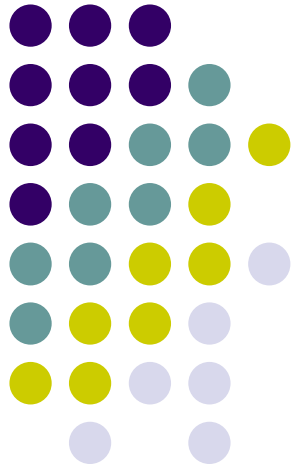
CS 528 Mobile and Ubiquitous Computing
Lecture 7b: Smartphone Sensing

Emmanuel Agu



Smartphone Sensors

- Typical smartphone sensors today
  - accelerometer, compass, GPS, microphone, camera, proximity
- Use machine learning to classify sensor data

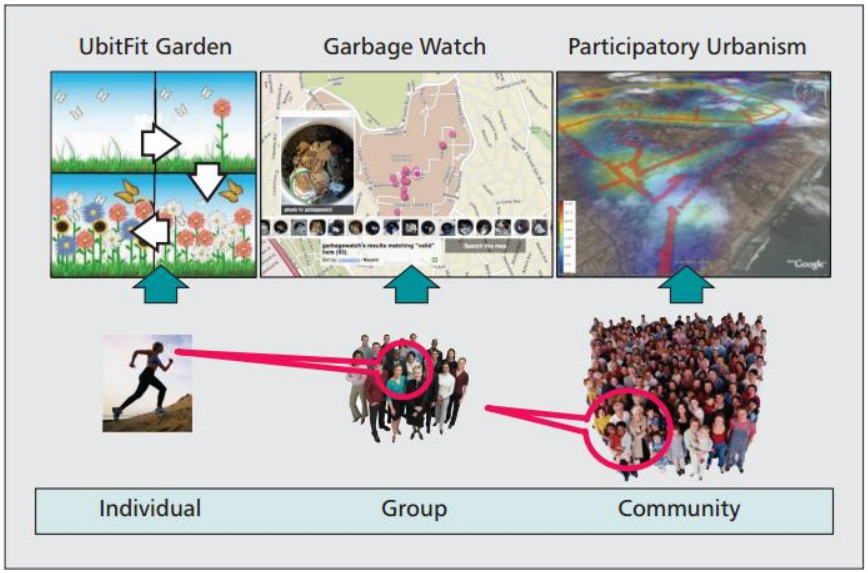
Future sensors?

- Heart rate monitor,
- Activity sensor,
- Pollution sensor,
- etc

Mobile CrowdSensing

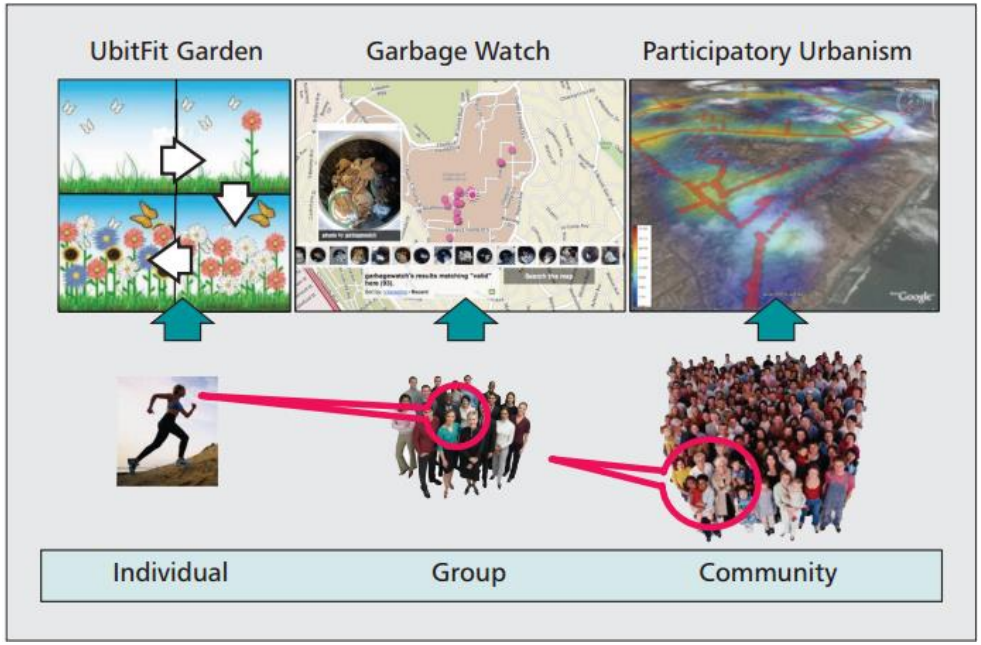
- **Mobile CrowdSensing:** Sense collectively
- **Personal sensing:** phenomena pertain to individual
  - E.g: activity detection and logging for health monitoring

- **Group:** friends, co-workers, neighborhood
  - E.g. GarbageWatch recycling reports, neighborhood surveillance



Mobile CrowdSensing

- **Community sensing (mobile crowdsensing):**
  - Large-scale phenomena monitoring
  - Many people contribute their individual readings
  - **Examples:** Traffic congestion, air pollution, spread of disease, migration pattern of birds, city noise maps

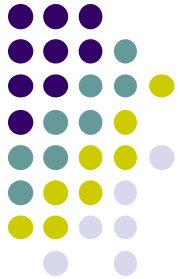


Mobile Crowd Sensing Types

- Many people cooperate, share sensed values
- 2 types:
  1. ***Participatory Sensing:*** User enters sensed values (**active** involvement)
     - E.g. Comparative shopping: Compare price of toothpaste at CVS vs Walmart
  2. ***Opportunistic Sensing:*** Mobile device automatically senses values (**passive** involvement)
     - E.g. Waze crowdsourced traffic

Sense What?

- **Environmental:** pollution, water levels in a creek
- **Transportation:** traffic conditions, road conditions, available parking
- **City infrastructure:** malfunctioning hydrants and traffic signs
- **Social:** photoblogging, share bike route quality, petrol price watch
- **Health and well-being:**
  - Share exercise data (amount, frequency, schedule),
  - share eating habits and pictures of food



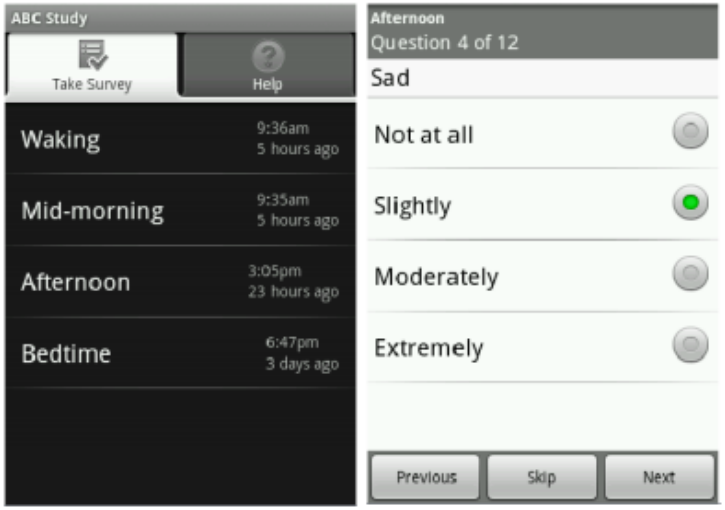
Smartphone Sensing Examples

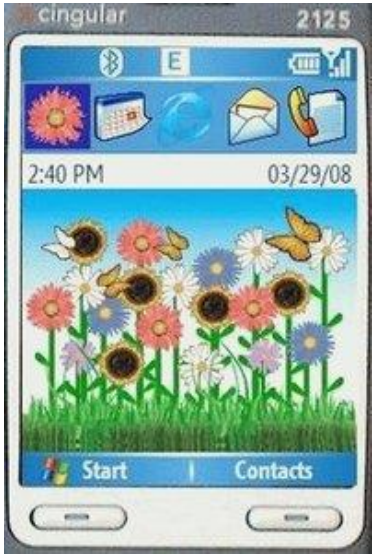
Personal Sensing

- Personal monitoring
- Focusing on user's daily life, physical activity (Khan et al. 404)

Other Examples of Personal Participatory Sensing

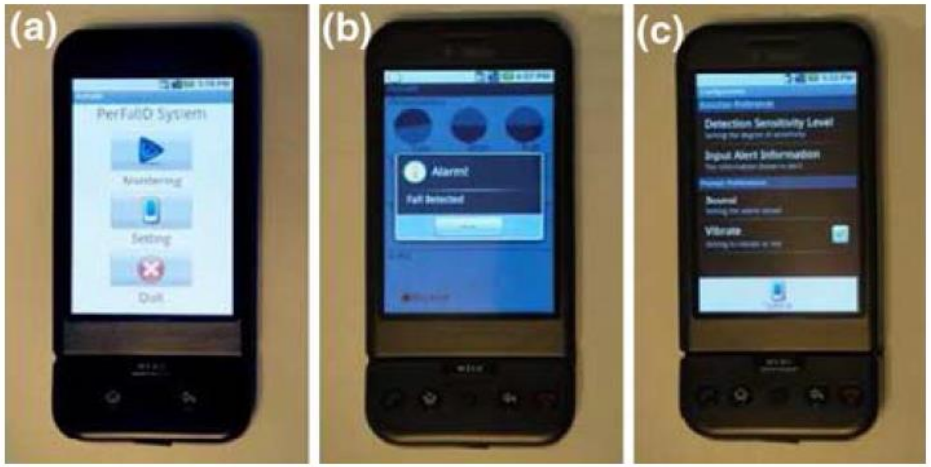
- AndWellness
  - “Personal data collection system”
  - Active user-triggered experiences and surveys
  - Passive recording using sensors
- UbiFit Garden
  - Uses smartphone sensors , real-time statistical modeling, and a personal, mobile display to encourage regular physical activity





Personal Opportunistic Sensing

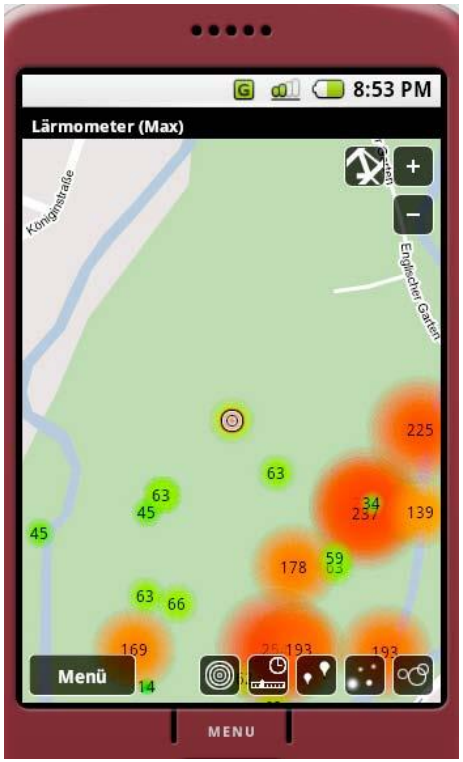
- PerFalld
  - How It Works
    - Detects if someone falls using sensor
    - Starts a timer if it detects that someone fell
    - If individual does not stop timer before it ends, emergency contacts are called



User interfaces in PerFallD: (**a**) bright, large virtual buttons on operating screen (**b**) clear alert window (**c**) simple, non-confusing preference screen

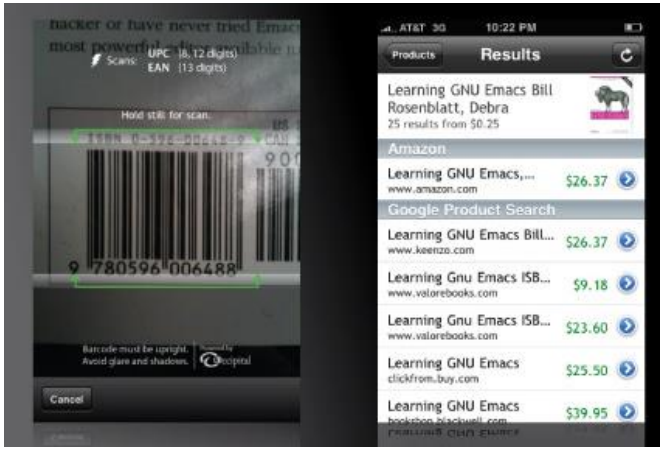
Public Sensing

- Data is shared with everyone for public good
- Traffic
- Environmental
  - Noise levels
  - Air pollution



Public Participatory Sensing

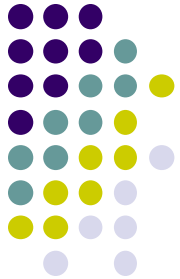
- **LiveCompare**
  - User-created database of UPCs and prices
  - GPS and cell tower info used to find nearby stores
- **PetrolWatch**
  - Turns phone into fully automated dash-cam
  - Uses GPS to know when gas station is near



Public Participatory Sensing

- **Pothole Monitor**
  - Combines GPS and accelerometer
- **Party Thermometer**
  - Asks you questions about parties
  - Detects parties through GPS and microphone

Sensing with Smartphones vs Dedicated Sensors

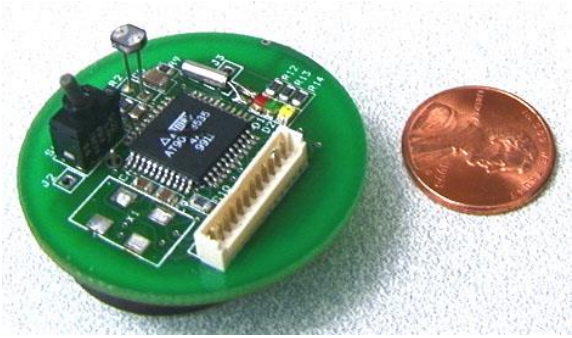


- **More resources:** Smartphones have much more processing and communication power

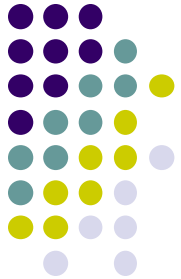
- **Easy deployment:** Millions of smartphones already owned by people
  - Instead of installing sensors in road, we detect traffic congestion using smartphones carried by drivers

- **Time-varying data:** population of mobile devices, type of sensor data, accuracy changes often due to user mobility and differences between smartphones

Smartphone Sensing vs Dedicated Sensors

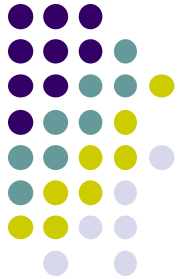


Sensing with Smartphones vs Dedicated Sensors



- **Reuse of few general-purpose sensors:** While sensor networks use dedicated sensors, smartphones reuse relatively few sensors for wide-range of applications
  - E.g. Accelerometers used in transportation mode identification, pothole detection, human activity pattern recognition, etc

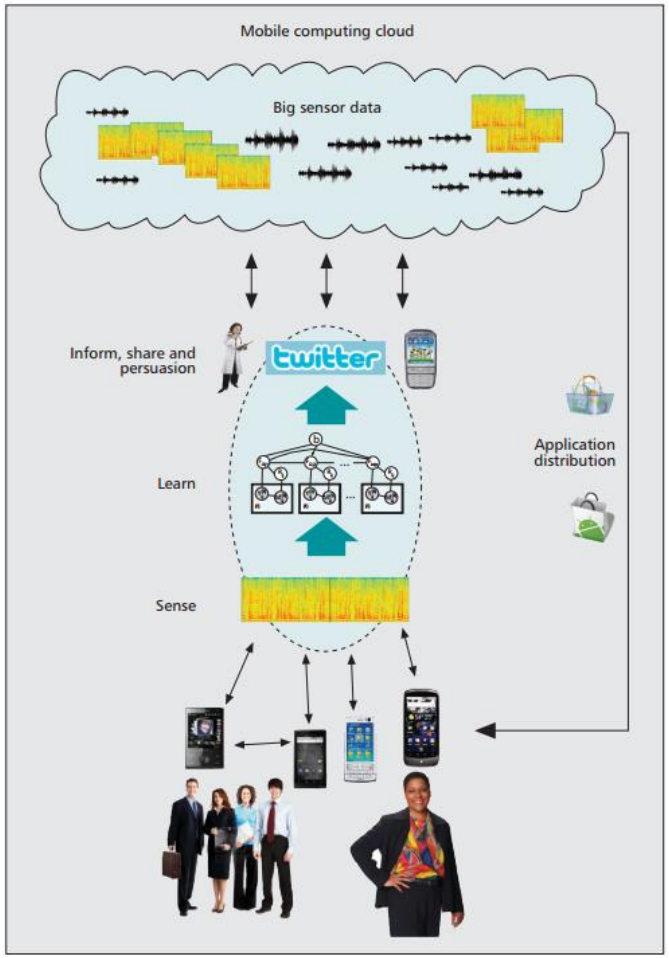
- **Human involvement:** humans who carry smartphones can be involved in data collection (e.g. taking pictures)
  - Human in the loop can collect complex data
  - Incentives must be given to humans

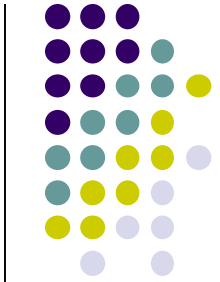


Smartphone Sensing Architecture

Smartphone Sensing Architecture

- Paradigm proposed by Lane *et al*
- **Sense:** Phones collect sensor data
- **Learn:** Information is extracted from sensor data by applying **machine learning and data mining** techniques
- **Inform, share and persuasion:** inform user of results, share with group/community or persuade them to change their behavior
  - **Inform:** Notify users of accidents (Waze)
  - **Share:** Notify friends of fitness goals (MyFitnessPal)
  - **Persuasion:** avoid speed traps (Waze)





Final Project Proposal

Final Project Proposal

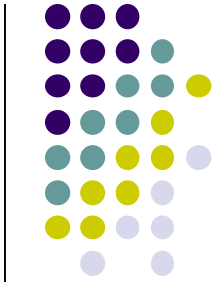
- While working on projects 3 & 4, also brainstorm on final project
- Nov 2, Propose mobile/ubicomp app, solves WPI problem or Machine learning
- Proposals should include:
  1. **Problem you intend to work on**
     - Solve WPI/societal problem (e.g. walking safe at night)
     - Use at least 3 mobile/ubicomp components (e.g. location, sensor or camera)
     - If games, must gamify solution to real world problem
  2. **Why this problem is important**
     - E.g. 37% of WPI students feel unsafe walking home
  3. **Related Work:** What prior solutions have been proposed for this problem
  4. **Summary of envisioned mobile app (?) solution**
     1. E.g. Mobile app automatically texts users friends when they get home at night

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

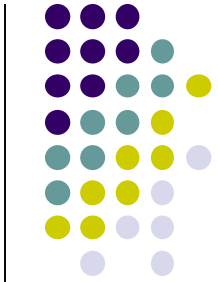
- Also propose evaluation plan
  - E.g. Small user study to evaluate app
  - Machine learning performance metrics (e.g. classification accuracy, cross validation, etc)
- Can bounce ideas of me (email, or in person)
- Can change idea any time

Rubric: Grading Considerations



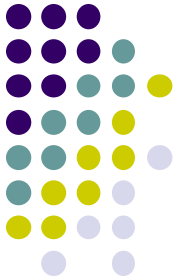
- **Problem (10/100)**
  - How much is the problem a real problem (e.g. not contrived)
  - Is this really a good problem that is a good fit to solve with mobile/ubiquitous computing? (e.g. are there better approaches?)
  - How useful would it be if this problem is solved?
  - What is the potential impact 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 many are the mobile/ubiquitous computing components (high level) proposed? (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.
  - E.g. small user studies for apps
  - Machine learning cross validation, etc

- 50 more points allotted for your slides + presentation



The Rest of the Class

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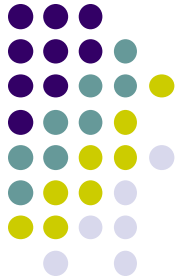
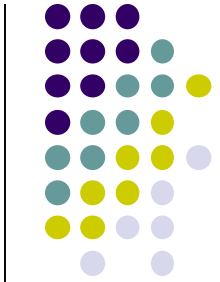


- **Part 1: Course and Android Introduction**
  - Introduce mobile computing, ubiquitous Computing, Android,
  - Basics of Android programming, UI, Android Lifecycle
- **Part 2: Mobile and ubicomp Android programming**
  - mobile Android components (location, Google Places, maps, geofencing)
  - Ubicomp Android components (camera, face detection, activity recognition, etc)
- **Part 3: Mobile Computing/Ubicomp Research**
  - Machine learning (classification) in ubicomp
  - Ubicomp research (smartphone sensing examples, human mood detection, etc) using machine learning
  - Mobile computing research (app usage studies, energy consumption, etc)

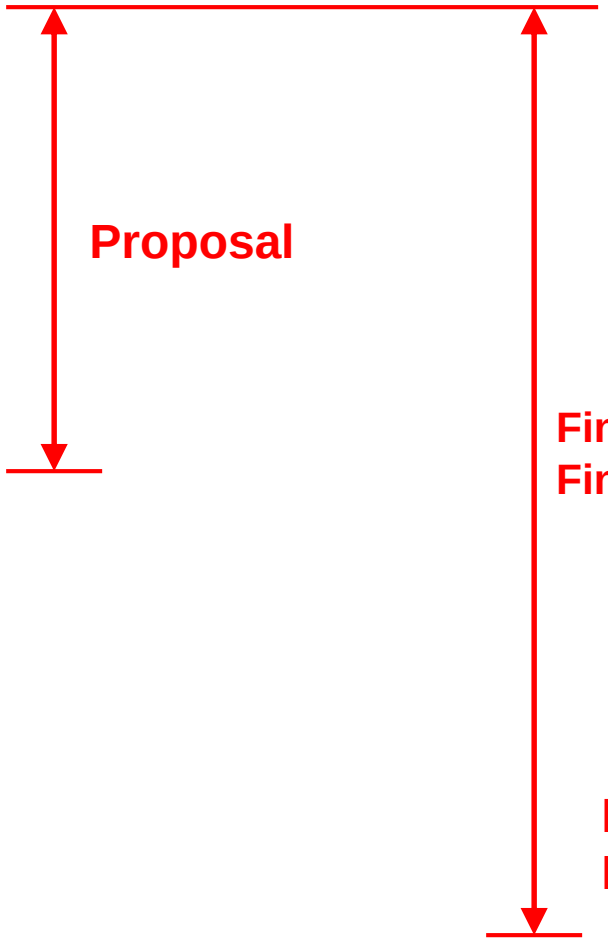


Final Project: Proposal Vs Final Submission

Final Project Proposal Vs Final Submission

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

- Evaluation/Results
- Discussion
- Conclusion
- Future Work



References

1. ***A Survey of Mobile Phone Sensing.*** Nicholas D. Lane, Emiliano Miluzzo, Hong Lu, Daniel Peebles, Tanzeem Choudhury, Andrew T. Campbell, In IEEE Communications Magazine, September 2010
2. ***Mobile Phone Sensing Systems: A Survey,*** Khan, W.; Xiang, Y.; Aalsalem, M.; Arshad, Q.; , Communications Surveys & Tutorials, IEEE , vol.PP, no.99, pp.1-26