

# ECE 1778: Creative Applications for Mobile Devices



Lecture 2  
January 12, 2016



(1)

# Today

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1. Logistics/Organization of Course & Project
2. Capabilities of Mobile Devices & Creative Applications
  - to get you thinking about ideas for applications
3. Continued introductions of Students & Idea Discussion



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# 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 Piazza website for discussion boards
- Announcements will be sent through Blackboard





# Recall: The Goal of This Course

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

# Background Reviews of Programmers

- Today, we will finish reviewing the background described by the programmers
- I will contact, by email, all programmers who appear to have insufficient programming background
  - For some it seems very clear
  - For others, we may need to talk
- Will send an announcement today when process finished
- After that, you should feel free to contact programmers to ...



# 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

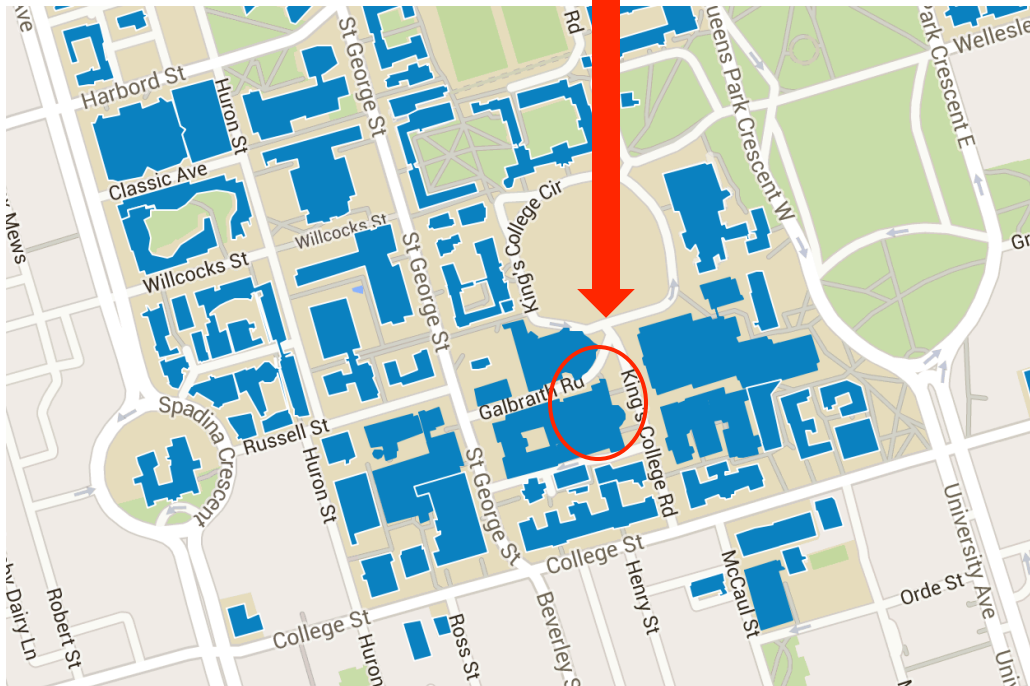
**Step 1:** Two Programmers should find each other

**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

- Tuesday January 19<sup>th</sup>
- 6:30pm-8:00pm (in addition to the class that day)
- Galbraith Building, Room 221
  - 35 St. George Street
  - Will help make matches.



# Numbers

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- Number Submitted Part 1 of Assignments S1 or P1:
  - Programmers: 75
  - Specialists: 21
- Registered: 130

# 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](mailto:Jonathan.Rose@ece.utoronto.ca)
- The email **must** contain (please read this):
  - Names of all students and student numbers
  - Department & Field 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 (others require a special discussion)





# 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. Subject **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 16

## 1. Forming Groups

- Within 3 weeks; extra meet Tuesday Jan 19 @6:30pm

## 2. Project Approval-in-Principle

- Done via piazza website Discussion Group/email
- Due January 26<sup>th</sup> prior to class; Must have approval to proceed

## 3. Project Proposal/Plan

- Document Due Feb 1<sup>st</sup>

## 4. Proposal & Plan Presentations

- February 9 & 11
- **NOTE EXTRA LECTURE Thursday Feb 11, 6-8pm, Loc:TBD**

## 5. Spiral 2 & Spiral 4 Presentations

- 2: March 1/8    4: March 15/22

## 6. Final Presentations

- Weeks of March 29/April 5

## 7. Final Report Due April 7<sup>th</sup>



# Assignment 1 Part 2 Due Next Week

- P1 and S1 Part 2 assignments due next week
  - 6pm, Monday January 18<sup>th</sup>
  - **There will be one assignment per week after that, for 3 more weeks (in addition to project work)!**
- Submit via Blackboard Portal – under Assignments
  - Click on either ‘Programmer Assignments’ or ‘Specialist Assignments’
  - Attach your file using ‘Browse My Computer’
- Programmers: **P1**
  - Any issues/questions?
- Specialists: **S1**
  - Any issues/questions?



# 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](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



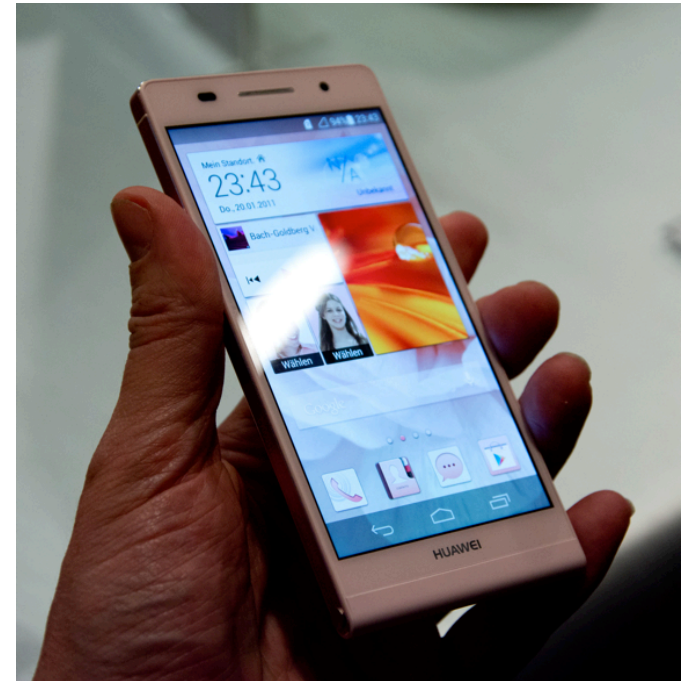
# Specialists: should be learning & doing

- About capabilities of phones (today's lecture)
- What other apps in their field look like that have already been done
- Taking this, and thinking of ideas, or areas of ideas for new apps



# Older Android Phones Available for Loan

- We have a number of Huawei Ascend P6 phones available for loan, for those who need them for assignments and the Project
  - Running Android 4.2 ☹
- Contact course TA to borrow:
  - Daniel Di Matteo
  - [dandm@ece.utoronto.ca](mailto: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 University development program, see:
  - <http://mobile.utoronto.ca/build/ios>
  - Contact [mike.spears@utoronto.ca](mailto:mike.spears@utoronto.ca) to sign up
- Allows free download to device,
  - which otherwise costs \$US 99
- Does not 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 ...

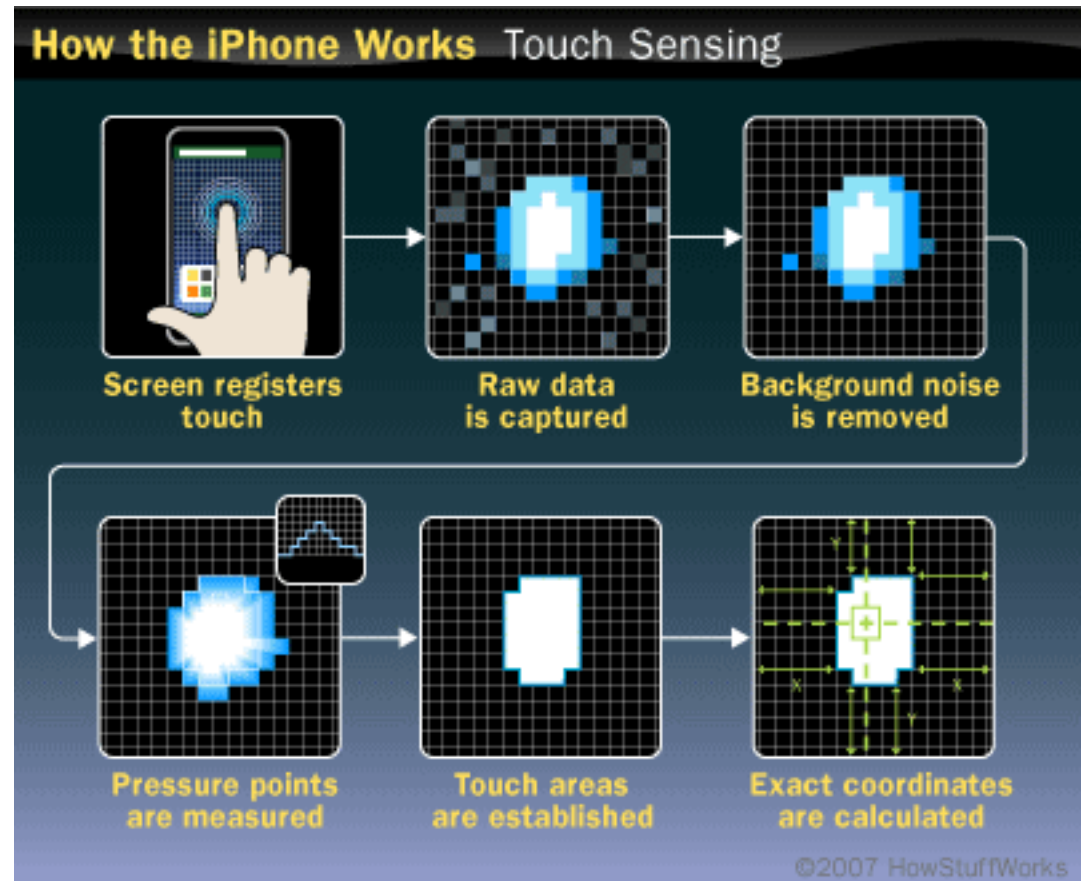
- A Computer small enough to unobtrusively carry, that
  - Is connected to the Internet – knowledge & compute power
  - Can **sense** its environment in many ways
  - Can **speak** to its environment in several ways
  
- *A Computer*
  - Will do whatever you tell it to do, automating any drudgery
    - and never complain
  - Capable of sophisticated computation, including
    - analysis of its inputs
    - generating complex sound and images

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# Inputs and Sensors

# Touch Screen

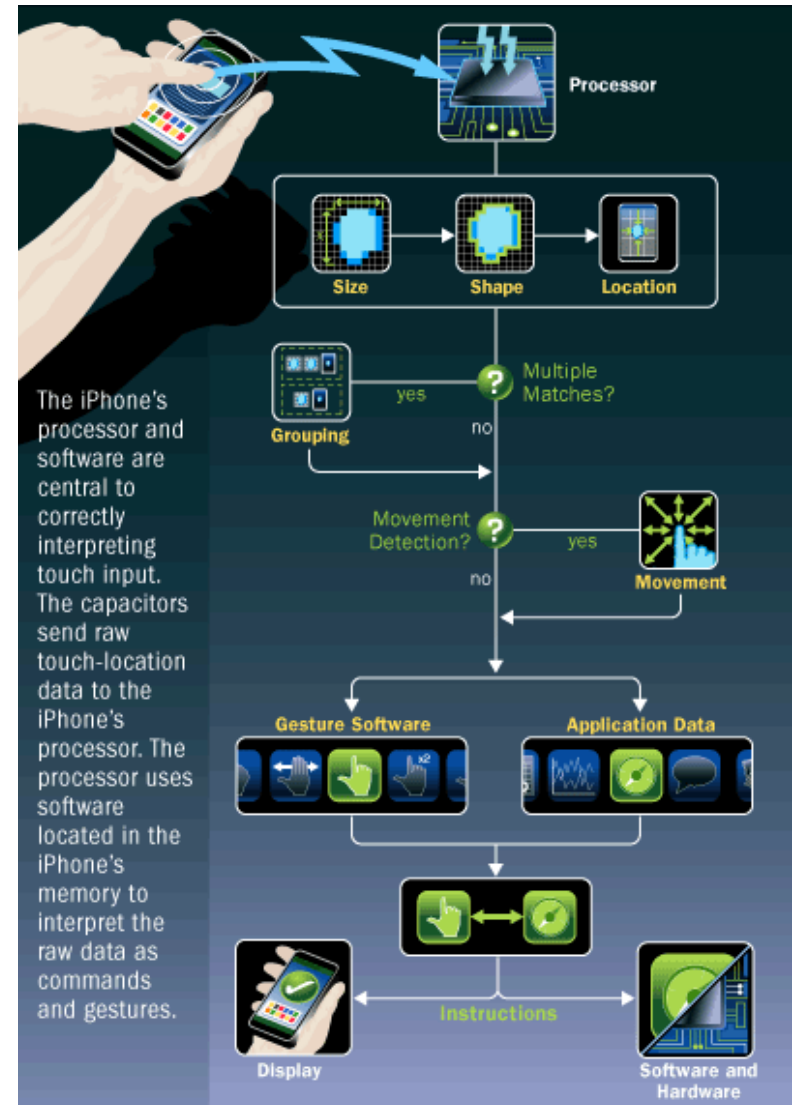
- The screen surface detects the touch of a finger
- Each touch can be turned into a specific coordinate



# Touch Screen

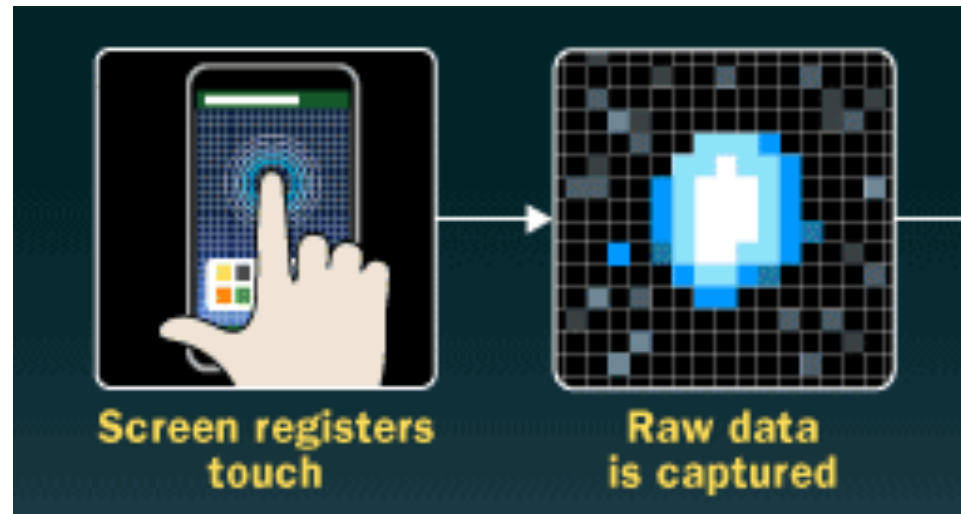
- Coordinates can be turned into several different types of input:

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



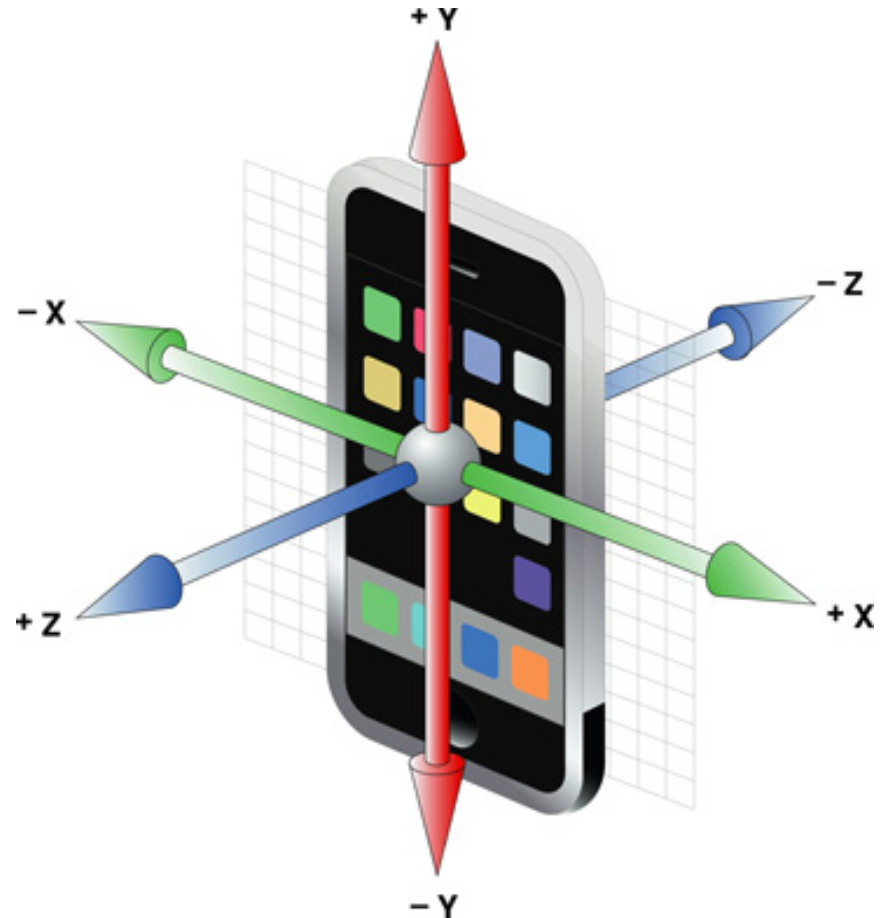
# Can Touch Screen Be More?

- Could this sensor be used to measure something about the finger?
  - Blood flow
  - Blood Pressure
  - Heart Rate
- Use for?
  - Medical Diagnosis
  - Lie Detector
- This one is my personal obsession, but in general, it is good to think how to use sensors in novel ways



# Accelerometer

- Can measure acceleration in 3-dimensions as shown
- Measured in  $\text{m/s}^2$ 
  - 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**

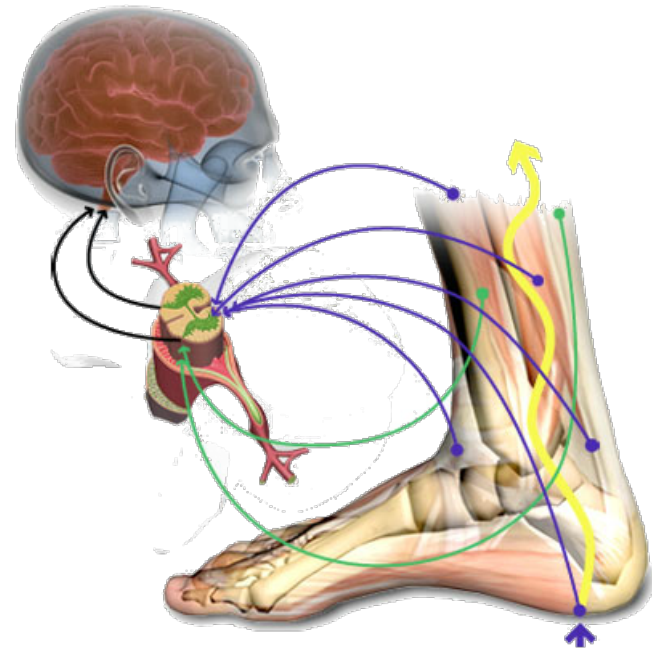
**Nirav Atre**

**Babneet Singh**

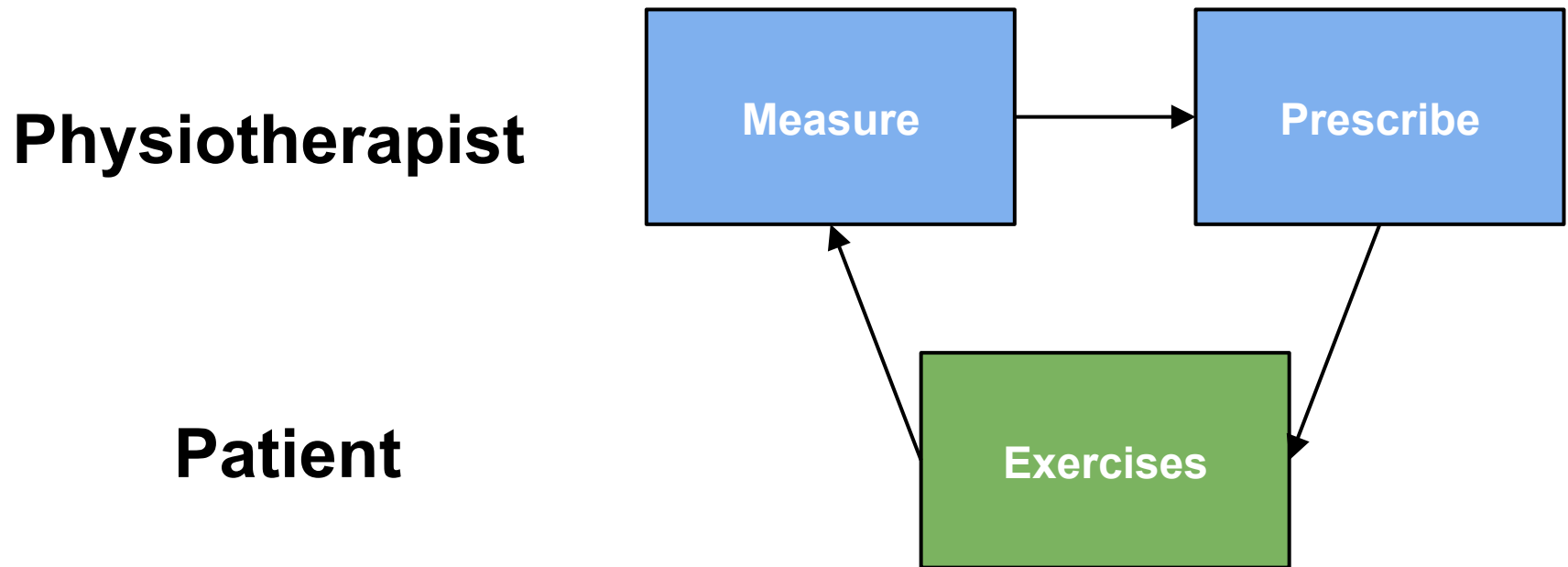


# myAnkle helps with ankle injuries

- Injury causes a loss of ability to balance
  - Leads to 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 - \$100/hr



# Usual Diagnosis & Treatment



**Physiotherapist 'measures' by watching you walk/balance!**

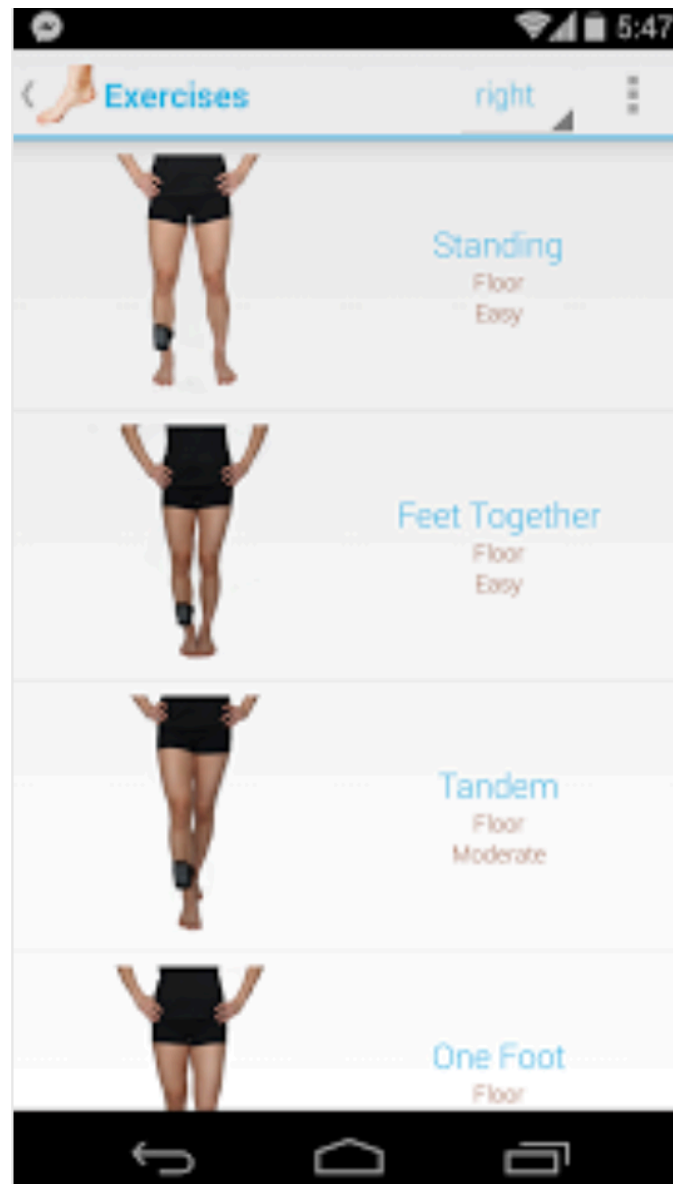
- very subjective

# myAnkle – Objective Measurement

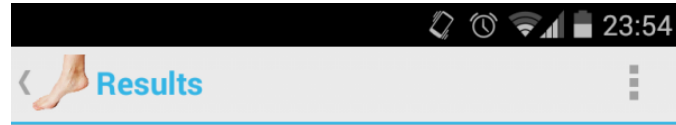
- Uses Accelerometer to measure ankle 'wobble'
  - When balancing, using the injured muscles
  - Just put phone in sock or strap to ankle:



# A Selection of Exercises



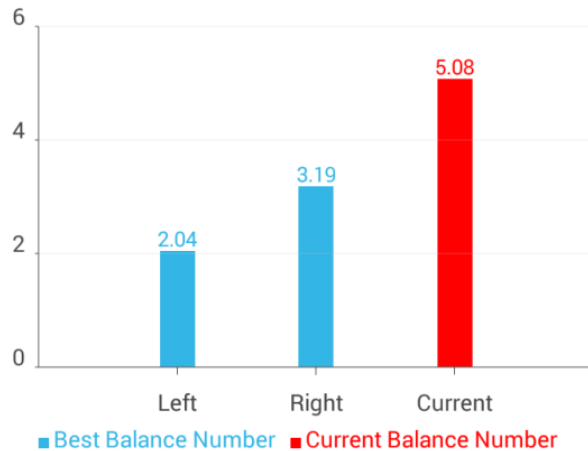
# Results



## Standing

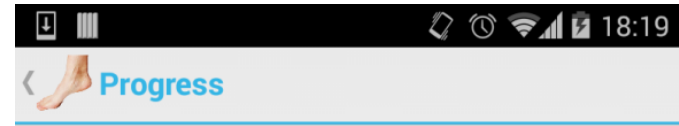
Floor  
(Right ankle)

Balance Number = 5.08



Retry exercise

New exercise

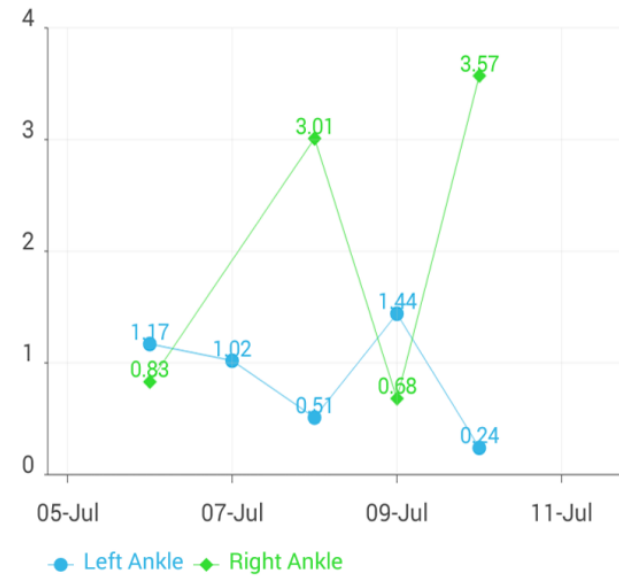


## Standing

Floor

Last 5 Days

All Time



Left Ankle Right Ankle

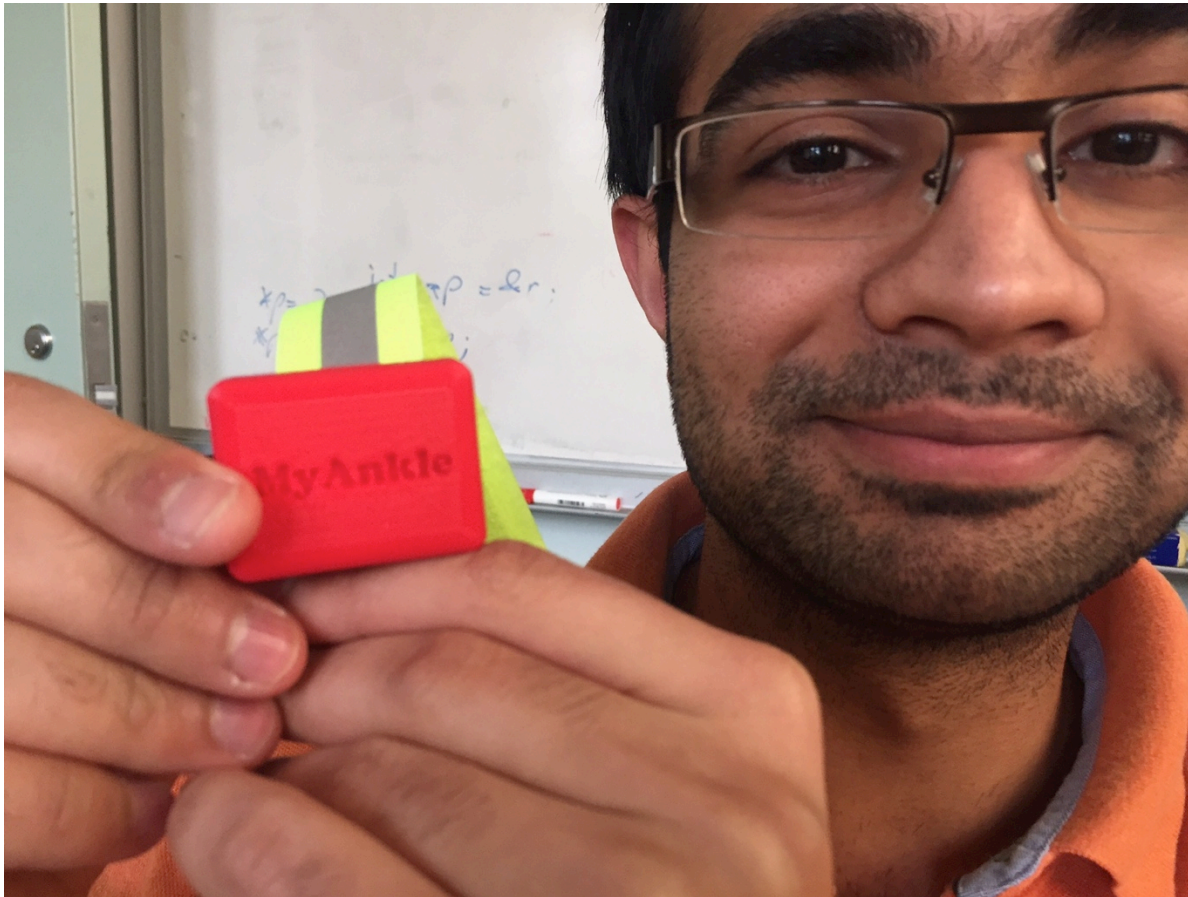
SWIPE UP FOR RESULTS



# Status

- Release 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

# My Anklet!



- Ankle strap with accelerometer inside
- Based on Metawear platform
- Undergraduate student Babneet Singh
- Should be able to port to new TI Sensor Tag soon

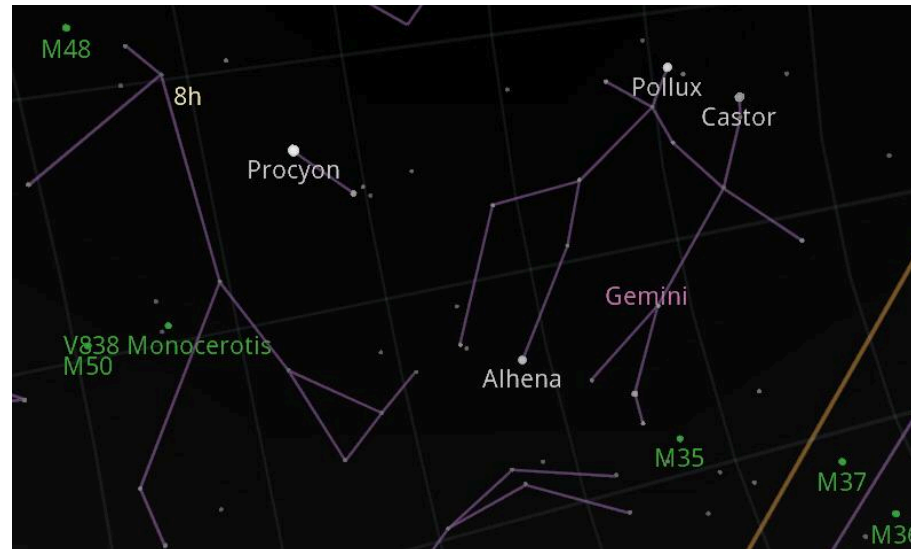


# Other Applications of Motion Sensing

- 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

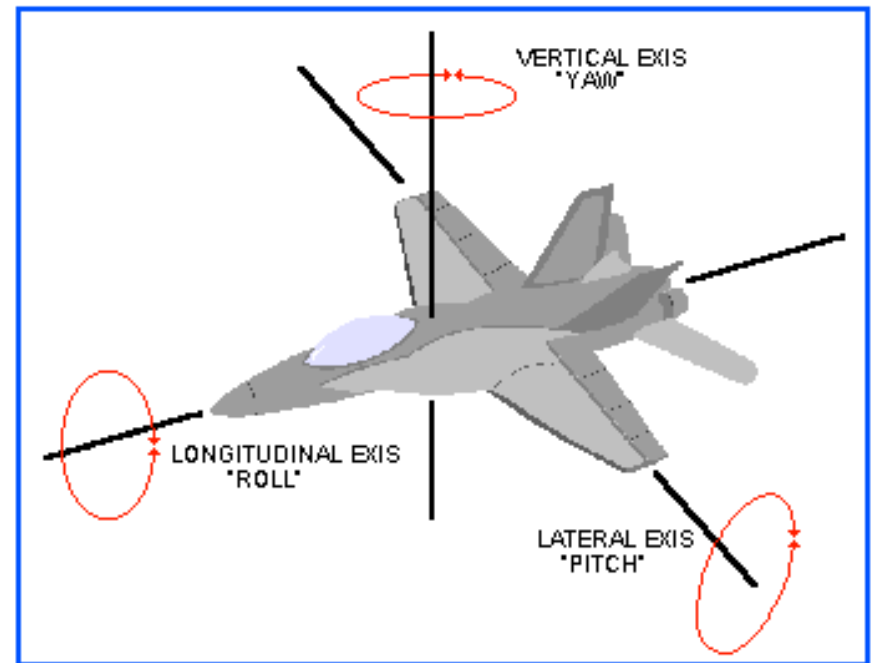
# Motion Sensing with Accelerometer

- Gravity causes acceleration  $9.8 \text{ m/s}^2$ 
  - If the phone is not accelerating (i.e. you're not moving it)
  - can determine the orientation of the phone,
  - by looking at which dimension has the '**G**':
    - X or Y or Z or some combination
- Used by stargazer apps to know where you're looking in the sky ...



# Gyroscope – measuring angular motion

- Gives: pitch, roll, and yaw
  - of phone, along X,Y,Z axis
- Rotation rate in radians/s
- Gives a better sense of the motion of the phone



# Compass

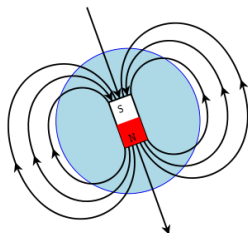
## ■ Really a magnetometer

- 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?

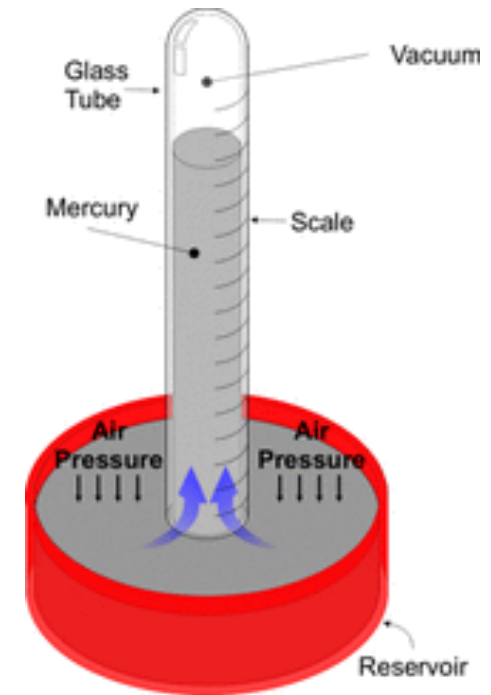


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# Barometer

- Typical on Android & iPhone 6
  - Not Ascend P6
  - 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?



# Weather Prediction Using Barometer

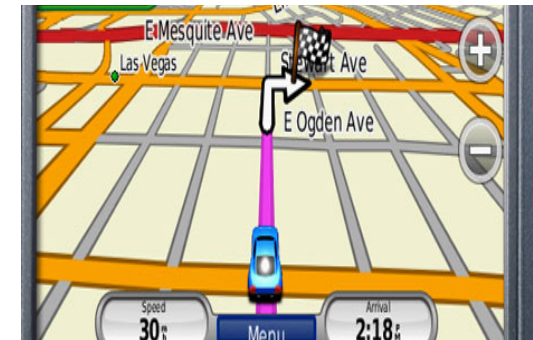
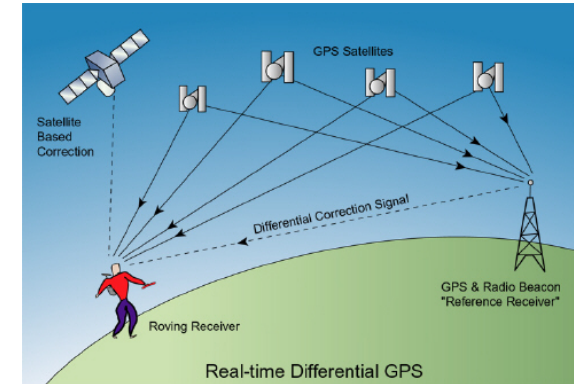
- Decreasing barometric pressure indicates storms, rain and windy weather.
- Rising barometric pressure indicates good, dry, and colder weather.
- Slow, regular and moderate falls in pressure suggest a low pressure area is passing in a nearby region. Marked changes in the weather where you are located 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

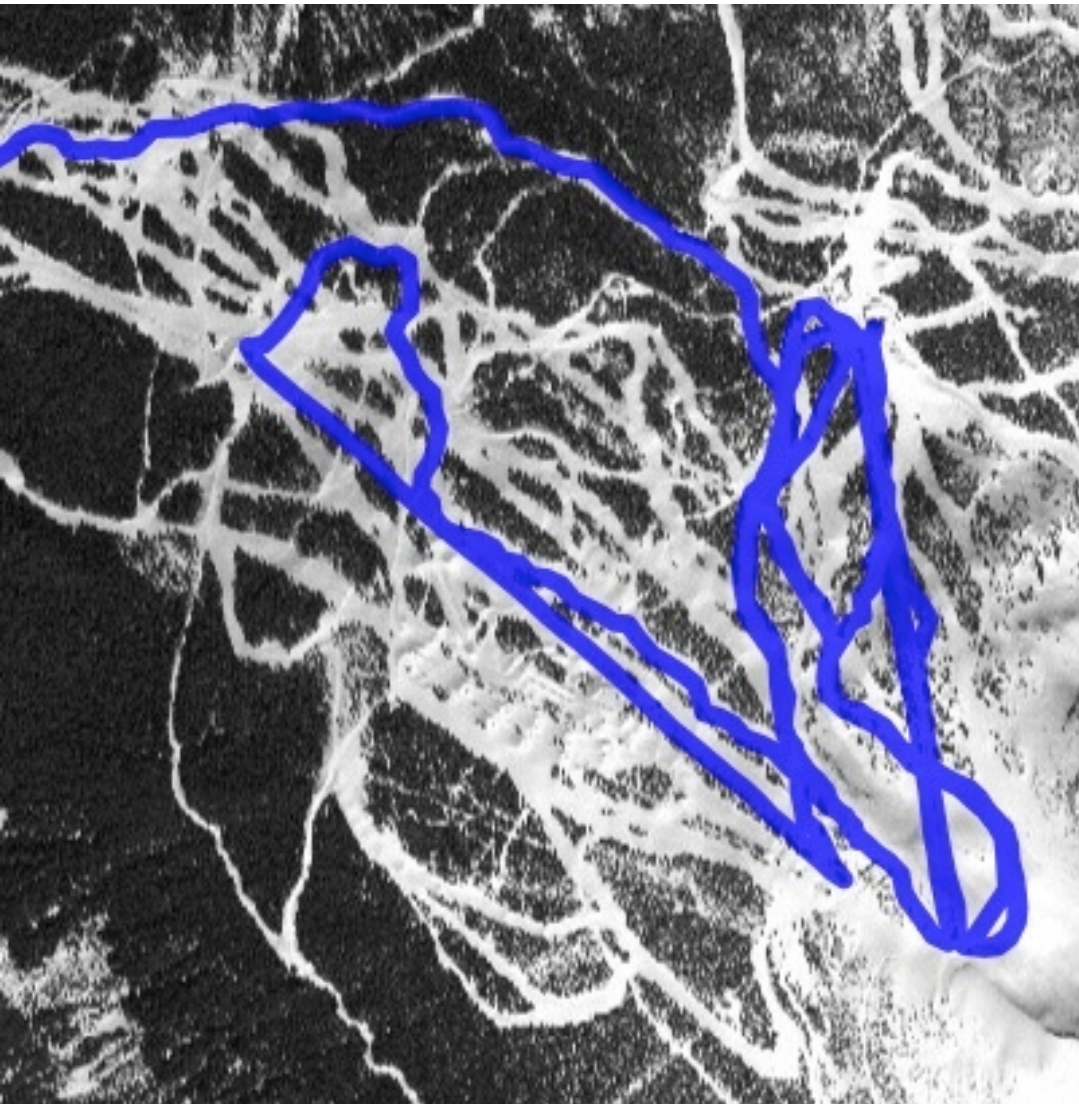
- Determines location of phone in geographic coordinates
- Quickly accurate to within 100 meters, longer to do better
  - Does not work inside buildings
  - Has trouble when lots of buildings around
- Knowing where you are is incredibly useful in business; can provide context for assistive apps



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



# Skiing in Whistler



(44)

**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

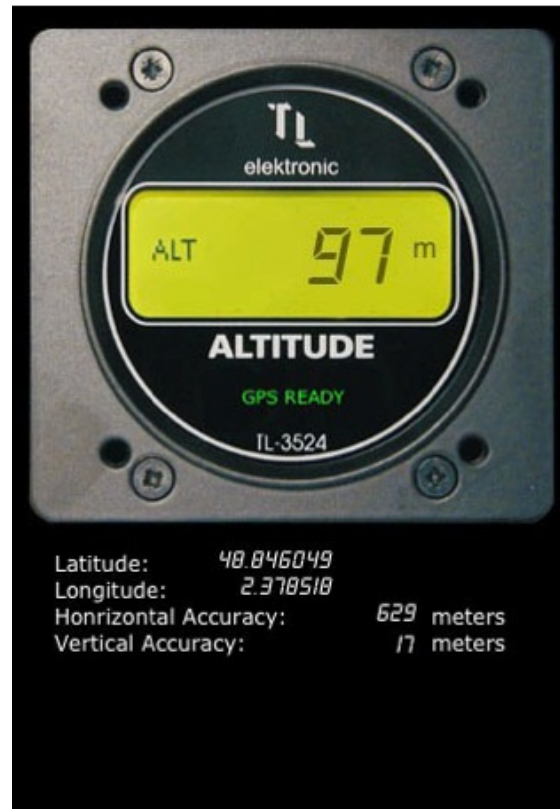
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- Can also get the raw position of the satellites themselves
  - Someone in Aerospace might want to do something interesting with that



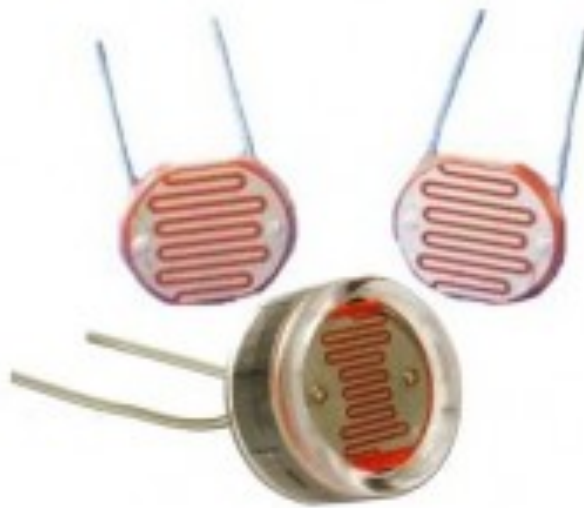
# Altimeter

- 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

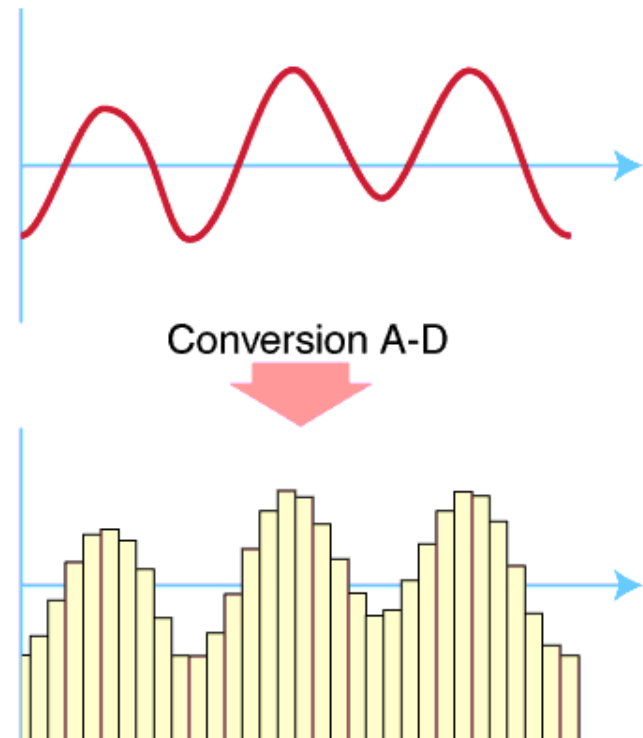
# Microphone

## ■ Converts sound into data

- Microphone converts sound waves into voltage
  - Which varies over time
- Circuit converts voltage 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**



# Microphone – Sonar Device

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

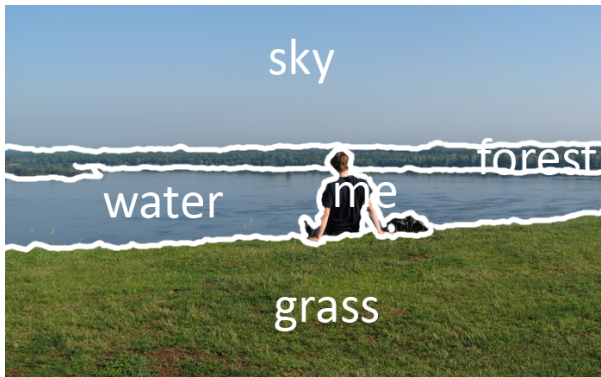
- Can record images
  - Large files with high resolution
    - 2MPixels – 13 MPixels
- Can record video
  - ~ 30 frames/second of pictures
- Can we use it to “see things”?
  - Yes!
  - Computer Vision field
  - Difficult, slow



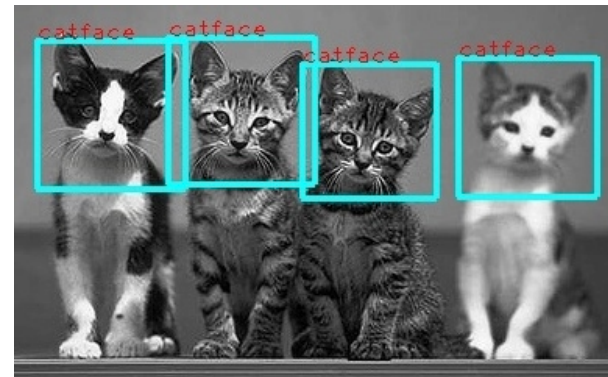


# Computer Vision

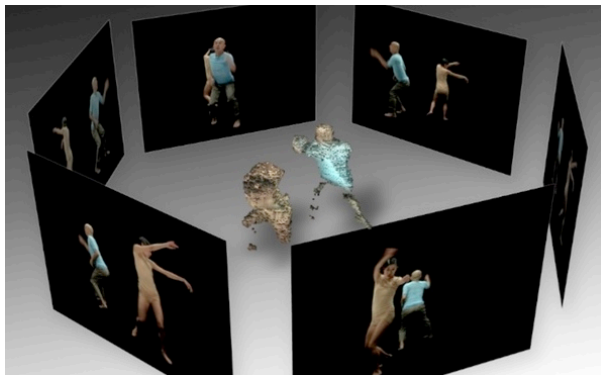
- Goal to 'see' the world in like people do



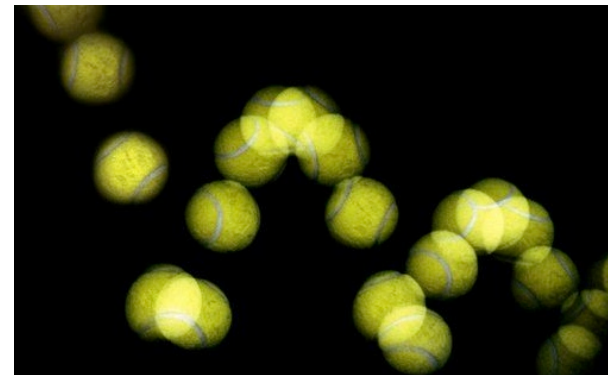
**Image Segmentation**



**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



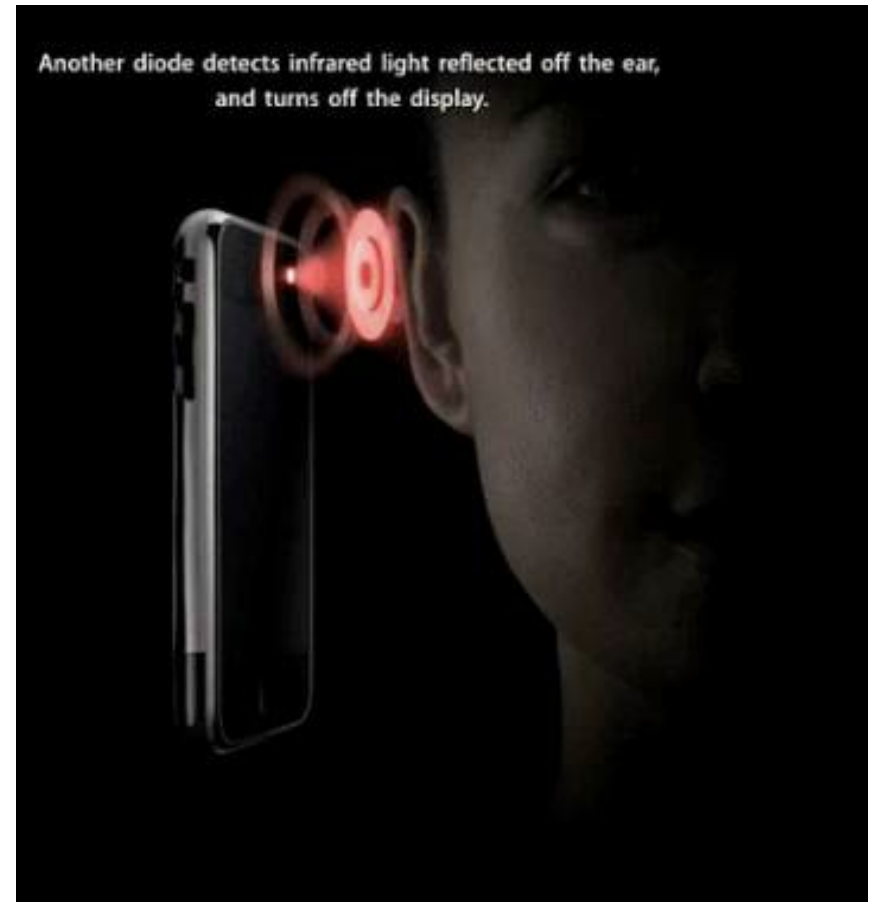
# Super Human Capability!

- **Cardio** – 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 too near to ear
- Simple Near/Not input
  - Doesn't give distance, yet





# Humidity and Temperature Sensors

- Apparently, some Android devices have a humidity sensor, but it is for sensing if you've dropped the device in water, and just turns colour and is permanently triggered
- There is also a temperature sensor, but it is just for the battery, not the ambient temperature (yet)
- Many of the external wearables/connected devices we have can measure temperature



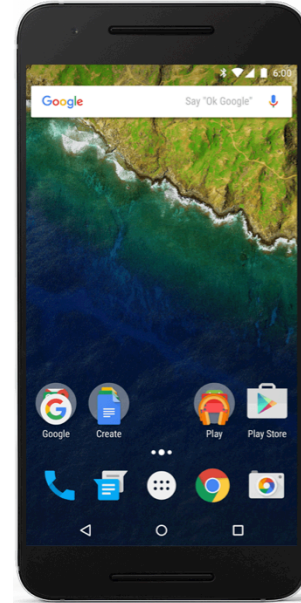


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# Output Devices

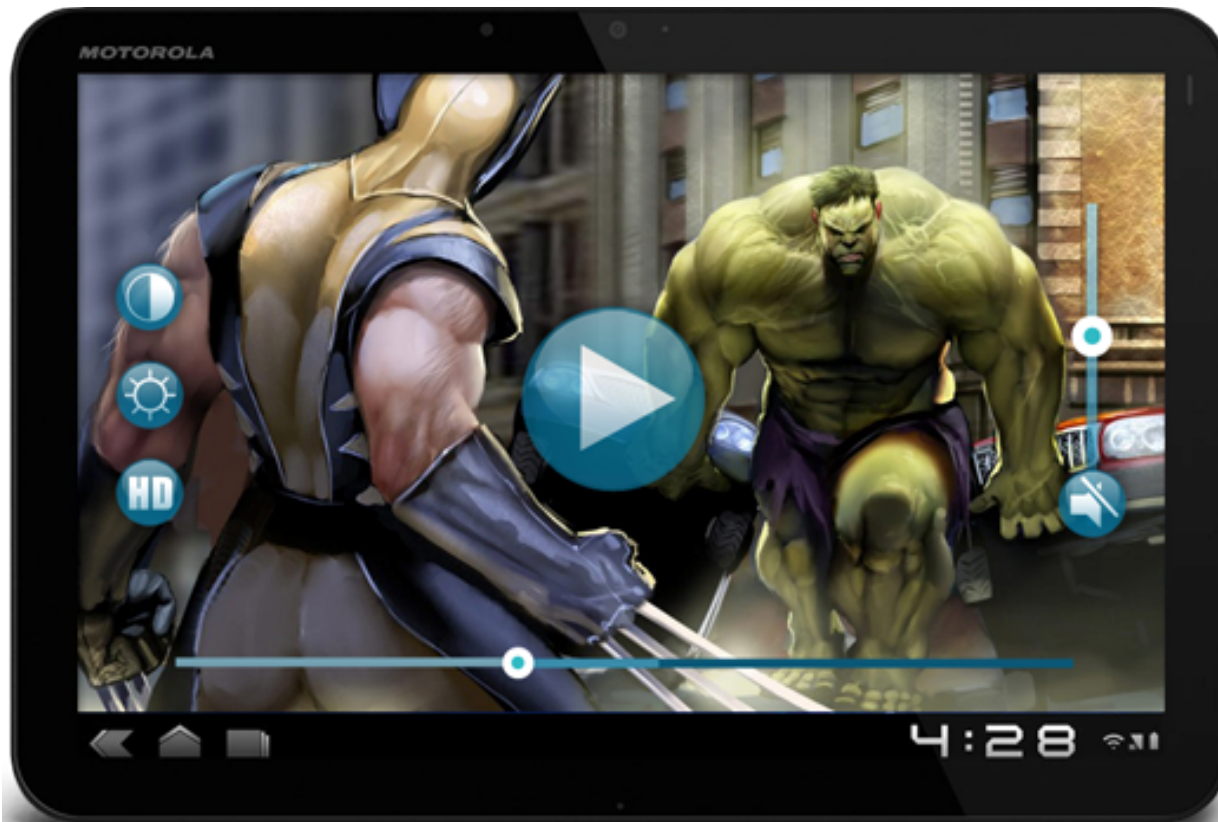
# Hi-Resolution Screen

- 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<sup>(62)</sup> -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

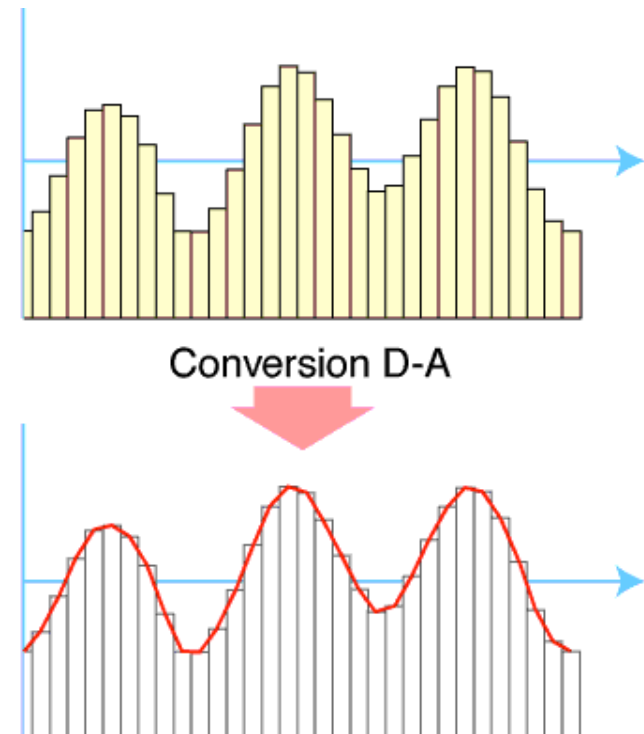


## ■ Play previously recorded files

- Should be able to do **text-to-speech**

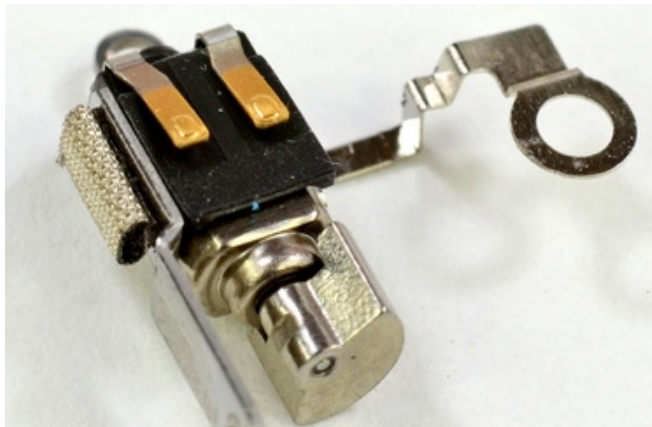
## ■ Many possible sound filters –

- Auto-tune voices to make at right pitch
- Make funny voices
- Synthesized Musical instruments



# 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**



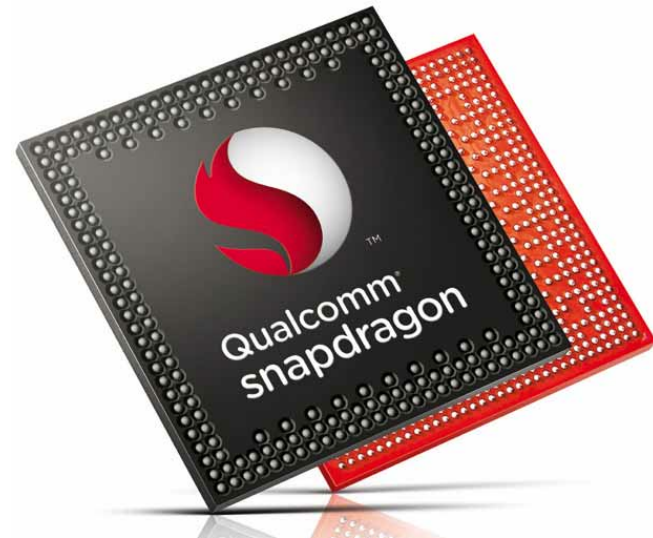
# Computer

## ■ What can a computer do?

- Processors are powerful
- Nexus S has 1GHz ARM Cortex A8 processor

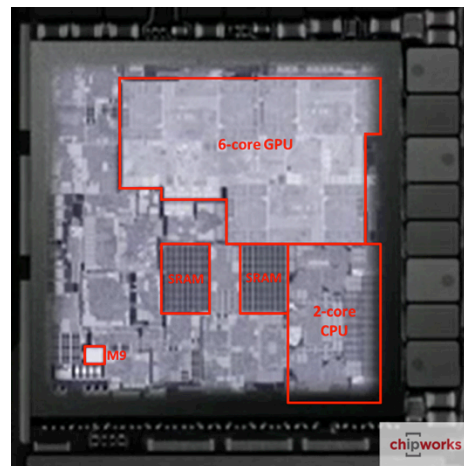
## ■ Many things!

- Optimization
- Search
- Sort
- Artificial Intelligence



# The Application Processor

- iPhone 6s has dual core ARM v8 and 6x Power VR GPU
- Huawei device is a 4 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



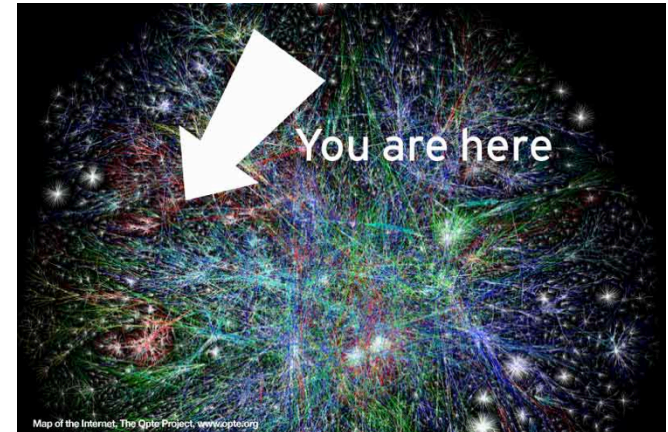
# Storage Capacity

- Local storage of 2 to 128 Gbytes of permanent storage
  - Flash-based solid-state disk
- Can load many databases locally onto the device
  - Dictionaries, no problem!
  - Maps
  - Phonebooks
  - Location Services



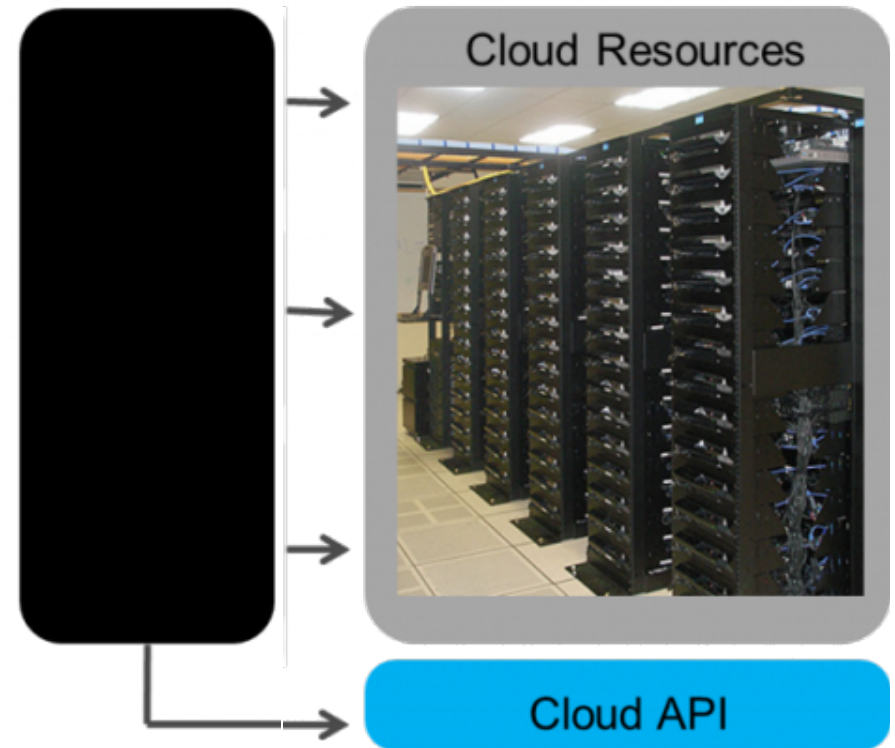
# Network – LTE/3G/Wifi: Gateway to Internet

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



# 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



A Sensor for Every Application

- 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.

(76)

\$25

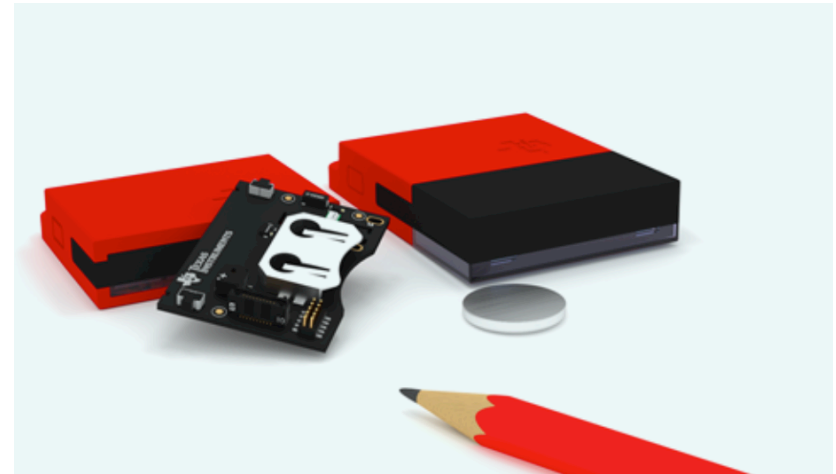
[click here to buy or learn more](#)





# Texas Instruments Sensor Tag 2

- **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 four of these for use in course
  - Can easily/quickly get more



# Button TrackR



- 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

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1



Affix the small Lumo Lift sensor on your clothing with the complimentary magnetic or bra clasp.

2



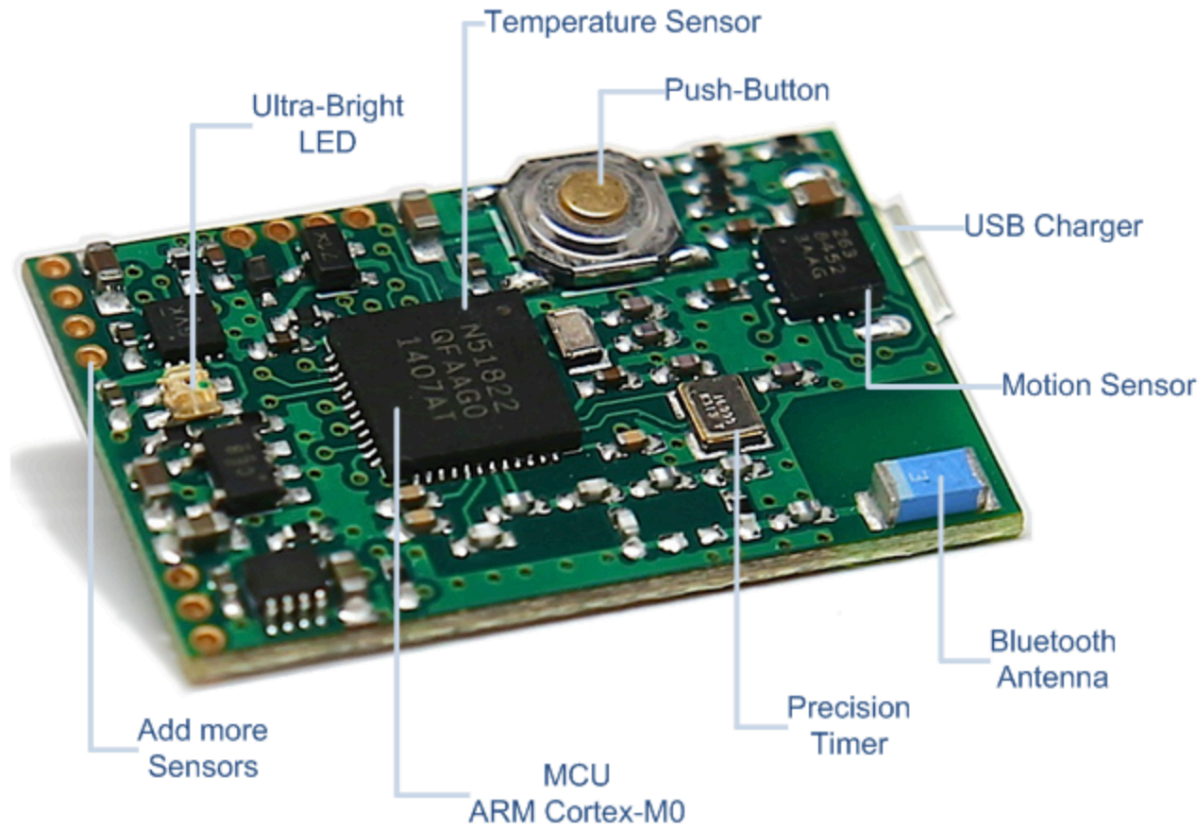
Align your Lift sensor by getting into your best posture then double pressing on the clasp.

3



The sensor will gently vibrate whenever you slouch, coaching you to better posture and a healthier back.

# Metawear



- Comes with ready-to-use software for Android and iOS
- <https://mbientlab.com/metawear/>

# Other Externals

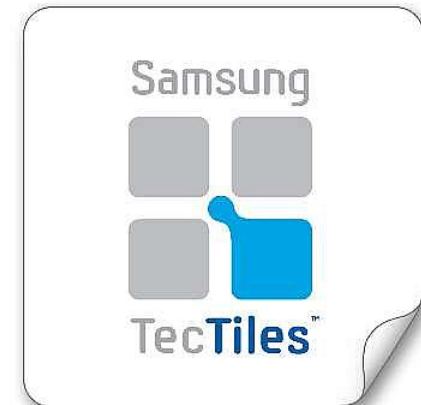
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- Microsoft Band 2 – expensive, but open
- Angel Sensor – cheaper, open



# 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!





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# Introductions, continued

To Help in Project Group-forming

# Introductions, Continued

- Last Day, specialists introduced themselves
- Today, let's try to make sure all of the 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.



# Please Introduce Yourself, Round 2

1. Name
2. What discipline you work in & degree sought
3. Taking Course for Credit – yes, maybe
4. Part time or full time
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 you're interested in doing app on



# Next Week: Meeting to Form Groups

- Tuesday January 19<sup>th</sup>
- 6:30pm-8:00pm (in addition to the class that day)
- Galbraith Building, Room 221
  - Will create categories

