CENTRALE NANTES

ENGINEERING PROGRAMME

2024-2025

Year 3

Professional Option

Science and Music

OP SCIMUS

PROGRAMME SUPERVISOR

Jean-François PETIOT

Autumn Semester

Course unit	ECTS Credits	Track	Course code	Title
UE 92	4	Core course	ACSIP MUNUM	Acoustics, Signal, Perception Digital music

Spring Semester

Course unit	ECTS Credits	Track	Course code	Title
UE 102	1	Core course	ACMUS PROMU	Musical acoustics Project

Acoustics, Signal, Perception [ACSIP]

LEAD PROFESSOR(S): Jean-François PETIOT

Requirements

basics in signal processing
Fourier transform
basics in statistics

Objectives

To present the tools and methods to represent, analyse and synthesize audio signals.
Basics of acoustics and sound propagations
Introduction to psychoacoustics and the study of sounds as perceived by humans.

Course contents

a) Basic tools for audio signal processing
- Classification of sounds
- spectral analysis - time-frequency representation - spectrogram - audio filtering
- digital sound

b) Basic acoustics
- Sound sources - Propagation - wave equation
- dimensions (intensity, power, decibels)
- the audio chain - captors - transducers - peripherals

c) Introduction to Psychoacoustics
- auditory physiology
- sound perception
- Masking effect - critical bands - auditory scenes organisation - audio streams - cocktail effect
- shepard sounds
- Psychoacoustic metrics (dBA, loudness, sharpness, roughness)

Listening tests and perceptual experiments (psychometry)
Analysis of perceptual data
- multidimensionnel analysis (ACP, MDS)
- Analysis of variance and statistical tests
- Signal detection theory

5 labs
Lab 1: sound analysis - example of additive synthesis - filtering - soustractive synthesis - sound effects (Matlab or Python)
Lab 3: masking effect - beats - perpetual scales - musical temperament
Lab 3: Audacity - audio editing - effects - sound design and synthesis
Lab 4: Data analysis of audio tests
Lab5 : Psychoacoustical Tests - Signal detection theory

Course material

Philippe GUILLAUME. Musique et acoustique - de l'instrument à l'ordinateur, Hermès, Lavoisier, 2005.
Olivier CALVET. Acoustique appliquée aux techniques du son. Educalivre, Casteilla 2002
Michèle CASTELLENGO. Ecoute musicale et Acoustique. Eyrolles, 2015.

Assessment

Collective assessment: EVC 1 (coefficient 0.5)

Individual assessment: EVI 1 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	2	20 hrs	12 hrs	0 hrs	0 hrs	0 hrs

Digital music [MUNUM]

LEAD PROFESSOR(S): Jean-François PETIOT

Requirements

basis in audio signal processing

Objectives

The digital music course offers specialized training in computational methods for music analysis and musical creation. It covers algorithms for the automatic processing of musical files, both in symbolic (i.e., sheet music) and audio formats. In doing so, the course gives an opportunity to learn about classical techniques in pattern machine and artificial intelligence.

At the end of the course, the student will be able to :
- design and operate digital audio effects ;
- extract audio features to retrieve similarities between musical recordings ;
- apply artificial intelligence systems to the identification of repeated patterns in musical recordings as well as sheet music.

Course contents

Outline :
- Digital audio effects : An ear for mathematics
- Audio content analysis : Organizing large digital audio archives
- Sheet music analysis : Structure retrieval and discovery of repeated patterns
- Music and data : Musical production in the XXIth century

Practicals (4 sessions) :
TP1 : Digital Audio Effects (Faust)
TP2 : Music Information Retrieval (Python)
TP3 : Discovery of motifs in sheet music of Bach sonatas (Python)
TP4 : Music structure analysis of Piano recordings (Python)

Course material

- DAFX - Digital Audio Effects, Udo Zölzer, John Wiley & Sons, 2002
- Fundamentals of Music Processing, Audio, Analysis, Algorithms, Applications ; Müller, Meinard, Springer (https://musicinformationretrieval.com)
- An Introduction to Audio Content Analysis: Applications in Signal Processing and Music Informatics: Alexander Lerch

Assessment

Collective assessment: EVC 1 (coefficient 0.5)

Individual assessment: EVI 1 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	2	20 hrs	12 hrs	0 hrs	0 hrs	0 hrs

Musical acoustics [ACMUS]

LEAD PROFESSOR(S): Jean-François PETIOT

Requirements

basics in signal processing
Fourier transform
Vibrations mechanic

Objectives

To present the main principles governing how musical instruments work and their design:
- wind
- strings (violin - piano)
- percussion

To give basics on room acoustics.

To present an overview of the History of music.

Course contents

Part 1 - Musical instruments - systemic and organological study - physical models
- specifications of a musical instrument
a) The functioning of musical instruments
auto-oscillations
free vibrations
Excitator and resonator
b) Different categories of instruments
- winds (reeds, flutes, singing voice)
- string (violin, piano)
- percussion

The input impedance of wind instruments
modal analysis of string instruments
Materials

Part 2 - Room acoustics
- Objective characterization of rooms - isolation
- models in room acoustics
- soundscape and quality of rooms
- Sound engineering

Part 3 - Sound production - mixing
sound mixing - peripherals - sound effects

Labs (4 sessions)
Lab 1: physical modeling of violin - sound simulations
Lab 2: physical modeling of brass instruments - sound simulations
Lab3: comparison of instruments.
Lab 4: exercise on a multitrack mixing (LMMS software)

Course material

Emile LEIPP. Acoustique et Musique. Masson, 1989.
Michèle CASTELLENGO. Ecoute musicale et acoustique. Eyrolles, 2015.
Philippe GUILLAUME. Musique et acoustique. Hermes, Lavoisier 2005.
M.CAMPBELL, J.GILBERT et A.MYERS. The science of brass instruments " ed. Springer-Verlag, 2021

Assessment

Collective assessment: EVC 1 (coefficient 0.5)

Individual assessment: EVI 1 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	0.5	24 hrs	8 hrs	0 hrs	0 hrs	0 hrs

Project [PROMU]

LEAD PROFESSOR(S): Jean-François PETIOT

Requirements

courses of the Music and Science specialization

Objectives

To apply a scientific approach to a musical field.

Course contents

Students can choose their own project, the subject of which must be related to the different aspects covered in the option:

- physics of musical instruments, physical models
- innovative musical instruments
- control of room acoustics
- sound recording, sound engineering, musical project
- automatic scores
- micro web-based services for browsing and musical creation
- MIR (music information retrieval)

Course material

Assessment

Collective assessment: EVC 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	0.5	0 hrs	0 hrs	0 hrs	40 hrs	0 hrs