ECE 1778:
Creative Applications for Mobile Devices

Lecture 2

September 23, 2016

Today

1. Logistics/Organization of Course & Project

2. Capabilities of Mobile Devices & Creative Applications
   – to get you thinking about ideas for applications

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>Blackboard</u>

Recall: The Goal of This Course

- Bring together people from different disciplines and to prototype an interesting & creative <u>mobile/wearable</u> 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

- **Tomorrow**, 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 with you
  - Reading Piazza & contacting by email
  - Next week's lecture
  - AND …

Extra Meeting to Form Groups

- This Coming Tuesday September 27th, 6:30pm-8:00pm
- Galbraith Building, Room 405, 35 St. George Street
- We will help make matches & be there to kick around ideas to help with direction/scope
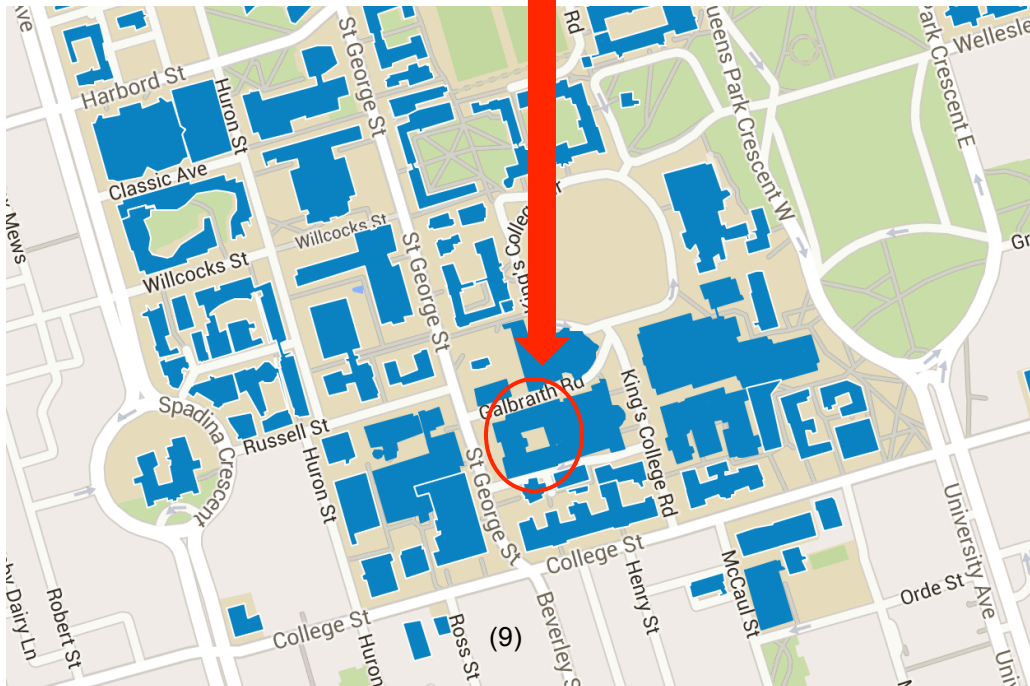
Numbers

- Number Submitted Part 1 of Assignments S1 or P1:
    - Programmers: 31
    - Specialists: 10 +

- Registered: 55

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

- **The email must contain (please read this):**
  - Names of all students and student numbers
  - <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 Programmer, who is Specialist and if someone is serving as both**
  - Mobile platform you plan to do the project on
    - one of Android, iPhone

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 have sufficient technical depth

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

4. **Must be a mobile/wearable application**
   – Not something that could as easily be done on desktop/laptop

Project Stages 16f

1. **Forming Groups**
   - Within 3 weeks; extra meet Tuesday Sept 27 @6:30pm GB405
2. **Project Approval-in-Principle**
   - Done via email –send short description to me; will respond fast
   - Due October 7th prior to class; must have approval to proceed
3. **Project Proposal/Plan**
   - Document Due October 14th
4. **Proposal & Plan Presentations**
   - October 20 & 21
   - **NOTE EXTRA LECTURE Thursday Oct 20, 6-8pm, SF 1101**
5. **Spiral 2 & Spiral 4 Presentations**
   - 2: November 4/11   4: November 18/25
6. **Final Presentations**
   - Weeks of December 2/9
7. **Final Report Due December 14th**

Assignment 1 Part 2 Due Next Week

- **P1 and S1 assignments Part 2 due next week**
  - 6pm, Thursday September 29th
  - **There will be roughly one assignment per week after that, for 3 more weeks (in addition to project work)!**

- **Submit via Blackboard Portal – under <u>Assignments</u>**
  - Click on either 'Programmer Assignments' or 'Specialist Assignments'
  - Attach your file using 'Browse My Computer'

What Programmers Should Be Learning

- **With Assignment 1:**
  - After downloading the various elements of the programming environment
- **Java/Swift/Objective C 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**

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)

■ Taking this, and thinking of ideas, or areas of ideas for the project apps

Programmers & Assignment P1

- There are a range of ways to do even the simple task of Assignment P1.

- For example, here is a video of a very sophisticated version of P1: Video Link
  - Not required to be this sophisticated

- Here is a not very good version: Video Link
  - This will not get full marks, because:
    - No image centering
    - Not following various instructions in assignment

Android Phones Available for Loan

■ We have a number of Huawei Ascend P6 and 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
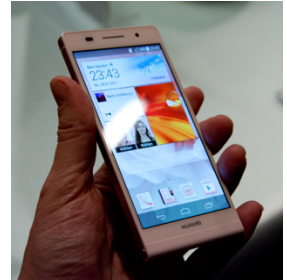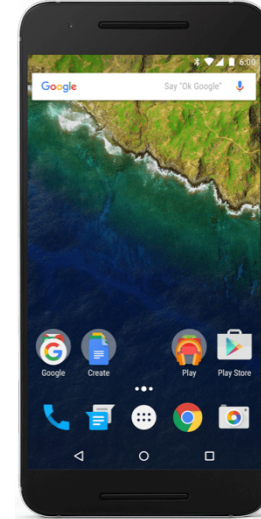
Note for Apple iPhone/iPad Users

- Recall you must have a Mac to do this
  - Also, you must be sure that your project group has aligned itself under the apple banner
- The University of Toronto has signed up under the Apple University development program, see:
  - http://mobile.utoronto.ca/build/ios
  - Contact mike.spears@utoronto.ca to sign up
- Allows free download to device,
  - which otherwise costs $US 99
- Does <u>not</u> allow for app store distribution
  - But if do pay $99 later, you will then be able to put on app store

Overview of Smartphone Capabilities
&
Example Applications

To Help your Creative Thinking about 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
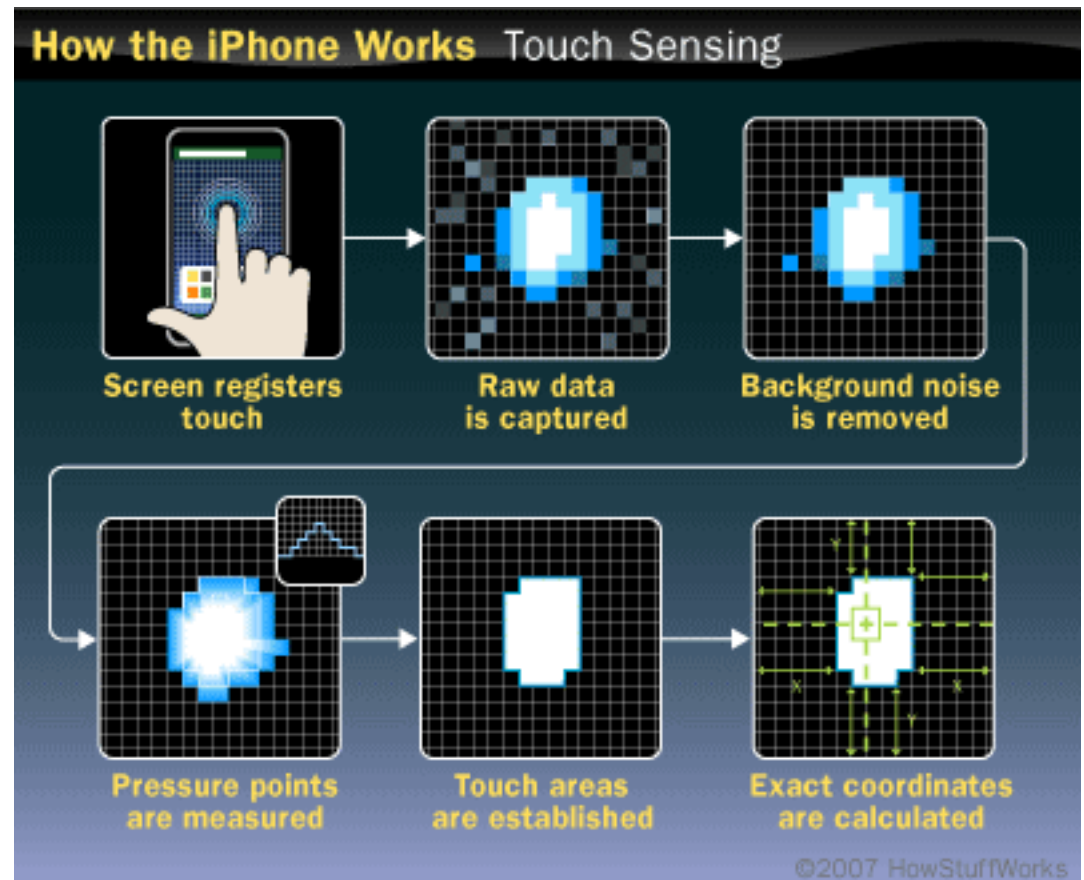
Touch Screen

■ 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 …

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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.
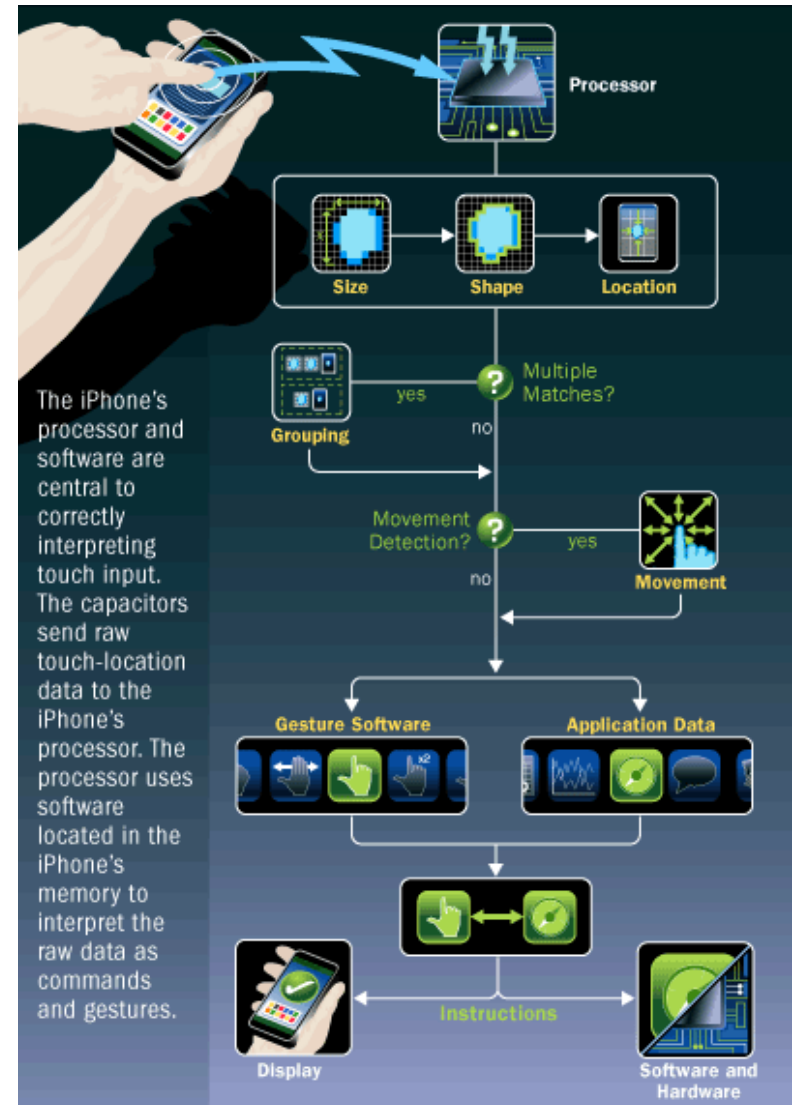
Can Touch Screen Be More?

- 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
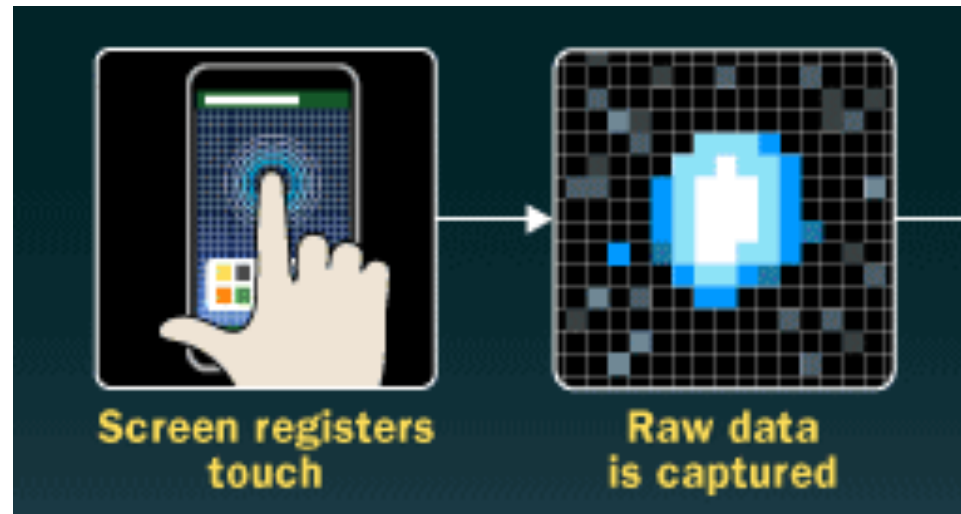
Nifty Touch Stuff Coming: Tactual Labs

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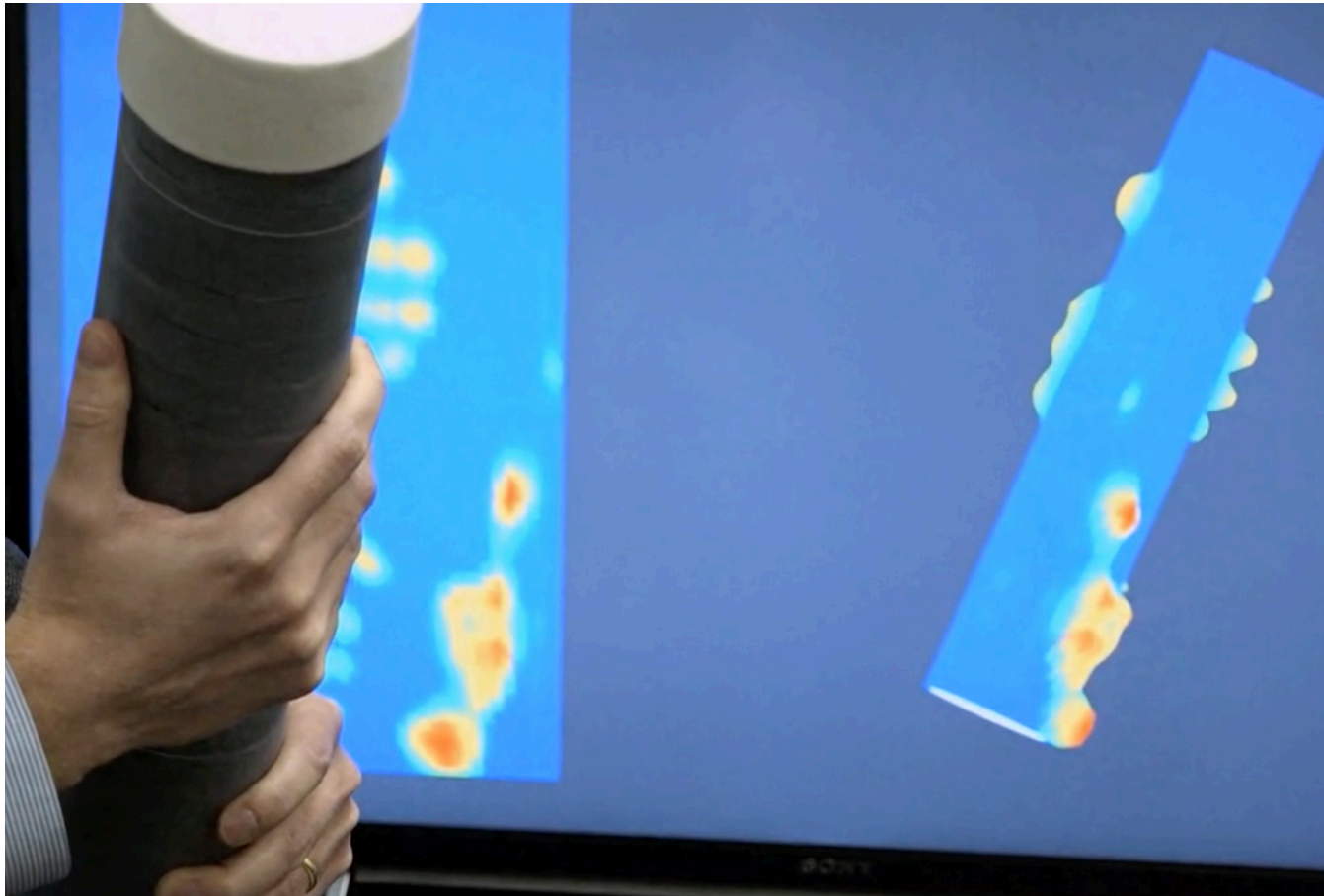
Accelerometer

- 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
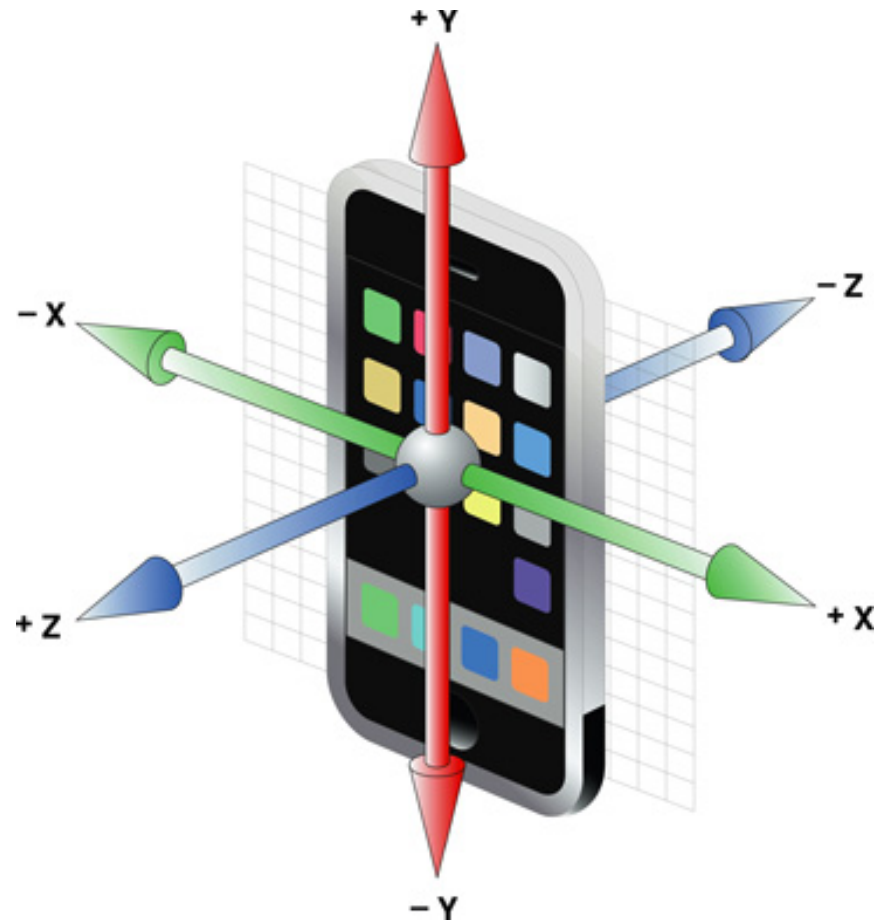
Can Feel What the User is Doing

- 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

myAnkle

A Personal Physiotherapist for Ankle Injuries

Nirtal Shah, Ivan So, Lyndon Carvalho

Vivian Liu

Braiden Brousseau

Nirav Atre

Babneet Singh

April 2011   Jordan Lee

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Ankle Injuries: Sprain

- **Tipping on side**
  - Stretches ligaments
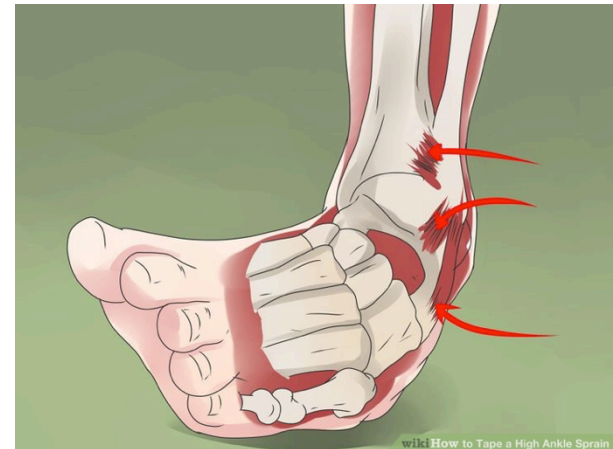
Ankle Injuries: Sprain or Break

- 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)
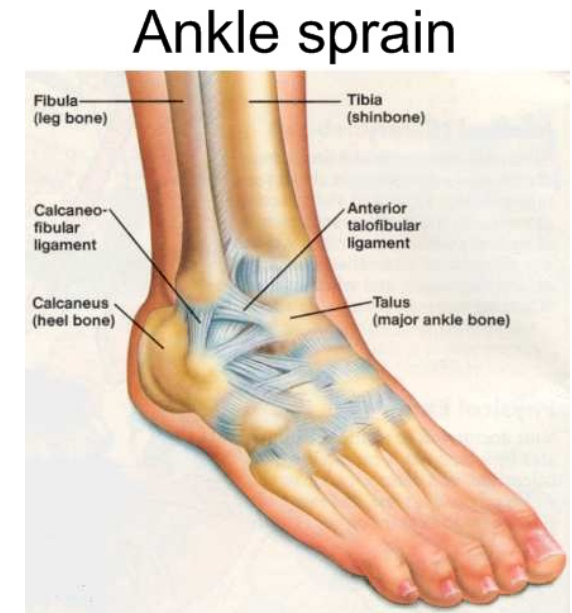
Usual Diagnosis & Treatment

Physiotherapist

| **Measure** | → | **Prescribe** |
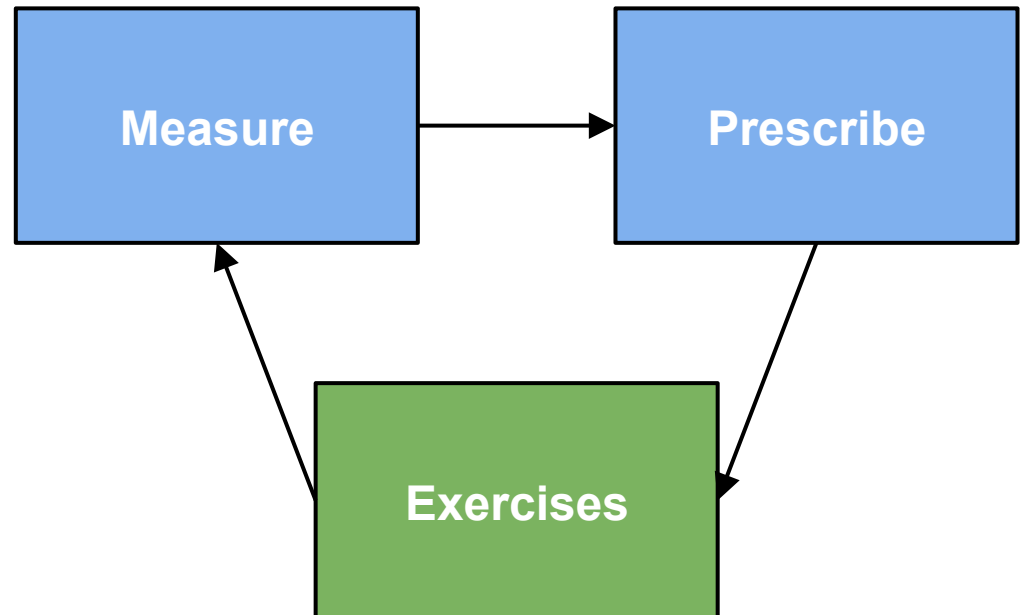
Patient

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!

One Foot
Floor

Difficulty : Moderate
Stand with only chosen foot on the floor for exercise duration

A Selection of Exercises
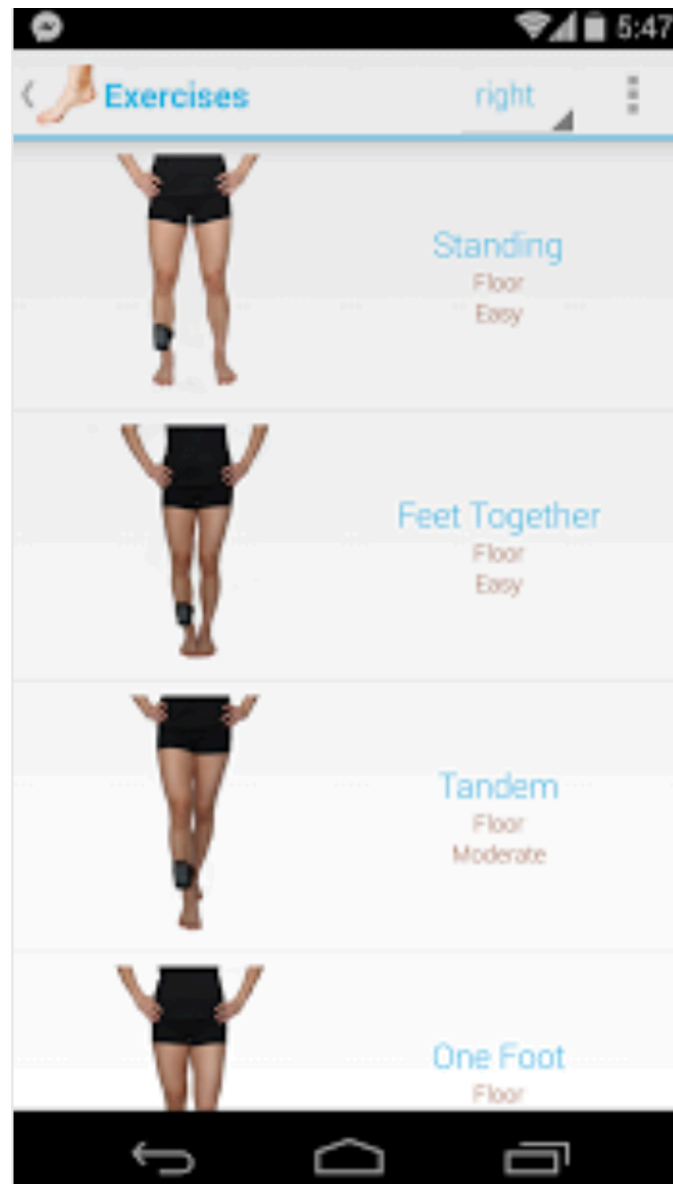
MyAnkle Gives A Number

- Measures the amount of movement when trying to balance!

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

- Demo using sensor tag – Need Volunteer!
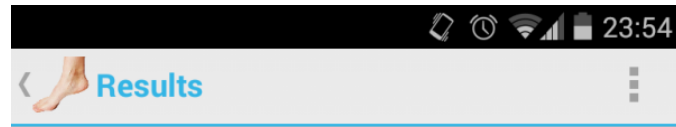
Results
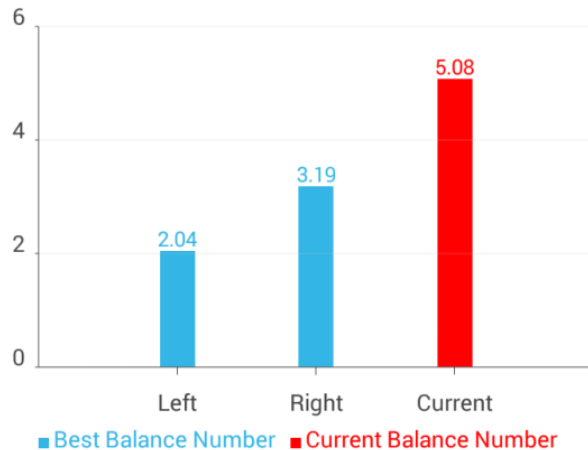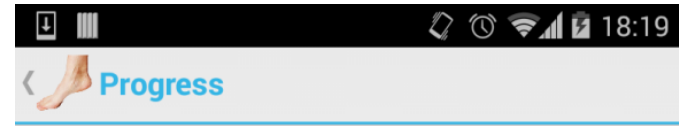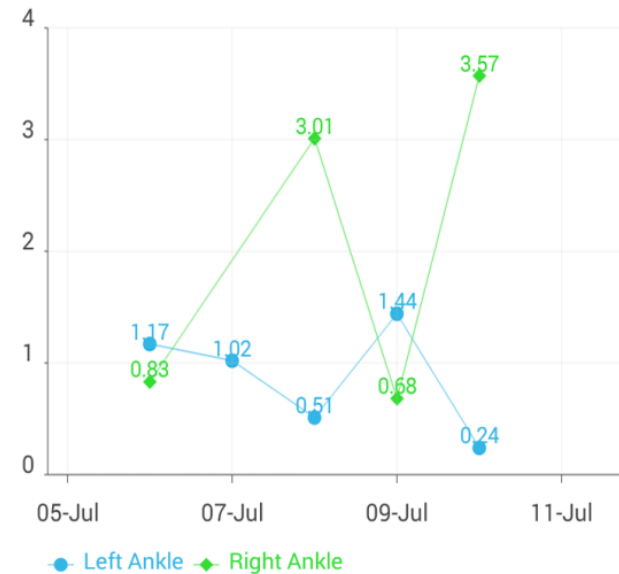
Status

- **Released to Google Play App Store**
- **App will only measures, does not prescribe**
  - Ongoing research project to collect data
    - Need to learn what the numbers mean
  - We hope to evolve it to prescribe
    - Currently building 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

Recently: Physiotherapy Exercises

- To get better balance – practice balancing!

- But it is boring to do

- Can we turn into a game?

- "Gamification"

Here is the Game as it stands now

■ Step 1: Measure how much you wobble to start

Game as it is Now

- **Step 2: Try to do better**
  - Show how did before
  - Measure every 2 seconds how your doing
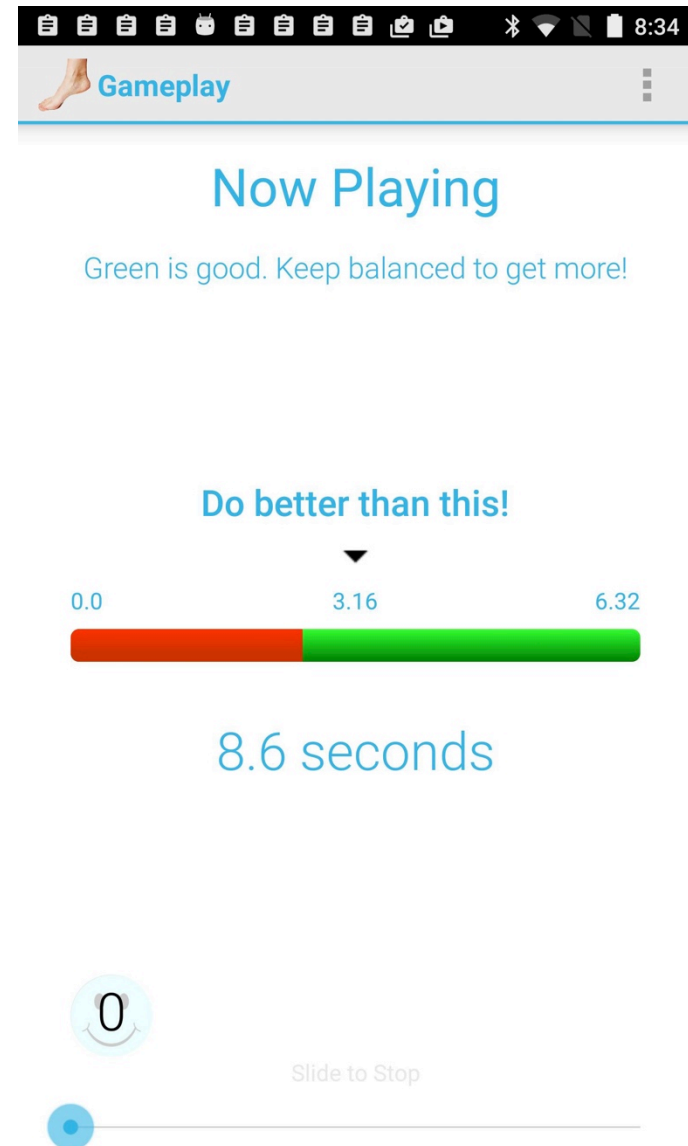
Game Demo

- Need Another 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?

- **Can detect if person fell down**
  - could alert someone

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**

VERTICAL EXIS "YAW"

LONGITUDINAL EXIS "ROLL"

LATERAL EXIS "PITCH"
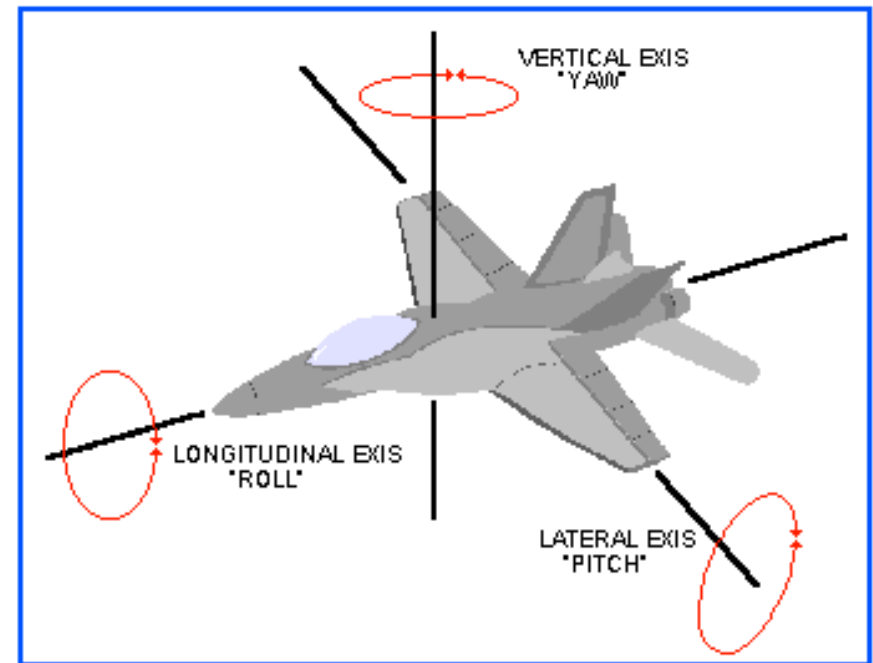
Compass

- **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
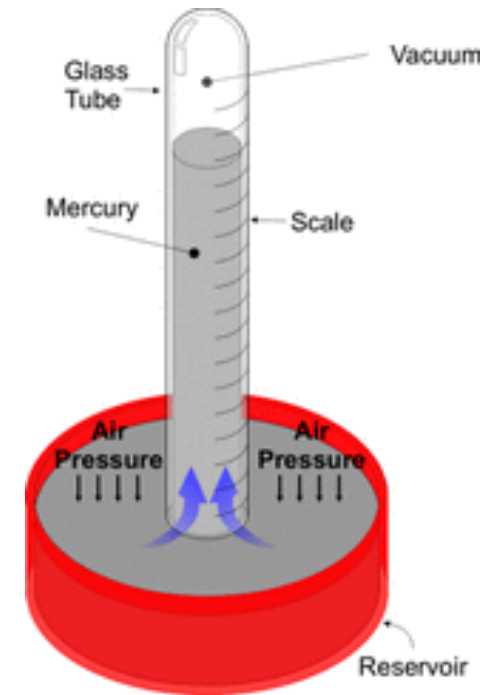
- **What are they used for?**
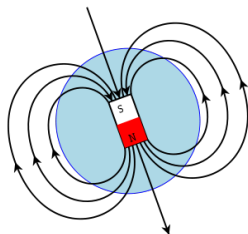
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Barometer

- **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.

Global Positioning Satellite Receiver

GPS Receiver

- 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
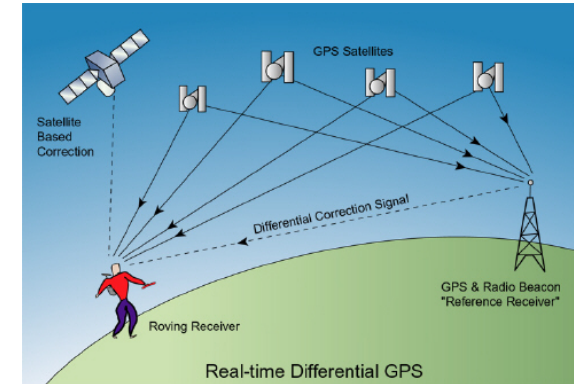
Latitude:	37° 19' 54.0804"
Longitude:	-122° 1' 50.6316"

Skiing in Whistler
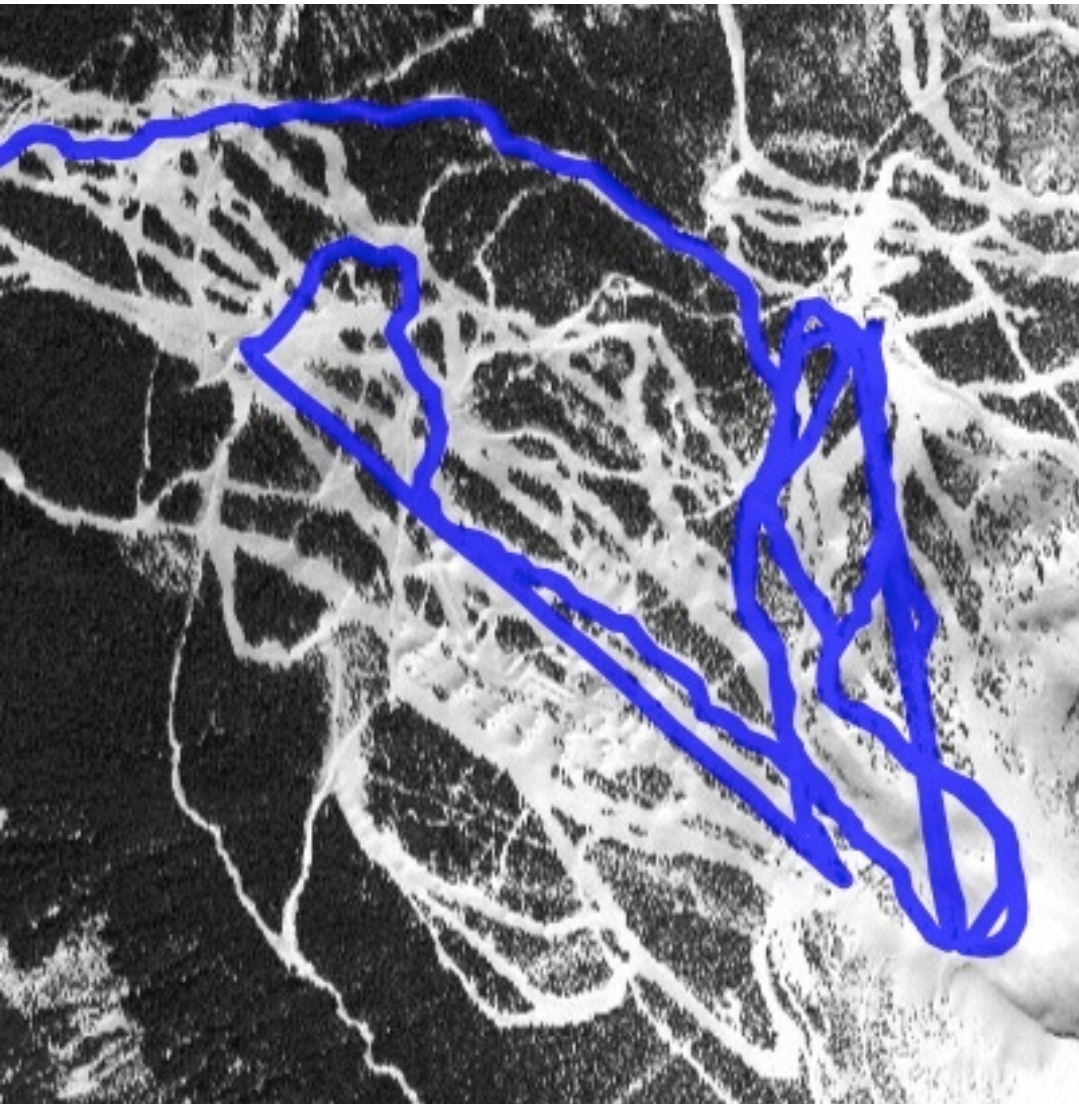
November 25, 2012, 10:15 AM

ski vertical: 3,223 m

total distance: 23.04 km

ski distance: 15.72 km

speed-maximum: 52.99 km/h

speed-average: 20.61 km/h

duration: 02:06:31

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**
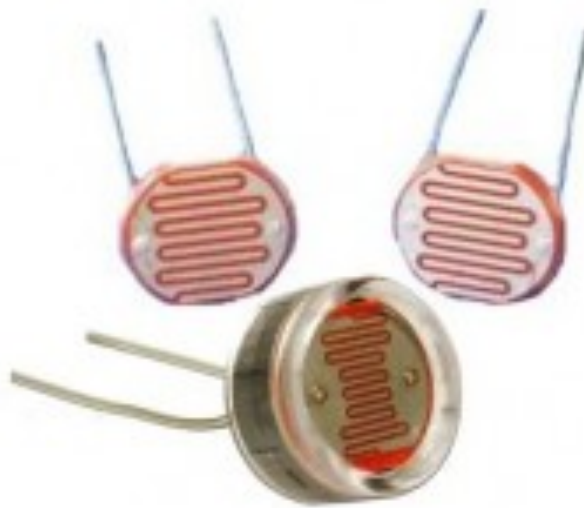 - Someone in Aerospace might want to do something interesting with that

Altimeter

- Using the GPS, can also determine the height of the phone
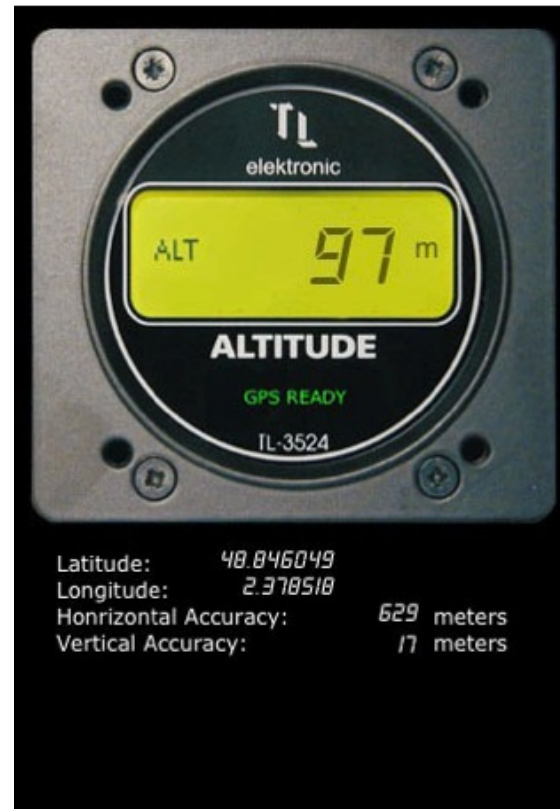
Ambient Light Sensor

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

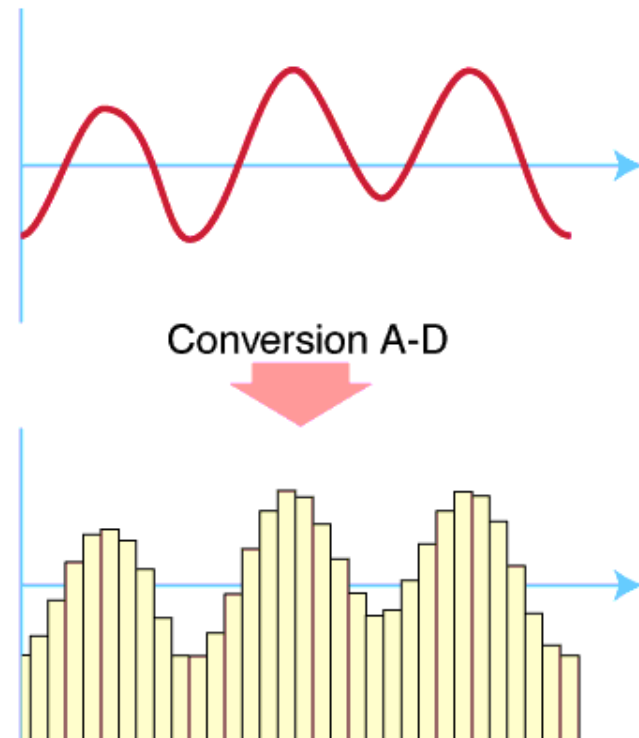Light Dependent Resistor (LDR)   Photodiode

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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**

(55)

Conversion A-D

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

■ 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
  - Difficult, slow

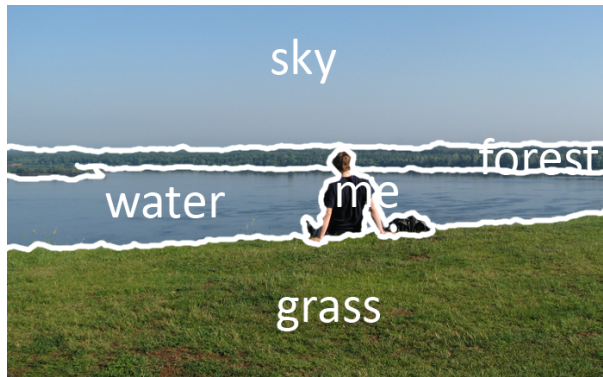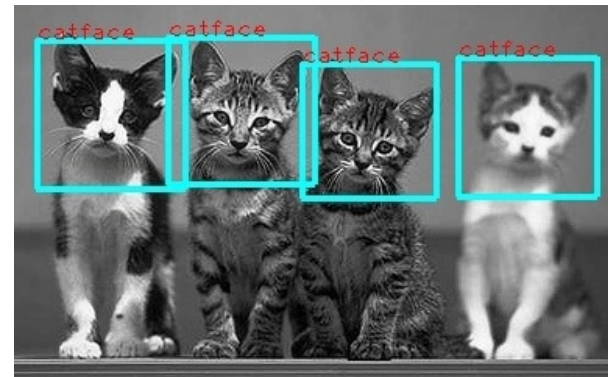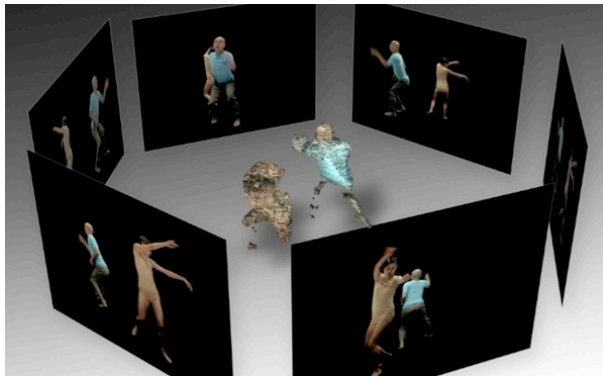# Computer Vision
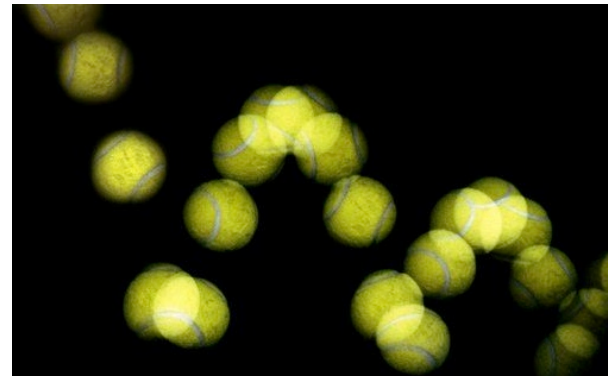
- Goal to 'see' the world in like people do

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

- Often too slow to do in real time, but not always
- There is some open-source software, **OpenCV**, which can do many things, but not very quickly
  - Has been ported to Android

- Braiden Brousseau's (TA) Master's thesis was about speeding up OpenCV on Android using an FPGA
  - He can help with using OpenCV, which now has fairly good ports to Android

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**
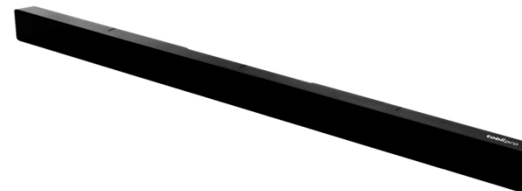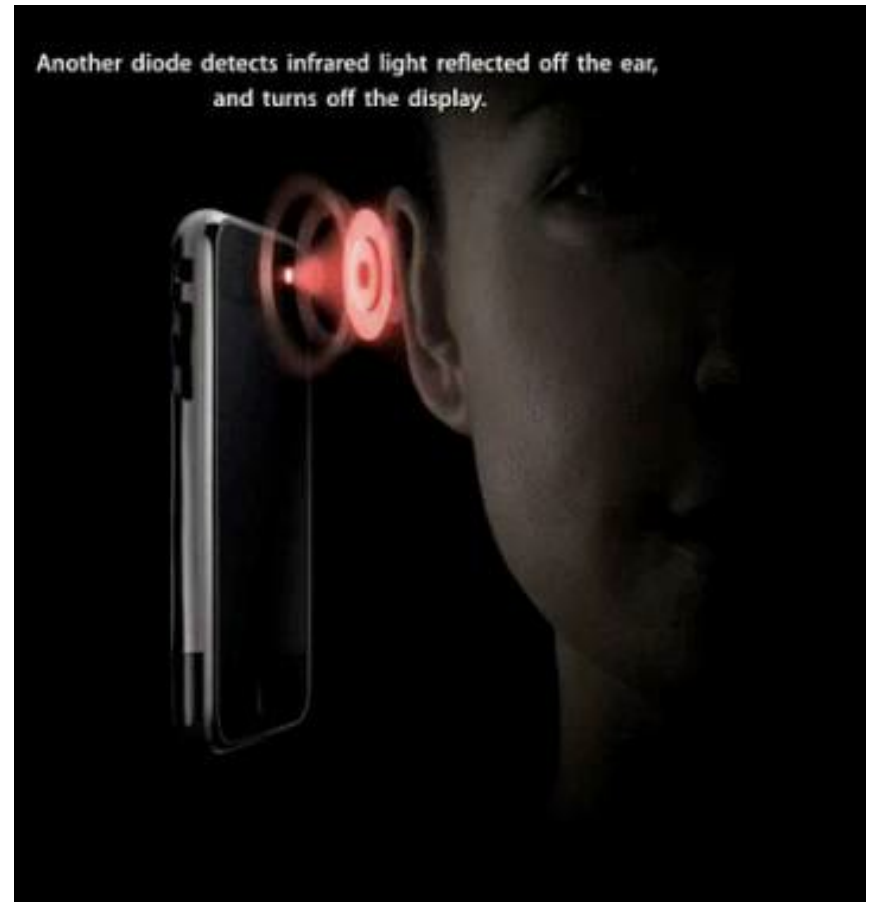
Super Human Capability!

- **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
  - 518pixels per inch

- **iPhone 6s**
  - 750 x 1334 resolution
  - 326 pixels per inch

- **Huawei Ascend P6**
  - 720x1280 total resolution [67] -312 ppi
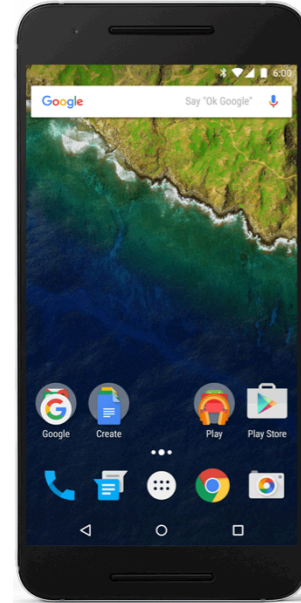
Video Display Hardware

■ Special hardware to display 30 frames/second video

– Displaying video would have used up much or all of the processor's computational capacity;
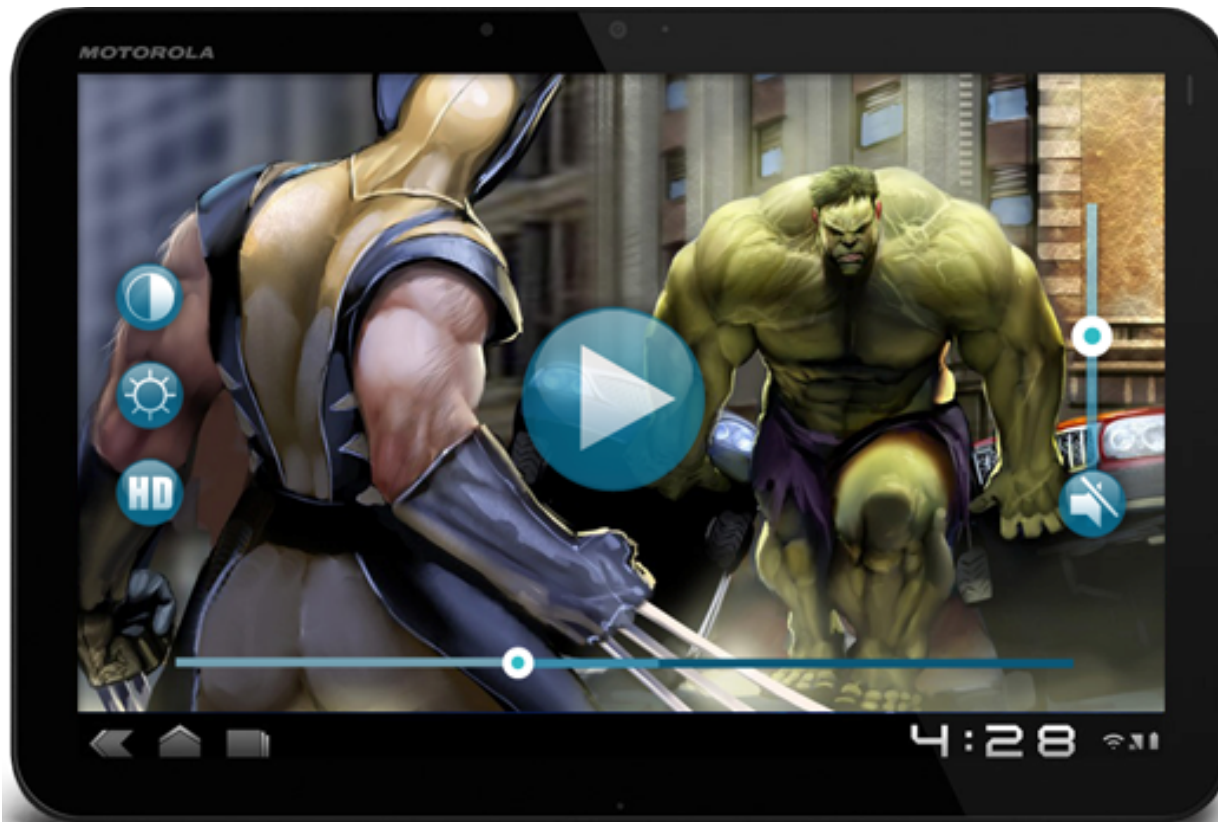
Speakers/Audio Out

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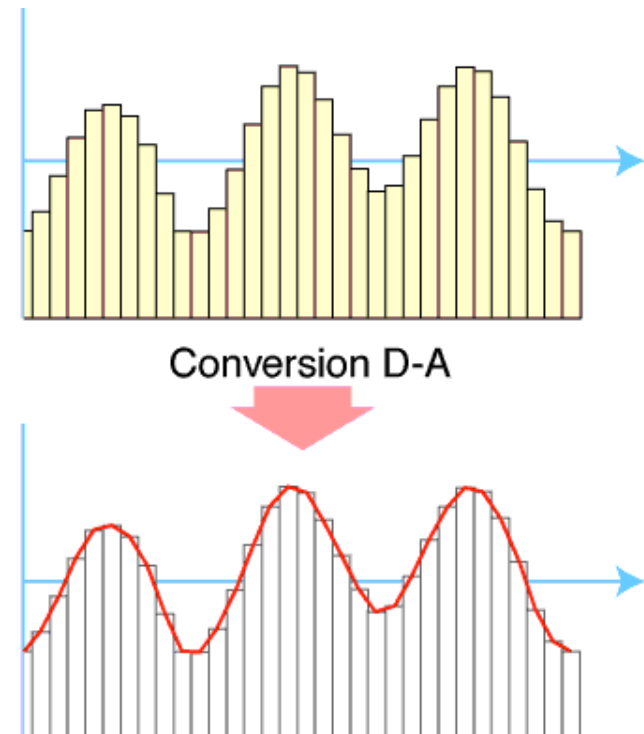 - Two speakers
    - Quiet one for ear
    - Loud speaker
- Play previously recorded files
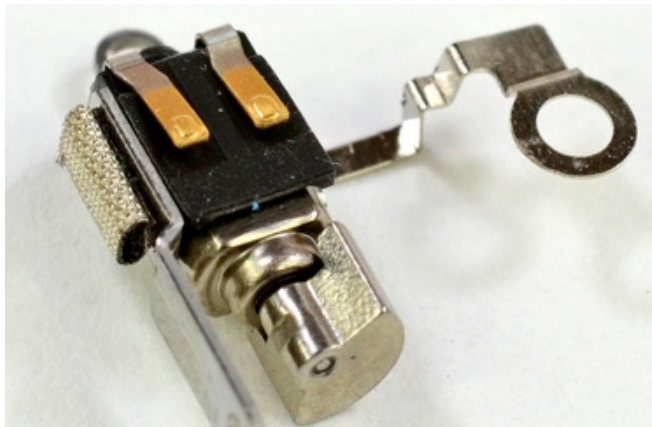 - Should be able to do **text-to-speech**
- Many possible sound filters –
  - Auto-tune voices to make at right pitch
  - Make funny voices
  - Synthesized Musical instruments

Conversion D-A

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Vibration Output

- Can create a short buzz

- Can control vibration pattern, duration and intensity

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

Brilliant Use of Vibration: Cylcoramic

- **Uses vibration rotate phone by itself**
  - Takes video
  - Will take panorma

- **Are there other uses for this?**

- http://cycloramic.com
- Video

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

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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
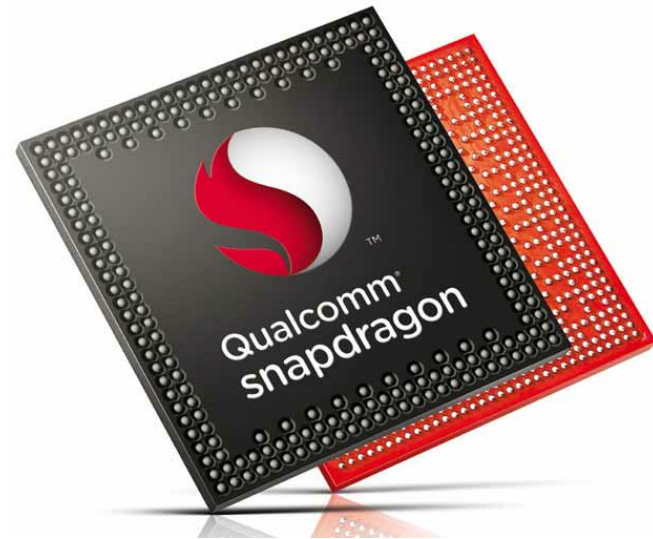
The Application Processor

- iPhone 6s has dual core ARM v8 and 6x Power VR GPU
- 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
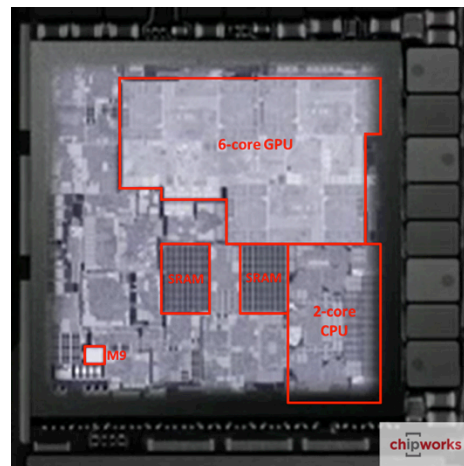
Storage Capacity

- **Local storage of 2 to 256 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

- **Connection to more computation and storage**

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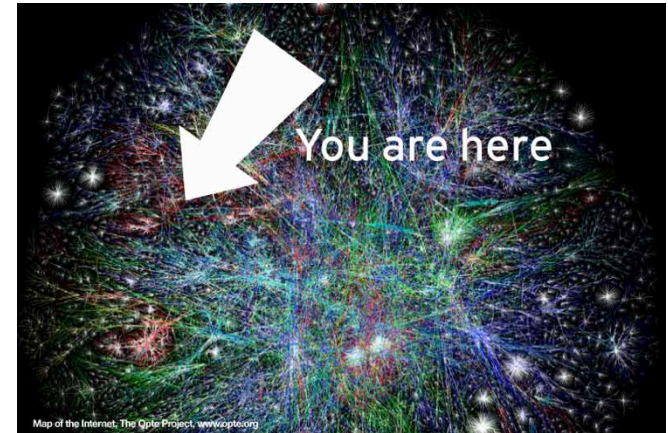
The Cloud Helps Too

- Many apps need 'backing' website/ database

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

- New This Year Assignment P3 ->cloud

Cloud Resources

Cloud API

(78)
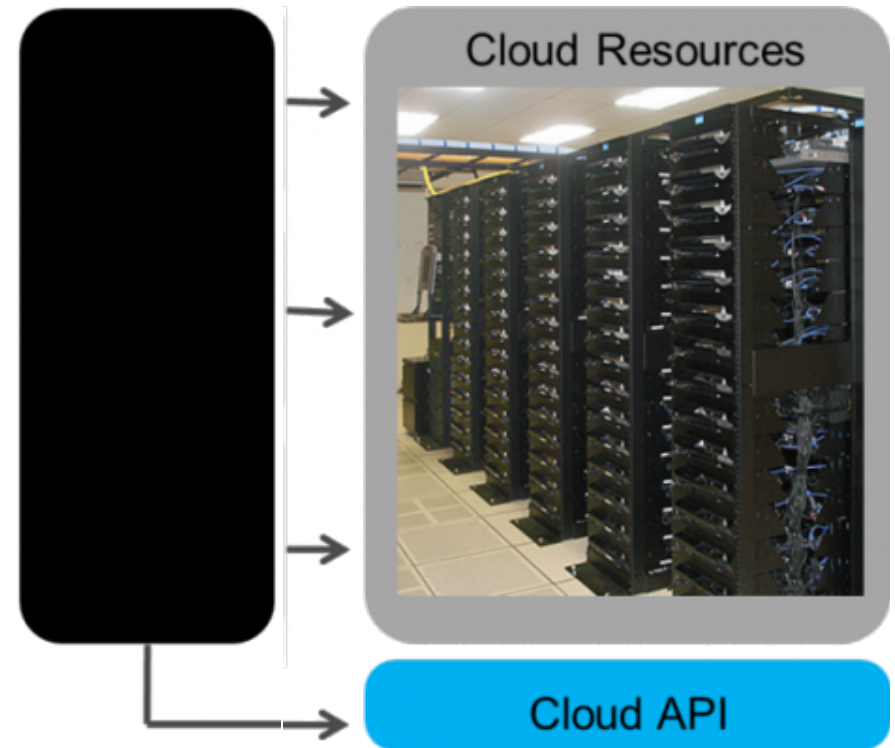
Bluetooth Connection

- **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

Aside: Sensors are Leaving the Phone

- Cost: $169 for base, more for each specific sensor

Additional Node Sensors End-Units

THERMOCOUPLE

Thermocouple can measure surface temperature temperatures in liquids, semi-solids- foods, and meats, for quality control, and temperature monitoring.

$75   click here to buy or learn more

OXA

With a NODE OXA gas module installed your smart device becomes a super sensor. Each OXA gas module detects one of the following gases: CO, NO, NO2, Cl2, SO2, and H2S.

$149   click here to buy or learn more

CO2

NODE + CO2 is a sensor module for the NODE+ bluetooth sensor platform. The CO2 module measures the Carbon Dioxide level of the air around the sensor.

$149   click here to buy or learn more

BARCODE

We're proud to announce new NODE+Barcode sensor module! NODE+Barcode can scan any item, keeping track of your inventory, pricing and availability.

$99   click here to buy or learn more

Or, build your own:

I/O

The i/o Module allows users to connect different sensors, lights, and buttons, to access the POWER of NODE in their own projects.
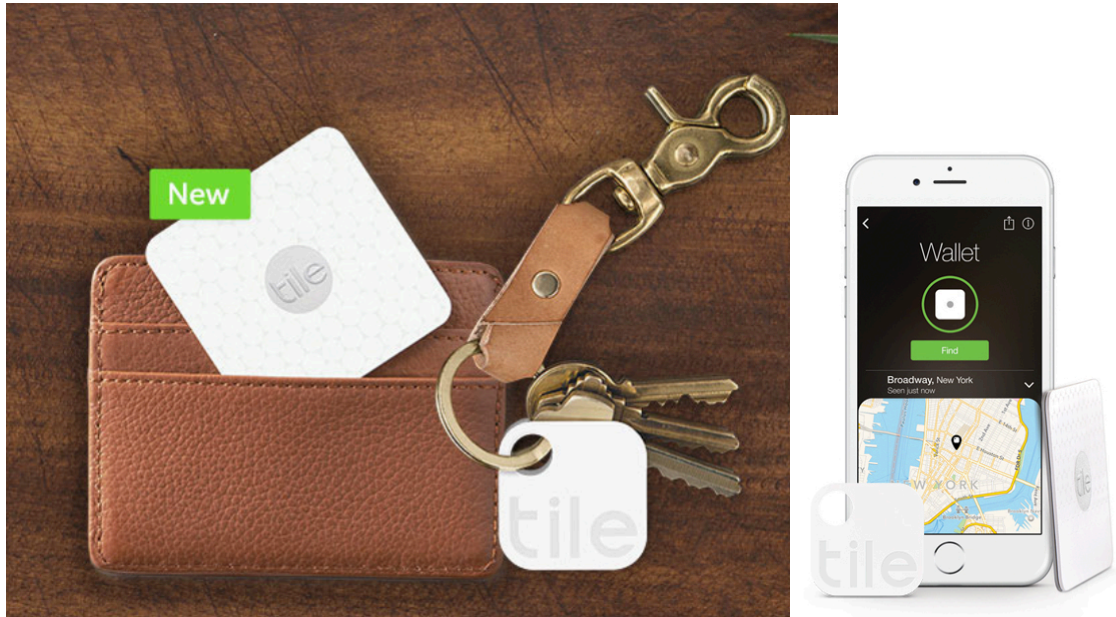
$25   click here to buy or learn more

Texas Instruments Sensor Tag 2: Demo

- **Cost:** $USD 29
- **Bluetooth Connection**
- **Sensors:**
  - 9 axis
  - Magnet sensor
  - Light
  - Ambient temperature
  - IR temperature
  - Humidity
  - Air pressure
  - Two Buttons, two lights, quiet buzzer!
- I have a number of these for use in course
  - Can easily/quickly get more
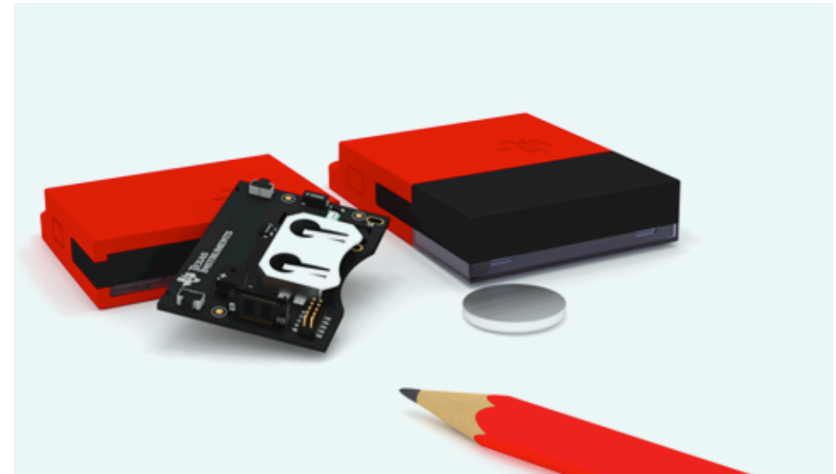
Tile Thing Tracker

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

Lumo Lift

■ **Posture Detection with accelerometer**

How it works

1	2	3
Affix the small Lumo Lift sensor on your clothing with the complimentary magnetic or bra clasp.	Align your Lift sensor by getting into your best posture then double pressing on the clasp.	The sensor will gently vibrate whenever you slouch, coaching you to better posture and a healthier back.

The Lumo Lift

You slouch, it vibrates.

Lumo Lift, the #1 best-selling posture coaching wearable device. Improve your posture in as little as 14 days. Try it risk free with our 30 day money-back guarantee.

How it Works

1. Attached to shirt with magnet
2. Double-click device when posture is good
   - It can then tell where 'down' is when posture is good
3. When your angle with respect to 'down' isn't good, for 2 minutes, it buzzes!
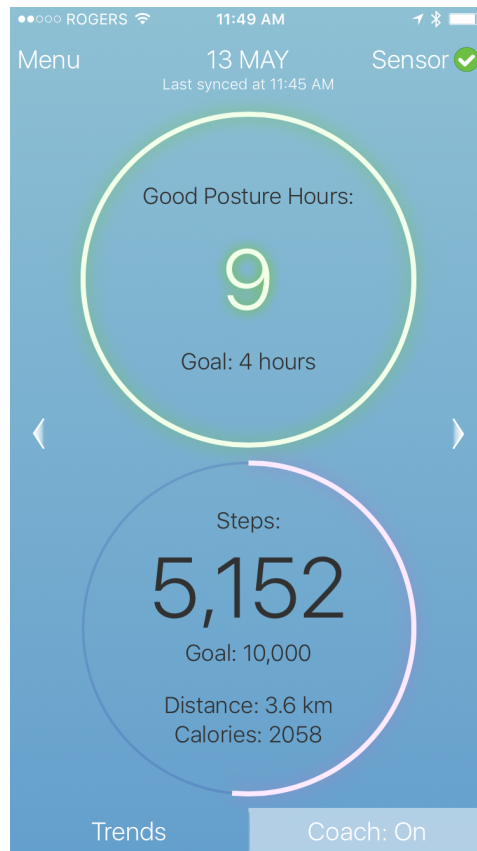4. Phone App tracks Data

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Does it Work?

- An attempt at behavior modification through feedback
- I think my posture is better! Some data to support.
- Step counter has modified my behavior for sure

Other Externals

- **Microsoft Band 2 – expensive, but open & many sensors**
    - Have one
- **Fitbit**
    - Popular – have 1 or 2.

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Muse Head Band

- Measures 'alpha' waves from brain
- Can detect if you're meditating properly
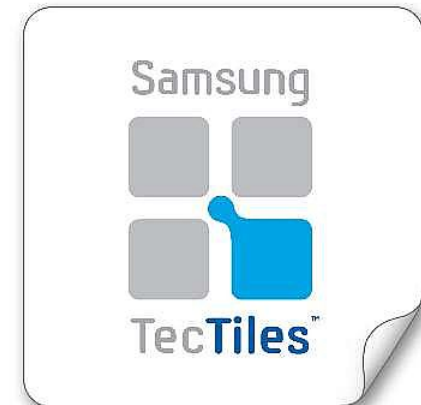- And perhaps much more!
- We have two of these

This is the 'Internet of Things'

Near-Field Communications (NFC)

- **Another radio for very fast connection**
- **for payments**
- **recognition of 'tag'**
  - When go home can walk past desk, brings up calendar
  - When dog goes by, gives reminder of stuff to do with dog

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, specialists introduced themselves**

- **Today, let's try to make sure any new specialists have introduced themselves**

  - 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 Tuesday 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 Tuesday: Meeting to Form Groups

- Tuesday September 27th

- 6:30pm-8:00pm

- Room GB 405, 335 St. George Street, Galbraith Bldg.
  - Will create categories