SPCOMIT Seminar Invitation

Title: Representation, measurement, and processing of sound fields in rooms using acoustic MIMO systems

Speaker: Hai Morgenstern (BGU)

Abstract

Room acoustics describes the manner in which sound behaves in enclosed spaces. This determines, for example, how music sounds in concert halls and how clearly speech is perceived in lecture halls. In particular, the spatial attributes of the sound field in a room have been shown to affect the perception of sound by human listeners. To evaluate these attributes, acoustic systems with microphone arrays have been proposed for measuring room impulse responses (RIRs), facilitating the computation of spatial measures which use sound field information to predict the acoustical performance of enclosures. Because of the three dimensional analysis that they provide, spherical microphone arrays (SMAs) have been studied for room acoustics analysis, for detecting the direction of arrival (DOA) of room reflections, and for computing directional room impulse responses. Systems that include loudspeaker arrays have also been proposed for evaluating spatial attributes of sounds fields, due to their ability to produce complex radiation patterns. Producing complex radiation patterns in a room enables, for example, the excitation of individual reflection paths in a room, which can improve the separability of individual reflections, providing high-resolution analysis. Moreover, the radiation patterns of different types of acoustic sources, such as musical instruments, can be modelled using compact spherical loudspeaker arrays (SLAs). RIRs measured using such arrays can therefore be used for evaluating the acoustical performance of a room for a variety of sources. Systems that combine both SMAs and SLAs, termed multiple-input multiple-output (MIMO) systems, retain the benefits of each array, and the ability to simultaneously control both arrays provides additional degrees of freedom. Especially, employing such systems for acquiring RIRs may deepen the understanding of an enclosure's spatial properties.

In this talk, the system transfer function of an acoustical MIMO system comprising a SMA and a SLA is formulated in matrix form for rooms, and its properties are studied using tools from linear algebra. For example, the rank and null space of a system are studied to reveal spatial information on a room, such as the number of dominant room reflections and the directions of radiation

(DORs) and DOAs from the SLA to the SMA, respectively. In practice, measured systems transfer functions include errors, which impose limitations on the processing of measured RIRs. To study a system's limitations, spatial aliasing and model mismatch errors are incorporated into the system model, and based on their analysis, operating frequency ranges (OFR) are defined for each array. The dependency of these errors on the SLA and SMA parameters are studied, and guidelines are proposed for a matched design of a system, in which parameters are chosen to assure matched OFRs of the arrays. A design example is provided to illustrate the superiority of a matched system over an unmatched system in the synthesis of directional RIRs. Finally, algorithms are proposed for the processing of MIMO measurements; for uniquely determining reflections paths in a RIR, facilitating an enhanced spatial analysis of room reflections; for changing acoustic attributes of the sound field in a room around a listener's position; for reproducing sound fields of directional sources and synthesizing binaural responses, by employing head-related transfer functions.

Hai Morgenstern is a PhD student of Prof. Boaz Rafaely.

The seminar will take place on **Monday, 8-2-2016, 12:10, in room 102 building 33.**