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Comments on “Detection of Distributed Sources Using Sensor Arrays”

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Abstract—In the above correspondence (Y. Jin and B. Friedlander, “Detection of distributed sources using sensor arrays,” IEEE Trans. Signal Process., vol. 52, no. 6, pp. 1537–1548, June 2004), Jin and Friedlander develop a GLR-based detector for detecting a random spatially distributed signal source using an array of sensors. We show that the expression for required SNR (RSNR) has been incorrectly derived, which has led the authors to draw incorrect conclusions in their work. In this correspondence, we correct this particular error and a few other typographical errors, and provide appropriate conclusions to the original work.

Index Terms—Distributed source, sensor array, signal detection.

In the above correspondence, [1, eq. (50)] expresses the required SNR (RSNR) incorrectly as

\[ \rho = \frac{P}{\sum_{j=1}^{r} \lambda_j^2} \left( \frac{\sum_{j=1}^{r} \frac{\rho \lambda_j}{\rho \lambda_j + 1}}{\sum_{j=1}^{r} \frac{\rho \lambda_j}{\rho \lambda_j + 1}} \right)^2 \frac{\psi_{v-1}(1 - PFA)}{\psi_{v-1}(1 - PD)}. \] (1)

The expression for RSNR when derived correctly should read as

\[ \rho = \frac{P}{\sum_{j=1}^{r} \lambda_j^2} \left( \frac{\sum_{j=1}^{r} \frac{\rho \lambda_j}{\rho \lambda_j + 1}}{\sum_{j=1}^{r} \frac{\rho \lambda_j}{\rho \lambda_j + 1}} \right)^2 \frac{\psi_{v-1}(1 - PFA)}{\psi_{v-1}(1 - PD)}. \] (2)

A simplified form of the above expression is obtained when we consider the case where all the principal eigenvalues of \( \mathbf{R}_s \) are approximately equal, i.e., \( \lambda_i \approx \rho/r, i = 1, \ldots, r \). Defining \( v = 2T/r = M_0 = M_1 \) as the degrees of freedom, we, thus, obtain

\[ \text{RSNR} \approx \frac{v}{2TP} \left[ \frac{\psi_{v-1}(1 - PFA)}{\psi_{v-1}(1 - PD)} - 1 \right] \] (3)

instead of

\[ \text{RSNR} \approx \frac{v}{2P} \left[ \frac{\psi_{v-1}(1 - PFA)}{\psi_{v-1}(1 - PD)} - 1 \right] \] (4)

as expressed in [1]. Consequently, the expression for output SNR defined as \( \text{RSNR} \times \text{SNRG} \) becomes

\[ \text{RSNR} \times \text{SNRG} \approx \left[ \frac{\psi_{v-1}(1 - PFA)}{\psi_{v-1}(1 - PD)} - 1 \right] \] (5)

as opposed to

\[ \text{RSNR} \times \text{SNRG} \approx T \left[ \frac{\psi_{v-1}(1 - PFA)}{\psi_{v-1}(1 - PD)} - 1 \right] \] (6)

mentioned as [1, eq. (51)] in the original work by Jin and Friedlander.

As a result of the incorrect expression in (4), Fig. 8 in the original correspondence, i.e., the plot of RSNR versus degrees of freedom \( v \) for different \( P_D \), fails to capture the variation in the RSNR performance for changing \( T \) (number of time snapshots) and changing \( r \) (effective rank of \( \mathbf{R}_s \), which is a measure of the angular spread of the signal), independently. The figure would be correct only under a special case of \( T = 1 \) snapshot, and not in general for all \( T \). The number of degrees of freedom \( v \) contains information of both \( T \) and \( r \), but the effect of increasing \( r \) on RSNR (\( T \), being held constant at different values) is markedly different from the effect of increasing \( T \) (\( r \), being held constant at different values) on RSNR. Figs. 1–4 in this correspondence depict this variation in the RSNR performance for four different cases.

Fig. 1. Normalized RSNR versus degrees of freedom (\( r \in [1, 25], T = 1 \)) for different target \( P_D = [0.95, 0.8, 0.5, 0.3] \) and \( PFA = 0.001 \).

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The cited paper [1], in addition to the aforementioned error, contains a few additional typographical errors, which are listed in Appendix I.

**CONCLUSION**

This correspondence comments on some of the errors contained in [1]. In the original paper, one of the equations (the expression for RSNR) was erroneously derived, leading to incorrect conclusions. The author’s claim that “one of the reasons for performance degradation of the detector was the increased number of time-snapshots” is incorrect.

**APPENDIX I**

In each of the equations in [1, eqs. (20), (21), and (23)] in the original paper, the expression $E_r \Sigma_r$ needs to be corrected to $(E_r \Sigma_r)^{-1}$, and eq. (22) must read as follows:

$$W \approx R_0^{-1} U_r \left[ (E_r \Sigma_r)^{-1} + U_r^H R_0^{-1} U_r \right]^{-1/2} = [w_1, \ldots, w_r].$$

In addition, the expression for the log-likelihood ratio in the first line of [1, eq. (39)] must be corrected to

$$L (\mathbf{X}, H_1) = \text{Tr} \left[ \mathbf{X}^H \mathbf{W} \mathbf{W}^H \mathbf{X} \right].$$

Also, the line preceding eq. (50) has an incorrect expression for $\tau_1/\tau_0$, as

$$\frac{\tau_1}{\tau_0} = \frac{\psi_5^{-1}(1 - F_{PA})}{\psi_3^{-1}(1 - P_D)}.$$

The correct expression is

$$\frac{\tau_1}{\tau_0} = \frac{\psi_5^{-1}(1 - F_{PA})}{\psi_3^{-1}(1 - P_D)}.$$

**REFERENCES**