

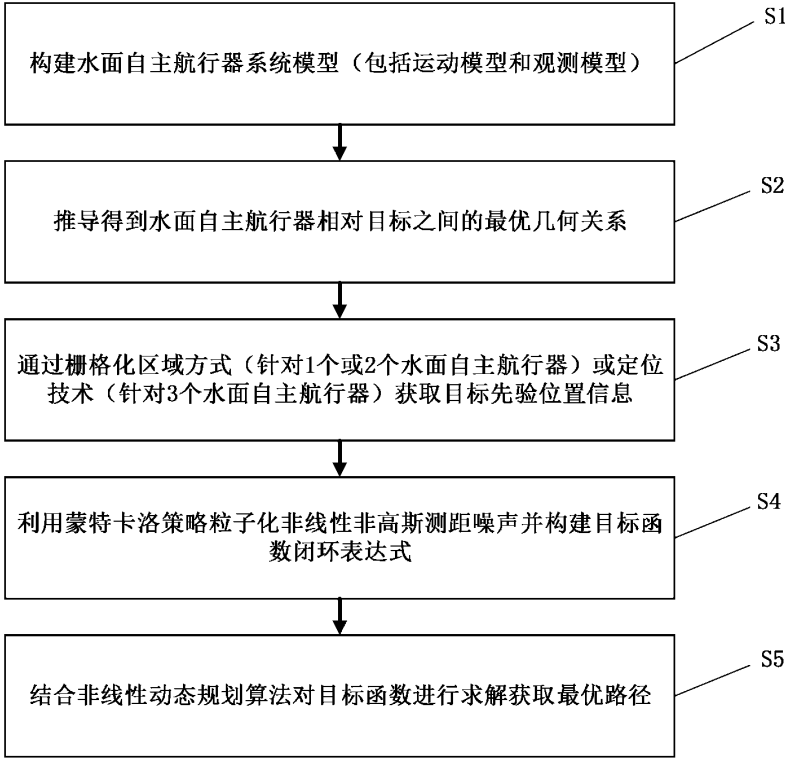


图 1

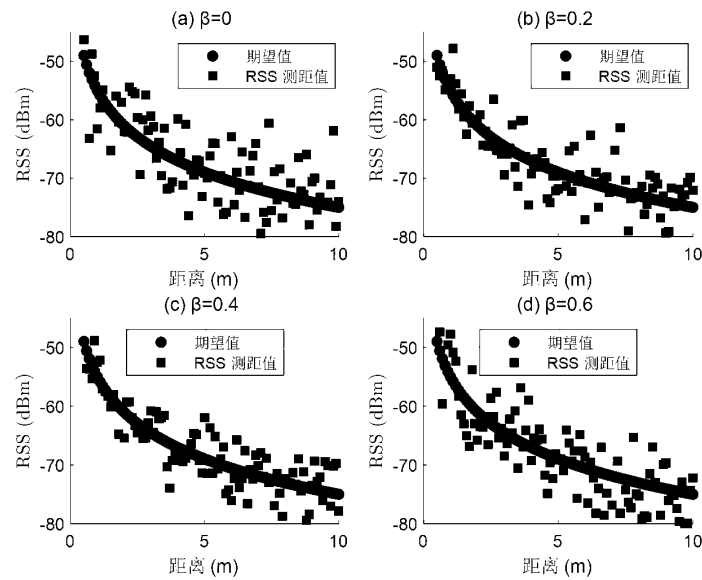


图 2

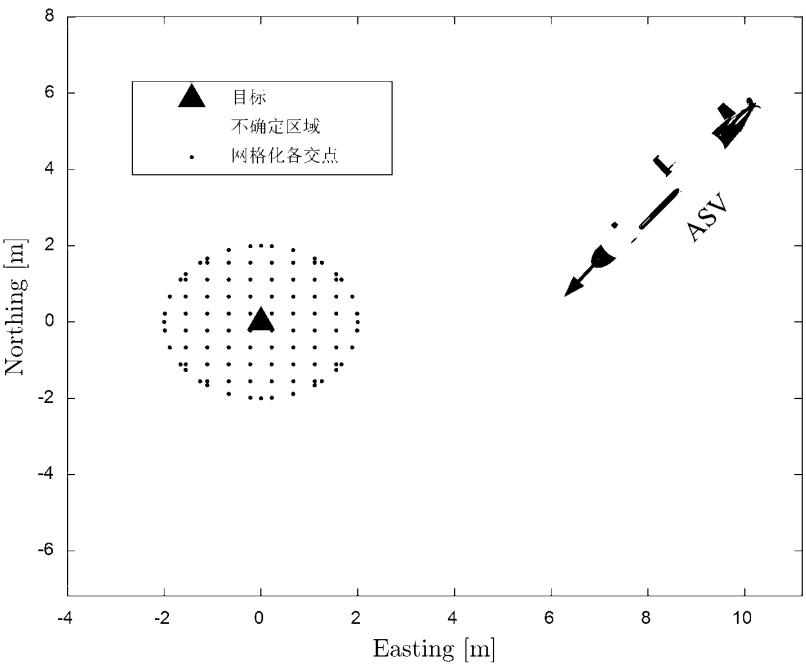


图 3

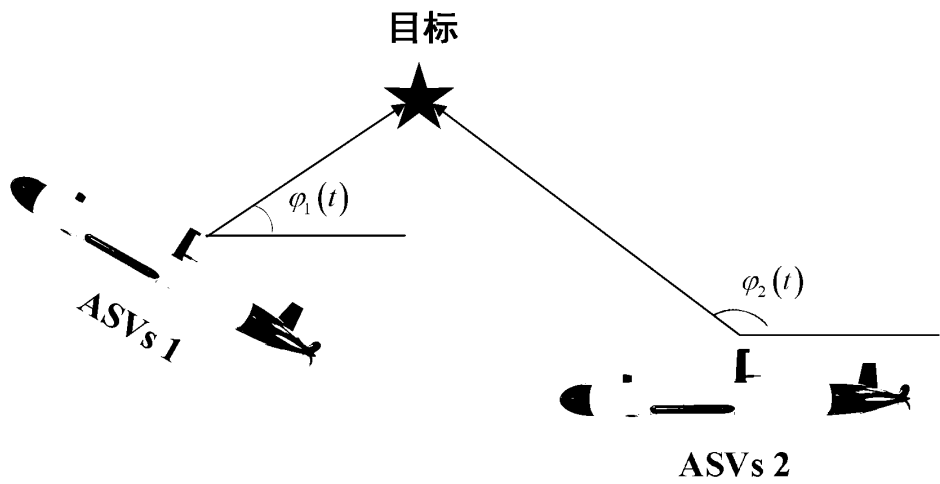


图 4

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**1 个 ASVs 目标定位最优路径:**


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1. 初始化:  $v(0)$ ,  $A_1^0$ ,  $\phi_1(0)$ ,  $r_1(0)$ , 网格中各交点  $k$
  2. **for**  $t=1:M$  **do**
  3.  $(I_\eta)^t \leftarrow (20)$
  4.  $\wp \leftarrow \min(\theta^t)$
  5.  $r_1^*(t) \leftarrow (15)$
  6.  $\phi_1(t) \leftarrow \phi_1(t-1) + r_1^*(t)$
  7. **if**  $r_1^*(t) = 0$  **do**
  8.  $A_1^t \leftarrow A_1^{t-1} + v(t)(g(\phi_1(t)) - g(\phi_1(t-1)))$
  9. **else**
  10.  $A_1^t \leftarrow A_1^{t-1} + \frac{v(t)}{r_1^*(t)}(O(\phi_1(t-1)) - O(\phi_1(t)))$
  11. **end if**
  12. **end for**
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图 5

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**2 个 ASVs 目标定位最优路径算法:**


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1. **Initiation:**  $v_1(0)$ ,  $v_2(0)$ ,  $A_1^0$ ,  $A_2^0$ ,  $\phi_1(0)$ ,  $\phi_2(0)$ ,  $r_1(0)$ ,  $r_2(0)$ , 网格中各交点  $k$
  2. **for**  $t=1:M$  **do**
  3.  $(I_\eta)^t \leftarrow (20)$
  4.  $\wp \leftarrow \min(\theta_{i=1,2}^t), \text{ s.t. } \theta_{i=1,2}^t = \left[ \sum_{j=1,2} J_{i1}^t, \dots, \sum_{j=1,2} J_{ik}^t \right]^T$
  5.  $r_{i=1,2}^*(t) \leftarrow \arg \max_{p \in \wp} \sum_{i=1}^2 \sum_{j=1,2} J_{ip}^t$
  6.  $\phi_1(t) \leftarrow \phi_1(t-1) + r_1^*(t)$ ,  $\phi_2(t) \leftarrow \phi_2(t-1) + r_2^*(t)$
  7. **if**  $r_1^*(t) = 0$  **do**
  8.  $A_1^t \leftarrow A_1^{t-1} + v(t)(g(\phi_1(t)) - g(\phi_1(t-1)))$
  9.  $A_2^t \leftarrow A_2^{t-1} + v(t)(g(\phi_2(t)) - g(\phi_2(t-1)))$
  10. **else**
  11.  $A_1^t \leftarrow A_1^{t-1} + \frac{v(t)}{r_1^*(t)}(O(\phi_1(t-1)) - O(\phi_1(t)))$
  12.  $A_2^t \leftarrow A_2^{t-1} + \frac{v(t)}{r_2^*(t)}(O(\phi_2(t-1)) - O(\phi_2(t)))$
  13. **end if**
  14. **end for**
- 

图 6

定位算法：

1. 初始化:  $y_{prev} = 0$ ,  $thre = 1e-7$ ,  $iter = 1$ , 迭代总数  $I$ ;

2. 计算对应收到的 RSS 测距值;

3. 重塑方程变为广义信赖域子问题;

4. **While**  $iter < I$ , **do**;

5. 根据下式计算每次迭代的乘子  $\lambda$ :

$$\left( \frac{\phi^T \omega^T \mathcal{R} - \lambda f}{\phi^T \omega \phi + \lambda D} \right)^T D \left( \frac{\phi^T \omega^T \mathcal{R} - \lambda f}{\phi^T \omega \phi + \lambda D} \right) + 2 f^T \left( \frac{\phi^T \omega^T \mathcal{R} - \lambda f}{\phi^T \omega \phi + \lambda D} \right) = 0;$$

6. 计算每次迭代最优  $\lambda^{iter*} = \max \left[ -diag(\phi^T \omega \phi) / diag(D), \lambda \right]$ ;

7. 根据下式计算每次迭代最优  $y$ :

$$y^{iter} = \frac{\phi^T \omega^T \mathcal{R} - \lambda^{iter*} f}{\phi^T \omega \phi + \lambda^{iter*} D};$$

8. **If**  $\|y^{iter} - y_{prev}\| / \|y^{iter}\| < thre$ ;

9. 停止;

10. **End if**;

11.  $y_{prev} = y^{iter}$ ;

12. **End while**;

图 7

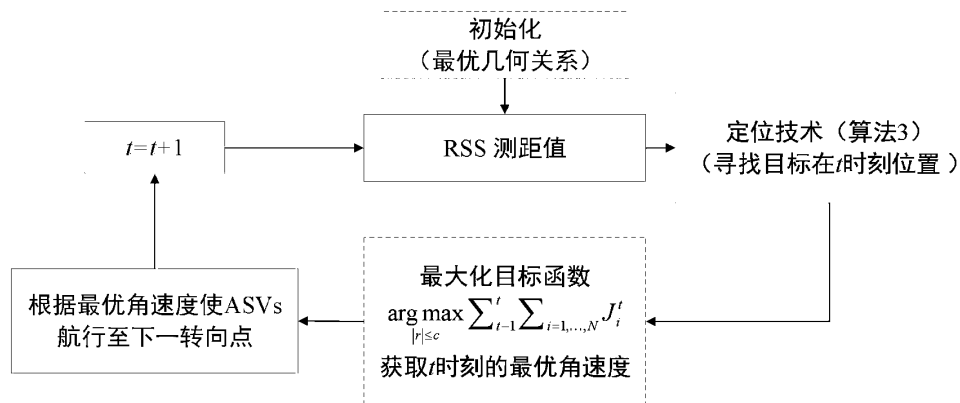


图 8

| 参数 <sup>(1)</sup>            | 对应数值 <sup>(1)</sup>  |
|------------------------------|----------------------|
| ASV1 初始位置(m) <sup>(1)</sup>  | $A_1^1 = [15, 15]^T$ |
| 目标位置 (m) <sup>(1)</sup>      | $B = [0, 0]^T$       |
| 初始航向 (rad) <sup>(1)</sup>    | $\phi_1(1) = \pi/2$  |
| 初始角速度 (rad/s) <sup>(1)</sup> | $r_1(1) = 0$         |
| 时间 (s) <sup>(1)</sup>        | $M = 200$            |
| 不确定区域半径 (m) <sup>(1)</sup>   | 2                    |
| 不确定区域点数量 <sup>(1)</sup>      | 96                   |
| ASV1 速度(m/s) <sup>(1)</sup>  | 1.5                  |

图 9

| 参数 <sup>(1)</sup>            | 对应数值 <sup>(1)</sup>                       |
|------------------------------|-------------------------------------------|
| ASVs 初始位置(m) <sup>(1)</sup>  | $A_1^1 = [30, 30]^T, A_2^1 = [30, -30]^T$ |
| 目标位置 (m) <sup>(1)</sup>      | $B = [0, 0]^T$                            |
| 初始航向 (rad) <sup>(1)</sup>    | $\phi_1(1) = \pi/2, \phi_2(1) = 0$        |
| 初始角速度 (rad/s) <sup>(1)</sup> | $r_1(1) = \pi/30, r_2(1) = \pi/18$        |
| 时间 (s) <sup>(1)</sup>        | $M = 400$                                 |
| 不确定区域半径 (m) <sup>(1)</sup>   | 2                                         |
| 不确定区域点数量 <sup>(1)</sup>      | 96                                        |
| ASVs 速度(m/s) <sup>(1)</sup>  | $v_1 = v_2 = 1.5$                         |
| 污染因子 <sup>(1)</sup>          | $\beta = 0.4$                             |

图 10

| 参数 <sup>(1)</sup>            | 对应数值 <sup>(1)</sup>                                                           |
|------------------------------|-------------------------------------------------------------------------------|
| ASVs 初始位置(m) <sup>(1)</sup>  | $A_1^1 = [30\sqrt{3}, 30]^T, A_2^1 = [-30\sqrt{3}, 30]^T, A_3^1 = [0, -60]^T$ |
| 目标位置 (m) <sup>(1)</sup>      | $B^1 = [0, 0]^T$                                                              |
| 初始航向 (rad) <sup>(1)</sup>    | $\phi_1(1) = \pi, \phi_2(1) = 0, \phi_3(1) = -\pi/2$                          |
| 初始角速度 (rad/s) <sup>(1)</sup> | $r_1(1) = \pi/18, r_2(1) = \pi/30, r_3(1) = \pi/10$                           |
| 时间 (s) <sup>(1)</sup>        | $M = 150$                                                                     |
| ASVs 速度(m/s) <sup>(1)</sup>  | $v_1 = v_2 = v_3 = 1.5$                                                       |
| 目标速度 <sup>(1)</sup>          | $v_x = 0.1, v_y = 0$                                                          |
| 污染因子 <sup>(1)</sup>          | $\beta = 0.4$                                                                 |

图 11

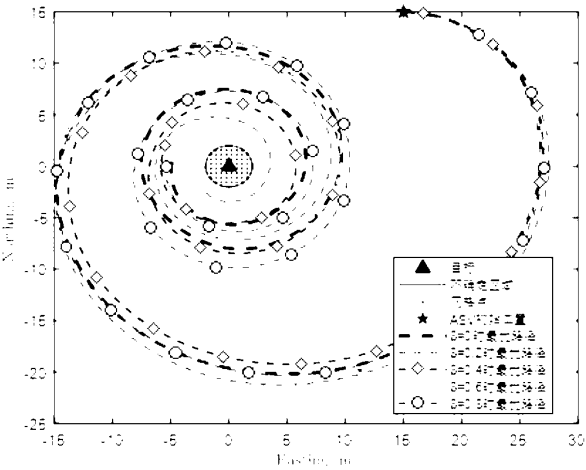


图 12

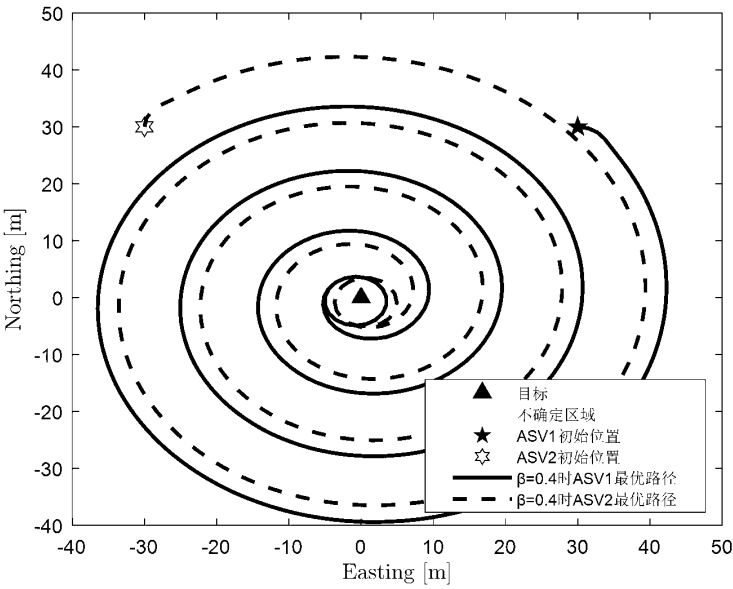


图 13

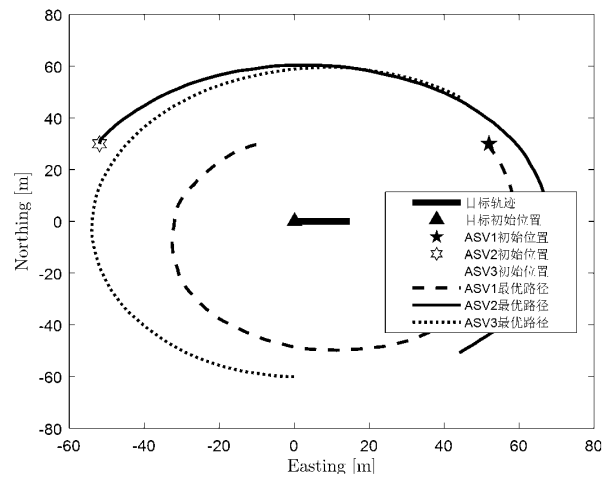


图 14

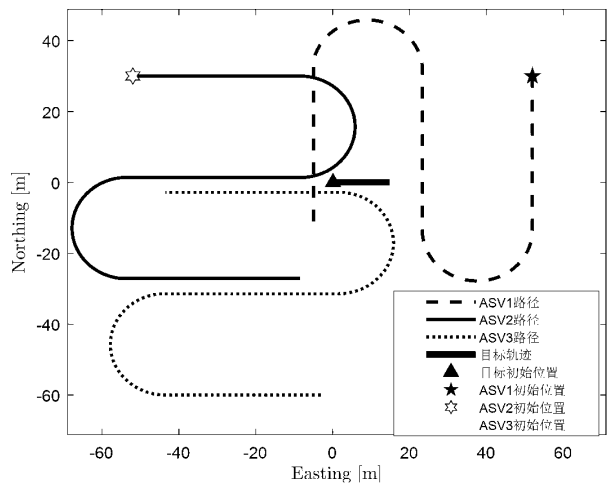


图 15

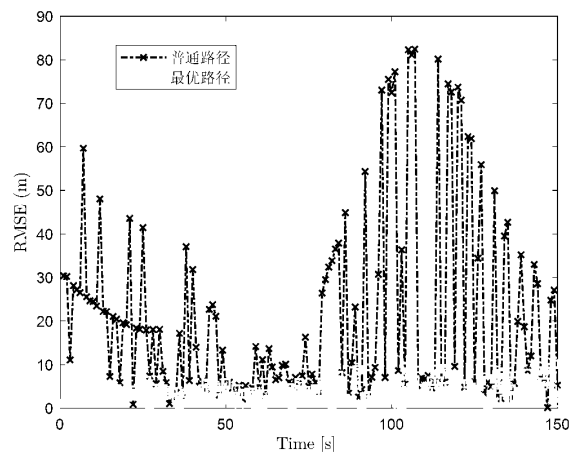


图 16