EE4.60 - Human Centered Robotics
Coursework Description (Oct->Dec 2016)

Introduction: For the EE4.60 module, you are required to **design** an interactive robot of your choice to test a research hypothesis, **implement** the required hardware and software components of your system, and **evaluate** it with human users. You will do so in groups of 4-5 students, and present the results on the last lecture of the 1st term, 14:00-16:00, Thursday 15th of Dec 2016.

Logistics: There are two routes to project allocation; you can self-organize in groups of 4-5 students, and inform me of the group composition (names, emails and degree registrations) by the 3rd lecture at the latest (20th Oct 2016; but **it is strongly suggested that you start much earlier, strongly advised to be ready by the second lecture**); 4 groups are expected for the current registered class list but this might change as people register/de-register from the course. Students that do not find a group by the 3rd 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, electronics, and mechanical design 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 were suggested at the end of lecture 1 (see below) to get your minds working along the right tracks, but I want to also allow for creative and imaginative 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.

For those of you that do not have any particular group preferences, five projects that are suggested at the end of the lectures were:

- **[1] A smart robotic wheelchair for people with disabilities**
- **[2] A humanoid robot that assists people to dress**
- **[3] The BaristaBot (Coffee making and serving robot)**
- **[4] The robotic rEEEceptionist**
- **[5] The Robot co-DJ (musical interaction with the robot)**

Deliverables [there will be no extensions; all submissions are 5pm on the day]:

- **20 Oct 2016: Deadline for formation of groups**
- ***3 Nov 2016*: [Group**] Design report, describing your research hypothesis, the proposed morphological, electronic and software components of your system, and your proposed experimental validation methodology. You should not exceed 4 double column pages. **[20% of coursework mark].**

- ***17 Nov 2016*: [*Individual*] Individual component paper: each member of the team will have to report the state of the art in the subcomponent of the system that (s)he is responsible for, and present the design to be followed for that subcomponent (e.g. speech recognition, navigation…). This should also not exceed 4 double column pages **[20% of coursework mark]**
- ***15 Dec 2016* [Group/Individual]** A live demonstration of your robotic system on the last HCR lecture slot of term, where I personally will serve as a subject for your experiment. You must demonstrate any aspects of your research claimed in your report. I will also ask detailed questions on each of the component systems to the corresponding team member.
- **22 Dec 2016 [Group] [60% of coursework mark**]. Final submission consisting of:
    - A research paper, essentially the experimental findings report. This should incorporate the final implemented version of your design, as well as an analysis of the experimental results with the human users. I reinforce that your report should be **written as a research paper**, not exceeding 8 double column pages. Examples of the format, style, and content of this report will have been placed on Imperial's HCR blackboard system.
    - A compressed file 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 the research equipment of the Personal Robotics Laboratory for the duration of your project. Depending on the requirements of your project, you can utilize the Baxter Humanoid Robot, two robotic wheelchairs, two ActivMedia Peoplebot platforms, one or more of the 10 Pioneer P3ATs with embedded computers, laptops, front and back sonars, laser scanners, and Kinect RGB-D cameras. Serious groups with suitably excellent ideas can potentially use the icub humanoid robot, or one or more of the NAO humanoid robots, although this will probably involve more committment (these robots are more complex). A motion capture system with 8 cameras is also available to you. You also have access to the Falcon Novint and Sensable Omni haptic interfaces, as well as a variety of tablet PCs, touch pads, single and stereo cameras. The department's mechanical workshop can assist with the construction of custom morphologies using these robots, while the departmental electronics workshop can support with custom circuits. Acquisition of new hardware is possible if justified and not too expensive.

Support

There are two graduate teaching assistants (Josh Elsdon and Mark Zolotas) for this course, who can provide technical support with the equipment above.

Laboratory lectures, to supplement the theoretical aspects of the course, will cover Human-Machine Interface software libraries, particularly the open source ones, including vision (OpenCV, OpenNI), motion planning (Open Motion Planning Library), haptic input (OpenHaptics) and speech (FestVox, and CMU Sphinx).

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.

Human-Centred Robotics (EE4.60)

Additional Coursework Content Information

Professor Yiannis Demiris

y.demiris@imperial.ac.uk

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 robotic system and answer questions about its design, internals, and operation. The first and last report are group submissions, while the second one (individual component paper) is individual.

The length of the papers to be written is intentionally kept low (4 pages for the first two, and 8 pages for the final result) to encourage concise thinking of content.

[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 robotic 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 survey)?
- Outline of your design, explaining design choices, and justification for your selected design.
- 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.

Some previous design reports have been uploaded on blackboard as examples, along with a number of survey papers.

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 paper [Individual Submission]

Your individual component paper counts 20% of your course mark*.*

By now, you will have already assigned individual roles to each member of your group - the literature review and design paper is meant to get each of you to read the scientific literature **on your particular individual module,** think about the design of your component and summarize your findings individually. The work you do here, summarized and mixed with the

reports of the other students in your group, will help form the background/literature review section and inform the design sections in your final joint report.

The length should again be 4 pages in double column format similar to the first (joint) report. In the report you should:

- Describe clearly what is the problem that you will be addressing in your part of the joint project. For example, "recognising speech in crowded environments", "construction of an anthropomorphic arm", "tracking humans", "path planning", "dialogue management", "information visualisation", "believable animation", "mapping"....
- You should explain why is it challenging, important, and how does it fit with the rest of the project.
- Describe what are the main scientific and technological challenges underlying your work (what is difficult, and why).
- Describe who else is working on this field, and what are they doing. As I mentioned in the last lecture, this should not take the form of "Yellow Pages" where you simply list people/places etc, but rather you should "digest" this work (e.g. summarise, categorise, group together approaches, describe commonalities/differences, describe common advantages/disadvantages, comment on their applicability etc).
- Describe the applicability of different research approaches to the particular work you are trying to do, and describe your first initial thoughts on the design of your component. There is no absolute requirement to report results of your component evaluation, but **it will help if you have started implementing it.** You might have to take some shortcuts to more elaborate approaches you have seen described - explain what they are and why they are reasonable.

Throughout your reports what I will be looking for evidence of is "a mind at work". I want to see that you preformed some professional background search to your problem, and thought about it in the context of the work of other researchers, rather than jumped straight into coding without much thought. I want to see that you understood the underlying issues, even if you chose (due to time or other constraints) a simpler approach. While Google (Scholar) will be a useful resource do not forget the traditional heavies in literature research such as IEEExplore, the ACM Digital Library, PubMed, among others. Make sure you properly reference each piece of work. Literature reviews also require extra vigilance so that your report is original despite the fact you are reviewing the work of others. Make sure you use your own words/thinking, and quote properly when you are using other people's output.

You should also go through the academic papers I have been uploading in the Blackboard system for your reading pleasure. Reading "professional" research papers will give you inspiration on how to do a technical literature survey properly.

[3] Final Project Report [Group submission]

Your final report should be 8 pages, double-column, single spaced, which counts for 60% of your grade. You have several examples from last year in Blackboard. Make sure that you have read them carefully.

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 in a bibliographic database, and you want him/her to be excited enough to want to 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; robot & environmental setup, initialisations, 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 (recall evaluation lecture!)
- 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. Be careful with this! In the past, in the literature surveys I received, some of you do not have complete bibliographic information for each paper. Again look at the examples from last year on Blackboard.

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 Human Centered Robotics. Most of the projects you are working on are unique and do 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 a robot", "multimodal communication was more effective than single-mode communication"), so think of me as a fellow scientist, not me as a "grader". Focus on system evaluation and results, not housekeeping information.

Demonstration/Oral Examination [Group]

You are also expected to do a final 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 demonstration (all group members are required to attend), you will need to:

- Demonstrate the functionality of the robot, 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. You are welcome to stage the demo as you wish, in any location that you wish (hopefully within 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)
- 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.

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