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OLS vs WLS for DOA Estimation Based on TDOA Estimates: Application to Infrasonic Signals

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Abstract

Monitoring of infrasound sources has received significant attention during the last decades for many civil and scientific applications. The two main problems are the detection of the signal on the one hand and the estimation of wave parameters. For azimuth estimation, the commonly used approach consists of estimating at first the time difference of arrival (TDOA) between any two sensors, using cross-correlation maximization. Then, assuming a plane wave propagation, it is easy to prove that these TDOA estimates depend linearly of two ancillary variables which are in a one-to-one mapping with the azimuth parameter. Usual estimation of the ancillary variables is made from the TDOA estimates, using an ordinary least square (OLS) criterion, implying that the estimation errors on the TDOAs may be considered as uncorrelated. Unfortunately, it is known that this property is not true. Therefore the estimator of the weighted least squares (WLS) must be preferred. In this paper, we determine the analytical expression of the correlation matrix of TDOA estimators based on the signal-to-noise ratio (SNR) of each sensor and then, using the sensor locations, derive the covariance matrices of OLS and WLS estimators. We also propose a procedure to estimate the SNR from the the observed signals. The main interest of our study is to show that, theoretically, the proposed WLS approach works always better, in terms of confidence ellipses, than the OLS except if the SNRs on each sensor are equal. Finally, numerical results in the infrasonic context are presented.

Intercorrelation maximization, TDOA estimates, WLS, OLS, Covariance matrix, Azimuth estimation, Confidence ellipse, Infrasonic sources