

PSI5720 - SPATIAL AUDIO SIGNAL PROCESSING

**PROFESSORS:**

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**COURSE INFORMATION:**

This course is designed for those students involved in Signal Processing and who seek a closer understanding and practice of Spatial Audio signals to enhance their expertise. It is also useful for those students in Acoustics, Multimedia and Robotics who seek practical knowledge of Spatial Audio and Signal Processing.

**COURSE OBJECTIVES:**

This course introduces various signal processing techniques that can help to understand, extract both the informational, locational and emotional information content of audio signals, which includes speech as a special case.

**SYLLABUS:**

1. **Perceptual models of audio/speech:** peripheral, neural and cognitive; loudness, pitch, timbre, HRTF/HRIR, binaural hearing, dichotic listening, etc.
2. **Generative models of speech/audio:** LTI model, TV model, sinusoidal model, waveform synthesis, reverb synthesis.
3. **Signal Analysis:** Short-time Fourier transform (STFT), Linear Prediction (LP) of speech/audio, lattice filter, AM-FM decomposition, time-scale/pitch-scale modification.
4. **Sound source localization:** Near-field Vs Far-field, beam forming, sound source motion, Doppler tracking, acoustic reflectors.
5. **Multi-channel Audio:** Audio mixing, stereophony, quadraphony, ambience synthesis. multi-channel LP, reverb suppression.
6. **Applications:** Spatial Audio coding (MP3, MP4), water-marking (spread spectrum), HuBot interaction, overview of microphones and Loudspeakers.

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**PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA ELÉTRICA**

**CLASS SCHEDULE:**

<b>Week</b>	<b>Date / Time Faculty</b>	<b>Topics / Activities</b>	
1	02 Jun, 2020 Tue, 9am-12  Faculty: TVS	<b>Ear-Hear-SpHear:</b> Loudness, Pitch, Timbre: physical parameters Vs perceptual parameters through Physical, Psychological and Signal models.	
2	09 Jun, 2020 Tue, 9am-12  Faculty: TVS	<b>Ear-Hear-SpHear:</b> Binaural perception; IID, ITD, HRTF / HRIR, Room Impulse response, Binaural unmasking, Dichotic / Diotic listening, peripheral, neural and cognitive models:	
3	16 Jun, 2020 Tue, 9am-12  Faculty: Wesley	<b>Signal Analysis:</b> Discrete Fourier Transform (DFT), Short-Time Fourier transform (STFT), Audio Features, Python examples.	
4	23 Jun, 2020 Tue, 9am-12  Faculty: Miguel	<b>Generative (Signal) Models:</b> LTI, LTV system models; Sinusoidal and waveform synthesis. <b>Signal Analysis:</b> Linear Prediction (LP) of speech / audio, lattice filter	
5	30 Jun, 2020 Tue, 9am-12  Faculty: TVS	<b>Spatial Analysis:</b> RIR measurement, RIR simulation; HRTF/HRIR measurement.	
6	07 Jul, 2020 Faculty: TVS		
7	Jul. 14, 2020 Tue, 9am-12  Faculty: Mário	<b>Spatial Analysis:</b> Concert Halls Acoustics	<b>Project proposal</b>
8	Jul. 21, 2020 Faculty: TVS	<b>Spatial Analysis:</b> Concert Halls Acoustics: Sala São Paulo <b>Sound source localization:</b> Space-Time signal processing; Spatial sampling for Mic-Array; Linear array, far-field planar	

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		field sensing; MPDR beamformers.	
9	Jul. 28, 2020 Faculty: TVS	<b>Optimum array performance:</b> SINR, MVDR and MPDR beamformers; A/B-format mics; MEMS mics / arrays.	
10	Aug. 04, 2020 Faculty: TVS	HuBot Y-array source tracking; TDoA estimation; Wireless Acoustic Sensor Network (WASN) localization; Region constrained; GCC-PHAT measurement.	
11	Aug 11, 2020 Faculty: TVS	<b>Signal Coherence &amp; Linearity;</b> DoA estimation; DoA based localization (WASN); Moving source parameter estimation; Multi-channel audio rendering.	
12	Aug. 18, 2020	<b>Project Presentations</b>	
13	Aug. 25, 2020	<b>Project Presentations</b>	<b>Proj Final report</b>

**\*Note: The schedule is getting planned, may change due to class needs, will be updated weekly**

**BIBLIOGRAPHY:**

- [1] Jens Blauert, *Spatial Hearing: The Psychophysics of Human Sound Localization*, MIT Press, Cambridge, Massachusetts, 1997.
- [2] William M. Hartmann, *Signals, Sound and Sensation*, American Institute of Physics AIP-Press, East Lansing, Michigan, 1998.
- [3] Thomas F. Quatieri, *Discrete-Time Speech Signal Processing: Principles and Practice*, Prentice-Hall PTR, Upper Saddle River, 2002.
- [4] Francis Rumsey, *Spatial Audio*, Focal Press, Oxford, 2012.

**TYPE OF ASSESSMENT:**

In each class, the teacher can ask some questions and all the students should give a short written answer. The answers should be uploaded in the **e-Disciplinas platform**, or sent to [wesley@lme.usp.br](mailto:wesley@lme.usp.br) (for those who do not have access). This continuous evaluation will be accumulated until the end of the course.

Assessment consisted of homework assignments (50%), continuous evaluation (10%), project