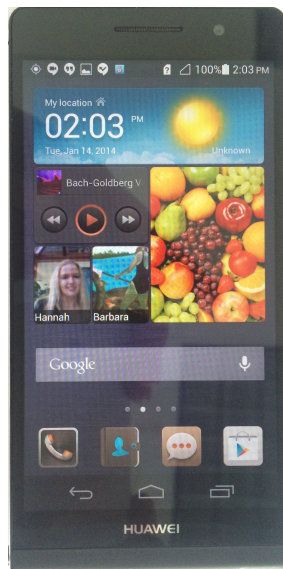


ECE 1778: Creative Applications for Mobile Devices

Lecture 2
January 15, 2014



(1)



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
-
- **Tonight:** Important Group Forming session
- 6:30-8:30pm Sanford Fleming Building room B560



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
 - 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
29	4	13	4	6	1

- Total of Yes & Maybe
 - Programmers & Both: 33
 - Appers: 17
- Submitted Part 1 of Assignments A1 or P1:
 - Programmers: 39
 - Appers: 18
- Registered on Blackboard: 67 (missing at least 10!)
- How many did not submit Assignment 1 Part 1 last night at 6pm, but still intend to be in course?
- 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
- Must be bona-fide attempt to form group with Apper before moving to non-Apper group alternatives



Work for you Today

- 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, in preparation for tonight's meeting
- Feel free to make initial contact through pepper messaging
 - Suggest setting notifications on Pepper settings to be notified of messages and posts



Extra Meeting to Form Groups

- Tonight: Wednesday January 15th
- 6:30pm-8:30pm
- Sanford Fleming Building, Room B560
 - After today's finishing introductions
 - Will find a way to help make matches there
 - Have arranged for extra space, if needed across hall
- Sandford Fleming building is south of Con Hall
 - Room B560 is on the south side, basement



Once You Have Formed a Group

■ Send email to:

- Me (jayar@eecg.utoronto.ca)

■ In that email, Provide:

- Names, 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



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
- should 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 2-3 weeks; special get together Wed Jan 15 @6:30pm

2. One-Page Proposal

- Due January 29th; Must receive approval to proceed

3. Project Plan

- Due Feb 5th

4. Proposal & Plan Presentations

- February 12 & 13
- **NOTE EXTRA LECTURE Thursday Feb 13, 6-8pm, TBD**

5. Spiral 2 & Spiral 4 Presentations

- 2: March 5/12 4: March 19/26

6. Final Presentations

- Weeks of April 2 & 9

7. Final Report Due April 10th



Assignment 1 Part 2 Due Next Week

- P1 and A1 part 2 assignments due next week, 6pm, Tuesday January 21st
 - **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? (15)



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



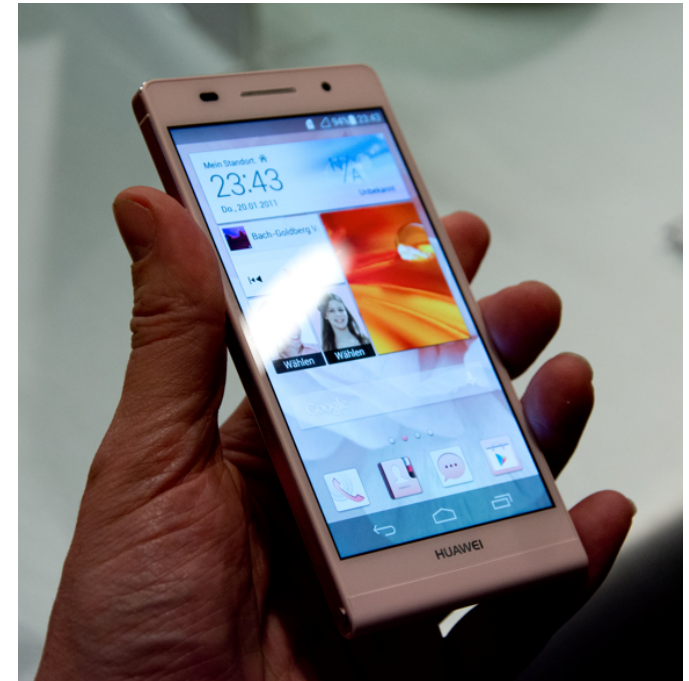
What Appers should be learning & doing

- 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 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!**



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 ...

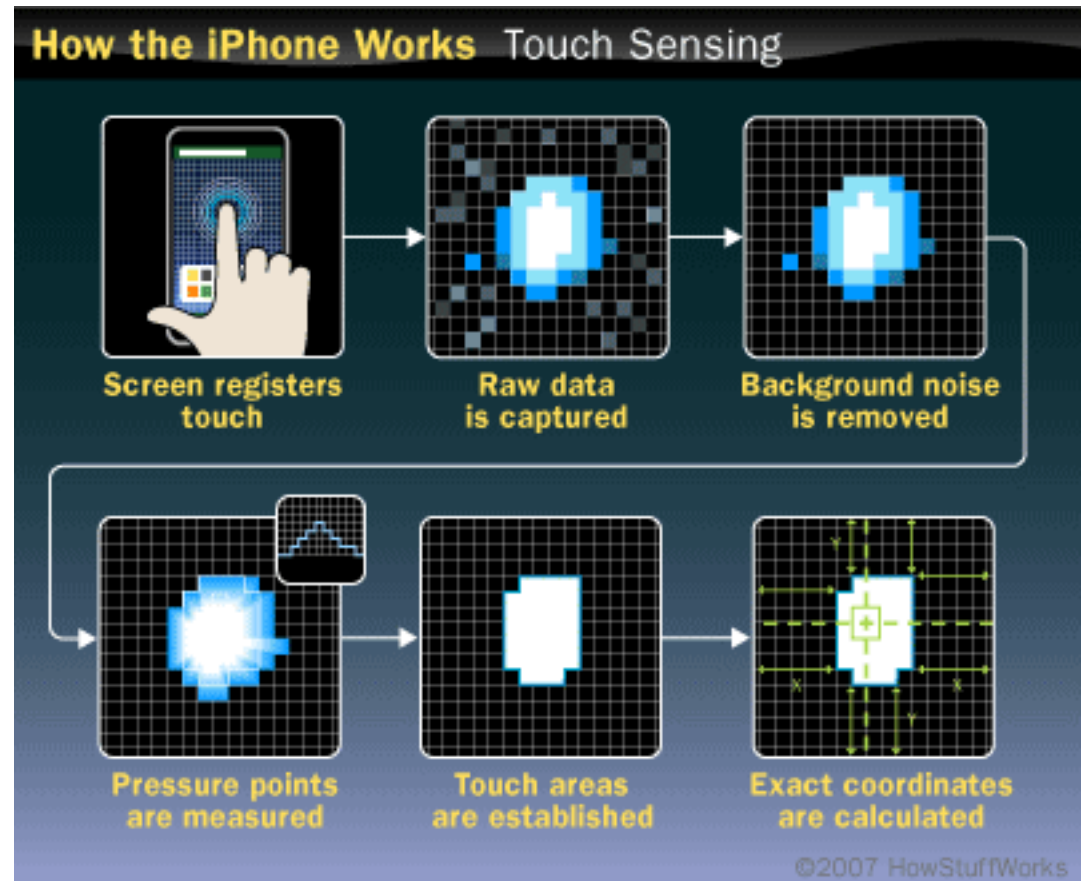
- A Computer small enough to unobtrusively carry, that
 - Is connected to the Internet – knowledge & compute power
 - Can **sense** its environment in many ways
 - Can **speak** to its environment in several ways

- *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

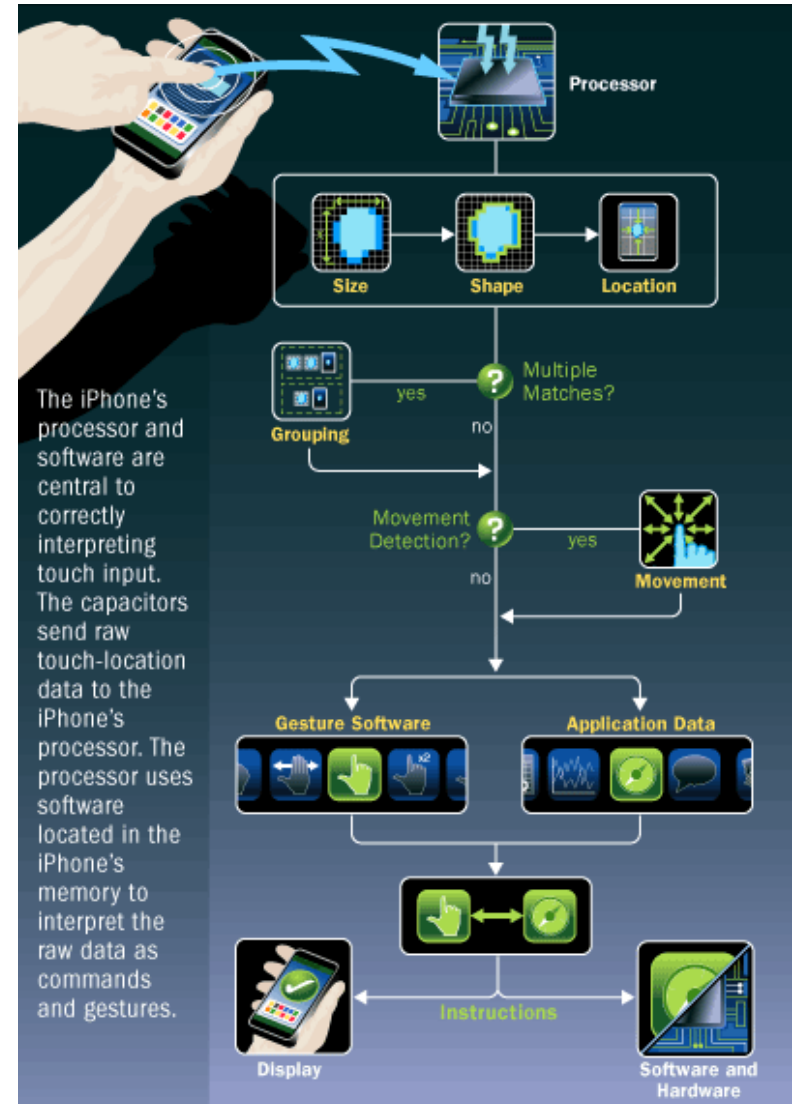
- The screen surface detects the touch of a finger
- Each touch can be turned into a specific coordinate



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 ...



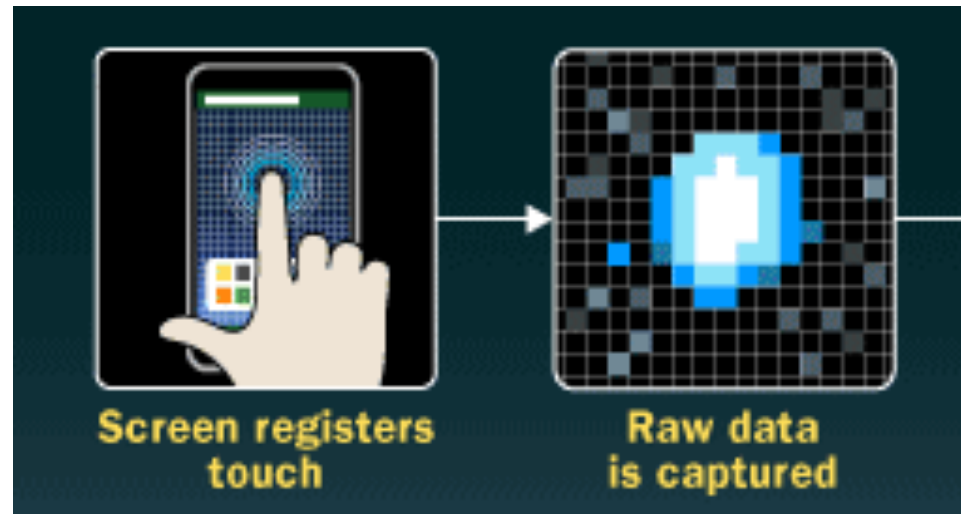
Can Touch Screen Be More?

- Could this sensor be used to measure something about the finger?

- Blood flow
- Blood Pressure
- Heart Rate

- Use for?

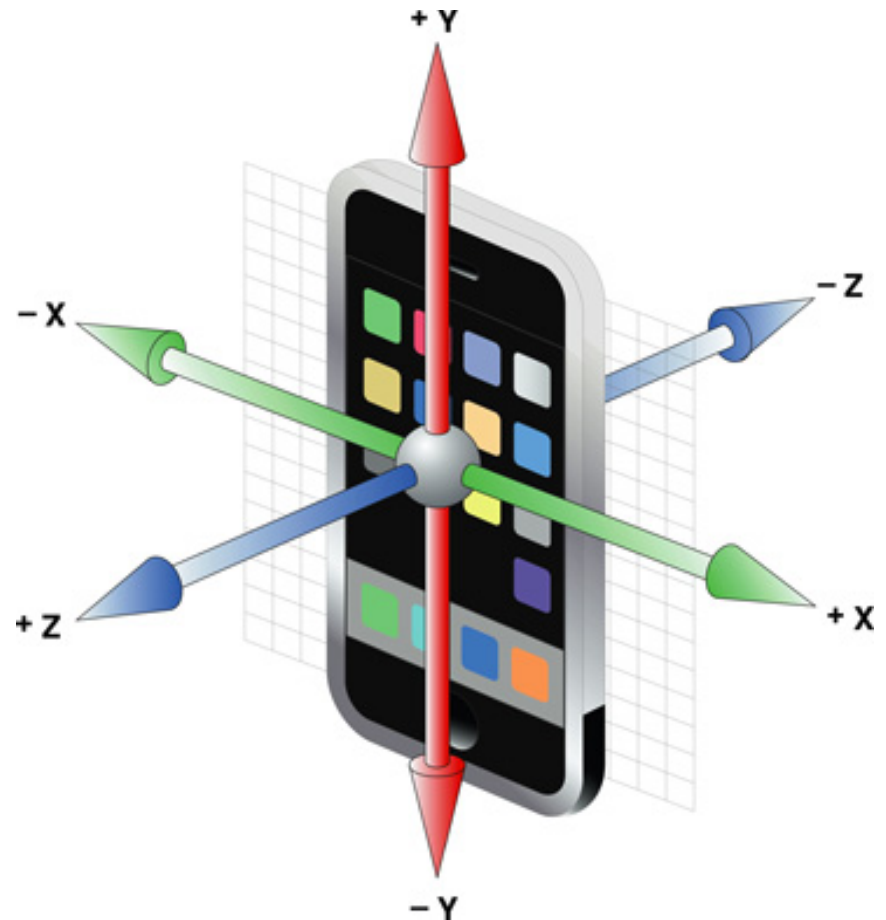
- Medical Diagnosis
- Lie Detector



- 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

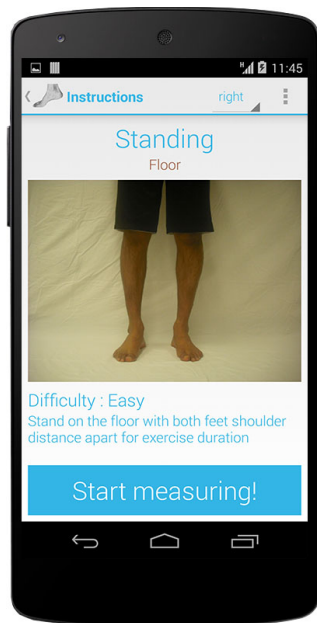
Nirtal Shah

Ivan So

Lyndon Carvalho

Vivian Liu

Braiden Brousseau



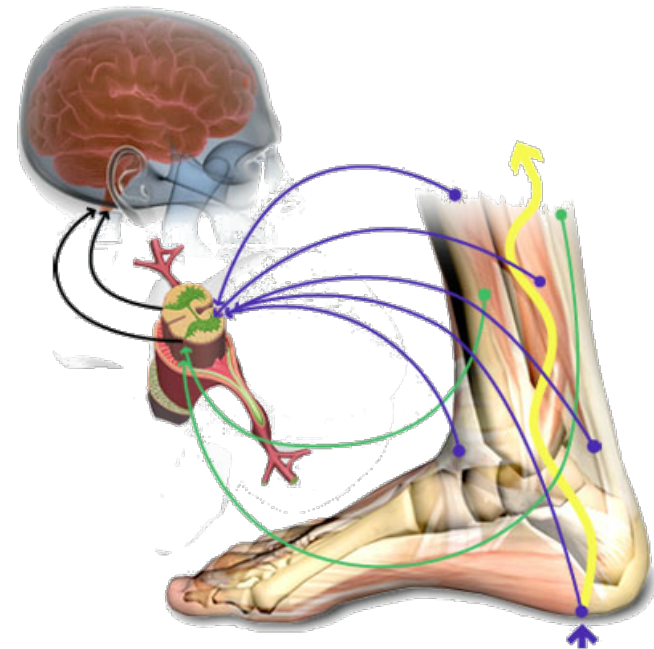
April 2011 – present

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The Problem with ankle injuries

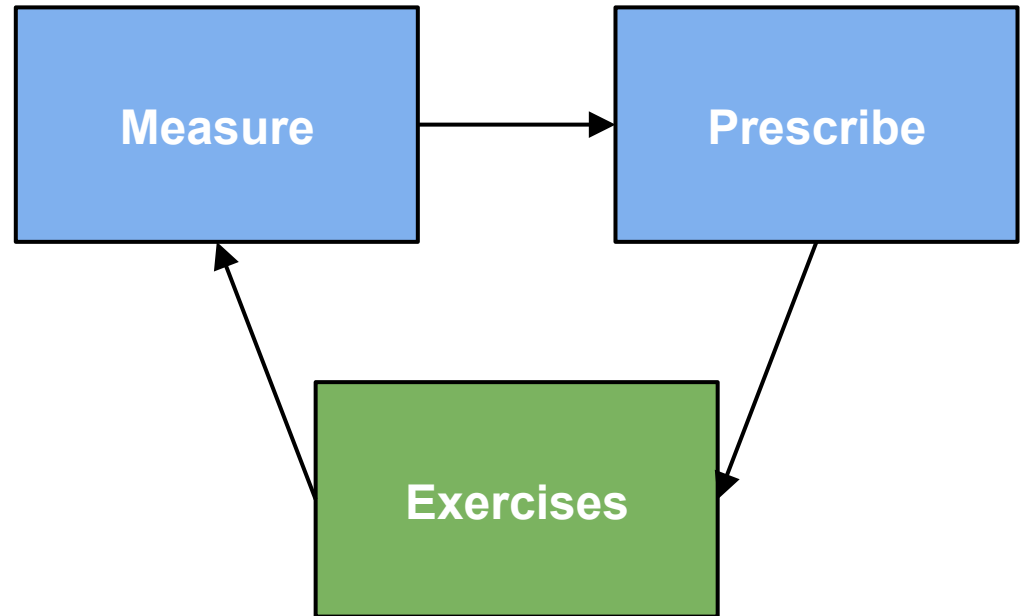
- Injury causes a loss of ability to balance
 - Leads to increased chance of re-injury
- If you sprain or break your ankle, you should do physiotherapy to get this balance back
- Most people don't!



What You're Supposed Do: Treatment

Physiotherapist

Patient



Why isn't proper treatment applied?

- Physiotherapy is time-consuming
- Physiotherapy is expensive (~\$100/hr)
- Easier to 'walk it off', rest to recover



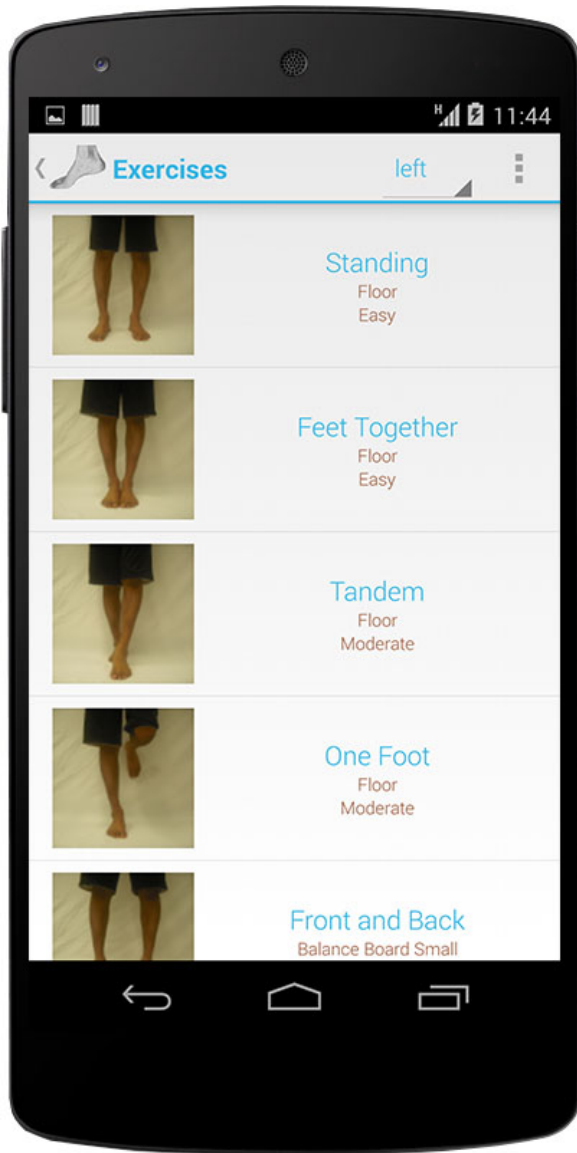
myAnkle



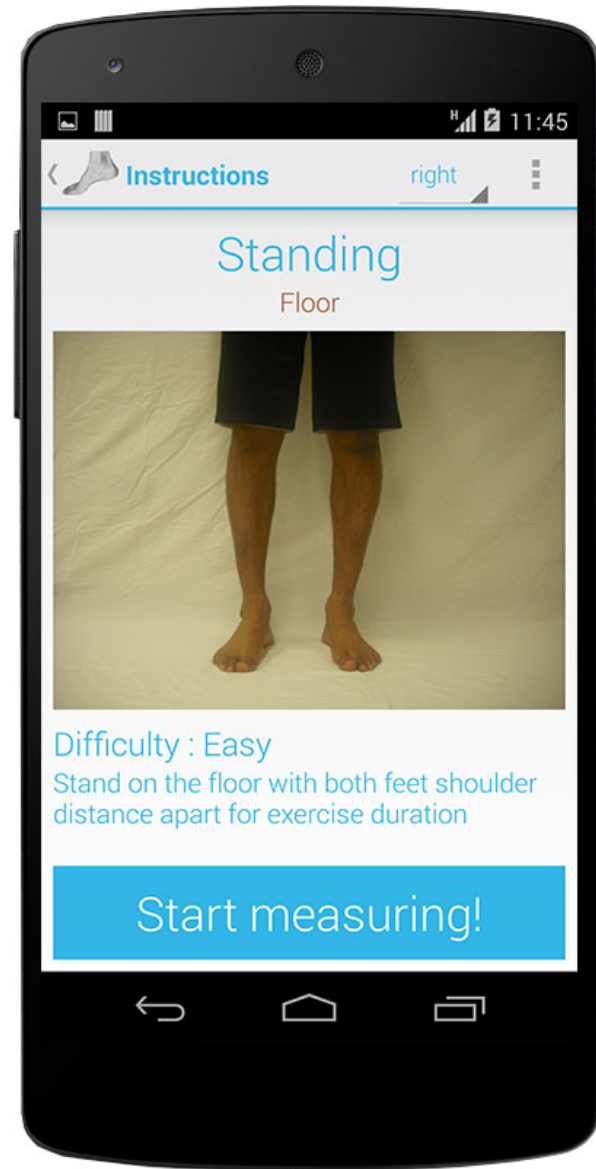
- Promotes proper treatment and active rehabilitation
- Use Accelerometer to measure ankle 'wobble'
 - Gives a 'Balance Number'
- Just putting finishing touches on a real release soon
 - App will only measure, not prescribe
 - Want to collect data for Nirtal Shah's M.P.H. research
 - Need to learn what the numbers mean
 - We hope to evolve it to prescribe



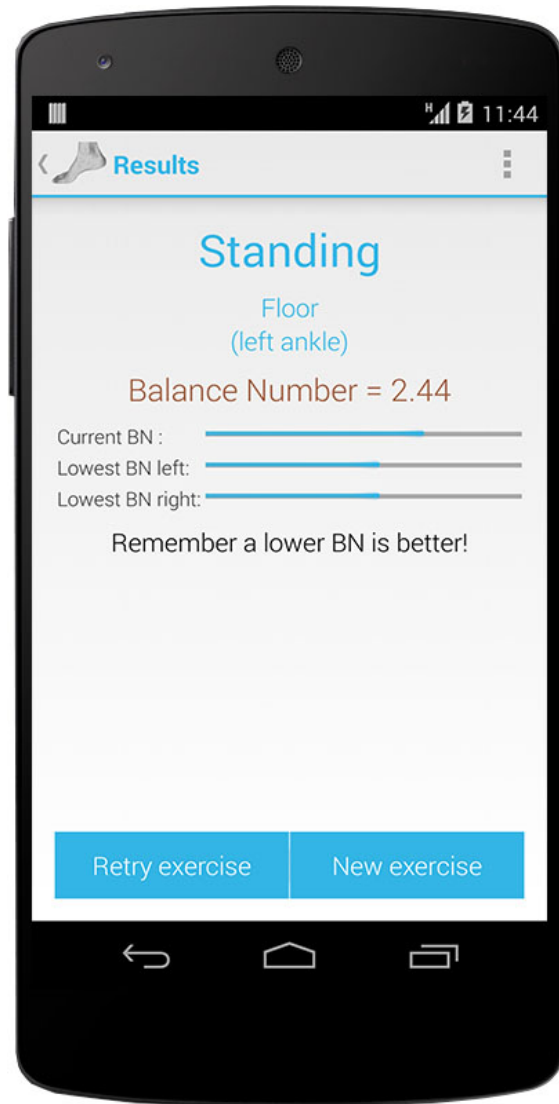
myAnkle Screen Shots



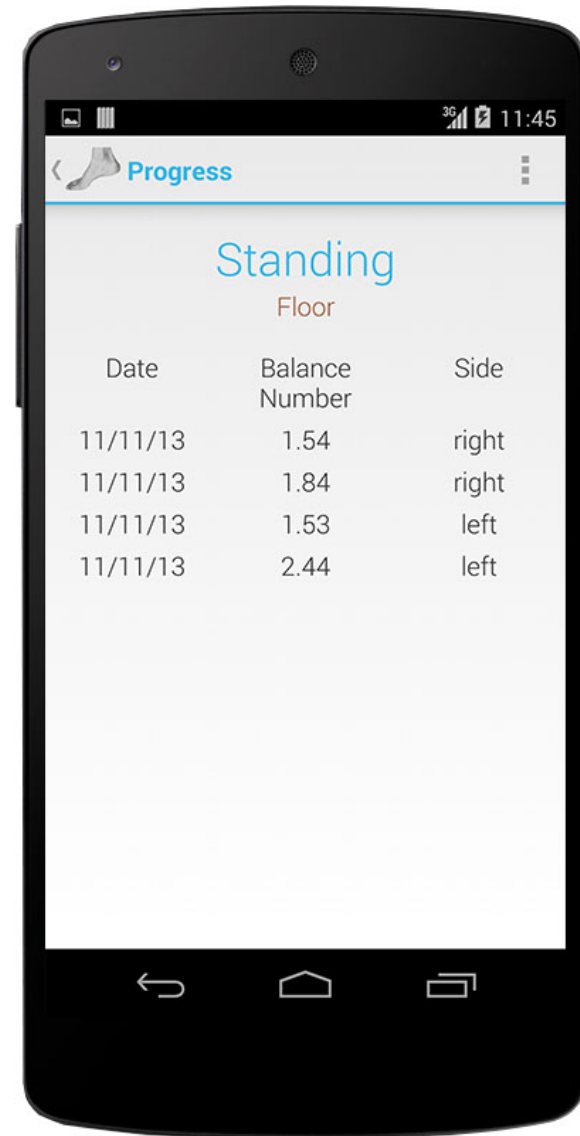
3)



myAnkle Screen Shots



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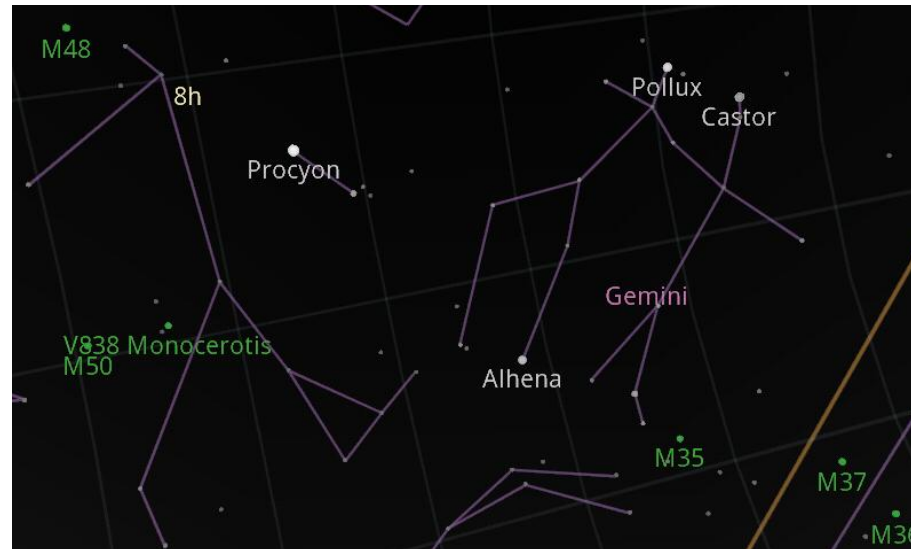
Other Motion Sensing

- 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

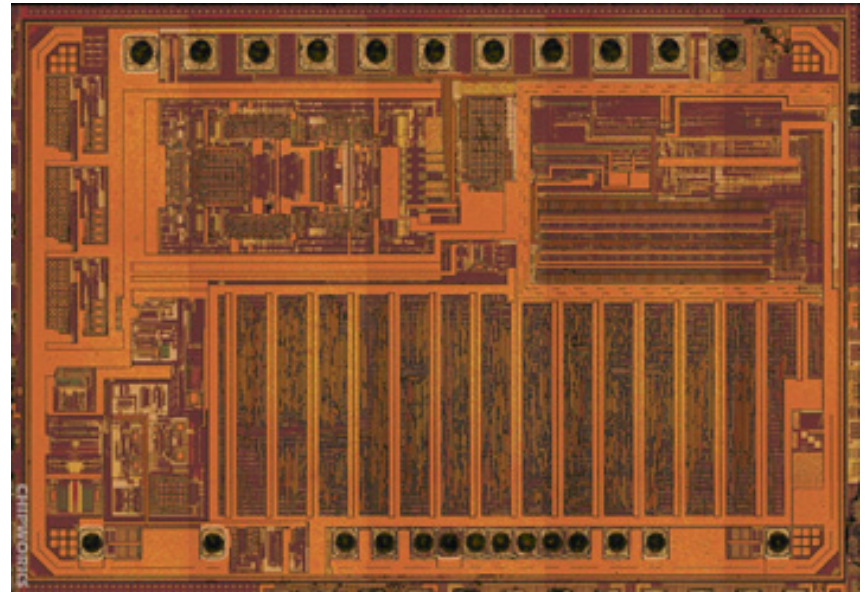
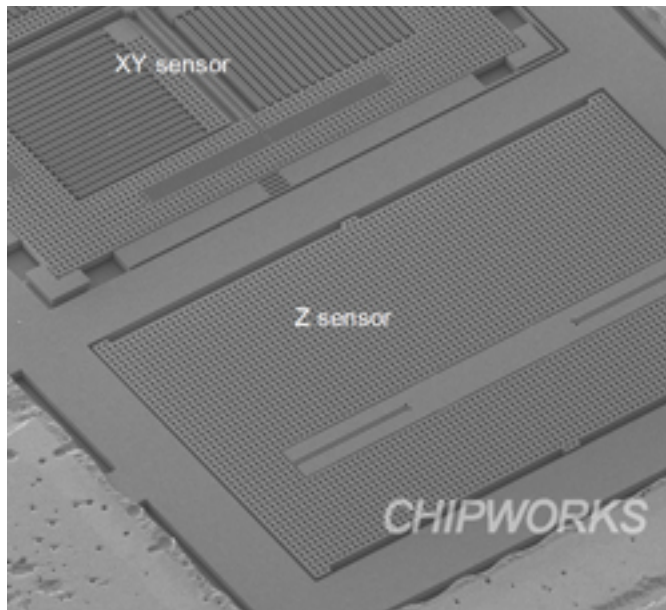
Motion Sensing with Accelerometer

- 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 ...



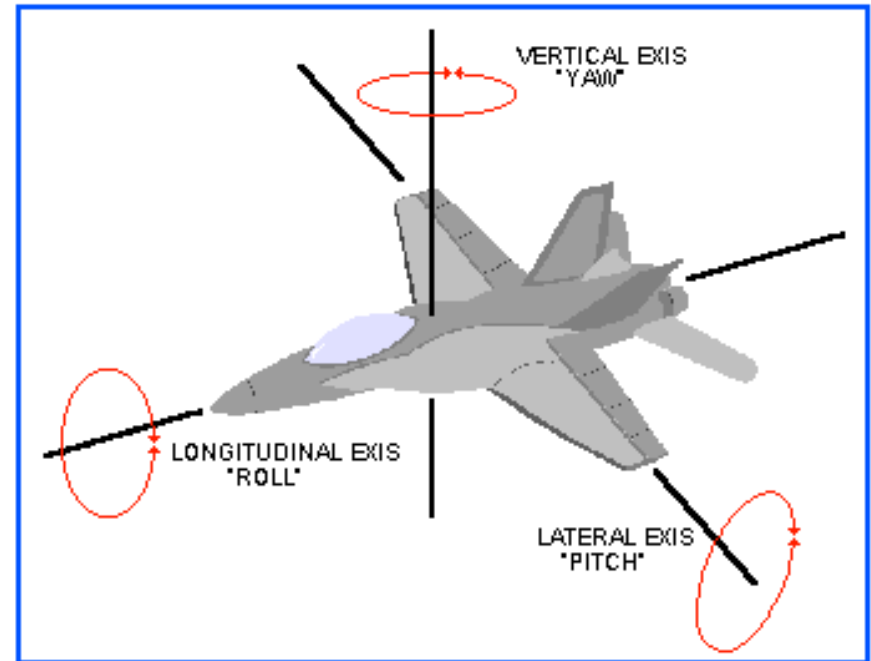
Accelerometer is a MEMs Chip + ASIC

- 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



Compass

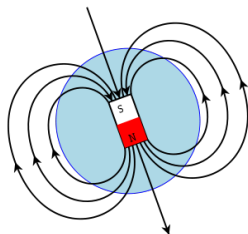
■ Really a magnetometer

- 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?

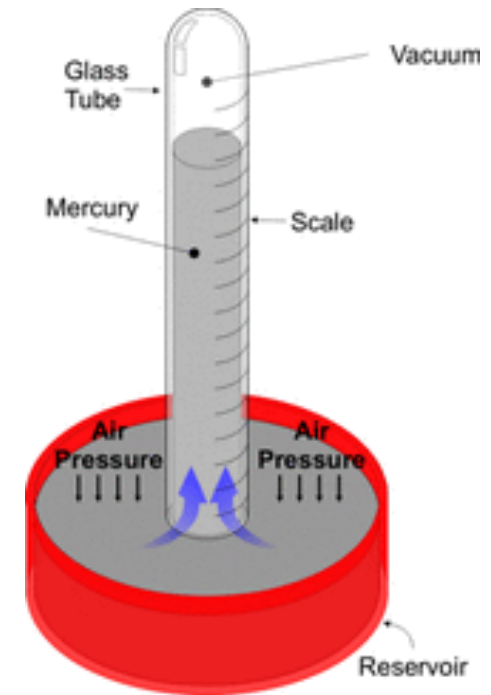


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Barometer

- Some recent Androids have Barometer
 - Not Ascend P6, but in Nexus S
 - 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

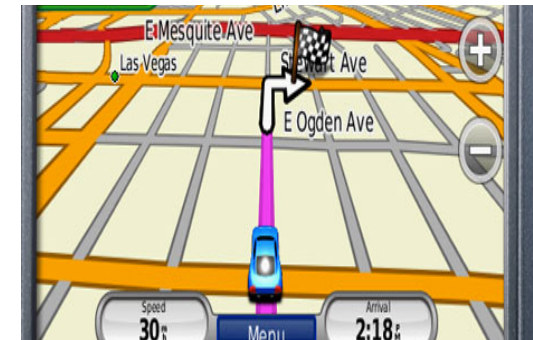
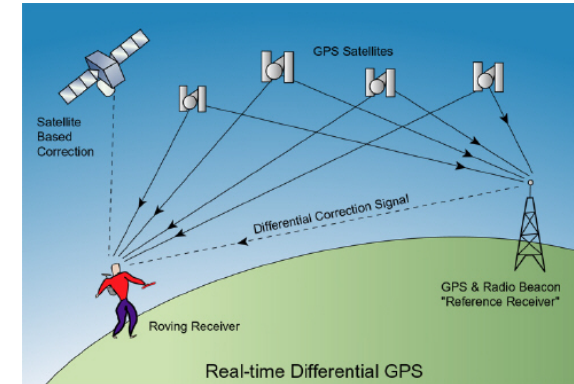
- Decreasing barometric pressure indicates storms, rain and windy weather.
- Rising barometric pressure indicates good, dry, and colder weather.
- Slow, regular and moderate falls in pressure suggest a low pressure area is passing in a nearby region. Marked changes in the weather where you are located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

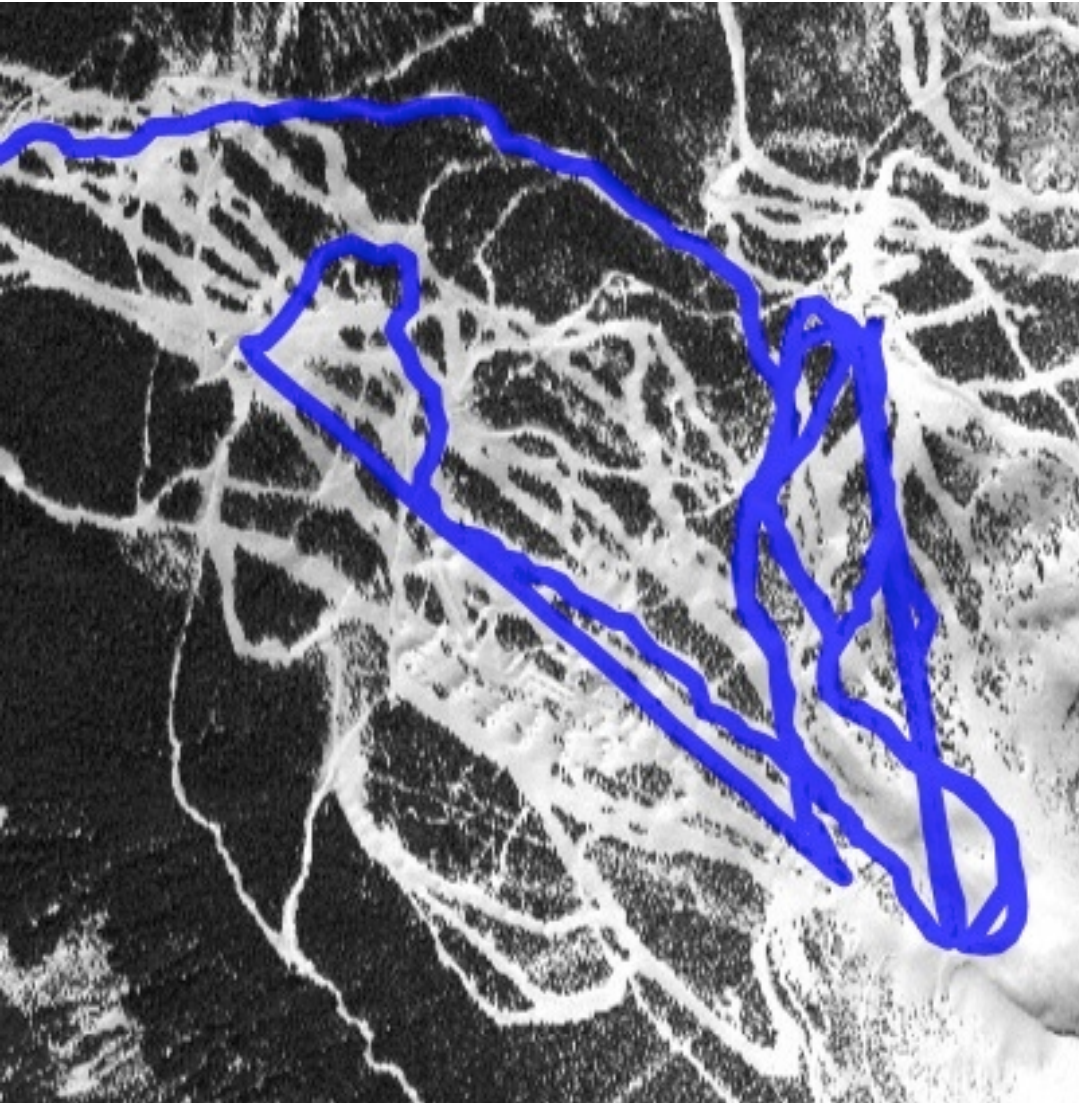
GPS Receiver

- 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



(43)

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



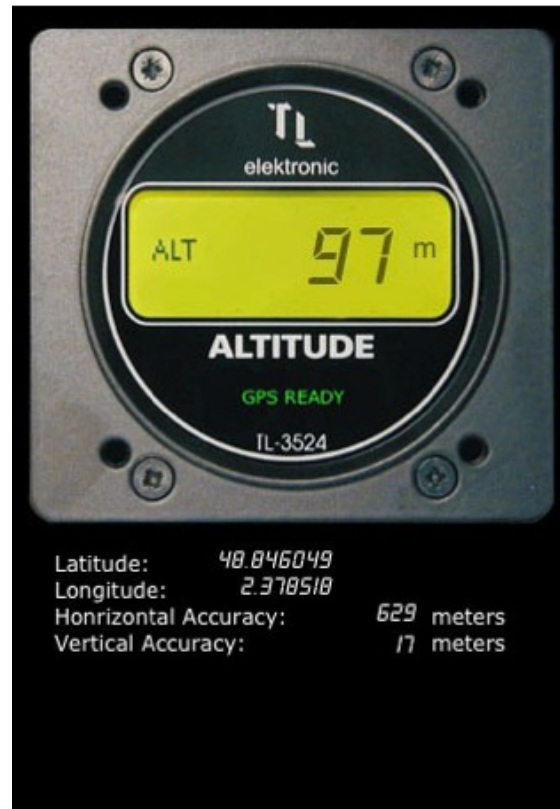
GPS

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



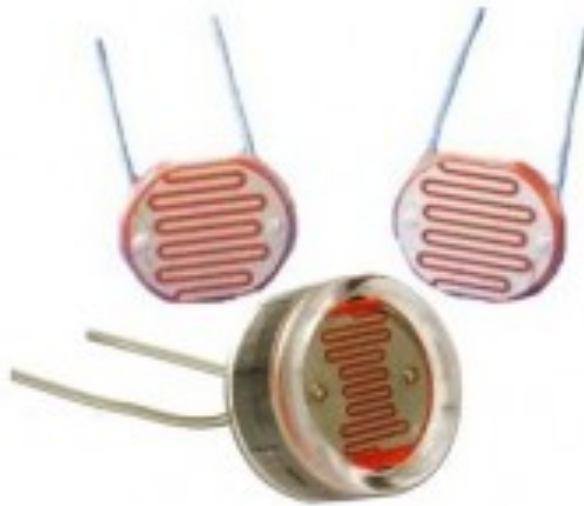
Altimeter

- 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

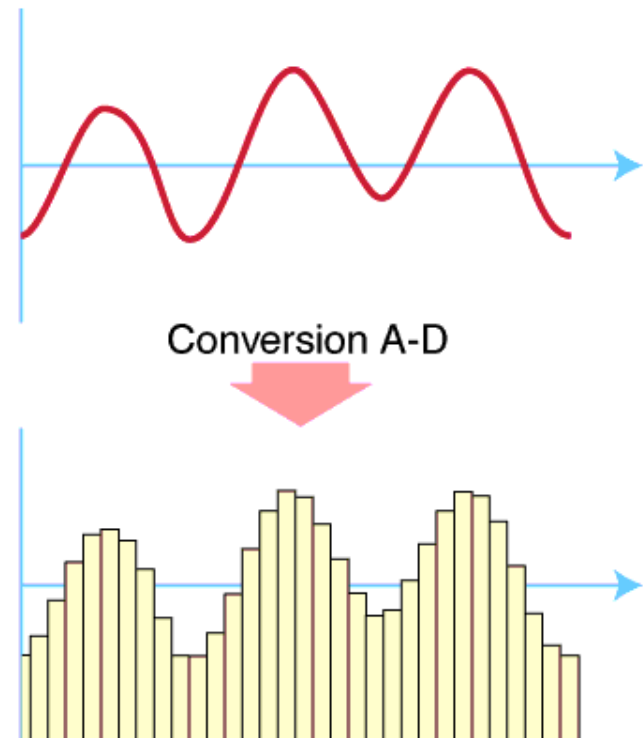
Microphone

■ Converts sound into data

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

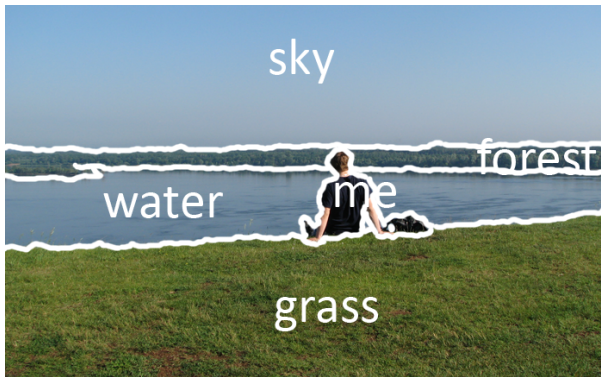
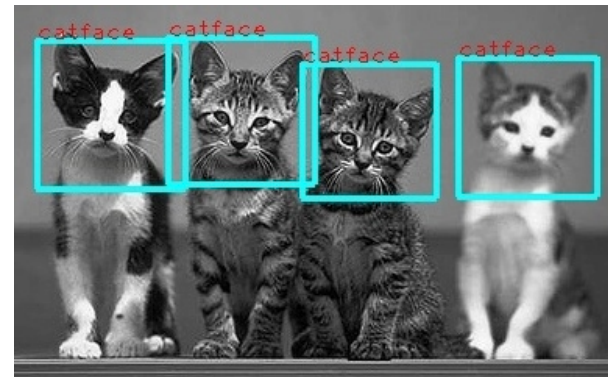
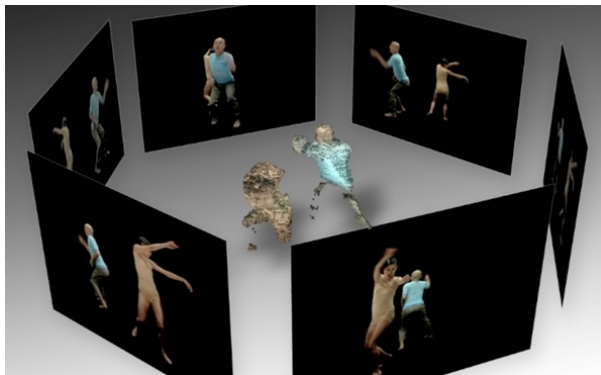


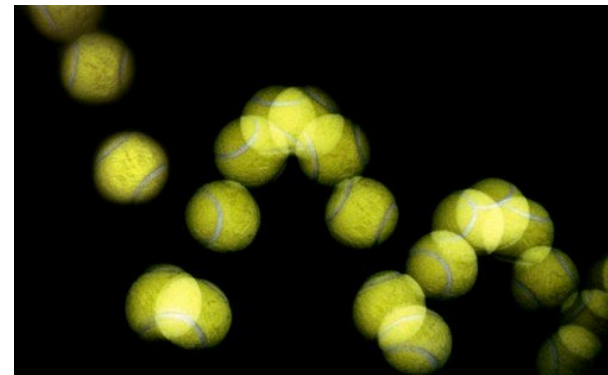
Image Segmentation



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



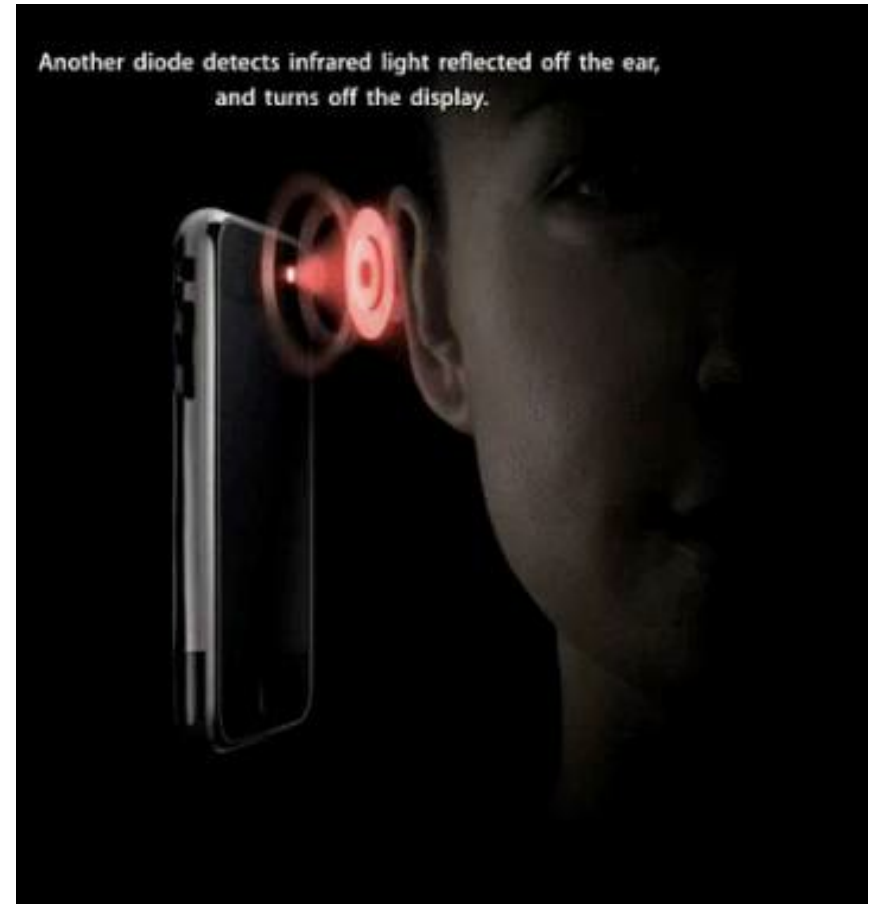
Super Human Capability!

- **Cardio** – measuring heart rate by looking at colour changes in your face:



Proximity Sensor

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



Humidity and Temperature Sensors

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



Output Devices

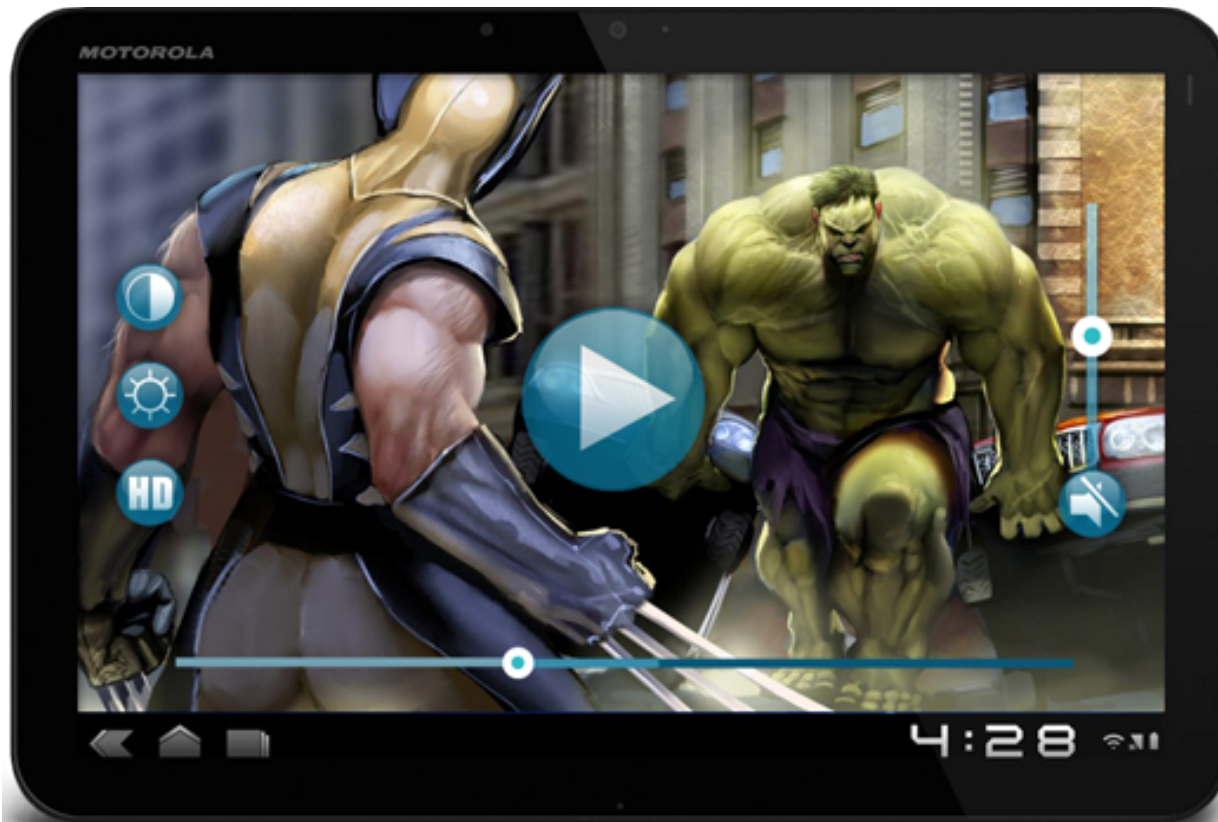
Hi-Resolution Screen

- Most recent phones have very high quality screens
 - Quality is the # & density of pixels
- Samsung Galaxy S III
 - 1080x1920 resolution
 - 441 pixels per inch
- iPhone 5s
 - 640 x 1136 resolution
 - 326 pixels per inch
- Huawei Ascend P6
 - 720x1280 total resolution⁽⁵⁹⁾ -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

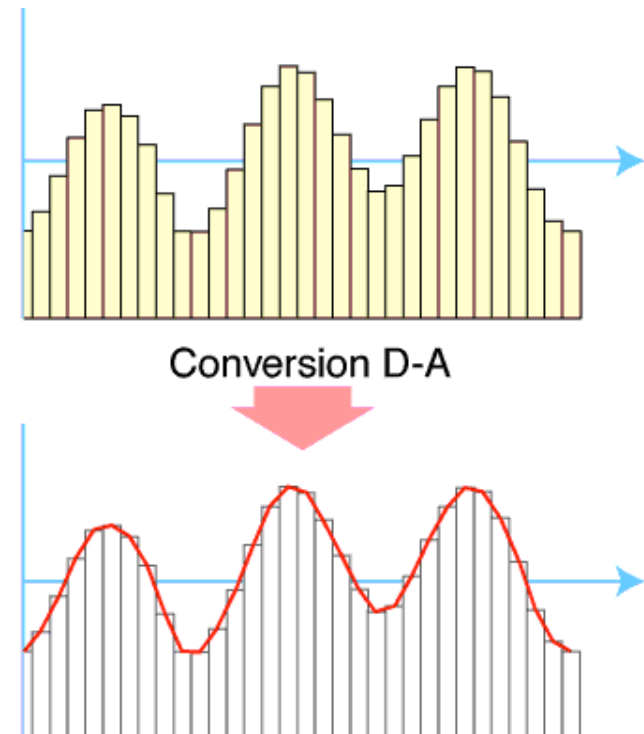


■ Play previously recorded files

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

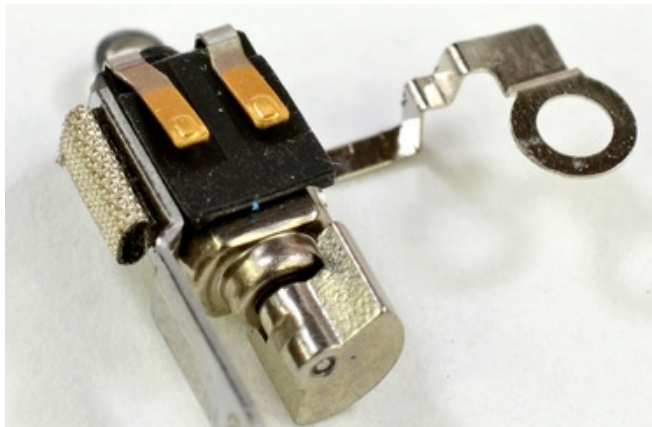
■ Many possible sound filters –

- 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>



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

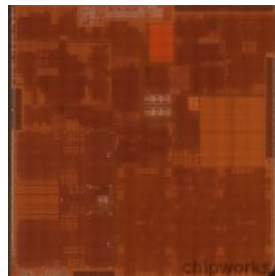
■ Many things!

- Optimization
- Search
- Sort
- Artificial Intelligence



The Application Processor

- iPhone 5s has dual core ARM Cortex A15 and 4x PowerVR 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



(67)



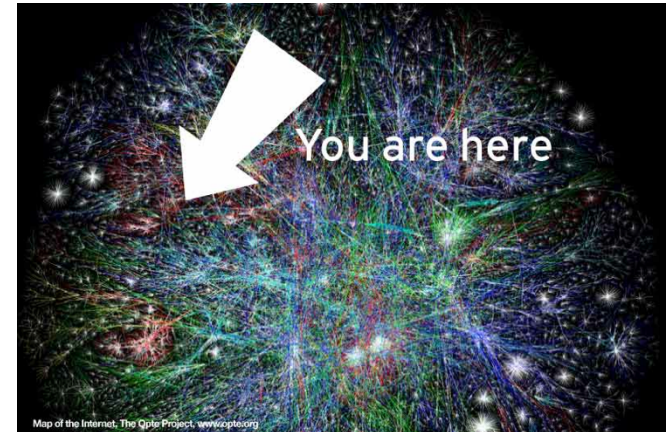
Storage Capacity

- Local storage of 2 to 64 Gbytes of permanent storage
 - A few tablets are up to 128G
 - Flash-based solid-state disk
- Can load many databases locally onto the device
 - Dictionaries, no problem!
 - Maps
 - Phonebooks
 - Location Services



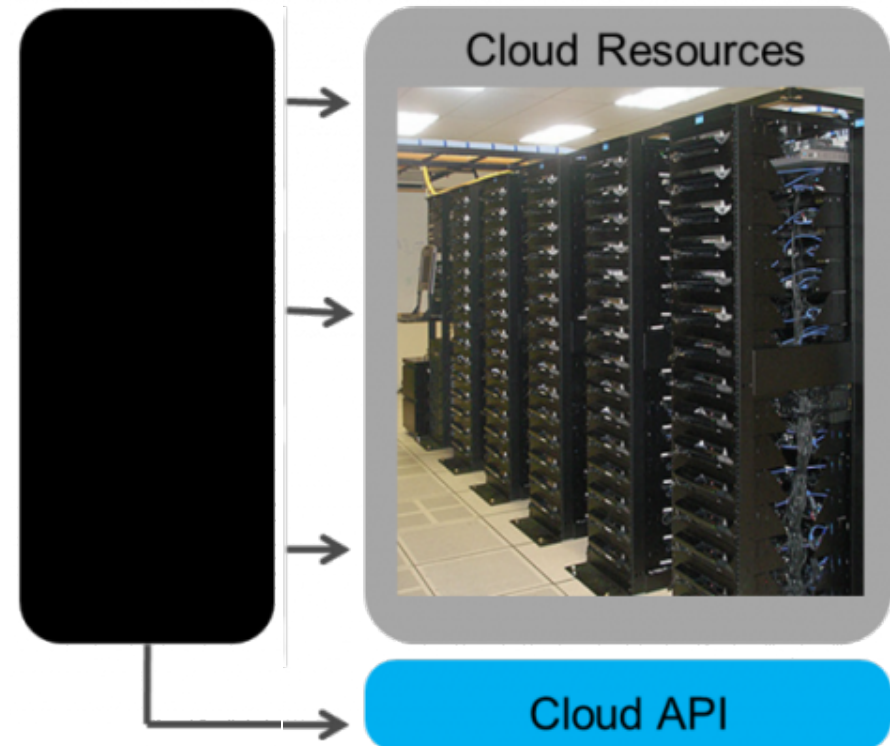
Network – 4G/3G/Wifi: Gateway to Internet

- Have at least 2 ways to talk to the Internet
 - Local WIFI
 - Cellular data networks
 - 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



A Sensor for Every Application

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

Recently Added 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.

(73)

\$25

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



Recall: Texas Instruments Sensor Tag

■ Similar to NODE

- Accelerometer, gyroscope, magnetometer
- Ambient Temperature
- IR Temperature
- Air pressure
- uglier

■ But: Only \$25!

■ I have four of these for use in the course

- Compatible with iOS and Android
- Needs Android 4.3 for low-energy Bluetooth



At This Year's CES

CES 2014 Trends: Everybody's Making Fitness Trackers and Smart Watches, But Who Will Succeed?

<http://spectrum.ieee.org/tech-talk/consumer-electronics/portable-devices/ces-2014-trends-everybodys-making-fitness-trackers-and-smart-watches-but-who-will-succeed>

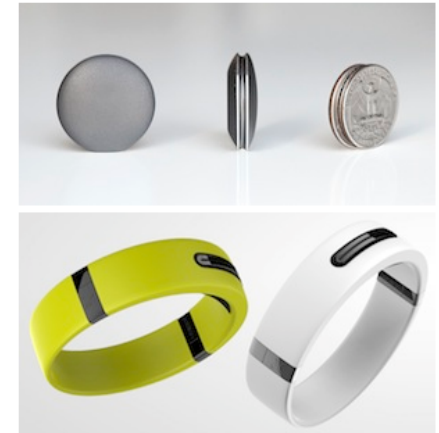
By Tekla Perry

Posted 9 Jan 2014 | 0:53 GMT

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This is the CES of the wearable gadget. And, while there are all sorts of technologies you can wear—after all, earbuds are wearable—the big explosion is in fitness trackers. The first wave of these small gadgets, worn on a wrist, clipped on waistband, or tucked into a pocket, came from a handful of companies including Nike, Jawbone, and Fitbit. This year, dozens more companies, including big and established hardware manufacturers like Epson and LG and small startups alike, jumped into the fitness tracker fray. At their most basic, these sensors track steps; most also do some kind of sleep tracking. More sophisticated models include heart rate sensors for quick pulse checks or connect wirelessly to pulse monitors worn on the chest. Some can tell the difference between swimming, biking, walking and running.

With so many entries, there's a surprisingly narrow range of prices and form factors; most are bands, and a few also clip on. The vast

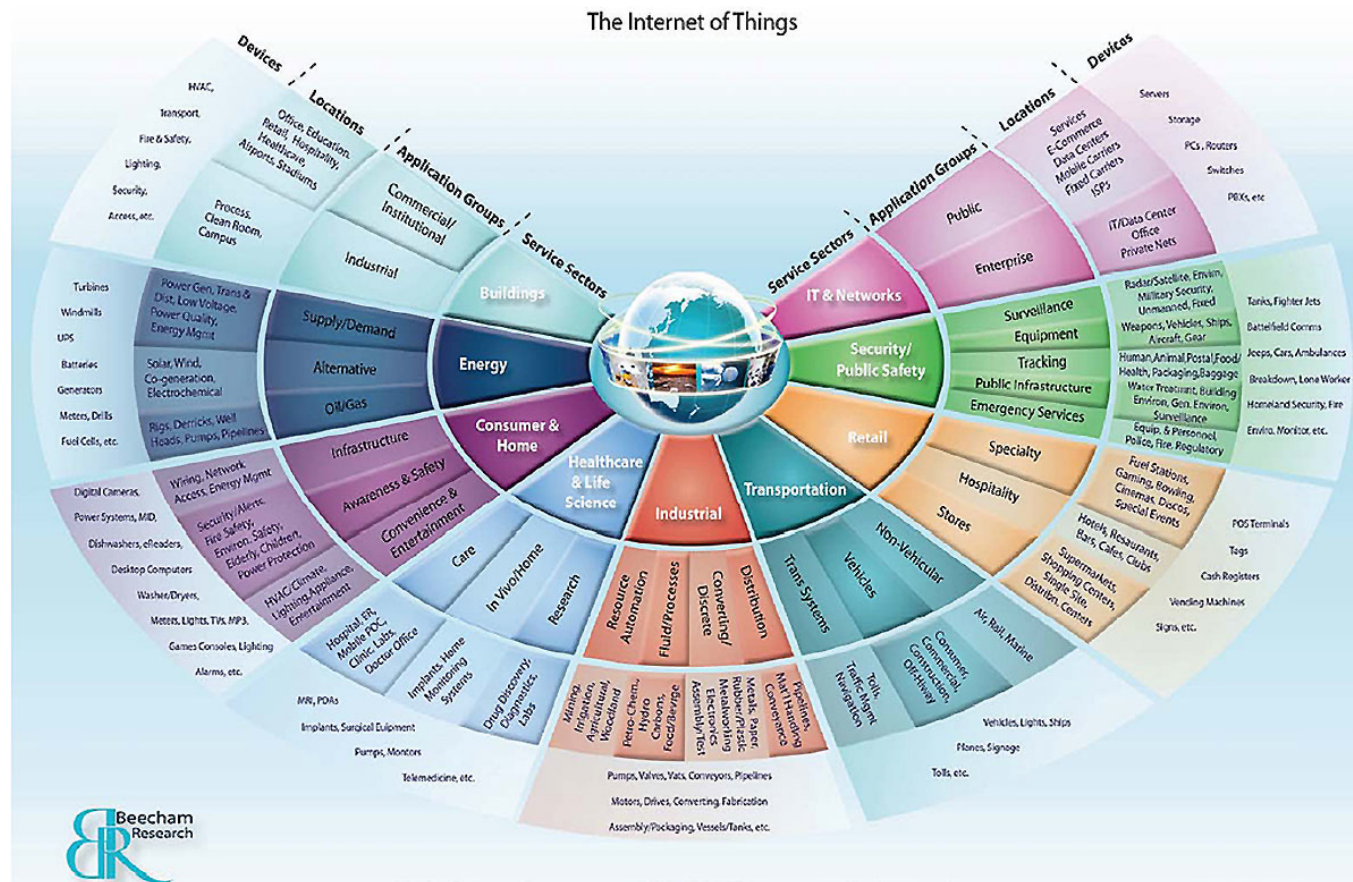


Misfit Shine [top], Jaybird Reign [bottom]



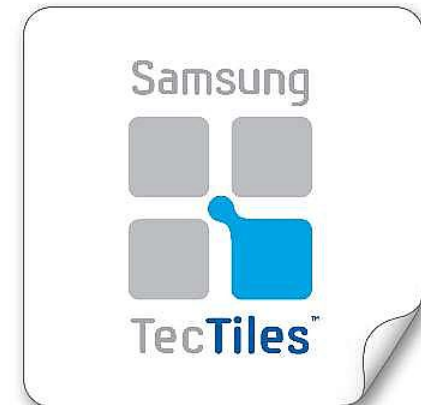
Relates to Industry's Latest Buzzword

■ 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



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
- 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.



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.



Tonight: Meeting to Form Groups

- Wednesday January 15th
- 6:30pm-8:00pm
- SF B560
 - Will create categories

