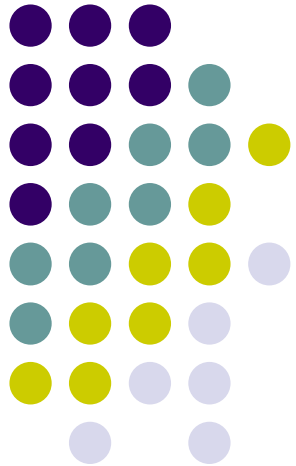
CS 4518 Mobile and Ubiquitous Computing
Smartphone Sensing

Emmanuel Agu



Smartphone Sensors

- Typical smartphone sensors today
  - accelerometer, compass, GPS, microphone, camera, proximity

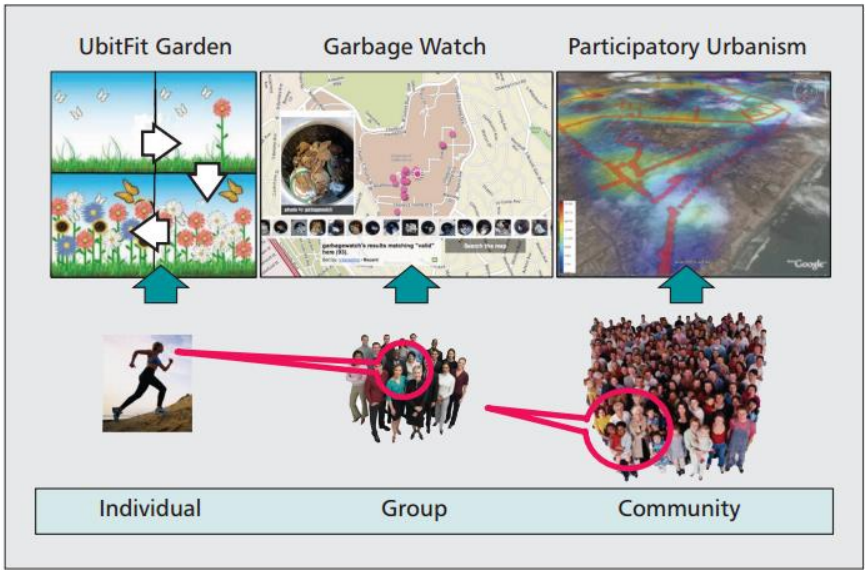
Future sensors?

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

Mobile CrowdSensing

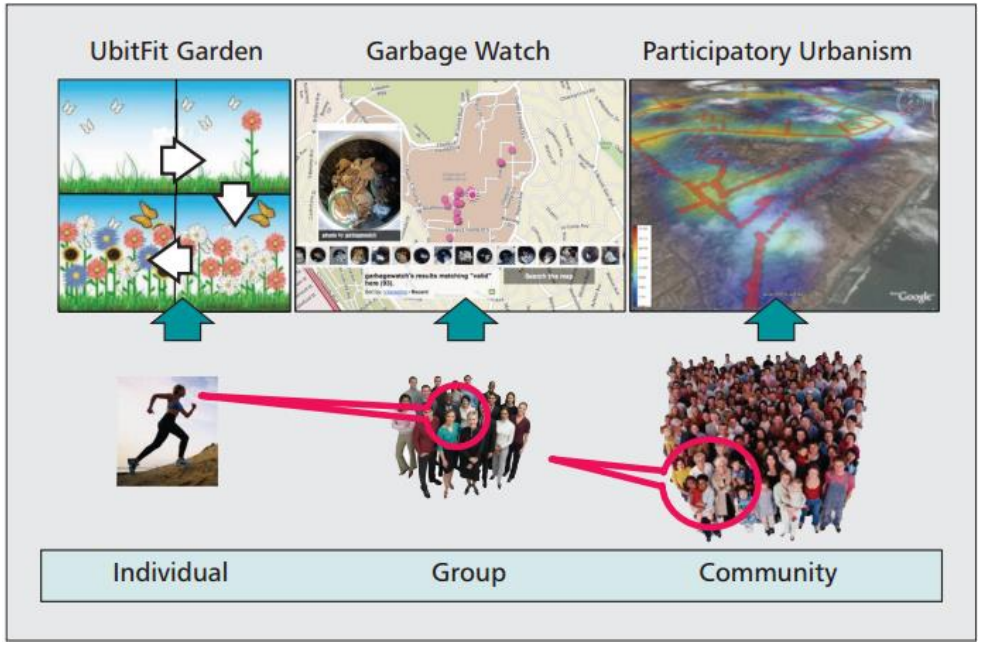
- **Mobile CrowdSensing:** Sense collectively
- **Personal sensing:** phenomena pertain to individual
  - E.g: activity detection and logging for health monitoring

- **Group:** friends, co-workers, neighborhood
  - GarbageWatch to improve recycling, neighborhood surveillance



Mobile CrowdSensing

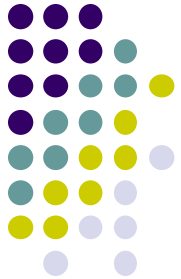
- **Community sensing (mobile crowdsensing):**
  - Large-scale phenomena monitoring
  - Many people contribute their individual readings
  - **Examples:** Traffic congestion, air pollution, spread of disease, migration pattern of birds, city noise maps



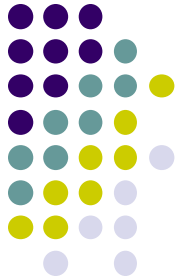
Mobile Crowd Sensing Types

- 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



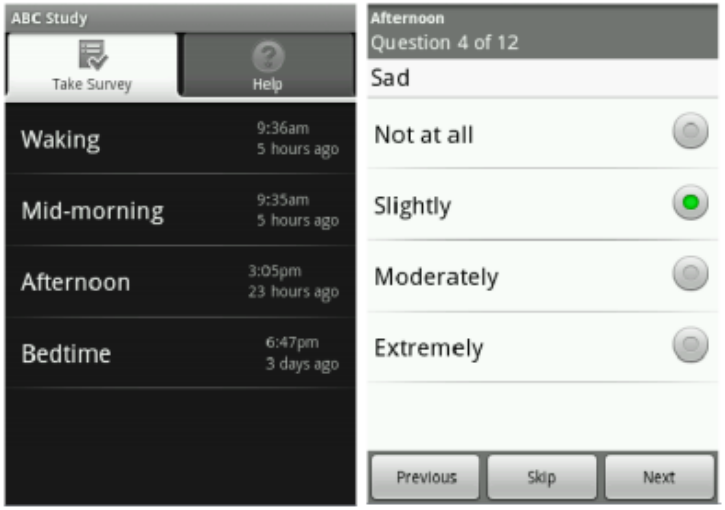
Smartphone Sensing Examples

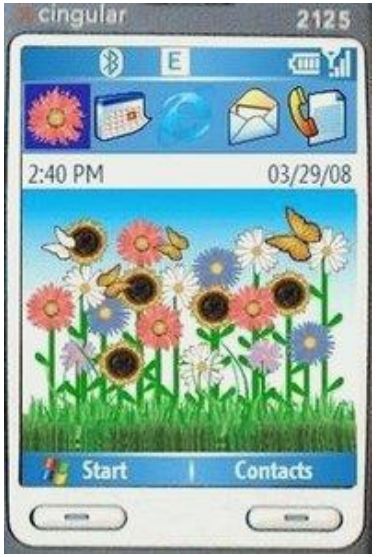
Personal Sensing

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

Other Examples of Personal Participatory Sensing

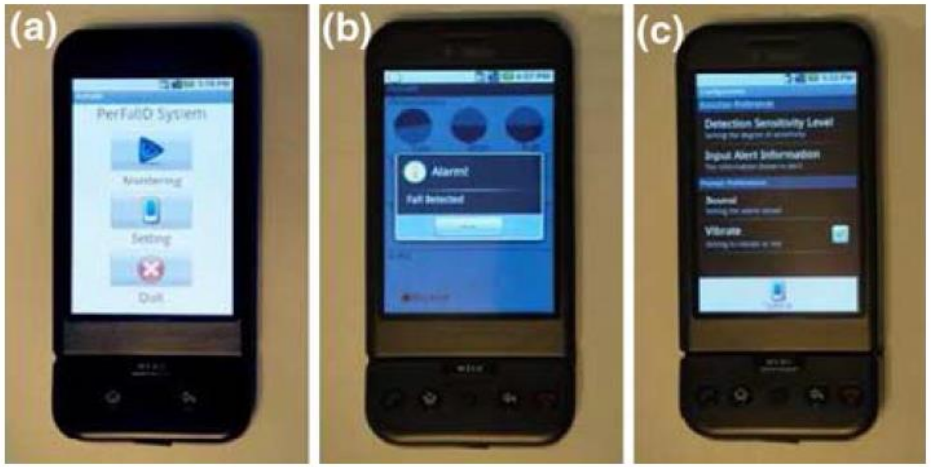
- AndWellness
  - “Personal data collection system” (Khan et al. 405)
  - Active user-triggered experiences and surveys
  - Passive recording using sensors
- UbiFit Garden
  - “Uses smartphone sensors , real-time statistical modeling, and a personal, mobile display to encourage regular physical activity” (Khan et al. 406)





Personal Opportunistic Sensing

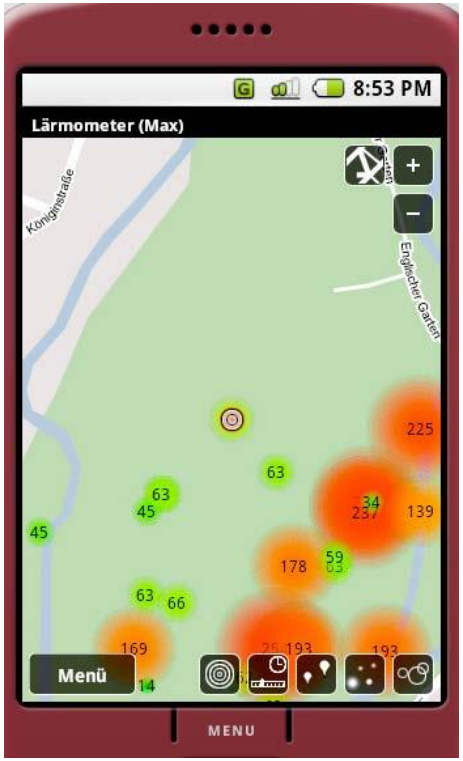
- PerFalld
  - How It Works
    - Detects if someone falls using sensor
    - Starts a timer if it detects that someone fell
    - If individual does not stop timer before it ends, emergency contacts are called (Khan et al. 416)



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

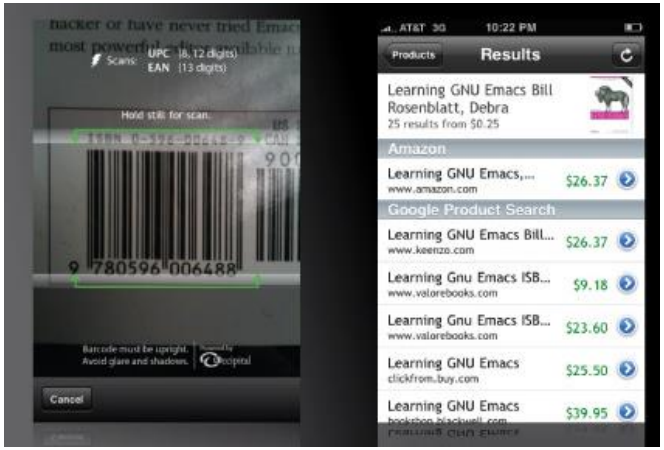
Public Sensing

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



Public Participatory Sensing

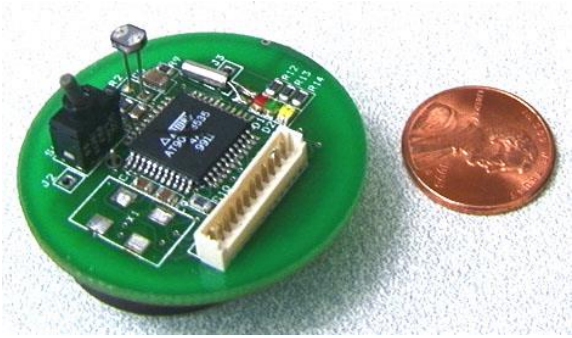
- **LiveCompare**
  - User-created database of UPCs and prices
  - GPS and cell tower info used to find nearby stores
- **PetrolWatch**
  - Turns phone into fully automated dash-cam
  - Uses GPS to know when gas station is near



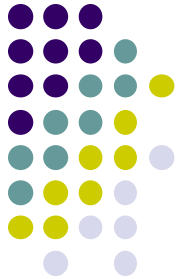
Public Participatory Sensing

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

Smartphone Sensing vs Dedicated Sensors



Sensing with Smartphones vs Dedicated Sensors

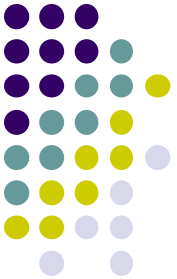


- **More resources:** Smartphones have much more processing and communication power

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

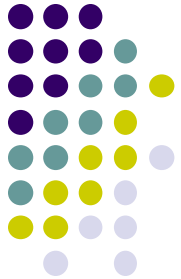
- **Time-varying data:** population of mobile devices, type of sensor data, accuracy changes often due to user mobility and differences between smartphones

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

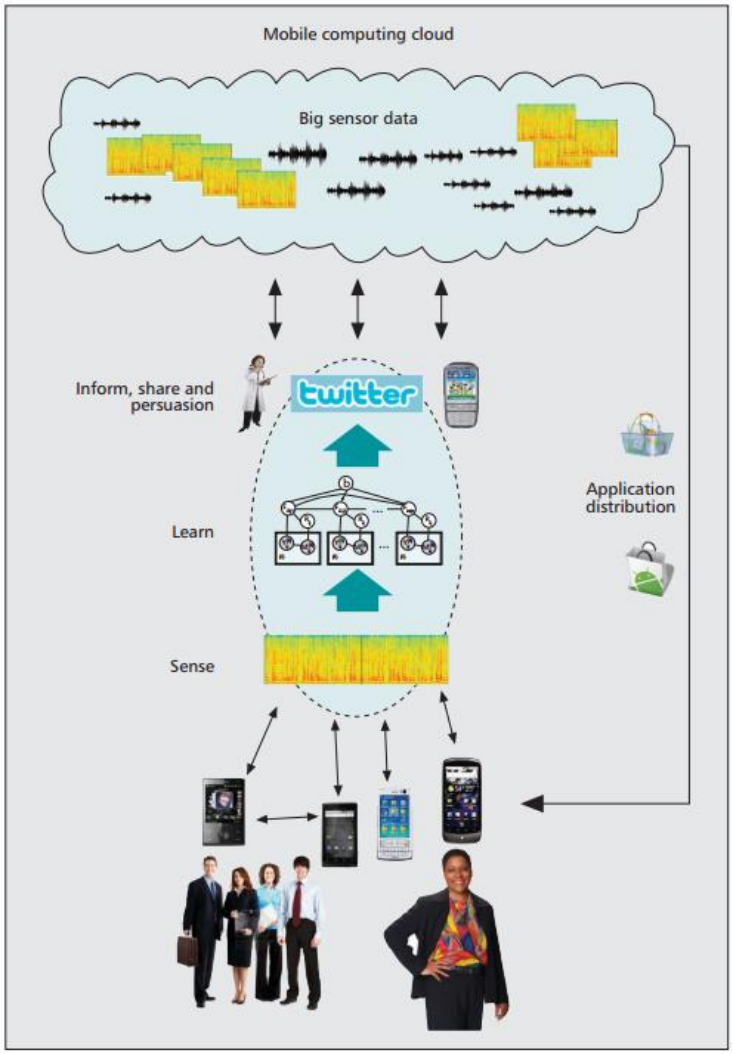
- **Human involvement:** humans who carry smartphones can be involved in data collection (e.g. taking pictures)
  - Human in the loop can collect complex data
  - Incentives must be given to humans



Smartphone Sensing Architecture

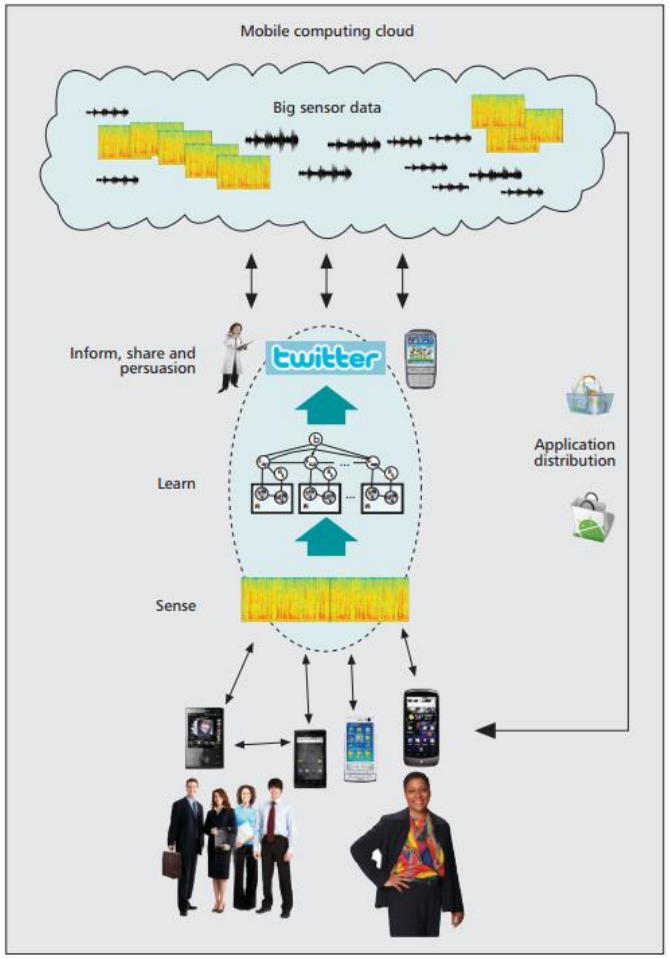
Smartphone Sensing Architecture

- **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



Smartphone Sensing Architecture

- **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)



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