

ECE 1778: Creative Applications for Mobile Devices



Lecture 2
January 20, 2021



(1)



Today

1. Logistics/Organization of Course & Project
2. Capabilities of Mobile Devices/Software
 - together with example Creative Applications
 - to get you thinking about ideas for applications and how to truly leverage technology
3. More Introductions & Time for Team-Forming



Logistics & Project Process



Websites & Lecture Postings

- If you missed the first lecture you can find it on the course websites:
 - on Quercus, in the table on **Course Content & Videos** page
 - Links to slides and videos
 - On <https://www.eecg.utoronto.ca/~jayar/ece1778/>
 - Look under content
 - Slides of lectures will be posted there
- Keep an eye on the Piazza website for team-member introductions & other discussions
- Announcements will be sent through Quercus



Recall: The Goal of This Course

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



Background Reviews of Programmers

- We have finished reviewing the background described by the programmers
- I have contacted, by email this morning, all programmers who I need to talk more to about their background
- Programmers, if you did not get an email from me, please carry on
 - However, if you find assignment P1 to be too difficult you should reconsider taking this course
 - Please get to work on P1 part 2 right away



Side Note on Specialists

- To be a specialist in this course, you must be working within an area of your expertise
 - You cannot be in one field and serve as a specialist in another field (without providing some justification for expertise in that other field).



Urgent Work for You: Form Group

- Must have group to stay in course!
- From Assignment 1, Part 1, on Piazza website:
 - Programmers have introduced themselves
 - Specialists introduced themselves & described their field
- **Right Away**, you should look at these, to achieve
 - Groupings of programmers
 - Outreach to Specialists
- Make initial contact through Piazza posts



Group Forming

Groups: 2 programmers and 1 Specialist

Step 1: Two Programmers should find each other

Step 2: Form group with Specialist

- Groups with 1 programmer will **not** be allowed
 - too few

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



Extra Meeting to Form Groups/Discuss ideas

- This Coming Wed January 27th, 6:30pm-8:00pm
 - On same Zoom Link
- We will help make matches & be there to kick around ideas to help with direction/scope
 - Will make use of having everyone there
 - Will use breakout rooms as necessary



Numbers

- Number Submitted Part 1 of Assignments S1 or P1:
 - Programmers: 50
 - Specialists: 21
- Total # Registered: 81
- Numbers are always fluid at this time in the course
 - Ratio is close to the correct balance!



Course Survey

- If you didn't last week, please fill out the course survey on Quercus
 - indicate name, Department, phone type, and if you are either:
- **Specialist:** non-programmer, with expertise
 - from specific discipline that project leverages in significant way
- **Programmer:** capable of learning new environment fast



Once You Have Formed a Group

- Send email to me:
 - Jonathan.Rose@ece.utoronto.ca
 - **Copy this email** to all group members
 - this a formal commitment – all must be included on email
- The email **must** contain (**please do this**):
 - Names of all students and student numbers
 - UofT email address of all members (otherwise if external)
 - 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 and who is Specialist**
 - Mobile platform: Android or iOS?
- Deadline **January 28th, 2021**



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 also have sufficient technical depth
3. *Should* be a new or novel in some way
 - Can be variant of existing app if enough different
4. **Should be a software application, mobile + web**
 - Course focus is mobile, and the assignments are mobile/web
 - However, will consider web-based if makes more sense & fits



Project Stages

1. Forming Groups

- Pair up Programmers, then together find Specialist
- Form group by Jan 28; extra meet Wed Jan 27th @6:30pm

2. Project Topic Approval-in-Principle

- via email; due February 3rd

3. Project Proposal/Plan

- Document Due February 10th

4. Proposal & Plan Presentations

- February 17th
- **NOTE EXTRA LECTURE Wed February 17th, 6-8pm**

5. Spiral 2 & Spiral 4 Presentations

- 2: March 10/17 4: March 24/31

6. Final Presentations

- Weeks of April 7/14

7. Final Report Due April 21st



Assignment 1 Part 2 Due Next Week

■ For both P1 and S1

- 6pm, Tuesday January 26th
- How are they going? P1 is a fair bit of work, start now.
- **There will be assignments over the next 1.5 months**

■ Submit via Quercus

- Be sure to submit to the correct assignment:

Assignment P1 - Introducing Yourself & Dev Environment & Instagram Front-End

Published Edit

This assignment has two parts - **Part I is due Tuesday January 14th by 6pm**, but you should try to do it sooner than that, as it is important for forming project teams.

Part II is a big assignment that gets you introduced to both the mobile development world, and to elements of Google's Firebase for online authentication and storage.

The assignment can be found here: [AssignmentP1.pdf](#)

Points 10
Submitting a file upload
File Types pdf and zip

Due	For	Available from	Until
Jan 26 at 6pm	Everyone	Dec 30, 2020 at 12am	Jan 27 at 11:59pm

+ Rubric

Assignment S1 - Introduce Yourself & Connecting Your Field to the Software/Mobile Apps

Published Edit

This assignment has two parts - **Part I is due Tuesday January 14th by 6pm**, but you should try to do it sooner than that, as it is important for forming project teams.

Part II is about exploring how your field, as a specialist, and mobile software have connected previously, by exploring and trying out apps in your field.

The assignment can be found here: [AssignmentS1.pdf](#)

Points 10
Submitting a file upload
File Types pdf

Due	For	Available from	Until
Jan 26 at 6pm	Everyone	Dec 30, 2020 at 12am	Jan 27 at 11:59pm

+ Rubric

What Programmers Should Be Learning

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



Specialists: Should be learning & doing

- About capabilities of phones (today's lecture)
- What other apps in their field look like that;
 - what has already been done? (assignment S1 part 2)
- Using this, and thinking of ideas, or areas of ideas for the project apps



Programmers & Assignment P1

- There are a range of ways to do the tasks of Assignment P1.
- Here is an example video of a version of P1: [video link](#)
- A less-good version would lose marks because
 - Awkward UI, doesn't attempt to make things clear
 - Small fonts, unbalanced screen ...
 - Doesn't follow the specifications in assignment



Note for Apple iPhone/iPad Users

- Recall you must have a Mac to develop for these
 - Also, you must be sure that your project group has aligned itself under the Apple banner
 - doing the assignments for iOS with Xcode
- You **do not** have to sign up under the Apple developer program to be able to use your own device
 - To put apps on app store, you need to be in the program
 - Not required for the course; costs \$USD 99/year to do so



Overview of Smartphone Capabilities & Example Applications

To Help your Creative Thoughts on the Project



A Smartphone is ...

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

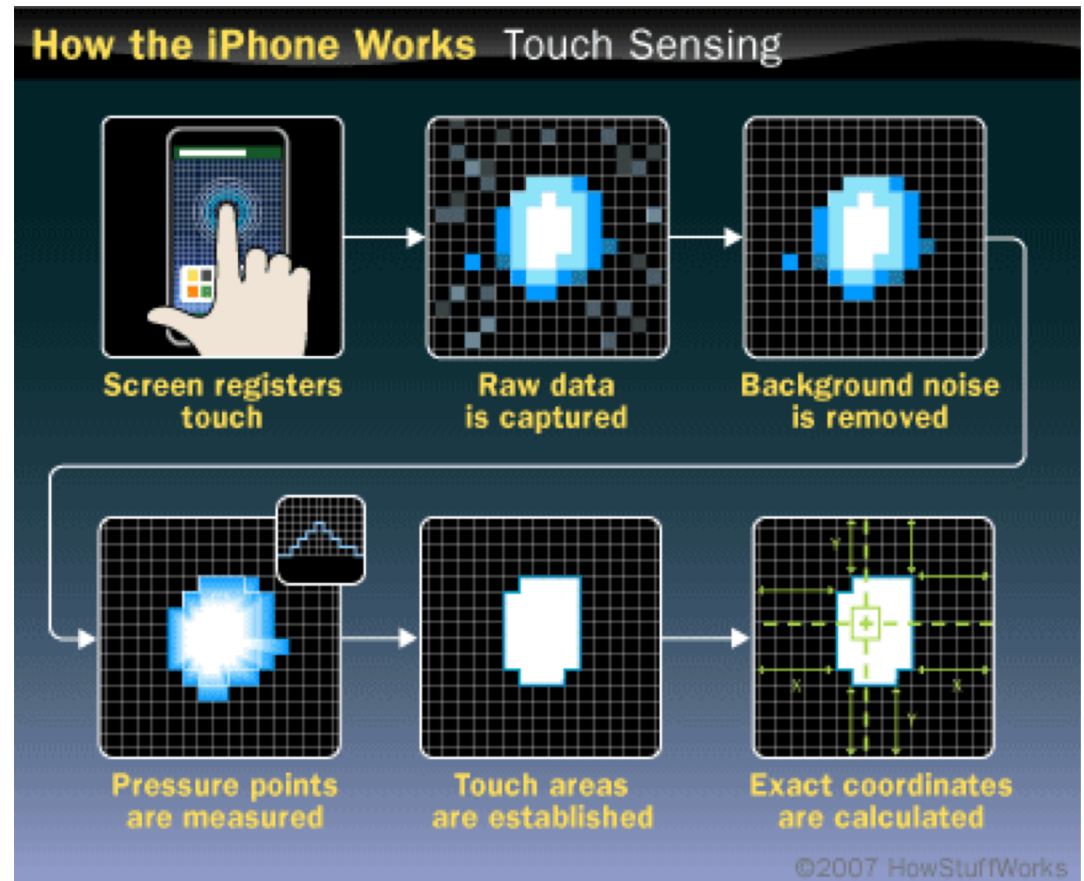


Inputs and Sensors



Touch Screen

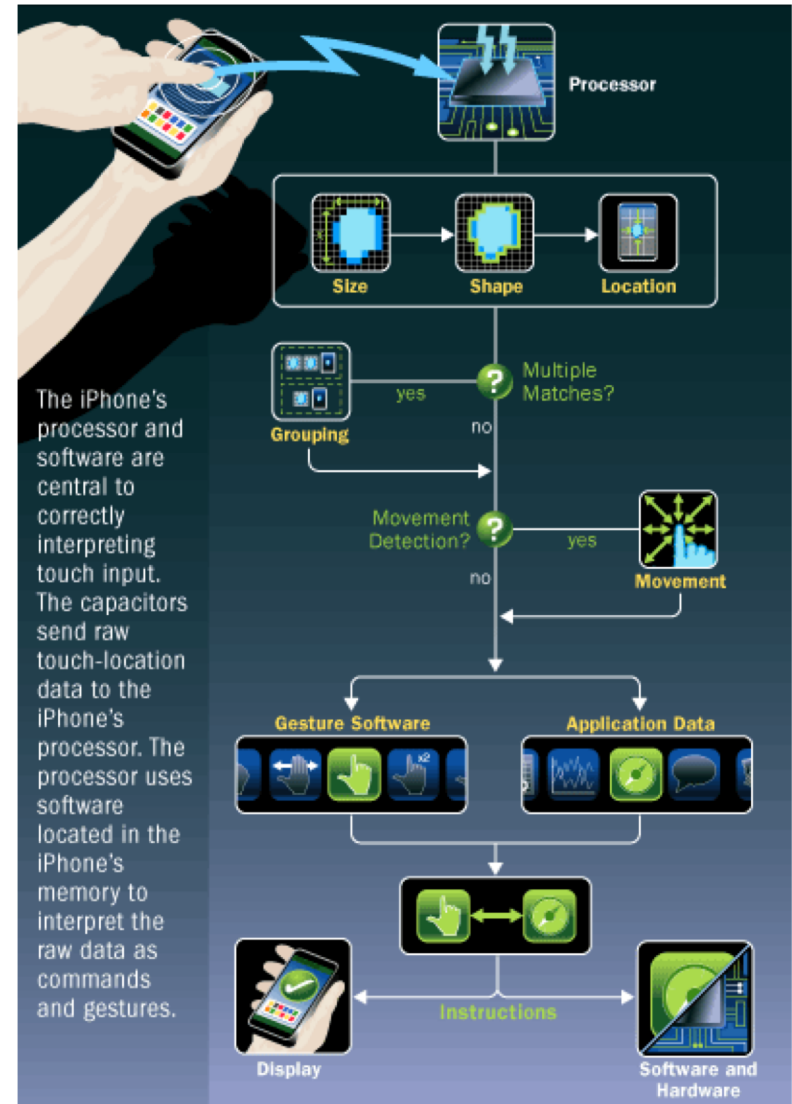
- The screen surface detects the touch of a finger
- Each touch can be turned into a specific coordinate



Touch Screen

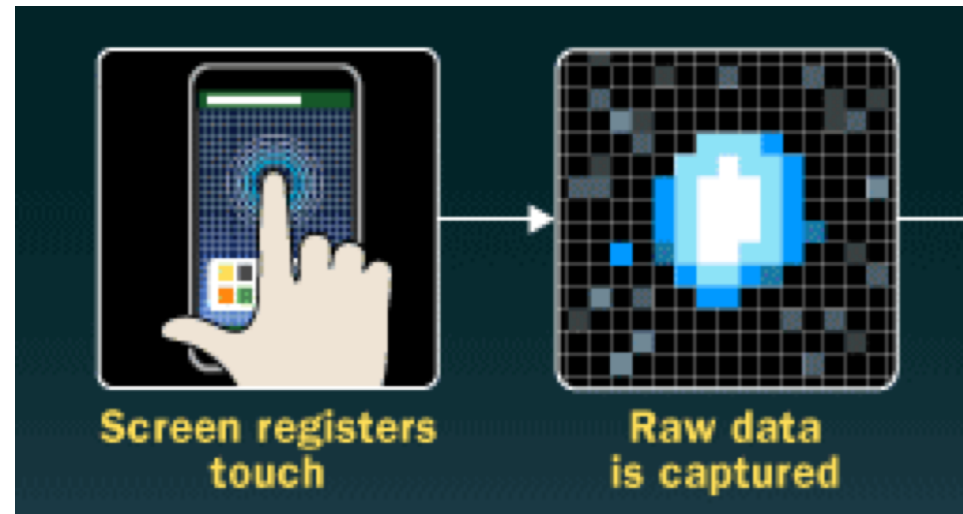
■ Coordinates can be turned into several different types of input:

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



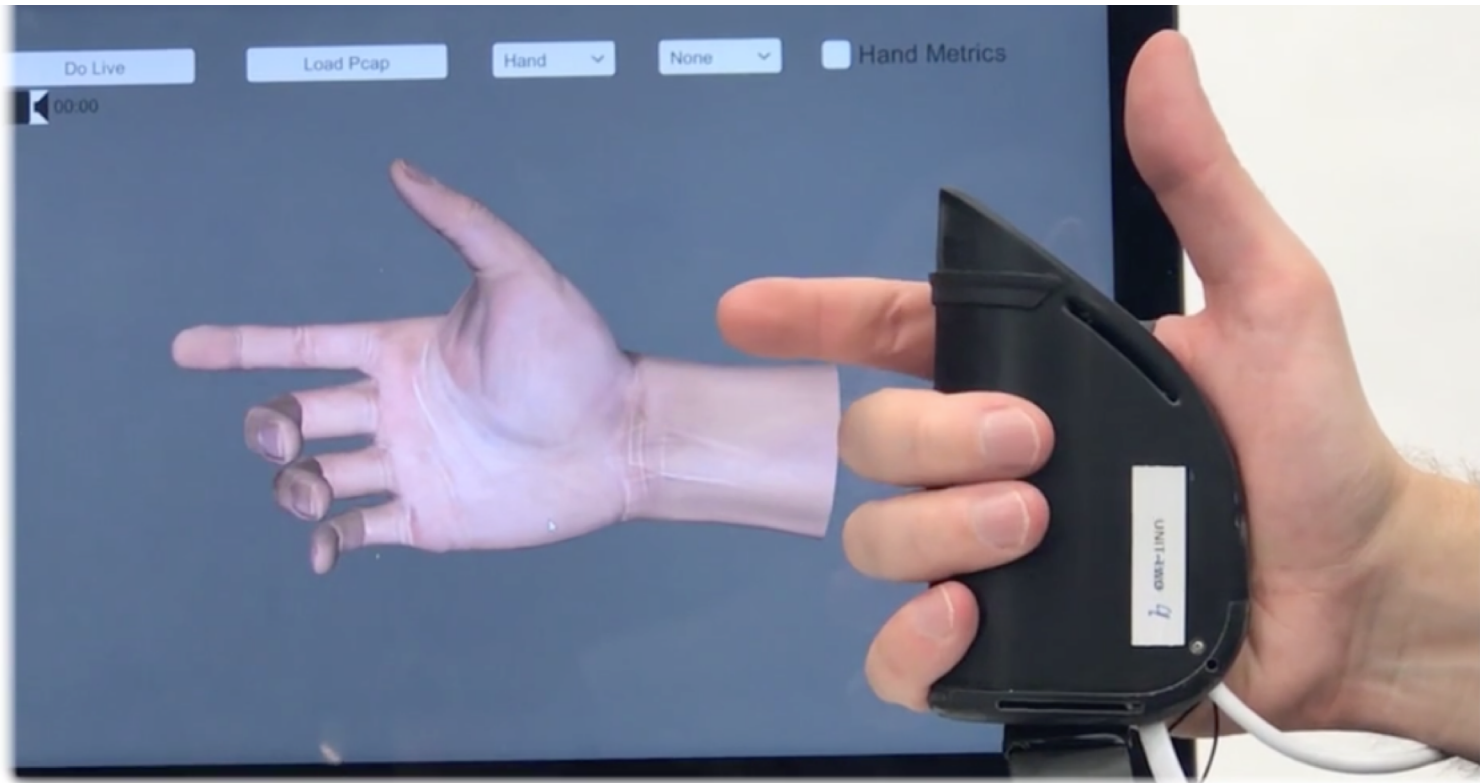
Can Touch Screen Be More?

- 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



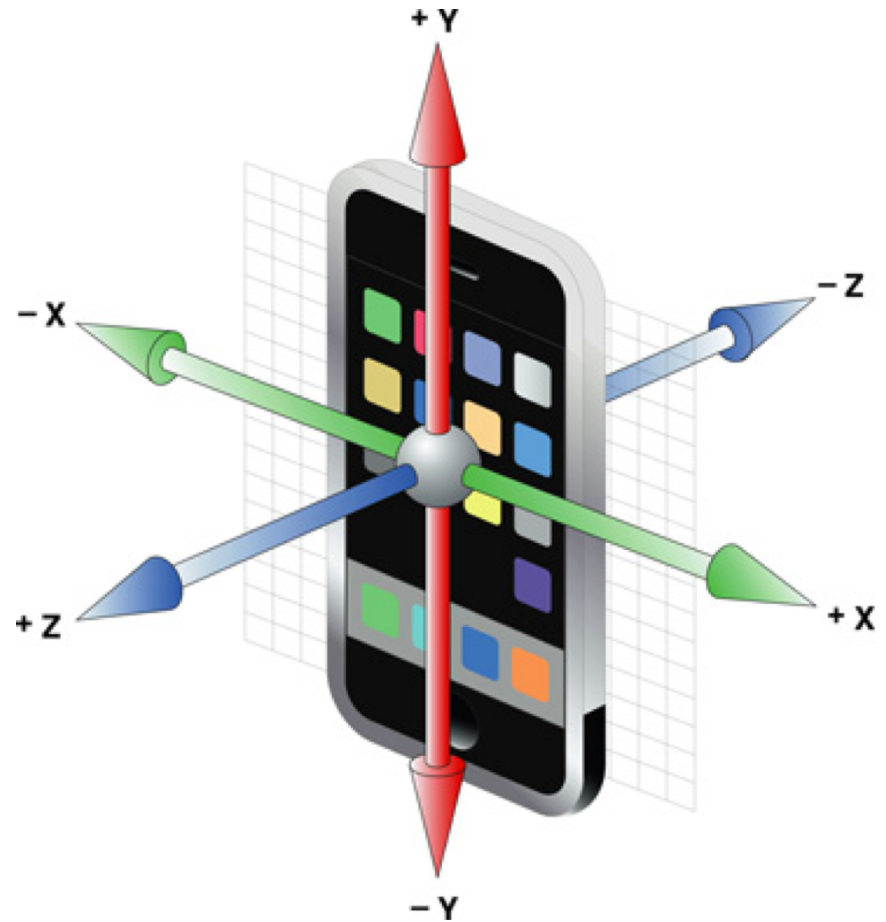
Nifty Touch Stuff Coming: Tactual Labs

- 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
 - There have been two prior gait analysis projects in this course



myAnkle

A Personal Physiotherapist for Ankle Injuries

Nirtal Shah, Ivan So, Lyndon Carvalho

Vivian Liu

Braiden Brousseau

Nirav Atre

Babneet Singh

Jordan Lee



April 2011

Ankle Injuries: Sprain

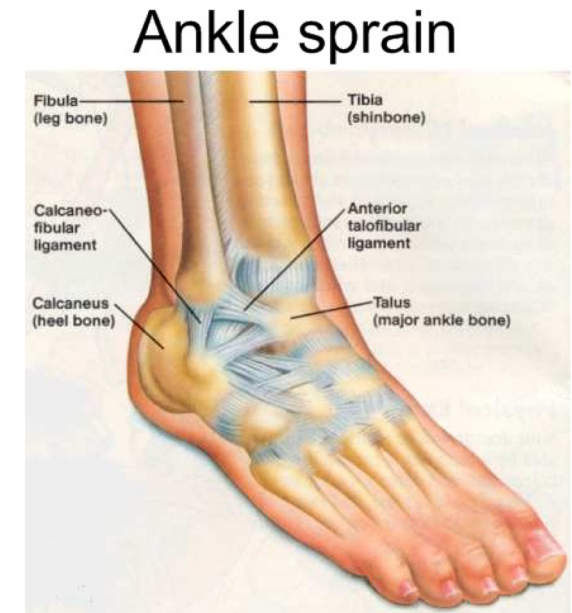


- Tipping on side
 - Stretches ligaments

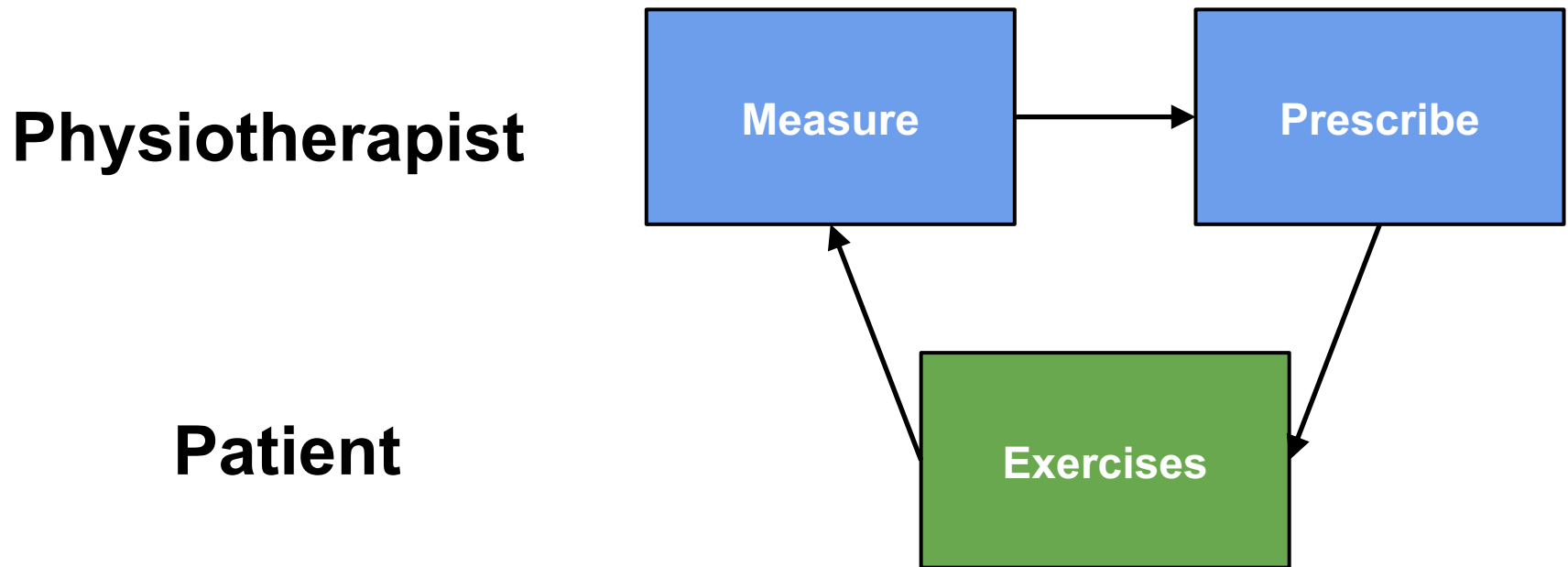


Ankle Injuries: Sprain or Break

- 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



Usual Diagnosis & Treatment



Physiotherapist 'measures' by watching you walk/balance!

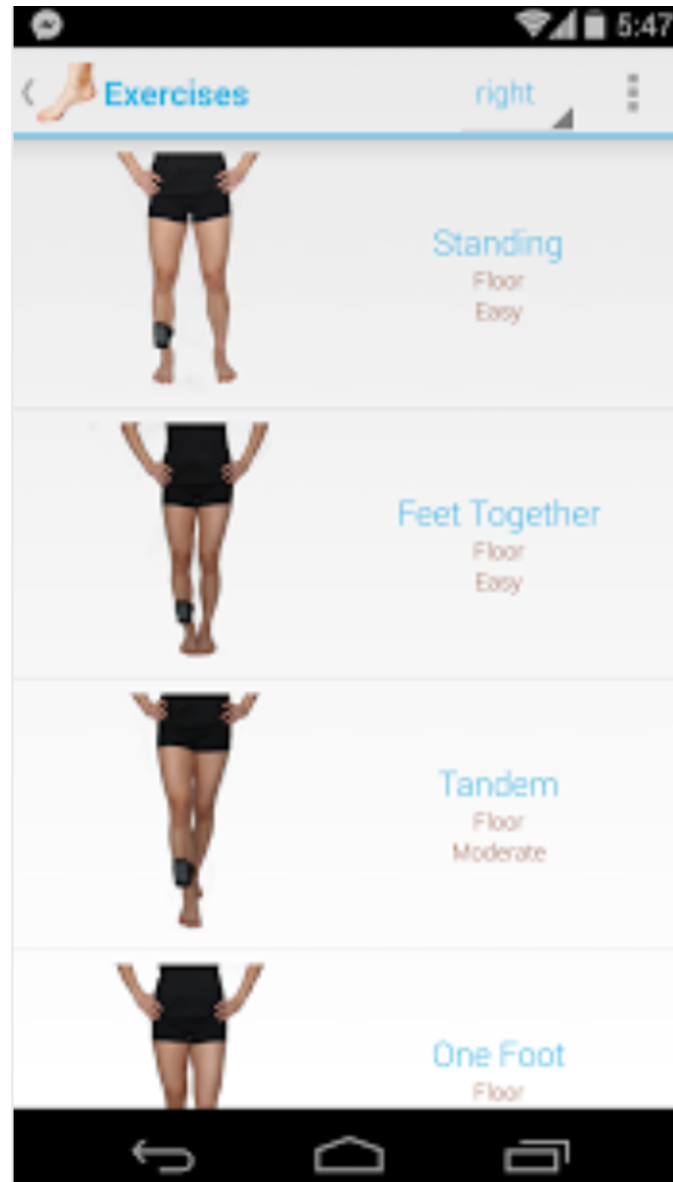
- **very subjective**

MyAnkle: Measure Balance with Accelerometer

1. Have patient do a balance exercise
 - stand on one foot
2. Strap Phone (or wearable) to ankle
3. Measure 'wobble' using accelerometer
 - Amount of motion while balancing measures your balance
4. Objective!



A Selection of Exercises



MyAnkle Gives A Number

- Measures the amount of movement when trying to balance!
- Have added ability to use wearable
 - The TI Sensor Tag that is often used in this course



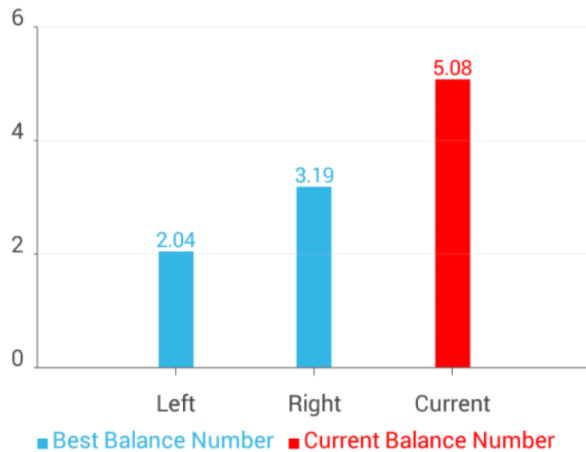
Results



Standing

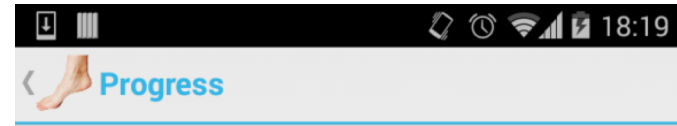
Floor
(Right ankle)

Balance Number = 5.08



Retry exercise

New exercise

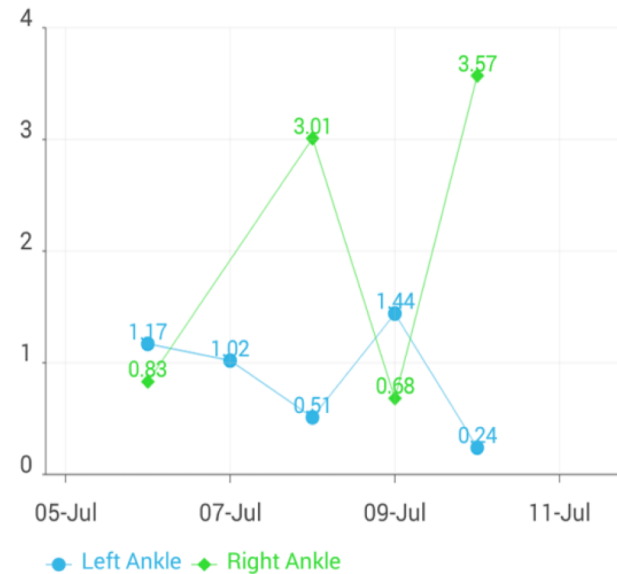


Standing

Floor

Last 5 Days

All Time



SWIPE UP FOR RESULTS



Status

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



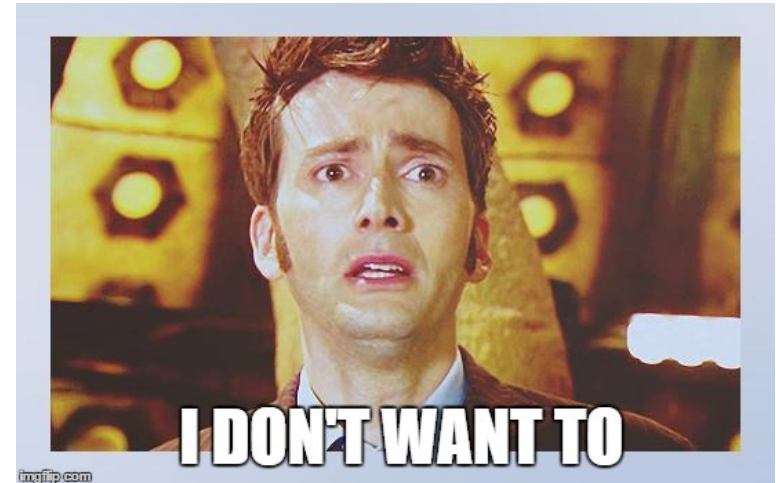
To Get Better: How To Recover Balance

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



However, People Don't Want To!

- “Compliance” is a big issue in physiotherapy
 - People know they should, but don't!
- With software, we can be creative
 - Can physio be fun?
 - Can we turn it into a game?
 - “Gamification”



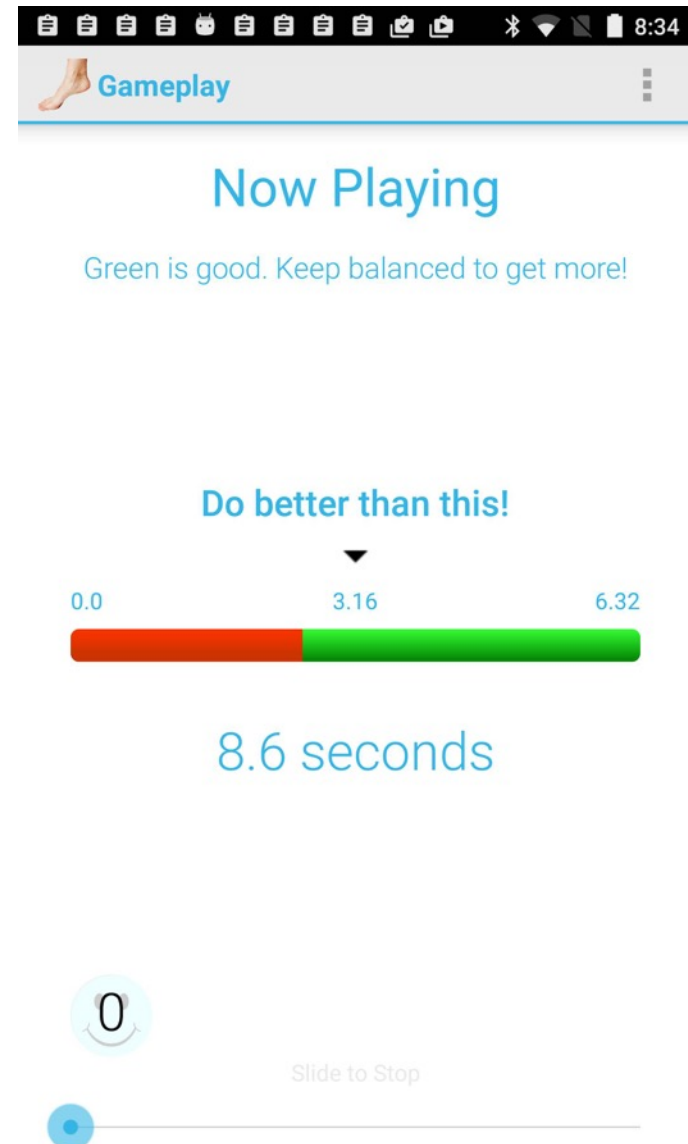
Here is the Game as it stands now

- Step 1: Measure how much you wobble to start



MyAnkle Game

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



MyAnkle Game Demo



Other Applications of Motion Sensing

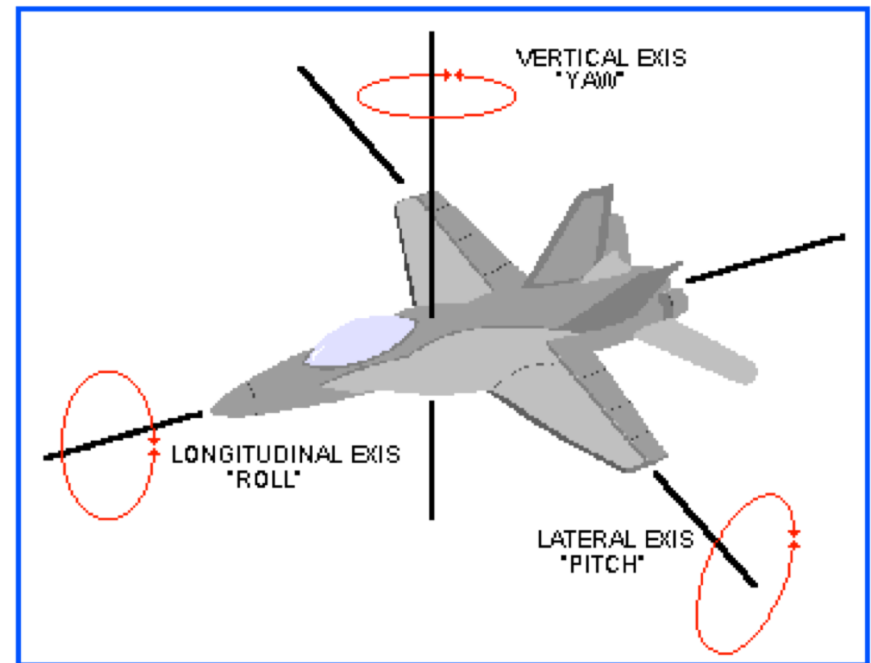
- Can tell if the phone is being shaken
 - Can use as an input
 - How sensitive is it?
 - Can it be used to measure Parkinson's tremors, in a medical application?
 - Delerium Tremens Detection: real vs. fake

- Can detect if person fell down
 - Could send alert



Gyroscope – measuring angular motion

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



Compass

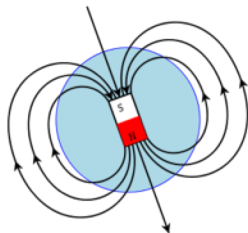
■ Really a magnetometer

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

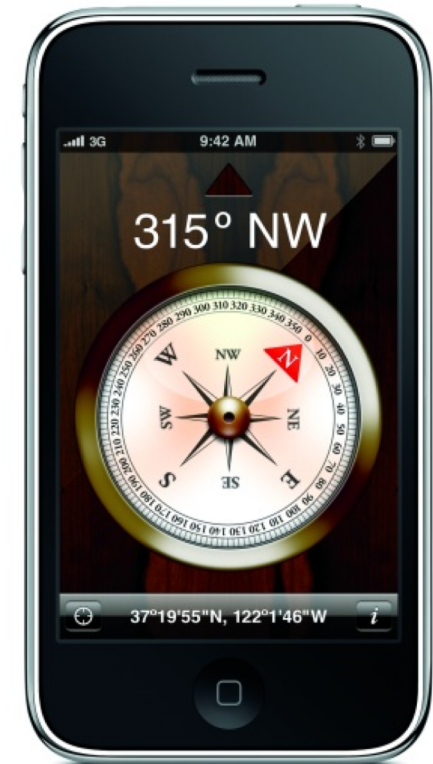
■ Where do magnetic fields exist?

- Speakers, motors, screens, medical imaging, earth, big factories

■ What are they used for?

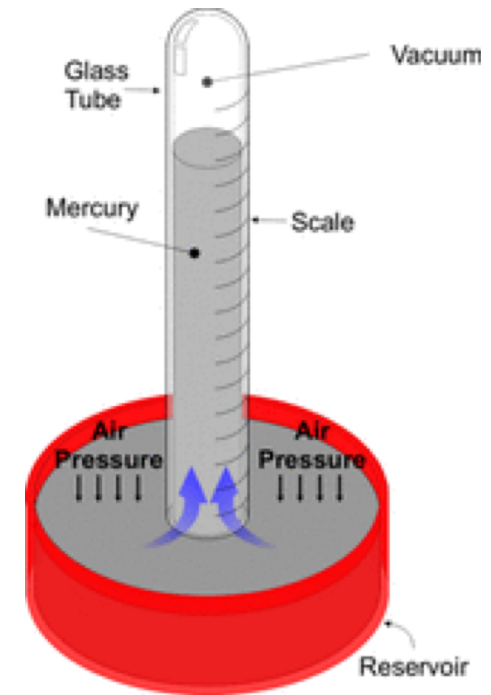


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Barometer

- On Android & \geq 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?



Weather Prediction Using Barometer

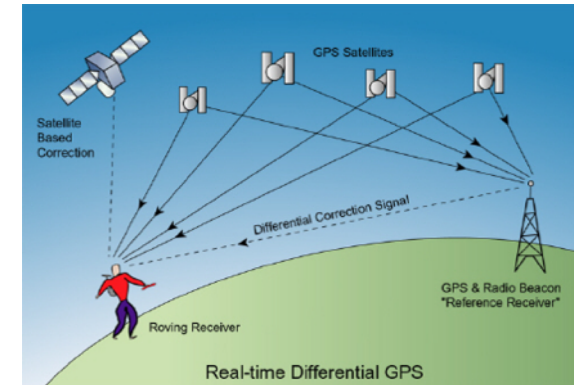
- Decreasing barometric pressure indicates storms, rain and windy weather.
- Rising barometric pressure indicates good, dry, and colder weather.
- Slow, regular and moderate falls in pressure suggest a low pressure area is passing in a nearby region. Marked changes in the weather where you are located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

GPS & Suicide Prevention

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

Dec. 31, 2018

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



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

Location Services

- In Android, there are several 'Location Services' available that include the GPS
 - GPS uses a fair bit of power, can't have on all the time without draining the battery quickly

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



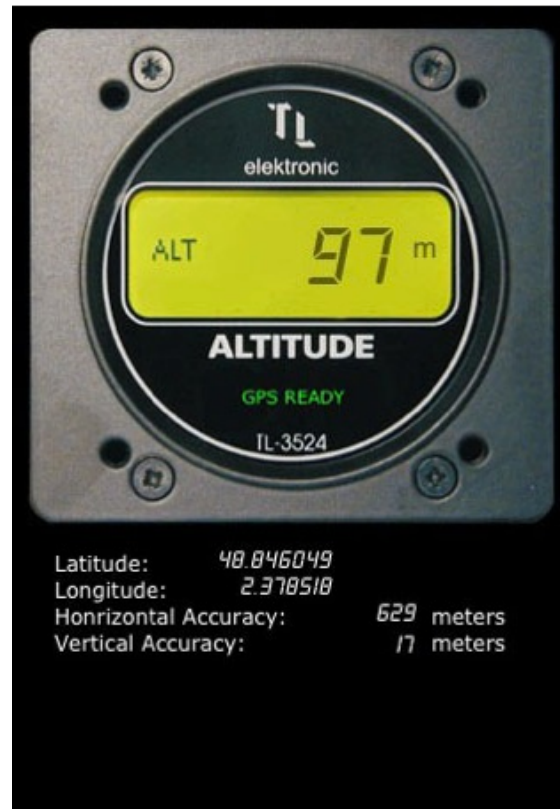
GPS

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



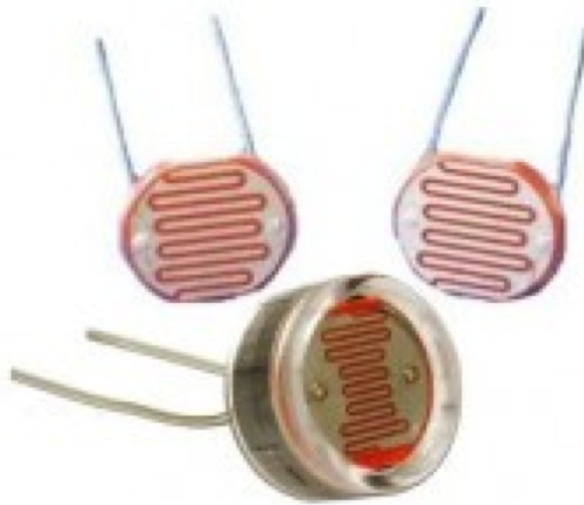
Altimeter

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



Ambient Light Sensor

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



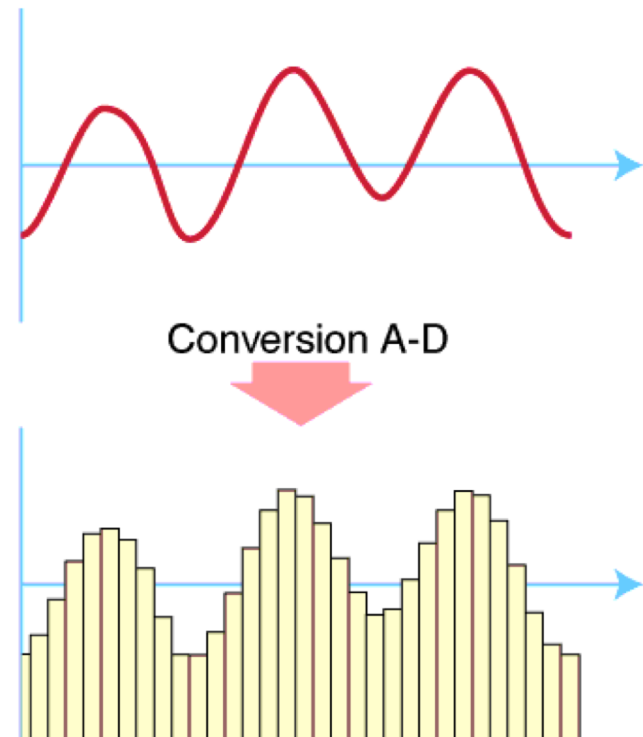
Light Dependent Resistor (LDR)



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/



Sound Processing Example

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



Back Camera

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



Computer Vision

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

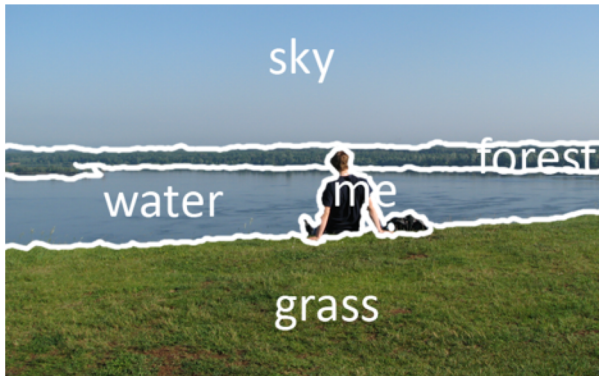
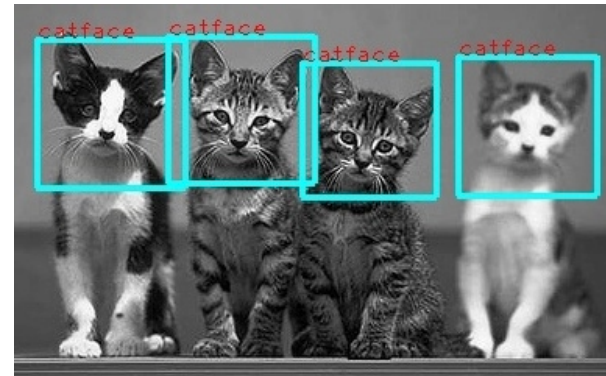
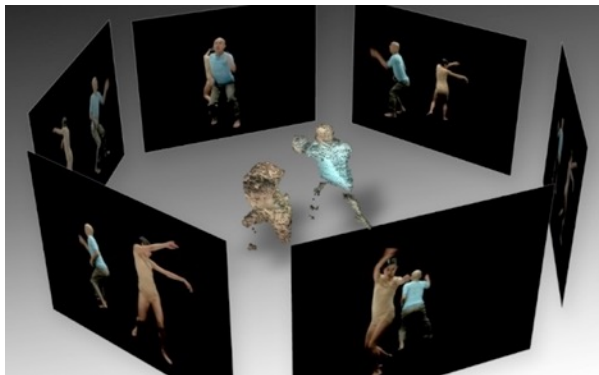


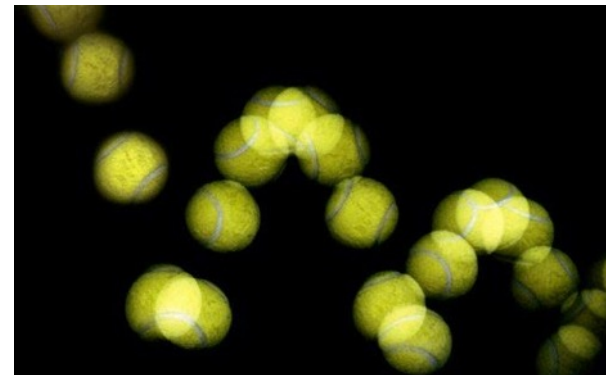
Image Segmentation



Object Detection



3D Scene Reconstruction



Motion Tracking Through Time

Computer Vision

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



Front Facing Camera

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



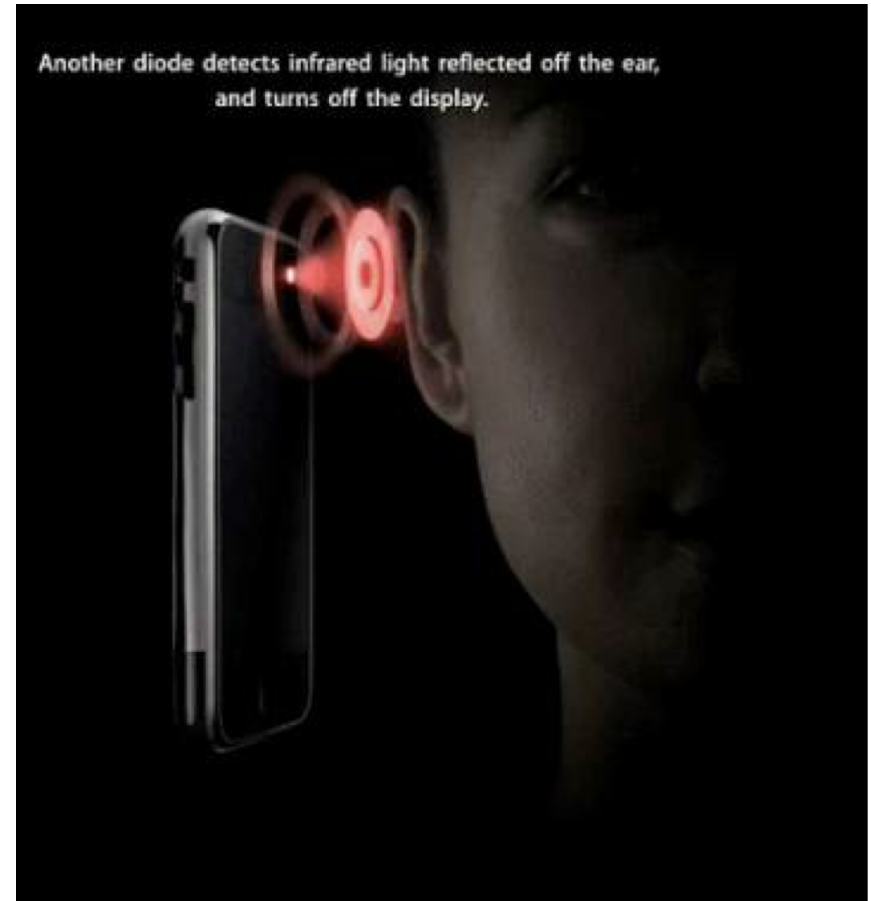
Eye Tracking

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



Proximity Sensor

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

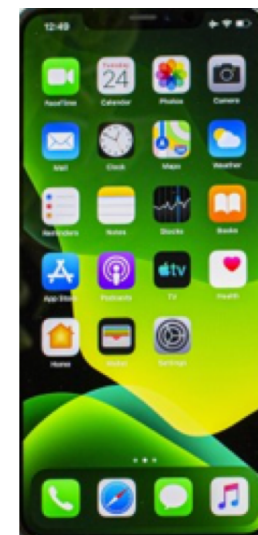


Output Devices



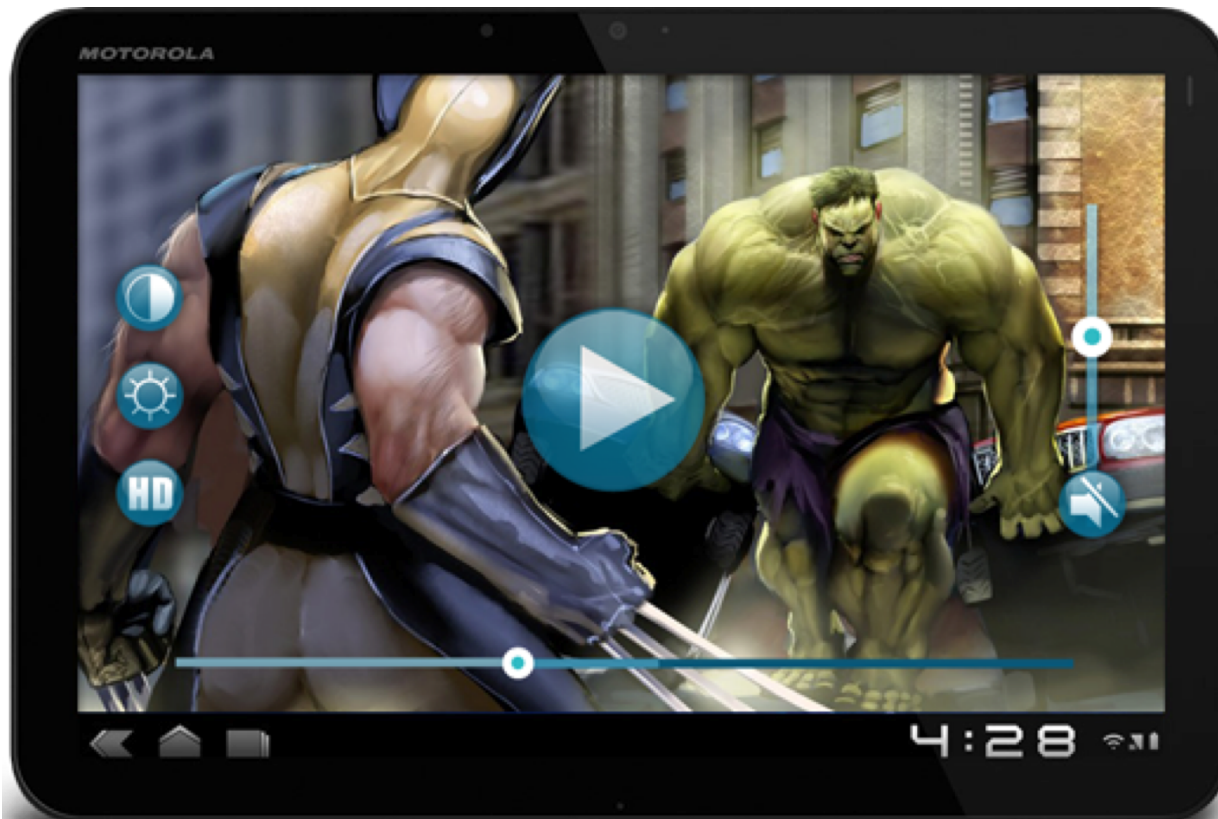
Hi-Resolution Screen

- Most recent phones have very high quality screens
 - Quality is the # & density of pixels
- Pixel 3a XL
 - 1080 x 2160 resolution
 - 402 pixels per inch
- iPhone Pro
 - 1125 x 2436 resolution
 - 458 pixels per inch



Video Display Hardware

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



Speakers/Audio Out

■ Sound Output

- Two speakers
 - Quiet one for ear
 - Loud speaker

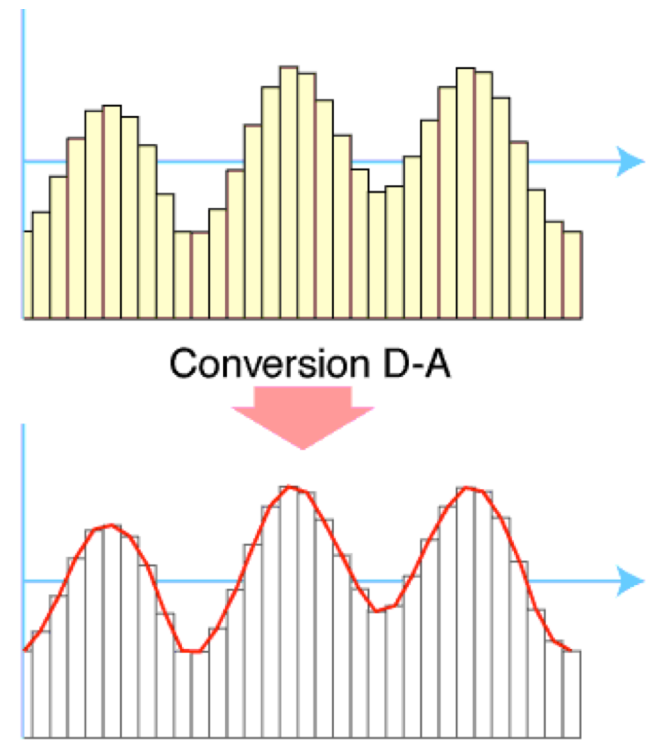


■ Play previously recorded files

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

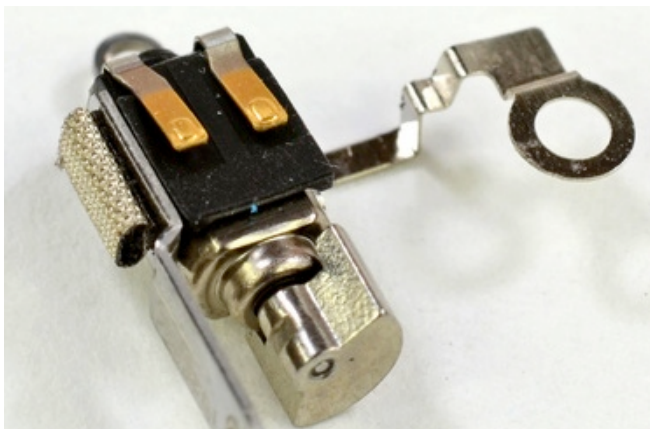
■ Many possible sound filters –

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



Vibration Output

- Can create a short buzz
- Can control vibration pattern, duration and intensity
- This can be a significant output device – ‘haptic’ feedback



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

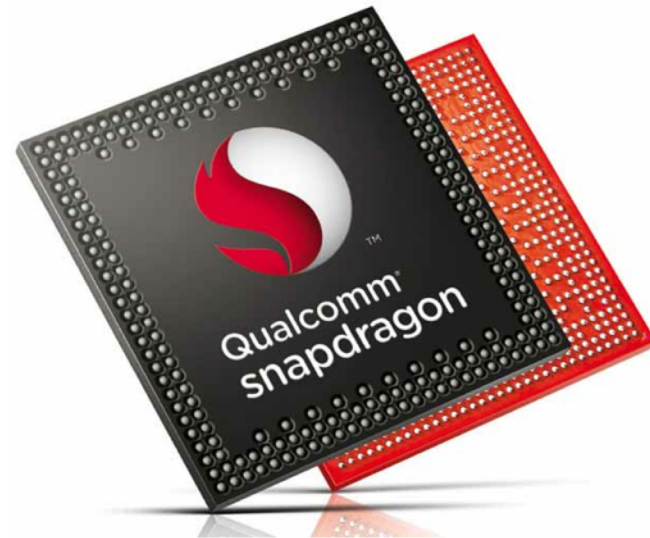


The Computer: Storage, Networking and External Devices



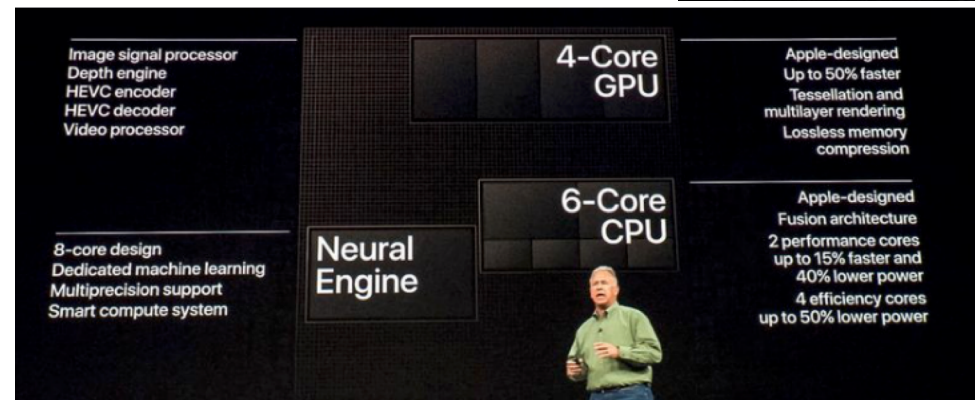
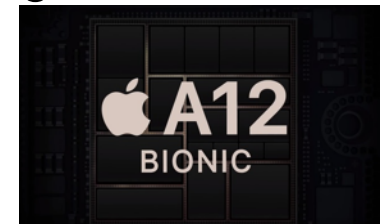
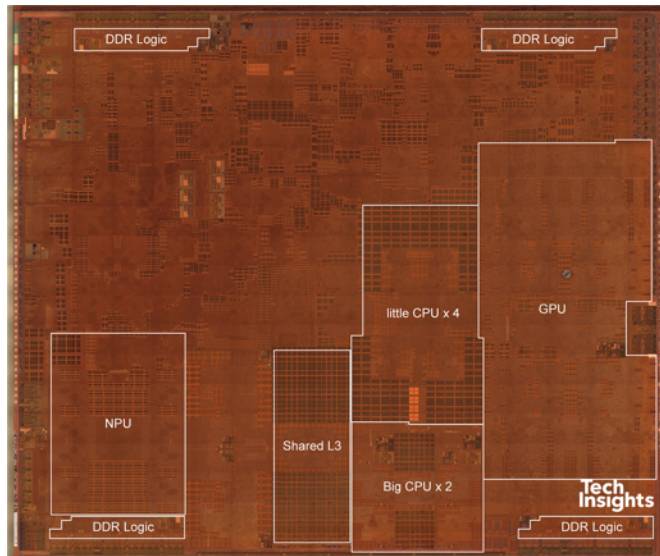
Computer

- What can a computer do?
 - Processors are powerful
 - Pixel 3A XL has 8 processor cores - (2x2.0 GHz Arm; 4x1.7 GHz)
- Many things!
 - Optimization
 - Search
 - Sort
 - Machine Learning Classification Tasks



The Application Processor

- iPhone XS has six core ARM and GPU + Neural Engine
- Pixel 3A XL 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



(73)

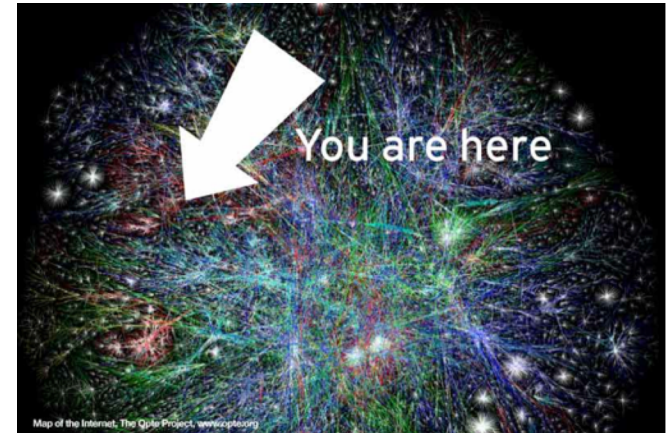
Storage Capacity

- Local storage of 8 to 512 Gbytes of permanent storage
 - Flash-based solid-state disk
- Can load many databases locally onto the device
 - Dictionaries, no problem!
 - Maps
 - Phonebooks
 - Location Services



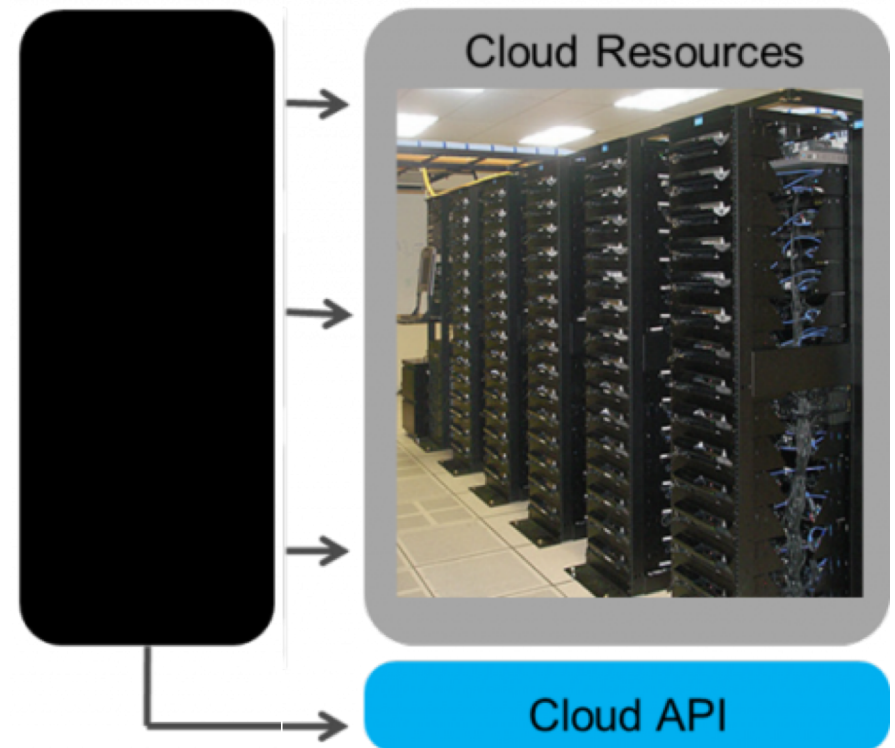
Network – LTE/Wifi: Gateway to Internet

- Have at least 2 ways to talk to the Internet
 - Local WIFI
 - LTE Cellular data networks
- Connection to **more** computation and storage
- Connection to other phones



The Cloud Helps Too

- Many apps need 'backing' website/database
- Provides phone with:
 - Communication to other people
 - Data
 - Backup
 - Information from Internet
- New this year – both P2 and P3 use cloud



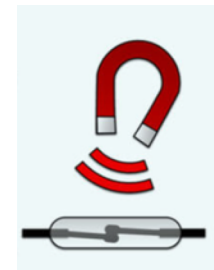
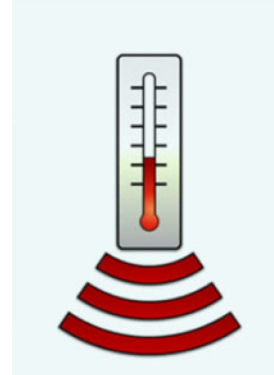
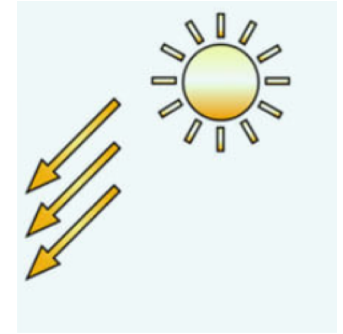
Bluetooth Connection

- Connect to a whole class of external devices, wirelessly
 - earphones
 - small spy cameras
- Could be important way to add other devices without physical connection
 - Make use of phone's capabilities without holding it



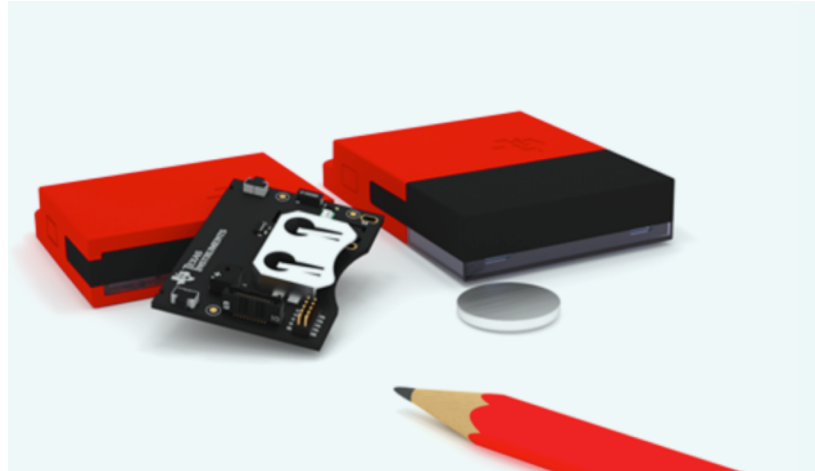
TI Sensor Tag: \$35 – Many Sensors!

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



Texas Instruments Sensor Tag 2: Demo

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



Tile Thing Tracker



Attach Tile.

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



Ring your things.

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



Find your phone.

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

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

Muse Head Band

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



(81)

This is the 'Internet of Things'



Near-Field Communications (NFC)

- Another radio for very fast connection
 - for payments
- Also recognition of 'tag'
 - walk past desk, brings up calendar
 - Dog tag, gives reminder of stuff to do with dog



Home > Accessories > TecTiles Help With My Order < Share

Experience Samsung TecTile™

Introducing Samsung TecTiles 2 compatible with Galaxy S⁺ 4

Get Started with TecTiles!

BUY NOW DOWNLOAD THE APP

Multiple Uses Easy Activation FAQs Shop

A screenshot of the Samsung TecTiles website. The page features a blue header with navigation links. The main content area has a blue background with a hand holding a TecTile tag and a Samsung smartphone displaying the product. Below the main content are two buttons: "BUY NOW" and "DOWNLOAD THE APP". At the bottom, there are four icons representing different features: "Multiple Uses", "Easy Activation", "FAQs", and "Shop".

Multiple Uses



Using All These & More

- This is the technology side.
- It needs to be combined with the problems/needs/ideas/inspiration from the fields of the specialists
- I'd encourage everyone to continuously ponder what might be possible, even well beyond the scope of this course
- Come up with something interesting in your field
- Make it work!



Introductions, continued

To Help in Project Group-forming



Introductions, Continued

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



Please Introduce Yourself, Round 2

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



Next Wednesday: Meet to Form Groups

- This Coming Wed January 27th, 6:30pm-8:00pm
- Via Same zoom link as usual
- We will help make matches & be there to kick around ideas to help with direction/scope
 - Will make use of having everyone there
 - Will use breakout rooms as necessary

