ECE 1778:
Creative Applications for Mobile Devices

Lecture 2

January 16, 2019

(1)

Today

1. Logistics/Organization of Course & Project

2. Capabilities of Mobile Devices/Software
   – Together with example Creative Applications
   – to get you thinking about ideas for applications and how to truly leverage technology

3. More Introductions & Time for Team-Forming

Logistics & Project Process

Websites & Lecture Postings

- **If you missed the first lecture you can find it on first of the course websites:**
  - http://www.eecg.utoronto.ca/~jayar/ece1778/
  - Look under content
  - All lectures will be posted there

- **Keep an eye on the <u>Piazza</u> website for team-member introductions & other discussions**

- **Announcements will be sent through <u>Quercus</u>**

Recall: The Goal of This Course

- To bring together people from different disciplines
- To *prototype* interesting & creative <u>mobile/software</u> software application

Background Reviews of Programmers

- We have finished reviewing the background described by the programmers

- I have contacted, by email this morning, all programmers who I need to talk more to about their background

- If you didn't get an email, carry on. Otherwise, see me as requested.

Urgent Work for You: Form Group

- Must have group to stay in course!
- From Assignment 1, Part 1, on Piazza website:
  - Programmers have introduced themselves
  - Specialists introduced themselves & described their field

- **Right Away**, you should look at these, to achieve
  - Groupings of programmers
  - Outreach to Specialists

- Make initial contact through Piazza posts

Group Forming

Step 1: Two Programmers should find each other

Step 2: Form group with Specialist

- Groups with 3 or 1 programmer(s) will **not** be allowed
  - Too many, too few

- Group forming will take place over the next week
  - Reading Piazza & contacting by email
  - Next week's lecture
  - AND …

Extra Meeting to Form Groups/Discuss ideas

- This Coming Wed January 23rd, 6:30pm-8:00pm
- Galbraith Building, Room 220, 35 St. George Street
- We will help make matches & be there to kick around ideas to help with direction/scope

(9)
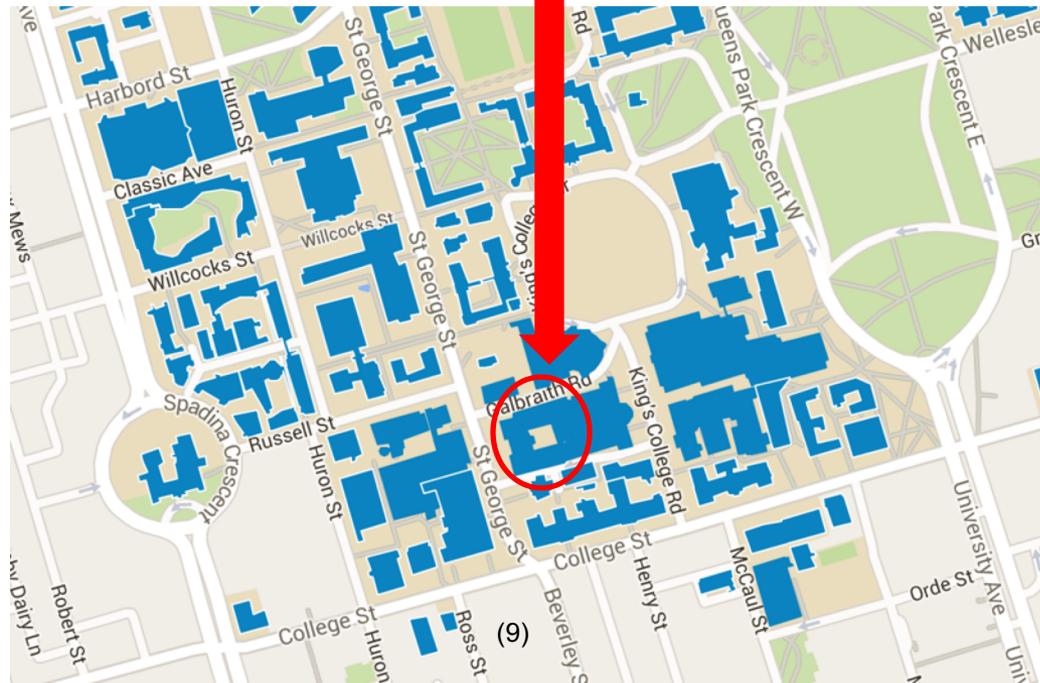
Numbers

- Number Submitted Part 1 of Assignments S1 or P1:
  - Programmers: 38
  - Specialists: 18

- Registered: 75
- Numbers are still fluid

Sign Up Sheets

- If you did not last do so week, please fill out the sign up sheets
  - Need to indicate name, dept, phone type, and if you are either:

- **Specialist:** non-programmer, with expertise
  - From specific discipline that app will leverage in significant way

- **Programmer**: capable of learning new environment fast

Once You Have Formed a Group

- **■** Send email to me:
    - Jonathan.Rose@ece.utoronto.ca
    - Copy email to all group members
    - this a formal commitment
- **■** The email **must** contain (**please do this**):
    - Names of all students and student numbers
    - UofT email address of all members (or otherwise if external)
    - <u>Department & Field</u> of each group member
    - Degree being pursued by each group member (M.A., Ph.D., M.A.Sc., M.H.Sc., M.Eng, M.S.A.C. etc.)
    - **Indicate who is a Programmer, who is Specialist/External Specialist**
    - Mobile platform: Android or iOS?

Initial Thoughts/Pointers on Project

- **Once you have a group:**
  - Specialist needs to give rough idea of discipline – teach!
  - Start kicking around ideas – you'll need to meet!
  - **Send me an email** when you think you have something concrete that you can describe in a few sentences
    - you will need my approval for any topic

- **Create a Plan: use Agile approach**
  - Begin by making some small version work, and grow, incrementally from there

Reprise: Rules on Project App

1. <u>Subject</u> **Must be in the discipline of the Specialist**
   - an idea to support research, or
   - something useful/worthwhile/interesting within the discipline
   - **must** leverage expertise that discipline & specialist

2. Must also have sufficient technical depth

3. *Should* be a new idea
   - Can be variant of existing app if enough different

4. **Should be a software application, mobile + web**
   - Course focus is mobile, and the assignments are mobile/web
   - However, will consider web-based if makes more sense & fits

Project Stages

1. **Forming Groups**
   - Form group by Thursday Jan 24; SEND EMAIL as DESCRIBED
   - extra meet <u>Wed Jan 23rd @6:30pm</u> GB 220
2. **Project Approval-in-Principle**
   - Done via <u>email</u> –send short description to me; will respond fast
   - Due January 29th prior to class; must have approval to proceed
3. **Project Proposal/Plan**
   - Document Due February 6th
4. **Proposal & Plan Presentations**
   - February 13th
   - **NOTE EXTRA Lecture Wed February 13th, 6-8pm, SF 1101**
5. **Spiral 2 & Spiral 4 Presentations**
   - 2: March 6/13 4: March 20/27
6. **Final Presentations**
   - Weeks of April 3/10
7. **Final Report Due April 17th**

Assignment 1 Part 2 Due Next Week

- For both P1 and S1
  - 6pm, Tuesday January 22nd
  - How are they going? P1 is new, different & harder this year
  - **There will be assignments over the next 1.5 months**
- Submit via Quercus
  - Be sure to submit to the correct assignment

What Programmers Should Be Learning

- With Assignment 1:
  - After downloading the various elements of the programming environment
- Java/Swift basics if not already known
  - http://en.wikibooks.org/wiki/Java_Programming/Language_Fundamentals
  - Or some basic Java Text, or the recommended Swift/Obj C
- Working within Android Studio/Xcode
- Running the basic environment
- Understanding the file infrastructure in each IDE
- Building basic user interfaces

Specialists: Should be learning & doing

- About capabilities of phones (today's lecture)

- What other apps in their field look like that have already been done (assignment S1 part 2)

- Using this, and thinking of ideas, or areas of ideas for the project apps

Programmers & Assignment P1

- There are a range of ways to do the tasks of Assignment P1.

- Here is an example video of a version of P1: video link

- A less-good version would lose marks because
  - Awkward UI, doesn't attempt to make things clear
    - Small fonts, unbalanced screen …
  - Doesn't follow the specifications in assignment

Android Phones Available for Loan

- We have a number of Huawei Nexus 6P phones available for loan, for those who need them for assignments and the Project

- Contact course TA to borrow:
  - Daniel Di Matteo
  - dandm@ece.utoronto.ca
  - You will take responsibility for the phones you borrow
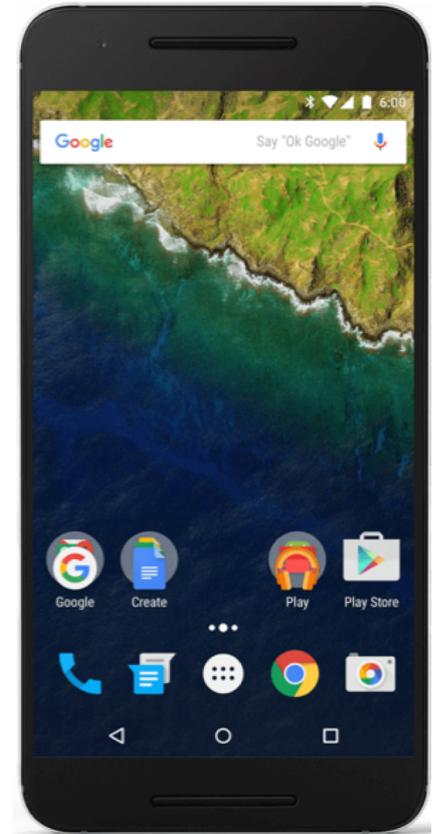
Note for Apple iPhone/iPad Users

- **Recall you must have a Mac to do this**
  - Also, you must be sure that your project group has aligned itself under the Apple – doing the assignments in Apple

- **You do not have to sign up under the Apple developer program to be able to use your own device**
  - To put apps on app store, you need to be in the program
  - Not required for the course; costs $USD 99/year to do so

Overview of Smartphone Capabilities
&
Example Applications

To Help your Creative Thoughts on the Project

A Smartphone is …

- **A Computer small enough to unobtrusively carry, that**
  - Is connected to the Internet – knowledge & compute power
  - Can **sense** its environment in many ways
  - Can **speak** to its environment in several ways

- **A *Computer***
  - Will do whatever you tell it to do, automating any drudgery
    - and never complain
  - Capable of sophisticated computation, including
    - analysis of its inputs
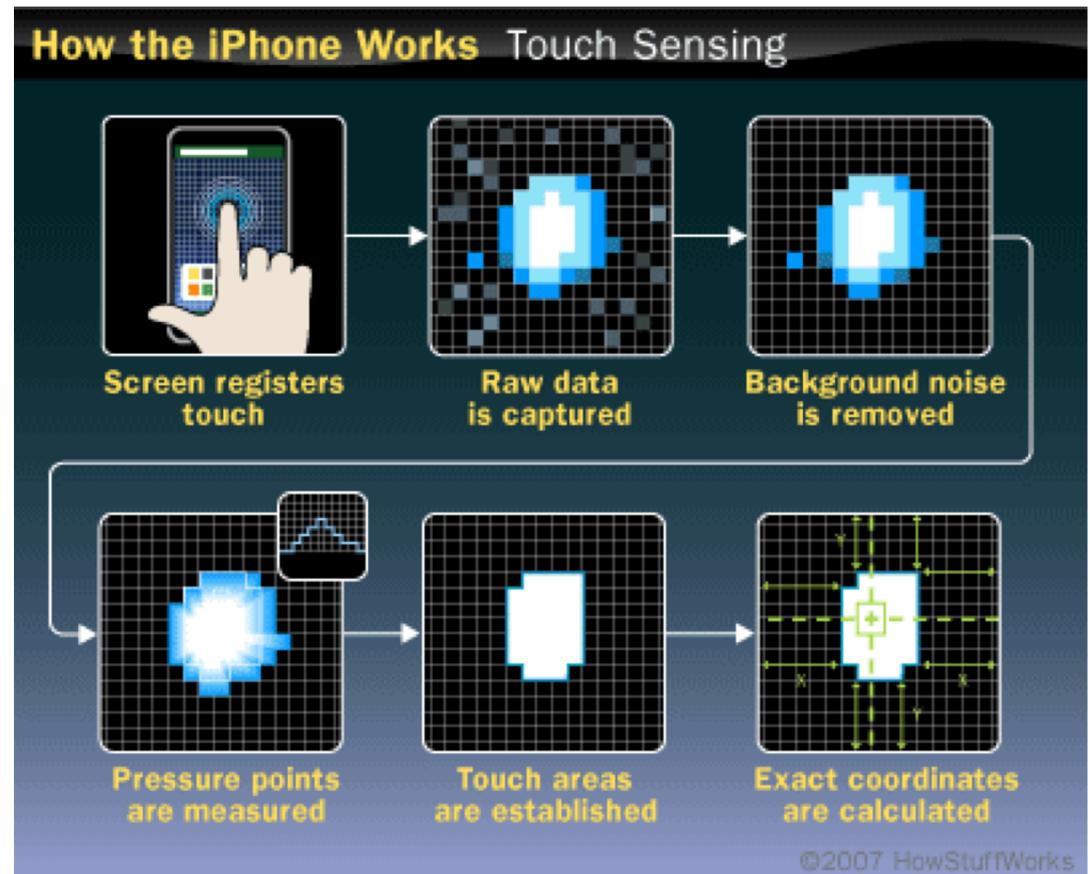   - generating complex sound and images
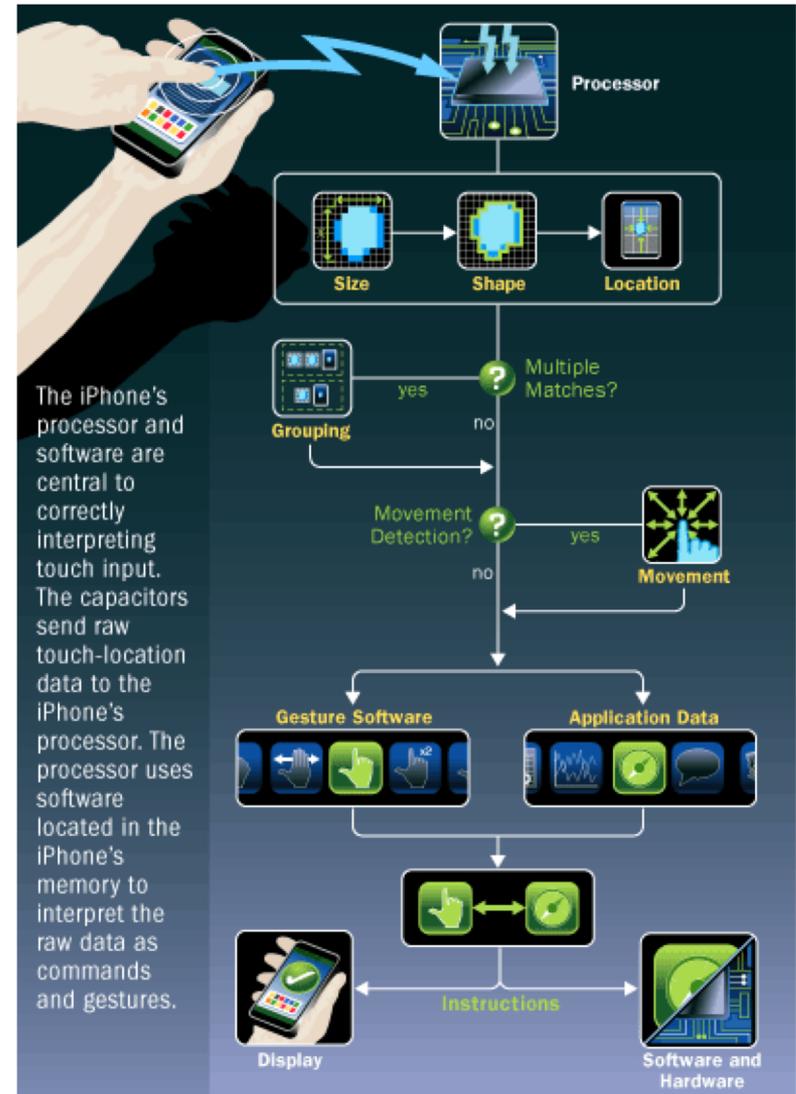
Inputs and Sensors

Touch Screen

- The screen surface detects the touch of a finger
- Each touch can be turned into a specific coordinate

How the iPhone Works Touch Sensing

Screen registers touch

Raw data is captured

Background noise is removed

Pressure points are measured

Touch areas are established

Exact coordinates are calculated

©2007 HowStuffWorks

(25)

Touch Screen

■ Coordinates can be turned into several different types of input:

1. Gestures
2. Selection actions
3. Tap counters
   - Double-tap
   - Triple-tap
4. Two Finger touch
5. Three Finger Touch …

The iPhone's processor and software are central to correctly interpreting touch input. The capacitors send raw touch-location data to the iPhone's processor. The processor uses software located in the iPhone's memory to interpret the raw data as commands and gestures.

(26)

Can Touch Screen Be More?

- Could this sensor be used to measure something about the finger?
    - Blood flow
    - Blood Pressure
    - Heart Rate

- Use for?
    - Medical Diagnosis
    - Lie Detector

Screen registers touch

Raw data is captured

- This one is my personal obsession, but in general, it is good to think how to use sensors in novel ways
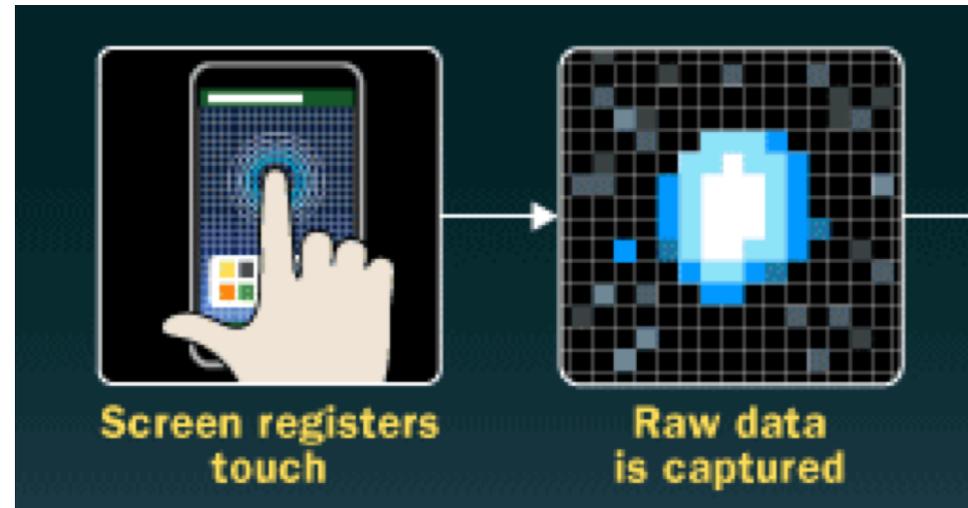
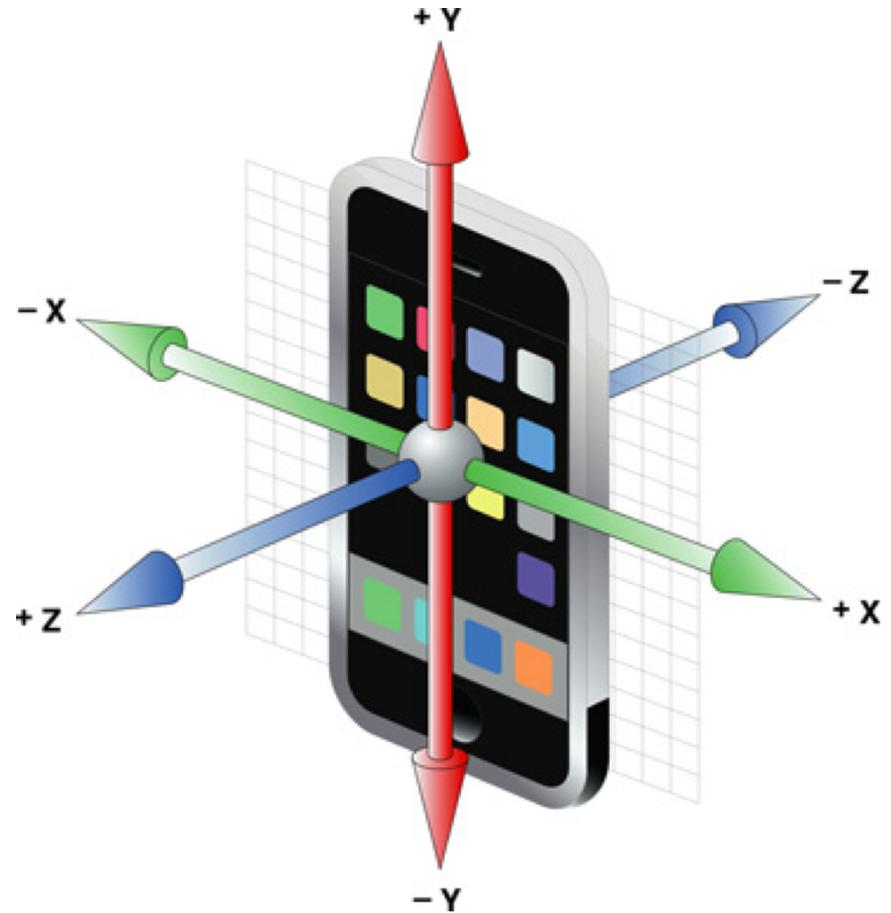# Nifty Touch Stuff Coming: Tactual Labs

- Company Specializes in low-latency touch
- Also 3D sensing on different objects

Accelerometer

- Can measure acceleration in 3-dimensions as shown

- Measured in **m/s^2**
  - Get measurement in each dimension X,Y,Z
  - Remember your high school physics!

- Phone can give a 'reading' 100 times/s
- Use for gestures

(29)

Can Feel What the User is Doing

- Walking – step counting

- Running – speed measurement

- Can it tell something about the user's walking Gait?
  - "Implementation of an iPhone as a wireless accelerometer for quantifying gait characteristics"
  - LeMoyne et. al, 32nd Annual International Conference of the IEEE EMBS Buenos Aires, Argentina, August 31 - September 4, 2010
  - There have been two prior gait analysis projects in this course

myAnkle

A Personal Physiotherapist for Ankle Injuries

Nirtal Shah, Ivan So, Lyndon Carvalho

Vivian Liu

Braiden Brousseau

Nirav Atre

Babneet Singh

Jordan Lee
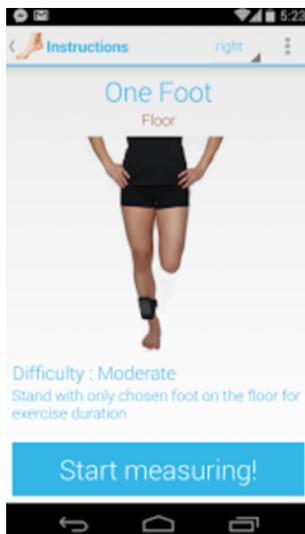
April 2011

(31)

Ankle Injuries: Sprain

- **Tipping on side**
  - Stretches ligaments

Ankle Injuries: Sprain or Break

- **Ankle injury causes a loss of ability to balance**
  - increased chance of re-injury

- **If you sprain or break your ankle, you should do physiotherapy to get this balance back**

- **Most people don't!**
  - Physiotherapist is expensive > $120/hr

Ankle sprain

Fibula (leg bone)
Tibia (shinbone)
Calcaneo-fibular ligament
Anterior talofibular ligament
Calcaneus (heel bone)
Talus (major ankle bone)

Usual Diagnosis & Treatment

Physiotherapist

Measure → **Prescribe**
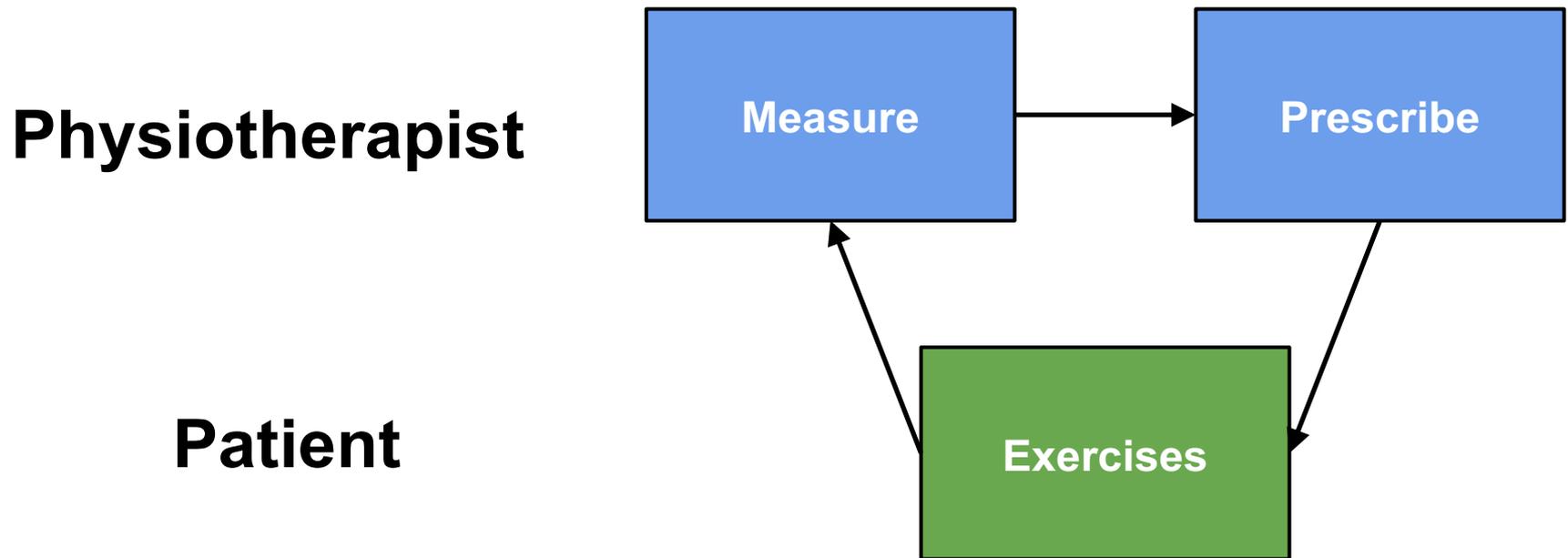
Patient

Exercises

Physiotherapist 'measures' by watching you walk/balance!
- **very subjective**

MyAnkle: Measure Balance with Accelerometer

1. Have patient do a balance exercise
   - stand on one foot

2. Strap Phone (or wearable) to ankle

3. Measure 'wobble' using accelerometer
   - Amount of motion while balancing measures your balance

4. Objective!
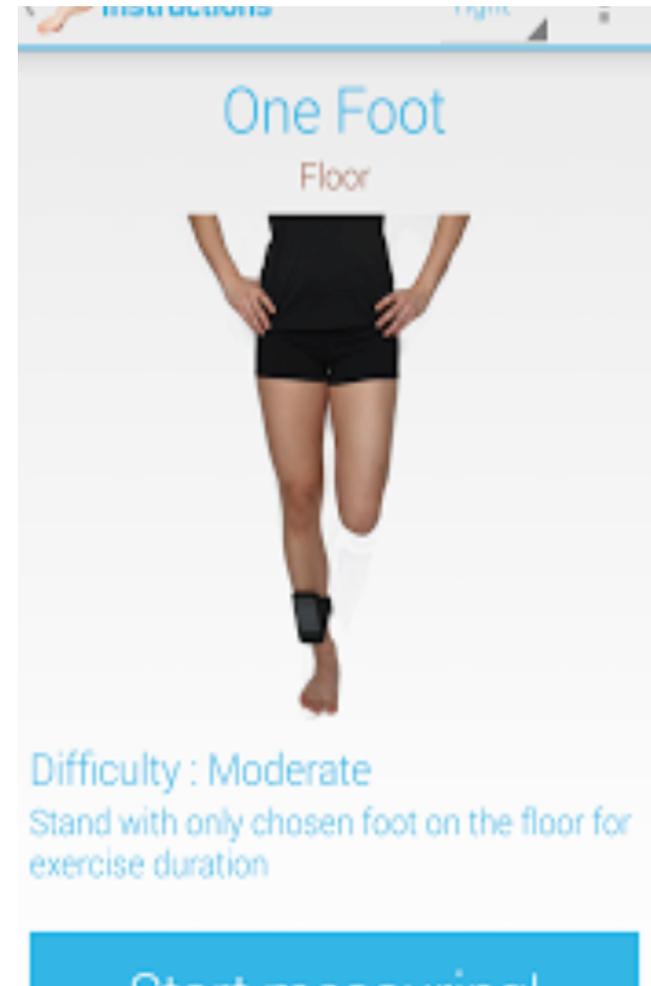
A Selection of Exercises
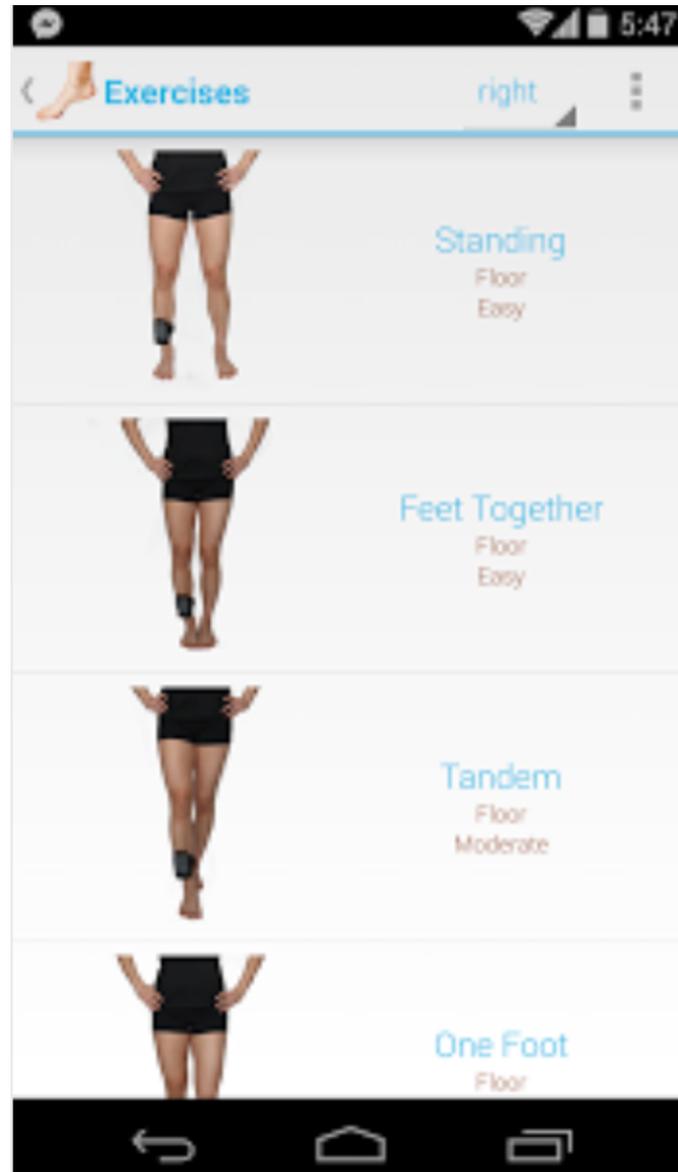
MyAnkle Gives A Number

- Measures the amount of movement when trying to balance!

- Have added ability to use wearable (the TI Sensor Tag that is used broadly in this course)

Results
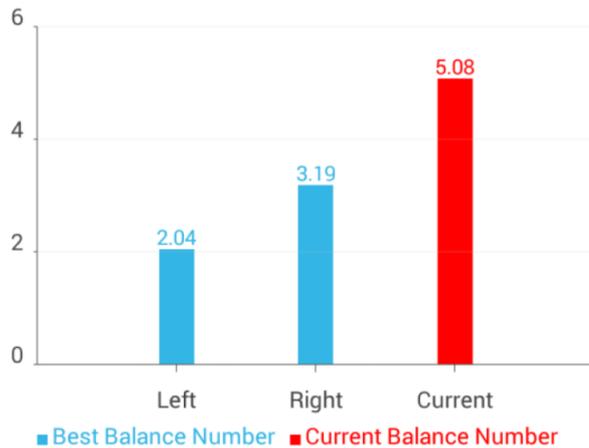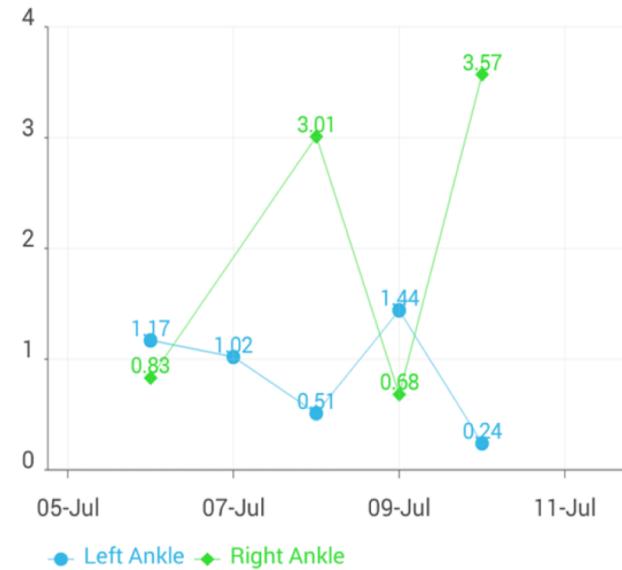
Status

- **Released to Google Play App Store**
  - Removed because we haven't kept it up to date
  - Need to re-compile!
- **App only measures, does not prescribe**
  - Ongoing research project to collect data
    - Need to learn what the numbers mean
  - Have experimented with other versions:
    - a 'prescription' front end web portal
    - Connects to phone to give instructions & measure outcome
- **Plan to continue working on this on both fronts**
  - Software development & clinical understanding

To Get Better: How To Recover Balance

- Key: Therapy is **same** as Measurement!
  - That is, to improve balance, stand on one foot for longer – say 60 to 150 seconds (hard!)

- To get better balance – practice balancing!

However, People Don't Want To!

- ■ "Compliance" is a big issue in physiotherapy
  - – People know they should, but don't!

- ■ With software, we can be creative
  - – Can physio be fun?
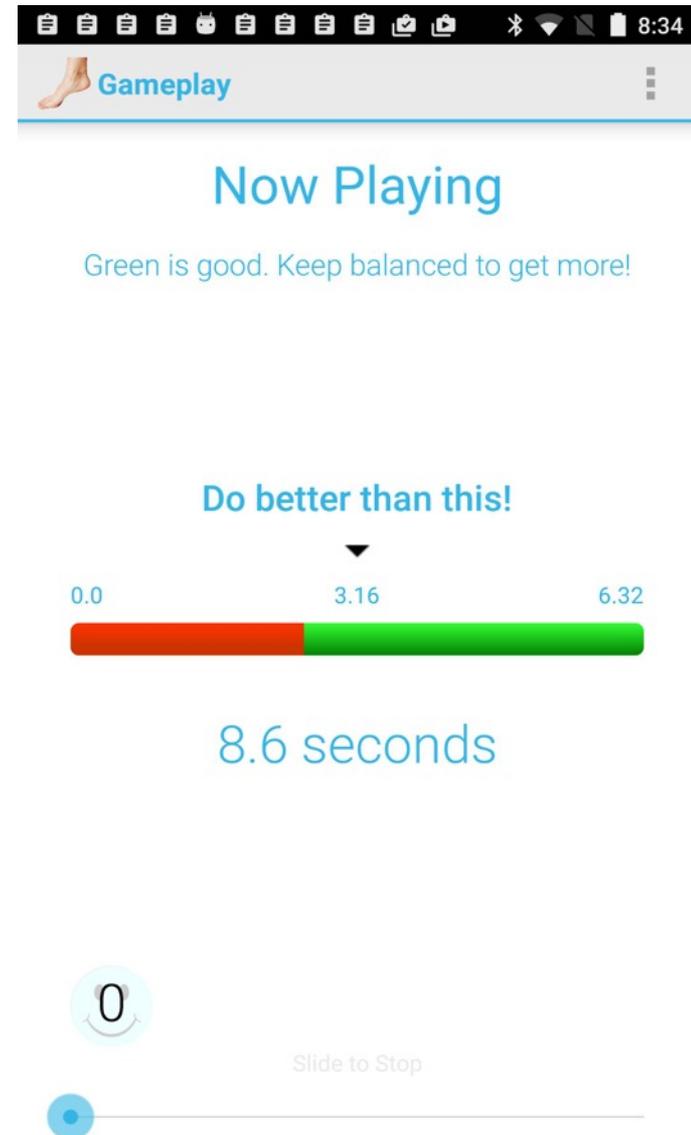 - – Can we turn it into a game?
  - – "Gamification"

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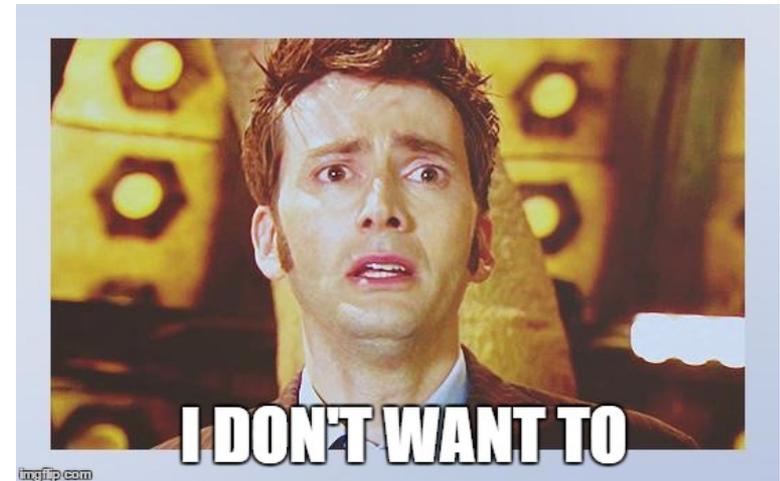
Here is the Game as it stands now

■ Step 1: Measure how much you wobble to start

MyAnkle Game

- **Step 2**: Try to do better
  - Show how did before
  - **Measure every 1.5 seconds** how you're doing
  - Display
  - Reward 5 seconds below calibration

MyAnkle Game Demo

Need Volunteer!

Other Applications of Motion Sensing

- Can tell if the phone is being shaken
  - Can use as an input
  - How sensitive is it?
  - Can it be used to measure Parkinson's tremors, in a medical application?
  - Delerium Tremens Detection: real vs. fake

- Can detect if person fell down
  - Could send alert

Gyroscope – measuring angular motion

■ **Gives: pitch, roll, and yaw**
  – of phone, along X,Y,Z axis

■ **Rotation rate in radians/s**

■ **Gives a different sense of the motion of the phone**
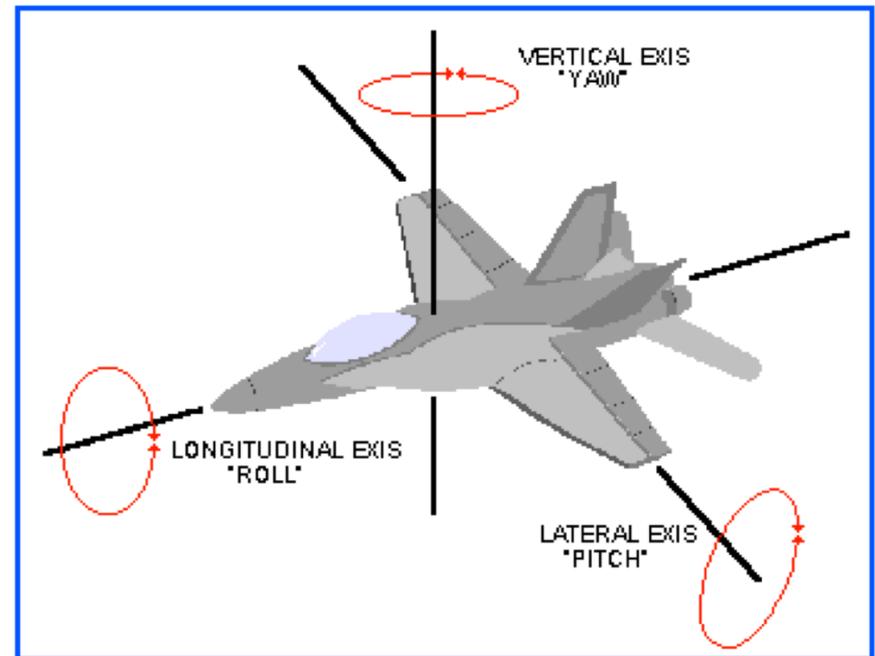
Compass

- **Really a magnetometer**
  - Can measure the magnetic field in 3 directions, X, Y, Z
  - Magnetic flux measured in micro-Tesla
  - Can use to make compass
  - Could also use as an instrument to measure presence of magnetic fields

- **Where do magnetic fields exist?**
  - Speakers, motors, screens, medical imaging, earth, big factories
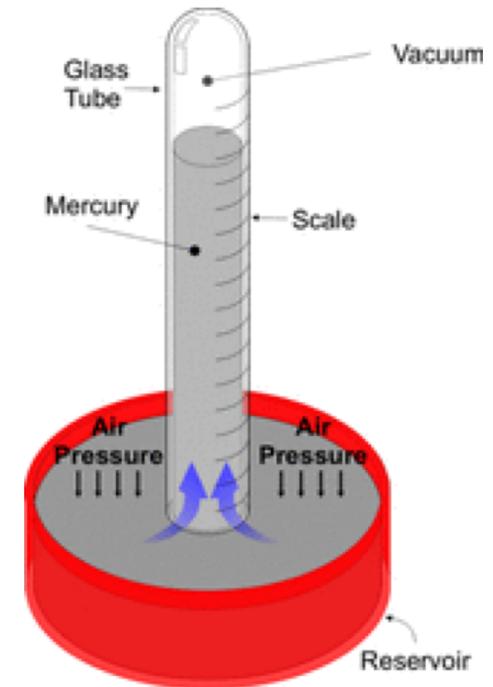- **What are they used for?**
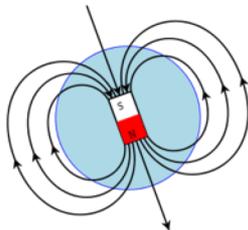
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Barometer

- **On Android & >= iPhone 6**
  - Measures atmospheric pressure
  - Change and rate of change gives an indication of weather

  - Measurement in hPA – hectoPascals
  - 1 atmosphere = 1013 hPA

- **Could use as Altimeter**
- **What could crowd-sourced pressure measurements reveal?**

Glass Tube — Vacuum — Mercury — Scale — Air Pressure — Air Pressure — Reservoir

Weather Prediction Using Barometer

- Decreasing barometric pressure indicates storms, rain and windy weather.
- Rising barometric pressure indicates good, dry, and colder weather.
- Slow, regular and moderate falls in pressure suggest a low pressure area is passing in a nearby region. Marked changes in the weather where you are located are unlikely.
- Small rapid decreases in pressure indicate a nearby change in weather. They are usually followed by brief spells of wind and showers.
- A quick drop in pressure over a short time indicates a storm is likely in 5 to 6 hours.
- Large, slow and sustained decreasing pressure forecasts a long period of poor weather. The weather will be more pronounced if the pressure started rising before it began to drop.
- A rapid rise in pressure, during fair weather and average, or above average pressure, indicates a low pressure cell is approaching. The pressure will soon decrease forecasting poorer weather.
- Quickly rising pressure, when the pressure is low, indicates a short period of fair weather is likely.
- A large, slow and sustained rise in pressure forecasts a long period of good weather is on its way.

(49)

Global Positioning Satellite Receiver

GPS Receiver

Real-time Differential GPS

- Determines location of phone in geographic coordinates
- Quickly accurate to within 100 meters, longer to do better
  - Does not work inside buildings
  - Has trouble when lots of buildings around

- Knowing where you are is incredibly useful in business; can provide context for assistive apps
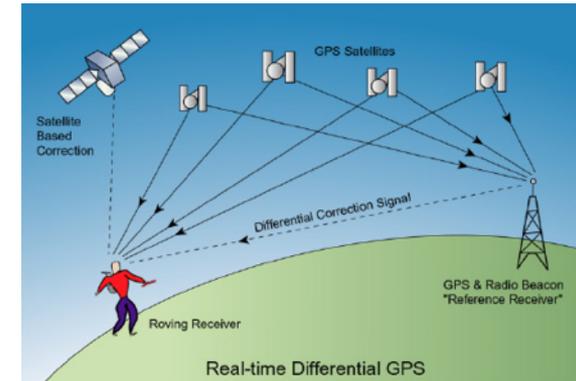
| Latitude: | 37° 19' 54.0804" |
| Longitude: | -122° 1' 50.6316" |

GPS & Suicide Prevention

In Screening for Suicide Risk, Facebook Takes On Tricky Public Health Role

Dec. 31, 2018

Facebook called Courtney Davis, left, a telecommunications operator at the Police Department in Rock Hill, S.C., about a man who was live-streaming a suicide attempt, helping Sgt. Bruce Haire find him.Logan R. Cyrus for The New York Times

Facebook called Courtney Davis, left, a telecommunications operator at the Police Department in Rock Hill, S.C., about a man who was live-streaming a suicide attempt, helping Sgt. Bruce Haire find him.Logan R. Cyrus for The New York Times

Location Services

■ In Android, there are several 'Location Services' available that include the GPS

- GPS uses a fair bit of power, can't have on all the time without draining the battery quickly

■ The other two methods of locating are using:

1. Cell phone tower triangulation
2. Wifi Network IP addresses of the routers

GPS

- ■ Can also get the raw position of the satellites themselves
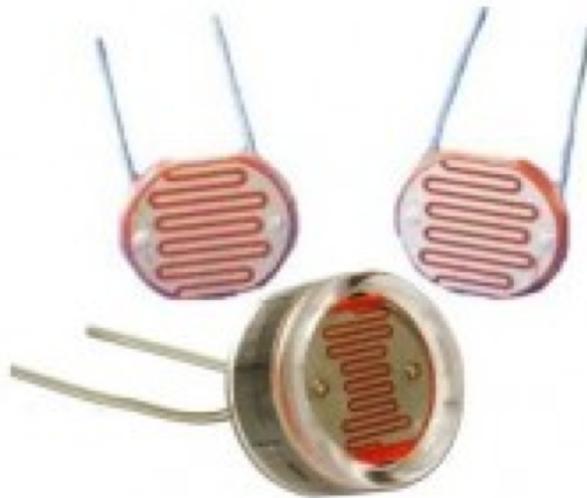 - – Someone in Aerospace might want to do something interesting with that

Altimeter

- Using the GPS, can also determine the height (from Sea Level) of the phone

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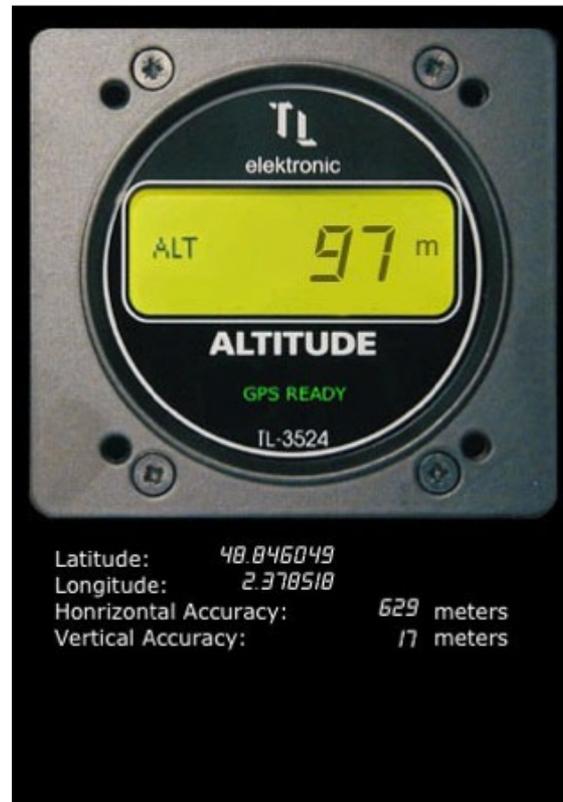
Ambient Light Sensor

- Used for measuring ambient light to set screen brightness
- Measures the light, in Lux
  - Across wide range of values
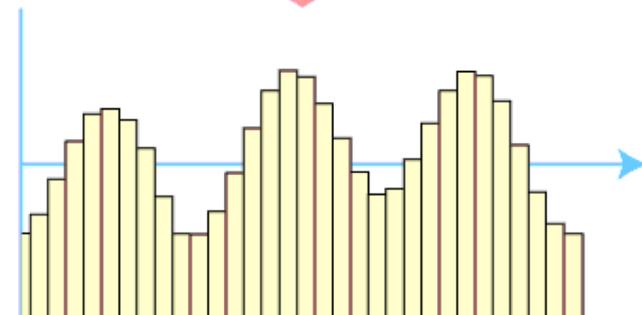

Light Dependent Resistor (LDR)   Photodiode

Microphone

- **Converts sound into data**
  - Microphone converts sound waves into voltage
    - Which varies over time
  - Circuit converts voltage into into digital values
  - Sound becomes a series of digital values
    - Get samples at 48K samples/s
    - Good quality sound!
- **Sound Processing**
  - aka **Digital Signal Processing**

Conversion A-D

(56)
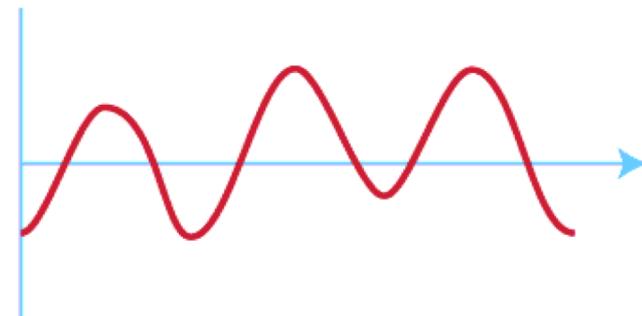
Microphone – Sonar Device

- **Could make a good sonar with this!**
  - Has been done, but is defunct:
  - www.creativeapplications.net/iphone/sonar-ruler-iphone/

Sound Processing Example

- **Famous Shazam app**
    - Listens to 15 seconds of song playing
    - Can tell you what the song is
    - Sends sound sample up to server to do this work
    - Lets you buy song
- **This is a class of application**
    - What other recognition tasks are there?

- **Most processing is done on a server**

Back Camera

- **Can record images**
  - Large files with high resolution
    - 2MPixels – 13 MPixels
- **Can record video**
  - ~ 30 frames/second of pictures
- **Can we use it to "see things"?**
  - Yes!
  - Computer Vision field
  - Previously: Difficult, slow
  - Recently: much better

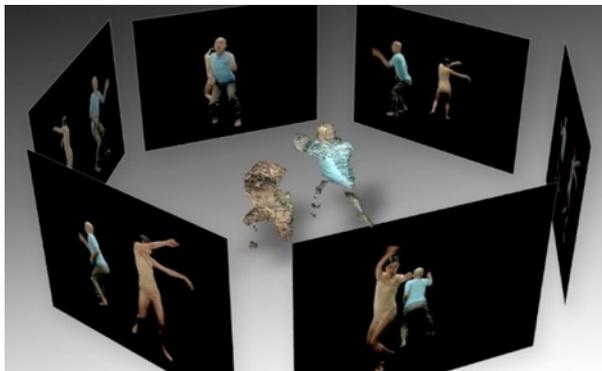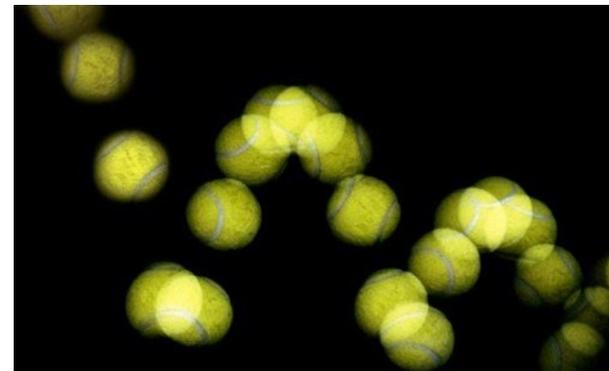# Computer Vision

■ Goal to 'see' the world in like people do
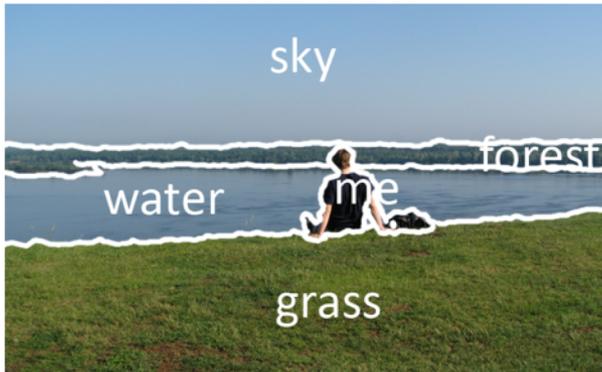
Image Segmentation
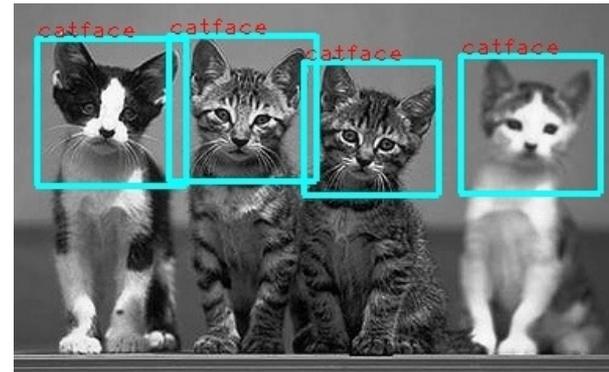
Object Detection

3D Scene Reconstruction

Motion Tracking Through Time

Computer Vision

- Computation to convert *many* pixels to information
- Computers 'see' in much the same way that people do
- Up until recently was hard to do!
- Modern machine learning has really enabled this in a big way
  - **Demo** of inception_V3 on android phone
 - Recent phones have specific hardware to accelerate!

Front Facing Camera

- **Allows for video interaction**
  - Skype uses this
  - Lower resolution than back camera
- **Can look at you and see how you're feeling**

Eye Tracking

- The ability to know where a person is looking on a screen
- Where your eyes look conveys huge amount of information
- Can present scenarios and see what people look at
- Local research uses this to diagnose:
  - Depression
 - Memory Loss
  - Anorexia
- Many other things possible
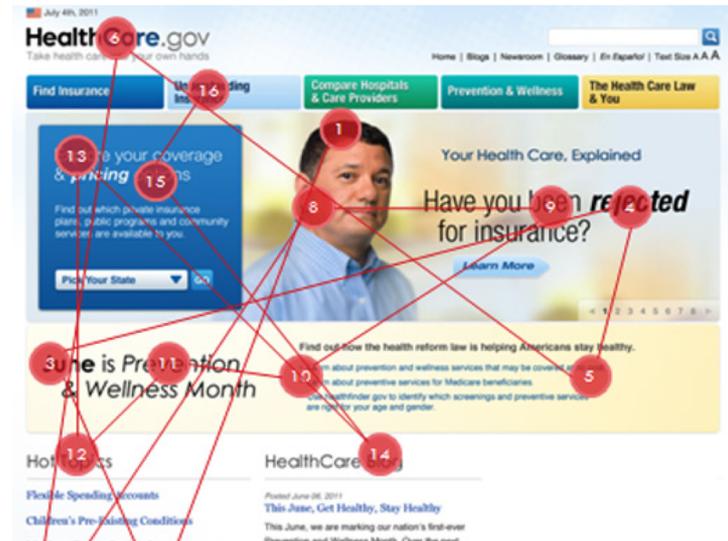
Eye Tracking

- **We have access to an eye-tracker + phone**
  - In our research
- **Perhaps a Reading application?**
  - Watch learner read, give help & support
- **Other application in the stimulus, view-view response**
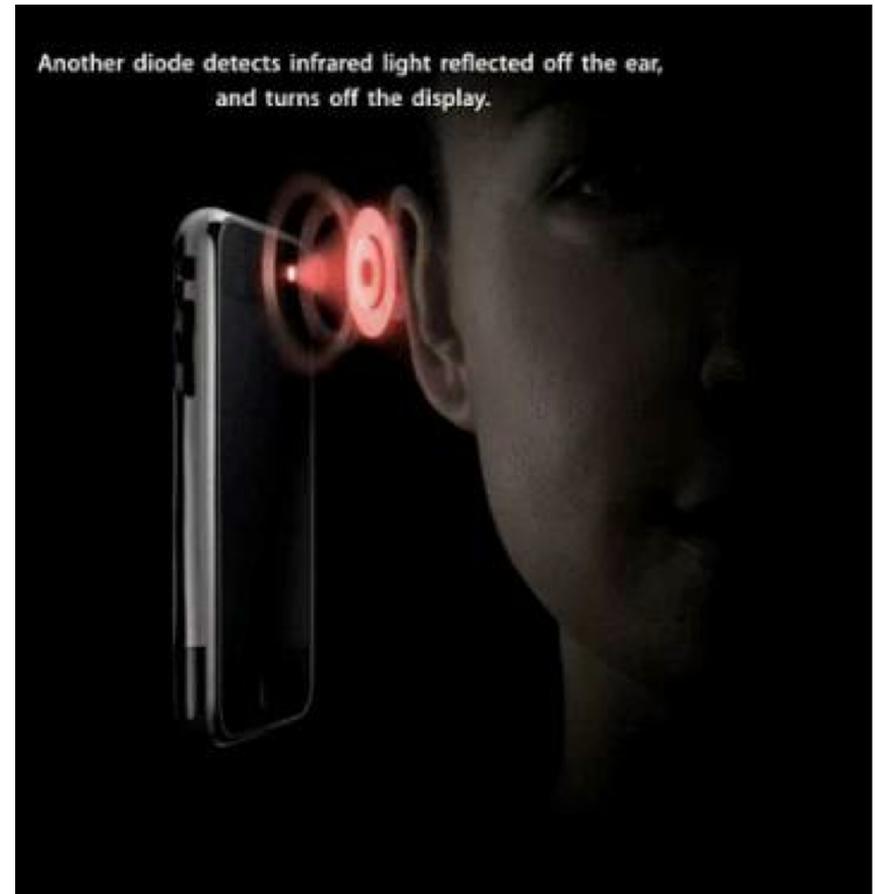- **Also have Tobii eye tracker bar which can connect to Android**

(64)

Super Human Capability!

- **Cardiio** – measuring heart rate by looking at colour changes in your face:
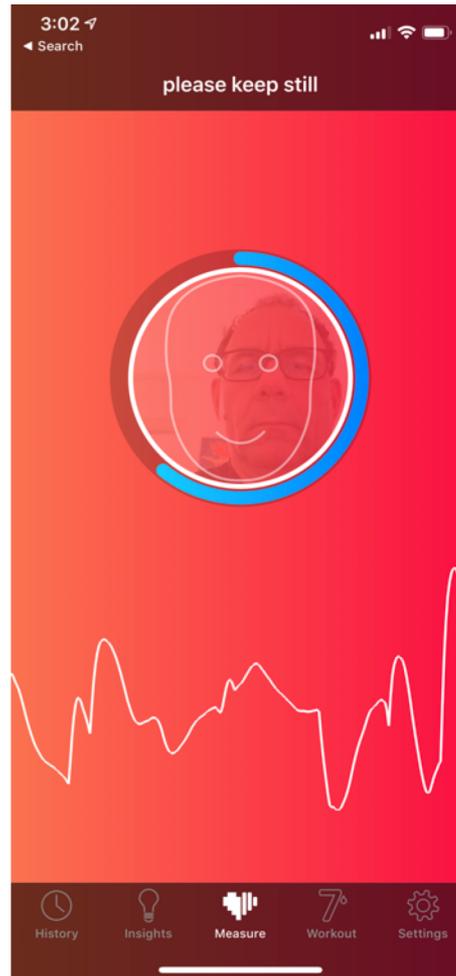
Proximity Sensor

- Can detect if phone is near to something, particularly the head
- Used to turn off touch screen when phone is to near to ear
- Simple Near/Not input
  - Doesn't give distance, yet

Another diode detects infrared light reflected off the ear, and turns off the display.

Output Devices

Hi-Resolution Screen

- **Most recent phones have very high quality screens**
  - Quality is the # & density of pixels

- **Nexus 6P**
  - 1560x1440 resolution
  - 518 pixels per inch

- **iPhone XS**
  - 1125 x 2436 resolution
  - 458 pixels per inch

Video Display Hardware

- **Special hardware to display 30 frames/second video**
  - Displaying video would have used up much or all of the processor's computational capacity;
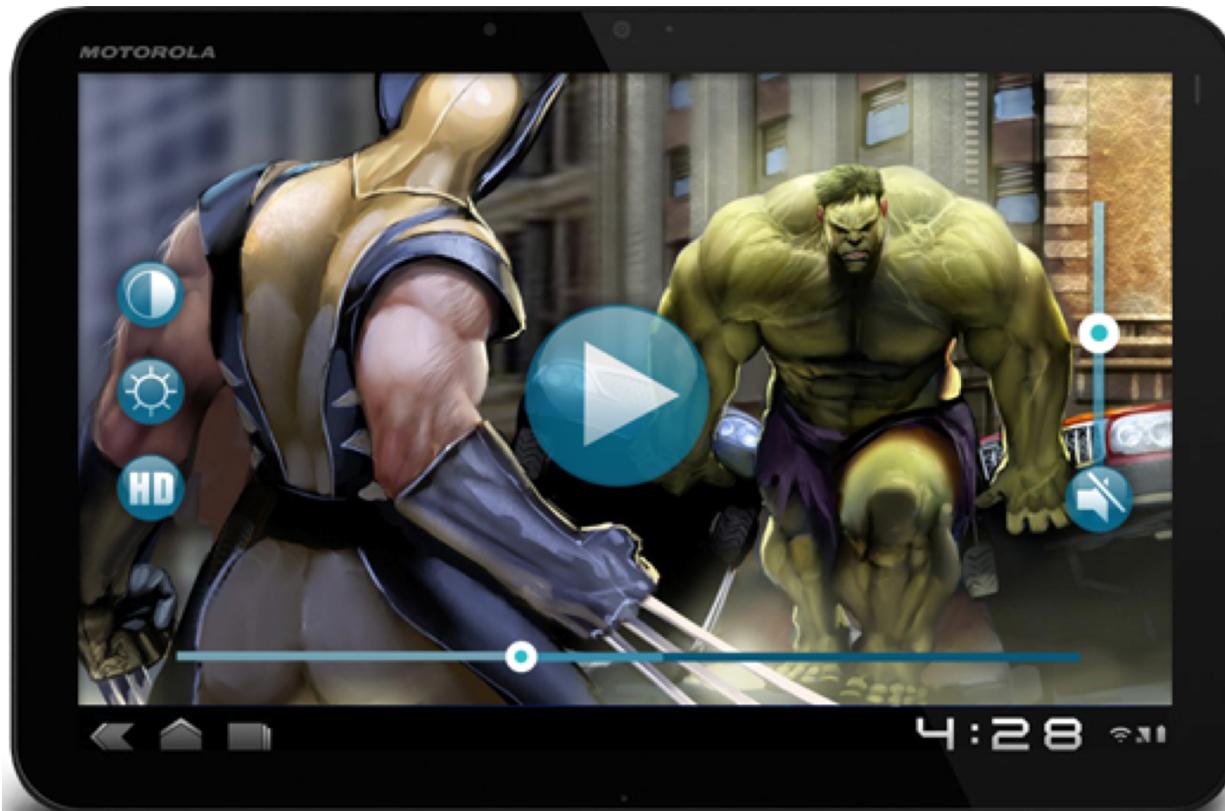
Speakers/Audio Out

- **Sound Output**
  - Two speakers
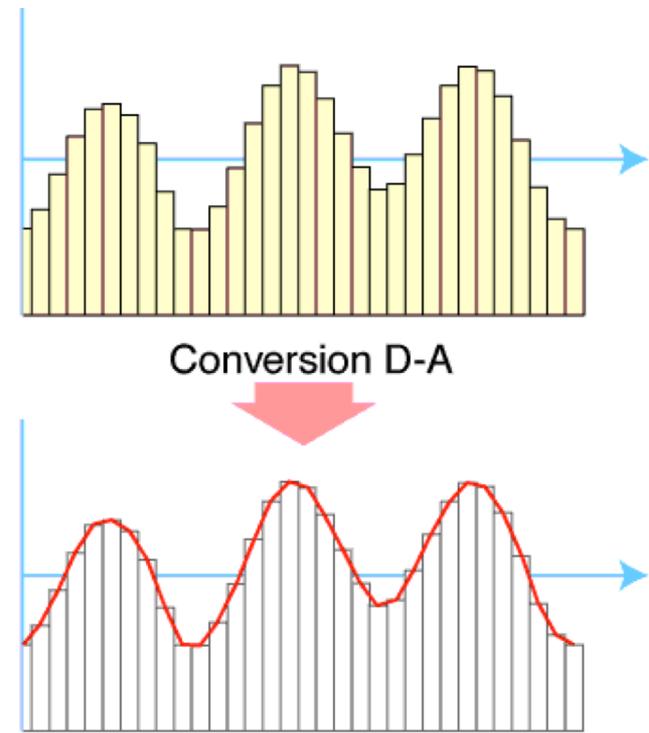   - Quiet one for ear
    - Loud speaker
- **Play previously recorded files**
  - Should be able to do **text-to-speech**
- **Many possible sound filters –**
  - Auto-tune voices to make at right pitch
  - Make funny voices
  - Synthesized Musical instruments

Conversion D-A

(70)

Vibration Output

- **Can create a short buzz**

- **Can control vibration pattern, duration and intensity**

- **This can be a significant output device – 'haptic' feedback**

(71)

Camera Flash

- **Bright White LED**
  - for taking pictures
  - Can light up a room
  - Signal someone
  - (transmit data?)

- **Undergrad Design project:**
  - Evoke red-eye effect **on purpose**
  - Is a picture of retina
  - To do eye-disease diagnosis
    - with computer vision

(72)

The Computer:
# Storage, Networking and External Devices

Computer

- **What can a computer do?**
  - Processors are powerful
  - Nexus 6P has 8 processor cores - (4x1.55 GHz Cortex-A53 & 4x2.0 GHz Cortex-A57)

- **Many things!**
  - Optimization
  - Search
  - Sort
  - Machine Learning Classification Tasks

The Application Processor

- iPhone XS has six core ARM and GPU + Neural Engine
- Huawei device is an 8 processor core
- Fairly serious processing power; can bring to bear all of the knowledge, algorithms and software in many fields
 - On-the-spot Optimization, Search, Machine Learning
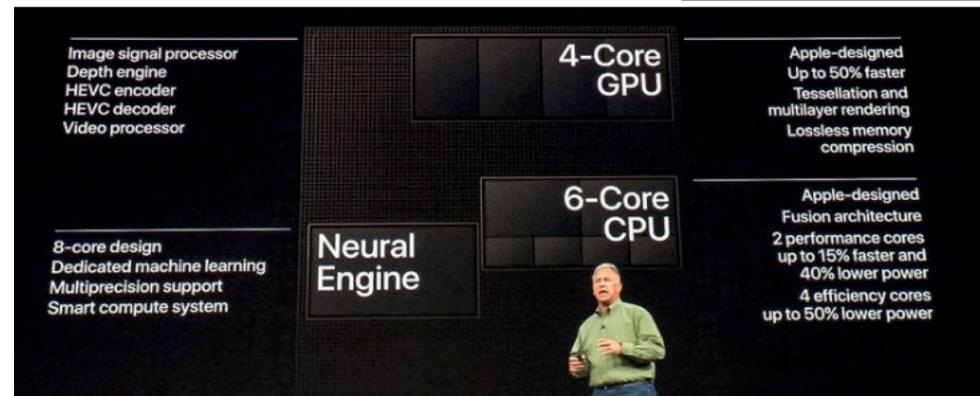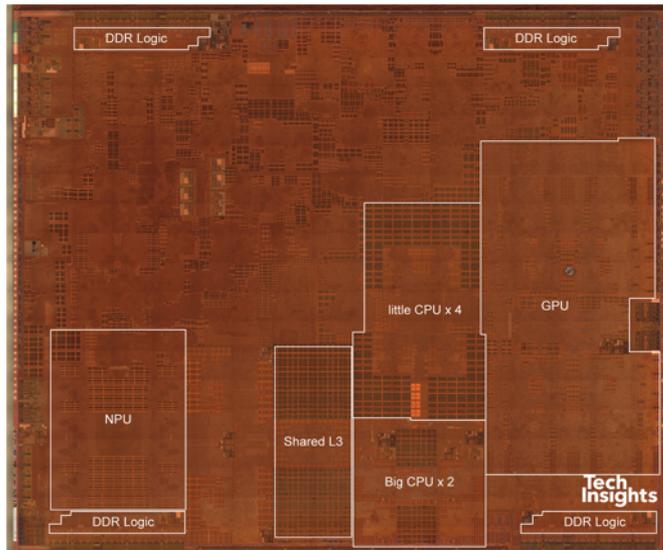
(75)

Storage Capacity

- **Local storage of 8 to 512 Gbytes of permanent storage**
  - Flash-based solid-state disk

- **Can load many databases locally onto the device**
  - Dictionaries, no problem!
 - Maps
  - Phonebooks
  - Location Services

Network – LTE/Wifi: Gateway to Internet

- **Have at least 2 ways to talk to the Internet**
  - Local WIFI
  - LTE Cellular data networks

You are here
Map of the Internet, The Opte Project, www.opte.org

- **Connection to more computation and storage**

- **Connection to other phones**
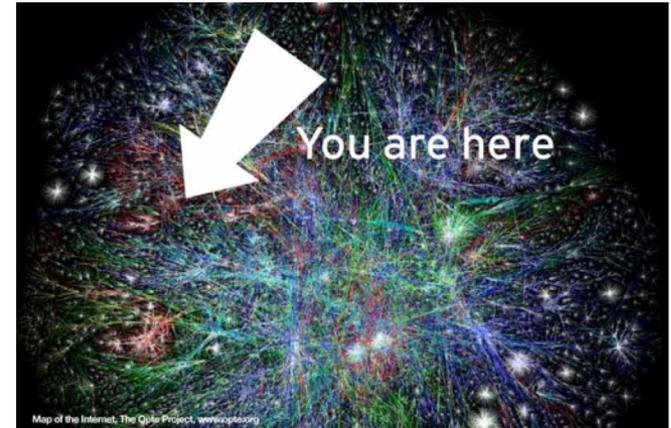
The Cloud Helps Too

- **Many apps need 'backing' website/database**

- **Provides phone with:**
  - Communication to other people
  - Data
  - Backup
  - Information from Internet

- **New this year – both P2 and P3 use cloud**

Cloud Resources

Cloud API
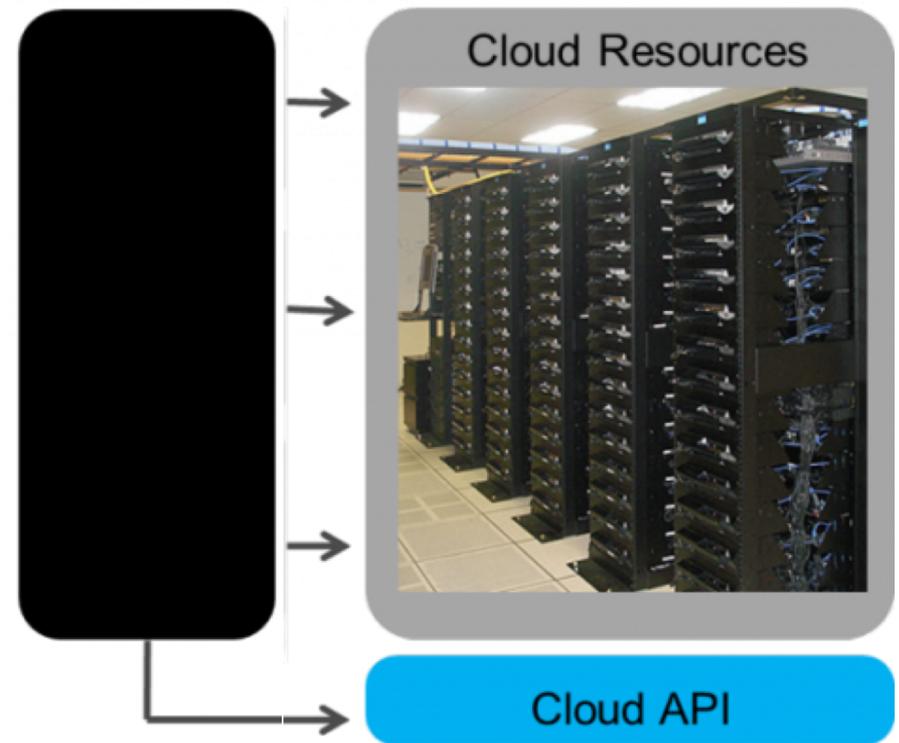
Bluetooth Connection

- **Connect to a whole class of external devices, wirelessly**
  - earphones
  - small spy cameras

- **Could be important way to add other devices without physical connection**
  - Make use of phone's capabilities without holding it
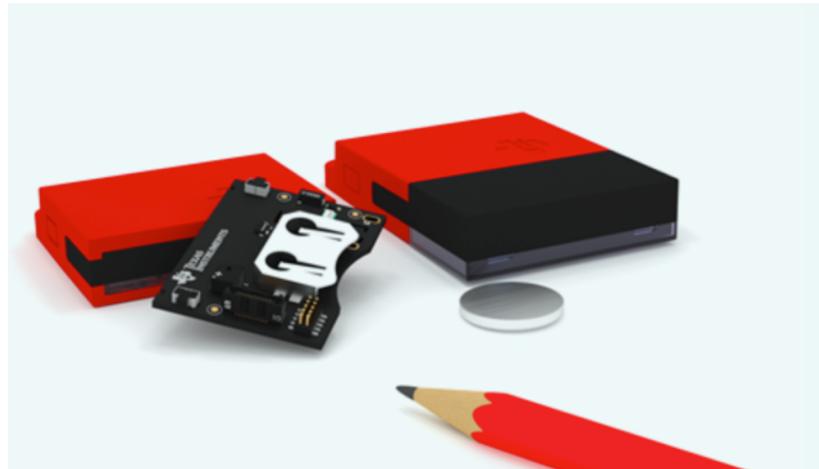
TI Sensor Tag: $35 – Many Sensors!

1. **3D Accelerometer**
2. 3D Gyroscope
3. 3D Magnetometer
4. Light
5. Ambient temperature
6. IR temperature
7. Humidity
8. Air pressure
9. Magnet sensor
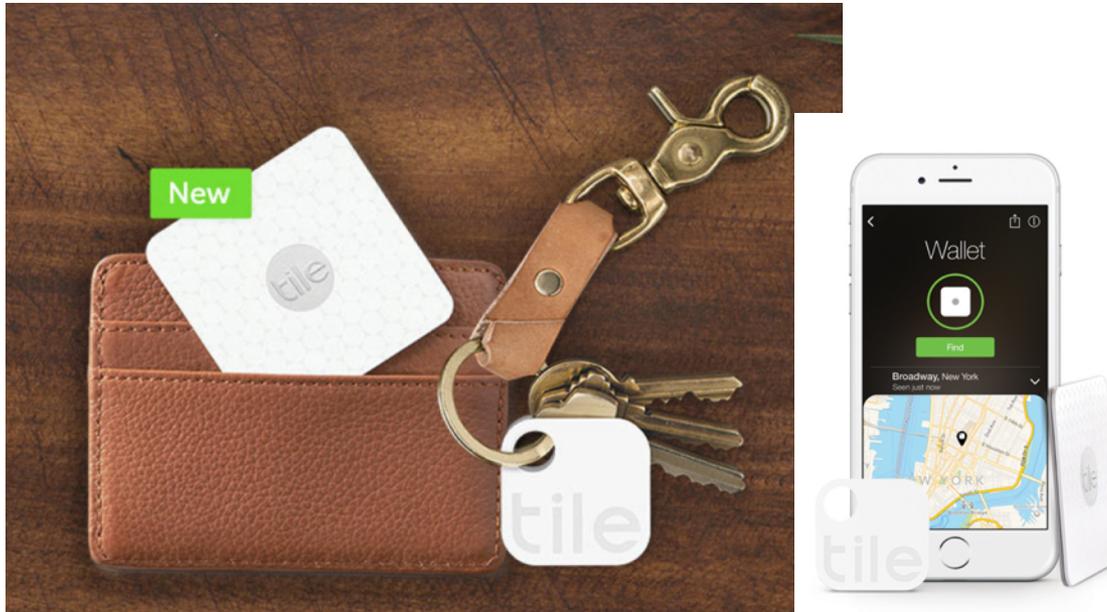10. Two Buttons,
11. Two lights,
12. Quiet buzzer!

(80)
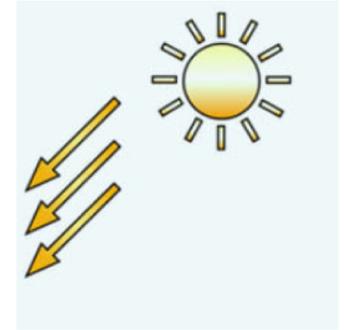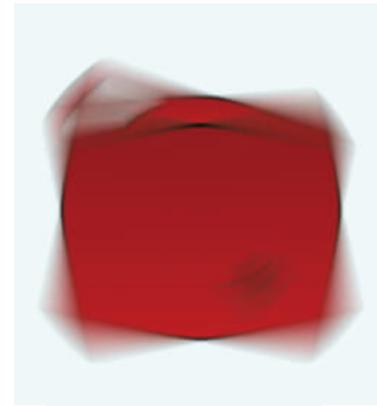
Texas Instruments Sensor Tag 2: Demo

- I have a number of these for use in course
  - Can easily/quickly get more

Tile Thing Tracker

Attach Tile.
Stick, hook or attach Tiles to anything you care about.

Ring your things.
Check the map to see their last known location and make them ring when you get close.

Find your phone.
Press the button on your Tile to make your phone ring — even on silent.

- Put in wallet, purse, knapsack
- Phone alarms if get separated
- Remembers where it was last seen (GPS)
- If someone with App walks by it, tells you

(82)

Muse Head Band

- Measures 'alpha' waves from brain

- Can detect if you're meditating properly

- And perhaps much more!

- We have two of these

(83)

This is the 'Internet of Things'

Near-Field Communications (NFC)

■ Another radio for very fast connection

– for payments

■ Also recognition of 'tag'

– walk past desk, brings up calendar

– Dog tag, gives reminder of stuff to do with dog

Multiple Uses

Using All These & More

- This is the technology side.

- It needs to be combined with the problems/needs/ideas/inspiration from the fields of the specialists

- I'd encourage everyone to continuously ponder what might be possible, even well beyond the scope of this course

- Come up with something interesting in your field

- Make it work!

Introductions, continued

To Help in Project Group-forming

Introductions, Continued

- Last Day, had variety of introductions
- Let's continue
  - Please take notes to keep track of people who you think might be compatible partners
- Next week, we'll try to put people in some categories to help you explore matches on Wednesday night

Please Introduce Yourself, Round 2

1. Name
2. Discipline you work in & degree sought
3. Taking Course for Credit – yes or maybe?
4. Part time or full time student?
5. What your thesis topic is (if doing thesis)?
6. If you work, where & what you do?
7. Why you're taking this course?
8. What kind of phone you're carrying?
9. **Specialist**: What idea, if any yet, you have for an app
10. **Programmer**: What areas are you interested in?

Next Wednesday: Meet to Form Groups

- Wednesday January 23rd
- 6:30pm-8:00pm
- Room GB 220, 335 St. George Street, Galbraith Bldg.
  - Will create categories; available to discuss topics