Mobile and Ubiquitous Computing (Fall 2015)

Brief course description

Mobile computing devices such as smartphones revolutionised the way in which we nowadays communicate and find information. In addition, these devices equipped with sensors that enable the inference of the surrounding context, including the position, activity, and the environment of the user. The aim of this course is to introduce students to mobile communication and sensing systems based on the above devices. The emphasis is on developing deeper understanding of the functioning of mobile wireless networks, mobile sensing, pervasive computing and applications of mobile systems. The course examines these systems both from a technical perspective, as well as in terms of interdisciplinary applications, thus touches upon machine learning, computer network analysis, and healthcare. Students are introduced to development tools and techniques for building mobile systems and their understanding is reinforced through practical work in the Android OS.

Expected level of expertise

- **Undergraduate computer communication networks.** This can be acquired through Computer Communications (http://www.fri.uni-lj.si/en/education/8626/class.html) course taught as an undergraduate course at FRI, or through similar courses available elsewhere.
- **Solid programming proficiency.** The class project will include **a lot of programming**! Java will be used for Android programming, while for data processing you might use a language of your choice. However, Python is probably the most widely applicable across all topics. Certain projects require a basic knowledge of database access.

Instructors

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Course meetings

	Lectures	**Lab sessions**	**Office hours Veljko**	**Office hours Fabio**
Time	M 9-12	W 14-16	W 12-13	T 11-12
Location	PR06	PR17	Rm 3.15	TBD

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.
Textbooks	The course discusses emerging topics and is not covered by a single textbook. The following represent recommended (but not required) readings for the course: ● Schiller, J. H. (2003). Mobile communications. Pearson Education. ● Schwartz, M. (2004). Mobile wireless communications. Cambridge University Press. ● Agrawal, D. & Zheng, Q. (2006). Introduction to wireless and mobile systems. Thomson. ● Murphy, M. L. (2008). The busy coder's guide to Android development. United States: CommonsWare, 2008. In addition, some lectures will be based on seminal papers from the corresponding area.

Full course description

The course introduces students to mobile communication and sensing systems. The course explores unique properties of mobile computing, not looking at it as a special case of conventional computing, but concentrating on key affordances of the new platform.

The first affordance is **mobile wireless connectivity**. The course refreshes students' knowledge of wireless transmission, channel properties, reasoning in spectrum-time-space domains. Then, it discusses general multiuser wireless issues such as channel selection and multiple access strategies. The smartphone, as the most ubiquitous personal computing device, is the platform of choice for the course, and WiFi and Bluetooth communication is particularly thoroughly covered in the course. Then wide-area coverage via cellular networks is covered, with an emphasis on radio resource assignment and the evolution of cellular networks all the way up to 5G. Recently, big data collected by mobile operators got used in various domains from disease tracking to transport network optimisation. This course introduces big network data analysis as well.

The second main affordance of the new platform is **mobile multimodal sensing**. Nowadays, smartphones can tell if their user is sleeping, jogging, at home or at work, even whether she is depressed or not. The road to these inferences goes over raw samples coming from phone's sensing hardware (e.g. accelerometer, GPS, microphone), and processing these samples with the help of machine learning. The course pays a special attention to challenges associated with mobile sensing, such as the need for intelligent sampling strategies that preserve battery charge while inferring the most out of the environment, and the problem of sharing raw-sample to high-level inference models across variably behaving populations (e.g. accelerometer samples of a 80 year old person walking are different than accelerometer samples of a 9 year old person walking). Finally, multimodal sampling opens up an endless horizon of applications, and the course particularly concentrates on novel healthcare and smart city applications.

The mobile phone is an excellent platform for a quick dissemination of innovative computer science work. Application stores let a programmer reach out to billions of potential users. The first part of Mobile and Ubiquitous Computing course features a crash course in Android. The basics of programming for this specific OS, together with the best practices in designing an interface for these input and output

limited devices are taught. The emphasis is then put on Android's communication and sensing tasks, and advanced concepts, such as on-device machine learning are covered. The learning is facilitated through a series of exercises. Finally, teams of students get to build their own mobile sensing application in Android, and are guided through the complete process of envisioning, planning, developing, testing and disseminating their work.

Course goals

On completing the course, the students should be able to:

- List mobile wireless communication technologies and explain their functioning.
- Explain the fundamental tradeoffs related to resource limitations and communication needs in mobile communication and sensing systems.
- Demonstrate an understanding of the range of novel applications based upon mobile systems as well as their particular requirements.
- Demonstrate practical skills in developing mobile sensing applications.

Tentative course outline

Week	Lectures	Labs	Notes
5.10 - 9.10	Introduction, Evolution of mobile computing systems, Affordances of mobile systems (ubiquitous connectivity, personalisation, context-awareness), Constraints of the mobile platform (wireless quality, battery limitations, UI limitations, sensing accuracy). Android platform basics, Dalvik virtual machine.	Android development environment. Installing and setting up the environment. Working with dalvik VM. Hello world application. Running the emulator. Inserting debug messages.	
12.10. - 16.10.	Android programming - Android Framework, Application structure, Manifest file, Application look and feel, Systems, Managers, Providers, Android Activity, Task back stack, Intents, Concurrency via AsyncTasks, Services.	Activities, Services, Broadcast receivers, AsyncTask. Activity lifecycle. Activity method call debugging. Saving the activity state. Invocation via Intents. Resource management: XML resources, accessing through Java.	Project proposal v1 due 12.10. v2 due 18.10.
19.10. - 23.10.	Android programming - UI components, Layouts, NotificationManager, Listeners	Android UI components: Fragments, ActionBar, Buttons, Groups, Dialogs, Layouts, SettingsFragment. GoogleMap in Android.	
26.10. - 30.10.	Android programming - Sensor sampling, Best practices in sensing, Sensing position, activity, environment.	Sensing in Android: LocationManager, Accelerometer sampling. Spawning a sensing	HW 1 due (user profile,

		AsyncTask. GooglePlayServices for sensing. Machine learning library.	user interface)
2.11. - 6.11.	Overview of wireless and mobile networks - large infrastructure networks 2G-5G, Enterprise WLAN, Home WLAN, Ad-hoc networks, Wireless sensor networks (WSNs), Delay-tolerant networking.	Communication management in Android. Java sockets. Data transfer with Android. Parcelable. Intent for result. Data Storage (SharedPreferences, SD card, SQlite). Google App Engine.	
9.11.- 13.11.	Wireless fundamentals revisited: Structure and functions of transmitter and receiver, characteristics of the modulated signal (spectral bandwidth, frequency, power), channel characteristics (attenuation, multipath, interference, unpredictability and the consequences), reasoning in space-time-spectrum domains.	ConnectivityManager class. WiFi connection sensing in Android. Gathering and analysing link quality metrics.	HW 2 due (store and send to google maps)
16.11. - 20.11.	Wireless fundamentals revisited: power control, channel selection and allocation, multiple access strategies (centralized scheduling vs. distributed MAC), critical review of CSMA/CA.	Consultation lab for the mid-semster presentation preparation	HW 3 due (sense WiFi, notify of high quality free APs)
23.11. - 27.11.	Mid-semester presentations	Case study: Android software-defined radio	10 mins each
30.11. - 4.12.	Local-area wireless interfaces on smartphones: details of IEEE 802.11 (infrastructure-based and ad-hoc mesh networks) and Bluetooth.	No class: conference trip.	
7.12. - 11.12.	Wide-area mobile networks: introduction to cellular infrastructure. Principles and evolution of radio interface and network architecture from 2G to 5G. Trade-off between “capacity” and infrastructure density. Principle of multi-layer multi-technology radio coverages.	Sensing infrastructure networks: type of connectivity, connectivity quality, geotagged data. SignalTracker and OpenSignal case studies.	
14.12. - 18.12.	Wide-area mobile networks: overview of radio resource assignment principles and	Wireless traffic analysis from large scale data sets. Call data record	

	mobility management. Impact of large-scale M2M traffic onto the infrastructure. Network-based data: CDR, VLR, signaling databases. Characteristics of network-based data: bias, population coverage, spatial accuracy, etc. Privacy aspects. Relation and differences between network-based data and mobile-based data.	analysis. Recognising patterns in the collected data.	
21.12. - 25.12.	Mobile sensing strategies: Trade-off between knowledge discovery and resource usage, Sampling frequency adjustment strategies.	Advanced sensing in Android: Sensing libraries, Sampling strategies, Resource usage measurements: energy, memory, CPU.	HW 4 due (report on trace analysis with WEKA)
28.12. - 1.1.	No class: Happy Holidays!	No class: Happy Holidays!	
4.1. - 8.1.	Sensor data processing: Local processing, Cloud processing,Hybrid strategies. Machine learning for mobile sensing: Feature extraction, Classification, High-level property inference and prediction.	Machine learning on Android phones: Case study - InterruptMe.	
11.1. - 15.1.	Applications of mobile sensing: Healthcare and wellbeing, Smart cities, Ethics and privacy in mobile sensing research.	Consultation lab for the final presentation preparation	
18.1. - 22.1.	Final project presentations	No class: work on your final report	15 mins each; Report due 22.1.

Blue - lectured by Veljko

Yellow - lectured by Fabio

Green - class presentations

Red - no class

Course components

Lectures	Lectures are essential to get a big picture of what you are learning about in this course and why. In the lectures you will be presented clear explanations of many mobile computing concepts that can be very hard 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. The attendance is mandatory (more about that in the course policies).
Homework	Homework assignments serve to help reinforce what you have learned during the lectures. They are tightly connected to the material covered in the lab sessions. You will be given a number of assignments throughout the semester. Assignments have to be submitted before their respective deadlines (see course website for details). You may not collaborate with others (not even your project partners) on homework assignments.
Lab Sessions	Lab sessions provide hands-on experience with Android and, wireless and sensor data analysis. During lab sessions we will introduce homework assignments, that you will later finish individually (see above). Some lab sessions will be devoted to questions and problems related to your final course projects.
Course project	The best way to understand a computer science concept is to implement it and test it. 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, but please be at least vaguely aware of the area you want to work in. The project has to be related to the topic of mobile and ubiquitous computing, 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 or three people. 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 one page 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, and ● 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 course website. Only one person per project team should submit, but the proposal should indicate full names of all other project team members.

	Note that there will be two versions of the proposal. Proposal v1 will be due on the evening of **Monday 12.10.2015**. 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 **Sunday 18.10.2015.** The second milestone is **the mid-semester presentation**. Each project team will give a mid-semester progress presentation to the entire class on **Monday 23.11.2015.** 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. The total presentation will be roughly 10 minutes (this number might change depending on the number of final project teams formed). The third milestone includes **the final project report and the final presentation.** 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 22.1.2016.** The presentations will be in class on **Monday 18.1.2016.**, and should show the progress made since the mid-semester presentation, and the conclusions of your project. 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.
Exam	You will have a written final exam in the end. The exam questions will be very related to what has been taught in class 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 practice exam near to the end of the semester. The exam is a closed book one -- no textbooks, or notes of any kind are allowed.
Quizzes	Occasional quizzes throughout the semester will provide you with early feedback about your strong and weak points and will help you prepare for the final exam. These quizzes will be posted online, will not be marked, but are mandatory.
Readings	Some lectures will have reading materials assigned to them. This will be either from the books or auxiliary materials posted on the course webpage. Reading the materials **before the class** is mandatory, and will greatly help with understanding the topics taught.

Marking

Course points are distributed as follows:

- 50% Coursework, out of which:
    - 10% Homework assignments (there will be a number of assignments so the points will be divided among them);
    - 90% Class project, out of which:
        - 15% Project proposal
        - 35% Mid-semester presentation

        - 50% Final presentation and report
- 50% Final exam

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

To pass the course you need to collect at least a half of the coursework project points and at least a half of the final exam points.

If you fulfil the above condition, the end mark will depend on your aggregate course completion percentage according to the following formula: $M = ceil(P/10)$ where M is the final mark, P the number of points you've got (0-100), and *ceil()* is an integer ceiling function.

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. With the exception of your project, DO NOT: ● turn in duplicate work (no matter how small the shared part is) ● copy work (even one line) from another student's assignment or from a published source without citing the original material ● lend another student your assignment or look at someone else's assignment to fix your problem ● e-mail or transfer any of your homework solutions to another student or store your solutions on a computer to which another student in the class has access. In addition, anyone caught cheating on the final exam 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). Note that cheating on the exam 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	In project work you are encouraged to collaborate, because this is what happens in the real world. However, we still need to evaluate your performance. It is your responsibility to make sure that each of the team members puts equal amount of effort into the project. You will be given a single grade for your project, and if your partner is slacking off - you will bear consequences, just like in a real company. Note, however, that we mentioned effort - we know that not all of you come with the same previous knowledge of computer science and that will be taken into account. Yet, everyone is expected to try hard. Through the project you will also develop skills that are necessary for team-work: managing and motivating your team mates, dividing tasks, etc. Please talk to your instructor or TA as soon as you spot problems in your team and we will help you sort them out.
Attendance	Attendance is required at all lectures and labs. The attendance is checked via sign up sheets. Therefore: you must sign in every time, and you may not sign in on behalf of another student, or ask someone else to sign in for you. In addition, you must take exams. There is only one exam per exam period, there are no make-up exams outside the scheduled periods.
Online course materials	A few books are suggested among resources, and you are encouraged to read them, however, there is no mandatory textbook for the course. On the other hand,

	the course webpage will feature papers and links to texts that you should consider mandatory, and that contain highly relevant content (that can be asked in the exam). Please respect the authors and copyright holders, as well as the applicable laws, by not distributing the materials further, either online or offline. This holds for all the materials (presentation slides, articles, book chapters, etc.) on the course webpage.

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 for handling such needs at FRI.

Acknowledgements

This course is based on the following courses taught elsewhere:

- CS65: Smartphone Programming, by Andrew Campbell, Dartmouth College, USA
- Programming Mobile Applications for Android Handheld Systems, by Adam Porter, University of Maryland College Park
- CS284: Mobile Computing, by Elizabeth Belding, University of California, Santa Barbara, USA
- Mobile and Ubiquitous Computing, by Mirco Musolesi, University of Birmingham, UK