Signal Processing for Suppressing Mutual Interferences in a Multiple Weather Radar Environment

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Abstract

Weather radar have a long history to contribute reducing adverse effects caused by weather phenomena. Recent technological developments enabled weather radars to accomplish high spatial and temporal resolution, and to monitor severe weather phenomena such as localized thunderstorms, tornadoes, and downbursts, which were difficult for traditional weather radar to detect; Pulse compression technique allowed weather radars to have high range resolution [1] [2], weather radar networking accomplished weather monitoring with a high frequency [3] [4], and phased array imaging realized a high frequency monitoring by a single radar [5], and indicated possibility to integrate weather radar and other radars such as airport radars to a single multi-function radar [6].

These new technologies, however, can cause mutual interferences between weather radars; the pulse compression demands a wide frequency band, the weather radar networking demands to assign frequency bands to each radar node, and phased array imaging increases the number of interference occurrences because of its wide radiating beam. In urban areas, there are not only weather radars but also radars for other purposes such as ocean monitoring and aircraft surveillance. Although mutual interferences between these radars are currently not paid a great attention, it has actually occurred and is being avoided by user operation. When high performance weather radars are deployed in near future, thus, weather radar mutual interferences would spoil performance to monitor severe weather phenomena.

In this research, a signal processing method for interference suppression is proposed. The proposed method is based on a governing equation which expresses a received signal of a weather radar with an interference from another radar which is assumed to exist nearby. Here, it is assumed that waveforms of the two radars are differently modulated and interfere in frequency domain with each other. It is furthermore assumed that the waveforms are known. The proposed method gives an adaptive filter both to range resolving (like pulse compression) and to suppress the interference via minimum mean square error (MMSE) [7] [8].

In order to evaluate performance of the proposed method, the numerical simulation has been carried out. A modulated long pulse was assumed for the weather radar, and a single-frequency short pulse was for the other radar, where both the transmitting signals almost overlap in frequency domain. The specifications of the weather radar were designated by considering an X-band phased array weather radar (PAWR) [5]. Received signals of the two radars were generated by an algorithm similar to a radar signal simulator [9], and the proposed method was applied to the simulated received signal. Since the two waveforms were uniquely modulated, a matched filter (MF), which is the most conventional

for radar ranging, for the weather radar can suppress the interference. As a result of the simulation, the proposed method suppresses interference 80 dB greater than the matched filter as shown in Fig. 1. In Fig. 1, blue solid, orange solid and black dashed lines are MF, MMSE and truth, respectively. Truth (dashed line) is a simulated desired signal utilizing a real measurement data from PAWR. The approximately -30 dBm that appears between about 25 and 35 km after MF application shown as the blue line is the effect of interference signal from the other radar. The result after MMSE application shown as the orange line shows that the interference signal is suppressed and only the desired signal is accurately estimated. The interference suppression almost reached a noise level designated in the simulation. The proposed method showed higher performance in other simulations with higher interference or a lower noise level.

References

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