Optimal Sensor Placement for the Localization of an Electrostatic Source

B. A. Kemp, T. M. Grzegorczyk, and J. A. Kong
Massachusetts Institute of Technology, USA

Electrostatic disturbance sensors have been developed for the passive detection and discrimination of charged bodies [1, 2]. Some proposed applications require the determination of source location or direction of arrival of a small charged object [2], which may be adequately modeled as a moving point charge. Source localization is an inverse problem in that the unknown coordinates of the electrostatic source at some instant in time are determined by the potential measurements from electrostatic disturbance sensors at known locations. This problem is solved by a multidimensional Newton search in the solution space. The solution is the iterative maximum likelihood (ML) estimator in additive white Gaussian noise (WGN), meaning that its performance is efficient in low noise. Since the estimator is iterative, a closed form expression for the solution variance cannot be determined. However, we show via numerical experiment that the iterative electrostatic localization estimator achieves the Cramer-Rao Lower Bound (CRLB) for low measurement noise. Therefore, the closed form expression of the CRLB can be used to represent the performance measure of the iterative estimator in low noise. We apply the expression for the CRLB to optimize the placement of electrostatic disturbance sensors such that for a specified estimator error tolerance, the sensor coverage is maximized at a known measurement noise level. We demonstrate the concept by numerical implementation for the 1D localization problem.

REFERENCES

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