ECE 1778:
Creative Applications for Mobile Devices

Lecture 2

January 16, 2013

Today

1. Logistics/Organization of Course & Project
2. Capabilities of Smartphones
   - To get you thinking about ideas for applications
3. Introductions of Students & Idea Discussion

■ Tonight: **Important** Group Forming session
   - 6:30-8:30pm Galbraith Building Room 244

Logistics & Project Process

Websites & Lecture Postings

- If you missed the first lecture see the on the course website:
    - 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, 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 a 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

- How many people here are not registered on ROSI?
  - Should be room in course for all on waiting list

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
  - Groups should 2 Programmers & 1 Apper

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

From Last Week's Signup

Programmers		Appers		Both		
Yes	**Maybe**	**Yes**	**Maybe**	**Yes**	**Maybe**	**Total**
32	7	20	6	15	3	83

- Were many 'both' Apper & Programmer from ECE
- Total of Yes & Maybe
  - Programmers & Both: 57
  - Appers: 26
- Submitted Part 1 of Assignments A1 or P1:
  - Programmers: 44
  - Appers: 25
- How many did not submit Assignment 1 Part 1 last night, but still intend to be in course?

Work for you Today

- **Programmers have introduced themselves on the Pepper website & given background**

- **Appers have introduced themselves & described their field**
  - Some have already suggested specific apps

- **Today, you should look at these, in preparation for tonight's meeting**

Extra Meeting to Form Groups

- Tonight: Wednesday January 16th
- 6:30pm-8:30pm
- Galbraith Building, Room 244
  - After today's finishing introductions
  - Will find a way to help make matches there.

- Galbraith building south-west of Con Hall
  - Room 244 is on the south side.

Once You Have Formed a Group

- **Send email to:**
  - Me (jayar@eecg.utoronto.ca)

- **Provide:**
  - Names, Student numbers
  - <u>Department & Field</u> of each group member
  - Degree being pursued by each group member (M.A., Ph.D., M.A.Sc., M.H.Sc. 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

Project Stages

1. **Forming Groups**
   - Special get together tonight: <u>Wed Jan 16 @6:30pm GB 244</u>

2. **One-Page Proposal**
   - Due January 30th; Must receive approval to proceed

3. **Project Plan**
   - Due Feb 6th

4. **Proposal & Plan Presentations**
   - February 11 & 13
   - **NOTE EXTRA LECTURE Monday Feb 11, 6-8pm, MP 137**

5. **Spiral 2 & Spiral 4 Presentations**
   - 2: March 6/13   4: March 20/27

6. **Final Presentations**
   - Weeks of April 3 & 10

7. **Final Report Due April 12th**

Assignment 1 Part 2 Due Next Week

- P1 and A1 part 2 assignments due next week, 6pm, Tuesday January 22nd
  - **There will be one assignment per week after that, for 3 more weeks (in addition to project work)!**

- Submit via Blackboard Portal – under <u>Course Materials</u>
  - Click on the assignment
  - Attach your file using 'Browse My Computer'

- Programmers: **P1**
  - Any issues/questions?

- Appers: **A1**
  - Any issues/questions? (12)

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 Eclipse**
  - or, can choose to do everything in command/shell environment
  - lose some of Eclipse' 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 18 Google Nexus S phones available for loan, for those who need them for assignments and the Project
  - Running Android 4.1.2

- Contact course TA to borrow:
  - Braiden Brousseau braiden.brousseau@utoronto.ca
  - Day-long loans till ascertain demand

Many thanks to Google **for the donation of these phones!**

Note for iPhone/iPad Users

- Recall you must have a Mac to do this
- The University of Toronto has signed up under the University development program, see:
  - http://www.its.utoronto.ca/communication-and-collaboration/Apple_iOS_Developers_Centre.htm
- Allows free download to device,
  - which otherwise costs $US 99
- Does <u>not</u> allow for app store distribution
  - But If do pay $99 later, you will then be able to put on app store

Initial Thoughts/Pointers on Project

- Once you have a group:
  - If **Apper** in group, Apper needs to give rough idea of discipline
  - All groups: start kicking around ideas
  - Send me an email when you think you have something concrete that you can describe – 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

Overview of Smartphone Capabilities

To Get You Thinking about the Project

Based on iPhone, but Android Phones have same capabilities

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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
  - Can also make phone calls

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

Inputs and Sensors

Touch Screen

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

How the iPhone Works Touch Sensing

Screen registers touch

Raw data is captured

Background noise is removed

Pressure points are measured

Touch areas are established

Exact coordinates are calculated

©2007 HowStuffWorks
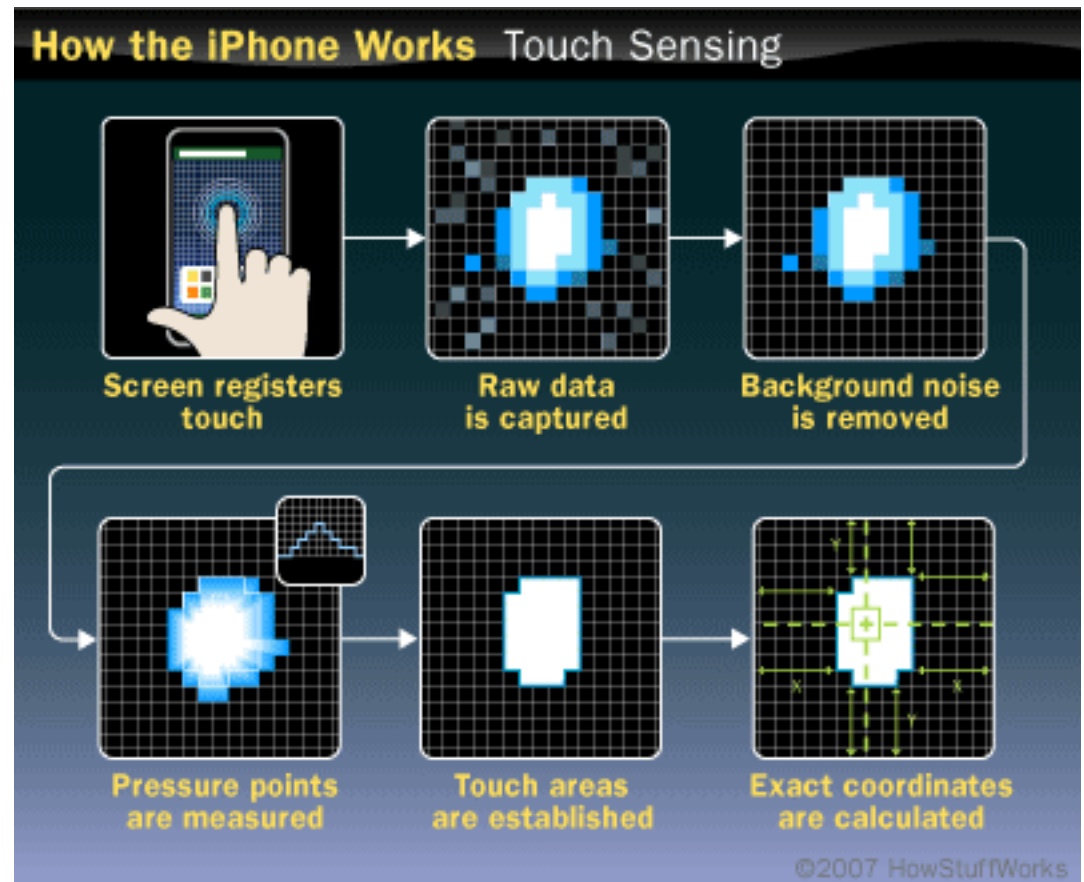
Touch Screen

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

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

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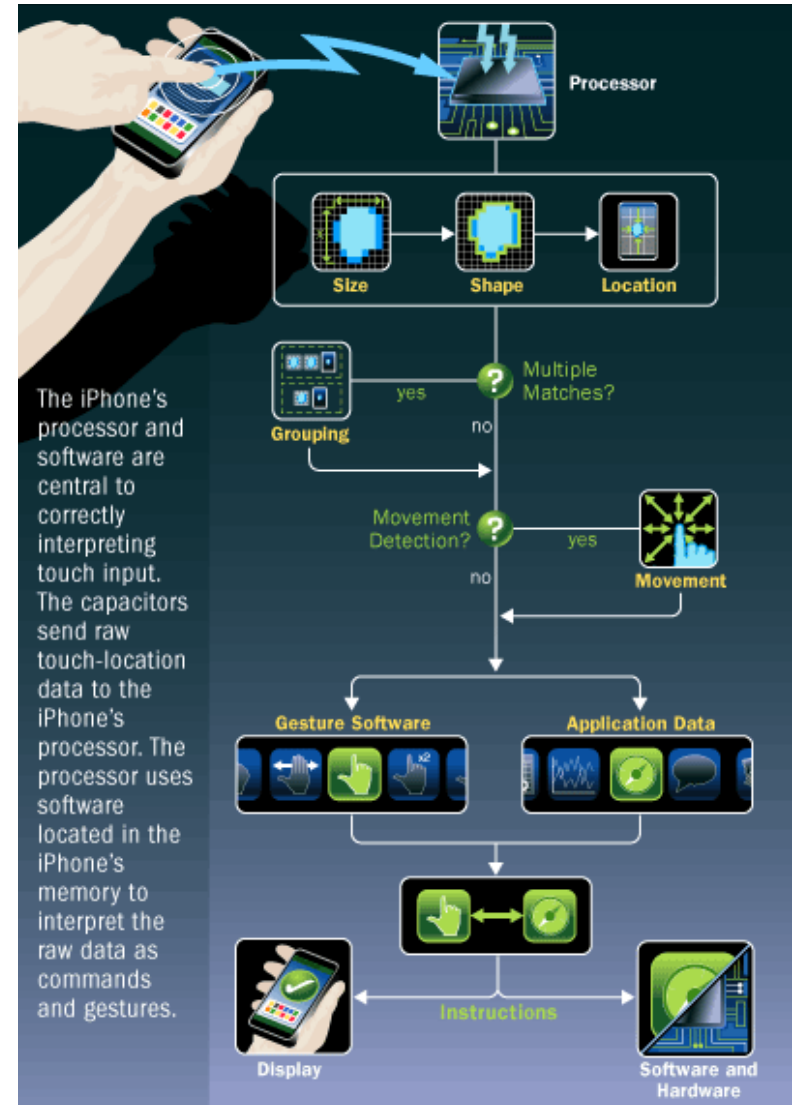
Can Touch Screen Be More?

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

- **Use for?**
  - Medical Diagnosis
  - Lie Detector

Screen registers touch → Raw data is captured
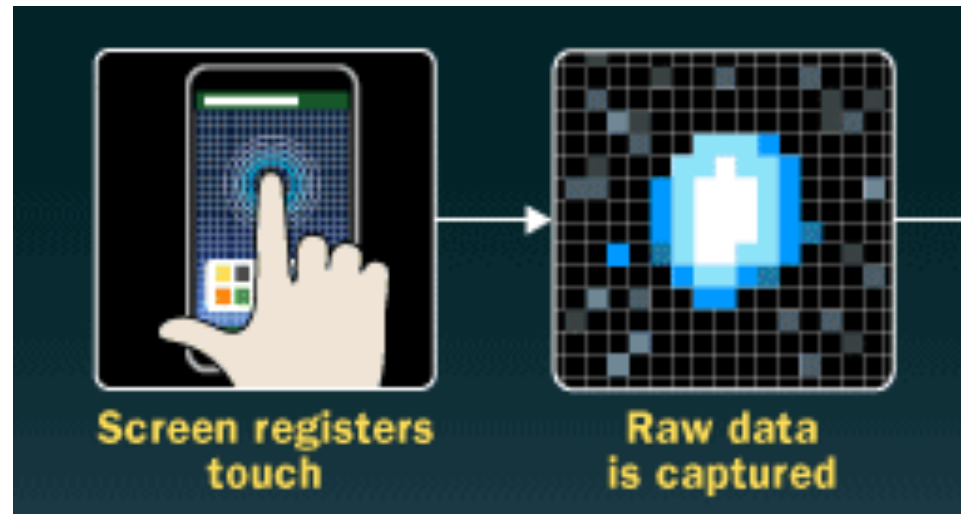
Accelerometer

- 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 gives can give a 'reading' 100 times/s
- Use for gestures
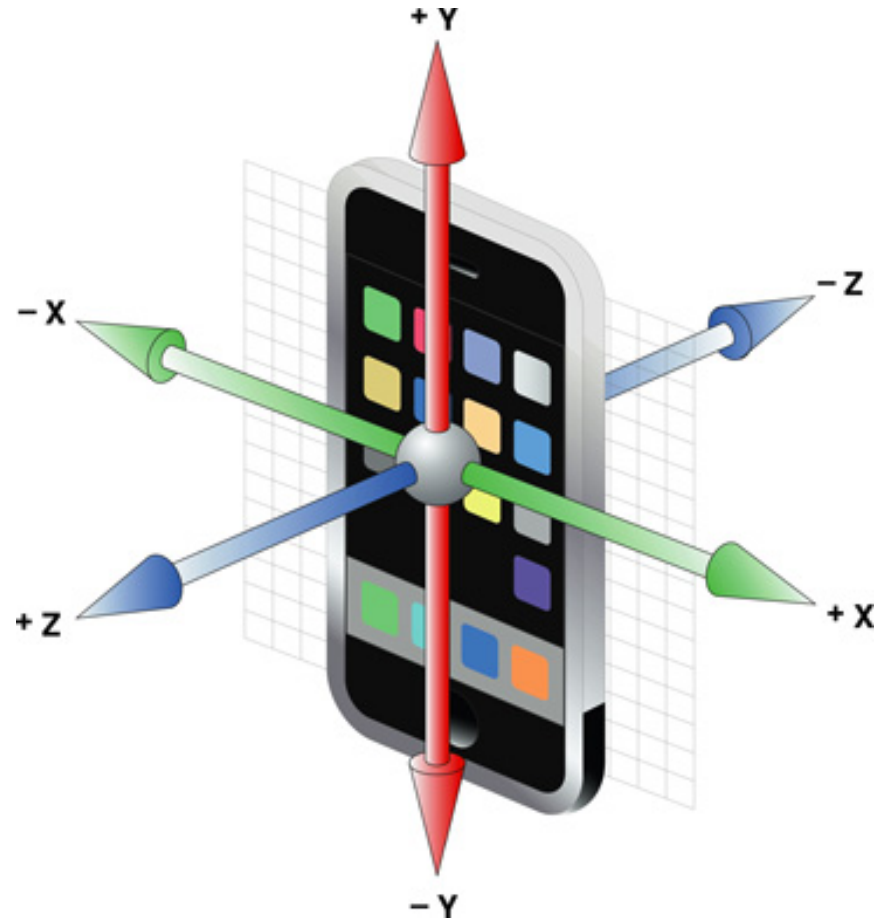
Can Feel What the User is Doing

- Walking – step counting
- Running – speed measurement

- Can it tell something about the user's 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
- Previous projects
  - Measure ankle stability – diagnosis & prescription of exercise
  - Measure step-time asymmetry – diagnosis & corrective exercise

Other 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 …**
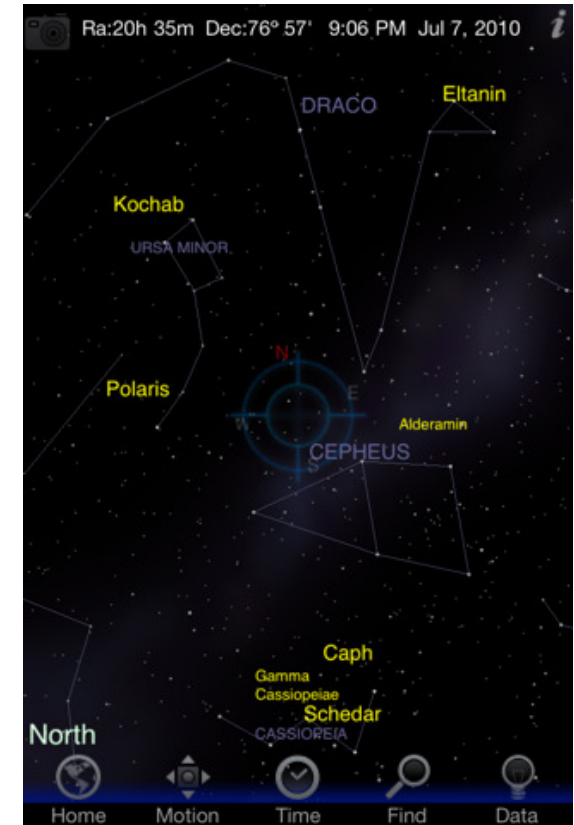
Accelerometer is a MEMs Chip + ASIC

■ This appears to be the case for many of the sensors
- – DSP for sensor not done on main processor
- – Leaves it for other work ☺ but hides raw data ☹
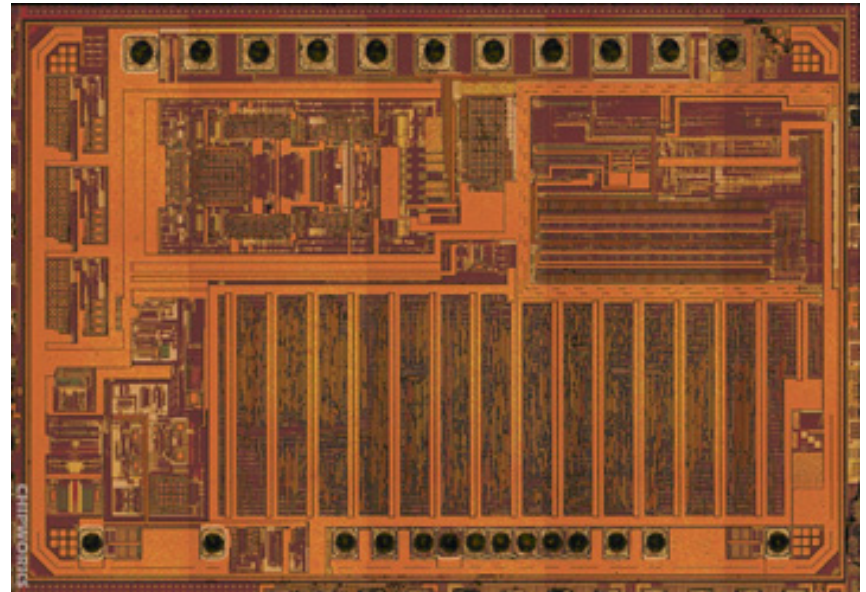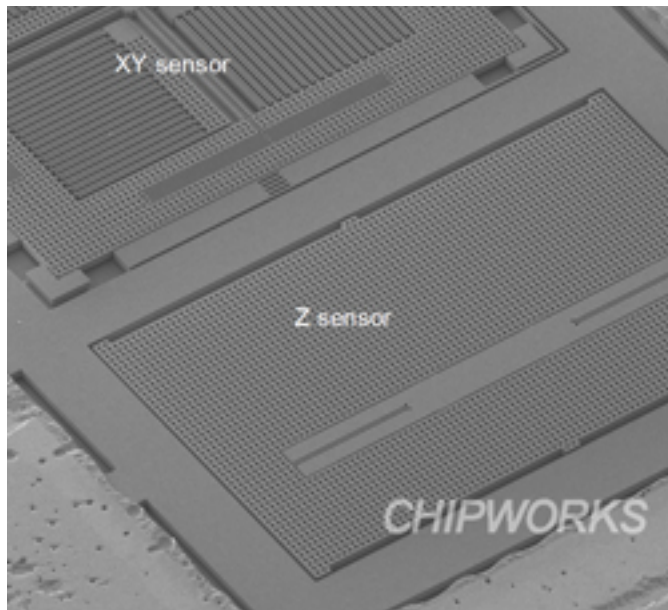
Gyroscope – measuring angular motion

- **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**

- **In iPhone 4 and Nexus S**
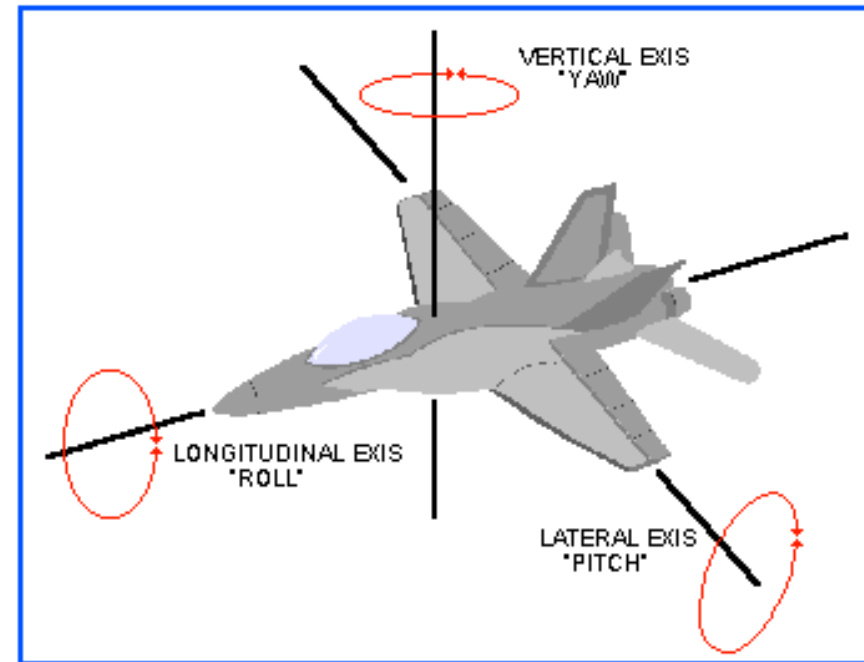
Compass

- **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?**
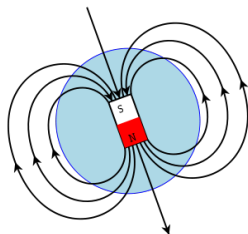
Barometer

- **Google Nexus S has Barometer**
  - 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?**
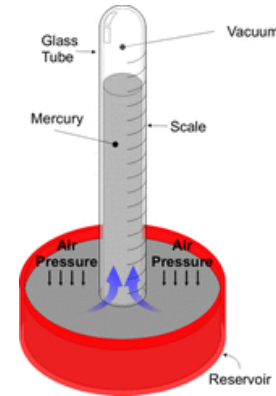
Weather Prediction Using Barometer

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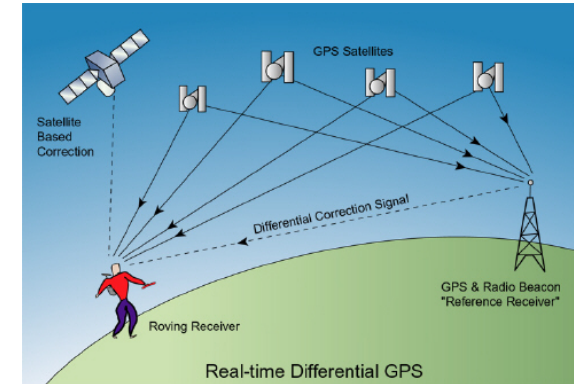
Latitude:	37° 19' 54.0804"
Longitude:	-122° 1' 50.6316"

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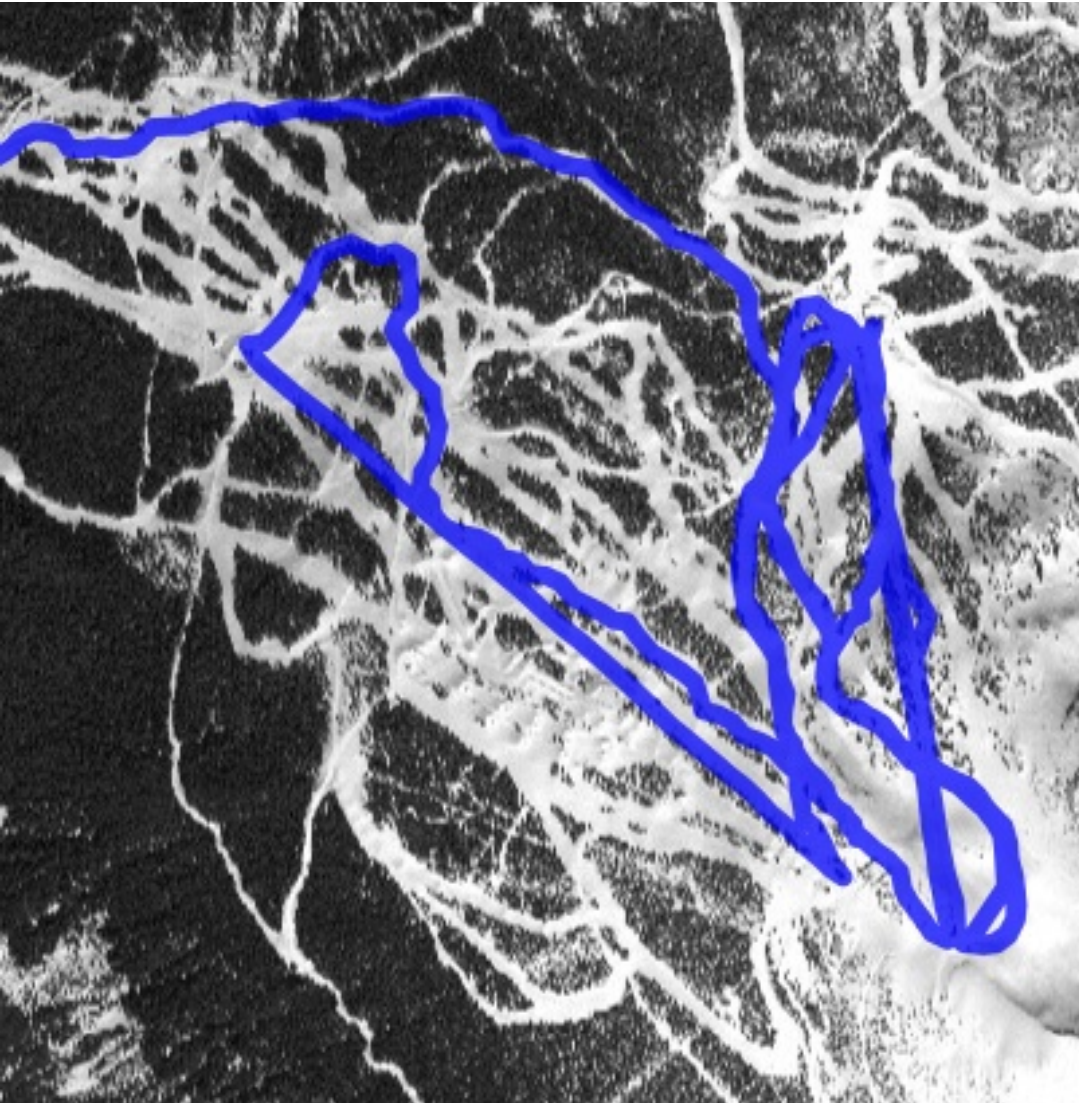
November 25, 2012, 10:15 AM

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

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
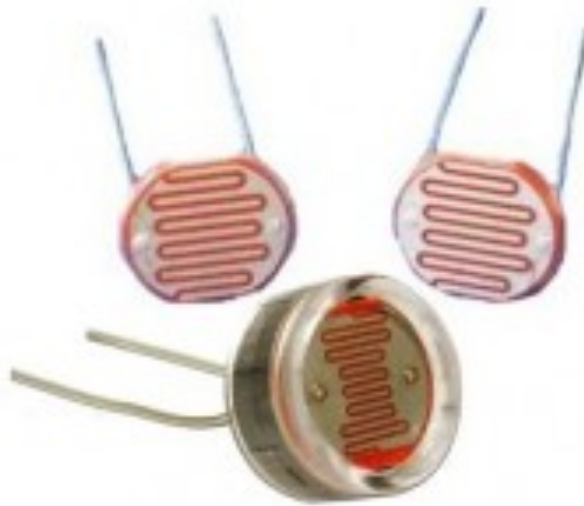
Light Dependent Resistor (LDR)   Photodiode
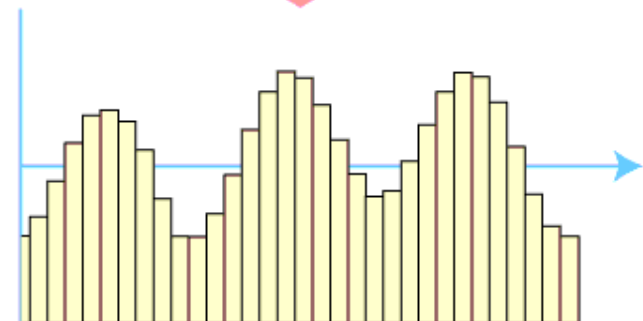
Microphone

- **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**

Conversion A-D

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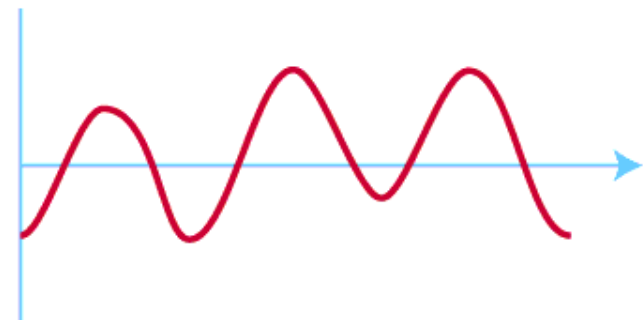
Microphone – Sonar Device

- Could make a good sonar with this!
  - Already been done
  - www.creativeapplications.net/iphone/sonar-ruler-iphone/

# Sound Processing Example 1

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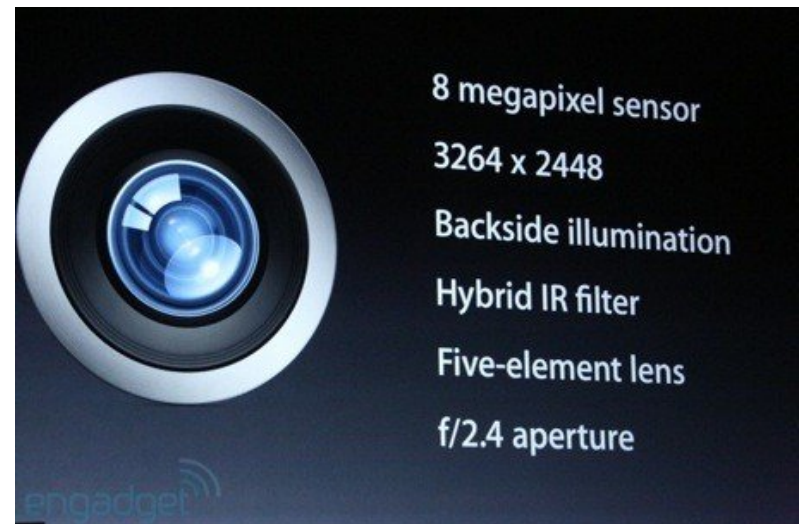
- **Most processing is done on a server**

Sound Processing Example 2

- Listen to a conversation, and measure the fraction of the conversation that each participant takes up!

- Daniel DiMatteo's, 4th Year Undergraduate
  - Known as 'Diarization'
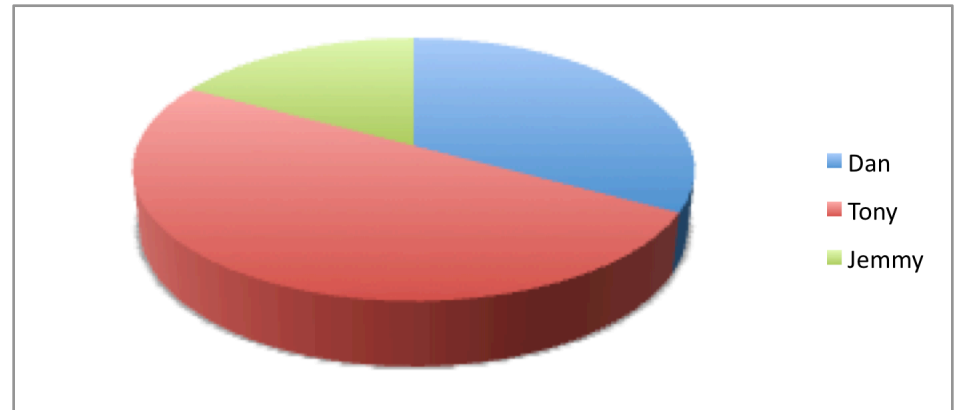
Back Camera

- **Can record images**
  - Large files with high resolution
    - 2MPixels – 8 MPixels
- **Can record video**
  - ~ 30 frames/second of pictures
- **Can we use it to "see things"?**
  - Yes!
  - Computer Vision field
  - Difficult, slow

8 megapixel sensor
3264 x 2448
Backside illumination
Hybrid IR filter
Five-element lens
f/2.4 aperture

Engadget.com

Computer Vision

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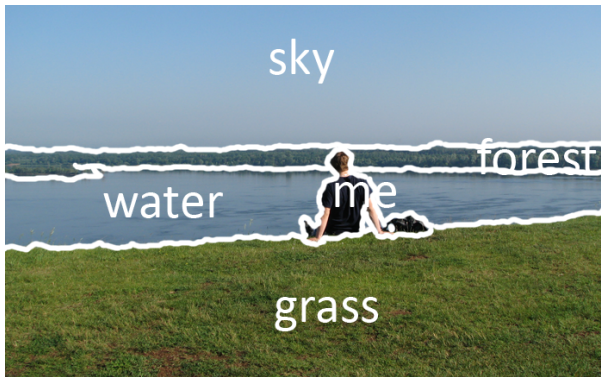
Image Segmentation

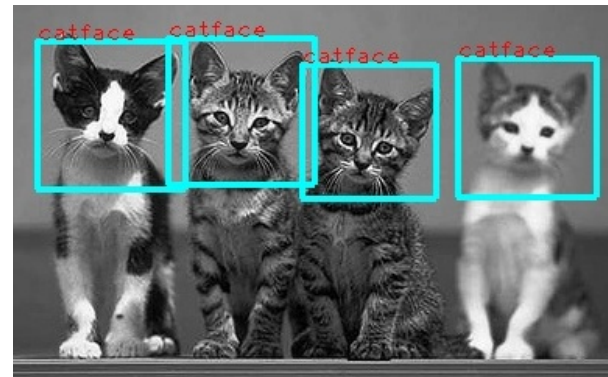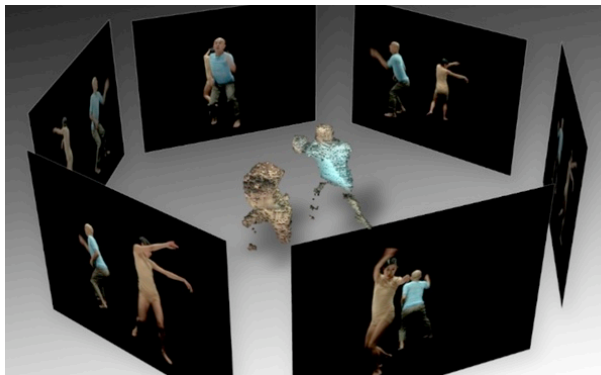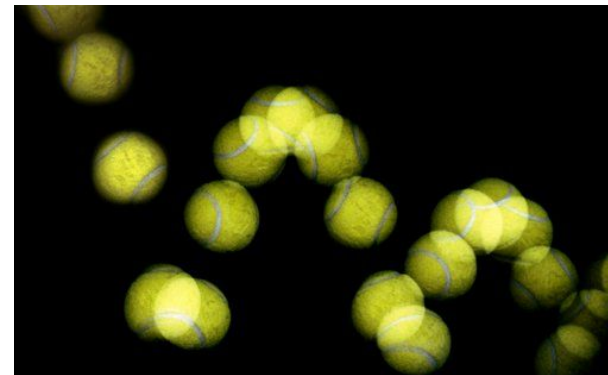**Object Detection**

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
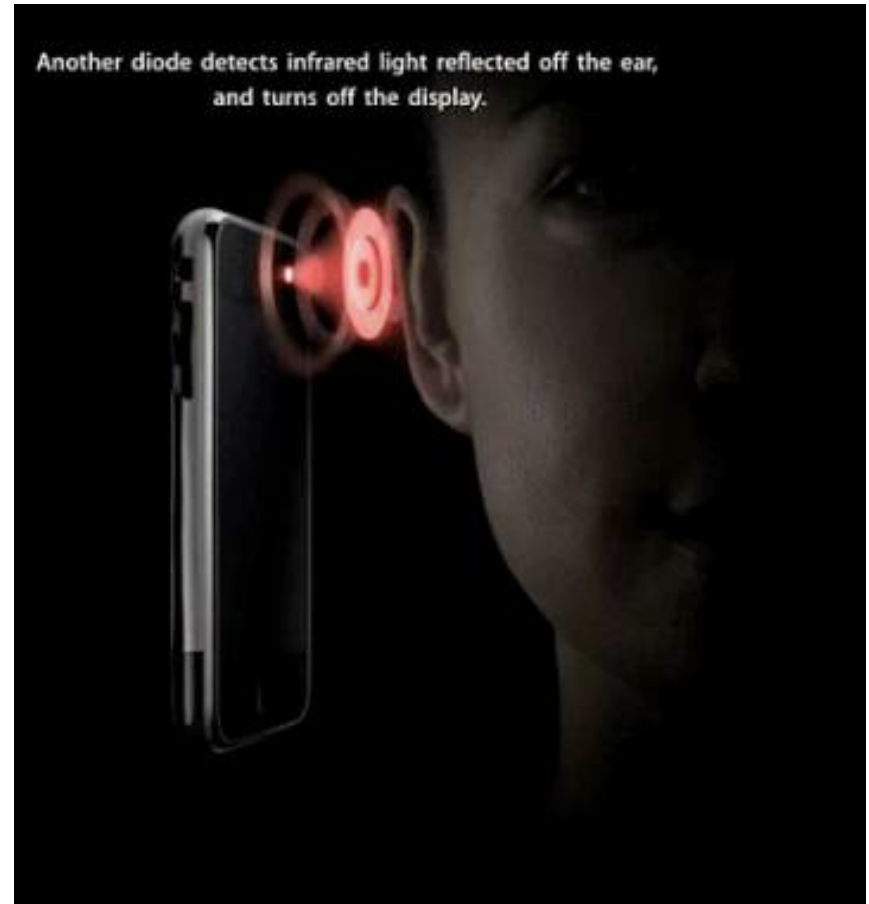 - He can help with using OpenCV, which now has fairly good ports to Android

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**
- **Can maybe track your eye movements as you watch things**
- **Diagnose depression?**
  - eyes are the window to the soul

Proximity Sensor

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

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

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)

Output Devices

Hi-Resolution Screen

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

- **Samsung Galaxy S III**
  - 720x1280 resolution
  - 306 pixels per inch

- **iPhone 5**
  - 640 x 1136 resolution
  - 326 pixels per inch

- **Google Nexus S**
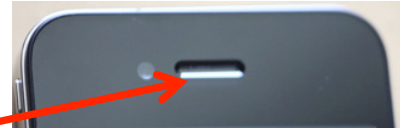 - 480x800 total resolution (50)

Video Display Hardware

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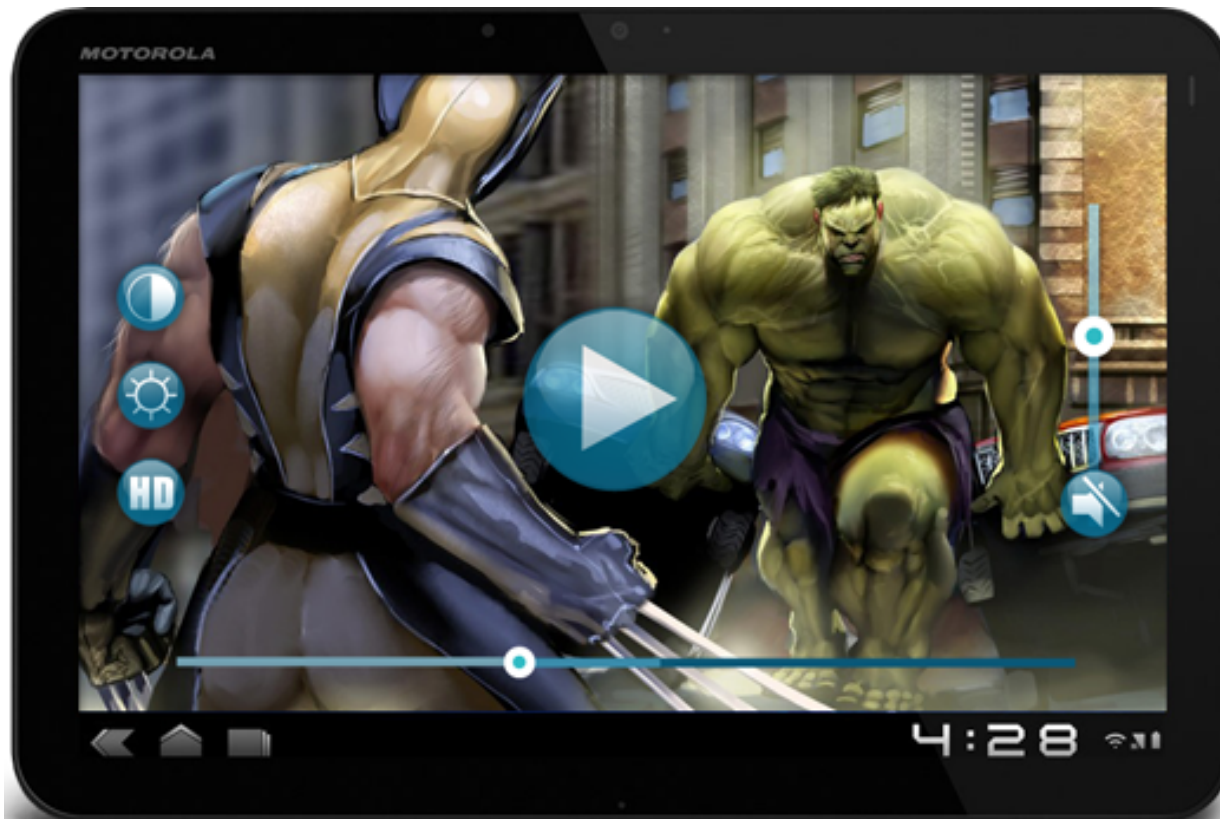
Speakers/Audio Out

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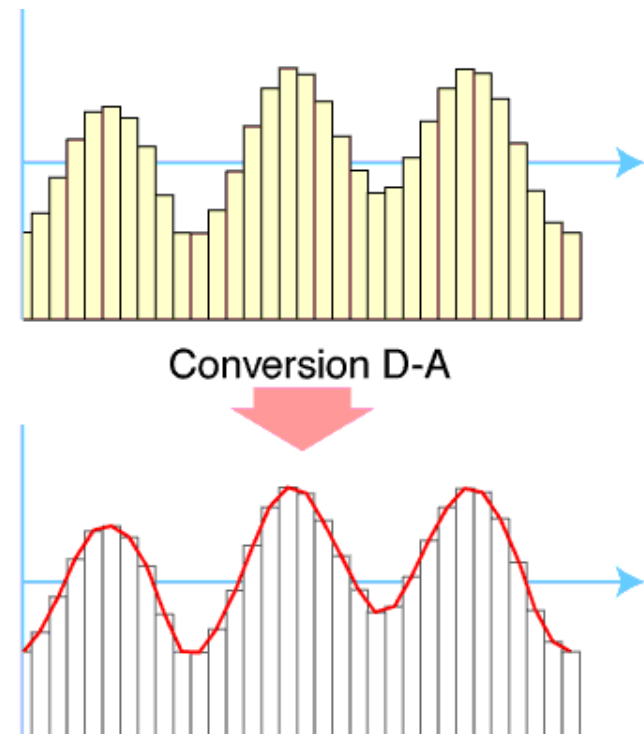   - Quiet one for ear
    - Loud speaker
- **Play previously recorded files**
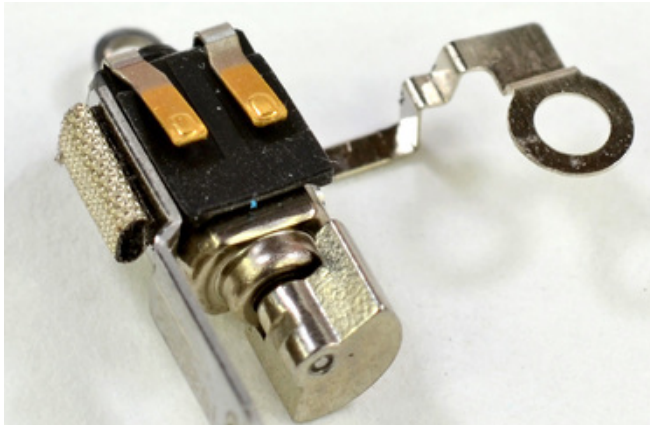 - Should be able to do **text-to-speech**
- **Many possible sound filters –**
  - Auto-tune voices to make at right pitch
  - Make funny voices
  - Synthesized Musical instruments

Conversion D-A

Vibration Output

- Can create a short buzz
- Can control vibration pattern, duration and intensity

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

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Brilliant Use of Vibration: CyIcoramic

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

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

- **http://cycloramic.com**

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 5 has dual core ARM Cortex A15 and 3x Power VR GPU

- 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

Dual ARM Cores

GPU

GPU

GPU

chipworks
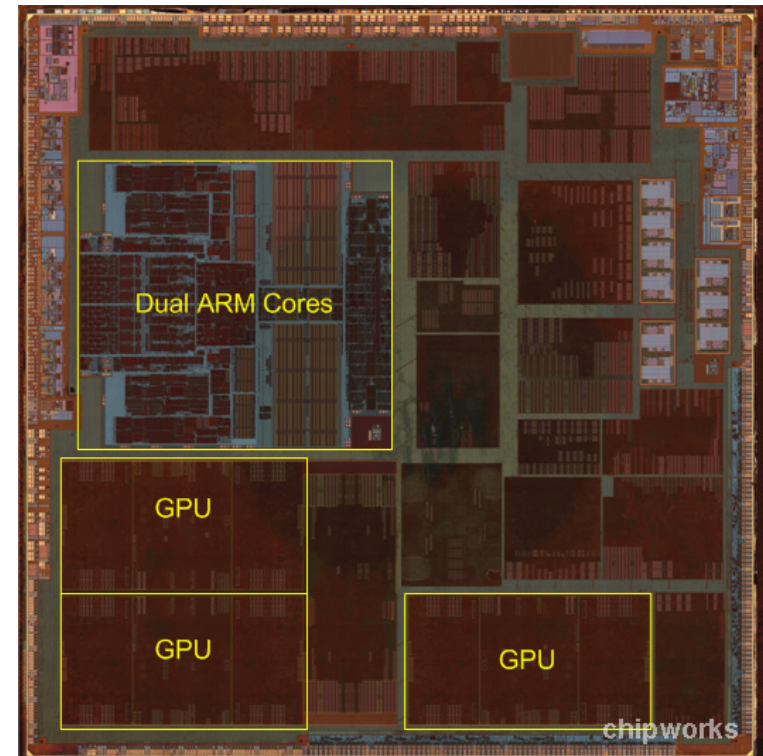
Storage Capacity

- **Local storage of 2 to 64 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 – 4G/3G/Wifi: Gateway to Internet

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

You are here

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

- **Connection to more computation and storage**

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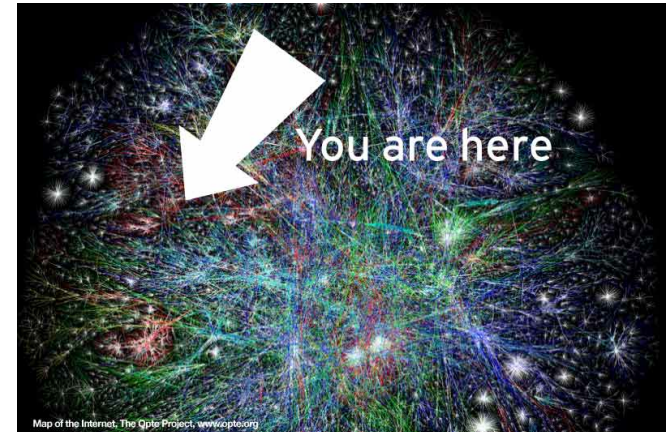
The Cloud Helps Too

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

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

Cloud Resources

Cloud API
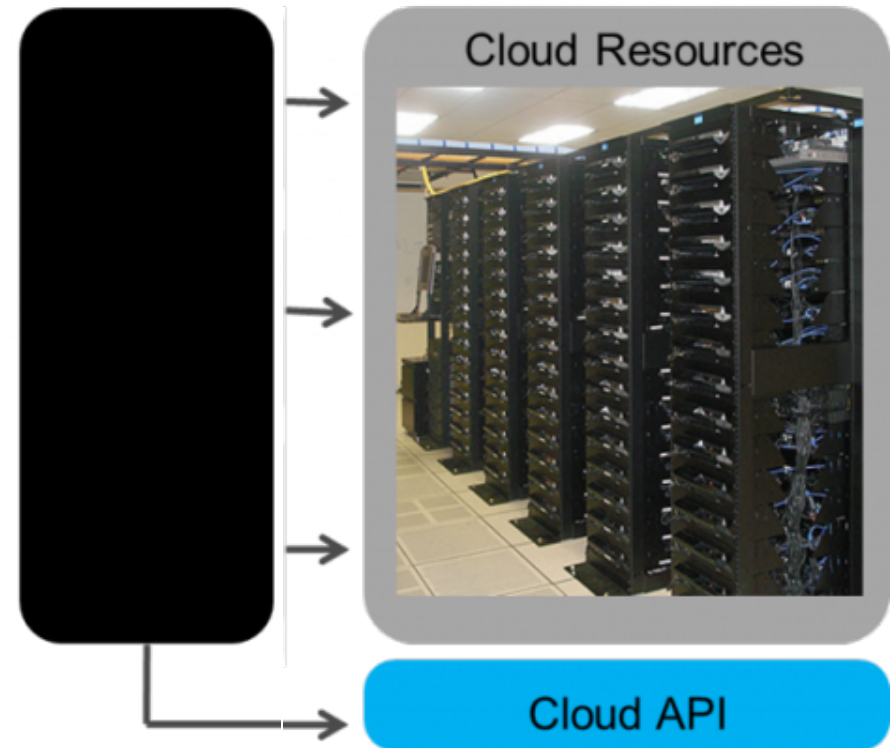
Bluetooth Connection

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

- **Could be important way to add other devices without physical connection**
  - Make use of phone's capabilities without holding it

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
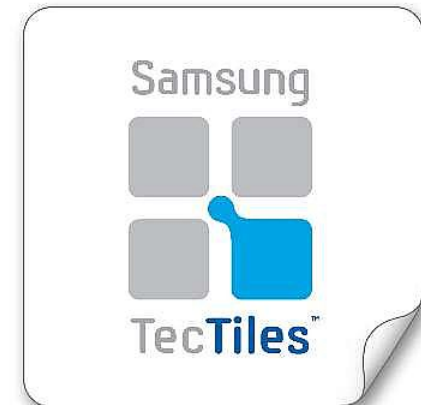
Using All These & More

- 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 make sure all of the appers have introduced themselves
  - Please take notes to keep track of people who you think might be compatible partners
- Sometime today look at submissions of Programmers & Appers on Pepper website
- Tonight, we'll try to put people in some categories to help you explore matches.
- Don't forget, the priority has to be on matching to Appers

Introduce Yourself, Round 2

1. Name
2. Taking Course for Credit – answer should now be yes
3. What discipline you work in & **degree**
4. What your thesis topic is (if doing thesis)
5. If you work/worked, where & what you do/did.
6. Why you're taking this course
7. What kind of phone you're carrying
8. Apper: What idea you have for an app
9. Programmer: What you're interested in doing app on.

Tonight: Meeting to Form Groups

- Wednesday January 16th
- 6:30pm-8:00pm
- GB 244
  - Will do super-fast introductions – name, field, interest
  - Then, talk amongst yourselves!