Learning with smart devices

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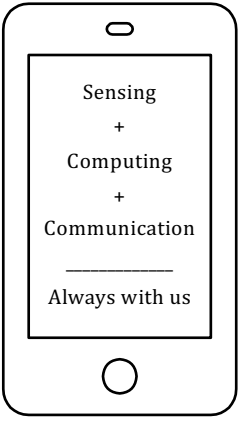
Smartphone as the platform

- Steve Jobs in 2008: « …Apple is about to introduce ***three revolutionary products***: An iPod with touch control, a revolutionary mobile phone, and a breakthrough internet communications device – ***in one device. »***



Overarching objective

- Invent and build smartphone-based systems for tackling some of the grand challenges facing society today
  - From the carbon footprint reduction to democratizing health care
- Research challenges are at the cusp of networking, machine learning, signal processing, systems research, etc.

Reducing the carbon footprint of on-street parking

- Problem: Drivers often spend over 20 min cruising for parking in city centers,
  - As much as 30% of the traffic congestion
- Current approaches: Dedicated (expensive) infrastructure
  - SF-Park: $18 million as start-up cost
- Our pitch, SmartPark[1]: Smartphone-based solution
  - Detects unparking events
  - Localizes its user
  - No user participation, no infrastructure cost

[1]Jean-Gabriel Krieg, Gentian Jakllari, Hadrien Toma and André-Luc Beylot, "Unlocking the Smartphone's Sensors for Smart City Parking" Pervasive and Mobile Computing, Vol. 43, January 2018

Challenges

1. Detecting when a user vacates a parking space
   - Difficulty: after parking, a user can take public transportations, walk, bike, enter another car, etc.

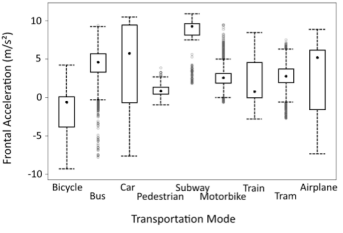
2. Incremental deployment
   - Difficulty: precise enough with a small initial fractions of users

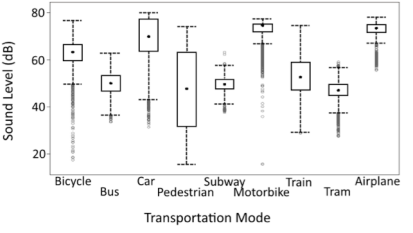
- Key constraint: energy consumption
  - No GPS for example

Detecting unparking event

1. *Detect user is in the same type of transportation as when parked*

- *Premise*: Acceleration, sound, lighting, atmospheric pressure,… can identify a transportation mode





Approach:

- Summary statistics to create features from the (energy frugal) sensor signals
- Supervised learning based on random forests to classify sensor readings into one of the possible transportation mode
- Interesting open question: minimize the number of features

Detecting unparking event

2. Detect a user is in the same vehicle as when parked

- Approach: Matching two physical locations using Wi-Fi and cellular base station signals
  - Wireless signal suffers from pathloss

Incremental deployment

- Catch 22: For SmartPark to be efficient it needs a wide roll-out in a city but users will only adopt a system that works

- Approach: An incremental deployment, starting with as little as 10% of the total users
  - Using information from the fraction of users using SmartPark, it can compute analytically the probability that a parking spot is available
  - Assuming parking times and user arrivals follow particular distributions

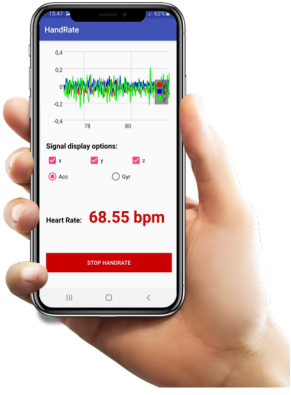
Digital healthcare

- Healthcare remains costly, administered by a complex apparatus, and often out of reach for many
- Smartphones can place, for the first time, advanced diagnosing and health monitoring capacities in people's hands

Lilian de Greef, Mayank Goel, Min Joon Seo, Eric C. Larson, James W. Stout, James A. Taylor, and Shwetak N. Patel. *Bilicam: using mobile phones to monitor newborn jaundice*. In *ACM UbiComp '14*

Smartphone-based heart monitoring

- Problem: cardiovascular diseases claim more lives every year than cancer and chronic lung diseases combined
- Current approach: dedicated medical equipment and/or specialist
- Our pitch: HandRate[2], a smartphone-based solution

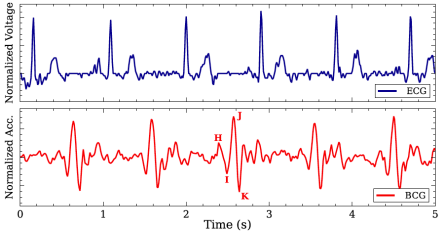


[2]Kevin Jiokeng, Gentian Jakllari and André-Luc Beylot "HandRate: Heart Rate Monitoring While Simply Holding a Smartphone" Proc. IEEE PerCom 2021

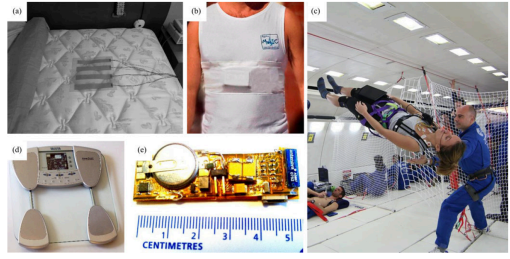
HandRate: Feasibility and challenges

Ballistocardiography

- Body recoils each time the heart ejects blood into the arteries

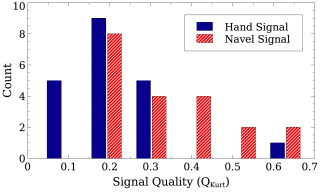


Traditional instruments



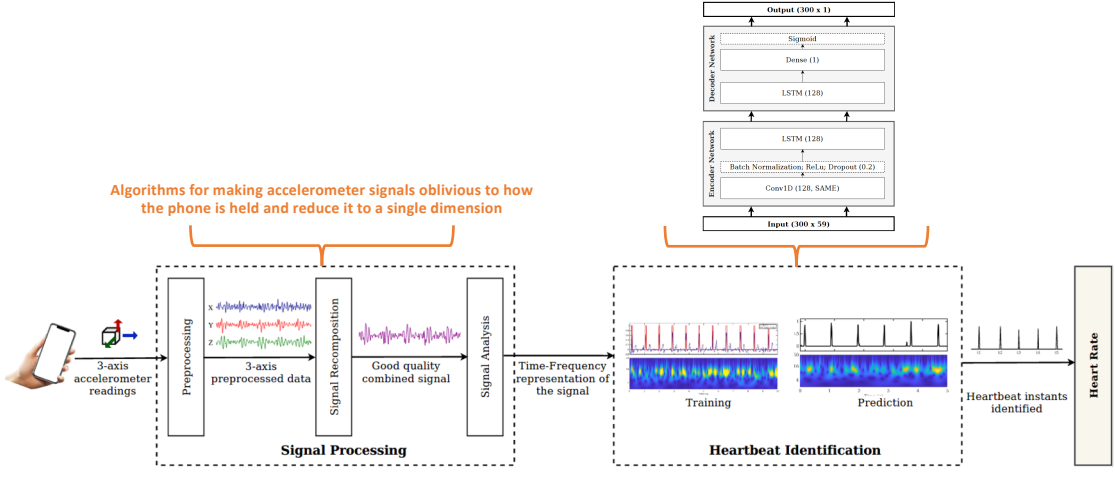
HandRate: Feasibility and challenges

- Smartphone accelerometers are able to sense very weak motions
  - Typical sensitivity value: 2 x 10^{-3} ms^{-2}
  - Peak average in our dataset: 9 x 10^{-2} ms^{-2}
  - noise level ~2 x 10^{-2} ms^{-2}



- But BCG signal acquired on hand can be of poor quality

HandRate Architecture



Performance

- 18 subjects, 22-52 years old
- Median errors of 2,92 and 2,06 bpm for HandRate-g and HandRate-p, respectively