Chapter 13

NOISE REDUCTION BASED ON MICROPHONE ARRAY AND POST-FILTERING FOR ROBUST SPEECH RECOGNITION IN CAR ENVIRONMENTS

Junfeng Li and Masato Akagi
School of Information Science, Japan Advanced Institute of Science and Technology, 1-1, Asahidai, Nomi, Ishikawa, 923-1292, Japan

Abstract: Robust speech recognition in a vehicular environment has been an important research field that has attracted great research interest in recent years. Performance of general-purpose speech recognizers dramatically degrade because of various kinds of prevailing noise sources in cars. To deal with acoustic noises, we have proposed two noise reduction systems based on microphone array and post-filtering. In this chapter, we first describe these two noise reduction systems. Then, we present our investigation into the performance improvements of the automatic speech recognition (ASR) system for in-car applications when the two noise reduction systems are used as the front-end processors. We report the speech recognition experiments we have conducted using car noise recordings and the AURORA-2J speech database, as well as the recognition results we have obtained. Finally, based on these experimental results, we present some discussions on the proposed noise reduction systems.

Key words: Microphone array; noise reduction; localized noise suppression; non-localized noise suppression; robust speech recognition.

1. INTRODUCTION

Recently there has been increased interest in the hands-free speech processing technology for the in-car environment, such as automatic speech recognition (ASR) systems. One main problem associated with this
technology is that the signals received by the distant microphones are severely corrupted by various kinds of noises. Although many algorithms have been published so far [1]-[5], the problem of suppressing noise signals and improving the performance of speech recognition systems in adverse car environments is still a very interesting challenge in the speech signal processing field. A potential solution is to construct a practically effective and computationally efficient noise reduction system as a front-end processor with the goal of improving the performance and robustness of the speech recognition system in car environments.

A variety of noise reduction algorithms for in-car applications have been reported in the literature [1]-[5]. Matassoni et al. [2] adopted the single-channel schemes, the magnitude spectral subtraction and the logarithmic minimum mean square error (MMSE) estimator, to suppress background noise. The noise-suppressed signals were then used in the speech recognition process, resulting in an improved recognition rate.

Compared to the single-channel technique, the multi-channel technique has shown substantial superiority in reducing noise due to its spatial filtering capability. Zhang et al. [4] proposed a "constrained switched adaptive beamformer", which combines a speech adaptive beamformer and a noise adaptive beamformer in a speech/noise constraint selecting scheme, for speech enhancement and recognition in real car environments. However, its relatively slow convergence rate degrades the performance in dealing with non-stationary noise signals in practical conditions. Moreover, Grenier [3] evaluated the performance of the generalized sidelobe canceller (GSC) beamformer in car environments. Where he pointed out that the GSC beamformer, as a front-end processor for an ASR system, is not effective in improving the performance of the ASR system in high-noise conditions.

In this chapter, we first study the characteristics of the noise fields in car environments and then introduce two noise reduction algorithms based on microphone array and post-filtering [7]-[12]. The suggested noise reduction algorithms are then evaluated as front-end processors for a speech recognition system to improve the robustness and recognition rate of the system in adverse car environments. Speech recognition results are also reported to show the effectiveness of these two noise reduction algorithms. Some discussions of the two noise reduction systems are finally presented based on the speech recognition results obtained in noisy car conditions.