EE4.67 – Mobile Healthcare and Machine Learning
Coursework Description (Jan->Mar 2019)
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Introduction: For the EE4.67 module, you are required to **design** a mobile healthcare system of your choice, **implement** the required hardware and software components of your system, and **evaluate** it with human users. You will do so in groups of ~6 students, and present the results on the last lecture of the 2nd term, 9am-11am, Wednesday 13th of Mar 2019.

Logistics: There are two routes to project allocation; you can self-organize in groups of ~6 students, and inform me of the group composition (names and degree/department registrations) by the 2nd lecture (16 Jan 2019; but **strongly suggested to be earlier**); 5-6 groups are expected for the current registered class list but this might change as people register/de-register from the course. Alternatively, students that do not find a group by the 2nd lecture should contact me at the end of that lecture so I can assign them to one of the formed groups. Depending on the topic of your selected project, you should aim for a balance of computing and electronics expertise among your group. Think carefully before you aim for significant construction of **new** hardware, you do not have much time for it!

Deciding on a project: while technical competence during the implementation stages of this project is important, and will form a very significant part of the final grade, a properly formulated experimental hypothesis, a principled design, and a structured evaluation with human users also form a crucial part of this project. A number of potential projects will be suggested at the end of lecture 1 to get your minds working along the right tracks, but I want to also allow for creative ideas coming from students. You are encouraged to discuss with me any potential ideas as soon as possible after the formation and first brainstorming session of your group to verify suitability and feasibility of your idea within the time frame.

Calendar and deliverables [there will be no extensions – all deadlines at 17:00 of corresponding dates]; a number of advisory steps are included to give an idea to each group on whether they should be at this stage. See further details for each deliverable at the end of this document.

- **16 Jan 2019:** Deadline for formation of groups; please note that although this is the deadline, you are strongly encouraged to form a group as soon as possible before this deadline so you can start working on your project. Time will be allowed before the end of the lecture on the 16th for groups to discuss their ideas with the lecturer and GTAs.
- **[Advisory]** 16 Jan 2019 **- Individual skills confirmation**. Individual students should have performed a diagnostic Self-Test (details below) to confirm that they have the minimal skills to take this course.
- **[Advisory]** 23 Jan 2019 - **Project feasibility confirmation**. The group has made firm decision regarding the application area, and has installed and tested the development tools for the hardware and software required to make their system work. It is advised to have *a mock-up version* of the healthcare system at this point (for example writing test stubs for the various functions, and/or displaying the raw signals from sensors, etc).

- **[Group Deliverable 1] 30th of January 2019 [5pm]:** Design report, describing your target system, its proposed electronic and software components, the overall system design, and your proposed experimental validation methodology; you should include any preliminary implementation work you have made so far (you should aim to have done some preliminary implementation work by then). You should not exceed 4 double column pages, including bibliography, and all related information. **[20% of coursework mark].**

- ***[Individual]: 20 Feb 2019, 5pm*: [*Individual Demo*] Individual demonstration of the first version of the subcomponent of the system that (s)he is responsible for (e.g. signal processing, machine learning, action selection, hardware...), showing what progress has been done so far on this component. **[20% of coursework mark]**
    - *A bonus of 5% will be given to ALL marks if the group also demonstrates that ALL subcomponents have been integrated in a preliminary integrated system*.

- [Advisory] 27 Feb 2019 [Group] - **First demonstration.** Demonstration of first integrated system in class; short presentations by each group and class discussion. At this stage, if you do not have an integrated system to demonstrate (even if fine-tuning and evaluation is still needed), you are falling behind!
- ***13 Mar 2019*** **[Group/Individual]** A presentation and a live demonstration of your healthcare system on the last lecture slot of term. You must demonstrate any aspects of your research claimed in your report. I and my GTAs will also ask detailed questions on each of the component systems to the corresponding team member.
- ***20 Mar 2019*** **[Group] [60% of coursework mark, together with the demonstration**]. Final submission consisting of:
    - A research report describing the experimental findings of the system. This should incorporate the final version of your design, description of its technical components, as well as an analysis of the experimental results with the human users. I reinforce that your report should be **written as a research report**, (i.e. there is no need for details on how the group was managed, any chronological or other administrative aspects of your work), **not exceeding 8 double column pages**, including all information.
    - A pointer to an accessible github repository with all schematics, software, datasheets, experimental results files, supplementary figures etc, along with a detailed README file explaining the contents. In theory, this should allow a future group to pick up the research from where you left it and move it forward.
    - [Optionally]: A video describing the hypothesis, experimental findings, and typical use cases of your system. A bonus of 5% will be given for a usable video that I can use for future teaching/demonstration purposes.

Resources

You will have access to a range of computing and sensor resources as described in the lectures, including laptops, mobile phones and a variety of sensors (e.g. NXP Quickjack

interface boards, TI sensortag sensors, multiple cameras etc). The departmental electronics workshop can support with custom circuits if needed, but you should take the corresponding lead times into consideration when planning your project. Acquisition of new hardware is possible if justified and not too expensive, but you should let the lecturer or GTAs **as soon as possible**, so they can get it in time for you!

Support

There are three graduate teaching assistants (GTAs) for this course, who can provide technical support with the equipment above, as well as advice on the design and implementation of your system, and its medical applications. A forum will be in operation on Imperial's blackboard VLE system to ask questions and share problems/solutions.

Any questions should be directed to Professor Yiannis Demiris, y.demiris@imperial.ac.uk. Answers will be shared [anonymously] with all groups.

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Additional Coursework Content Information

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There are **three** pieces of coursework associated to this course, as well as a system demonstration session during the last week of the term, where you will need to demonstrate your healthcare system and answer questions about its design, internals, and operation. The first and last report are group submissions, while the second one (individual component demonstration) is individual.

The length of the reports/"papers" to be written is intentionally kept low (4 pages for the first, and 8 pages for the final result) to encourage concise thinking of content, and focus on the technical rather than reporting aspects.

[0] Diagnostic Self-Test [Individual]

It is strongly suggested that students do a self-test to check whether their software skills are up to scratch for this course. Here is what is recommended to do before the second lecture has commenced:

- Decide which app development platform you would prefer to use – for example iOS, Android, Microsoft or other (or cross-platform if you feel particularly ambitious). There is no preference imposed to you from the professor or GTAs of this course.
- Download and install the corresponding development environment. For example, for iOS it could be Xcode, for Android it could be Android Studio, etc. There are plenty of online tutorials directly from the developers of these platforms for you to follow, so there is no need for this course to replicate them.
- Create a simple app that displays "Hello World" on the smartphone screen, which disappears either when you click on a menu button on the screen, or if you shake the smartphone.
- Install the app on your phone and test it to satisfy yourself that it works.
- Use github to put your code online – ask a member of your group to download and use your code, and do the same for him/her

If you cannot do this by the 2nd lecture, or struggle considerably (this task takes you more than 2-3 hours), you might want to re-consider your decision to take this course.

[1] Design Report [Group submission]

Your design report counts for 20% of your course mark. Your report should be 4 pages in double column format, and cover the following points:

- Introduction: what healthcare system are you designing and what is its purpose? What is the hypothesis (-es) that you will be testing regarding its performance, and associated human factors?
- Who else has done similar work (Literature and market survey)?
- Outline of your design, explaining design choices (e.g. sensors, communication infrastructure, intended functionality etc), and justification for your selected design. Describe any initial implementation.
- Outline of your planned experiments, paying particular emphasis on your initial thoughts of how you will evaluate the design, and confirm/disprove your initial hypothesis.

A number of survey papers have been uploaded on Blackboard VLE.

This design report will also form part of the full "research paper" you will be writing at the end of the course (see below). This initial report is not binding, meaning that you can change parts of it when they do not prove useful during the experiments. But good design and good preparation now will certainly save you time on the final report.

[2] Individual component demonstration [Individual assessment]

By the end of the previous deliverable (the design report), you will have already assigned individual roles to each member of your group (for example, signal processing, computer vision, data encryption and privacy, action selection, etc) - the individual component demonstration is meant to get each of you to demonstrate that:

- You thought about the design of your component, what information you are expecting from other components of the overall system, and what information you will be providing.
- You have implemented one or more alternatives
- You can successfully run a basic form of your component, and produce verifiable results.
- Additionally, if the group as a whole has managed to integrate ALL the components from all the group members, and is able to demonstrate that, every individual mark will receive 5% bonus.

[3] Final Project Report [Group submission]

Your final report should be 8 pages, double-column, single spaced, which counts for 60% of your grade. All information including bibliography, diagrams, etc should be included in these 8 pages. Do not exceed this limit!

The style of the final deliverable should be that of a research paper; there is NO NEED for management descriptions, team decompositions, how you spent your time or anything like that. Concentrate on telling the research community what was the essence of the research you did in a professional manner.

You should have the following sections at least:

- Abstract: a quick summary introduction of the problem or hypothesis and the results of your work; in most cases, this is all that is available to a researcher looking at your entry in a bibliographic database, and you want him/her to be excited enough to want to download read the rest of your paper.
- Introduction: motivate the problem you are trying to solve -- use facts, references, numbers, to justify the need for your solution. What is your hypothesis that you are trying to test through the construction of your system and its evaluation with human users?
- Background: a literature review on the various aspects of your problem/ hypothesis/system/solution. Who else is doing what you are doing and how you differ from them? In what ways are you advancing the state of the art (if any), or are confirming results first found by others? (that’s fine too, replicating research findings is essential in science and engineering). You can re-use material from the individual background reports.
- System design: describe the overall design of your system, explain design

alternatives, metrics for evaluating alternatives, your decisions, and justifications. Borrow as much as you want from the design report you did in the beginning.
- Experimental setup & methodology: details of your experiments; system & environmental setup, initialization, calibration, description of control/baseline user groups, experimental protocols.
- Results: experimental findings using your systems with users. Details of number of users, evaluations of subcomponents/whole system, statistical tests.
- Discussion: explanation of your results, interesting issues that arise from your work
- Conclusions / future work: what other experiments need to be done, should be done to confirm/disprove this or subsequent hypotheses.
- Bibliography: list of references of material used, papers you refer to in the text etc. Include complete bibliographic information for each paper.

A final note on this report: in this course I try to emphasize the experimental, research nature of a young and cutting-edge field such as Mobile Healthcare & Machine Learning. Most of the projects you are working on might be unique and not have any equal. You should report your findings having in your mind the scientific community ("We discovered that humans tend to do X when interacting with our system", "multimodal communication was more effective than single-mode communication"), so think of me as a fellow scientist, not a "grader". Focus on system evaluation and results, not housekeeping information.

Demonstration/Oral Examination [Group]

You are also expected to do a final presentation demonstration of your system, as part of the grade of the final report. This will take place during the last week of the term, during the last lecture – the length of the presentation will depend on how many projects we end up with, but it will probably be maximum of 20 minutes. During the presentation and demonstration (all group members are required to attend), you will need to:

- Demonstrate the functionality of the system, with one of you as a "typical user". I want one of you to be the user, to allow for a "best-case" demonstration of your system. If your demo requires outside functionality (for example needs a GPS signal), you are welcome to stage the demo as you wish, in any location that you wish (hopefully within/close to the EEE department, so I don't have to rush between multiple group demos, but fine if is somewhere else due to the particular application domain; we might to have to schedule an alternative time if it gets too complicated logistically).
- Allow me to use the system as a user (the "average case" demonstration of your system) so I can get first hand experience of its capabilities.
- Answer any questions I might have regarding the design decisions, the evaluation results, the contribution of individual members on the final result, or anything else.

Video [Group submission, Optional]

Any report that is accompanied by a self-contained interesting video of your system (for example, an introduction to your system with examples of users using it) along with interesting technical details, will receive UP to 5% bonus marks, depending on whether I can use it for educational purposes in subsequent years. You should not rely on the video to explain the report, or vice-versa; both should be able to stand on their own. Do not make the video longer than it needs to be in order to explain the concepts and your findings. Do not use copyrighted material (background music for example) in your videos, so we can potentially post them on the department's social media feeds.

For further information, contact Professor Demiris at y.demiris@imperial.ac.uk or of course after the lectures.