ECE 1778:
Creative Applications for Mobile Devices

Lecture 2

January 14, 2015

Today

1. Logistics/Organization of Course & Project

2. Capabilities of Smartphones & Creative Applications
   - to get you thinking about ideas for applications

3. Continued introductions of Students & Idea Discussion

Logistics & Project Process

Websites & Lecture Postings

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

- Keep an eye on the Pepper website for discussion boards

- Announcements will be sent through Blackboard

Sign up – sheets and ROSI

- If you did not last week, please sign up on the sign up sheets
  - Need to indicate name, dept, phone type, and if you are either:
- **Apper:** non-programmer, with expertise
  - From specific discipline that app will leverage in significant way
- **Programmer**: capable of learning new environment fast
- Can be both, which means you can program well and have expertise in some specific field

Recall: The Goal

- The goal of this course is to bring together people from different disciplines and to build an interesting/creative mobile application

- First Priority is to create those inter-disciplinary groups
  - Step 1: Two Programmers should find each other
  - Step 2: Form group with Apper

- Groups of 3 or 1 programmer will not be allowed
  - Too many, too few

From Last Week's Signup

Programmers		Appers		Both	
Credit	Maybe	Credit	Maybe	Credit	Maybe
29	9	24	3	3	2

- Total of Yes & Maybe
  - Programmers & Both: 43
  - Appers: 27
- Submitted Part 1 of Assignments A1 or P1:
  - Programmers: 41
  - Appers: 26
- Registered on Blackboard/ROSI: 86

Are There Others Not Counted?

1. How many have no submitted Assignment 1 Part 1 Monday, but still intend to be in course?

2. How many people here are not registered on ROSI?

Note on Group Forming

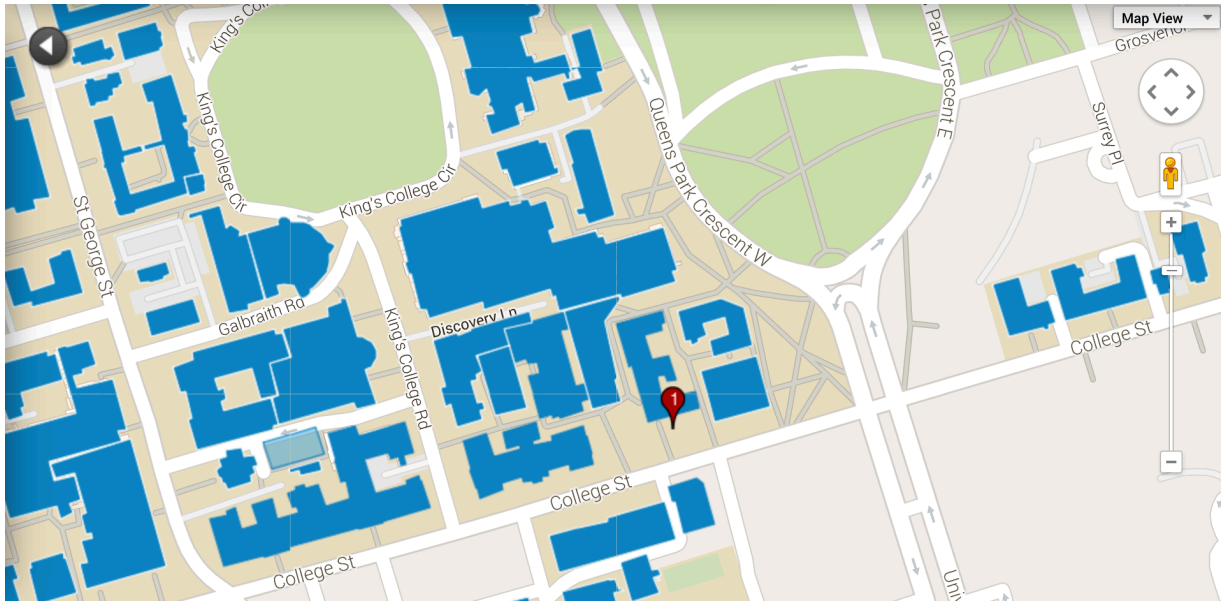
- Need to be in a group to stay in the course!
- Each group must have one Apper
  - And two Programmers
- Currently, there may not be enough programmers
  - Programmer numbers may go down, as our review of their qualifications show that some might not be at the right level
  - We will be contacting some programmers shortly
- So, the onus may be on the Appers this year

Work for you Soon

- Programmers have introduced themselves on the Pepper website & given background
- Appers introduced themselves & described their field
  - Some have already suggested specific apps
- Today, you should look at these, to achieve
  - Groupings of programmers
  - Prepare for group forming next Wednesday night
- Feel free to make initial contact through pepper messaging
  - I suggest setting notifications on Pepper settings to be notified of messages and posts

Extra Meeting to Form Groups

- Next Week: Wednesday January 21st
- 6:30pm-8:30pm
- Fitzgerald Building, Room 103
  - 150 College Street
  - Will find a way to help make matches there



Once You Have Formed a Group

- Send email to:
  - Me (Jonathan.Rose@ece.utoronto.ca)

- In that email, Provide:
  - 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 Apper 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)
    - if thinking about using Tablet
    - if you have your own device(s) you can use

Initial Thoughts/Pointers on Project

- Once you have a group:
  - Apper needs to give rough idea of discipline – teach!
  - Start kicking around ideas – 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; be sure to use **Spiral/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 Apper**
   - an idea to support research
   - or something useful/worthwhile/interesting within the discipline
   - Must leverage expertise that discipline

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 application**
   - Not something that could as easily be done on desktop/laptop

Project Stages

1. **Forming Groups**
   - Within 3 weeks; special get together Wed Jan 21 @6:30pm
2. **Project Approval-in-Principle**
   - Done via Pepper website Discussion Group/email
   - Due January 28th prior to class; Must have approval to proceed
3. **Project Proposal/Plan**
   - Document Due Feb 4th
4. **Proposal & Plan Presentations**
   - February 11 & 12
   - NOTE EXTRA LECTURE Thursday Feb 12, 6-8pm**, FG 103**
5. **Spiral 2 & Spiral 4 Presentations**
   - 2: March 4/11 4: March 18/25
6. **Final Presentations**
   - Weeks of April 1 & 8
7. **Final Report Due April 9th**

Assignment 1 Part 2 Due Next Week

- P1 and A1 part 2 assignments due next week
  - 6pm, Tuesday January 20th
  - **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 the assignment
  - Attach your file using 'Browse My Computer'
- Programmers: **P1**
  - Any issues/questions?
- Appers: **A1**
  - Any issues/questions?

What Programmers Should Be Learning

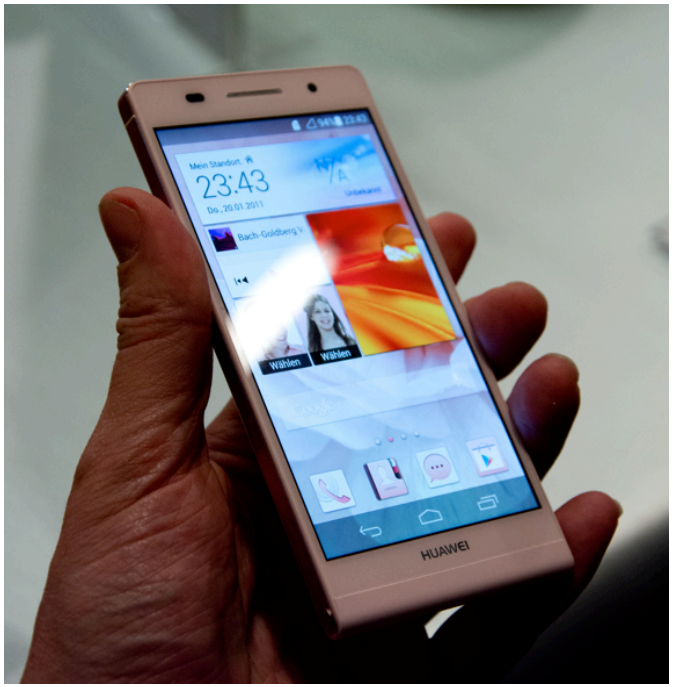
- With Assignment 1:
  - After downloading the various elements of the programming environment
- Java basics if not already known
  - http://en.wikibooks.org/wiki/Java_Programming/Language_Fundamentals
  - Or some basic Java Text
  - I liked John Carter, '**Using Java**'
- Working within Android Studio
  - or, can choose to do everything in command/shell environment
  - lose some of IDE good features
- Running the basic environment
- Understanding File Types in the Android Project

What Appers 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

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:
  - Braiden Brousseau braiden.brousseau@utoronto.ca
  - You will take responsibility for the phones you borrow

Many thanks to for the donation of these phones!

HUAWEI

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 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 …

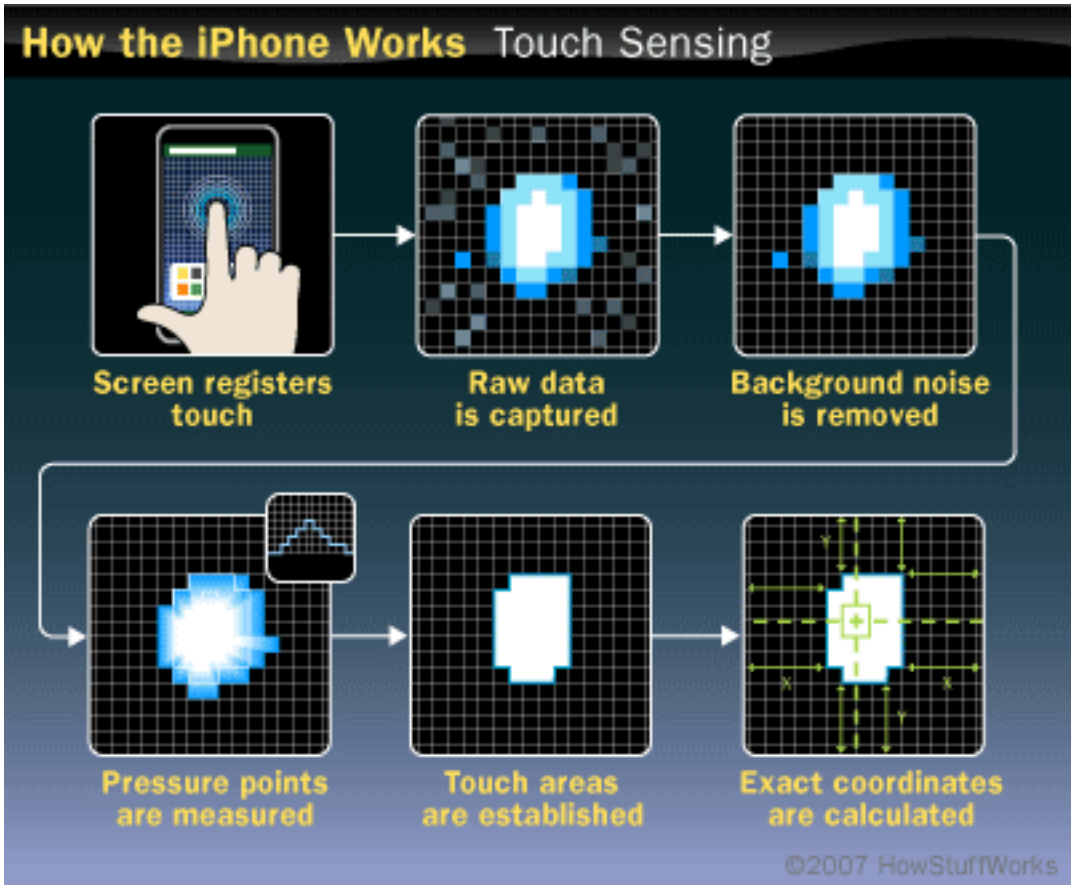
- A Computer small enough to unobtrusively carry, that
  - Is connected to the Internet – knowledge & compute power
  - Can **sense** its environment in many ways
  - Can **speak** to its environment in several ways

- 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

Inputs and Sensors

Touch Screen

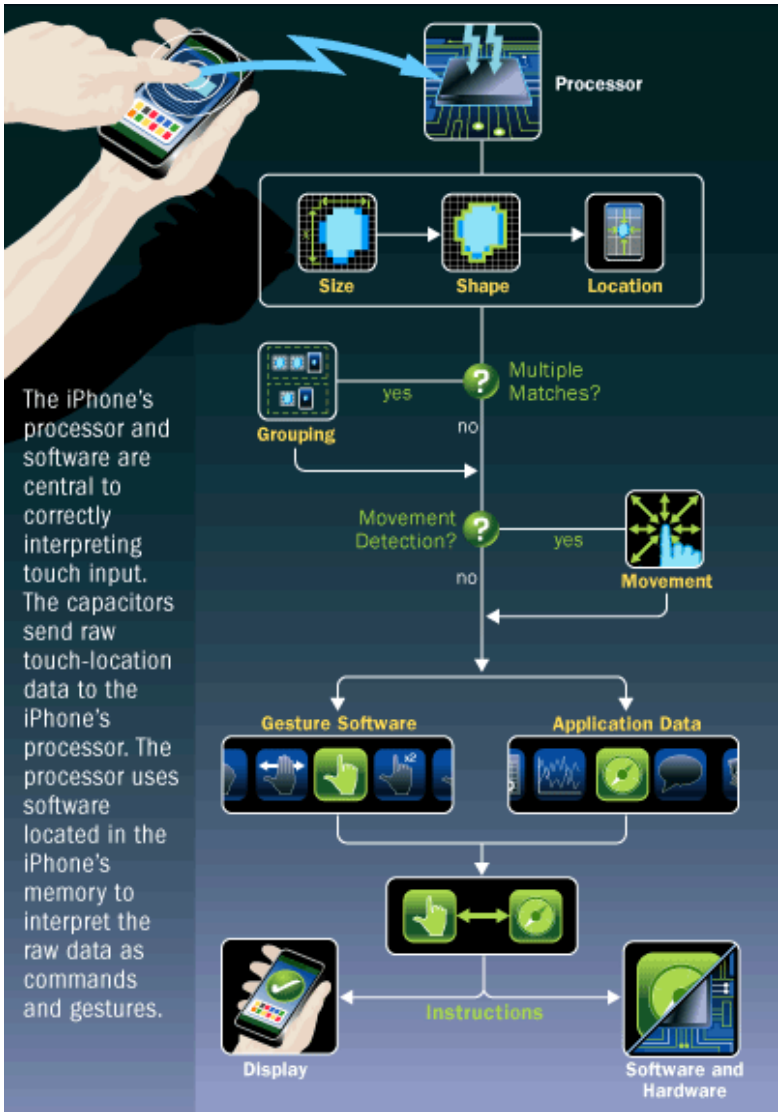
- The screen surface detects the touch of a finger
- Each touch can be turned into a specific coordinate



Touch Screen

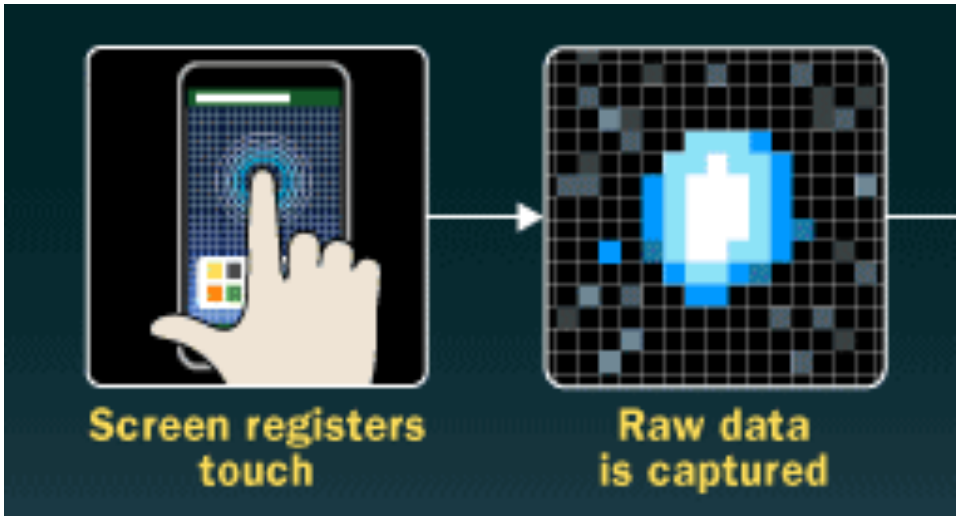
- Coordinates can be turned into several different types of input:

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?

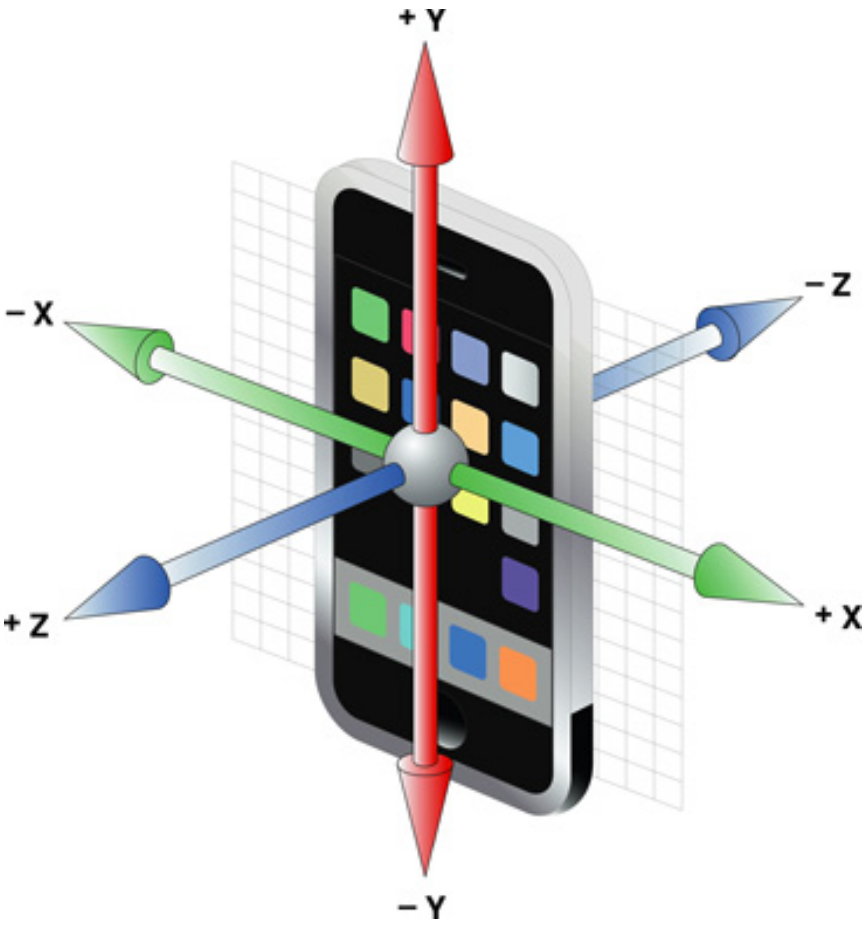
- Could this sensor be used to measure something about the finger?
  - Blood flow
  - Blood Pressure
  - Heart Rate
- Use for?
  - Medical Diagnosis
  - Lie Detector



- 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 **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

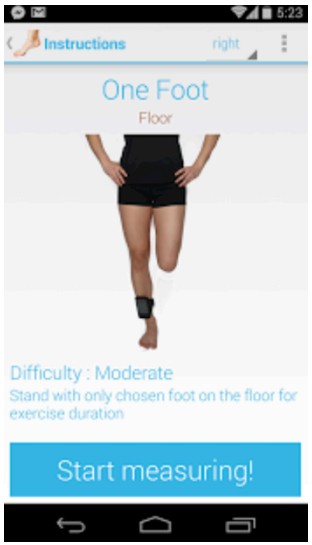
Nirtal Shah, Ivan So, Lyndon Carvalho

Vivian Liu

Braiden Brousseau

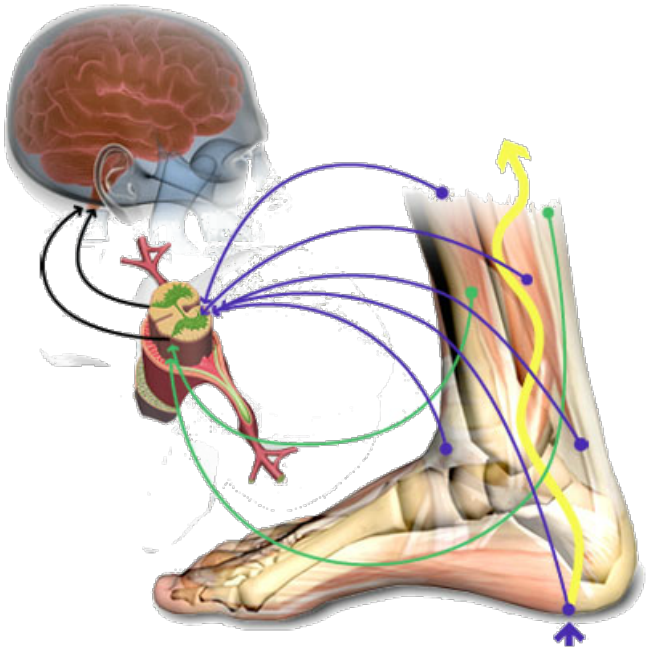
Nirav Atre

Babneet Singh



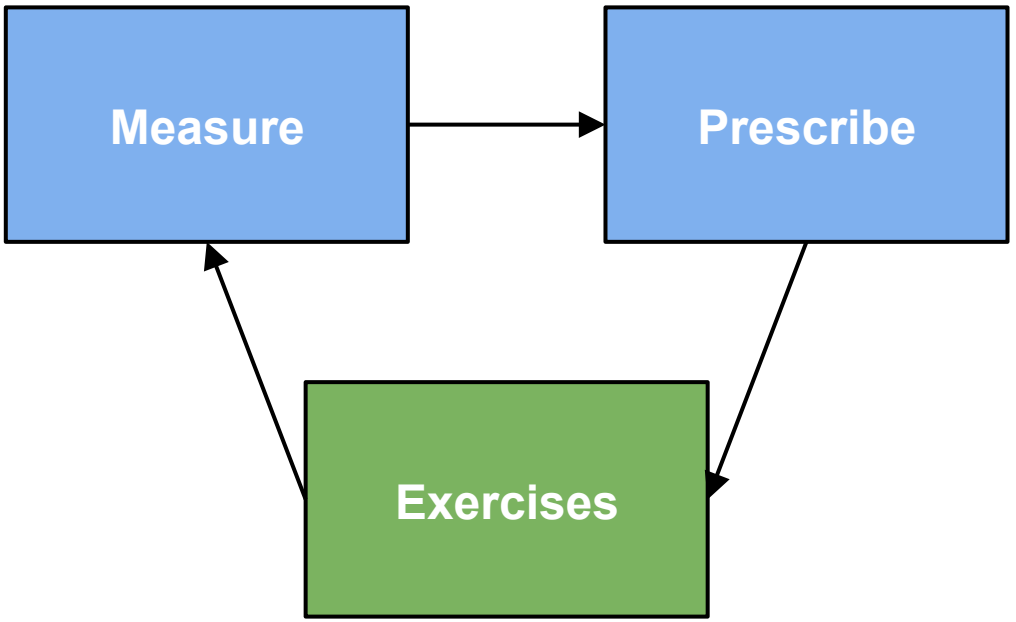
myAnkle helps with ankle injuries

- 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



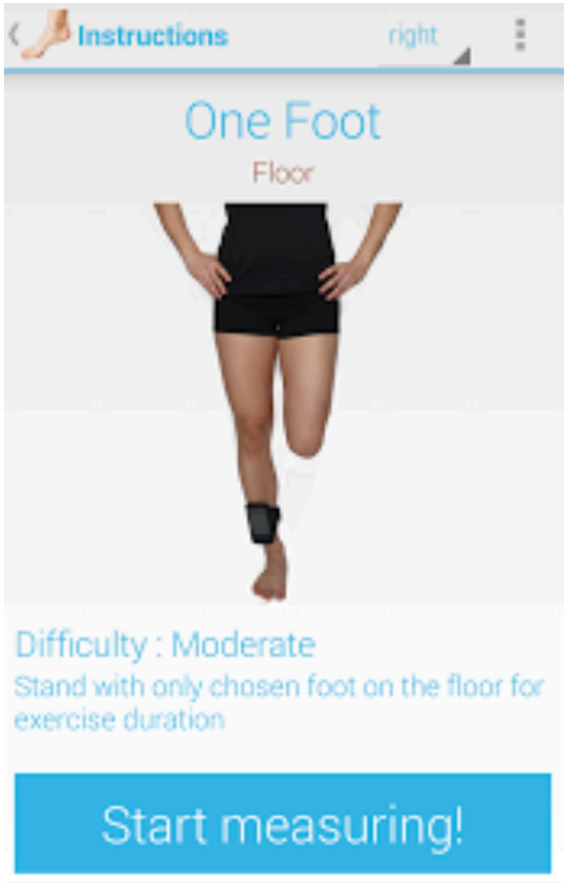
Patient

Physiotherapist 'measures' by watching you walk/balance!

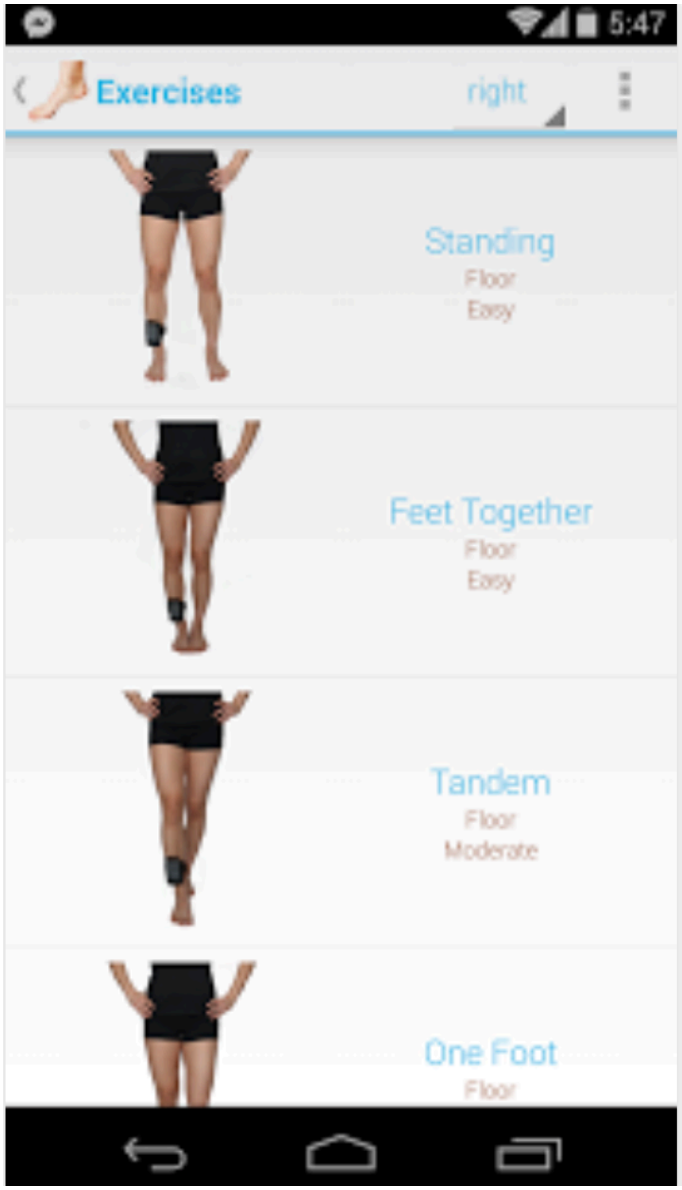
- **very subjective**

myAnkle – Objective Measurement

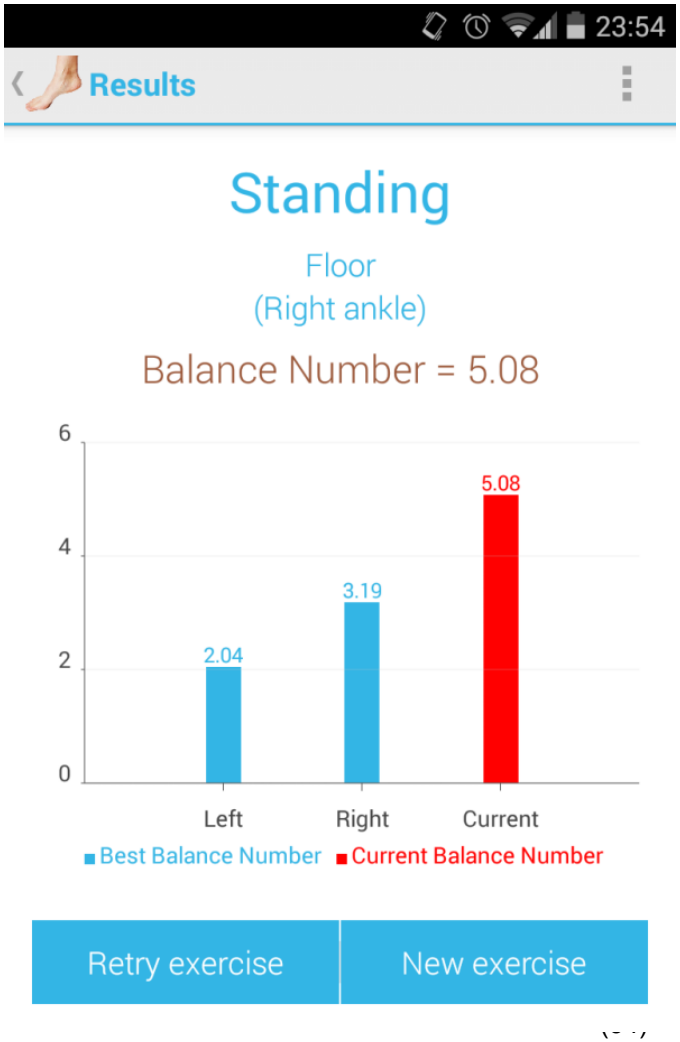
- Uses Accelerometer to measure ankle ‘wobble’
  - When balancing, using the injured muscles
  - Just put phone in sock or strap to ankle:

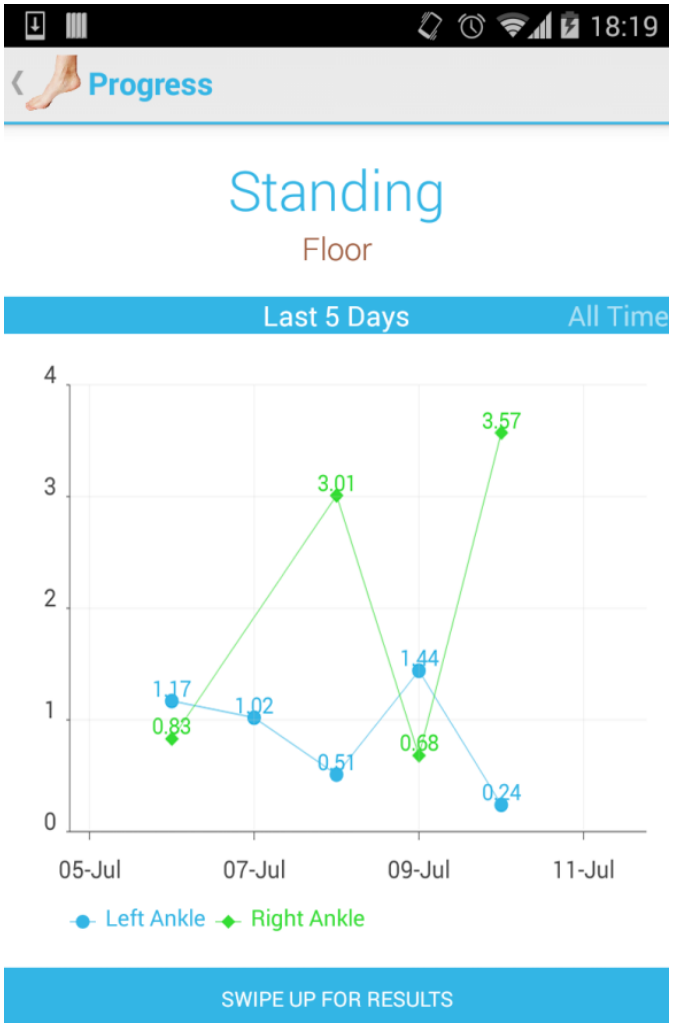


A Selection of Exercises



Results

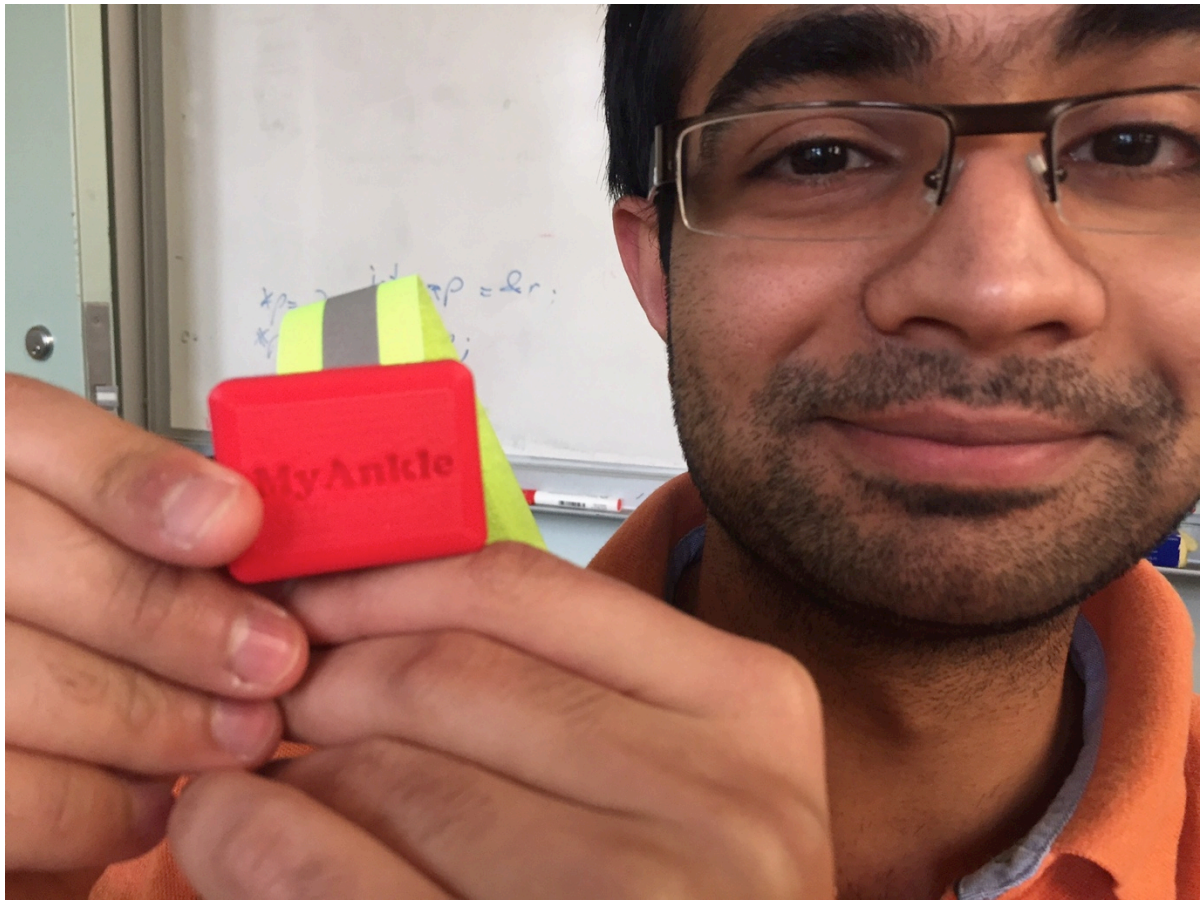

23:54
Results
Standing
Floor
(Right ankle)
Balance Number = 5.08
6
4
2
0
2.04
3.19
5.08
Left
Right
Current
Best Balance Number
Current Balance Number
Retry exercise
New exercise


18:19
Progress
Standing
Floor
Last 5 Days
All Time
4
3
2
1
0
3.57
3.01
1.44
1.17
1.02
0.83
0.68
0.51
0.24
05-Jul
07-Jul
09-Jul
11-Jul
Left Ankle
Right Ankle
SWIPE UP FOR RESULTS

Status

- Release to Google Play App Store Last February
  - Updated and improved in September
- App will only measures, does not prescribe
  - Collecting data for Nirtal Shah's M.P.H. research
  - Need to learn what the numbers mean
  - We hope to evolve it to prescribe
  - New version to be released soon
- 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

Other Applications of Motion Sensing

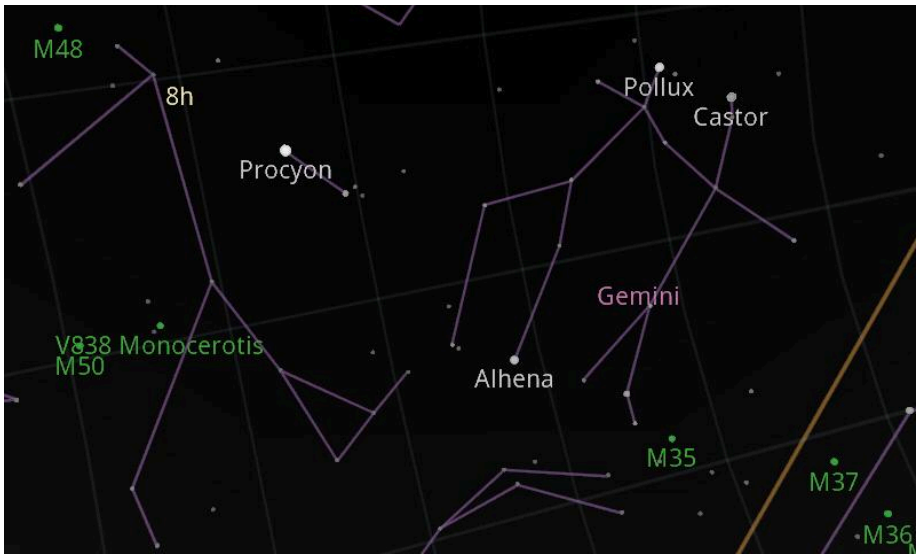
- Can tell if the phone is being shaken
  - Can use as an input
  - How sensitive is it?
  - Can it be used to measure Parkinson's tremors, in a medical application?

- Can detect if person fell down
  - could alert someone

Motion Sensing with Accelerometer

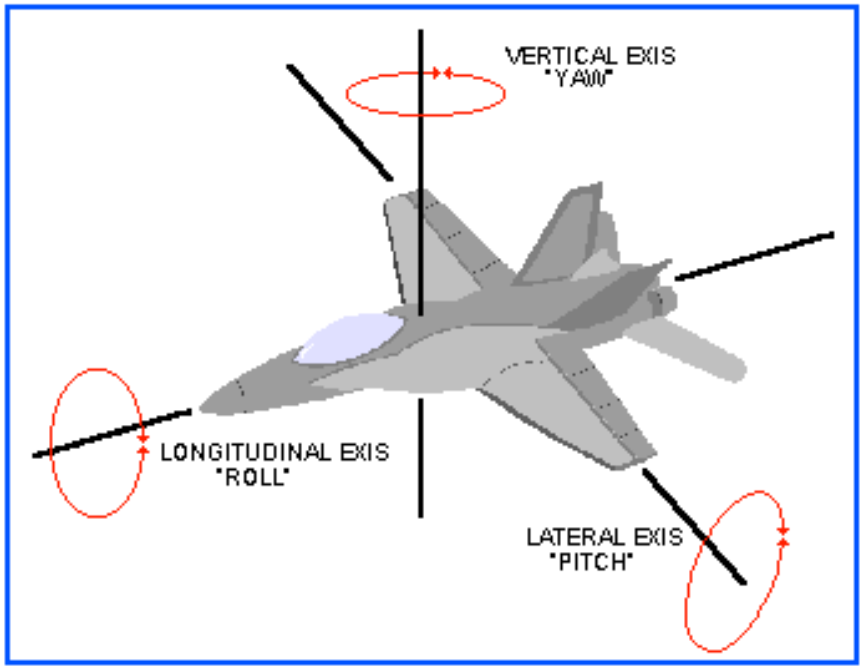
- Gravity causes acceleration 9.8 m/s^2
  - If the phone is not accelerating (i.e. you're not moving it)
  - can determine the orientation of the phone,
  - by looking at which dimension has the '**G**':
    - X or Y or Z or some combination

- Used by stargazer apps to know where you're looking in the sky …



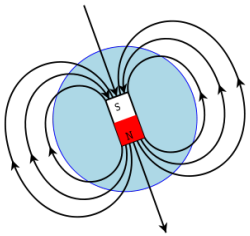
Gyroscope – measuring angular motion

- 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



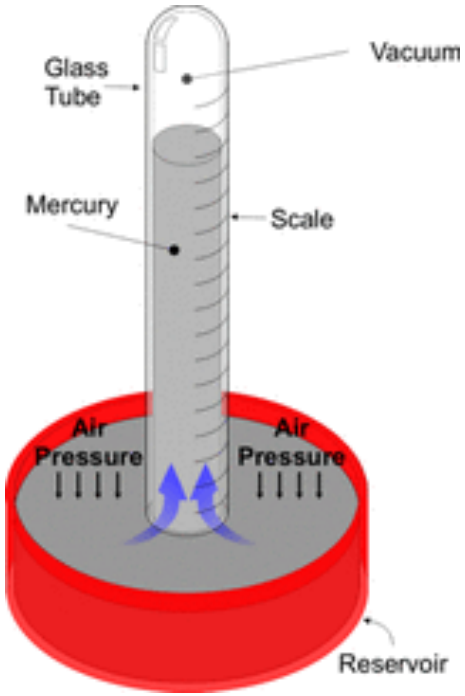
Compass

- 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?



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?



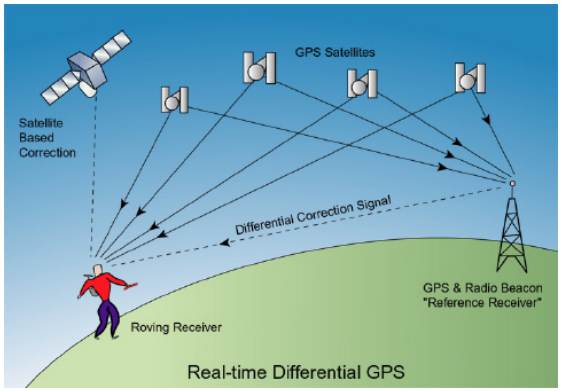
Weather Prediction Using Barometer

- 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

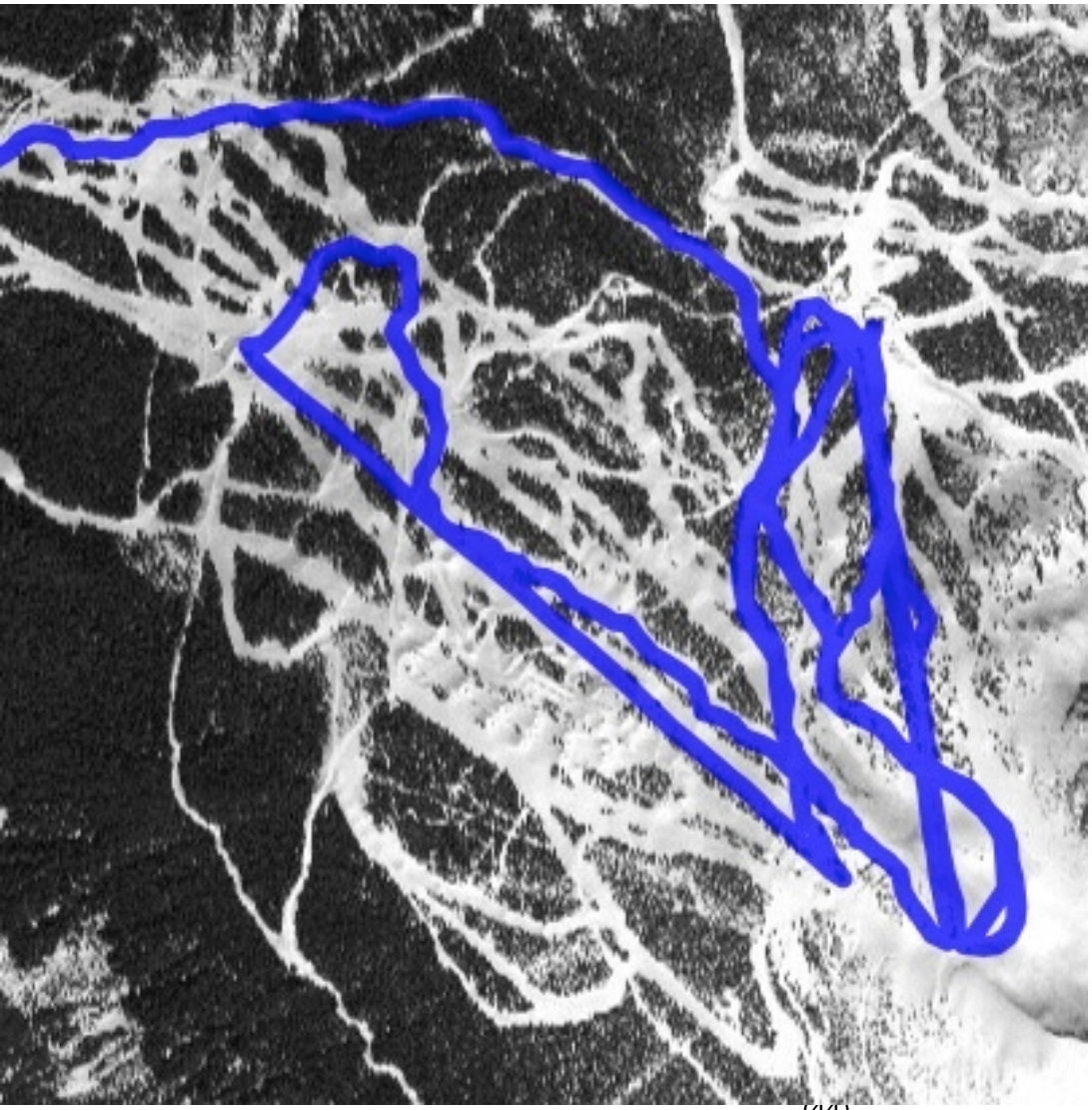
- Determines location of phone in geographic coordinates
- Quickly accurate to within 100 meters, longer to do better
  - Does not work inside buildings
  - Has trouble when lots of buildings around



- 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



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

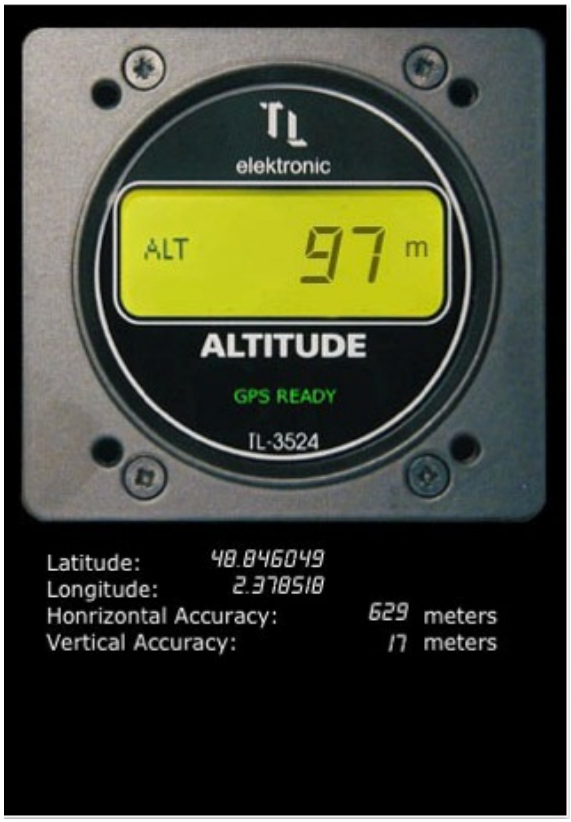
- The other two methods of locating are using:
  1. Cell phone tower triangulation
  2. Wifi Network IP addresses of the routers

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

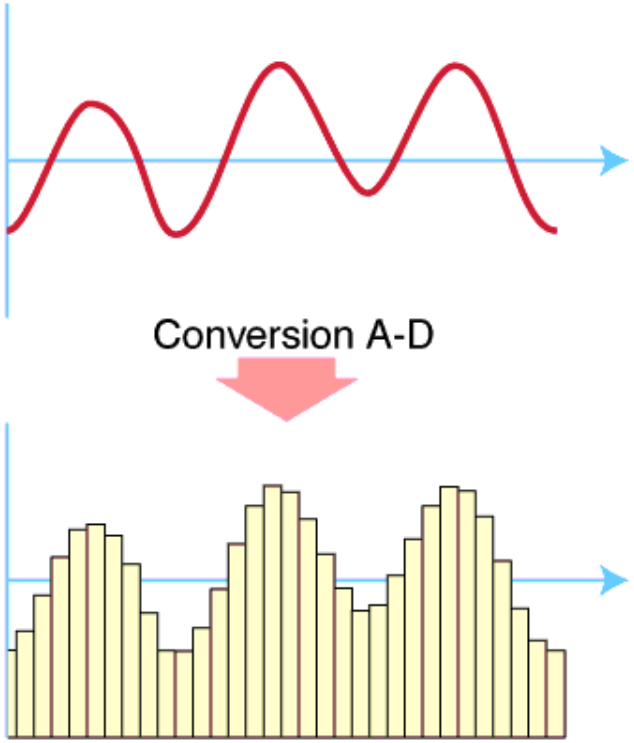
- Used for measuring ambient light to set screen brightness
- Measures the light, in Lux
  - Across wide range of values

Light Dependent Resistor (LDR)

Photodiode

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**



Microphone – Sonar Device

- Could make a good sonar with this!
  - Already been done
  - 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

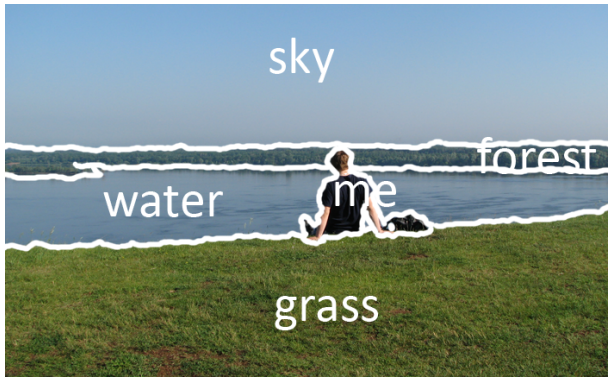
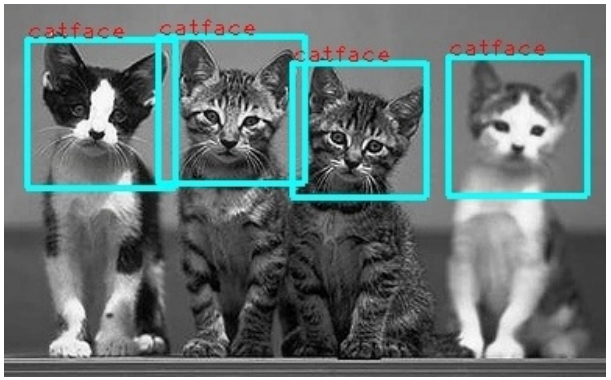
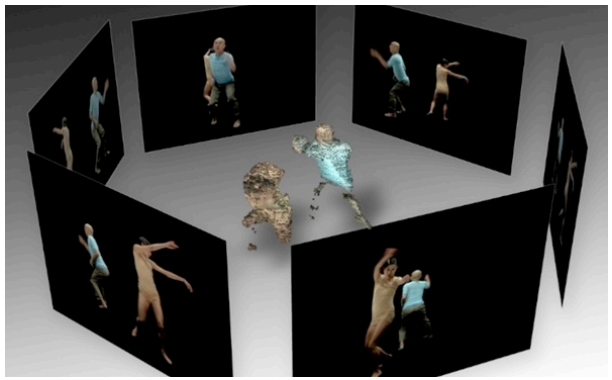


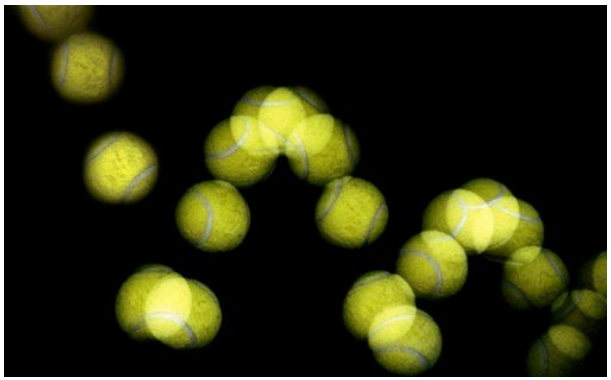
Image Segmentation



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

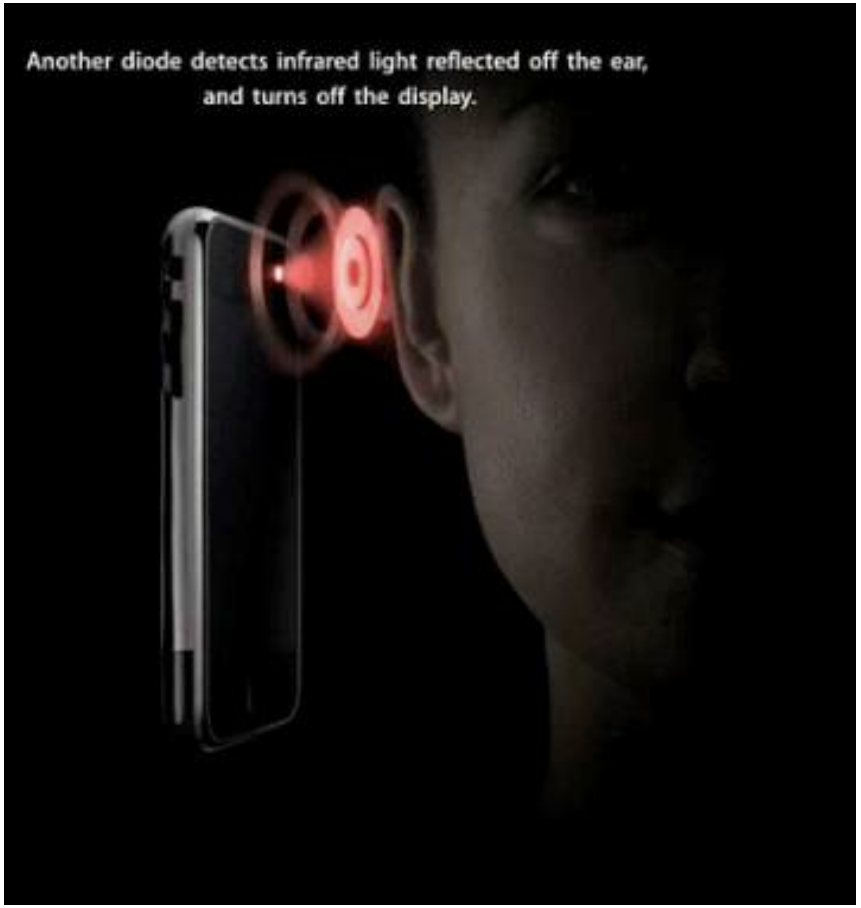
- We have access to an eye-tracker + tablet
  - From a local startup, interesting in seeing application development
- Perhaps a Reading application?
  - Watch learner read, give help & support
- Other application in the stimulus, view-view response

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



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

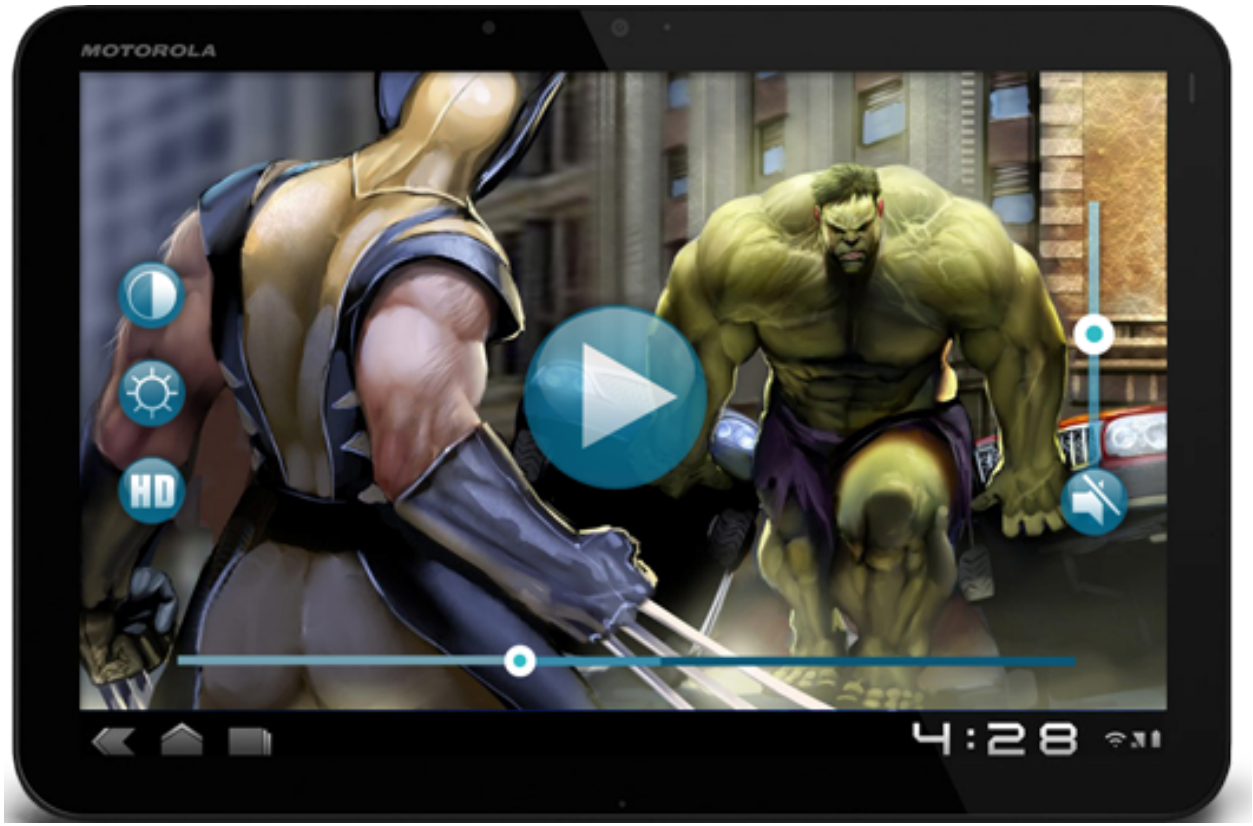
Output Devices

Hi-Resolution Screen

- Most recent phones have very high quality screens
  - Quality is the # & density of pixels
- Nexus 5
  - 1080x1920 resolution
  - 445 pixels per inch
- iPhone 5s
  - 750 x 1334 resolution
  - 326 pixels per inch
- Huawei Ascend P6
  - 720x1280 total resolution -312 ppi

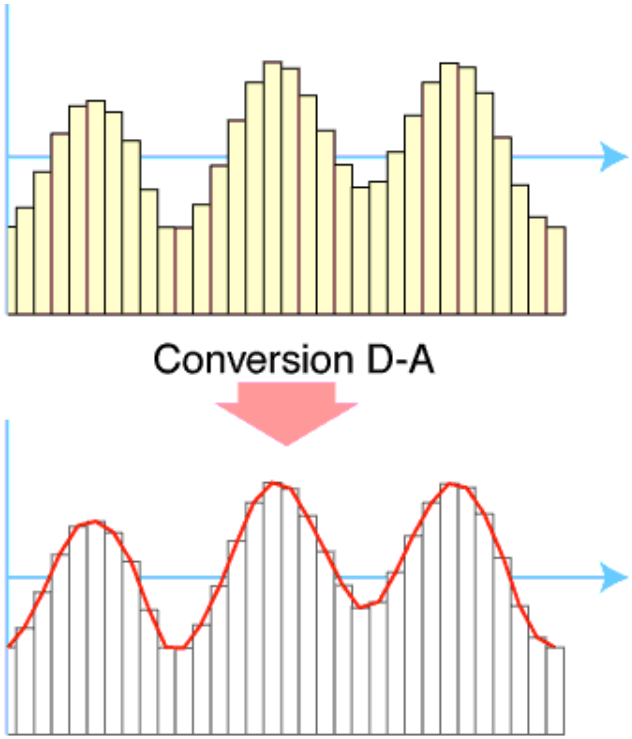
Video Display Hardware

- 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

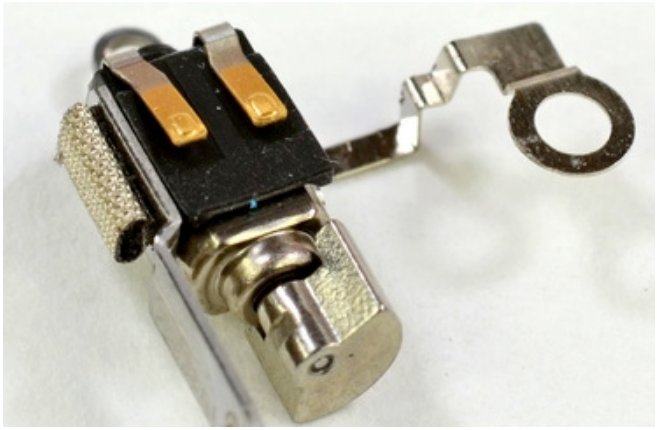
- Sound Output
  - Two speakers
    - Quiet one for ear
    - Loud speaker
- Play previously recorded files
  - Should be able to do **text-to-speech**
- Many possible sound filters –
  - Auto-tune voices to make at right pitch
  - Make funny voices
  - Synthesized Musical instruments



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

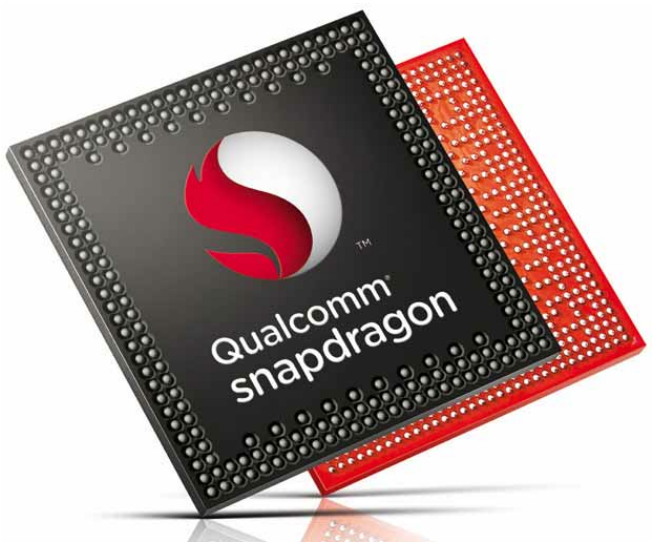
Camera Flash

- 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

The Computer: Storage, Networking and External Devices

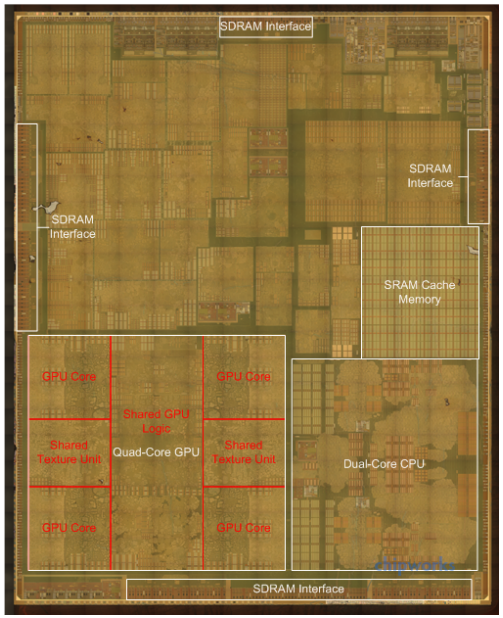
Computer

- 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 6 has dual core ARM v8 and 4x 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

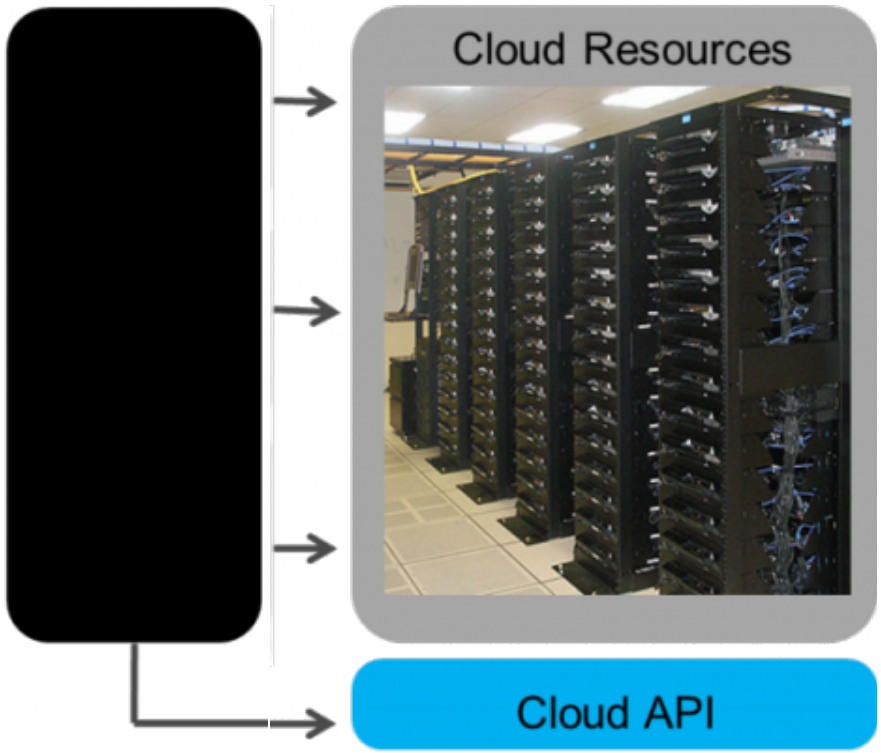
- Local storage of 2 to 128 Gbytes of permanent storage
  - Flash-based solid-state disk
- Can load many databases locally onto the device
  - Dictionaries, no problem!
  - Maps
  - Phonebooks
  - Location Services

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

- Have at least 2 ways to talk to the Internet
  - Local WIFI
  - Cellular data networks
  - LTE is faster and better than Wifi
- 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

- 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

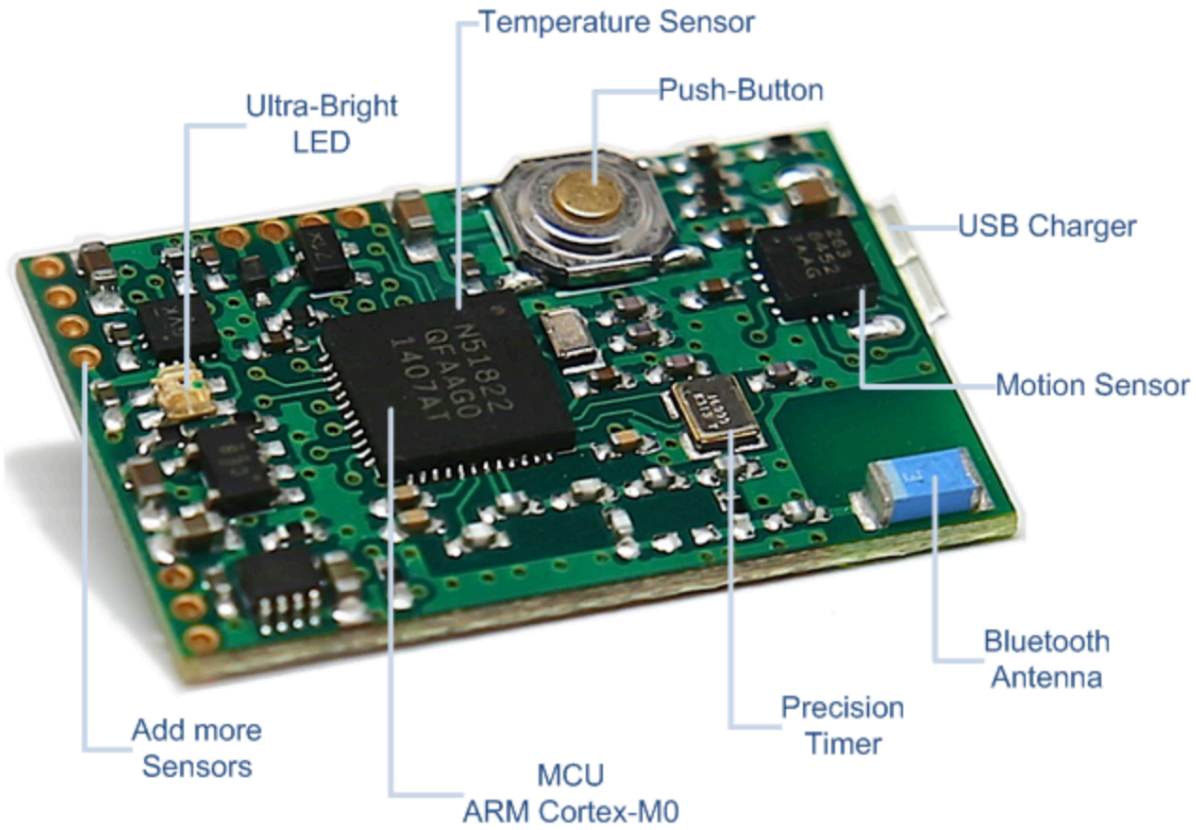
Texas Instruments Sensor Tag

- Similar to NODE
  - Accelerometer, gyroscope, magnetometer
  - Ambient Temperature
  - IR Temperature
  - Air pressure
  - uglier
- **But: Only $25!**
- I have several of these for use in the course
  - Compatible with iOS and Android
  - Needs Android 4.3 or above for low-energy Bluetooth

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

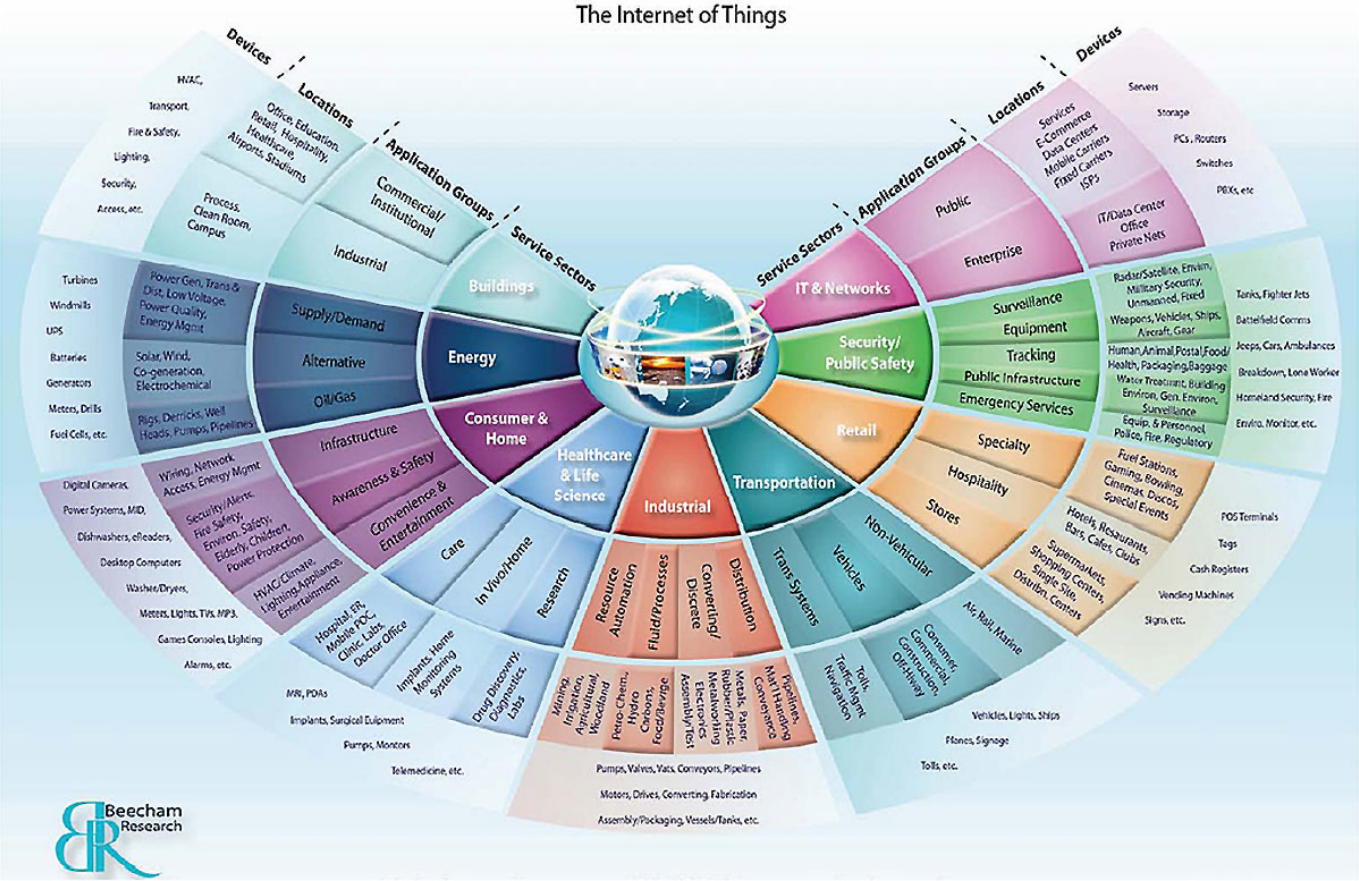
Metawear



- Comes with ready-to-use software for Android and iOS

Relates to Industry's Latest Buzzword

- 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

Samsung
TecTiles™

Using All These & More

- Come up with something interesting in your field
- Make it work!

Introductions, continued

To Help in Project Group-forming

Introductions, Continued

- Last Day, some of the class introduced themselves
- Today, let's try to make sure all of the appers have introduced themselves
  - Please take notes to keep track of people who you think might be compatible partners
- Today look at submissions of Programmers & Appers on Pepper website
- Next week, we'll try to put people in some categories to help you explore matches.

Introduce Yourself, Round 2

1. Name
2. What discipline you work in & degree sought
3. Taking Course for Credit – yes, no, 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. **Apper**: 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

- Wednesday January 21st
- 6:30pm-8:00pm
- Fitzgerald Building, Room 103
  - Will create categories