3D Estimator for Hyperbolic Location

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Introduction

- TDOA
  The idea of locating a mobile source by TDOA technology is to determine the TDOA value of multiple sets of sensors in three-dimensional space and then to find the distance difference between a mobile source and every two base stations, which make up a set of information about the location of the mobile source Hyperbolic equations, by solving these equations, we can find the coordinates of the mobile source location.
- Arbitrary and Linear Array of the sensors
  In a 3-D plane, the sensors will be set to the two kinds
- Solution
  Taylor-series, chan, CRLB, SI

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Solution

- Taylor-series
  We first get the Gt and the ht

$$ht = \begin{bmatrix} r_{2,1} - (r_2 - r_1) \\ r_{3,1} - (r_3 - r_1) \\ \cdots \\ r_{M,1} - (r_M - r_1) \end{bmatrix}$$

Solution

- Taylor-series
  We first get the Gt and the ht

$$ht = \begin{bmatrix} r_{2,1} - (r_2 - r_1) \\ r_{3,1} - (r_3 - r_1) \\ \cdots \\ r_{M,1} - (r_M - r_1) \end{bmatrix}$$

- So we can get the x and y deviation

$$\begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix} = (G_t^T Q^{-1} G_t)^{-1} G_t^T Q^{-1} h_t$$

Solution

- Chan
  First we get the z_a

$$z_a = (G_a^T \psi^{-1} G_a)_{-1} G_a^T \psi^{-1} h \tag{1}$$

  Then is the z_a' :

$$z_a' = (G_a'^T \psi'^{-1} G_a')^{-1} G_a'^T \psi'^{-1} h' \tag{2}$$

  So we get the Zp as

$$z_p = -\sqrt{z_a'} + \begin{bmatrix} x_1 \\ y_1 \\ z_1 \end{bmatrix}$$

- when it is linear we use

$$w_l = (G_l^T) \psi^{-1} G_l)^{-1} G_l^T \psi^{-1} h \tag{3}$$

Solution

- CRLB
  First we get the B"

$$B'' = \begin{bmatrix} (x^0 - x_1) & 0 & 0 \\ 0 & (y^0 - y_1) & 0 \\ 0 & 0 & (z^0 - z_1) \end{bmatrix}$$

  So

$$\Phi = c^2 B'' G_a'^T B'^{-1} G_a^{0\,T} B^{-1} Q^{-1} B{-}1 G_a^0 B'^{-1} G_a' B'')^{-1} \quad (4)$$

- When the CRLB linear

$$\Phi = c^2 (T^T G_l^{0\,T} B^{-1} Q^{-1} B^{-1} G_l^0 T)^{-1} \quad (5)$$

Solution

- Four sensors situation
  There is a special formula to solve it:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = - \begin{bmatrix} x_{2,1} & y_{2,1} & z_{2,1} \\ x_{3,1} & y_{3,1} & z_{3,1} \\ x_{4,1} & y_{4,1} & z_{4,1} \end{bmatrix}^{-1} \left\{ \begin{bmatrix} r_{2,1} \\ r_{3,1} \\ r_{4,1} \end{bmatrix} r_1 + \frac{1}{2} \begin{bmatrix} r_{2,1}^2 - K_2 + K_1 \\ r_{3,1}^2 - K_3 + K_1 \\ r_{4,1}^2 - K_4 + K_1 \end{bmatrix} \right\}$$

- When it comes to linear

$$-2x_{i,1}(x + az) - 2y_{i,1}(y + bz) - 2r_{i,1}r_1 = r_{i,1}^2 - K_i + K_1$$

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Simulation

Arbitrary and Linear

Table 1

MSE	M=4	M=5	M=6	M=7	M=8
SI		0.00126	0.00018		
Chan_3D	0.00799	0.01292	0.01139	0.00801	0.00783
Taylor	0.00080	0.00051	0.00016	0.00008	0.00007
CRLB	0.00270	0.00185	0.00137	0.00087	0.00086

Figure: Arbitrary result

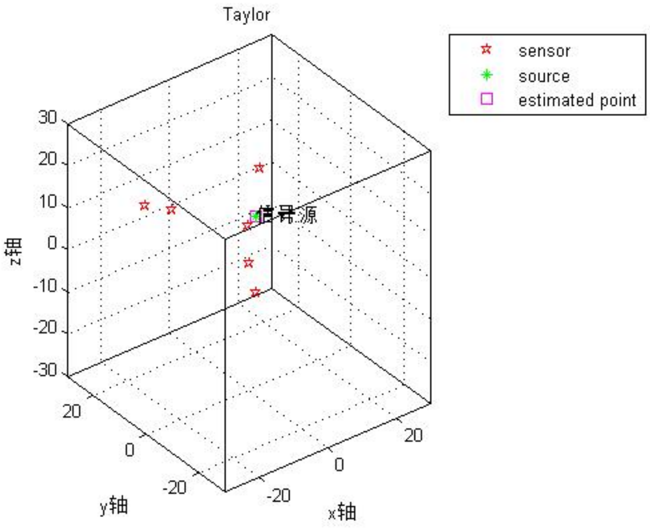
Table 2 (linear)

MSE	M=4	M=5	M=6	M=7	M=8
Chan_3D	0.00004	0.00124	0.00123	0.00138	0.00130
Taylor	0.00219	0.00127	0.00121	0.00118	0.00107
CRLB	0.11525	0.10188	0.10182	0.05794	0.04431

Figure: Linear result

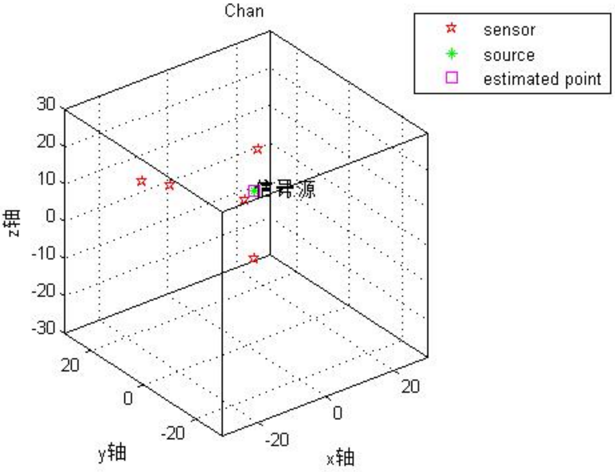
Simulation

taylor



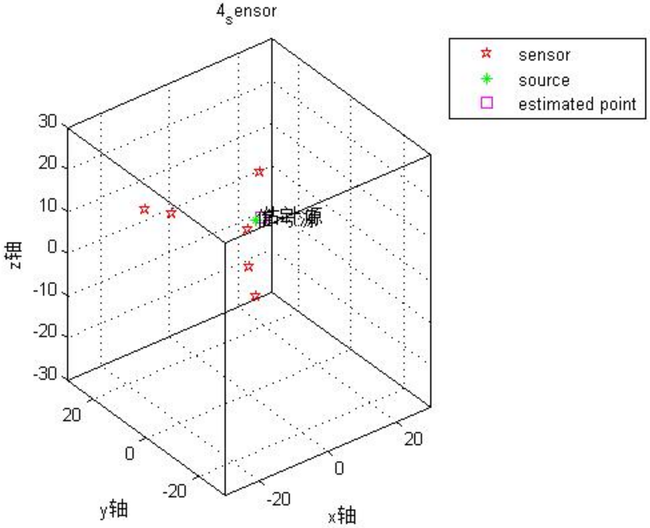
Simulation

chan



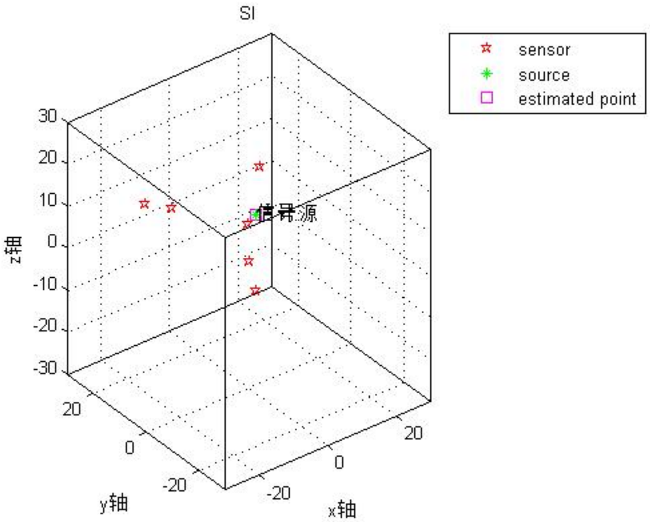
Simulation

4sensors



Simulation

SI



Simulation

CRLB threshing effect

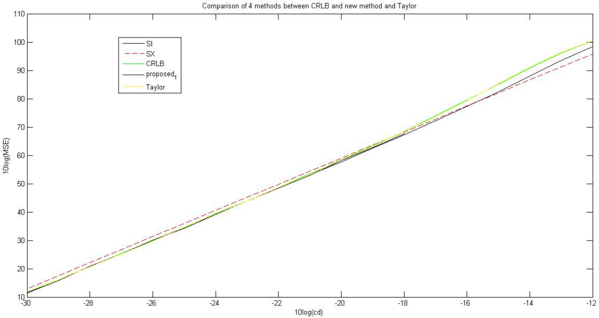


Figure: CRLB threshing effect

Conclusion

- The linear array has a less MSE than the arbitrary.
- Chan perform better than Taylor and SI. And the CRLB acts as the theoretical standard.

END I

Thanks for watching!

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Reference

"A simple and efficient estimator for hyperbolic location."