A Perspective on the Identification of Acoustic Impulse Responses

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Abstract

In many applications related to the acoustic environment, there is a strong need to model or estimate an unknown impulse response, which may be the result of the acoustic coupling between the loudspeaker and microphone of a hands-free communication device. Nevertheless, there are multiple challenges related to such scenarios, since the acoustic impulse responses that need to be identified are time-variant systems, which depend on many factors, e.g., temperature, pressure, humidity, and movement of objects or bodies in the room. In addition, they could have excessive lengths in time (up to hundreds of milliseconds) due to the slow speed of sound in the air, together with multiple reflections caused by the room environment. In this context, a critical issue is related to the identification of long-length room acoustic impulse responses, which are usually modeled as finite-impulse-response filters with hundreds or even thousands of coefficients. In practice, this challenging aspect raises significant difficulties in terms of the complexity and accuracy of the solution. Consequently, it is of major importance to improve the overall performance of the methods and techniques used for the identification of such acoustic systems. In this framework, exploiting the intrinsic nature of the room acoustic impulse responses represent a natural path to follow, which could potentially lead to improved results and further open new perspectives on the identification problem.

Recently, we introduced a novel decomposition-based approach for dealing with high-dimension system identification problems. The basic idea is to exploit the Kronecker product decomposition of the long-length impulse responses, together with low-rank approximations, thus solving the system identification problem based on a combination of low-dimension solutions (i.e., shorter filters). The gain of such an approach is important, in terms of both improved performance and reduced complexity. In this keynote, we further present an improved decomposition-based approach for the identification of long-length room acoustic impulse responses, which is a key issue in different challenging scenarios, like acoustic echo cancellation. The main idea is to exploit the intrinsic characteristics of the acoustic impulse response, taking into account its main components, i.e., early reflections and late reverberation, which are very different in nature. Thus, by separately processing these components via the Kronecker product decompositions, their individual low-rank features can be better revealed and exploited. Extensive simulation results obtained in the context of acoustic echo cancellation support the theoretical findings and the performance features of these decomposition-based solutions.