METEOR ARRAY GEOMETRY PERFORMANCE BASED ON THE CRAMER-RAO BOUND

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Abstract Submission Form

2006 National Radio Science Meeting

Abstract: kang18744

Date Received: September 18, 2005

Interferometric techniques commonly used in all-sky meteor radar systems to determine the position of the meteor in the sky. Essentially, interferometric techniques use the phase information recorded from different receiving antennas to estimate the elevation and azimuth of the meteors. Prior efforts have been made determine an antenna geometry that improves the performance for meteor system. For example, Hocking and Thayaparan (1997) used four antennas typically spaced by 1.5 to 3 wavelengths to locate the meteors. Jones (1992) and Hocking (1997) presented an antenna geometry using a 5 element array with minimum antenna spacing of 2 wavelength to estimate the direction of arrival (DOA) of the meteors. By spacing the antennas more than 1 wavelength apart, these array geometries were successful in reducing the coupling effect between the antennas. However, it is not clear if these arrays can improved or are optimal without a metric for comparison. One metric for performance is the Cramer-Rao bound (CRB), which is the minimum variance that can be obtained for any unbiased estimator. The CRB is only dependent upon the array geometry and the unknown parameters of elevation and azimuth angles. In this work, we derive the CRB for the azimuth and elevation angle given a planar array with arbitrary sensors and multiple temporal measurements from each sensor. Several array geometries are studied all of which utilize 5-antennas. These are the cross-array, T-array and the L-array. For all of these geometries the elevation angles can be estimated more accurately at a high elevation angle and the azimuth angles are determined less accurately. Our analysis shows that, at a fixed elevation angle cone, the cross-array has the worst performance in estimating the azimuth and elevation angle compared with the other two arrays. L-array shows better estimation accuracy than the cross array except for a few azimuth-elevation angles. T array also performed better than the cross-array at all azimuth and elevation angles. Increasing the number of temporal samples from each antenna will improve the estimation accuracy of azimuth-elevation angles. Our study shows that using 50 samples will improve the estimation performance by 20dB, while increasing from 50 to 100 samples will improve the estimation performance by an additional 5dB. The CRB study can be helpful in designing arrays with optimum DOA estimation ability, based on the array geometry DOA estimation algorithm can be developed to achieve this CRB. Simulation results using the DOA method proposed by Jones indicates that at an elevation angle of 30 degree, the variance of the estimated azimuth-elevation angles will meet the CRB at a signal to noise ratio of 15dB with 10 samples and at a signal to noise ratio of 4 dB with 100 measurements.

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2. G - Ionospheric Radio and Propagation
3. (a) S-G/H2
4. C - Contributed Paper, Program chair: John D. Mathews
5. No special instructions