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FAKULTÄT FÜR ELEKTROTECHNIK, INFORMATIK UND MATHEMATIK

Abstract of the PhD thesis:

Geometriekalibrierung akustischer Sensornetze

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The recording of acoustic signals by several microphones is of great importance for many modern signal processing algorithms. Multi-channel recordings can be used to exploit spatial information and thus enable, for example, the suppression of speech signals or interfering noises impinging from certain directions. Furthermore, multi-channel recordings are prerequisite for the localization of speakers or acoustic events. The aforementioned techniques are applied for automatic speech recognition systems, hearing aids, advanced teleconferencing- and hands-free systems. Moreover, the performance of the algorithms that are used increases with the number of microphones as well as their spatial diversity. Therefore, spatially distributed sensors, that are composed to an acoustic sensor network (ASN) are preferred to a local accumulation of microphones.

The spatial configuration of theses sensors is mostly unknown, although it is mandatory for applications like acoustic localization. Hence, the task of geometry calibration algorithms is to automatically determine the geometric configuration of the sensors. So far, the existing algorithms primarily utilize special calibration signals and measure signal propagation times or time differences of arrival (TDOA), that allow for a computation of the corresponding distances. Timing measurements, however, require a sampling rate synchronization, which is not always present due to the spatial separation of the sensors.

This thesis is concerned with the development of geometry calibration algorithms for acoustic and audio-visual sensor networks, that do not require special calibration-signals and minimize the synchronization requirements. The calibration is carried out based on direction of arrival estimates (DOA-estimates), that are extracted from speech signals. Therefore, this thesis firstly addresses the development and analysis of DOA-estimators. However, the focus is on the design and examination of geometry calibration algorithms.

Due to reverberation and imperfect correlation properties of speech signals the DOA-estimates contain errors. Furthermore, outlier measurements are caused if no line-of-sight (LOS) propagation path from the source to the microphones is present. Core aspect of this thesis is the embedding of developed calibration techniques into a random sample consensus (RANSAC) framework to ensure a robust calibration. A calibration solely based on direction estimates only achieves a relative calibration whereby an unknown scaling factor remains. In order to fix the scaling ambiguity different strategies are examined. First of all, acoustic concepts are investigated, but the main objective is the development of audio-visual approaches. Finally, the performance of developed geometry calibration algorithms is evaluated by simulations as well as experiments in real environments.