Initialization of FCME Algorithm for Noise Floor Estimation

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1 Introduction

In this paper, we investigate a real-time noise power estimation with Forward Consecutive Mean Excision (FCME) algorithm. In the real-time noise power estimation, the observed samples may include both noise-only samples (H_0) and noise-plus-signal samples (H_1) [1]. The FCME algorithm extracts noise-only samples with an iterative process in which a set of estimated noise-only samples is updated iteratively. We investigate an appropriate size for the initial noise samples set, denoted by $|\boldsymbol{Q}_0|$, in FCME algorithm while $|\boldsymbol{Q}_0|$ is typically assumed to be 10% smallest samples from the total observed samples (N). In this paper, the appropriate size $|\boldsymbol{Q}_0|$ is obtained analytically based on a relationship between false alarm rate (P_{FA}) and $|\boldsymbol{Q}_0|$.

2 Relationship between Noise Floor Estimation Performance and $|\boldsymbol{Q}_0|$

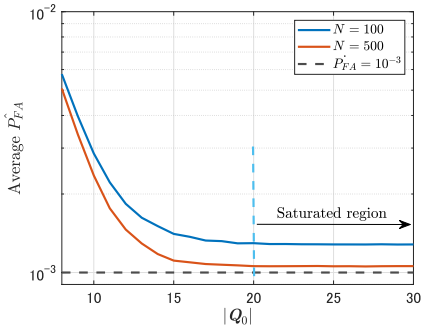

Fig. 1: Average $\hat{P}_{FA}$ with $|\boldsymbol{Q}_0|$ in noise-only case

Fig. 1 shows the average obtained false alarm rate $\hat{P}_{FA}$ as a function of $|\boldsymbol{Q}_0|$ with $N = 100, 500$ and target false alarm rate $P_{FA}^{\cdot} = 10^{-3}$. For both N, the average $\hat{P}_{FA}$ become saturated in the region where $|\boldsymbol{Q}_0| > 20$ and the gap between the average $\hat{P}_{FA}$ and $P_{FA}^{\cdot}$ are relatively small. As an indication of the saturated region, we define appropriate $|\boldsymbol{Q}_0|$ to be the minimum value of $|\boldsymbol{Q}_0|$ within the saturated region.

3 Approximated Theoretical Average $\hat{P_{FA}}$

The average $P_{FA}^{\cdot}$ in [2] is approximated by

$$\text{Average } \hat{P_{FA}} \approx \sum_{i=|\boldsymbol{Q}_0|}^{|\boldsymbol{Q}_0|+5} (\alpha_{i-1} - \alpha_i)(\kappa_i) + \left(1 - \sum_{i=|\boldsymbol{Q}_0|}^{|\boldsymbol{Q}_0|+5} (\alpha_{i-1} - \alpha_i)\right) \frac{1}{(1 + T_{\text{CME}}/N)^N}. \quad (1)$$

where i is the index number of the sorted H_0 samples, α_i is the probability that $(i+1)$th H_0 sample being successfully collected into the assumed noise samples set and κ_i is the biased $\hat{P_{FA}}$ when only i samples out of N sorted samples are successfully collected [3]. Let the probability that FCME algorithm succeeds to collect samples up to i samples and finally stops at $(i+1)$th sample denoted as $(\alpha_{i-1} - \alpha_i)$, average $\hat{P_{FA}}$ can be calculated based on the summation of multiplication between $(\alpha_{i-1} - \alpha_i)$ and the corresponding κ_i from $i = |\boldsymbol{Q}_0| \sim N$. The appropriate $|\boldsymbol{Q}_0|$ is obtained based on the relationship between Average $\hat{P_{FA}}$ and $|\boldsymbol{Q}_0|$. Specifically, the minimum $|\boldsymbol{Q}_0|$ in the saturated region like in Fig. 1 is chosen as the appropriate $|\boldsymbol{Q}_0|$.

4 Numerical Evaluation and Conclusion

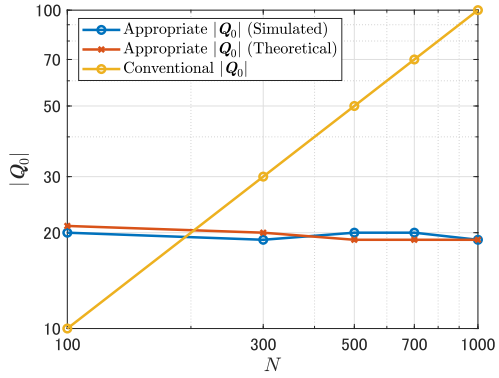

Fig. 2: Appropriate $|\boldsymbol{Q}_0|$ vs N

Fig. 2 shows selected $|\boldsymbol{Q}_0|$ as a function of N by typical approach, i.e. 10% of N, the proposed appropriate $|\boldsymbol{Q}_0|$, and simulation result. Specifically, in the $|\boldsymbol{Q}_0|$ with simulation result, $|\boldsymbol{Q}_0|$ is chosen empirically from the simulation result in Fig. 1. It can be seen that the proposed appropriate $|\boldsymbol{Q}_0|$ and simulation result remain relatively constant with N in contrast to the conventional approach which assumes that $|\boldsymbol{Q}_0|$ is 10% of N.

References

[1] H. Saarnisaari, P. Henttu, and M. Juntti, "Iterative multidimensional impulse detectors for communications based on the classical diagnostic methods," *IEEE transactions on communications*, vol. 53, no. 3, pp. 395–398, 2005.

[2] J. J. Lehtomaki, J. Vartiainen, M. Juntti, and H. Saarnisaari, "CFAR outlier detection with forward methods," *IEEE Transactions on Signal Processing*, vol. 55, no. 9, pp. 4702–4706, 2007.

[3] M. Lops, "Hybrid clutter-map/L-CFAR procedure for clutter rejection in nonhomogeneous environment," *IEE Proceedings-Radar, Sonar and Navigation*, vol. 143, no. 4, pp. 239–245, 1996.