Ubiquitous and Mobile Computing
CS 403x: *Mobile Phone Sensing Systems: A Survey*

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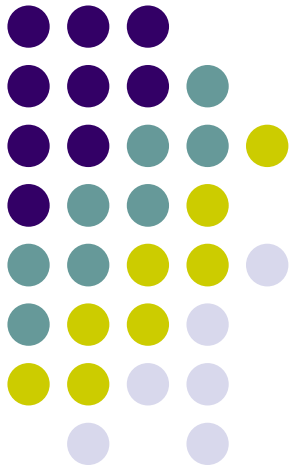
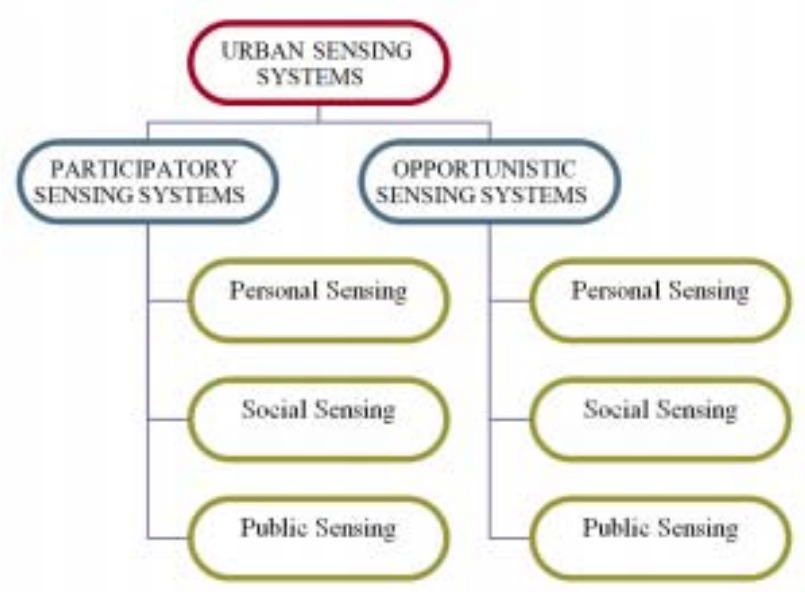


"The mobile phone is well on its way to becoming a personal sensing platform in addition to a communication device."
(Khan et al. 402)

Authors' Contributions

- "The collection and study of all the mobile phone sensing systems and applications, highlighting the existing work done so far in this field of research" (Khan et al. 403)
- Created categories:
  - Participatory vs. Opportunistic
  - Personal, Social, and Public



Personal Sensing

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

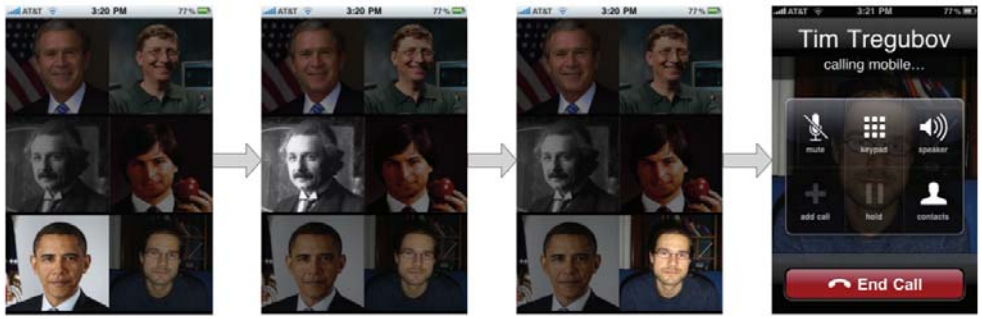
Personal Participatory Sensing

- NeuroPhone
  - Neural signals to control mobile phones
  - Hands-free and silent
  - “Using cheap off-the-shelf wireless electroencephalography (EEG) headsets” (Khan et al. 404)

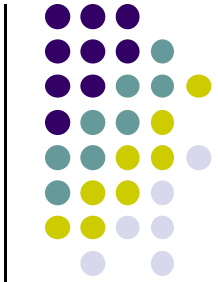
Test subject using NeuroPhone (Campbell et al. 4)

Personal Participatory Sensing

- NeuroPhone
  - Brain-controlled address book dialing app
    - Flashes sequence of photos of contacts
    - A P300 brain potential is elicited when flashed photo matches person the user wants to call, and phone number is dialed (Khan et al. 404)
    - Tested in various scenarios (sitting and walking)
    - Laptop relays data through Wifi to phone
    - “Initial results are promising for a limited set of scenarios and many challenges remain unsolved” (Khan et al. 404)



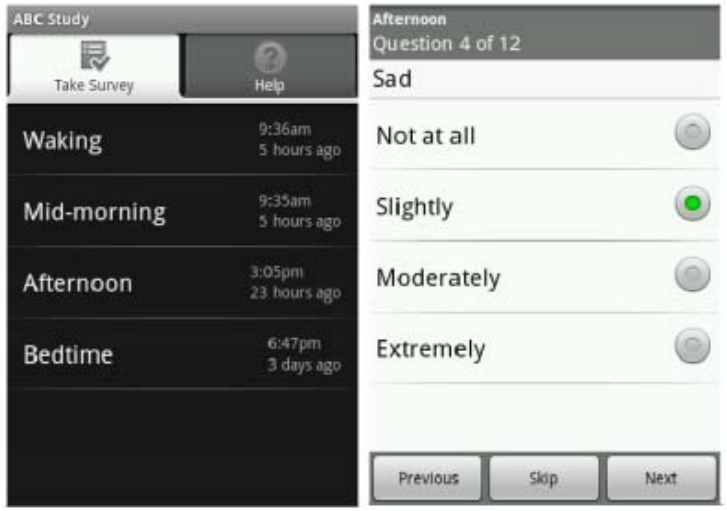
P300? What's that?



- "When somebody concentrates on a task-specific stimulus among a pool of stimuli, the task-related stimulus will elicit a positive peak with a latency of about 300ms from the stimulus onset in subject's EEG signal. This positive peak is known as the P300 signal in neuroscience literature." (Campbell et al. 4)
  - Brain wave elicited in decision-making process
  - Found in central-parietal region of brain

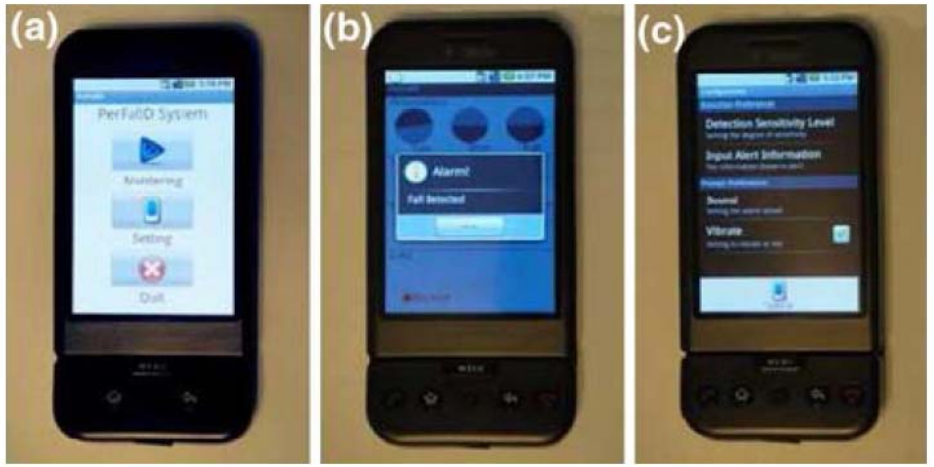
Other Examples of Personal Participatory Sensing

- AndWellness
  - "Personal data collection system" (Khan et al. 405)
  - Active user-triggered experiences and surveys
  - Passive recording using sensors
- UbiFit Garden
  - "Uses technologies like small inexpensive 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

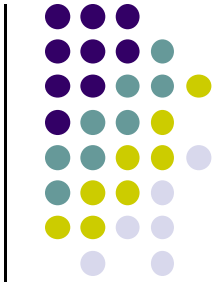
  - Comments
    - "PerFalld achieves strong detection performance and power efficiency"
    - "PerFalld outperforms existing algorithms, and achieves better balance between false negative and false positive when compared with the commercial product" (Khan et al. 417)

Other Example of Personal Opportunistic Sensing

- HeartToGo
  - "Cell phone-based personalized medicine technology for cardiovascular disease" (Khan et al. 417)
  - Monitors user and generates reports
  - "Uses state-of-the-art wireless ECG and heart monitor"
    - Light-weight, low-power wearable 2-lead ECG sensing device capable of recording 300 8-bit samples per second
    - Uses Bluetooth to transmit data (Cheng, 1)

Early prototype for HeartToGo (Cheng, 1).

Social Sensing

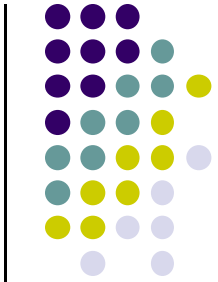


- Sensing information is shared within social groups
- Collect and share user's information with friends on social networks

Social Participatory Sensing Example #1

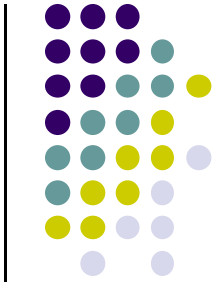
- CenceMe
  - Connects to Facebook, MySpace, Skype, Pidgin
  - Users status in terms of
    - activity
    - disposition
    - habits
    - Surroundings

Social Participatory Sensing Example #2



- MoVi
  - Video Highlights app for mobile phones
  - Organizes video by social importance
    - Scans app from phones on the network and
    - Selects the most interesting event
    - The best video for that event then
    - A clip from that video that summarizes the event well

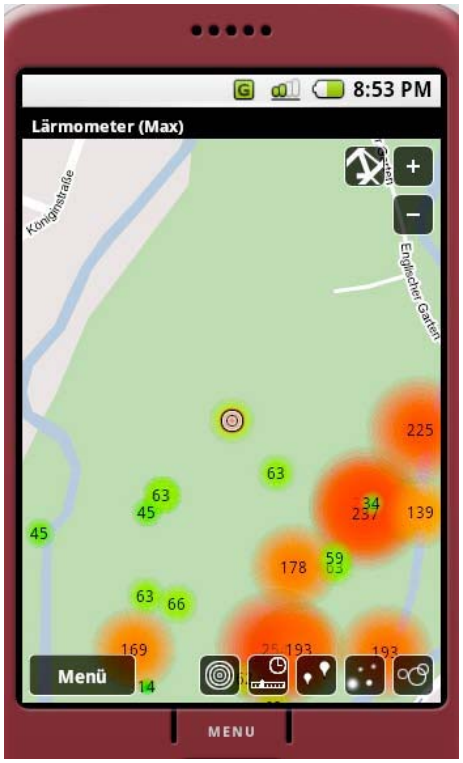
Social Opportunistic Sensing



- WhozThat
  - Finds music about nearby people from their social networking accounts on their phones
- OLS: Opportunistic Localization system
  - Find any phones near you to find your location in a building

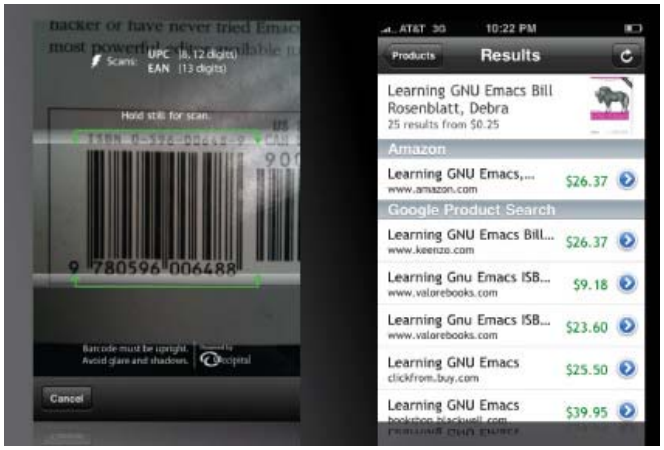
Public Sensing

- 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

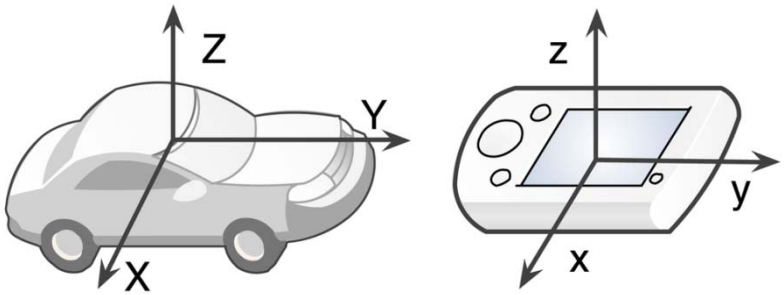


Public Participatory Sensing

- Citizen Journalist
  - Asks people location and event based questions
  - Fast response time necessary
- Party Thermometer
  - Asks you questions about parties
  - Detects parties through GPS and microphone

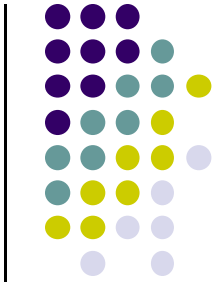
Public Opportunistic Sensing

- Road Bump Monitor
  - Combines GPS and accelerometer
- Nericell
  - Adds microphone listening to detect “chaos”
  - Data used for benefit of public works, traffic police



References

- Khan, Wazir Zada; Xiang, Yang; Aalsalem, Mohammed; Arshad, Quratulain. “Mobile Phone Sensing Systems: A Survey.” *IEEE Communications Surveys and Tutorials Vol 15 (2013)*. <http://ieeexplore.ieee.org.ezproxy.wpi.edu/stamp/stamp.jsp?tp=&arnumber=6177188&tag=1>
- Campbell, Andrew; Choudhury, Tanzeem; Hu, Shaohan; Lu, Hong; Mukerjee, Matthew K.; Rabbi, Mashfiqui; Raizada, Rajeev D.S. “NeuroPhone: brain-mobile phone interface using a wireless EEG headset.” *Proceedings of the second ACM SIGCOMM workshop on Networking, systems, and applications on mobile handhelds (MobiHeld '10).* ACM, New York, NY, USA, 3-8. DOI=10.1145/1851322.1851326 <http://doi.acm.org/10.1145/1851322.1851326>
- Cheng, Allen C. “HeartToGo: A Smartphone-based Mobile Platform for Continuous and Real-Time Cardiovascular Disease Monitoring.” University of Pittsburg (2009). <http://research.microsoft.com/en-us/events/ersymposium2009/hearttogo-mobile_platform.pdf>
- *P. Mohan, V. N. Padmanabhan, and R. Ramjee, “Trafficsense: Rich monitoring of road and traffic conditions using mobile smartphones,” Tech. Rep. no. MSR-TR-2008-59, April 2008.*
- *M. Bilandzic, M. Banholzer, D. Peev, V. Georgiev, F. Balagtas-Fernandez, and A. De Luca, “Laermometer: a mobile noise mapping application,” in Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges, ser. NordiCHI ’08. New York, NY, USA: ACM, 2008, pp. 415–418. [Online]. Available: <http://doi.acm.org/10.1145/1463160.1463208>*
- Dong, Yi Fei, et al. "Automatic image capturing and processing for petrolwatch." *Networks (ICON), 2011 17th IEEE International Conference on*. IEEE, 2011.
- *T. Das, P. Mohan, V. N. Padmanabhan, R. Ramjee, and A. Sharma, “Prism: platform for remote sensing using smartphones,” in Proceedings of the 8th international conference on Mobile systems, applications, and services, ser. MobiSys ’10. New York, NY, USA: ACM, 2010, pp. 63–76. [Online]. Available: http://doi.acm.org/10.1145/1814433.1814442*
- *P. Mohan, V. N. Padmanabhan, and R. Ramjee, “Nericell: rich monitoring of road and traffic conditions using mobile smartphones,” in Proceedings of the 6th ACM conference on Embedded network sensor systems, ser. SenSys ’08. New York, NY, USA: ACM, 2008, pp. 323–336. [Online]. Available: <http://doi.acm.org/10.1145/1460412.1460444>*



Questions? Comments? Concerns?

(Anyone get ideas for their projects for this class?)