Audio technologies for virtual reality

Academic Year: (2022 / 2023) **Review date: 16-05-2022**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: AZPICUETA RUIZ, LUIS ANTONIO

Type: Electives ECTS Credits : 3.0

Year : Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Physics, Systems and Circuits and Linear Systems

OBJECTIVES

- To understand the differences and peculiarities of virtual reality, augmented reality and mixed reality systems.
- To know the sound reproduction devices employed in virtual reality at present.
- To know the particularities of the human auditory system on which virtual reality systems are based.
- To understand the basic fundamentals of sound propagation and acoustics.
- To understand the differences among audio system based on channels, objects and scenes.
- To understand the different parts of a 3D binaural rendering system for virtual reality.
- To know the features of the acoustic sources that allow their simulation and representation in a 3D binaural rendering system for virtual reality.
- To know acoustic propagation theories that allow modeling this propagation in a binaural 3D rendering system for virtual reality.
- To know the characteristics of the receiver (human being), by modeling the HRTF responses, and to understand the differences between the different estimation methods of these responses.
- To use acoustic simulation software to perform an auralization, considering the particularities of the source, the acoustic propagation and the receiver.
- To know the different formats used in binaural audio for virtual reality, and the reproduction systems for 3D audio, emphasizing their particularities when they are implemented in applications focused on videogames, music production and cinema, among many others.

DESCRIPTION OF CONTENTS: PROGRAMME

1.- Introduction.

1.1 Definition of Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR).
1.2 Playback devices.
1.3 Fundamentals of human auditory system.
1.4 Immersive spatial audio.

2.- Binaural 3D audio for virtual reality.

2.1 Binaural Rendering:
- Introduction. Auralization concept.
- Sound source modelling:
  - I - Sound power and directivity.
- Receiver modelling:
  - I - HRTF (head-related transfer function).
  - II - Individualized Binaural Rendering.
  - III - Movement tracking.
- Acoustic propagation modelling.
  - I- Reverberation time and room impulse response.
  - II - Acoustic theories for indoor acoustic propagation:
    - a) Statistical theory. Acoustic absorption.
    - b) Geometric theory. Echogram.
    - c) Undulatory theory. Room modes.
  - III -Acoustic Environment Rendering Techniques .

IV - Simulation software.

2.2 3D audio reproduction formats.
- Channel-based audio.
- Object-based audio.
- Scene-based audio. Ambisonics.

2.3. 3D Audio reproduction systems: examples of systems and their equalization.

LEARNING ACTIVITIES AND METHODOLOGY

Three teaching activities are proposed: theoretical classes, guided projects and lab exercises.

THEORETICAL CLASSES
The theoretical class will be given in the blackboard, with slides or by any other means to illustrate the concepts of the lectures. In these classes the explanation will be completed with realistic examples of virtual audio.

In these sessions the student will acquire the basic concepts of the course. The students will have to work on the explained concepts, working out and solving the proposed assignments in order to consolidate the concepts of the course.

GUIDED PROJECT
The students will carry out a guided projects. To this end, the students will be given a detailed guide and some specific tutoring.

LABORATORY EXERCISES
The lab exercises will help the students familiarize themselves with important concepts in virtual audio technologies. They include the measurement of binaural room impulse responses., and the use of software for acoustic design and auralizations development.

ASSESSMENT SYSTEM

The final grade will be a weighted sum of partial grades coming from: guided project (30%) and lab exercises (70%).

% end-of-term-examination:	30
% of continuous assessment (assigments, laboratory, practicals…):	70

BASIC BIBLIOGRAPHY

- Higini Arau ABC de la Acústica Arquitectónica, Grupo CEAC, 1999
- Kuttruff, H. Room Acoustics, Elsevier Applied Science, 1991
- Nicol, Rozenn Binaural Technology, AES Monograph, Audio Engineering Society, 2010
- Vorländer, M Auralization: Fundamentals of Acoustics, Modelling, Simulation, Algorithms and Acoustic Virtual Reality, Springer, 2008
- Zotter, Franz, Frank, Matthias Ambisonics. A Practical 3D Audio Theory for Recording, Studio Production, Sound Reinforcement, and Virtual Reality, Springer. Topics in Signal Processing., 2019

ADDITIONAL BIBLIOGRAPHY

- Manuel Recuero López Acústica arquitectónica aplicada, Thomson-Paraninfo, 1999
- Blauert, J. Spatial Hearing - Revised Edition: The Psychophysics of Human Sound Localization, The MIT Press, 1996
- Rafaely, Boaz Fundamentals of Spherical Array Processing, Springer. Topics in Signal Processing., 2015
- Zwicker, E. and Fastl, H. Psychoacoustics - Facts and Models, Springer, 1998