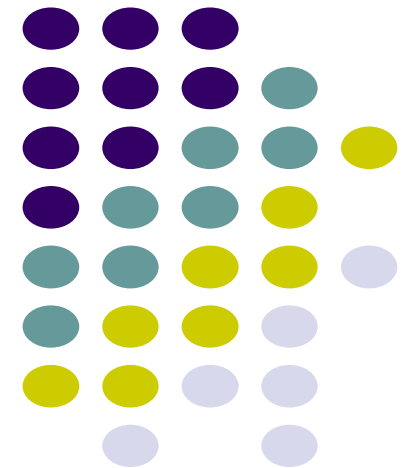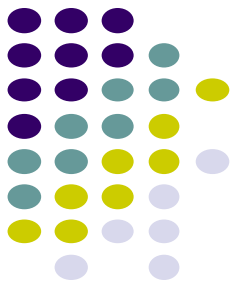# CS 528 Mobile and Ubiquitous Computing
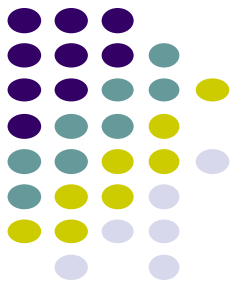## Lecture 7a: Ubicomp: Human Activity Recognition (HAR)

Emmanuel Agu

# Student Presentation: Mobile Technologies

Talk: Mobile Technology

- GROUP to research, master and present on any TWO mobile technologies.
- Overarching goal is to explore new/emerging topics in fast-changing mobile world
- Your talk should cover:
  - Background on the technology (tell a story about its history, etc)
  - Specific problems it's designed to solve
  - Typical example use case: When is it typically used?
  - Real world examples of where it is being used. E.g. by XYZ company for ABC
  - Overview of how it works?
  - Code snippet: Walk through a simple program that uses the technology including how to compile it and how to run it.
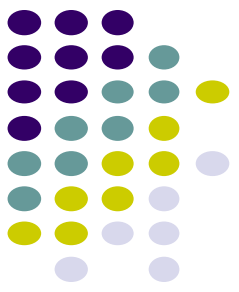
Talk on Mobile Technology

- Submit talk slides + working code
- To avoid duplicate presentations, each group email me their TWO topics by October 28, 2019
- This talk is 15% of your grade!
- The idea is to become expert, help any groups that need your help on that technology
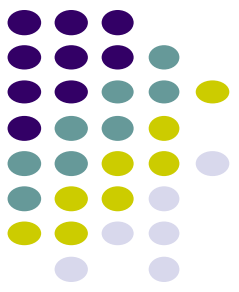
Example Topics on Mobile Technology

- Mobile programming/develpment:
  - Kotlin
  - iPhone development
  - 3rd part libraries: E.g. Xamarin
  - Mobile web programming
  - PhoneGap
  - AppInventor
  - Mobile game development tools: Unity,
- Machine/Deep Learning:
  - Deep Learning/machine learning in Android: Tensorflow, etc
  - Mobile machine/deep learning support in MATLAB
  - Keras support for Android Deep learning
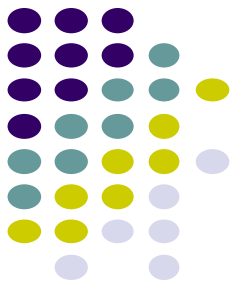 - Neural Networks API (NNAPI)

Talk on Mobile Technology

- More Google APIs (that could be used by mobile devices):
  - Analytics
  - Google Drive
  - Google Fit
  - Google Cast
  - Advertising: E.g. Adwords, Admobs
- More Android APIs:
  - Firebase (database, messaging, authentication, analytics, etc)
  - Speaking to Android (Speech recognition, Voice Actions)
  - Renderscript
  - Media Recorder
  - Wireless Communication: Bluetooth, WiFi, NFC, etc
  - Android Pay
  - Telephone/SMS
  - Nearby Connections API
  - Depth Sensing: Project Tango
  - Augmented Reality: ARtoolkit, vuforia, EasyAR

Talk on Mobile Technology

- MobiLoud: Turn Wordpress site into Native Mobile app
- Nativescript, Sencha: Use web technologies to develop mobile apps
- Onsen UI: Nice set of UI components
- Fliplet: Minimal coding framework
- Appsheet, Quick base: zero coding framework
- BuildFire: Zero coding, drag and drop
- ML kit

Final Project Proposal

Final Project Proposal

- While working on projects 3 & 4, also brainstorm on final project
- Oct 28, Propose mobile/ubicomp app, solves WPI problem or Machine learning
- **General problem:** Design and develop an Android app that solves helps WPI students cope with or manage the COVID situation.
  - Apps uses mobile or ubiquitous computing components (e.g. location, sensors or camera)
  - Projects difficulty will be graded based on the difficulty points sheet
  - If games, must gamify solution to real world problem
- Proposals should include:
  1. **Problem you intend to work on**
     - App that finds available study spaces (safe + available), dynamically updated

  2. **Why this problem is important**
     - E.g. 32% of WPI students living with roommates, hard to find places to study
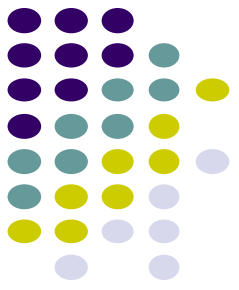
# Final Project Proposal
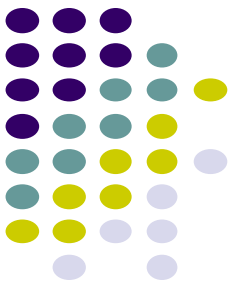
3. **Related Work:** What prior solutions have been proposed for this problem

4. **Summary of envisioned mobile app (?) solution**
   - E.g. Mobile app maintains dynamic list of available and safe study spots including Android/third party modules app will have

- Can bounce ideas of me (email, or in person)
- Can change idea any time
- **Reminder: 1 slide due today**

Final Project Proposal

- Can also do Machine learning project that classifies/detects analyzes a dataset of builds a real-time app to classify some human sensor data. E.g. Classifies
  - A speaker's voice to determine if nervous, sad, etc
  - A user's accelerometer data and recognizes their walk from 5-10 other people
  - A picture of a person's face and determines their mood
  - Data from a person's phone to measure their sleep duration or/and quality
  - Video of a person's face to detects their heart rate
  - A person's communication/phone usage patterns to detect their mood
- Can use existing smartphone datasets online
- See project difficulty points rubric
- Also propose evaluation plan
  - E.g. Small user study to evaluate app.
  - Can trade with another team: you review our app, we review yours
  - Machine learning performance metrics (e.g. classification accuracy, cross validation, etc)
- Can bounce ideas off me (email, or in person)
- Can change idea any time
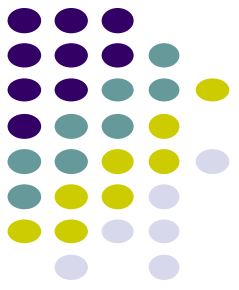
Rubric: Grading Considerations
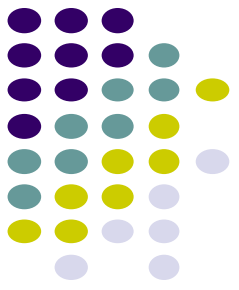
- **Problem (10/100)**
  - How much is the problem a real problem (e.g. not contrived)
  - Is this really a good problem that is a good fit to solve with mobile/ubiquitous computing? (e.g. are there better approaches?)
  - How useful would it be if this problem is solved?
  - What is the potential impact on the community (e.g. WPI students) (e.g. how much money? Time? Productivity.. Would be saved?)
  - What is the evidence of the importance? (E.g. quote a statistic)

- **Related Work (10/100)**
  - What else as been done to solve this problem previously

- **Proposed Solution/Classification (10/100)**
  - How good/clever/interesting is the solution?
  - How sophisticated and how are the mobile/ubiquitous computing components (high level) used? (e.g. location, geofencing, activity recognition, face recognition, machine learning, etc)

Rubric: Grading Considerations
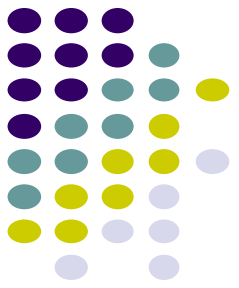
- **Implementation Plan + Timeline (10/100)**
  - Clear plans to realize your design/methodology
  - Android modules/3rd party software used
  - Software architecture,
  - Screenshots (or sketches of UI), or study design + timeline

- **Evaluation Plan (10/100)**
  - How will you evaluate your project, metrics
  - E.g. small user studies for apps
  - Machine learning cross validation, etc

- 50 more points allotted for your slides + oral presentation

Final Project: Proposal Vs Final Submission (Presentation + Paper)
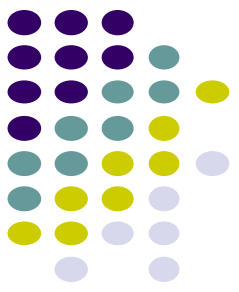
Final Project Proposal Vs Final Submission

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

- Evaluation/Results
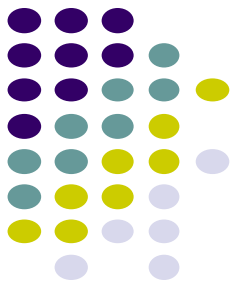- Discussion
- Conclusion
- Future Work

Proposal

Final Talk Slides
Final Paper

Note: No timeline
In final paper
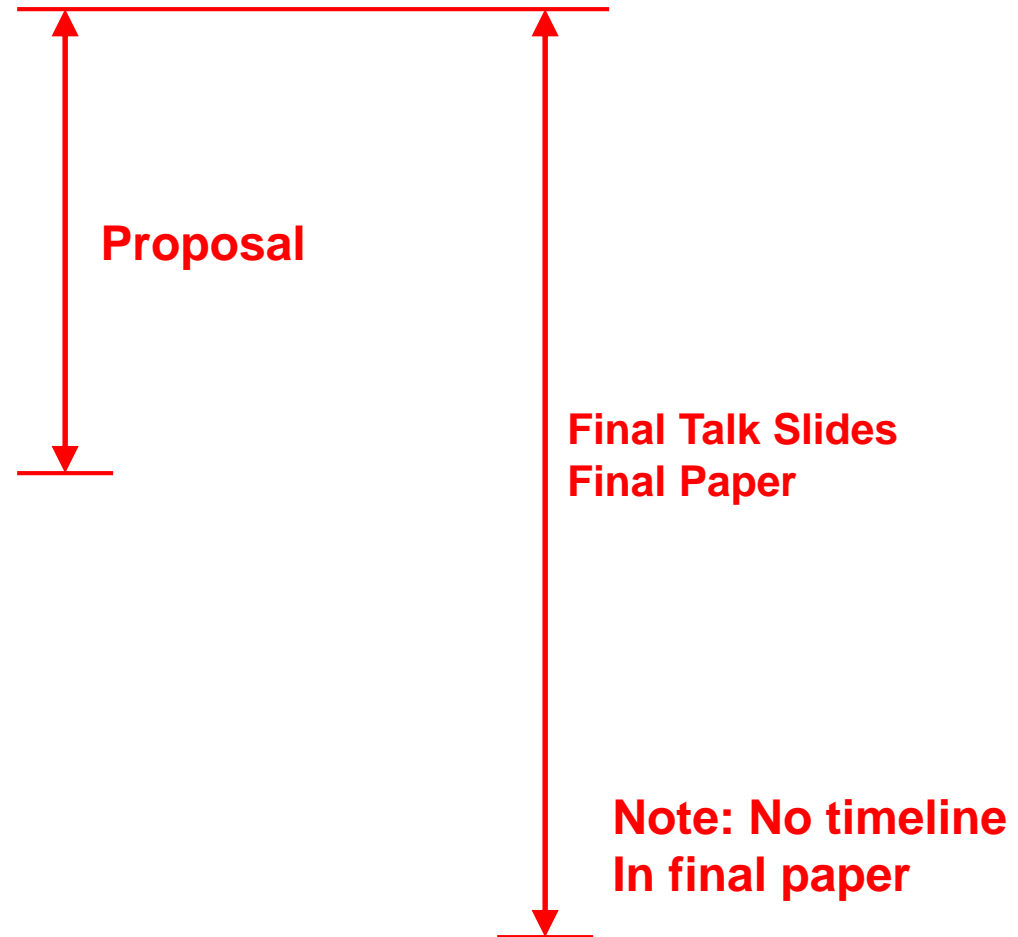
The Rest of the Class

The Rest of this class

- **Part 1: Course and Android Introduction**
  - Introduce mobile computing, ubiquitous Computing, Android,
  - Basics of Android programming, UI, Android Lifecycle

- **Part 2: Mobile and ubicomp Android programming**
  - mobile Android components (location, Google Places, maps, geofencing)
  - Ubicomp Android components (camera, face detection, etc)

- **Part 3: Mobile Computing/Ubicomp Research**
  - Machine learning (classification) in ubicomp
  - Ubicomp research (smartphone sensing examples, activity recognition, human mood detection, etc) using machine learning
  - Mobile computing research (app usage studies, energy consumption, etc)

Next!!

Introduction to Activity Recognition

Activity Recognition

- **Goal:** Want our app to detect what activity the user is doing?

- **Classification task:** which of these 6 activities is user doing?
  - Walking,
  - Jogging,
  - Ascending stairs,
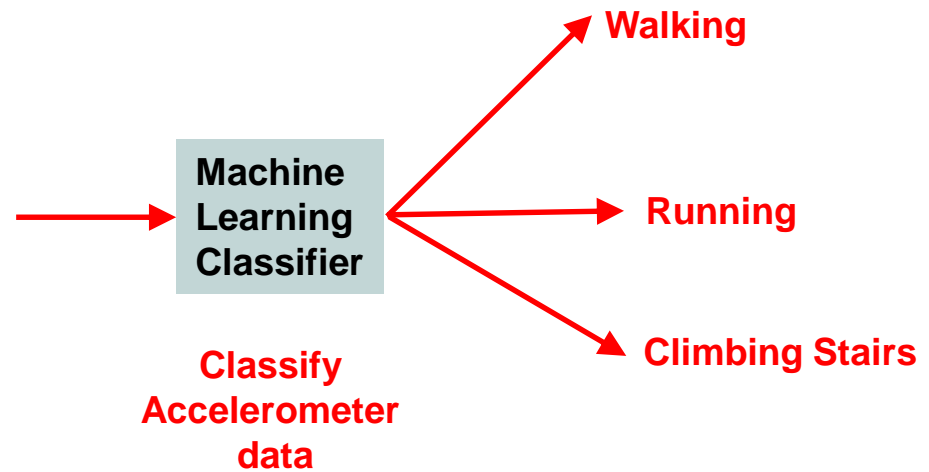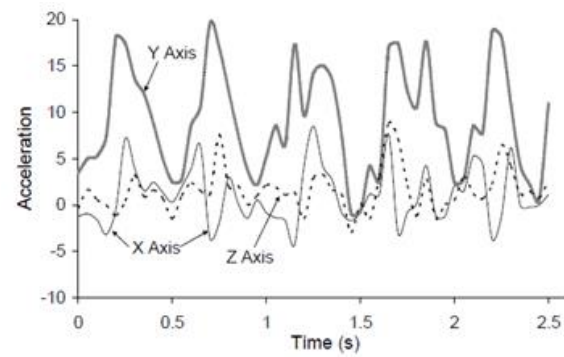 - Descending stairs,
  - Sitting,
  - Standing
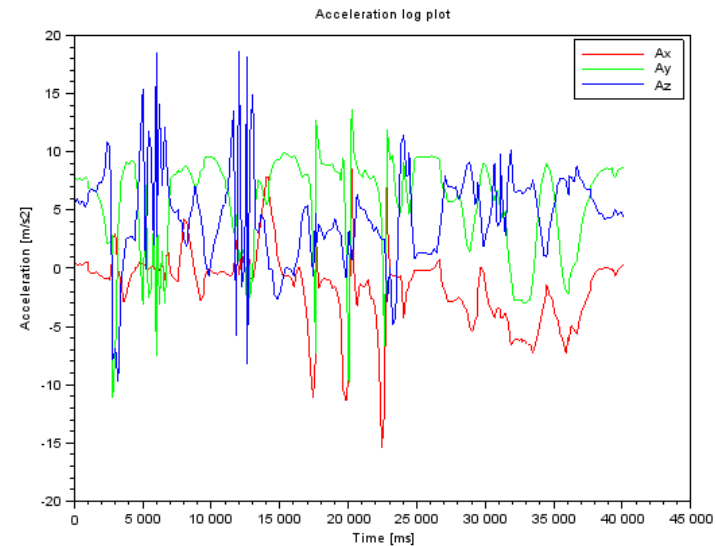
- Typically, use machine learning classifers to classify user's accelerometer signals
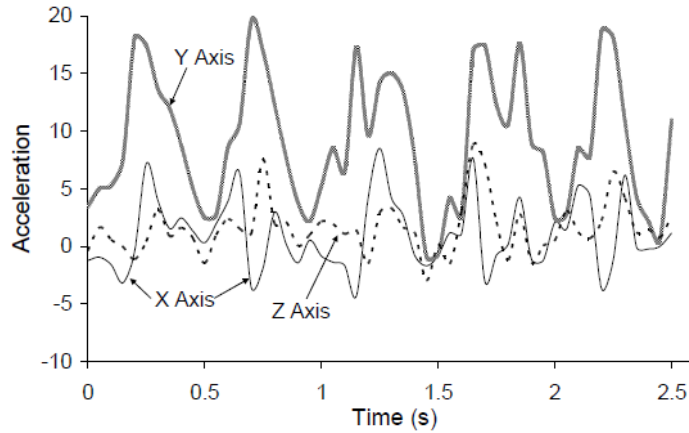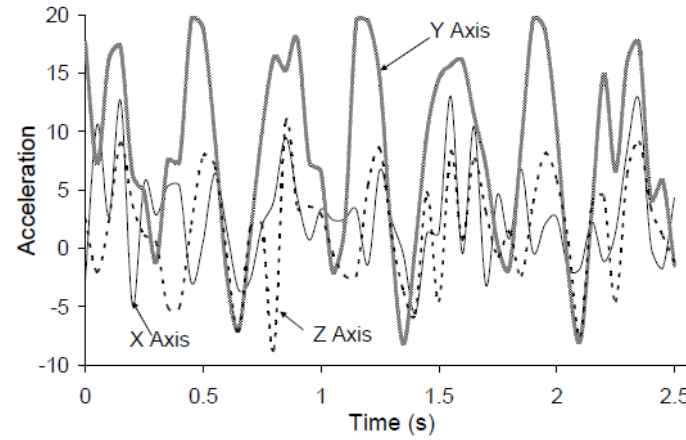
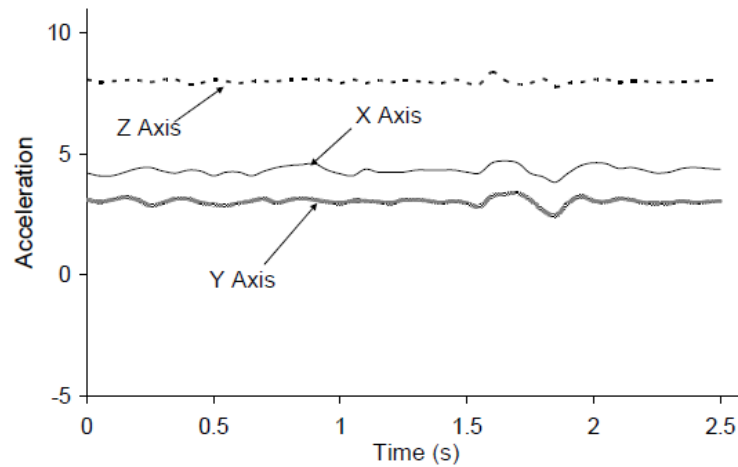# Activity Recognition Overview

Gather Accelerometer data

Machine Learning Classifier

Classify Accelerometer data

Walking
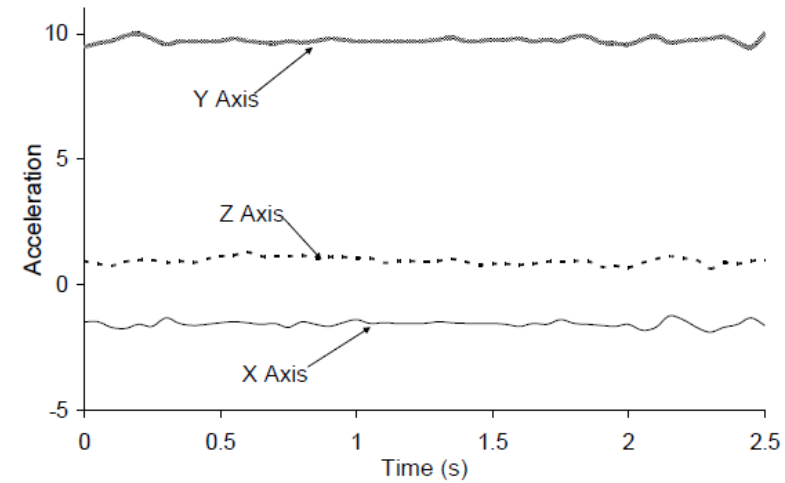
Running

Climbing Stairs

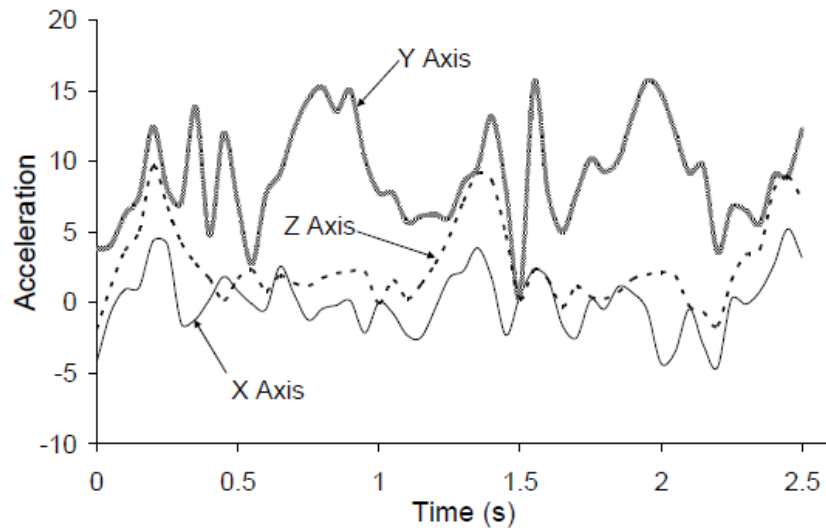# Example Accelerometer Data for Activities
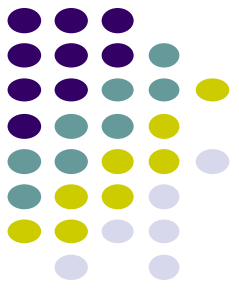
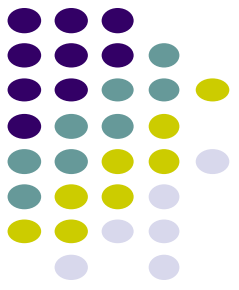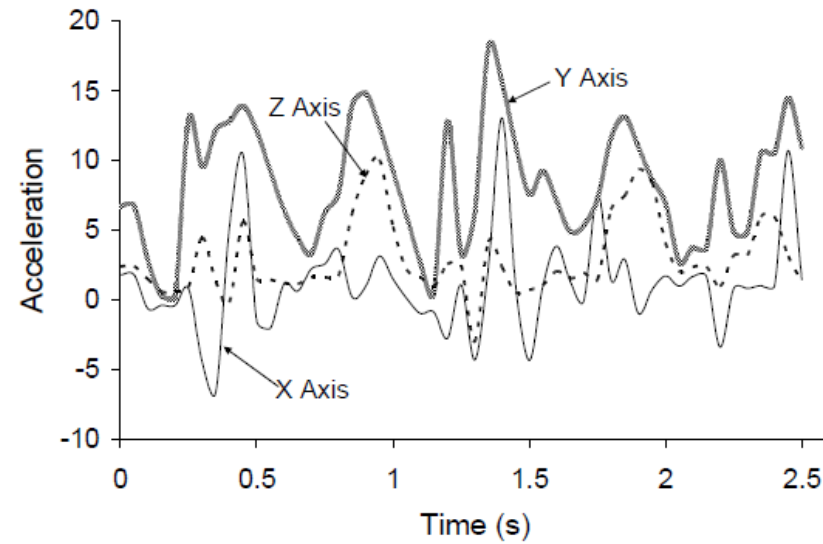
(a) Walking

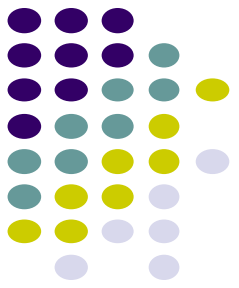(b) Jogging

(e) Sitting

(f) Standing

Example Accelerometer Data for Activities
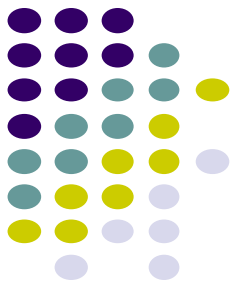

(c) Ascending Stairs

(d) Descending Stairs

Applications of Activity Recognition

Applications of Activity Recognition (AR)

Ref: Lockhart *et al*, Applications of Mobile Activity recognition

- **Fitness Tracking:**
  - **Initially:**
    - Physical activity type,
    - Distance travelled,
    - Calories burned

  - **Newer features:**
    - Stairs climbed,
    - Physical activity
      (duration + intensity)
    - Activity type logging + context e.g. Ran 0.54 miles/hr faster during morning runs
   - Sleep tracking
    - Activity history

Note: AR refers to algorithm
But could run on a range of devices
(smartphones, wearables, e.g. fitbit)

Applications of Activity Recognition (AR)

Ref: Lockhart *et al*, Applications of Mobile Activity recognition

- **Health monitoring:** How **well** is patient performing activity?
- Make clinical monitoring pervasive, continuous, real world!!
  - Gather context information (e.g. what makes condition worse/better?)
  - E.g. timed up and go test
- Show patient contexts that worsen condition => Change behavior
  - E.g. walking in narror hallways worsens gait freeze
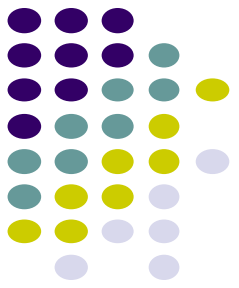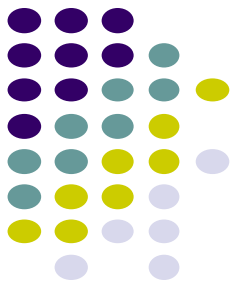

**Parkinsons disease
Gait freezing**

**Question: What
data would you need
to build PD gait classifier?
From what types of subjects?**

COPD, Walk tests in the wild

Applications of Activity Recognition

Ref: Lockhart *et al,* Applications of Mobile Activity recognition
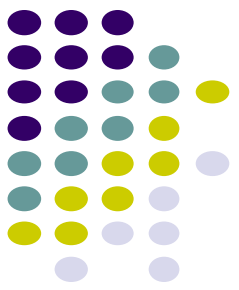
- **Fall:** Leading cause of death for seniors

- **Fall detection:** Smartphone/watch, wearable detects senior who has fallen, alert family
  - Text message, email, call relative

Fall detection + prediction

Applications of Activity Recognition (AR)

Ref: Lockhart *et al,* Applications of Mobile Activity recognition

- **Context-Aware Behavior:**
    - In-meeting? => Phone switches to silent mode
    - Exercising? => Play song from playlist, use larger font sizes for text
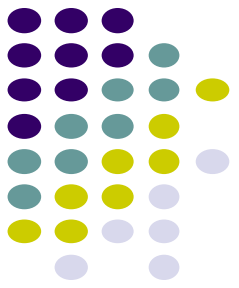   - Arrived at work? => download email

- Study found that messages delivered when transitioning between activities better received

- **Adaptive Systems to Improve User Experience:**
    - Walking, running, riding bike? => Turn off Bluetooth, WiFi (save power)
    - Can increase battery life up to 5x
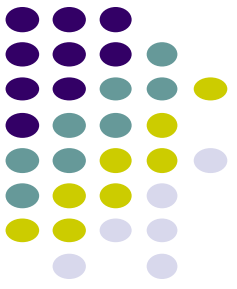
Applications of AR

- **Smart home:**
  - Determine what activities people in the home are doing,
    - **Why?** infer illness, wellness, patterns, intrusion (security), etc
    - E.g. TV automatically turns on at about when you usually lie on the couch

Applications of AR: 3rd Party Apps

Ref: Lockhart *et al,* Applications of Mobile Activity recognition
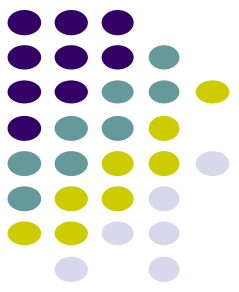
- **Targeted Advertising:**
  - AR helps deliver more relevant ads
  - E.g user runs a lot => Get exercise clothing ads
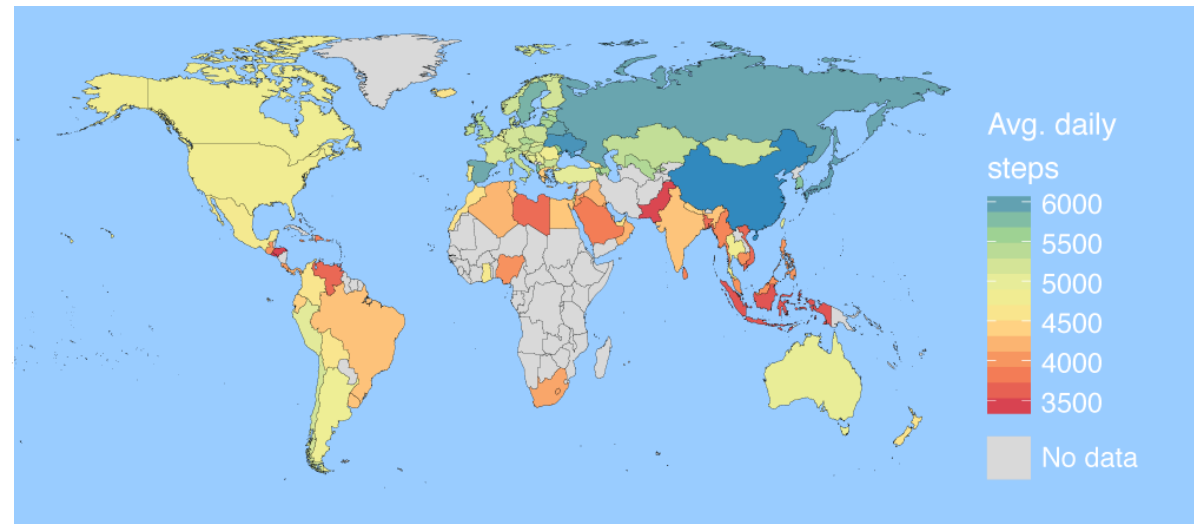 - Goes to pizza places often + sits there => Get pizza ads

Applications of AR: 3rd Party Apps

Ref: Lockhart *et al,* Applications of Mobile Activity recognition

- **Research Platforms for Data Collection:**
  - E.g. public health officials want to know how much time various people (e.g. students) spend sleeping, walking, exercising, etc
  - Mobile AR: inexpensive, automated data collection
  - E.g. Stanford Inequality project: Analyzed physical activity of 700k users in 111 countries using smartphone AR data
  - http://activityinequality.stanford.edu/

Applications of AR: 3rd Party Apps

Ref: Lockhart *et al,* Applications of Mobile Activity recognition
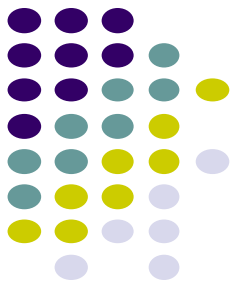
- **Track, manage staff on-demand:**
    - E.g. at hospital, determine "availability of nurses", assign them to new jobs/patients/surgeries/cases

Applications of AR: Social Networking

Ref: Lockhart *et al*, Applications of Mobile Activity recognition

- **Activity-Based Social Networking:**
  - Automatically connect users who do same activities + live close together

Applications of AR: Social Networking

Ref: Lockhart *et al,* Applications of Mobile Activity recognition

- **Activity-Based Place Tagging:**
  - Automatically "popular" places where users perform same activity
  - E.g. Park street is popular for runners (activity-based maps)

- **Automatic Status updates:**
  - E.g. Bob is sleeping
  - Tracy is jogging along Broadway with track team
  - Privacy/security concerns => Different Levels of details for different friends
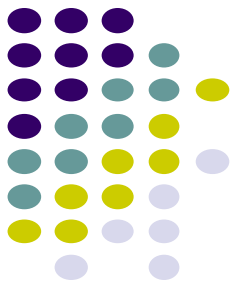
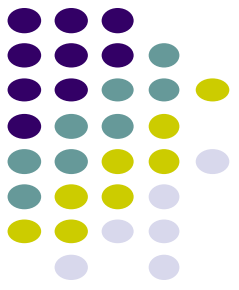# **Activity Recognition Using Google API**
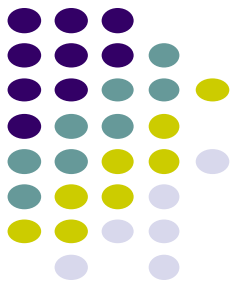
Activity Recognition

- Activity Recognition? Detect what user is doing?
  - Part of user's context
- Examples: sitting, running, driving, walking
- Why? App can adapt it's behavior based on user behavior
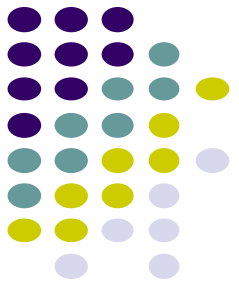- **E.g.** If user is driving, don't send notifications
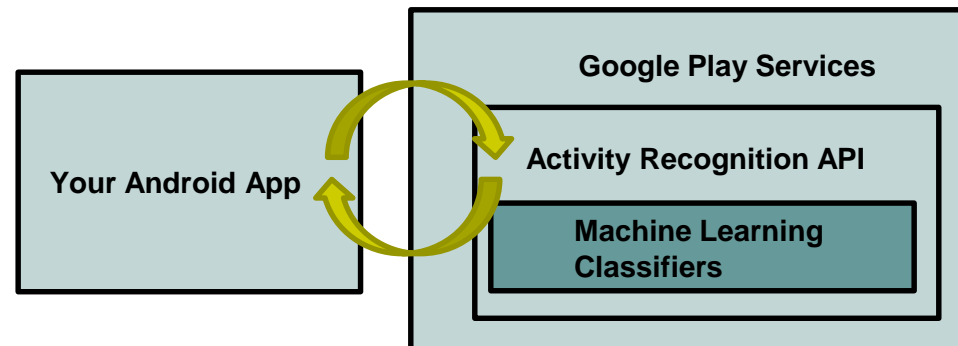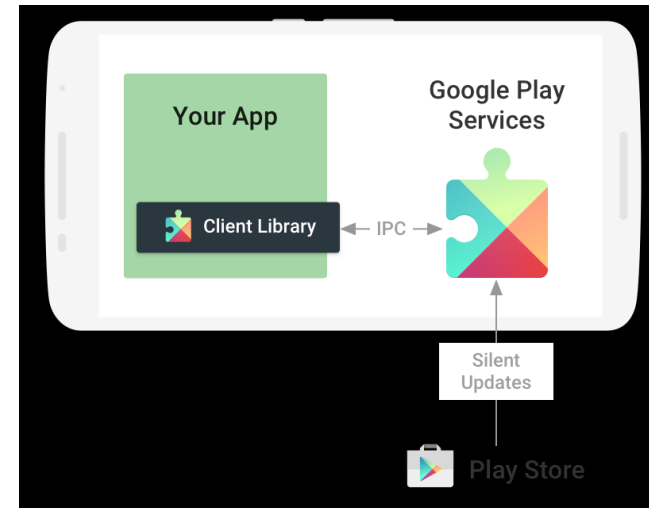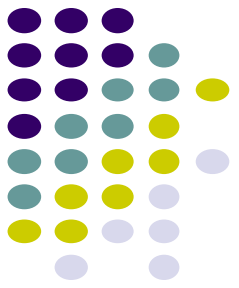
Google Activity Recognition API

- API to detect smartphone user's current activity
- Programmable, can be used by your Android app
- Currently detects 8 states:
  - In vehicle
  - On Bicycle
  - On Foot
  - Running
  - Walking
  - Still
  - Tilting
  - Unknown

Google Activity Recognition API

● Deployed as part of Google Play Services

Android Activity Recognition: Some Updates

Activity Recognition

- Older way: ActivityRecognitionApi deprecated
- Code sample in Android studio implements this unfortunately
- Typically used along with GoogleApiClient
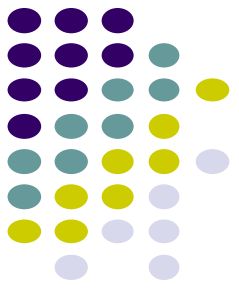
```
new GoogleApiClient.Builder(context)
        .addApi(ActivityRecognition.API)
        .addConnectionCallbacks(this)
        .addOnConnectionFailedListener(this)
        .build()
```

Activity Recognition

- New Way: ActivityRecognitionClient

- Provides 2 APIs

  - Activity Recognition Transition API: notifies when user's activity has changed!

    - Saves battery power

    - E.g. User was in car. Detect when user has exits the car

  - Activity Recognition Sampling API:

    - Can sample user's current activity at higher frequency

    - Can request periodic user activity updates using requestActivityUpdates(long, PendingIntent)

- Either API is fine as long as it works

- Probably best to use this version if you want your code to work in future

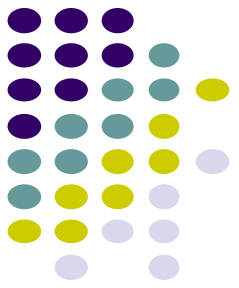# Activity Recognition

- Official Google documentation with example
  - https://developers.google.com/android/reference/com/google/android/gms/location/ActivityRecognitionClient

- Good reference articles with good examples, gentle walkthrough:
  - https://medium.com/@abhiappmobiledeveloper/android-activity-recognition-api-b7f61847d9dc

Android Awareness API

Awareness API
https://developers.google.com/awareness/overview

- Single Android API for context awareness released in 2016
- Combines some APIs already covered (Place, Activity, Location)

Context type	Example
Time	Current local time
Location	Latitude and longitude
Place	Place, including place type
Activity	Detected user activity (walking, running, biking)
Beacons	Nearby beacons matching the specified namespace
Headphones	Are headphones plugged in?
Weather	Current weather conditions
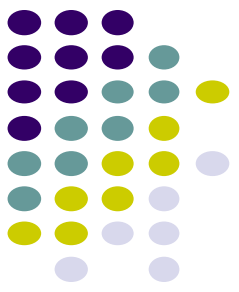
Awareness API

- **Snapshot API:**
  - Return cached values (Nearby Places, weather, Activity, etc)
  - System caches values
  - Optimized for battery and power consumption

- **Fences API:**
  - Used to set conditions to trigger events
  - E.g. if(user enters a geoFence & Activity = running) notify my app

- Official Android Awareness API has good examples:
  - https://developers.google.com/awareness

References

- Android Sensors Overview, http://developer.android.com/ guide/topics/sensors/sensors_overview.html
- Busy Coder's guide to Android version 6.3
- CS 65/165 slides, Dartmouth College, Spring 2014
- CS 371M slides, U of Texas Austin, Spring 2014

References

- John Corpuz, 10 Best Location Aware Apps
- Liane Cassavoy, 21 Awesome GPS and Location-Aware Apps for Android,
- Head First Android
- Android Nerd Ranch, 2nd edition
- Busy Coder's guide to Android version 6.3
- CS 65/165 slides, Dartmouth College, Spring 2014
- CS 371M slides, U of Texas Austin, Spring 2014