Cooperative Positioning Using Angle of Arrival and Time of Arrival

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Introduction

Localization of wireless nodes can be achieved using a variety of techniques, in which range measurement and angle measurement are most commonly used. In the presence of both angle and range measurement, a hybrid model can be developed. In this paper we analyse a hybrid angle of arrival-time of arrival (AoA-ToA) model for localization of wireless nodes, the model is modified to remove the bias from the estimated positions. We also explore the idea of cooperative localization using both angle and range measurements and develop a linear least squares (LLS) scheme.

Background

A least squares solution for hybrid AoA-ToA model was developed in [1]. The estimator produced better estimates of the coordinates as compared to a non-hybrid system. However the estimator produced biased estimates. According to [1] the x and y coordinates of the target node, in the presence of range and angle estimates can be calculated by using (1) and (2).

$$\hat{x} = \bar{x}_i + d_i cos\theta_i \qquad (1)$$

$$\hat{y} = \bar{y}_i + d_i Sin\theta_i \qquad (2)$$

The cooperative model

The hybrid model discussed is modified by introducing an unbiasing constant 'δ'. This modification is necessary to make the system unbiased. In the presence of both angle (AoA) and range (ToA) measurement the x and y coordinates of an unknown target node (say j^{th} target node) can be estimated by

$$\hat{x}_j = \bar{x}_i + d_{ij} cos\theta_{ij}\delta_{ij} \qquad (3)$$

$$\hat{x}_j = \bar{x}_i + d_{ik} cos\theta_{ik}\delta_{ik} - D_{jk} cos\alpha_{jk}\delta_{jk} \qquad (4)$$

$$\hat{y}_j = \bar{y}_i + d_{ij} Sin\theta_{ij}\delta_{ij} \qquad (5)$$

$$\hat{y}_j = \bar{y}_i + d_{ik} Sin\theta_{ik}\delta_{ik} - D_{jk} Sin\alpha_{jk}\delta_{jk} \qquad (6)$$

Equ. (3) and (5) is the contribution from the anchors while equ. (4) and (6) is the contribution from the rest of the target nodes. The parameters in Equ. (1), (2), (3),(4), (5) and (6) are defined in table 1.

$\hat{x}_j, \hat{y}_j$	*x and y coordinates of unknown j^{th} target.*
$\bar{x}_i, \bar{y}_I$	*x and y coordinates of known i^{th} Anchor.*
d_{ij}	*Distance between i^{th} Anchor and j^{th} target.*
D_{jk}	*Distance between j^{th} target and k^{th} target.*
θ_{ij}	*Angle between i^{th} Anchor and j^{th} target*
α_{jk}	*Angle between j^{th} target and k^{th} target*
δ_{ij}	*Unbiasing constant*

Table 1

Results

A 100mx100m network of M anchors and N target nodes was considered. From the simulation it was shown that the bias in the hybrid model was reduced to zero (Fig. 1).

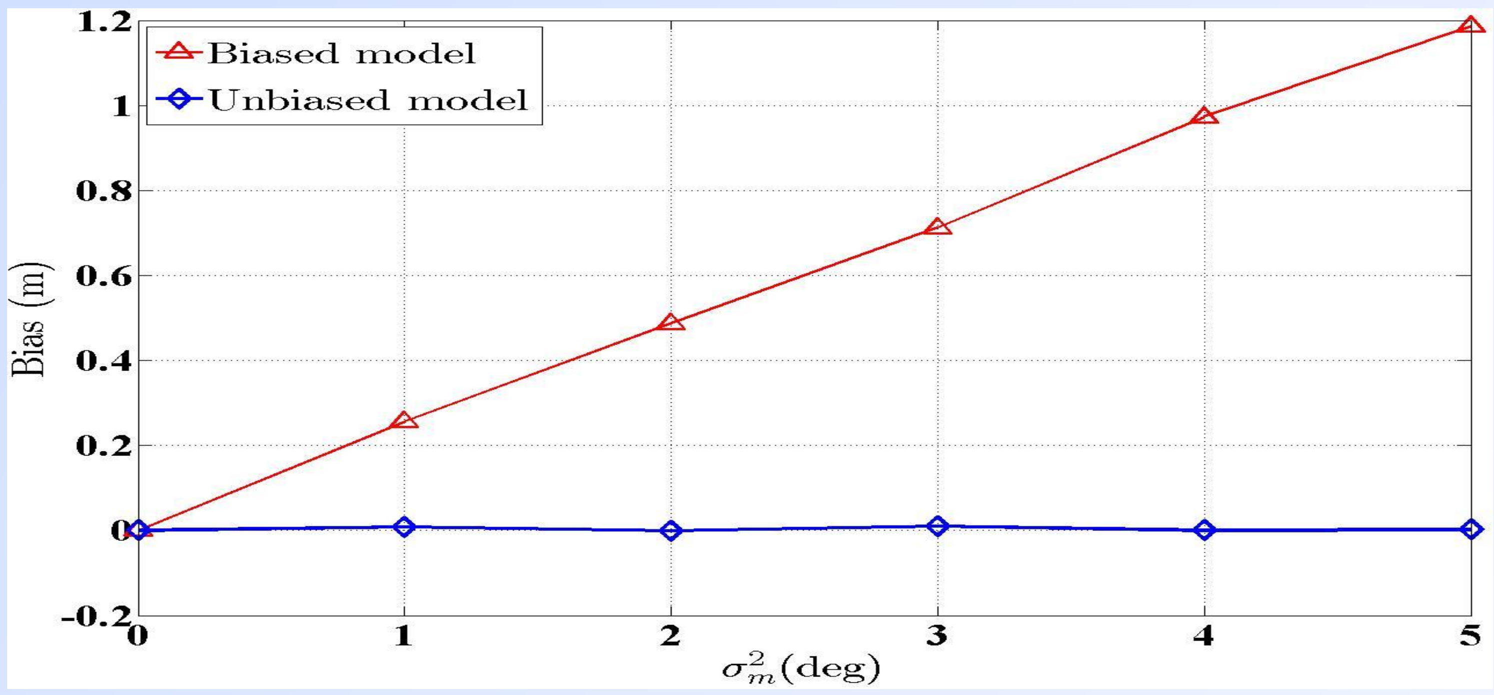


Fig. 1

This modification showed a small improvement in the average root mean square error (Avg. RMSE) in the final estimates of the target nodes (Fig. 2).

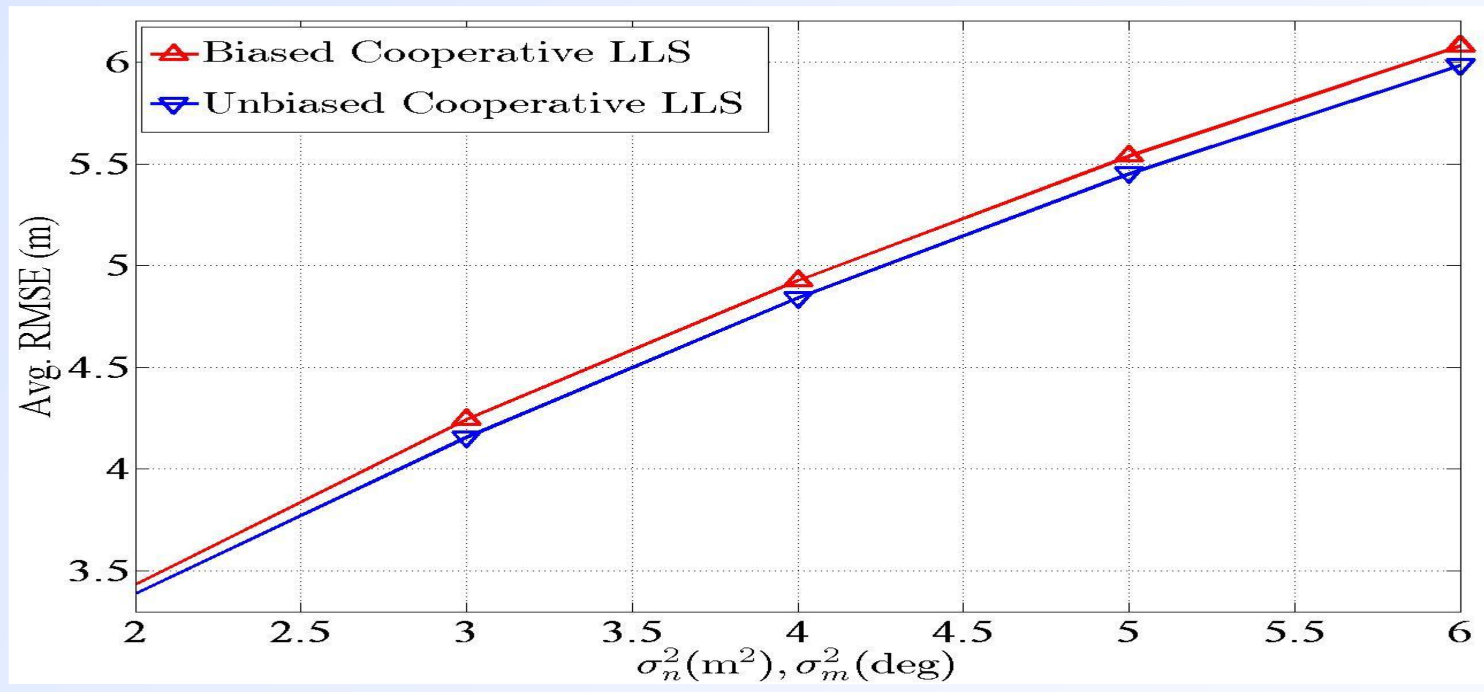
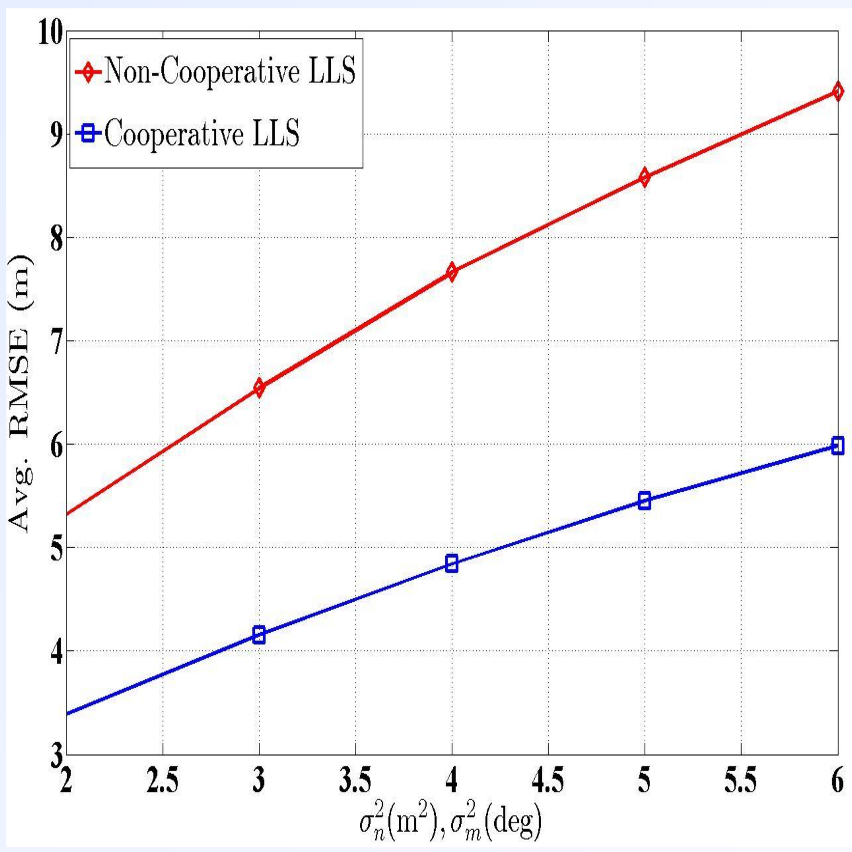


Fig. 2

To further improve the performance, cooperation between target nodes is considered. This significantly improve the performance of the system (Fig. 3 and 4).



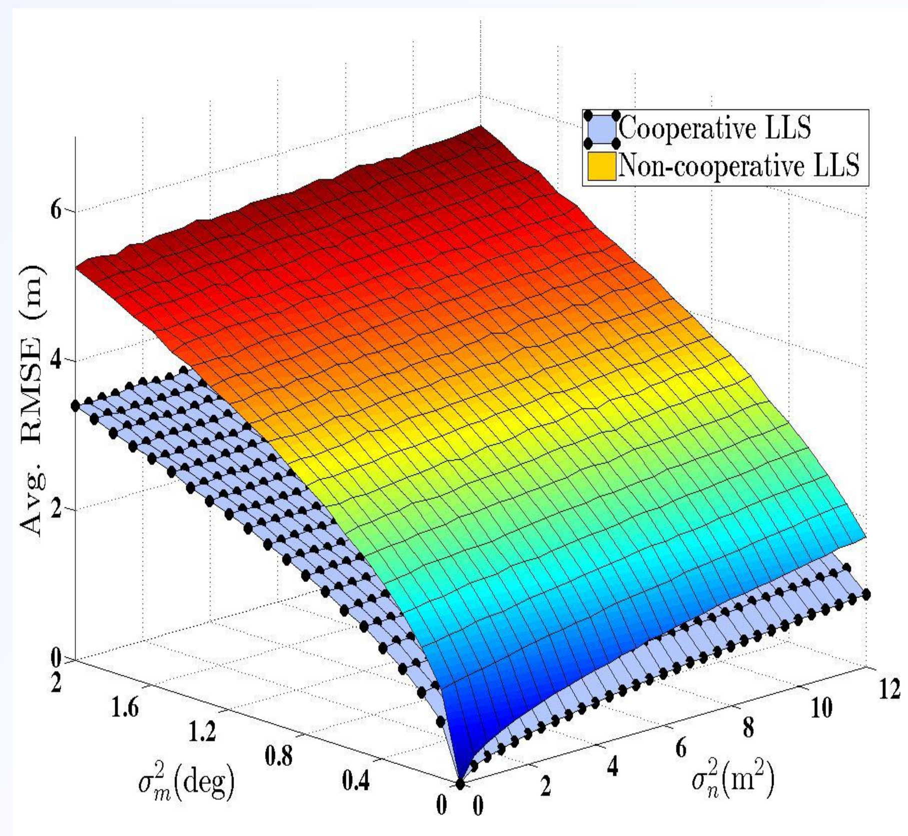


Fig. 3 Fig. 4

Conclusion

A hybrid AoA-ToA model for localization is analyzed and is modified to eliminate the bias in final estimates. This enhances system performance. Further improvement in performance is seen by establishing a cooperative positioning between the target nodes.

References

[1] K. Yu, "3-d localization error analysis in wireless networks," Wireless Communications, IEEE Transactions on, vol. 6, no. 10, pp. 3472–3481, 2007.