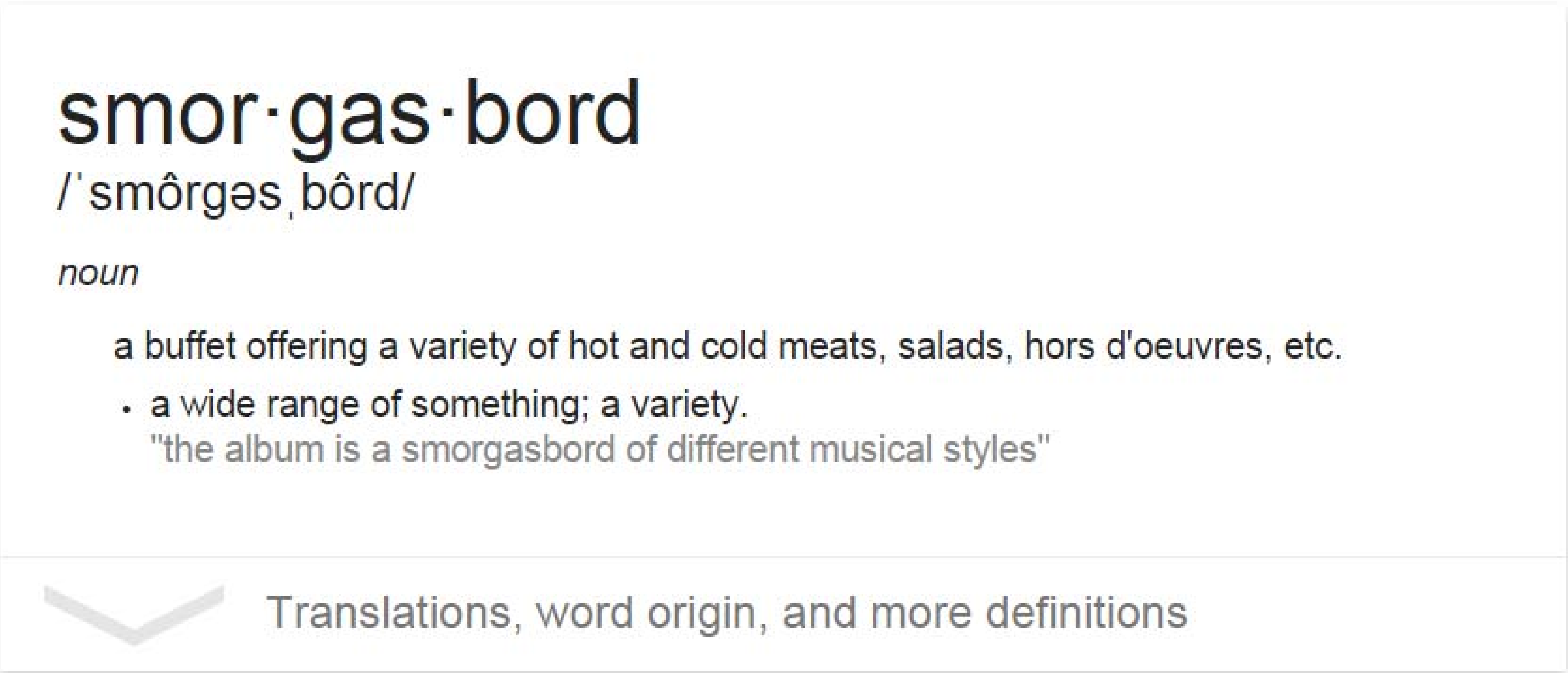
CS 403X Mobile and Ubiquitous Computing

Lecture 7: Final Projects + Smorgasbord of Stuff!!

Emmanuel Agu



smor·gas·bord

/ˈsmôrɡəsˌbôrd/

noun

a buffet offering a variety of hot and cold meats, salads, hors d'oeuvres, etc.

- a wide range of something; a variety.
  "the album is a smorgasbord of different musical styles"

Final Project Overview & Proposal Guidelines

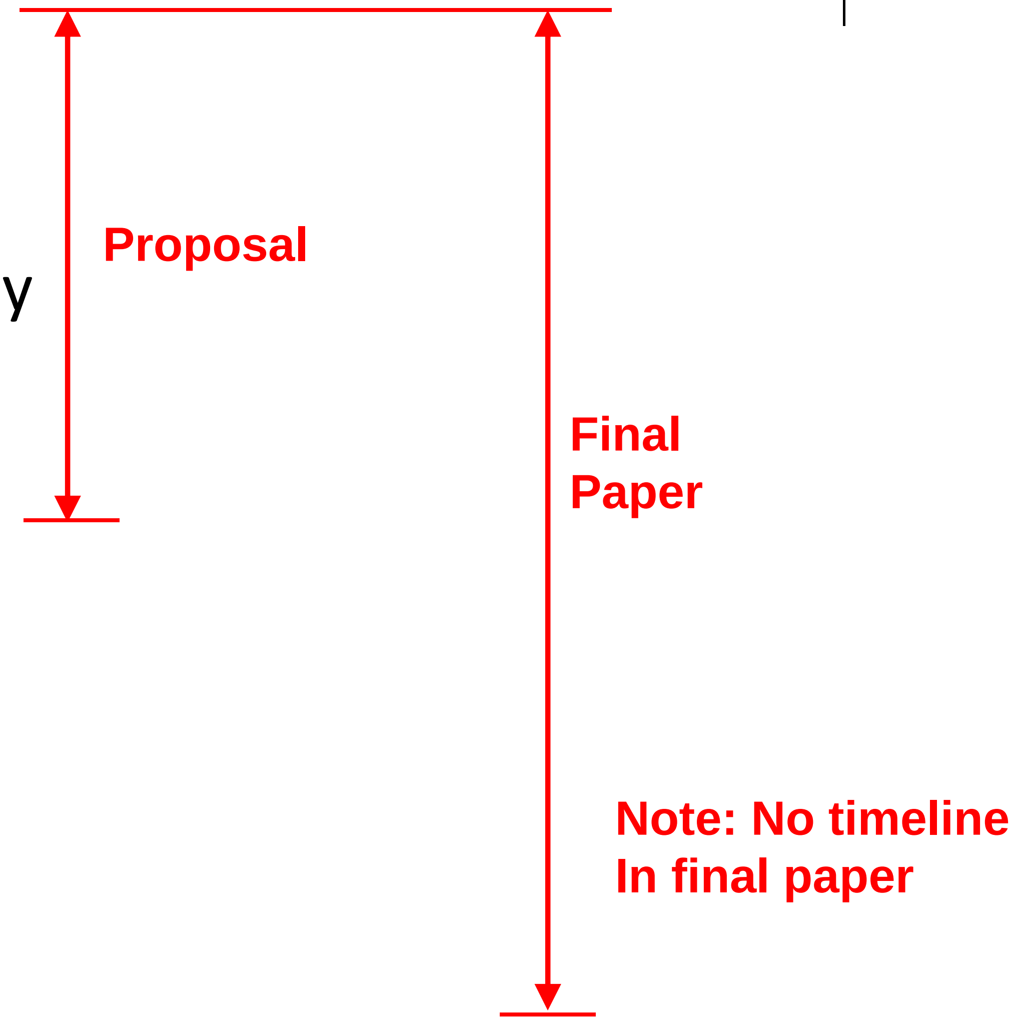
Final Project

- Most projects will probably build an app
- App solves some societal problem
- App should be **mobile** or/and **ubicomp**
  - **Mobile?** Probably location-dependent, maps, deliver time-sensitive information
  - **Ubicomp?** Uses at least 1 sensor (accelerometer, microphone, camera, etc)
- Don’t build app that has no mobile or ubicomp aspects
- If you have questions, talk to me

Typical Paper

- Introduction
- Related Work
- Approach/methodology
- Implementation
- **Project timeline**

- Evaluation/Results
- Discussion
- Conclusion
- Future Work



Proposal

Final Paper

Note: No timeline In final paper

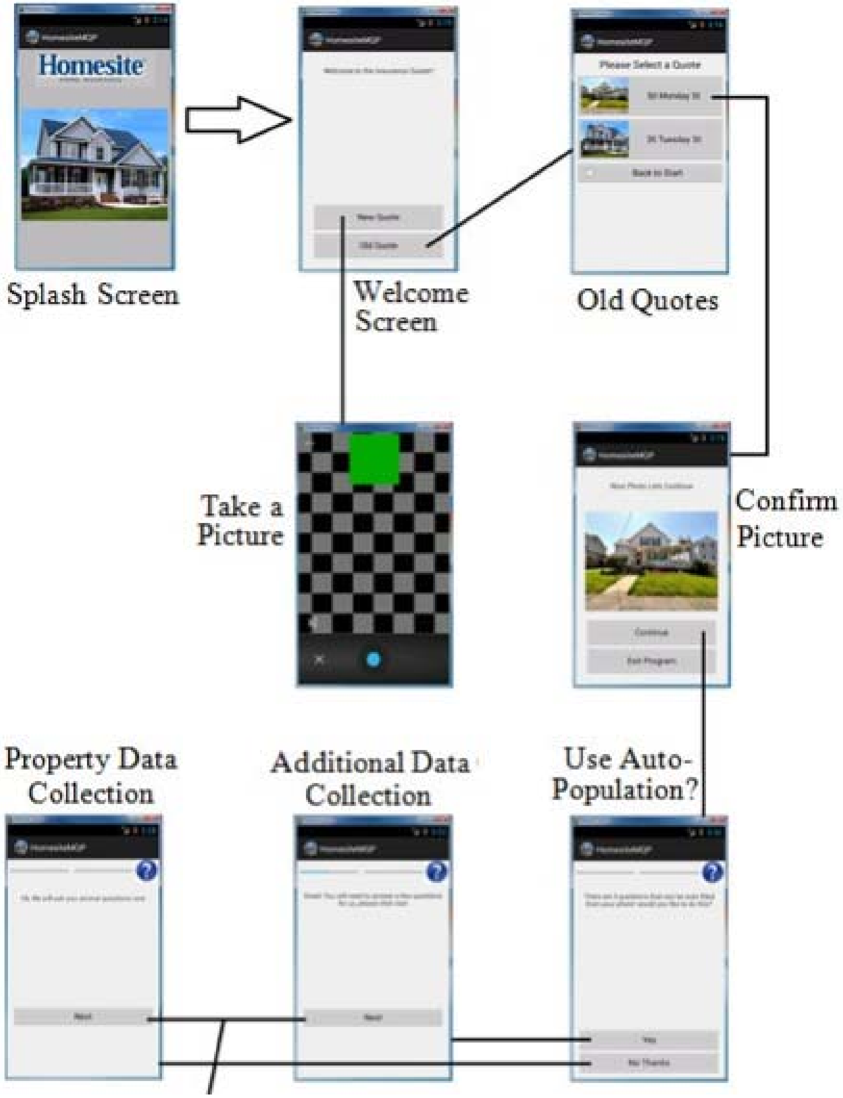
Proposal

- Submit (Written 2 pages max PDF file): due Apr 16!!
  - Introduction
    - List team members
    - State problem app will solve. Preferably has social benefit
    - Why is problem important?
    - E.g. Find statistics: How much time, money, resources is being wasted on this problem today? How many people problem affects
    - Potential gain: how will your solution save time, money, etc?
  - Related work
    - What other research has been done to solve this problem (academic + commercial apps)
    - How is your app/approach/work different?

Proposal

- Methodology/Design/Tools:
  - Brain storm!
  - Summary of what you intend to do
  - How you intend to do it? Build android app, use scenario, etc
  - App screen mock-ups:
    - Hand-drawn? Android Studio? Lucid Charts?
  - Don’t promise too much,
    - Some features can be future work

Methodology



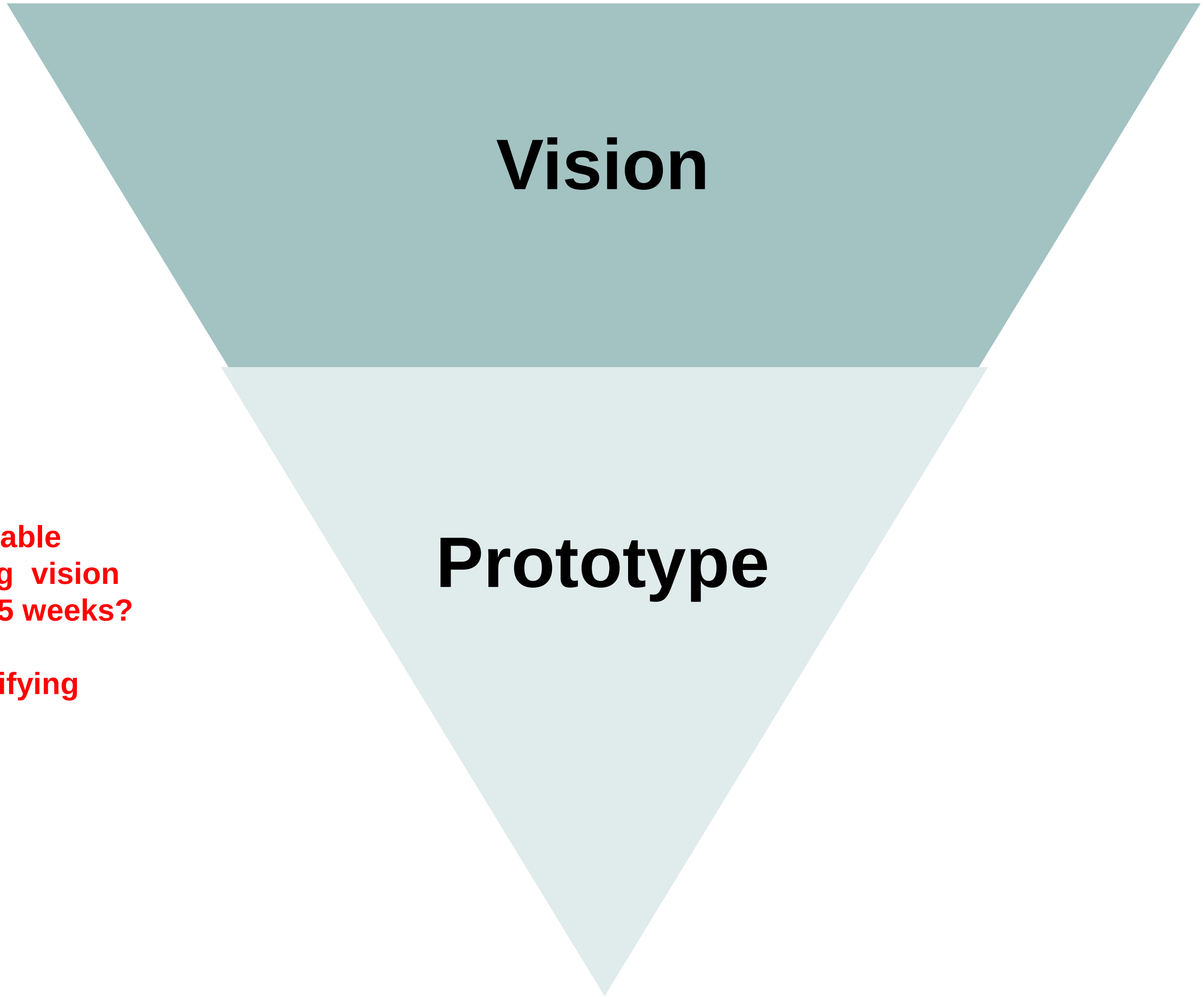
- Preliminary design from team
- Screen mock-ups + flow
- Use Android Studio Design view, lucidcharts.com, hand-drawn?

Proposal

- Implementation **plan**:
  - E.g. Android, what modules? external tools? Packages? etc
- Timeline
  - Break down tasks, mini-deadlines, allot time for each task
- Proposal due April 16!!

Separate Vision and Prototype

1. Big picture
if funds/time not
an issue
(e.g. company of
200 employees over
6 years)



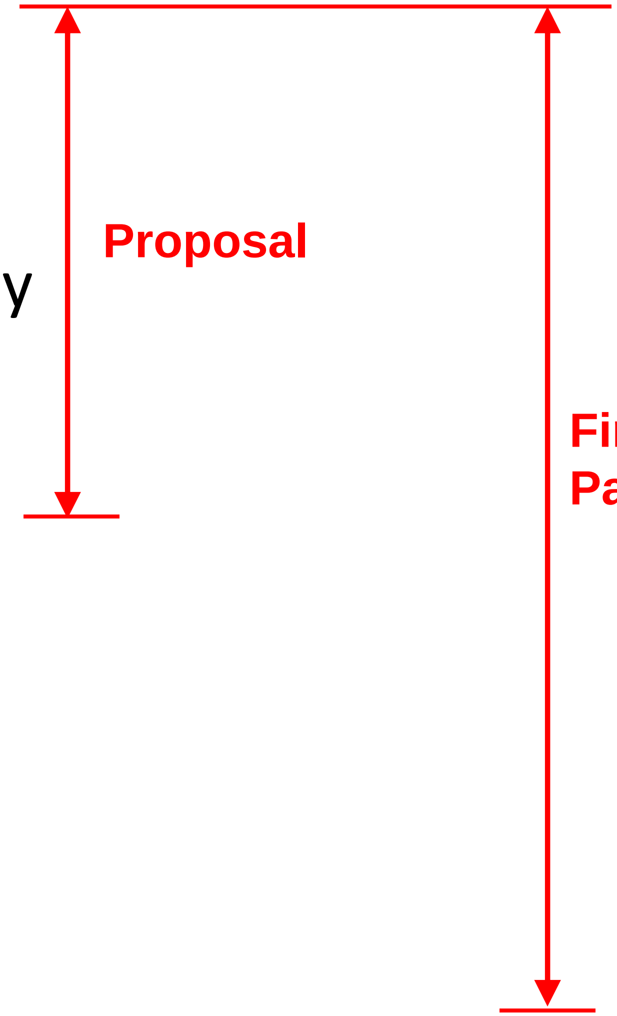
2. Which reasonable
Subset of the big vision
can you do in 2.5 weeks?

Can make simplifying
assumptions

Typical Paper

- Introduction
- Related Work
- Approach/methodology
- Implementation
- **Project timeline**

- Evaluation/Results
- Discussion
- Conclusion
- Future Work



Proposal

Final Paper

Note: No timeline
In final paper

Final Paper: Evaluation

- Depends on what your project is.
- **Basic question:** How well did your solution work?
  - User studies
  - Measure performance. E.g. energy consumption, bandwidth consumption, etc

- User Studies
  - Pre-Survey:
    - Establish problem exists, need for your app, gather/refine requirements
  - Post-Survey:
    - Get users to use/rate your app, ask about likes dislikes

Recruiting Subjects For User Studies

- 3Fs: Friends, Family and ??
- Classmates (Do a trade with another group)
- On campus: post flyers, set up table at campus center

Discussion, Conclusion, Future Work

- Discussion:
  - How was your app received? Rationalize your findings in user studies, Say why certain features worked, did not work, etc

- Future work
  - Talk about features that would extend prototype
  - Revisit big vision

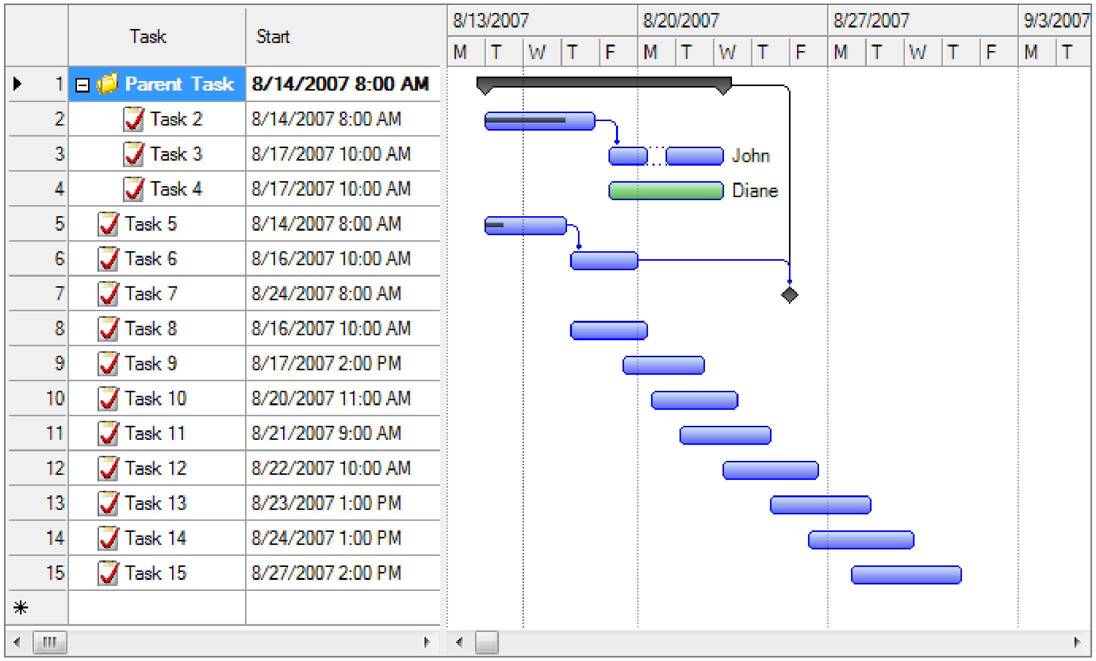
Your Team

Some Team Tips

- You already have a team!
- Everyone (team members) doesn’t have to do everything equally
- Team members can work on project aspects they are good at
- Example: Who is good at:
  - Android UI design (Android Studio design view, XML file, widgets, nice look)
  - Android programming (database, sensors, maps, backend)
  - Experimental evaluation/user studies
  - Machine learning
  - Writing, making presentations

Some Team Tips

- Team should have an honest conversation
- Doing something different doesn’t mean chilling
- Consider team online management tools, gantt charts, etc
- Assign tasks, mini-deadlines (every few days)
- Integrate features every few days => new version
- **Mantra:** Always have a working prototype, improve



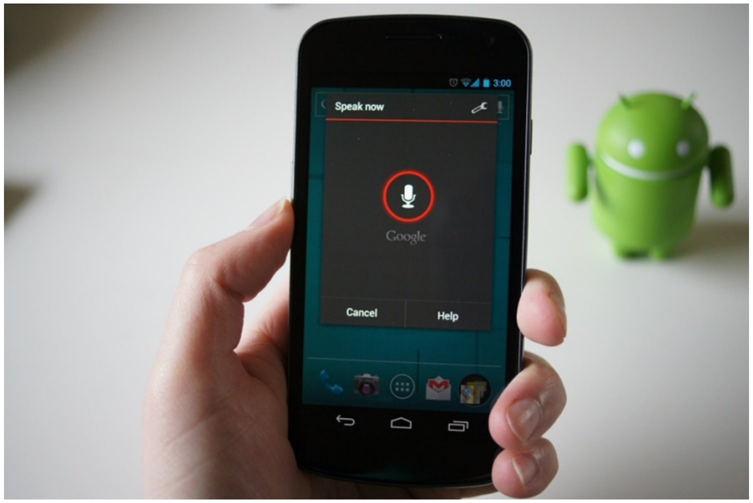
		Task	Start
▶	1	⊟ Parent Task	**8/14/2007 8:00 AM**
	2	Task 2	8/14/2007 8:00 AM
	3	Task 3	8/17/2007 10:00 AM
	4	Task 4	8/17/2007 10:00 AM
	5	Task 5	8/14/2007 8:00 AM
	6	Task 6	8/16/2007 10:00 AM
	7	Task 7	8/24/2007 8:00 AM
	8	Task 8	8/16/2007 10:00 AM
	9	Task 9	8/17/2007 2:00 PM
	10	Task 10	8/20/2007 11:00 AM
	11	Task 11	8/21/2007 9:00 AM
	12	Task 12	8/22/2007 10:00 AM
	13	Task 13	8/23/2007 1:00 PM
	14	Task 14	8/24/2007 1:00 PM
	15	Task 15	8/27/2007 2:00 PM
✱			

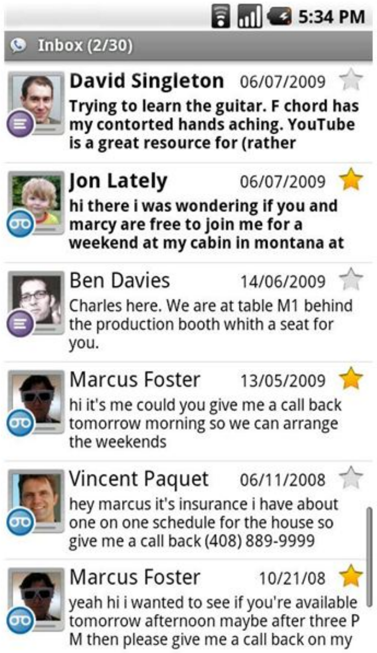
What other Android APIs may be useful for ubicomp?

Speaking to Android

Ref: Professional Android 4 Development, Meier, Ch 11, pg 437

- Speech recognition:
  - Accept inputs as speech (instead of typing) e.g. dragon dictate app?
  - Note: Google (remote) service Requires internet access
- Speech-to-text
  - Convert user's speech to text. E.g. display voicemails in text





5:34 PM

Inbox (2/30)

David Singleton 06/07/2009
Trying to learn the guitar. F chord has my contorted hands aching. YouTube is a great resource for (rather

Jon Lately 06/07/2009
hi there i was wondering if you and marcy are free to join me for a weekend at my cabin in montana at

Ben Davies 14/06/2009
Charles here. We are at table M1 behind the production booth whith a seat for you.

Marcus Foster 13/05/2009
hi it's me could you give me a call back tomorrow morning so we can arrange the weekends

Vincent Paquet 06/11/2008
hey marcus it's insurance i have about one on one schedule for the house so give me a call back (408) 889-9999

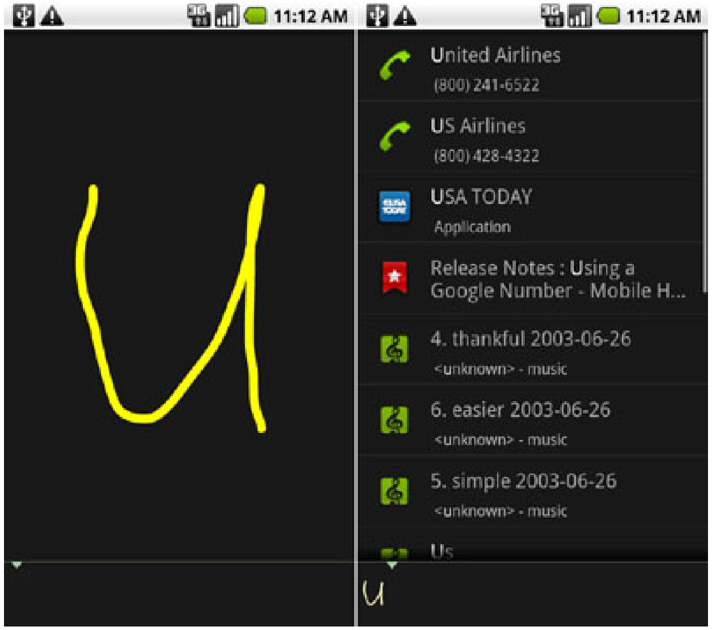
Marcus Foster 10/21/08
yeah hi i wanted to see if you're available tomorrow afternoon maybe after three P M then please give me a call back on my

Gestures

Ref: 3 cool ways to control your phone

http://www.computerworld.com/article/2469024/web-apps/android-gestures--3-cool-ways-to-control-your-phone.html

- Search your phone, contacts, etc by handwriting onto screen
- Speed dial by handwriting first letters of contact's name
- Also multi-touch, pinching



United Airlines
(800) 241-6522

US Airlines
(800) 428-4322

USA TODAY
Application

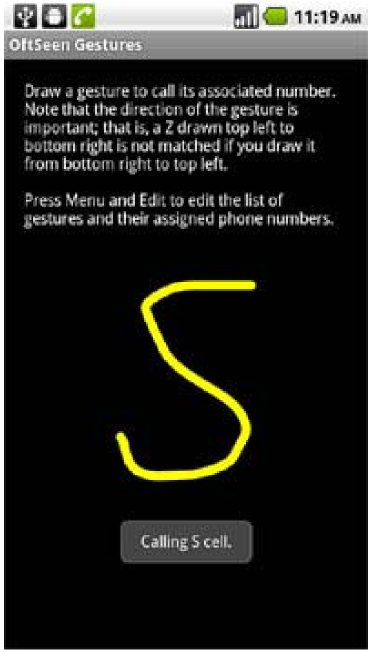
Release Notes : Using a Google Number - Mobile H...

4. thankful 2003-06-26
<unknown> - music

6. easier 2003-06-26
<unknown> - music

5. simple 2003-06-26
<unknown> - music

Us



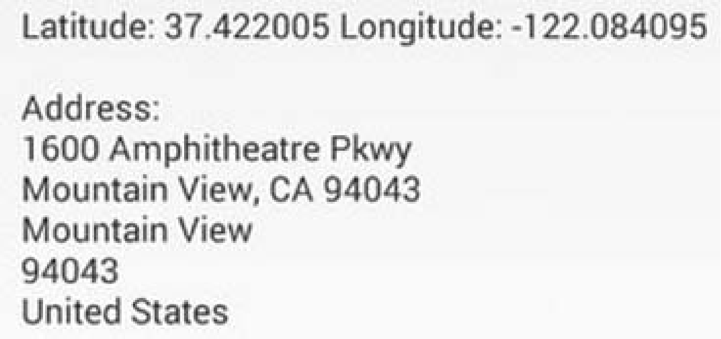
Draw a gesture to call its associated number. Note that the direction of the gesture is important; that is, a Z drawn top left to bottom right is not matched if you draw it from bottom right to top left.

Press Menu and Edit to edit the list of gestures and their assigned phone numbers.

Doing More with Locations: Geocoding

Ref: Professional Android 4 Development, Meier, Ch 13, pg 513

- Maps, GPS discussed so far use longitude/latitude to pinpoint geographic addresses
- Users more likely to think in terms of street addresses



```
Latitude: 37.422005 Longitude: -122.084095

Address:
1600 Amphitheatre Pkwy
Mountain View, CA 94043
Mountain View
94043
United States
```

- **Geocoder** converts between longitude/latitude and street address
  - **Forward geocoding:** Finds latitude and longitude of an address
  - **Reverse geocoding:** Finds street address for given longitude/latitude
- Can also set proximity alerts
  - Intent delivered to your app when you are within a pre-set distance from a given location

More on Audio, Video and Camera

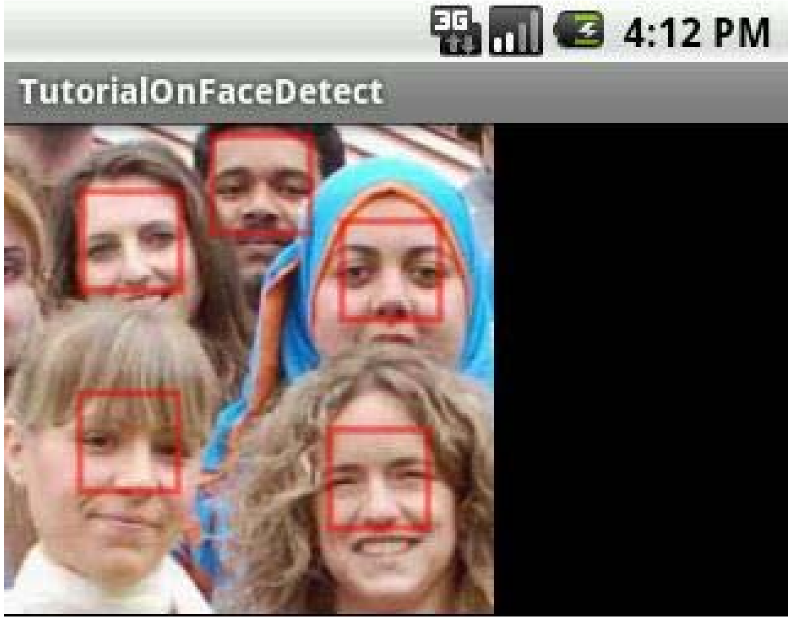
Ref: Professional Android 4 Development, Meier, Ch 13, pg 513

- Android MediaPlayer previously used to play audio
- Media Player can also:
  - Play videos (e.g. MPEG 4)
  - Record audio and video
  - Preview video
  - Manipulate raw audio from microphone/audio hardware, PCM buffers
    - E.g. if you want to do audio signal processing, speaker recognition, etc

More on Audio, Video and Camera

Ref: Professional Android 4 Development, Meier, Ch 13, pg 513

- Can control Camera parameter settings
  - Flash mode, scene mode, white balance
- Camera can also do face detection and feature recognition
  - Detects face up to a max number of faces + accuracy



RenderScript

- High level language for GPGPU
- Use Phone’s GPU for computational tasks
- Very few lines of code = run GPU code

Wireless Communication

Ref: Professional Android 4 Development, Meier, Ch 16, pg 665

- Bluetooth
  - Discover nearby bluetooth devices
  - Control your smartphone's (device's) discoverability
  - Communicating over bluetooth

- WiFi
  - Scan for WiFi hotspots
  - Monitor WiFi connectivity, Signal Strength (RSSI)
  - Do peer-to-peer (mobile device to mobile device) data transfers

Wireless Communication

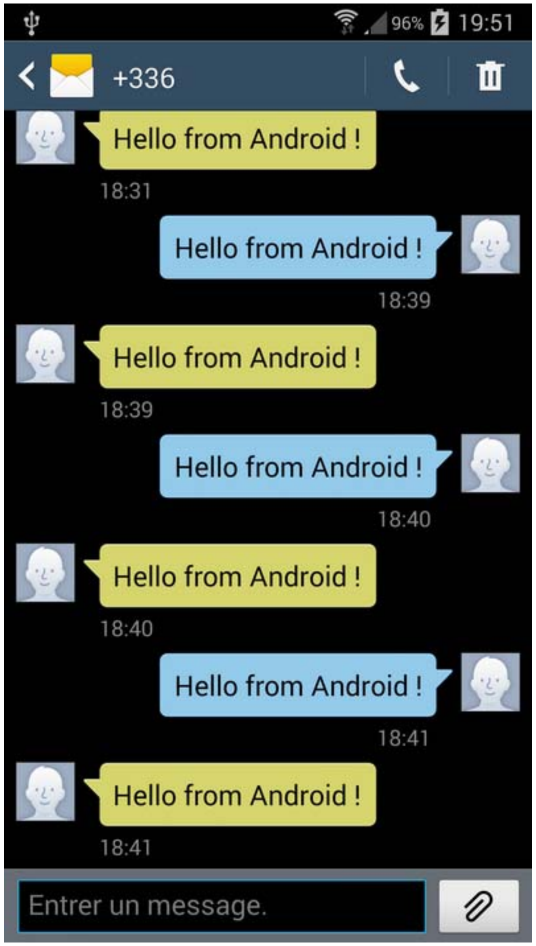
Ref: Professional Android 4 Development, Meier, Ch 16, pg 665

- NFC:
  - Contactless technology
  - Transfer small amounts of data over short distances
  - **Applications:** Share spotify playlists, Google wallet
  - **Google wallet?**
    - Store debit, credit card on phone
    - Pay by tapping terminal
    - Fly through checkout?

Telephony and SMS

Ref: Professional Android 4 Development, Meier, Ch 17, pg 701

- **Telephony:**
  - Initiate phone calls from within app
  - Access dialer, etc
- **SMS:**
  - Send/Receive SMS/MMS from app
  - Handle incoming SMS/MMS in app



Hello from Android !
18:31

Hello from Android !
18:39

Hello from Android !
18:39

Hello from Android !
18:40

Hello from Android !
18:40

Hello from Android !
18:41

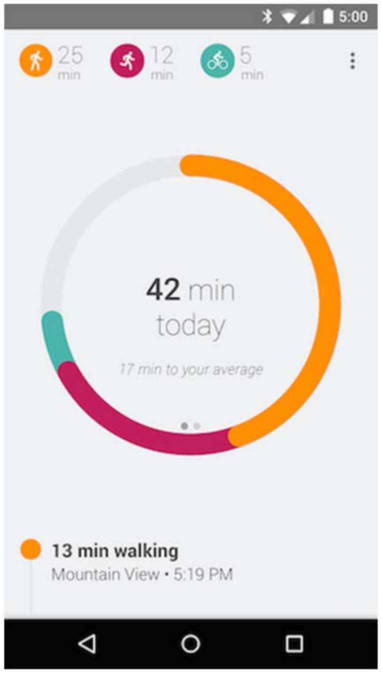
Hello from Android !
18:41

Entrer un message.

Google Fit API

http://en.wikipedia.org/wiki/Google_Fit

- Google Fit API: Single cloud storage record for all user’s fitness apps (myfitnesspal), gadgets (fitbit), etc
- Complimentary Google Fit app supports fitness tracking, view progress
- You can program app to access, read, write Google Fit record



Google Fit API

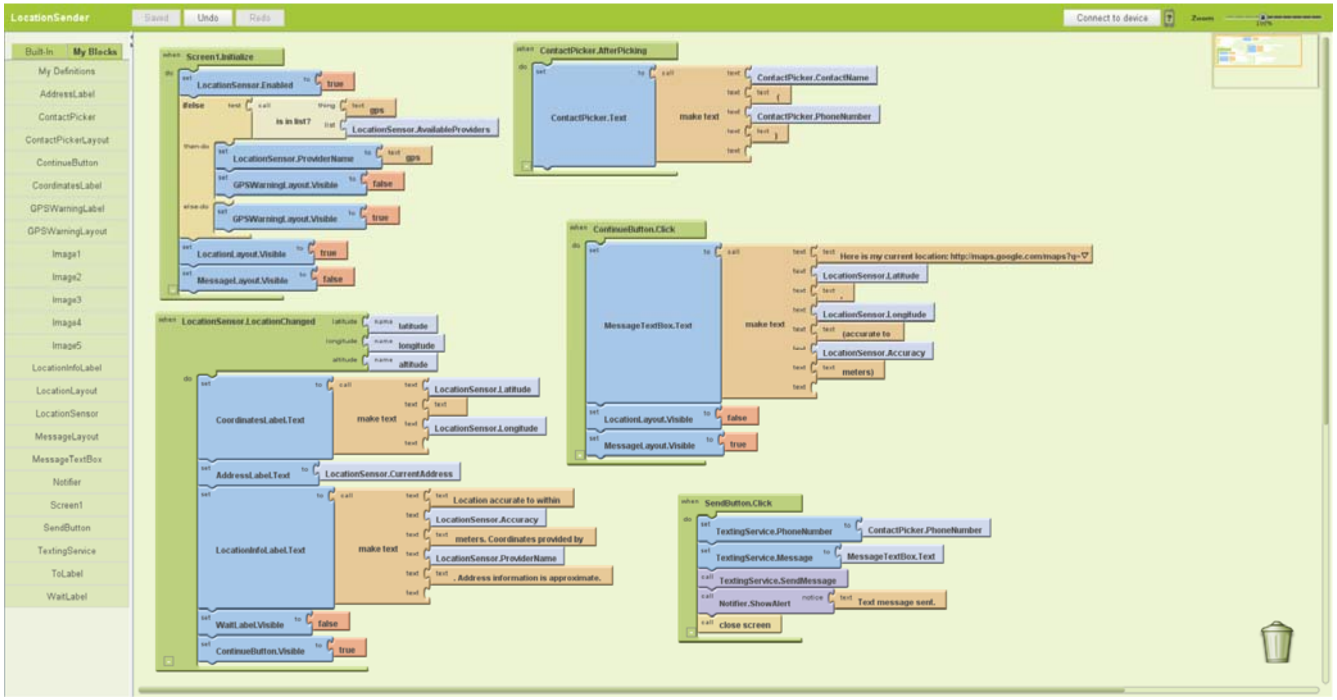
http://en.wikipedia.org/wiki/Google_Fit

- Google Fit API also has API for step counting
- i.e. Low end phones without step counter can use Google Fit's step counting API
  - Implemented as a Google service
- Also **DetectedActivity** API to detect smartphone user's current activity
- Currently detects 6 states:
  - In vehicle
  - On Bicycle
  - On Foot
  - Still
  - Tilting
  - Unknown

Alternate Implementation Options

AppInventor (http://appinventor.mit.edu/)

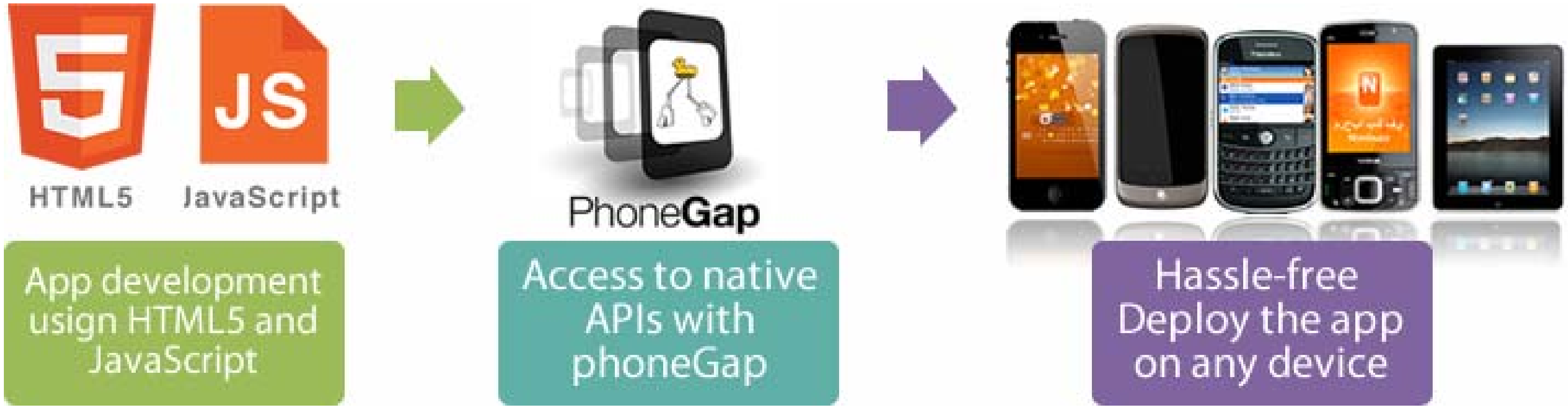
- MIT project, previously Google
- Use lego blocks to build app, easy to learn
- **Pro:** Quick UI development
- **Con:** sensor access, use third party modules restricted



```
when Screen1.Initialize
do  set LocationSensor.Enabled to true
    ifelse test call is in list? thing text gps
                                 list LocationSensor.AvailableProviders
    then-do set LocationSensor.ProviderName to text gps
            set GPSWarningLayout.Visible to false
    else-do set GPSWarningLayout.Visible to true
    set LocationLayout.Visible to true
    set MessageLayout.Visible to false

when LocationSensor.LocationChanged latitude name latitude
                                    longitude name longitude
                                    altitude name altitude
do  set CoordinatesLabel.Text to call make text text LocationSensor.Latitude
                                                text text
                                                text LocationSensor.Longitude
                                                text
    set AddressLabel.Text to LocationSensor.CurrentAddress
    set LocationInfoLabel.Text to call make text text text Location accurate to within
                                                 text LocationSensor.Accuracy
                                                 text text meters. Coordinates provided by
                                                 text LocationSensor.ProviderName
                                                 text text . Address information is approximate.
                                                 text
    set WaitLabel.Visible to false
    set ContinueButton.Visible to true

when ContactPicker.AfterPicking
do  set ContactPicker.Text to call make text text ContactPicker.ContactName
                                             text text (
                                             text ContactPicker.PhoneNumber
                                             text text )
                                             text

when ContinueButton.Click
do  set MessageTextBox.Text to call make text text text Here is my current location: http://maps.google.com/maps?q=
                                              text LocationSensor.Latitude
                                              text text ,
                                              text LocationSensor.Longitude
                                              text text (accurate to
                                              text LocationSensor.Accuracy
                                              text text meters)
                                              text
    set LocationLayout.Visible to false
    set MessageLayout.Visible to true

when SendButton.Click
do  set TextingService.PhoneNumber to ContactPicker.PhoneNumber
    set TextingService.Message to MessageTextBox.Text
    call TextingService.SendMessage
    call Notifier.ShowAlert notice text Text message sent.
    call close screen
```

PhoneGap

- Develop Apps using HTML, CSS, javascript
- **Pro:** Access to most native APIs, sensors, UI
- **Con:** Need to know HTML, CSS javascript


HTML5
JS
JavaScript
App development usign HTML5 and JavaScript
PhoneGap
Access to native APIs with phoneGap
Hassle-free Deploy the app on any device

Making Apps Intelligent (Sensors Inference & Machine Learning)

My Goals in this Section

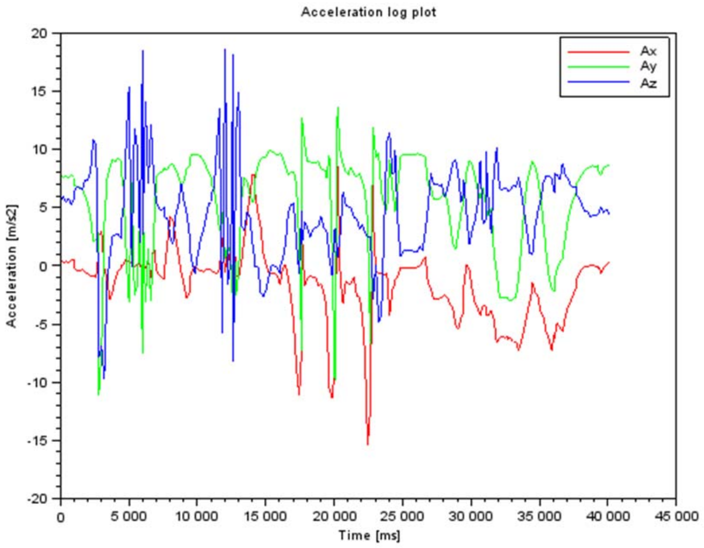
- If you already know machine learning => set off light bulb
- If you don’t know machine learning => General idea of it, how it’s used

Example: Activity Recognition

- Android can now recognize 6 activities (in vehicle, on bicycle, etc)
- How is it done? Machine learning classifiers
- Next explain activity recognitions. Use it to explain
  - Machine learning + concepts
  - Data collection (FUNF)
  - Feature extraction, explain features
  - Inference:
    - Hard-coded rules by inspection, trial & error
    - Machine learning (supervised learning)

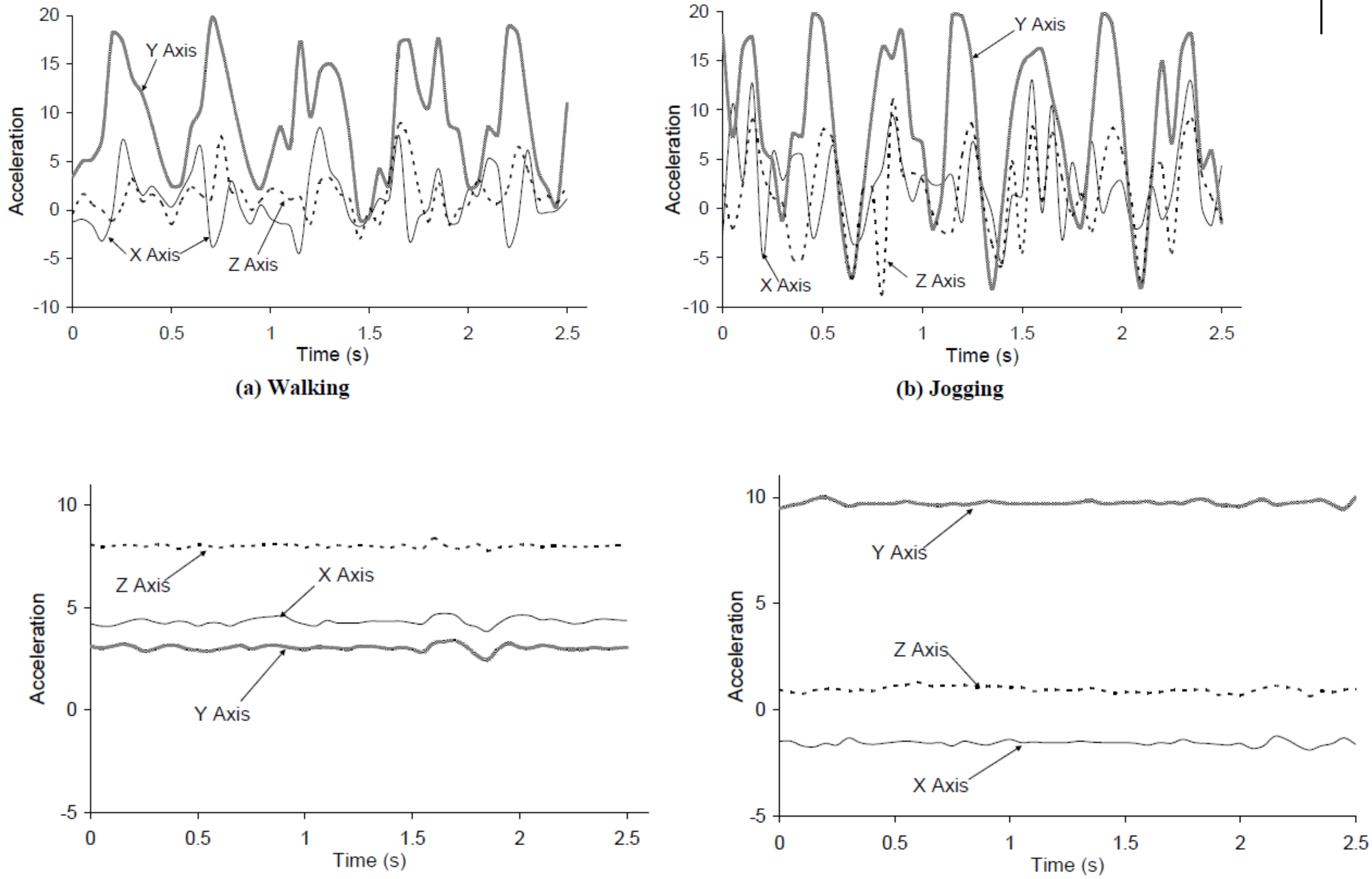
Activity Recognition

- Want our app to detect when user is performing any of the following 6 activities
  - Walking,
  - Jogging,
  - Ascending stairs,
  - Descending stairs,
  - Sitting,
  - Standing



- Need to collect sample data from sensors while user performing activity (called training data)
- **Example:** Phone’s accelerometer data sensitive to movements

Example Accelerometer Data for Activities



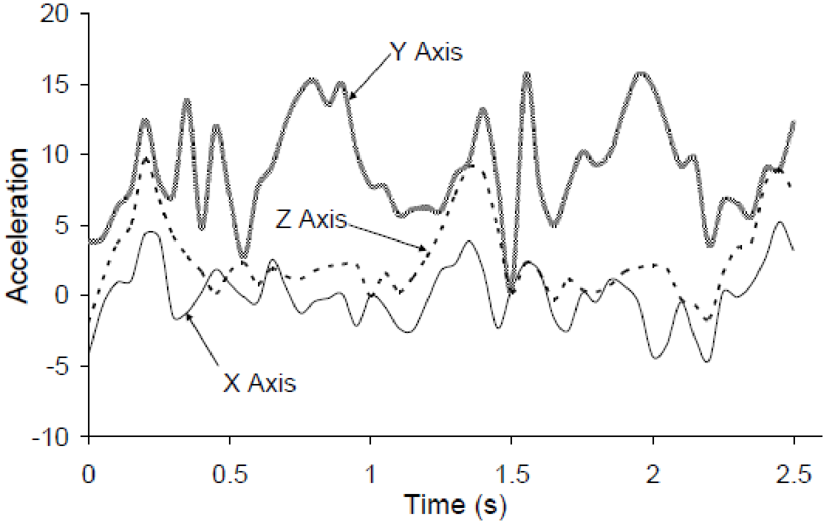
(a) Walking

(b) Jogging

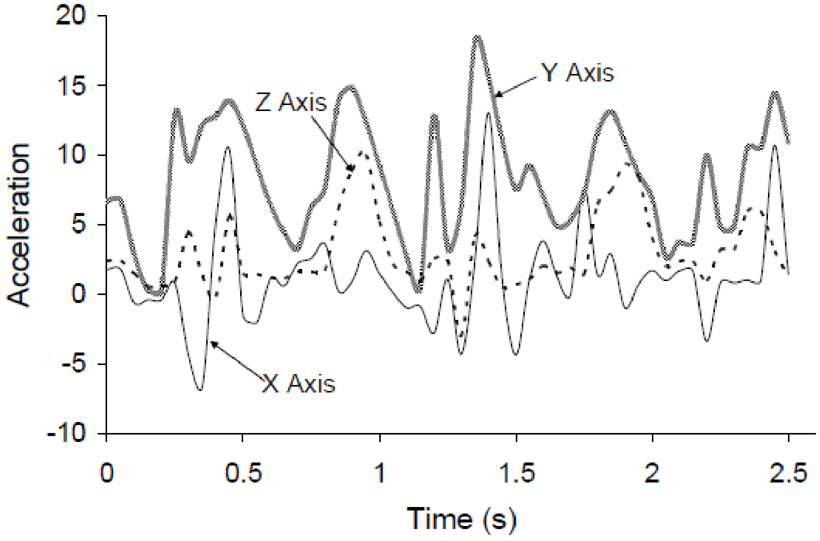
(e) Sitting

(f) Standing

Example Accelerometer Data for Activities



(c) Ascending Stairs

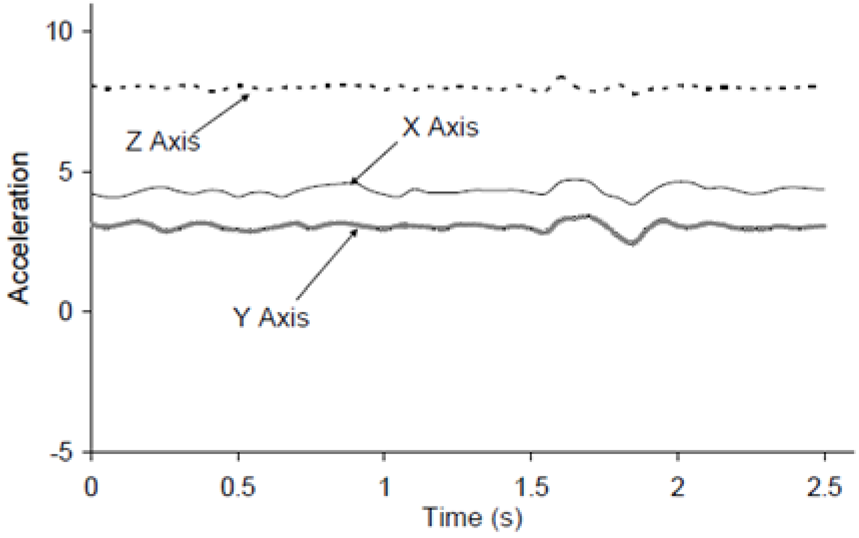


(d) Descending Stairs

Gathering Accelerometer Data

- Can write simple app that retrieves accelerometer data while user is doing each of 6 activities (1 at a time)

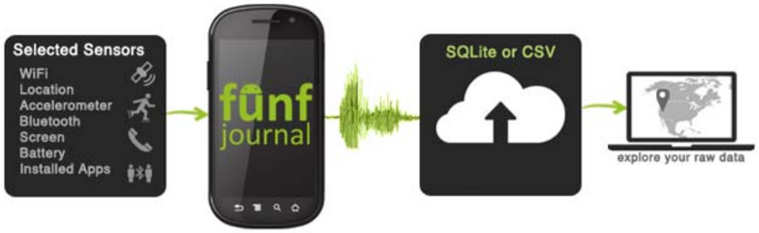
- Label each data with activity performed. E.g. label the following data as sitting

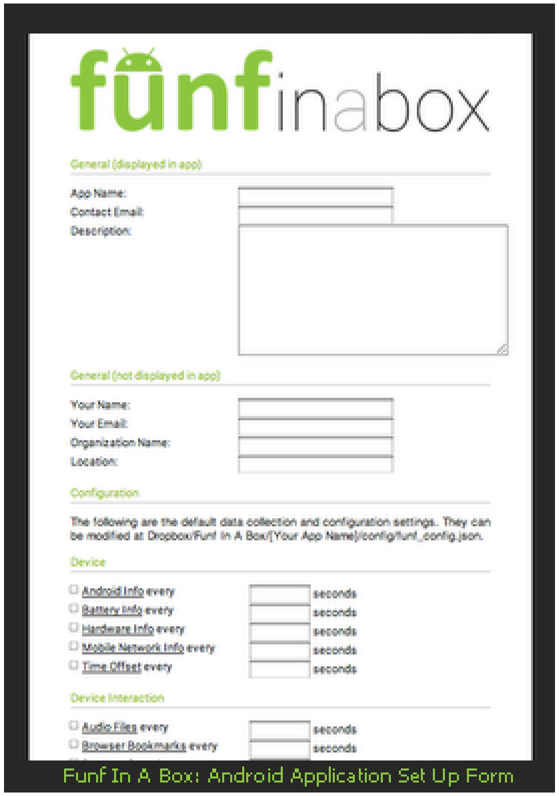


(e) Sitting

Funf (funf.org)

- Can also download, FUNF app to gather data
- Capable of collecting user data
  - Log sensor readings
  - Web URLs visited
  - Phone calls + duration
  - SMS messages sent, etc
- Check boxes to specify sensors to log, sampling rate, intervals





General (displayed in app)

App Name:

Contact Email:

Description:

General (not displayed in app)

Your Name:

Your Email:

Organization Name:

Location:

Configuration

The following are the default data collection and configuration settings. They can be modified at Dropbox/Funf In A Box/[Your App Name]/config/funf_config.json.

Device

□ Android Info every ____ seconds
□ Battery Info every ____ seconds
□ Hardware Info every ____ seconds
□ Mobile Network Info every ____ seconds
□ Time Offset every ____ seconds

Device Interaction

□ Audio Files every ____ seconds
□ Browser Bookmarks every ____ seconds

Funf In A Box: Android Application Set Up Form

Methodology (Data Collection)

- Data collected from 29 subjects
- Users carry phone in front pant leg pocket
  - For all activities
  - Perform each of 6 activities
- Accelerometer data collected every 50ms
  - 20 samples/second

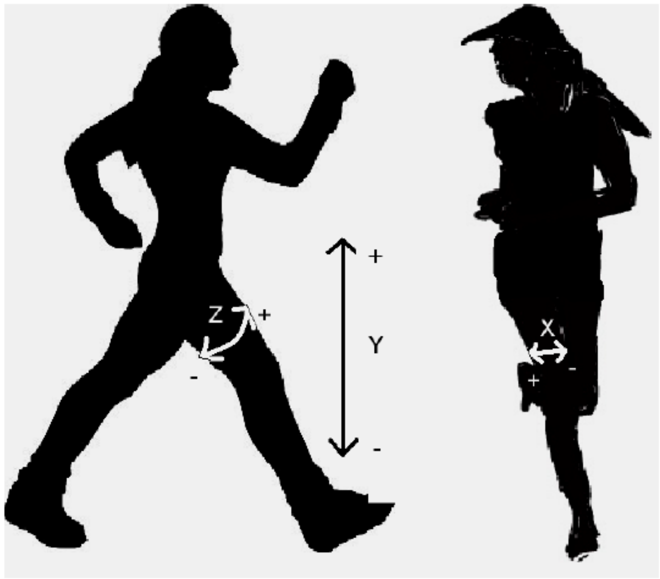
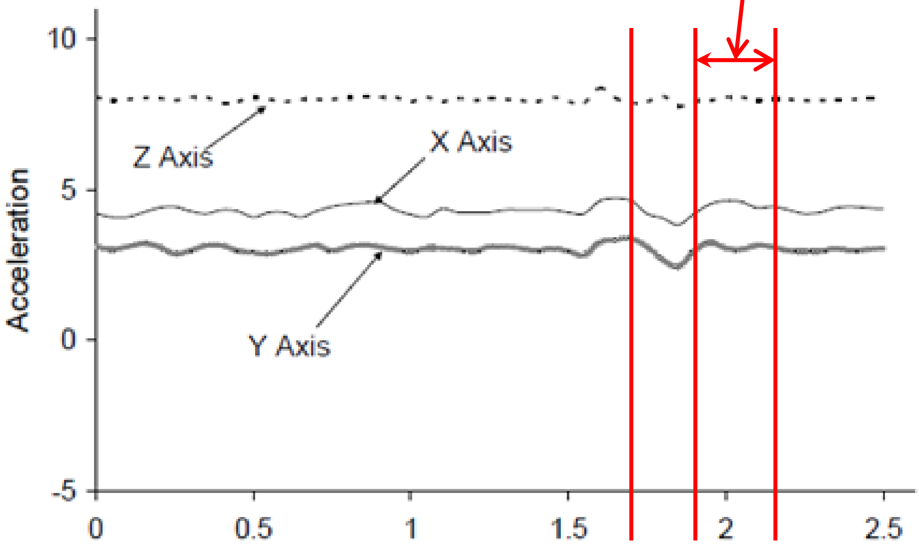


Figure 1: Axes of Motion Relative to User

Segment Data (Windows)

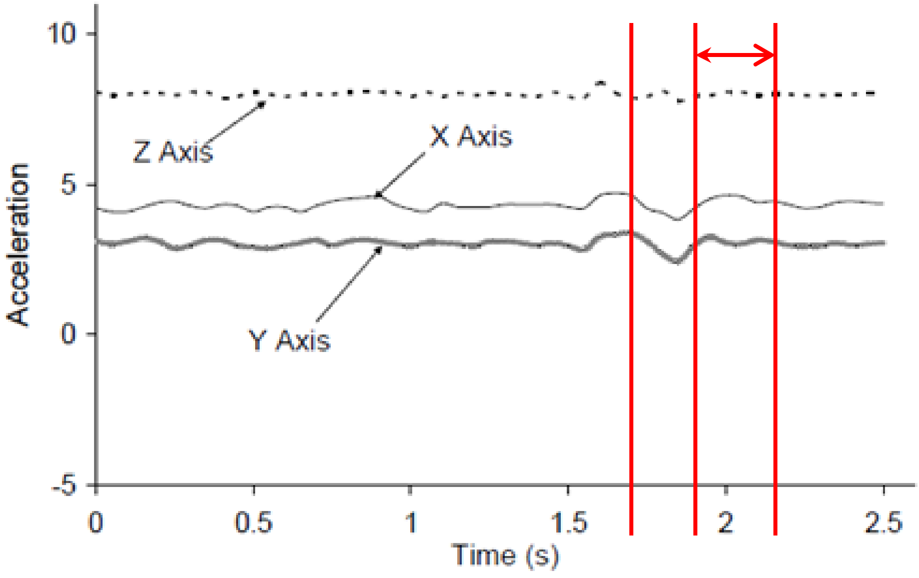
- Raw time-series data cannot be used with classification algorithms
- Data divided into segments (e.g. 10 seconds)



(e) Sitting

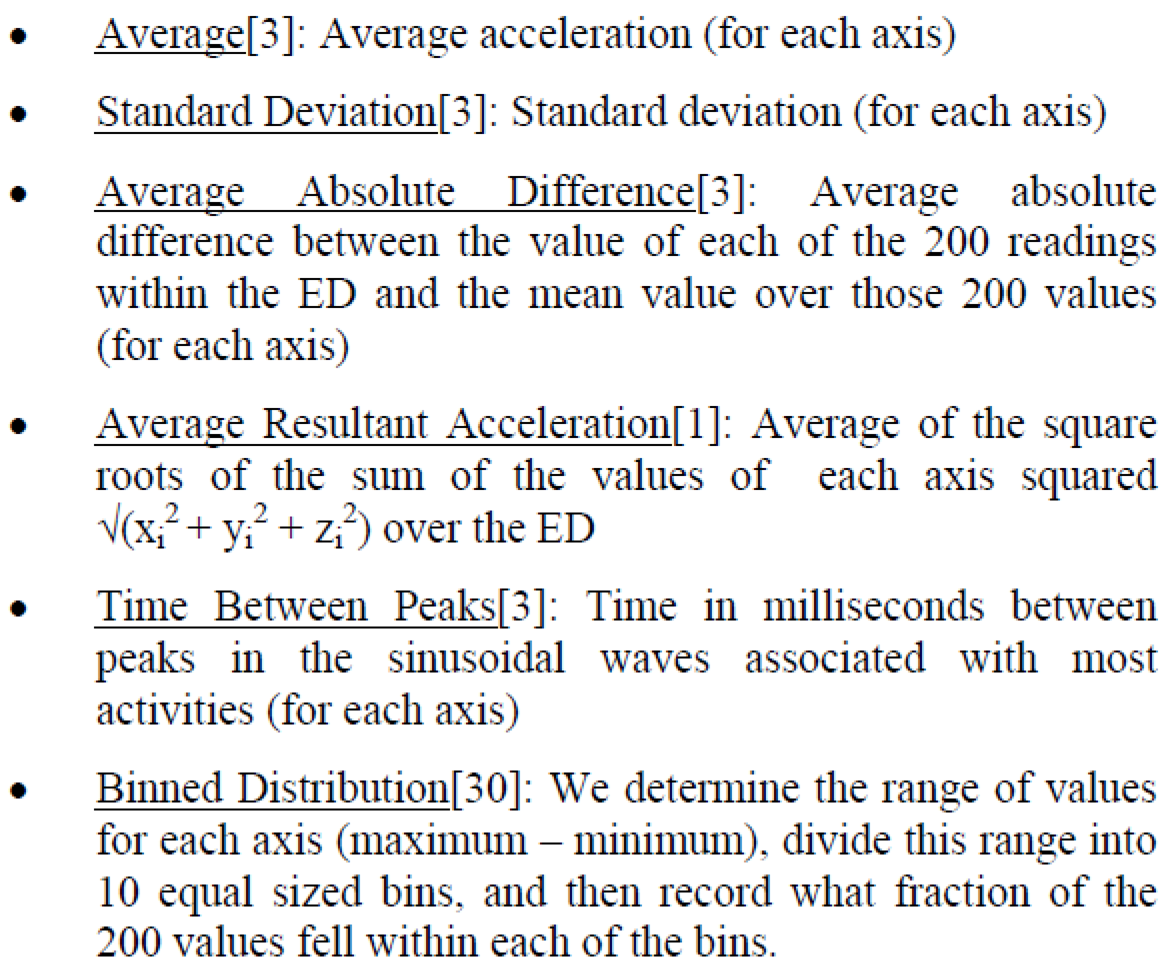
Compute Features

- Within segments, compute features
- **Features:** Derivatives that capture important characteristics, but still stable
- **Examples:** moving average, standard deviation, min-max values within segment, magnitude within segment



(e) Sitting

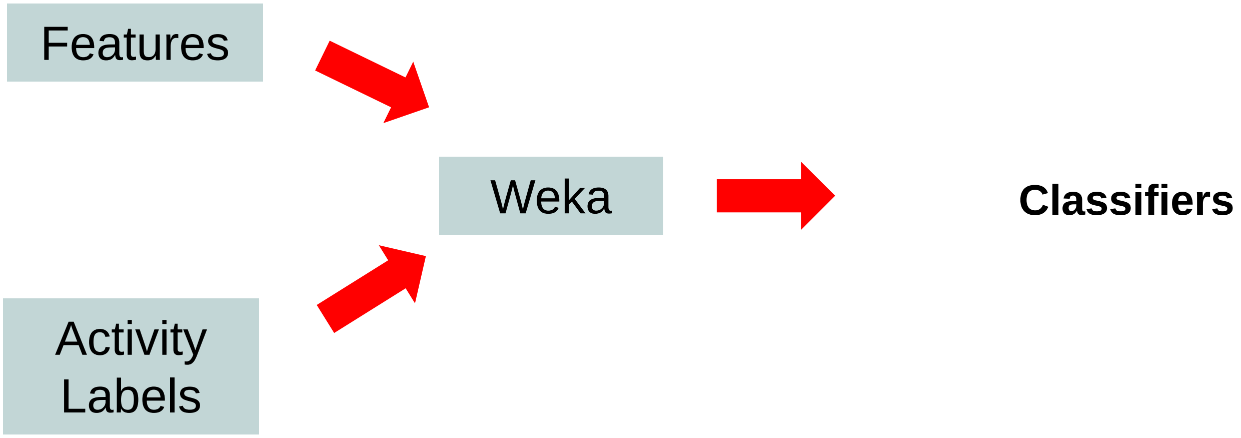
Methodology (Feature Generation)



- Average[3]: Average acceleration (for each axis)
- Standard Deviation[3]: Standard deviation (for each axis)
- Average Absolute Difference[3]: Average absolute difference between the value of each of the 200 readings within the ED and the mean value over those 200 values (for each axis)
- Average Resultant Acceleration[1]: Average of the square roots of the sum of the values of each axis squared $\sqrt{}(x_i^2 + y_i^2 + z_i^2)$ over the ED
- Time Between Peaks[3]: Time in milliseconds between peaks in the sinusoidal waves associated with most activities (for each axis)
- Binned Distribution[30]: We determine the range of values for each axis (maximum – minimum), divide this range into 10 equal sized bins, and then record what fraction of the 200 values fell within each of the bins.

Machine Learning

- Pull features + activity labels into Weka (or other Machine learning Framework)



- Export classifiers as Java JAR file
- Run classifier in your app
- Given an accelerometer pattern while user is performing activity => Guess (infer) what activity

Accuracy of Classifiers

- Classifiers can achieve > 90% accuracy for most activities

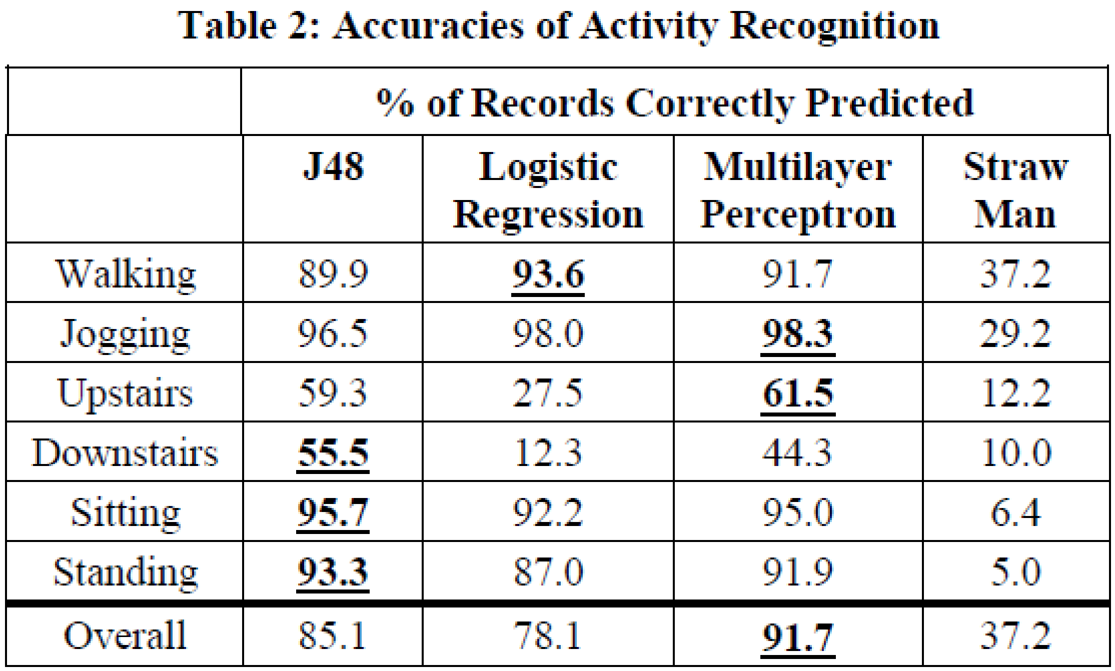
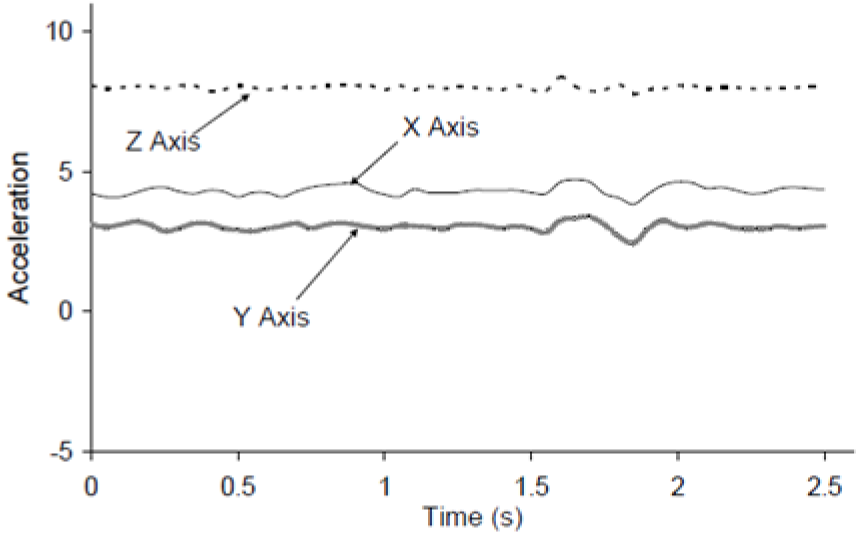


Table 2: Accuracies of Activity Recognition

	% of Records Correctly Predicted			
	J48	**Logistic Regression**	**Multilayer Perceptron**	**Straw Man**
Walking	89.9	**93.6**	91.7	37.2
Jogging	96.5	98.0	**98.3**	29.2
Upstairs	59.3	27.5	**61.5**	12.2
Downstairs	**55.5**	12.3	44.3	10.0
Sitting	**95.7**	92.2	95.0	6.4
Standing	**93.3**	87.0	91.9	5.0
Overall	85.1	78.1	**91.7**	37.2

What if you don’t know Machine Learning

- Visually inspect accelerometer waveform, come up with rules by trial and error
- E.g. If (min-max range < threshold), activity = sitting



(e) Sitting

Inference across multiple sensors

- Note that features can be from multiple sensors
- E.g. accelerometer features, gyroscope features, web URL features, etc.

Finding Idea to Work on

Pick an Idea to Work on

- Examples of previous projects from grad class:
  - Hearing aid
  - WiFi vulnerability
  - Mobile tweeter mining (mobile computing, ubicomp stuff),
  - weather prediction along user's path

- Projects from Andrew Campbell class

  https://docs.google.com/document/d/1hg44pm9PPPnIxBfNthAktUD9XoHBLmkMdmq6BmJiWaI/pub

- What else is detected in ubicomp (5W's, 1H), examples ideas, how to do it in Android

Coming up with a Project

1. Click on papers,
   1. What areas you like?
   2. What are your strengths? Machine learning? Signal processing?
2. Find papers you like within area or search Google Scholar, ACM digital library or IEEE Xplore
3. Can each paper be extended?
   a. Look at future work
   b. Repeat experiments + other things they didn't try. E.g.
      i. Re-implement a simple idea: E.g. Bewell
      ii. Implement PART(S) OF complex idea (e.g. place sense paper)
      iii. Propose new idea based on your prior knowledge/experience (GREAT!!! Maybe publishable?)

Other Random Project Ideas?

Some Project Ideas

- **Machine learning:**
  - Detect personality type from detecting/analyzing daily interactions.
  - E.g. number of friends seen per day, number of people talked to per day, activity levels/type, etc.

- **Signal/processing:**
  - Detect speaker, extract conversations, convert speech to text, record
  - Detect emotion/stress levels from speech
  - Detect sleep duration, quality detection from accelerometer, microphone (iSleep paper)

Some Project Ideas

- **Image/Video Analysis:**
  - Detect a person's emotion/mood from an image video of their face
  - Detect if a person/student watching a youtube video is engaged/not engaged

- **Mobile Twitter**
  - Search Twitter messages, analyze how much important mobile topics are being discussed (e.g. security, malware, health)

References

- Busy Coder's guide to Android version 4.4
- CS 65/165 slides, Dartmouth College, Spring 2014
- CS 371M slides, U of Texas Austin, Spring 2014