摘要

雖然在陣列信號處理中，聲學傳遞函數（Acoustic Transfer Functions）通常比相對傳遞函數（Relative Transfer Functions）具有更好的性能，但由於源輸入信號通常不可用，獲得可靠的聲學傳遞函數估計具有挑戰性。為了解決這一問題，我們提出了一種基於卷積傳遞函數（Convolutive Transfer Functions）的創新盲聲學傳遞函數估計方法。我們首先使用到達時間差（Time Difference of Arrival）和廣義互相關相位變換（Generalized Cross Correlation-Phase Transform）估計來定位分佈式陣列中的聲源。接著，我們應用加權預測誤差（Weighted Prediction Error）算法對混合緊湊-分佈式陣列接收到的信號進行去混響，並使用延遲和求和波束形成器作為源信號的初步估計。卷積傳遞函數係數可以使用維納濾波器或卡爾曼濾波器計算，並使用粒子群優化（Particle Swarm Optimization）優化其參數。數值模擬和使用十三麥克風混合陣列進行的實驗證明了所提出技術的有效性。最先進的自適應多通道時域最小均方（Adaptive Multi-channel Time Domain Least Mean Square）方法被用作基線。為了進一步驗證，我們將所提出的方法應用於信號去混響、聲源分離和語音增強等應用。

關鍵詞 — 卷積傳遞函數，加權預測誤差算法，延遲和加總波束成形器，維納濾波器，卡爾曼濾波器，粒子群優化

ABSTRACT

While Acoustic Transfer Functions (ATFs) generally lead to better performance than Relative Transfer Functions (RTFs) in array signal processing, obtaining reliable ATF estimates is challenging because the source input is usually unavailable. To address this problem, we propose a novel blind ATF estimation approach formulated using Convolutive Transfer Functions (CTFs). We start by locating the source using Time Difference of Arrival (TDOA) estimated by Generalized Cross Correlation-Phase Transform (GCC-PHAT), by using a distributed array. Next, we apply the Weighted Prediction Error (WPE) algorithm to de-reverberate the signals received by a hybrid compact-distributed array, using the Delay and Sum beamformer as an initial estimate of the source signal. The CTF coefficients can be computed using either the Wiener filter or the Kalman filter with the parameters optimized using Particle Swarm Optimization (PSO). Simulations and experiments using a thirteen-microphone hybrid array demonstrate the efficacy of the proposed technique. The state-of-the-art Adaptive Multichannel Time Domain Least Mean Square (MCLMS) method was used as the baseline. For further validation, we applied the proposed technique to applications, including signal dereverberation, source separation, and speech enhancement.

Index Terms — convolutive transfer functions, weighted prediction error, delay and