Dear Students,

As part of this module, you have to complete:

1. A research project on a medical electronics or e-health challenge.
2. A signal processing project

Each challenge is described below, and you will have to carry out research on your allocated challenge as directed by the description. You are welcome to propose your own challenge, but it will need to be approved by Dr Actis ([p.actis@leeds.ac.uk](mailto:p.actis@leeds.ac.uk)) to make sure the topic is aligned with the module’s learning outcomes. You will then give a 15-minute presentation on your research (indicatively 10 minutes on the research project and 5 minutes on the signal processing). You will receive a mark as a group that will count for 40% of the total module mark.

This mark assumes that all group members have contributed equally to the presentation. If this is not the case, please let the module leader (Dr Paolo Actis) know via e-mail as it is not fair that you are penalised if your group members did not engage in the assignment.

You will deliver the presentation in person and further details about date and time will be shared in due course.

**Research Project Challenges**

Challenge 1 Scenario: You are an engineering team at a wearable technology company. You have been asked by your Chief Technology Officer (CTO) to research the opportunities and challenges of the integration of wearable technology with glucose monitoring. The CTO has asked you to review the area broadly, but with the focus on the human/biosensor interface and the challenges associated with signal processing.

Challenge 2: Scenario: You are an engineering team at an in vitro diagnostic company with specific expertise in amperometric glucose sensing. You have been asked by your Chief Technology Officer (CTO) to research the opportunities and challenges of the integration of a glucose sensor into a smart watch. The idea would be for the data to be transmitted to a centralized server (e.g. via a linked mobile phone) where the data would be analyzed and used together with other data collected by the smart watch to make recommendations to the patient (in addition to the need for insulin injections) such as choice of food etc. The CTO stated that he still expects you to use an electrochemical approach for the blood glucose measurements and use a variant of the standard glucose tests strips as this is where the company has a lot of IP. The CTO asked you to review the technical feasibility (e.g. increased demands on battery life), but in particular asked you to review potential ethical implications.

Challenge 3: Wearable activity trackers are widely used nowadays for tracking daily activity, in particular for monitoring sport performances, but also for continuous evaluation of physical conditions of specific patients. Choose an example of an available product on the market that allows for the monitoring of pregnant women in the third trimester of pregnancy. Which data could be useful to evaluate the health status of the mother and the development of the foetus? Which additional sensors could you integrate with this device to improve the efficiency or to add additional relevant parameters? Specify the type of data you aim to include, the range of values, timing, and the required sensitivity/reliability/accuracy. What are the limitations and the critical aspects for the adoption of the device for treatment/diagnosis/therapy of this class of patients? Examples: sensor positioning, application scenarios, conflict or redundancy with other equipment, ethical concerns.

Challenge 4 Organs-on-a-chip technologies are set to revolutionize the drug testing process. Imagine using one brain-on-a-chip system to test the efficacy of a new drug for Alzheimer’s disease. Define the main characteristics of the organ-on-a-chip system, explaining the main functionalities to be reproduced, describing how this system would change the testing protocols in a big pharmaceutical company.

Challenge 5 The Topol Review on preparing the healthcare workforce to deliver the digital future has been published in 2019 (<https://topol.hee.nhs.uk/)> . Please select one chapter and present its findings. Also select one or two technologies described in the chapter and discuss in details how are they are (or will) be used to deliver the digital future.

Challenge 6. You are part of the R&D team of a company manufacturing electronic test and measurement equipment and your manager asked you to talk about in-vivo neuroscience research and in particular about the Neuropixel probes (www.neuropixels.org).

Challenge 7: NICE (National Institute for Health and Care Excellence) is the UK body that decides whether a new technology will be adopted by the NHS or not. Few years ago, NICE evaluated diagnostic tests capable of measuring levels of procalcitonin in a patients’ bloodstream. Procalcitonin is present in the bloodstream when there is a bacterial infection. Review NICE’s decision and associated recommendation and discuss the overall evaluation process.

Challenge 8: NICE (National Institute for Health and Care Excellence) is the UK body that decides whether a new technology will be adopted by the NHS or not. MiniMed Paradigm Veo and Vibe and G4 PLATINUM CGM are sensor-augmented pump therapy systems, which combine continuous glucose monitoring and continuous subcutaneous insulin infusion, for people with type 1 diabetes. Review NICE’s decision and associated recommendation and discuss the overall evaluation process.

Challenge 9: During the COVID pandemic, pulse oximetry devices were used for warning of low blood oxygenation. According to a study of Sjoding et al published in the New England Journal of Medicine, these devices may be missing three times as many cases of occult hypoxaemia in black patients as in white. Review the study finding by describing first how a pulse oximeter work and what form of adjustment for individual patients’ skin colour maybe appropriate.

Challenge 10: Wang et al reported in the journal Nature Biomedical Engineering the development of a wearable electrochemical biosensors for the continuous monitoring of metabolites in sweat. <https://www.nature.com/articles/s41551-022-00916-z>

Present the wearable sensor design and its novelty compared to other published technologies. Discuss the main findings of the paper and the limitations of the technology. Propose a technological solution to address the limitations.

If you have any questions related to the Research Project Challenge you can contact Dr Paolo Actis ([p.actis@leeds.ac.uk](mailto:p.actis@leeds.ac.uk))

**Signal Processing Challenge**

In week 21, you will be given a raw data set acquired from a continuous glucose monitor (CGM) implanted for 2 weeks in the upper arm of the module leader. Please complete the following tasks and present your findings in the group presentation:

Task 1) Design a filter in Matlab/python to remove the high frequency noise

Task 2) Display the de-noised data and discuss the performance of the filter

Task 3) Develop/apply peak detection routines to automatically detect the high/low peaks in glucose

Task 4) Analyse what is the physiological relevance of these peaks and discuss what are the ethical implications of a breach of CGM data. For example, you can discuss what information about the lifestyle of the module leader you can (or can’t) extract from the data (i.e when does the module leader go to sleep, when does he eat breakfast, does he exercise regularly? ,..)

If you have any questions related to the Signal Processing Challenge you can contact Dr Zhi-Qiang Zhang ([z.zhang3@leeds.ac.uk](mailto:z.zhang3@leeds.ac.uk))

**Presentation Mark Scheme**

(as per the Framework for Higher Education Qualifications)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Excellent** | **Very Good** | **Good** | **Adequate** | **Marginal** | **Inadequate** |
| Relationship to assessment criteria | Exceptional response to all the assessment criteria (>80%) | Very strong response to the assessment criteria (70-79%) | Good thorough response to assessment criteria (60-69%) | Sufficient response to assessment criteria for the task  (50-59%) | Weak response to main assessment criteria (40-49%) | Very poor response to main assessment criteria (<40%) |
| **Advanced knowledge and understanding**  (40% Weight) | Exceptional systematic mastery of advanced knowledge, principles and concepts in area of study, together with very strong independent critical and evaluative understanding of current issues and insight at the forefront of the discipline | Highly developed systematic advanced knowledge and critical understanding of area of study, including independent critical awareness of current issues and insights at the forefront of the discipline | Good systematic advanced knowledge and understanding of area of study including awareness of current issues and insights at the forefront of the discipline | Adequate sound advanced knowledge and understanding of the area of study, some of which is informed by developments at the forefront of the discipline | Limited advanced knowledge and understanding of area of study | Very limited advanced knowledge and understanding of area of study |
| **Critical analysis**  (40% Weight) | Goes well beyond what is taught in insightful, advanced study/research, to develop original critical analysis and evaluation that shows exceptional initiative and an authoritative independent grasp of issues | Evidence of systematic breadth and depth of critically appraised and insightful advanced study/ research to develop independent original critical analysis and evaluation | Evidence of systematic breadth and depth of independent engagement with advanced study and research to develop relevant critical analysis to inform good response to task | Evidence of independent engagement with advanced research and study to inform satisfactory response to task, but limited in range and depth of critical analysis | Insufficient evidence of independent engagement with advanced research and study and/or of relevant current academic references | Significantly inadequate evidence of independent engagement with advanced research and study |
| **Argument**  (20% Weight) | Exceptional skills in constructing academic arguments and communicating complex ideas/ viewpoints/ information/ evidence to advance knowledge and understanding | Very well-developed communication/ presentation of complex ideas/ viewpoints/ information/ evidence to sustain scholarly arguments that advance understanding | Effective logical and coherent communication/ presentation of complex ideas/ viewpoints/ information/ evidence to sustain informed arguments | Competent logical and coherent communication/ presentation of complex ideas/ viewpoints/ information/ evidence to sustain argument with some weaknesses, eg in structure, coherence or currency, but generally sound if standard judgement | Argument/ explanation is weak/poorly constructed, unsubstantiated or significantly lacking in coherence or validity | Little evidence of an independently constructed argument with appropriate supporting analysis or evidence |