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Structural total least squares algorithm for locating multiple disjoint sources based on AOA/TOA/FOA in the presence of system error

Key words: Single-station; Structural total least squares; Inverse iteration; Angle-of-arrival (AOA); Time-of-arrival (TOA); Frequency-of-arrival (FOA); Disjoint sources

Corresponding author: Ding WANG
E-mail: wang_ding814@aliyun.com

Motivations

1. Compared with active location technology, passive location technology has the advantages of stronger concealment and longer detection distance, which can greatly improve the survivability and combat capability of the system in electronic warfare.

2. Single-station passive location technology not only avoids time synchronization and data fusion between multiple observation stations, but also has flexibility, mobility, and simplicity.

3. The measurements from different sources contain the same number of displacements in the station position and velocity, which helps improve the positioning accuracy

Main ideas

1. Develop an STLS localization algorithm for locating multiple disjoint sources when the station position and velocity are not known accurately.

2. Use the measurements from other unknown sources with the same position and velocity displacements to improve the source localization accuracy.

Methods

1. Deduce the pseudo linear equations according to the available spatial-, time-, and frequency-domain measurements.

2. Construct an STLS optimization model and apply the inverse iteration method to solve this problem and obtain the source position.

3. Strictly prove that the theoretical performances of STLS and CTLS methods are consistent under first-order error analysis and coincide with that of CRLB.

Major results

The proposed algorithm can achieve CRLB under moderate noise and suffer from the thresholding effect later than other algorithms.

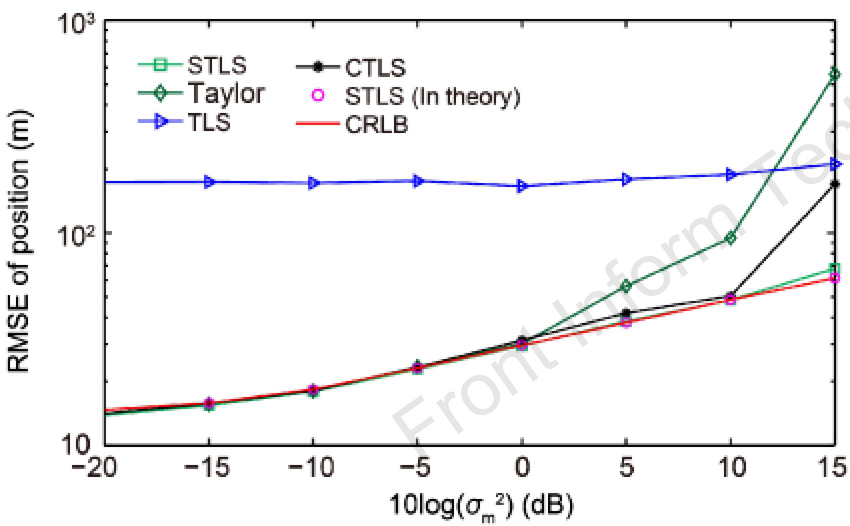

Fig. 2 Curves of source position RMSEs as the measurement noise varies

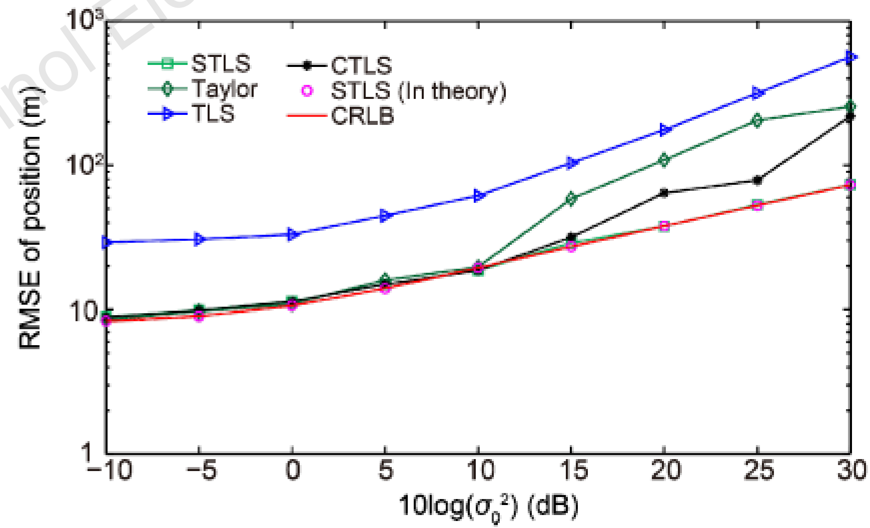

Fig. 3 Curves of source position RMSEs as the system error varies

Major results (Cont'd)

Compared with the previously developed single source localization algorithm, the proposed algorithm can achieve a lower CRLB; that is, lower optimal performance is obtained.

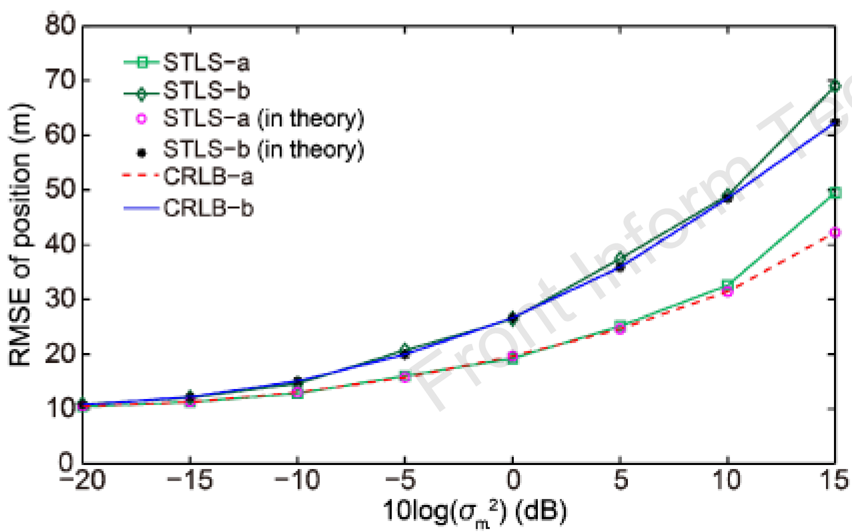

Fig. 4 Curves of source position RMSEs as the measurement noise varies

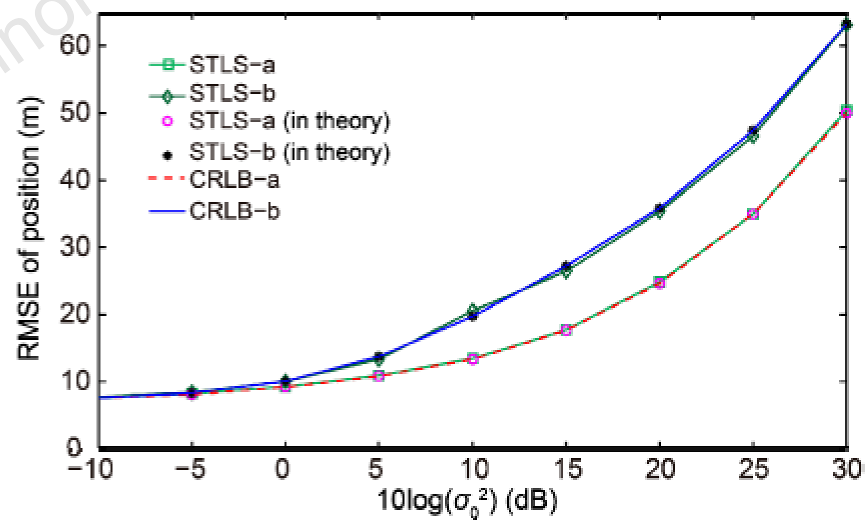

Fig. 5 Curves of source position RMSEs as the system error varies

Conclusions

1. For the multi-source scenario, when only one source position is of interest, the proposed algorithm can still exploit the same station position and velocity displacements of measurements from other unknown sources to improve source localization accuracy.

2. The cooperative positioning gain is proportional to the distance from the sources to the station.

3. The proposed localization algorithm requires less computation than the CTLS and Taylor series algorithms.