CRLB for DRSS-based Factor Graph of Wireless Geolocation

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***Abstract*—This paper derives a Crammer Rao lower bound (CRLB) for wireless geolocation technique based on differential received signal strength (DRSS) measured parameter and factor graph framework. Then, the CRLB is derived by modifying the Fisher information matrix (FIM). In particular, the derivation inside the FIM focuses on Jacobian matrix having relationship between the target coordinate and the measured DRSS. Finally, the simulation results show that the derived CRLB is excellence with the lowest root mean square error (RMSE) curve.**

***Index Terms*—CRLB, DRSS, FIM, Factor Graph, Geolocation**

I. Introduction

Wireless geolocation has been progressively required for the present and future technologies due to the dramatic growth of new location based services and applications. It is shown by the emergence of various techniques, e.g., factor graph and ultra wideband (UWB). Furthermore, the most of the techniques usually utilize the electromagnetic properties, e.g., received signal strength (RSS) and differential RSS (DRSS) [1], [2]. In addition, a theoretical bound, e.g., Cramer Rao lower bound (CRLB), plays crucial role to validate the effectiveness of new proposed technique as well as to open the opportunity in future technology innovations. It should be noticed that we have proposed DRSS-based wireless geolocation technique under factor graph framework in [2], however, without its lower bound. Hence, this paper derives the CRLB for DRSS-based wireless geolocation with factor graph framework.

II. System Model and CRLB Derivation

The CRLB in general is expressed as $\sqrt{\text{trace}(\mathbf{F}^{-1})}$. Then, $\mathbf{F}$ denoting Fisher information matrix (FIM) is found to $(\mathbf{J}^T\Sigma_\theta^{-1}\mathbf{J})K$, with K being the number of measured DRSS samples, Σ_θ being the covariance of assumed Gaussian noise, $(\cdot)^{-1}$ being the inverse matrix function, $(\cdot)^T$ being the transpose function, and $\mathbf{J}$ being Jacobian matrix. The key to obtain the CRLB is located on the Jacobian matrix taking into account the main function containing relationship between the target position coordinate and the measured DRSS as [1], [2]

$$a_{x_{i,j}} \cdot x + a_{y_{i,j}} \cdot y + a_{P_{i,j}} \cdot P_{i,j} = c, \quad (1)$$

where x and y are the target coordinate, $P_{i,j}$ is the measured DRSS, i and j are the primary and secondary sensor indexes, respectively, and $c_{i,j}$ is set as 1. Furthermore, $a_{x_{i,j}}$, $a_{y_{i,j}}$, and $a_{P_{i,j}}$ are the coefficients where the detailed discussion can be found in [2]. Finally, the first derivative of $P_{i,j}$ in (1) yields

$$\mathbf{J} = \left[-\frac{a_{x_{i,j}}}{a_{P_{i,j}}} \quad -\frac{a_{y_{i,j}}}{a_{P_{i,j}}}\right]. \quad (2)$$

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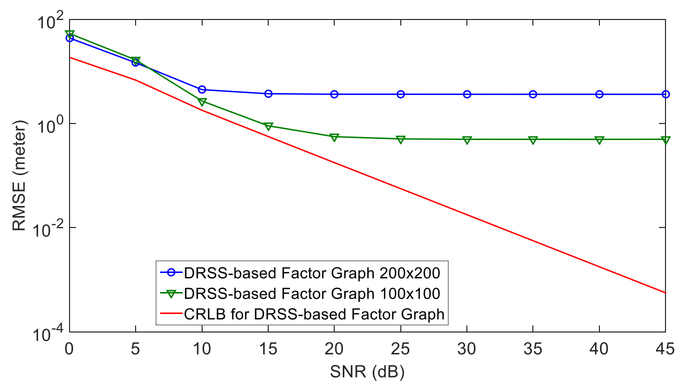

Fig. 1. The RMSE of CRLB and DRSS-based factor graph technique.

III. Simulation Results

The derived CRLB is evaluated by computer simulation with $11,000$ random permuted target positions. Then, 100 assumed Gaussian distributed of DRSS measured samples and 100 iterations are taken for each positions. Furthermore, 3 sensors are located at $(100, 0), (1100, 0), (600, -1000)$ m. It should be noticed that the outlier, moving and multiple target, and correlated measured DRSS are left for future work. Hence, as shown in Fig. 1, the CRLB with the root mean square error (RMSE) curve having the highest accuracy is excellence as the lower bound for the DRSS-based factor graph of wireless geolocation technique in [2].

IV. Conclusion

The derived CRLB for DRSS-based wireless geolocation with factor graph framework has been presented. It is shown that the CRLB is excellence as the theoretical lower bound.

References

[1] C.-T. Huang, C.-H. Wu, Y.-N. Lee, and J.-T. Chen, “A novel indoor RSS-based position location algorithm using factor graphs,” *IEEE Trans. on Wireless Comm.*, vol. 8, no. 6, pp. 3050–3058, June 2009.

[2] M. R. K. Aziz, K. Anwar, and T. Matsumoto, “DRSS-based factor graph geolocation technique for position detection of unknown radio emitter,” in *Proc. European Wireless 2016*, Oulu, Finland, May 2016, pp. 300–305.