Republic of Tunisia
Ministry of Higher Education and Scientific Research
University of Tunis El Manar
National Engineering School of Tunis
Signals & Smart Systems Lab (L3S)

Research Master's program: Information Processing and Complexity of the Living
Mastère de recherche : Traitement de l'Information et Complexité du Vivant (TICV)
TC : Tronc commun, SPI : Option Signal Perception – Image, Option BioS : Biosystémique

TICV MASTER

SPI – Perceptual Approaches in Sound Processing

Semester: Fall, **Academic Year:** 2020/21

Instructor information

Name	Sonia DJAZIRI-LARBI, Associate Professor
Contact Info	Sonia.djaziri-larbi@enit.utm.tn
Office location / Affiliation	Ecole Nationale d'Ingénieurs de Tunis

Course Description

This course is part of the Teaching Unit "Audio and Perception". It focusses on the understanding of the human auditory mechanisms and how they are related to digital audio processing techniques. Perceptual audio processing methods are explained and discussed in terms of perceptual efficiency and perceptual (subjective) quality evaluation.

Objectives and Learning Outcomes

Upon successful completion of the course, students will have an understanding of the close relationship between perceptual audio processing techniques and human auditory characteristics and associated topics. Specific learning objectives are:

- Understand the basics of auditory perception, psychoacoustics, and psychoacoustic models
- Apply psychoacoustics in coding, features extraction, data hiding, etc.

Prerequisites

Advanced Digital Signal Processing

Learning Resources

Personal computers, Matlab or Scilab

Assessments

The final course grade will be calculated using the following categories:

Assessment	Percentage of Final Grade
Final exam	80%
Programming assignment	20%

Students will be assigned the following points, based on calculations coming from the course assessment section: **Grade** = gained points from a total of 20 points

Course Schedule

Lecture #	Theme/Topic	Learning Outcomes Addressed
#1 (3H)	Audio perception	The human ear's mechanisms (basilar membrane, cochlea, ear cells,…) Quantifying perception: Sones and Phones, Loudness, Sound Pressure Level Auditory Masking: Frequency Masking, Absolute Hearing Threshold, Critical Bands, Bark scale, Psychoacoustic Models
#2 (3H)	Audio coding	MPEG-1 Layer III coder
Programming Assignment (3H)	MPEG – 1 layer 3	Understand and test the psychoacoustic model, the filter bank, using provided Matlab/Scilab codes
#3 (3H)	Practical session MPEG – 1 layer 3	MPEG – 1 layer 3 manipulation of the complete coder with Matlab (Scilab). Quality vs. bitrate evaluation, testing with different music genre, …
#4 (3H)	Perceptual audio data hiding	Spread spectrum techniques Quantization Index Modulation techniques
#5 (3H)	Audio features extraction OR[1] Subjective vs. Objective Quality Assessment	Music: Features related to rhythm, tempo, melody Speech: MFCC, spectrogram, … Quality definitions, Objective assessment (PEAQ, PESQ, SegSNR, SegLLR, etc.) Subjective assessments : Standards (ITU-T) and Methods
Reading Assignment (3H)	Scientific article	

[1] The decision is made depending on the students interests

TICV MASTER

SPI – Learning Algorithms and Audio Applications

Semester: Fall, **Academic Year:** 2020/21

Instructor information

Name	Meriem JAÏDANE Professor
Contact Info	meriem.jaidane@enit.utm.tn
Office location / Affiliation	Ecole Nationale d'Ingénieurs de Tunis

Course Description

This course uses as prerequisites: Signals and Systems, Signal Processing, Digital Signal Processing generally taught in 1st and 2nd year to address system design in generic applications of optimal filtering. Students will learn to problematize generic situations where a linear and nonlinear optimization solution in a non-stationary context is required and that adaptive algorithms are used. The theoretical analysis of adaptive algorithms is done. They will apply this more precisely in audio signal processing. This is done from the "design" angle in order to develop the critical analysis of an optimal filtering method in the project spirit.

Objectives and LearningOutcomes

- Problematize generic situations where an optimization solution in a non-stationary context is required
- Analyze the performance of optimal and adaptive filters in stationary and non-stationary contexts in these different generic situations
- Design and analyze the performance of learning algorithms
- Audio applications

Prerequisites

- Signals and Systems basics
- Digital Signal Processing basics

Learning Resources

[1] Monson H. Hayes, *Statistical Signal processing and modeling*, Wiley,1996.
[2] Christian Jutten, *Filtrage linéaire optimal*, Polytech Grenoble,2010.
[3] J. Benesty, *Lectures in Adaptive Filtering and Spectral Analysis*, lecture L1 à L15 (ppt).
http://externe.emt.inrs.ca/users/benesty/course.html
[4] Brian D. O. Anderson, John B. Moore, *Optimal Filtering*, Prentice Hall,1979.

[5] Maurice Bellanger, *Adaptive Digital Filters*, Signal processing and Communications Series, Marcel Dekker, 2nd Edition,2001.
[6] S. Haykin, *Adaptive Filter Theory*. Fourth Edition, Prentice Hall,2002.

Assessments

The final course grade will be calculated using the following categories:

Assessment	Percentage of Final Grade
Final exam: project	80%
Reading and problem sets	20%

Students will be assigned the following points, based on calculations coming from the course assessment section: **Grade** = gained points from a total of 20 points

Course Schedule

Lecture #	Theme/Topic	Learning Outcomes Addressed
#1 (1H30)	Generic Optimization Situation in a Non-Stationary Context	Keywords: Learning algorithms, Channel identification, Denoising, Signal prediction, Identification of the inverse of a channel, Right and left identification, Predistortion, ...
#2 (1H30)	Optimal filtering, criteria and structures	Keywords: Quadratic criteria, non-quadratic criteria, linear structures, non-linear structures, optimal filtering, optimal filter performance, ...
#3 (4x1H30)	Learning Algorithms and Performance in a Non-Stationary Context	Keywords: Adaptive algorithms, Learning algorithms, Performance of adaptive filters, deep learning case, theoretical analysis: convergence, parameter initialization, local minima problem and instability problems,....
#4 (3x1H30)	Designing Learning Algorithms and Audio Applications	Keywords: Acoustic echo cancellation, audio denoising, audio coding, loudspeaker pre-distortion,...
#5 (5x1H30)	Project	Article analysis and programming

TICV MASTER

SPI – Image and segmentation

Semester: Fall, **Academic Year:** 2020/21

Instructor information

Name	Rabaa YOUSSEF DOUSS, Associate Professor
Contact Info	rabaa.youssef@supcom.tn
Office location / Affiliation	Higher Institute of Applied Sciences and Technology of Kairouan ISSATKr / Higher School of Communication Sup'COM

Course Description

- This course is an introduction to image processing, analysis techniques and concepts. It introduces theoretical material and mathematics behind images and imaging. Topics include image formation, specificities of digital images (image contrast, luminosity, noise, geometric deformation etc...), image transformations (histogram equalization, thresholding etc...) and segmentation.
- The students should become familiar with issues such as image enhancement, segmentation and morphological image processing. They could quickly be able to build computer vision applications in their respective disciplines.
- Teaching hours: 12 hours of course, 3 hours of tutorials
- Test and demonstration tools: Matlab + image processing toolbox

Objectives and Learning Outcomes

Upon successful completion of the course, students will have an understanding of image processing challenges and associated topics. Specific learning objectives are:

- Explain how digital images are represented and manipulated in a computer, including reading and writing from storage, and displaying.
- Write a program which implements fundamental image processing algorithms such as contrast enhancement by histogram equalization and thresholding.
- Know when and how to use a specific segmentation technique, according to the image specificities and complexity.
- Be conversant with the mathematical morphology tools such as dilation, erosion, closing and opening

Prerequisites

- Linear Algebra and Differential Equations
- Probability and Statistics
- Algorithmic and Programming skills

Learning Resources

- No specific resources are required. The tutorials are collaborative and conducted with the instructor.

Assessments

The final course grade will be calculated using the following categories:

Assessment	Percentage of Final Grade
Final exam	100%

Course Schedule

Lecture #	Theme/Topic	Learning Outcomes Addressed
#1 (3H)	Introduction to digital image acquisition and processing	Know how the images are formed with analogy to human vision system, Discover image acquisition systems exploiting various light wavelengths, Understand how we moved from analogical to digital images through sampling and quantification, Know some of image properties: luminance, contrast, noise, deformation., Open up to fields of applications.
#2 (3H)	Spatial and intensity resolution of images	Understand the effect of spatial and intensity variation on image. Get familiar with image interpolation (mapping function) when performing spatial transformation. Use histogram and perform equalization using probability density and other adaptive algorithms Know how to perform these changes using Matlab commands
#3 (3H)	Segmentation techniques	Know why we need segmentation Pixel intensity distribution and threshold techniques: from simple global to local adaptive approaches Region based segmentation Contour based segmentation
#4 (3H)	Mathematical morphology tools	Understand the basic definitions of pixel connexity, duality between 4-8 connexity on background/foreground, structuring element and connected components. Learn to apply dilation, erosion, opening and closing operations to restore information after binarization process.
#5 (3H)	Tutorials	Apply the acquired knowledge on different examples: from histogram equalization, thresholding, contour detection to morphological operations to improve obtained segmentation results.

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TICV MASTER

Video Sequence Analysis

Semester: Fall, **Academic Year:** 2020/21

Instructor information

Name	Nicolas LOMENIE Associate Professor
Contact Info	Nicolas.lomenie@u-paris.fr
Office location / Affiliation	University of Paris

Course Description

In this course, the aim is to be able to model and calculate motion in digital image sequences following this sequence :
Chapter 1: Description of a camera and problem of camera calibration including the PnP problem for pose estimation.
Chapter 2: Characterization of apparent motion in sequences and optical flow calculation using two reference methodologies: Lucas-Kanade and Horn-Shunck and two generic theoretical frameworks.
Chapter 3 : the tracking of points, objects or shapes by classical methods such as heuristic matching, Kalman filtering, particle filtering and active contours.

Objectives and Learning Outcomes

Upon successful completion of the course, students will have an understanding of video sequence analysis and associated topics. Specific learning objectives are:

- **Camera calibration**
- **Pose Estimation**
- **Augmented Reality**
- **Optical Flow**
- **SVD decomposition and implementation of linear algebra basics**
- **Library openCV (python and C++)**
- **Tracking methods such as Lucas and Kanade tracker**

Prerequisites

- Linear Algebra
- Basic image processing

Learning Resources

- Laptops or computer stations with C++ and python

Assessments

The final course grade will be calculated using the following categories:

Assessment	Percentage of Final Grade
Final exam	60%
Based on Reading and problem sets	25%
And Programming assignment	15%

B.P. 37 . 1002 Le Belvédère Tunis. Tunisie
ص ب 37. البلفدار
تونس 1002. تونس
Tél. : +216 70 014 400 : الهاتف
Fax : +216 71 872 729 / +216 70 860 548 : الفاكس
www.enit.rnu.tn

TICV MASTER

TC – 3D Imaging

Semester: Fall, **Academic Year:** 2020/21

Instructor information

Name	Zouhour Ben Azouz
Contact Info	Zouhour.benazouz@isi.utm.com ++21624284864
Office location / Affiliation	Institut Supérieur d'Informatique, Ariana /Ecole Nationale d'Ingénieurs de Tunis

Course Description

Recovering three-dimensional scene properties is ubiquitous for several fields such as robotics, autonomous vehicles, virtual tourism, quality control and medicine. This course opens the doors for student who are interested in learning the fundamentals of 3D computer vision. It addresses the pipeline of 3D modeling from data acquisition to surface reconstruction with a focus on image-based techniques. The goal of the course is to develop an understanding of the current state of the art and gain appreciation of its limits and potential. The course primary involves lectures by the instructor. Students are also required to read papers related to approaches that are not addressed during lectures.

Objectives and Learning Outcomes

Upon successful completion of the course, students will have an understanding of the following topics:

- 3D data representation
- Fundamental principles of main acquisition techniques
- Image-based reconstruction techniques
- Mesh reconstruction from point clouds.

Students will also demonstrate the ability to read papers that are not addressed within lectures and evaluate the advantages and the limitations of the studied techniques. Hence, they are more prepared to conduct research projects.

Prerequisites

- Basic knowledge of image processing
- A background in linear algebra

Learning Resources

- Textbook: Computer Vision: Algorithms and Applications, by Rick Szeliski
- Papers (e.g) :
  - Schönberger,J. L., and J.-M.Frahm . 2016. "Structure-from-Motion Revisited." In *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (2016)*, 4104–4113.
  - Curless, b. abd Levoy, M., "Avolumetric method for building complex model from range images". *In Proceedings of SIGGRAPH'96, ACM Press (1996),* 303-312.

Assessments

The final course grade will be calculated using the following categories:

Assessment	Percentage of Final Grade
Final exam:	
Questions related to the content of lectures	50%
Questions related to the reading of papers	50%

Students will be assigned the following points, based on calculations coming from the course assessment section: **Grade** = gained points from a total of 20 points

Course Schedule

Lecture #	Theme/Topic	Learning Outcomes Addressed
#1 (1H30)	Introduction	Applications of 3D modeling
#2 (1H30)	3D data representations	Point cloud, Depth map, polygonal meshes, implicit, parametric surfaces, volumetric representation (voxel, tetrahedral meshes representation)
#3 (3H)	Revue of 3D acquisition techniques	- Reflective VS transmissive techniques - Passive (image based) VS active techniques - Single-view (Based on CNNs) VS Multi-view techniques
#4 (3H)	Stereovision	Epipolar Rectification, Stereo Matching, Triangulation

#5 (3H)	Shape from Motion	Feature tracking, 3D Points and Camera Poses estimation, Bundle Adjustment
#6 (3H)	Mesh Reconstruction from Point Clouds	- Implicit Surface Techniques - Voronoi/Delaunay Techniques
Homework	**Theme/Topic**	**Learning Outcomes Addressed**
(6H)	Papers Reading	Reading of papers proposing different approaches to solve problems addressed within lectures