Intelligent Signal Processing

Module description

This module aims to provide you with a broad experience of digital signal processing techniques and applications. You will study how audio and video signals can be captured and processed by a computer program. You will learn about time domain and frequency domain representations and processing. You will learn how you can extract information from audio signals. You will implement movement and face detection systems that work with live camera input.

Intelligent signal processing involves capturing, storing, playing, processing and crucially, extracting meaningful information from various signals found in the real world, using a computer system. You interact with intelligent signal processing systems every day, for example, voice-controlled digital assistants. This module builds on other topics in the computer science programme such as computer graphics, data representation and artificial intelligence. It provides you with an advanced skill set for writing computer programs that can work with a range of digital signals.

Module goals and objectives

Upon successful completion of this module, you will be able to:

1. Explain how audio and video signals can be represented digitally and what the key properties of these signals are.
2. Write computer programs that can capture, process and play back audio and video signals.
3. Understand and use discrete Fourier transforms to process audio signals in the frequency domain and explain the process of feature extraction.
4. Implement simple movement and face detection systems that work with live camera input.
5. Describe the key components of a speech recognition system and analyse the design decisions involved.
6. Select and describe appropriate techniques for compressing audio and video signals.

Textbook and Readings

Specific essential readings for this module will be taken from the following text books:

Hosken, D. W. *An introduction to music technology*. (New York: Routledge, 2011).
Collins, N. *Introduction to computer music*. (Chichester: John Wiley & Sons, 2010).
Smith, S. *Digital signal processing: a practical guide for engineers and scientists*. (Burlington, MA: Elsevier, 2013).
Downey, A. B. *Think DSP: digital signal processing in Python.* (Newton: O'Reilly Media, Inc, 2016).
Bovik A. C. (ed). *The Essential Guide to Video Processing*. (New York: Elsevier Academic Press, 2009).

The specific pages for the reading activities will be given on the platform, and there is no need to read beyond the recommended pages.

There will also be discussion prompts asking you to do some independent research using online sources.

Module outline

The module consists of ten topics that focus on different areas of signal processing.

Topic 1. Digitising, representing and storing audio signals.	Key concepts: • Audio fundamentals • Digitising audio signals • Audio editors: Introduction to Audacity • Audio programming with p5.js • Introduction to audio programming with Python.

Topic 2. Editing and processing digital audio.	Key concepts: • Digital audio editing. • Processing digital audio. • Advanced audio processing.
Topic 3. Frequency domain representations.	Key concepts: • Sound analysis. • Convolution and the frequency domain.
Topic 4. Extracting features from audio signals.	Key concepts: • Audio signal feature extraction. • Real-time audio visualizations with Javascript. • Audio signal feature extraction with Python.
Topic 5. Speech recognition.	Key concepts: • Introduction to speech recognition. • Speech recognition in p5.js. • Speech recognition in Python.
Topic 6. Capturing, representing and processing camera input.	Key concepts: • Introduction to digital video. • Capturing and processing digital video. • Capturing and processing video with p5.js.

Topic 7. Computer vision: movement detection.	Key concepts: • Introduction to Computer vision. • Computer vision: movement detection. • Movement detection with p5.js.
Topic 8. Computer vision: face detection.	Key concepts: • Computer vision: face detection. • Face detection with p5.js
Topic 9. Audio file formats. Compressing audio signals.	Key concepts: • Audio file formats. • Compressing audio signals. • Compressing audio signals: software. Compressing audio with python.
Topic 10. Video file formats. Compressing video signals.	Key concepts: • Video file formats. • Compressing video signals. • Record, convert and stream audio and video with ffmpeg. • p5.js and python applications with ffmpeg.

Activities of this module

The module is comprised of the following elements:

- Lecture videos. In each topic, you will find a sequence of videos identifying the core aspects of learning for the topic.

- Readings. Each topic may include several suggested readings. These are a core part of your learning, and, together with the videos, will cover all of the concepts you need for this module.
- Practice Quizzes. Each topic will include practice quizzes, intended for you to assess your understanding of the topics. You will be allowed unlimited attempts at each practice quiz. There is no time limit on how long you take to complete each attempt at the quiz. These quizzes do not contribute toward your final score in the class.
- Practice exercises. The course includes several practical, engaging exercises. These assignments do not contribute toward your final score in the class.
- Discussion Prompts. Each practice exercise includes discussion a prompt. You will see the discussion prompt alongside other items in the lesson. Each prompt provides a space for you to respond. After responding, you can see and comment on your peers' responses. All prompts and responses are also accessible from the general discussion forum and the module discussion forum.
- Graded Assignments. There are two graded assignments, each is worth 50% of the final module grade. Each of these assignments is comprised of multiple parts which learners work on during earlier weeks. All assignments will be graded by the project tutors.

How to pass this module

The module has two major assessments:

- Midterm assignment (50%): This assignment is to be submitted in week 12 of the module. It comprises multiple programming assignments worked on during earlier weeks.
- Endterm assignment (50%): This assignment is to be submitted in week 22 of the module. It comprises of multiple programming assignments worked on during earlier weeks.

This is a detailed breakdown of all of the marks.

Activity	Required?	Deadline week	Estimated time per week	% of final grade
Midterm submission	Yes	12	25 hours	50%
Endterm submission	Yes	22	25 hours	50%