Mobile Sensing: Course Goals, Organization, Policies and Sample Topics

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Instructor

- Dr Veljko Pejović
  - PhD in resource-efficient wireless networks (UCSB, USA)
  - Postdoc working on mobile sensing, human behaviour inference (Uni. Birmingham, UK)
  - Current projects and research interests:
    - Resource-efficient approximate mobile computing
    - Modelling user behaviour using mobile sensors (mostly security aspects)
  - Veljko.Pejovic@fri.uni-lj.si (“63545C” in the subj.)
    - Use Slack for questions of general interest

Teaching Assistant

- Dr Octavian Machidon
  - PhD on reconfigurable computing from Transilvania University of Brasov, Romania
  - Research on ubiquitous computing, embedded systems, and Web programming
  - Octavian.Machidon@fri.uni-lj.si
  - Your main point of contact for project-related questions!

Why Mobile Sensing?

You already have a computer science degree

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

$$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$$

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) e^{i\omega t} d\omega$$

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Smartphone Revolution 2008 -

Wearables Take Off 2010s -

Home Automation 2015ish -

Towards Metaverse 2020ish -

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Cyber-Physical World

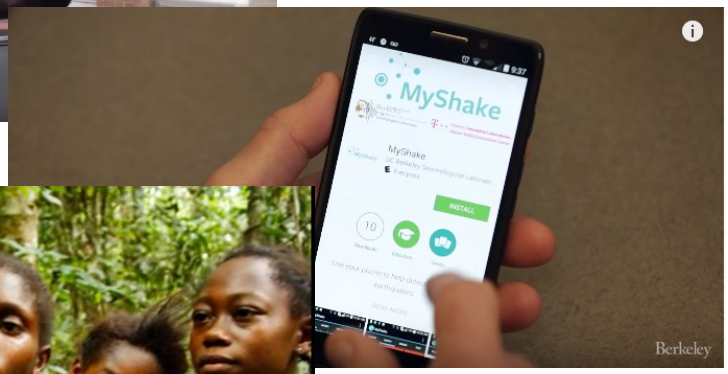
- Computing devices are getting rapidly integrated into our physical world
  - Smartphones (more than 6 bn of them in the world!) are very personal devices, carried by their users at all times
  - Wearable computing devices are in a constant physical contact with their users
  - Internet-of-Things (IoT) devices embedded in our everyday environment

Context-Aware Computers

- Computing devices (and systems) have evolved to the point where they can infer more about their surroundings and their users' needs
  - Devices are equipped with an array of sensors
  - Computing capabilities enable complex computation
  - Ubiquitous connectivity enables gathering of big data and, building and distribution of advanced machine learning models

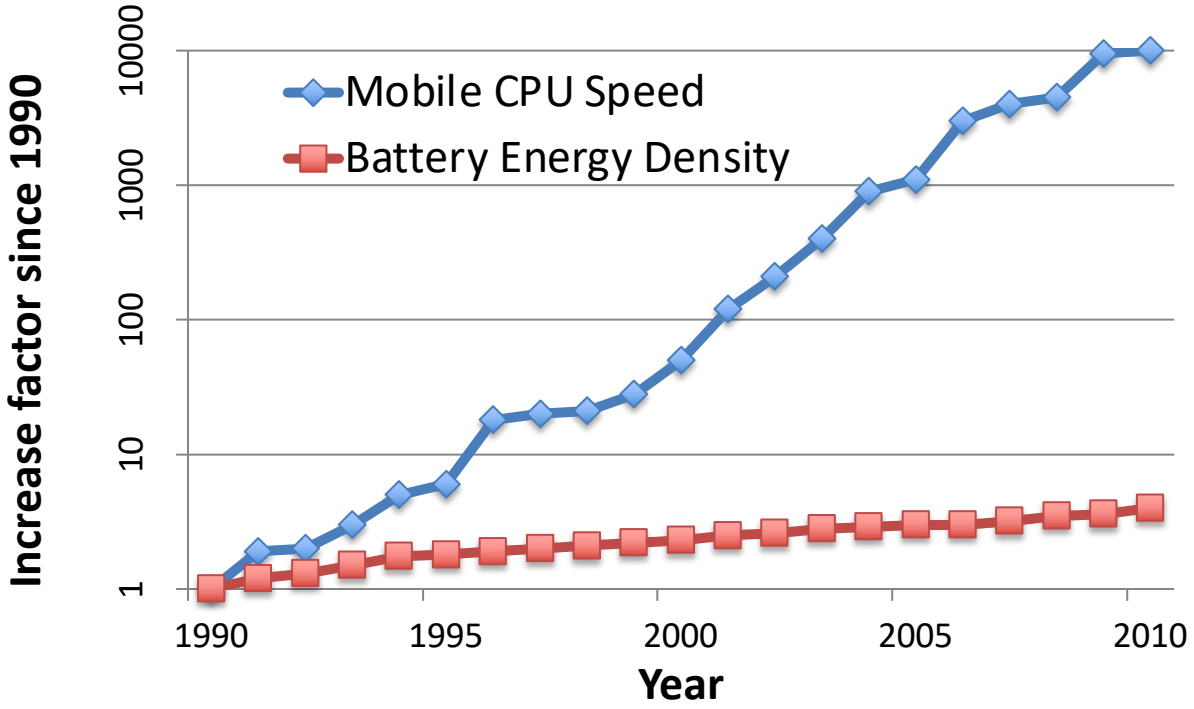
Novel Applications

- Health care
- Driving safety
- Earthquake sensing
- Environment monitoring



Challenges in Building Mobile Sensing Applications

- Cost of obtaining the data
  - Sensor sampling is energy hungry



Src: Niroomand, M., & Foroughi, H. R. (2016). A rotary electromagnetic microgenerator for energy harvesting from human motions. Journal of applied research and technology, 14(4), 259-267.

Challenges in Building Mobile Sensing Applications

- Quality of the sensed data
  - Noisy, affected by parameters beyond our control
  - One data stream reflecting multiple phenomena
    e.g. emotion detection via galvanic skin response, yet we sweat also because of:
    - Physical activity
    - Health
    - Outside temperature
    - etc.

Src: Gao, W., Emaminejad, S., Nyein, H. Y. Y., Challa, S., Chen, K., Peck, A., ... & Javey, A. (2016). Fully integrated wearable sensor arrays for multiplexed in situ perspiration analysis. Nature, 529(7587), 509-514.

Challenges in Building Mobile Sensing Applications

- Devising good machine learning models
  - Be familiar with recent advances in ML
  - Understand the application domain – are we sensing the right modality?
  - Implementing machine learning algorithms on resource constrained devices

Challenges in Building Mobile Sensing Applications

- User-oriented design
  - Human-Computer Interaction issues
    - Mark Weiser 1991: Interaction with ubiquitous computing devices should be like “a walk in the woods”
- Preserving privacy, security, ethics

Four major dating apps expose precise locations of 10 million users

Updated: In some countries, such lax security can be of real risk to a user's personal safety.

By Charlie Osborne for Zero Day | August 13, 2019 -- 10:04 GMT (11:04 BST) | Topic: Security

Challenges in Building Mobile Sensing Applications

- Doing all of this at scale
  - Big data gathering and mining
    - More data you have, better your models will be
  - Distributing computation across mobile devices and the infrastructure (cloud)

Course Goals

- Investigate the existing best practices and recent achievements in mobile sensing, so that future solutions for ongoing challenges can be invented

How do I build an application that recognizes users' emotions?

How often do I need to sample location in my trajectory prediction app?

Can I make online sign translation app faster?

I want my fitness wristband to recognize my aikido moves!

Course Approach

- Develop the understanding of the history and the direction in which mobile sensing is going
- Learn practical approaches to mobile sensing application development (focus on Android)
- Use the practical and theoretical knowledge to solve real-world mobile sensing problems (through a semester-long project)

Learning Outcomes

Course Outcomes

- After you successfully complete the course, you will be able to:
  - Present different mobile sensing domains and hardware/software solutions used in each of the domains;
  - List mobile sensing challenges and discuss the existing solutions in each of the challenge domains;
  - Understand mathematical foundations of signal sampling and filtering;
  - Using the existing tools, implement sensor sampling on a mobile computing device;

Course Outcomes

- After you successfully complete the course, you will be able to:
  - Construct machine learning models connecting raw sensed data and high-level inferences;
  - Construct own data processing pipeline for large-scale analysis of pre-collected mobile sensing data;
  - Analyze mobile sensing solutions in diverse domains, such as healthcare, location and trajectory modelling, wireless sensing, and security, among others;

Prerequisites

Programming

- Java or Kotlin programming is a must
- Android programming is a week 2 must
  - We expect that you have completed UL FRI's Platform Based Development or a similar course
  - Recommended: *Programming Mobile Applications for Android Handheld Systems: Part 1 and Part 2* on Coursera
- Machine learning basics
  - Andrew Ng's course on Coursera
  - The Elements of Statistical Learning by Hastie et al.

Course Components

Lectures

- Help you get a big picture
- Ask for clarifications
- Voice your opinion – discuss!
- Thursdays ∈ [10am – 3pm] at P19 or P03
- There is no comprehensive book for this class!
  - Slides and readings on Ucilnica
  - Take notes!

Paper Presentations

- Most of the lectures associated with one or more seminal/cutting-edge research papers from the area
- You will present these papers in the class (Thu)!
  - Everyone must present!
  - 25 min presentation + 20 min Q&A
  - Sign up for your slot
  - This is 10% of your grade!
  - Discussion participation also a part of your grade
- You must read the papers even if not presenting!

You need at least 50% of this grade to pass the course!

Lab Sessions

- On your own laptop/PC!
- Android programming
  - Ideally, have a physical Android phone with Lollipop (5.0) API 21 or higher
- For some labs you will need Python
- Lab communication via Slack #labs channel

Let us know now if you don't have one

Lab Sessions

- Completion mandatory
  - Via Bitbucket
    - Create private Bitbucket repos FRIMS2022-LAB-N (from 1 to 10)
    - Add PBDFRITA (pbdfrita@gmail.com) user as a read only member
  - Submit your solution for each lab in the appropriate repository strictly before the deadline
  - Graded ”pass”/”no pass”
  - Two jokers – you may fail to complete up to two labs

Mobile Sensing Project

- Implement a full-fledged mobile sensing application (in Android)
  - Sensing, machine learning, user interface, communication, data gathering, data storage, etc.
- Work in teams
  - Two member – predefined teams!
  - Individual contributions must be clearly stated
- Define a topic
  - Preselected ideas on Ucilnica
  - Something you are passionate about

Discuss your idea during mandatory office hours on Monday

Mobile Sensing Project

- Milestones:
  - **Project proposal** (due Feb 23rd v1 and Feb 28th v2) stating the motivation for the project, your approach, clear plan of attack with dates
  - **Mid-semester presentation** (Mar 31st)
    5 + 5 min presentation of the progress
  - **Final presentation and demo** (May 26th)
    Show us a working demo of your app, summarize your experiences, present evaluation results
  - **Final report** (May 27th)
    Six-page two-column report written as a workshop paper

Oral Exam

- If you successfully pass the coursework part you are invited to a mandatory oral exam
- Related to:
  - Lectures
  - Labs
  - Readings
  - Project work
- Closed book
- Practice questions at the end of the semester

Policies and grading

Final mark

- Lab completion: pass/no-pass
- Paper presentation 10% (must get 50% of that)
- Project 90% (must get 50% of that)
  - 10% Project proposal
  - 25% Midsemester presentation
  - 55% Final demo, presentation, and report
- Preliminary mark: M=ceil[total_score/10]
- Final mark: MF=max[M+E, 10]
  - E∈ {-1,0,1} is the oral exam mark

Policies

- Read the syllabus
- Subscribe to ucilnica and Slack
- Use English for course-related communication
- No cheating!
  - Cite any already existing ideas or technical solutions you use in your work
  - Do not copy code from elsewhere without citing the source
- No freeriding!
  - Clearly state contributions of each team member