Mobile Sensing (Spring 2021-2022)

Brief course description

The course investigates the use of sensors, embedded in mobile computation devices (e.g. smartphones, smartwatches, etc.), for understanding a user's context, modelling a user's behaviour, and devising novel applications based on the acquired information. The course covers *the historical, theoretical, and research ground* in order to help students understand modern mobile sensing approaches. Further, the course *equips students with tools for a practical realisation of mobile sensing.* The framework of choice is Android, the most popular mobile operating system. Within Android, the course investigates methods for one-off and periodic sensing of different sensors, data pre-processing, and on-device machine learning. Equipped with the theory, best practices, and the tools needed for application development, *the course empowers students to develop their own state-of-the-art mobile sensing solutions*. The solutions will be developed in small (two people) teams, will be continuously guided by the instructors, progress will be checked via two in-class presentations, and the final report, in the form of a workshop paper, will be written for each of the projects. Lectures are accompanied by labs, where students will implement theoretical concepts in practice. Certain labs will be based on the analysis of publicly available mobile sensing research datasets, some will cover Android programming concepts, while some labs will be focused on specific issues that emerge during the students' project development.

Learning Outcomes

After successfully completing the course, students should 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;
- Construct machine learning models connecting raw sensed data and high-level inferences;
- Analyze mobile sensing solutions in diverse domains, such as healthcare, location and trajectory modelling, wireless sensing, and security, among others;
- Construct their own data processing pipelines for large-scale analysis of pre-collected mobile sensing data.

Expected level of expertise

- **Java programming proficiency (mandatory).** Please do not take this course if you have no Java programming experience.
- **Android programming proficiency (mandatory starting from Week 2).** Prior experience in building Android applications is a must! We will not teach Android from scratch as we expect that you have taken UL FRI Platform Based Development or a similar course. In case you don't have suitable Android experience, **you must take care of learning Android fundamentals by yourself by the start of Week 2!** Courses, such as *Programming Mobile Applications for Android Handheld Systems: Part 1 and Part 2* on Coursera are appropriate for this.
- **Machine learning fundamentals.** We will use both conventional machine learning (e.g. SVM, Bayesian, Random Forest, etc.) as well as neural networks. We expect you to at least be familiar with conventional machine learning techniques. *The Elements of Statistical Learning* by Hastie et al. is a good introductory book.

Instructor

name: Veljko Pejović
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Teaching assistant

name: Octavian Machidon
email: Octavian.Machidon@fri.uni-lj.si (put “63545C” in the subject line; please use the course webpage for any questions that may be of general interest for people in the class)

Course meetings

	Lectures	**Lab sessions**	**Office hours Veljko**	**Office hours Octavian**
Time	Thursday 12:15pm - 3:00pm	Thursday 10:15pm - noon	Schedule via email	Schedule via email
Location	P19	P03	Schedule via email	Schedule via email

Resources

Course website	https://ucilnica.fri.uni-lj.si/course/view.php?id=101 NOTE: The course website is a main point for all the time-sensitive course information, for all class-related discussions, lecture and lab session materials, and for additional assigned readings. It is your responsibility to ensure that you are following updates from ucilnica.fri.uni-lj.si.
Communication	A Slack workspace **msfri2022.slack.com** is the main forum for discussing programming issues. Please sign up with your full name and add your picture to the profile! https://join.slack.com/t/slack-mvq4025/shared_invite/zt-12n97joaa-ihAB1J1IV9Uh0KZtIJvxfQ
Software and Hardware Requirements	*It is essential that you have a laptop or a PC with Android Studio installed!* *It is your responsibility to ensure that Android Studio is running properly - “it doesn’t compile/run on my computer” is not a valid excuse for an unfinished project.* Specific issues during use/installation can probably be solved with the help of https://developer.android.com/ and https://stackoverflow.com/ ; a dedicated Slack channel #android_env_setup is also available in case the above resources don’t help. In addition, *it is highly advisable that you have access to an Android phone* that you can use for programming and testing during the semester. The phone should be running Android Lollipop (5.0) or higher. This means pretty much any phone made in the last five years should do. If you don’t have a phone, please ask your friends/family for one (lots of older phones are collecting dust) *before the end of the first week of the semester*.

Tentative course outline

Week	Lectures	Labs	Readings/ Tasks
14.2 - 18.2	Course organization and rules. History of mobile sensing. Mobile sensing applications.	Mobile sensing project planning.	[ZPH19] and [LML+10] (but no presentations!) Project proposal v1 deadline 23.2.
21.2 - 25.2	Obtaining sensor data. Sampling fundamentals. Signal filtering.	AWARE framework	Project proposal v2 deadline 28.2.
28.2 - 4.3	Learning from sensor data. Machine learning pipeline. Libraries for ML on mobiles.	Python framework for data processing (part 1)	[MLF+08] Also: [RMM+11]
7.3 - 11.3	Advanced learning from sensor data. Deep learning fundamentals.	Python framework for data processing (part 2)	[OR16] Also: [NTA+18]
14.3 - 18.3	Deep neural networks on mobile devices.	TensorFlow Lite	[LBG+16] Also: [LBM+17]
21.3. - 25.3.	Health and wellbeing. Depression monitoring using mobile sensing. Digital behaviour change interventions.	Mandatory pre-presentation meetings	[HdW+20] Also: [WCC+14]
28.3. - 1.4.	Midsemester presentations!	Mandatory feedback lab	
4.4. - 8.4.	Physiological signal sampling and processing.	Obtaining physiological signals from a wearable device	[GLG+17] Also: [AAB16]
11.4. - 15.4.	Location sensing.	Geofencing lab part 1	[CTS+14] Also: [EP06]
18.4.- 22.4.	Markov chains for trajectory modelling.	Geofencing lab part 2	[LZL+17]
25.4. - 29.4.	No class - work on your projects	No labs - work on your projects	
2.5. - 6.5.	Voice sensing and processing. Emotion and stress inference from voice data.	TensorFlow for voice recognition	[LRC+12] Also: [RMM+10]

9.5. - 13.5.	Attention inference and notification management.	Notification management	[MPV+16] Also: [CHS+18]
16.5. - 20.5.	Guest lecture: Andraz Krasovec, Security, privacy and ethics in mobile sensing.	Last minute project check	[TLL+18] Also: [MHV+13]
23.5. - 27.5.	Final presentations!	Academic writing	Report due 27.5.

Blue - lectured by Veljko

Yellow - labs by Octavian

Purple - consultation labs

Green - you present!

Red - no class

Course components

Lectures	Lectures are essential to get a big picture of what you are learning in this course and why. In the lectures you will be presented with clear explanations of many (mobile and embedded) computing concepts that can be difficult to understand on your own. Moreover, a lot of the course material does not come from textbooks, which makes it difficult to organise by yourselves. You will be able to ask for clarifications and occasionally express your opinion on how the course is progressing, thus directly influence the amount of learning that happens in the class.
Paper presentations	We will read some seminal and cutting-edge research papers in this class. To make the content more approachable to everyone and to practice presentation skills each student will be assigned one class slot for a selected paper presentation. The presentation should be technical, to the point, and delivered smoothly. The presentation should take no more than 25 minutes and 20 minutes are reserved for Q&A. Note that more complex papers might be handled by two presenters. Reading the materials **before the class** is mandatory even if you are not scheduled to present a paper during the class. Moreover, the instructor might call you to comment on the readings during the Q&A session.
Lab Sessions	Lab sessions provide hands-on experience with advanced mobile sensing topics that we will experiment with in Android. Some lab sessions will be devoted to questions and problems related to your projects.
Mobile sensing project	The best way to understand a computer science concept is to implement it and test it. The course project lasts throughout the whole semester and requires you to implement a full-fledged mobile sensing app in Android. The application should involve user interfacing, sensing, data processing, remote communication, and other aspects we will learn about in the class. The course project lasts for the whole semester and requires you to 1) select a problem for which a solution is likely to be found within the course topics, and come up with a plan of building such a solution, 2) investigate the related work in the selected field, choose your approach towards solving the problem, and prototype

	one or more candidate solutions for the problem, or develop key pieces leading towards the solution, and finally 3) evaluate your solution(s) and share your findings from the problem formulation, investigation, solution development, and evaluation to a wider research audience. You can shape a project in a discussion with your instructor, or select from a set of sample topics. The project has to involve mobile sensing, it must not be a copy or a minor variation of a known solution, and it has to entail practical Android implementation. The project should be challenging enough to keep your team busy for a semester. Each project is done in teams of two people. Teams will be determined by the TA and the instructor. There are three milestones for the course projects. The first one is **the project proposal.** Once you decide on your project, you will be asked to write a short project proposal that should clearly state: ● the problem you are solving (along w/ background and related work); ● motivations (if this is your own idea) and challenges; why is this problem important and difficult? ● your proposed solution or approach and why it's new; ● your plan of attack with milestones and dates; ● any resources you might need so we can take care of this early on in the semester. The proposal should be 1-2 pages. The mark you get on the proposal will be a part of your overall project grade. Project proposals are submitted via the Ucilnica. Only one person per project team should submit, but the proposal should indicate the full names of all team members. Note that there will be two versions of the proposal. Proposal v1 will be due on the evening of **Wednesday 23.2.2022**. We will provide written feedback on the project proposals via email. Feel free to drop by during office hours to discuss and develop your project ideas further. Project v2 is the revised, more detailed and more thought-out version, to be submitted later the same week, on the evening of **Monday 28.2.2022.** The second milestone is **the mid-semester presentation**. Each project team will give a mid-semester progress presentation to the entire class in the **week of 28.3** Each presentation will give the audience a quick idea of the project motivations, approach to solving a problem, and current progress made by the team. Each presentation must not go over 5 minutes. With another 5 minutes reserved for Q&A after each presentation. The third milestone includes **the final project report and the final presentation with a demo.** The final project report should not exceed 6 two-column pages using 10pt fonts. The content should be similar to a research workshop publication. Make sure you include enough detail for a reader to understand all of your design and experimental evaluation decisions. Your final report is evaluated according to the same standards that one would review a paper submission for a top workshop. The report is due on **Friday 27.5.2022.** The presentations will be in class in **the last week of classes**, should show the progress made since the mid-semester presentation, and must demonstrate the project. No demo - no grade! The smoothest way to succeed in your project is to have a solid, realistic plan of work early on, to prepare an alternative in case your initial idea fails, to meet your instructors frequently and talk about issues that prevent your work from progressing, and to balance the work across all the team members.

Oral Exam	You will have a brief oral exam in the end. The exam questions will be very related to what has been taught in lectures and lab sessions. Note that relying solely on the material from the books might not be enough for you to successfully prepare for the exam. You will be given a set of practice questions near the end of the semester. The exam is a closed book one -- no textbooks or notes of any kind are allowed.

Marking

Course points are distributed as follows:

- 10% In-class paper presentation, including your discussion activity;
- 90% Class project (in parts of the total coursework):
    - 10% Project proposal
    - 25% Mid-semester presentation
    - 55% Final demo, presentation and report

if you don't do well on the project -- you cannot pass the course!

To pass the course you need to collect at least half of the in-class paper presentation points and half of the class project points. If you fulfil the above conditions, your preliminary final mark is calculated as $M = ceil(P/10)$ where M is the mark, P the number of points you've got (0-100), and *ceil()* is an integer ceiling function. If M is greater or equal to 6, you are invited for the mandatory oral exam. **The oral exam** can lead to one of the following outcomes for your final mark: M-1, M, or M+1, depending on the quality of your answers.

Policies

Plagiarism and cheating	Cooperative work is an important part of learning; you are encouraged to study together, discuss the lectures, and discuss the software solutions. However, DO NOT: ● turn in duplicate work (no matter how small the shared part is) ● copy work (even one line) from another team's project or from a published source without citing the original material; ● have anyone else but the team members contribute to your project In addition: ● Clearly state contributions of each team member in the final report Finally, anyone caught breaching the above guidelines will fail the course. The University of Ljubljana policy on academic honesty can be found here: http://www.uni-lj.si/o_univerzi_v_ljubljani/organizacija__pravilniki_in_porocila/predpisi_statut_ul_in_pravilniki/20130712144206 51/ (in Slovenian, but Google translate does a good job in translating it to English). Cheating is considered a major breach of policy and can result in a suspension from the University. Finally, if you are struggling with the course and need help, contact the instructor or the TA and we will do all that we can to help, including meeting outside of regular office hours if need be, just DO NOT CHEAT.
Project work	The project is to be done in teams. However, that doesn't mean you should not discuss issues with your class peers. Feel free to use Ucilnica forum for that.
Lab requirements	The labs are mandatory and have to be submitted via BitBucket by the stated deadline. You have two **jokers** that you can use in place of two lab assignments. If you fail to complete two or more labs you fail the class.

Attendance	You must attend your classmates' paper presentations. You have additional **two jokers** for paper presentation attendance. If you fail to attend two or more paper presentations you fail the class. All team members must attend and present at the midterm and final presentation. In addition, you must take the oral exam, if eligible for it. There is only one exam per exam period, there are no make-up exams outside the scheduled periods.

Students with Disabilities

If you are a student with a disability and would like to discuss special academic accommodations, please contact the instructor. In addition, the University of Ljubljana has adopted special guidelines regarding university procedures and the study process itself to ensure special needs students have equal rights and access to public information. Please contact Helena Zupan (phone: 01 476 81 80, e-mail: helena.zupan@fri.uni-lj.si) who is in charge of handling such needs at FRI.

Disclaimer

The lecturer reserves the right to modify course content within the boundaries of the accredited programme.