use multiple base stations simultaneously via *time-division multiplexing* (TDM)
- Base station modes:

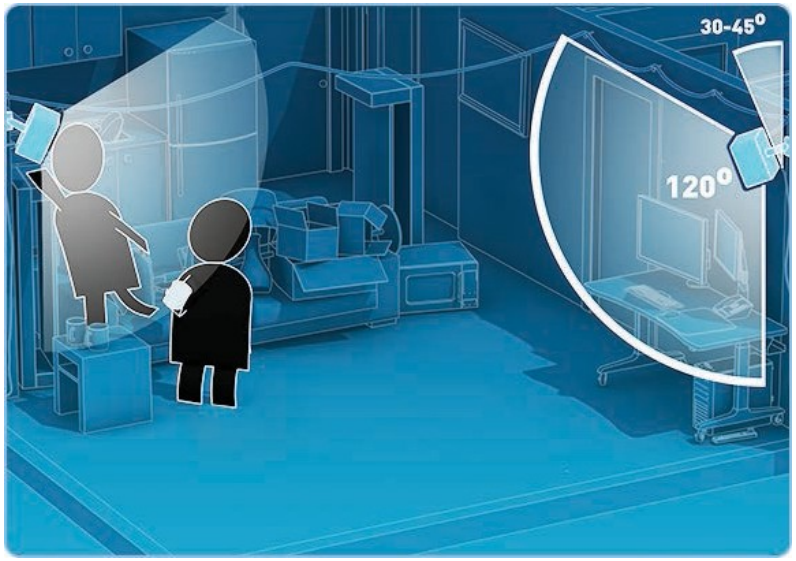
  A: TDM slave with cable sync

  B: TDM master

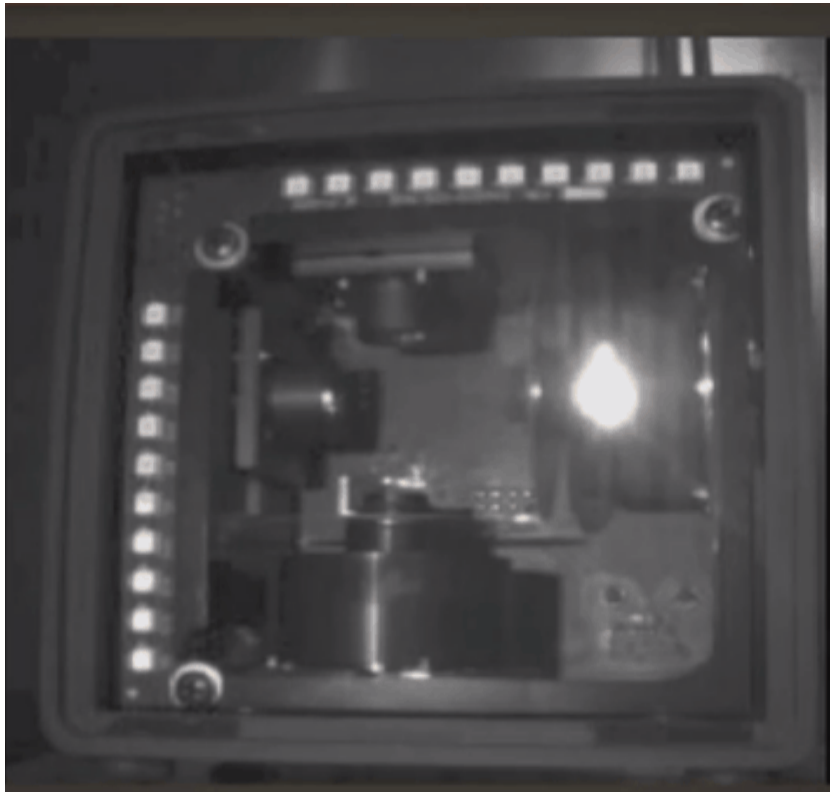
  C: TDM slave with optical sync

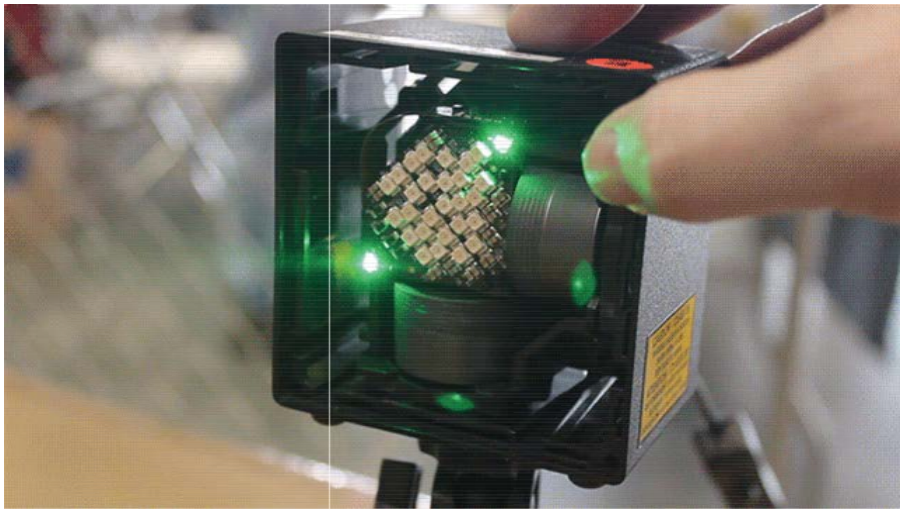



HTC



# HTC Lighthouse





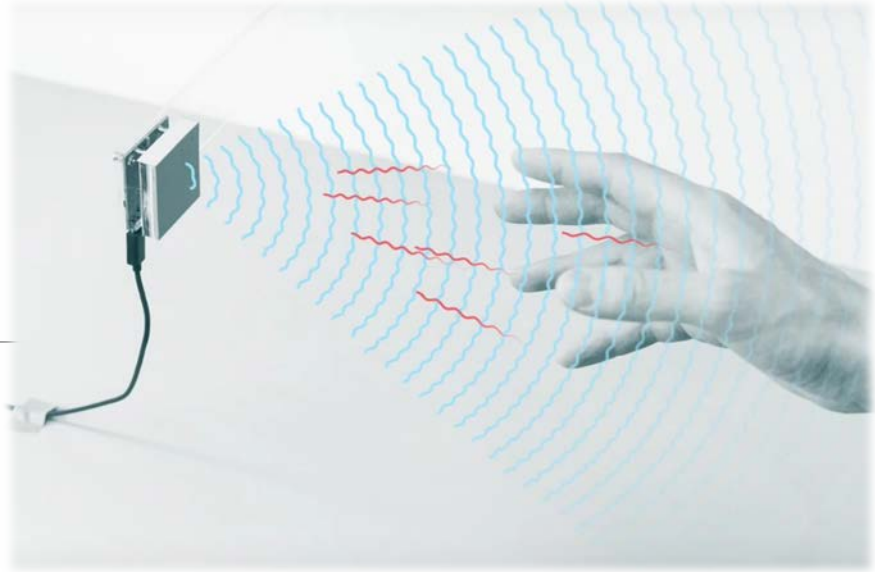
http://gizmodo.com/this-is-how-valve-s-amazing-lighthouse-tracking-technol-1705356768

# HTC Lighthouse


https://www.youtube.com/watch?v=J54dotTt7k0

# Tracking with Radar

# Radar



Tracking with radar is early stage technology.

Most prominent example: Google's Project Soli from 2015

- https://www.youtube.com/watch?v=0QNiZfSsPc0

Soli sensor technology works by emitting electromagnetic waves in a broad beam.

Objects within the beam scatter this energy, reflecting some portion back towards the radar antenna.

Properties of the reflected signal, such as energy, time delay, and frequency shift capture information about the object's characteristics and dynamics, including size, shape, orientation, material, distance, and velocity.

# Application-Specific Tracking

# Application-Specific Devices

Virtual hang-gliding over Rio de Janeiro (L. Soares at. al.)

Virtual canoe, Siggraph 2005

https://www.youtube.com/watch?v=8kjZ-nKjfgE

# Cave Painting

Physical props (brush, color palette, bucket) allow intuitive painting

Created by Daniel Keefe at Brown University (now Prof. at Univ. of Minnesota) in 2001

Google Tilt Brush and Oculus Quill are modern versions for HMDs


# Cave Painting Video

http://www.youtube.com/watch?v=WQv-LnHrmwU

# Outside-In/Inside-Out Tracking

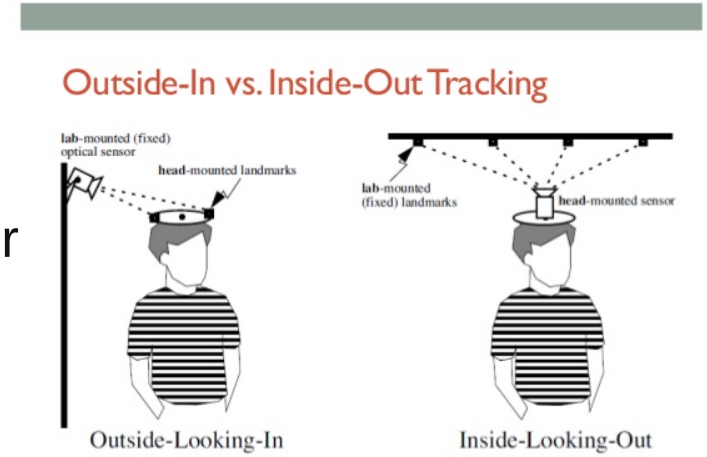
# Types of Positional Tracking

"**Outside-in tracking**": external sensors, cameras, or markers are required (i.e., tracking constrained to specific area)

- Used by Oculus Rift, HTC Vive

"**Inside-out tracking**": camera or sensor is located on HMD, no need for other external devices to do tracking (but can still have them)

- Simultaneous localization and mapping (SLAM) – classic computer vision problem



# Outside-In Tracking

Cameras or markers are placed around the room

Pros:

- Highest tracking accuracy and latency
- More trackers can be placed to increase accuracy and tracking volume

Cons:

- Limited tracking volume
- More equipment required
- Set up takes time

# Inside-Out Tracking

Device tracks itself without special preparation of environment

Typical solution:

- Simultaneous localization and mapping (SLAM)

Pro: unrestricted tracking volume

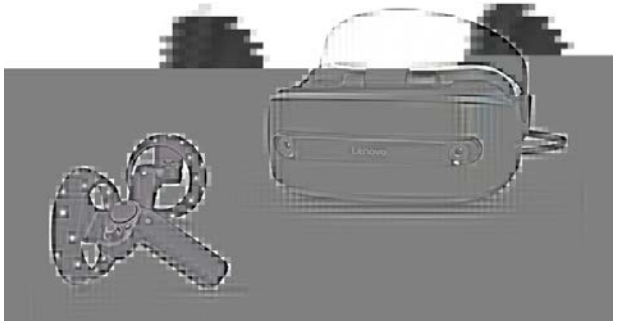
Cons:

- Lower accuracy and latency
- Significant computational requirements for image processing

# Inside-out Tracking

Marker-less inside-out tracking

Examples: Microsoft HoloLens, Microsoft Mixed Reality HMDs, Oculus Quest, Oculus Rift S



Lenovo Mixed Reality

Oculus Quest

# Outside-in Tracking

mechanical tracking

ultra-sonic tracking

magnetic tracking

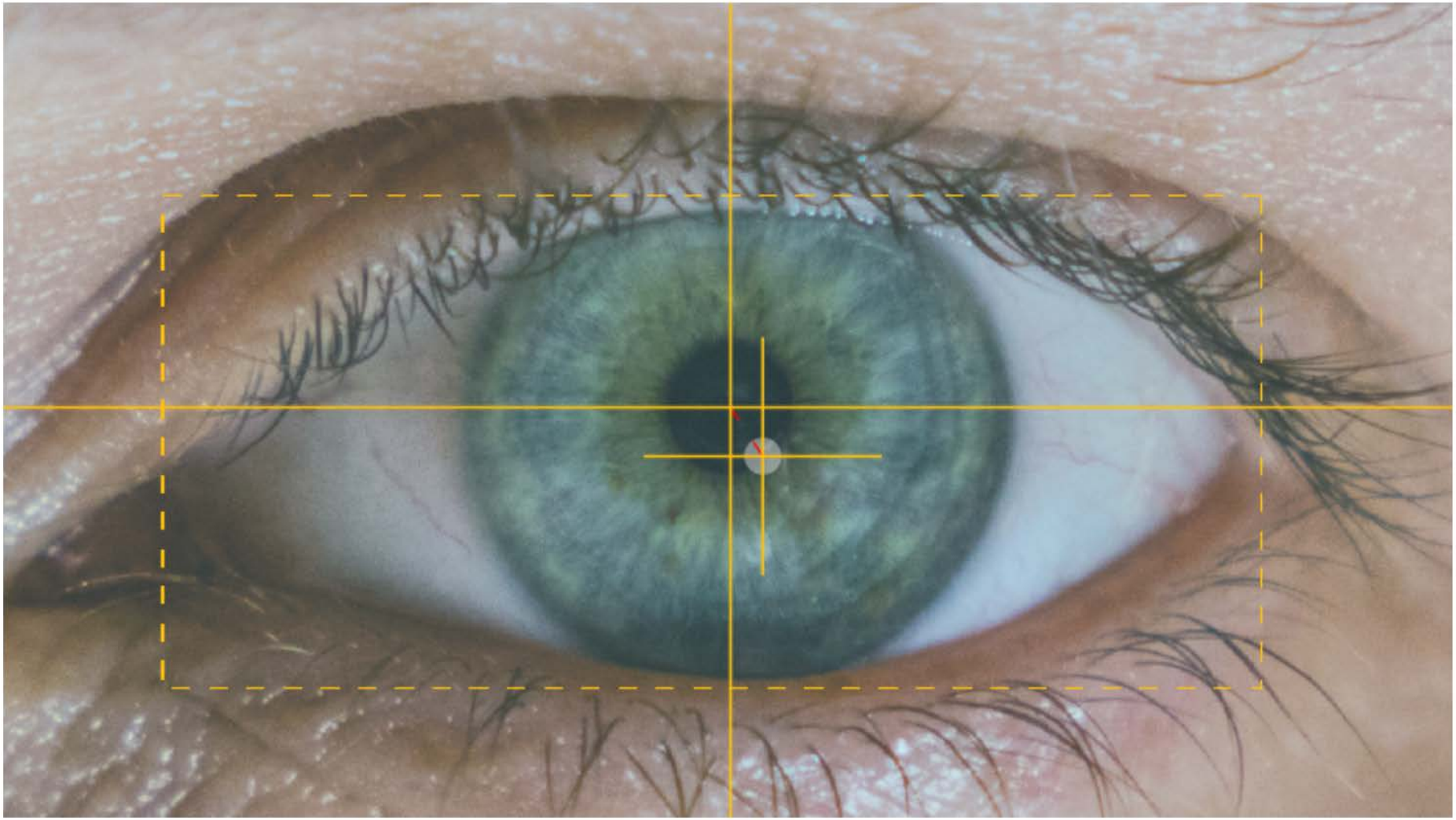
optical tracking

GPS

WiFi positioning

marker tracking

# Eye Tracking



The center of the eye (pupil center) is tracked in relation to the position of the corneal reflection. The relative distance between the two areas allows the calculation of the direction of the gaze.

# Tobii Eye Tracking

Add-on for VR headsets

Video: https://www.youtube.com/watch?v=q8GhIfsrizM

# Vive Pro Eye

Vive Pro with built-in eye tracking

Separate product from regular Vive Pro

# FOVE


Released Nov 2016

OLED display

2560×1440 pixels

70Hz refresh rate

90-100 degree field of view

6 DOF tracking with external camera

Eye Tracking: 120FPS infrared x2 (accuracy <1 degree)

Headphone jack (no built-in audio)

# Magic Leap

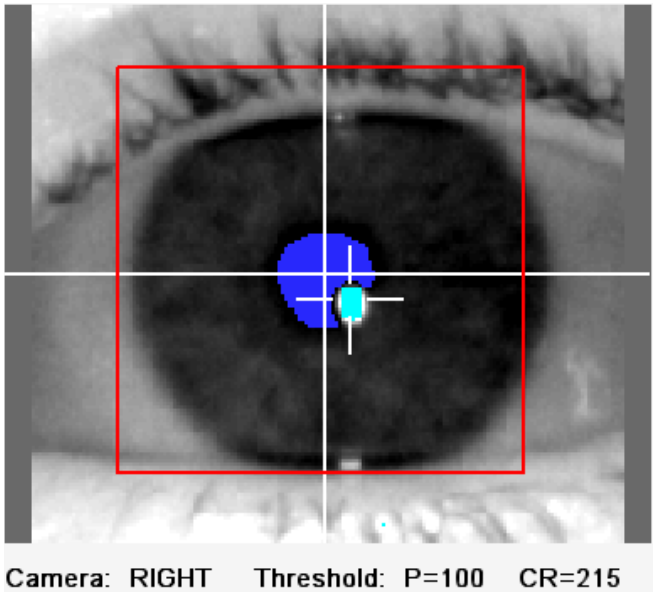
Built-in infrared eye tracking

# Eye Tracking Challenges

Pupil deforms during fast eye motion, inertia effects

Eye motion can be very fast

Small angular eye motion can mean large differences for distant objects



# Finger Tracking

# Hybrid Devices: Haptic Feedback Devices

Immersion CyberForce

PHANToM haptic device

Force feedback joystick

Exoskeleton-like devices

Microsoft force feedback joystick

LEXOS: Frisoli et. al., Italy

SensAble PHANToM

# Pinch Gloves

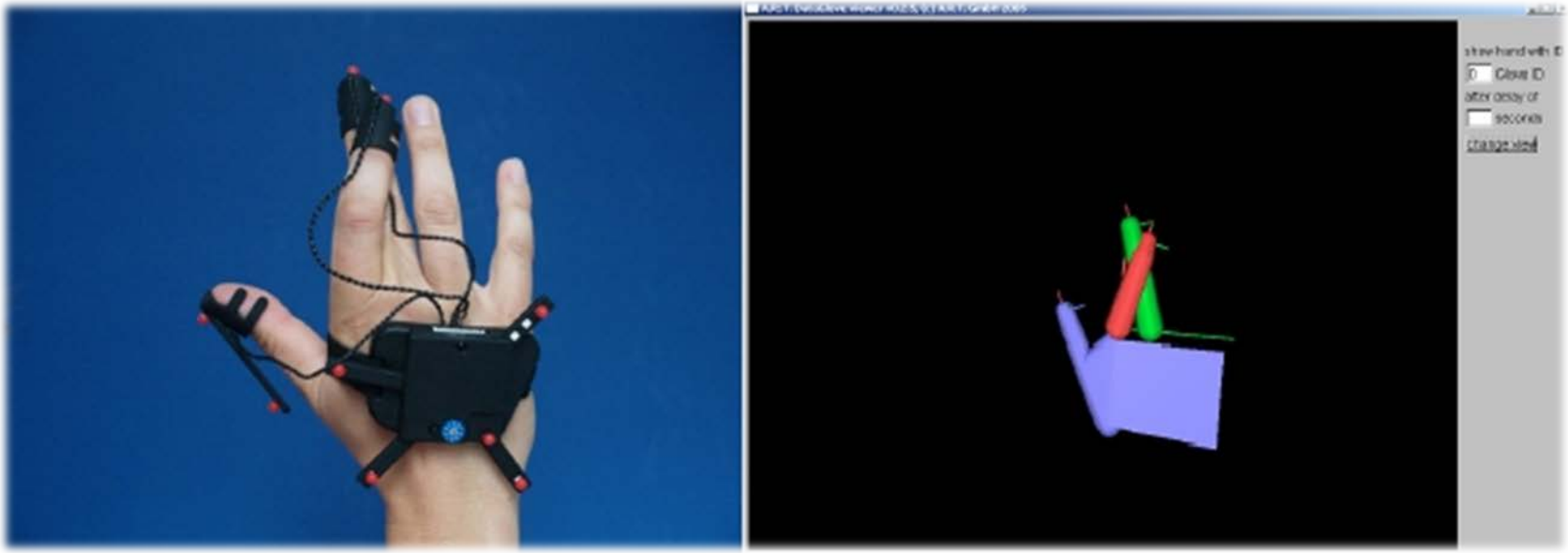
- Determine if two or more fingertips are touching
- Use conductive cloth to close circuit
- Tethered to controller box
- Designed for pinching and grabbing gestures
- Recognize any gesture of 2 to 10 fingers touching, plus combinations of gestures

www.fakespacelabs.com

# Optical Finger Tracking

Extension of ART system

Tracks three fingers and the hand



# Optical Finger Tracking

Oblong Industries g-speak

- Video: http://www.youtube.com/watch?v=9OpmxbPzDM0