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1 .

16

208

b b$_1$

b$_2$ b b$_1$ b$_2$

A

$A_{ij} = -\int \frac{\nabla \phi_i}{I_i} \bullet \frac{\nabla \phi_j}{I_j} dxdy$, A_{ij} j i φ_i i

I_i φ_j j I_j

$\nabla \phi_i$, $\nabla \phi_j$ φ_i φ_j

$f(\sigma)$ b σ $f(\sigma)$ b

$\Delta b = \frac{df(\sigma)}{d\sigma} \cdot \Delta\sigma$, $\Delta\sigma$ Δb

Ag b

g

$F(g) = = \frac{\lambda}{2} \| Ag - b \|_2^2 + \alpha_1 \|\nabla g - v\|_1 + \alpha_0 \|\varepsilon(v)\|_1$, $\alpha_1 \|\nabla g - v\|_1$

$\alpha_0 \|\varepsilon(v)\|_1$ α_1 α_0

λ $\frac{1}{2} \| Ag - b \|_2^2$

$\bar{g} = \arg\min_g F(g)$;

$\bar{g} = \arg\min_g F(g)$ $\min_{g,v} \max_{p \in P, q \in Q} \langle \nabla g - v, p \rangle + \langle \varepsilon(v), q \rangle + \frac{\lambda}{2} \| Ag - b \|_2^2$,

P $\{p \quad (p_1, p_2) \mid \|p\|_\infty \le \alpha_1\}$ $Q = \left\{ q = \begin{pmatrix} q_{11}, q_{12} \\ q_{21}, q_{22} \end{pmatrix} \middle| \|q\|_\infty \le \alpha_0 \right\}$;

$\bar{g} = \arg\min_g F(g)$

9) g^{k+1} v^{k+1}

g

(Electrical Tomography ET) 20 80

(Electrical Resistance Tomography ERT) (Electrical Impedance Tomography EIT) (Electrical Capacitance Tomography ECT) (Electrical Magnetic Tomography EMT)

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Tikhonov

Ag b A b g

$$F(g)==\frac{\lambda}{2}\| Ag-b \|_2^2+\alpha_1\left\|\nabla g-v\right\|_1+\alpha_0\left\|\varepsilon(v)\right\|_1$$

λ ( ) $\left\|Ag-b\right\|_2^2$ (

) $\alpha_1\left\|\nabla g-v\right\|_1+\alpha_0\left\|\varepsilon(v)\right\|_1$ α_1 α_0

$$\overline{g}=\arg\min_g F(g)$$

1. b A

b b_1 b_2

2. , Ag b

3.

4. $\overline{g}=\arg\min_g F(g)$

5. $\overline{g}=\arg\min_g F(g)$,

6.

Tikhonov

Tikhonov

1

2

3 Tikhonov

4 (Relative Error RE)

(Correlation Coefficient CC)

5(a) RE CC (b)

RE CC

1 2 3 4 5

1

2

16 5 2 1

3 4

3

Tikhonov

((a) (c))

((d) (f)) Tikhonov

Tikhonov

Tikhonov

$$\min_g\{F(g)\}=\min_g\left\{\|Ag-b\|_2^2\right\}$$ F(g)

F(g)

$F(g)=\frac{1}{2}\|Ag-b\|_2^2+\lambda R(g)$ λ $\|Ag-b\|_2^2$ R(g)

Tikhonov Tikhonov

$$F(g)=\frac{1}{2}\|Ag-b\|_2^2+\lambda\|g\|_2^2$$

L_2

$F(g)=\frac{1}{2}\|Ag-b\|_2^2+\lambda\int_\Omega|\nabla g|\mathrm{d}x$ L_1

16

208 b b_1 b_2 b b_1 b_2

A

$A_{ij}=-\int\frac{\nabla\phi_i}{I_i}\bullet\frac{\nabla\phi_j}{I_j}dxdy$ A_{ij} j i φ_i i

I_i φ_j j I_j

φ_i φ_j

f(σ) b σ f(σ)

b $\Delta b=\frac{\mathrm{d}f(\sigma)}{\mathrm{d}\sigma}\cdot\Delta\sigma$， Δσ Δ

b

Ag b g

$F(g)==\frac{\lambda}{2}\|Ag-b\|_2^2+\alpha_1\|\nabla g-v\|_1+\alpha_0\|\varepsilon(v)\|_1$ $\alpha_1\|\nabla g-v\|_1$

$\alpha_0\|\varepsilon(v)\|_1$ α_1 α_0

λ $\frac{1}{2}\|Ag-b\|_2^2$

$\bar{g} = \arg\min_{g} F(g)$ 。

$\bar{g} = \arg\min_{g} F(g)$ ： $\min_{g,v} \max_{p \in P, q \in Q} \langle \nabla g - v, p \rangle + \langle \varepsilon(v), q \rangle + \frac{\lambda}{2} \| Ag - b \|_2^2$

P {p (p$_1$,p$_2$)|||p||$_\infty$ ≤ α$_1$} $Q = \left\{ q = \begin{pmatrix} q_{11}, q_{12} \\ q_{21}, q_{22} \end{pmatrix} \middle| \|q\|_\infty \le \alpha_0 \right\}$ 。

$\bar{g} = \arg\min_{g} F(g)$

1) w 0, v 0, $\bar{v} = 0, p = 0, \bar{p} = 0$, q 0, g_0 0, τ 1/L, σ 1/L

2) $p^{k+1} = \text{proj}_P(p^k + \sigma(\nabla \bar{p}^k - \bar{v}^k))$

3) $q^{k+1} = \text{proj}_Q(q^k + \sigma(\varepsilon(\bar{v}^k)))$;

4) $w^{k+1} = \text{prox}^{\sigma}(w^k + \sigma(A\bar{g}^k - b))$;

5) $g^{k+1} = g^k + \tau(\text{div}\nabla p^{k+1} - A^T w^{k+1})$;

6) v^{k+1} $v^k + \tau(p^{k+1} + \text{div}\varepsilon q^{k+1})$

7)

8) $\bar{v}^{k+1} = 2v^{k+1} - v^k$;

9) g^{k+1} v^{k+1}

3 Tikhonov Tikhonov Tikhonov

RE CC

(1) (2) RE CC

RE CC 5

$$\mathrm{RE} = \frac{\left\| \sigma - \sigma^* \right\|_2^2}{\left\| \sigma^* \right\|_2^2} \quad (1)$$

$$\mathrm{CC} = \frac{\sum_{i=1}^{t} \left(\sigma_i - \bar{\sigma}\right)\left(\sigma_i^* - \bar{\sigma}^*\right)}{\sqrt{\sum_{i=1}^{t} \left(\sigma_i - \bar{\sigma}\right)^2 \sum_{i=1}^{t} \left(\sigma_i^* - \bar{\sigma}^*\right)^2}} \quad (2)$$

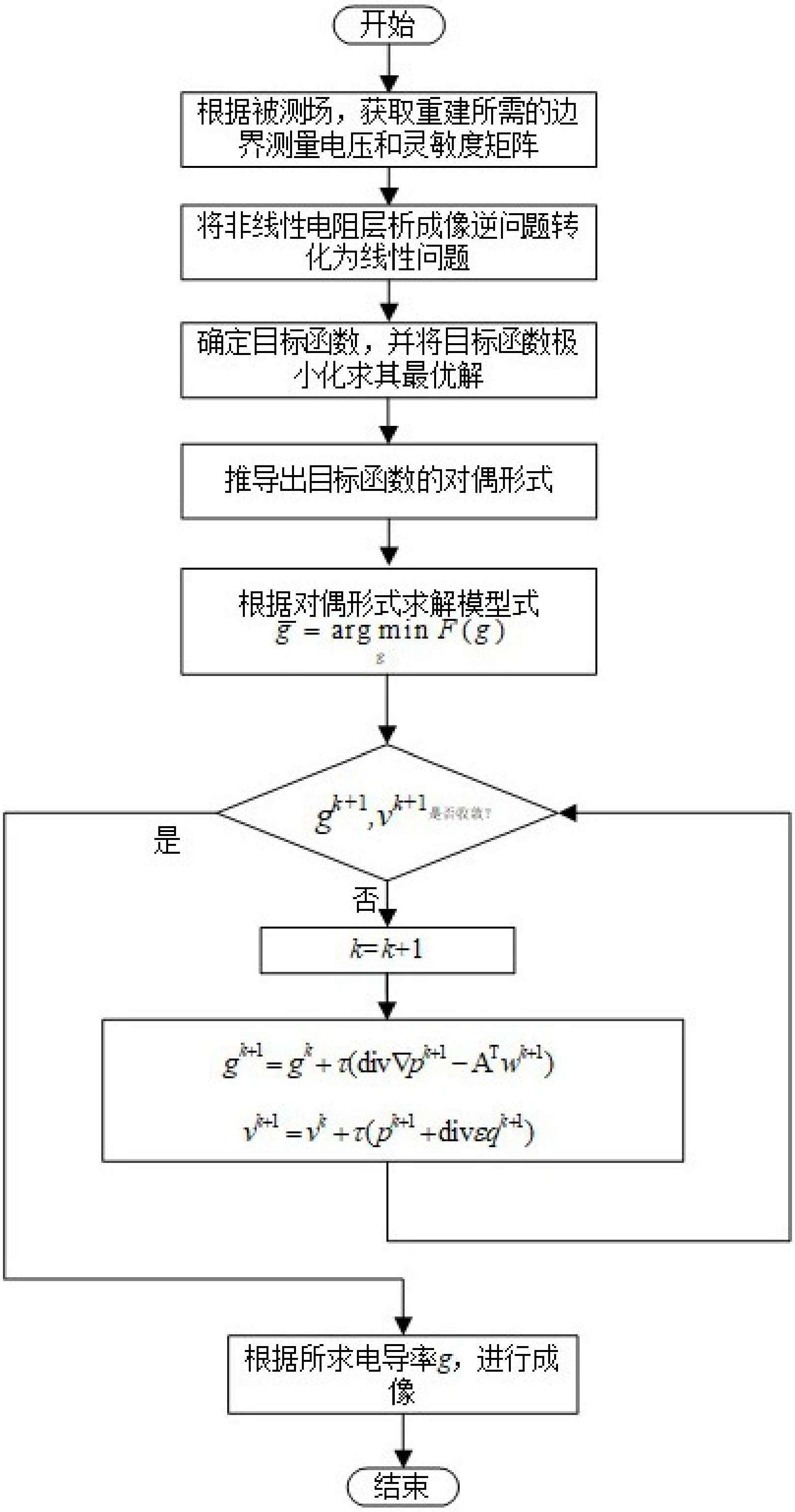
σ σ^* t $\bar{\sigma}$ $\bar{\sigma}^*$ σ σ^* σ_i σ_i^* σ σ^* i

4 RE CC Tikhonov ((a) (c))

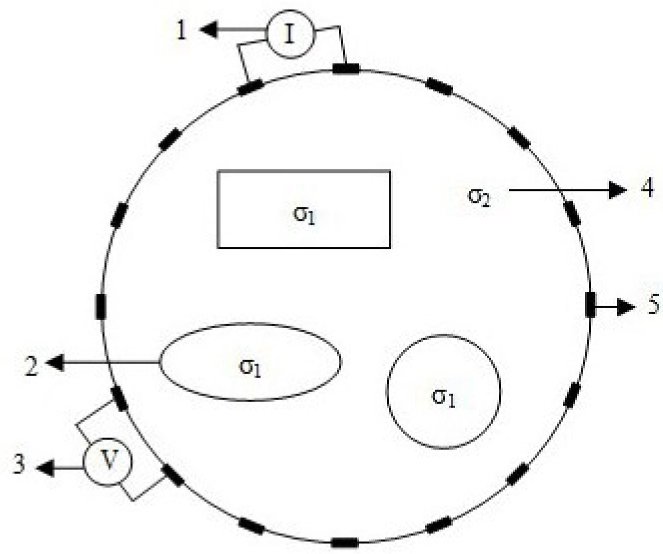
RE CC

((d) (f)) RE CC
((a) (c)) (
(d) (f))

0 2.5 5 7.5 10
(a) (e) 5
RE CC RE CC Tikhonov
(a) 5(a) RE
CC
(e) RE CC 5(b)


开始
根据被测场，获取重建所需的边界测量电压和灵敏度矩阵
将非线性电阻层析成像逆问题转化为线性问题
确定目标函数，并将目标函数极小化求其最优解
推导出目标函数的对偶形式
根据对偶形式求解模型式
$\bar{g} = \arg\min_{g} F(g)$
g^{k+1}, v^{k+1}是否收敛?
是
否
$k=k+1$
$g^{k+1} = g^{k} + \tau(\mathrm{div}\nabla p^{k+1} - A^{T} w^{k+1})$
$v^{k+1} = v^{k} + \tau(p^{k+1} + \mathrm{div}\,\varepsilon q^{k+1})$
根据所求电导率g，进行成像
结束

1



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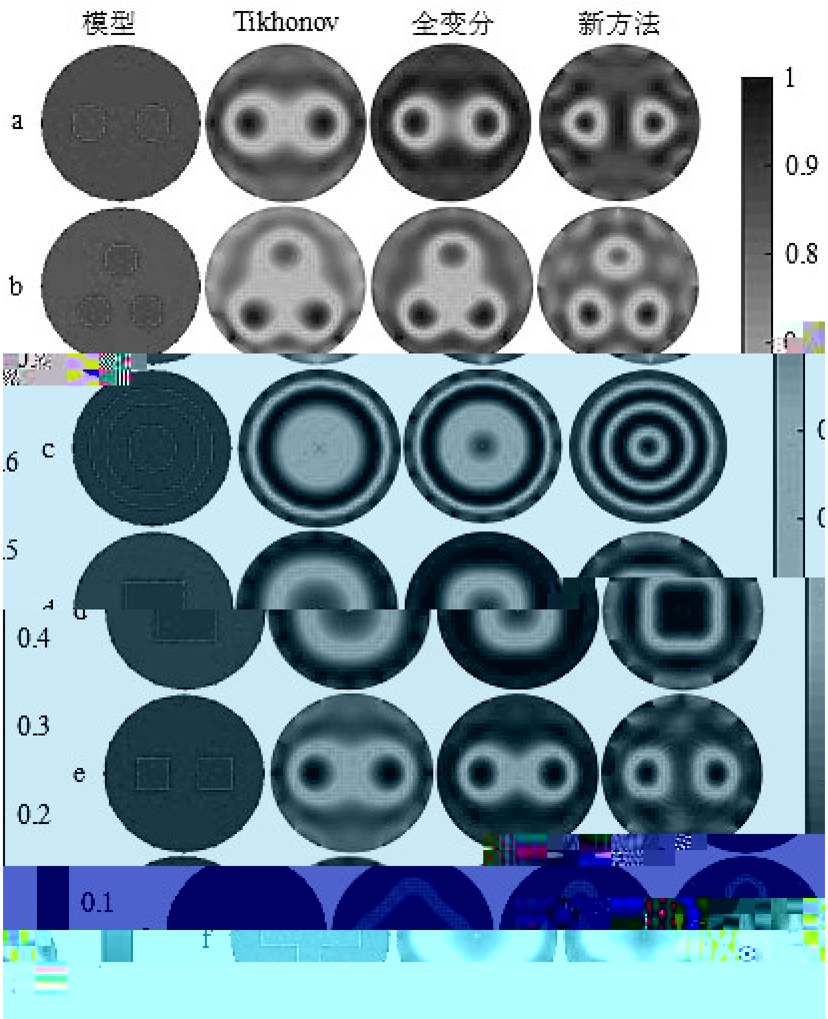

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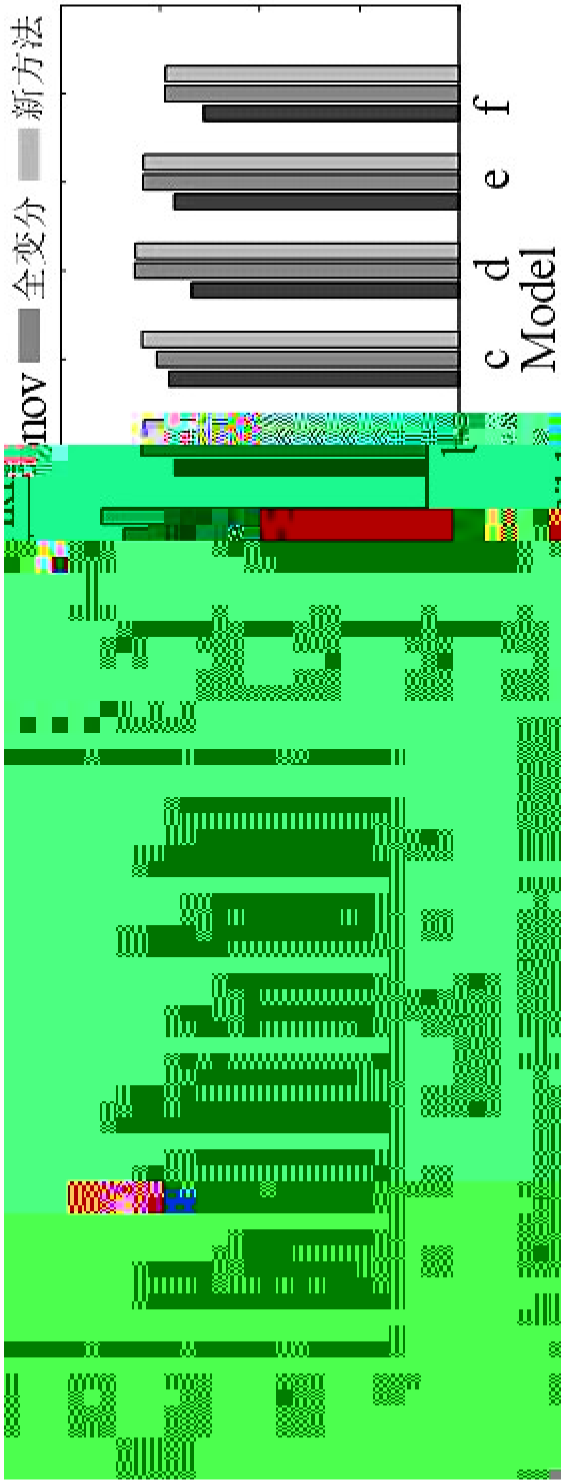

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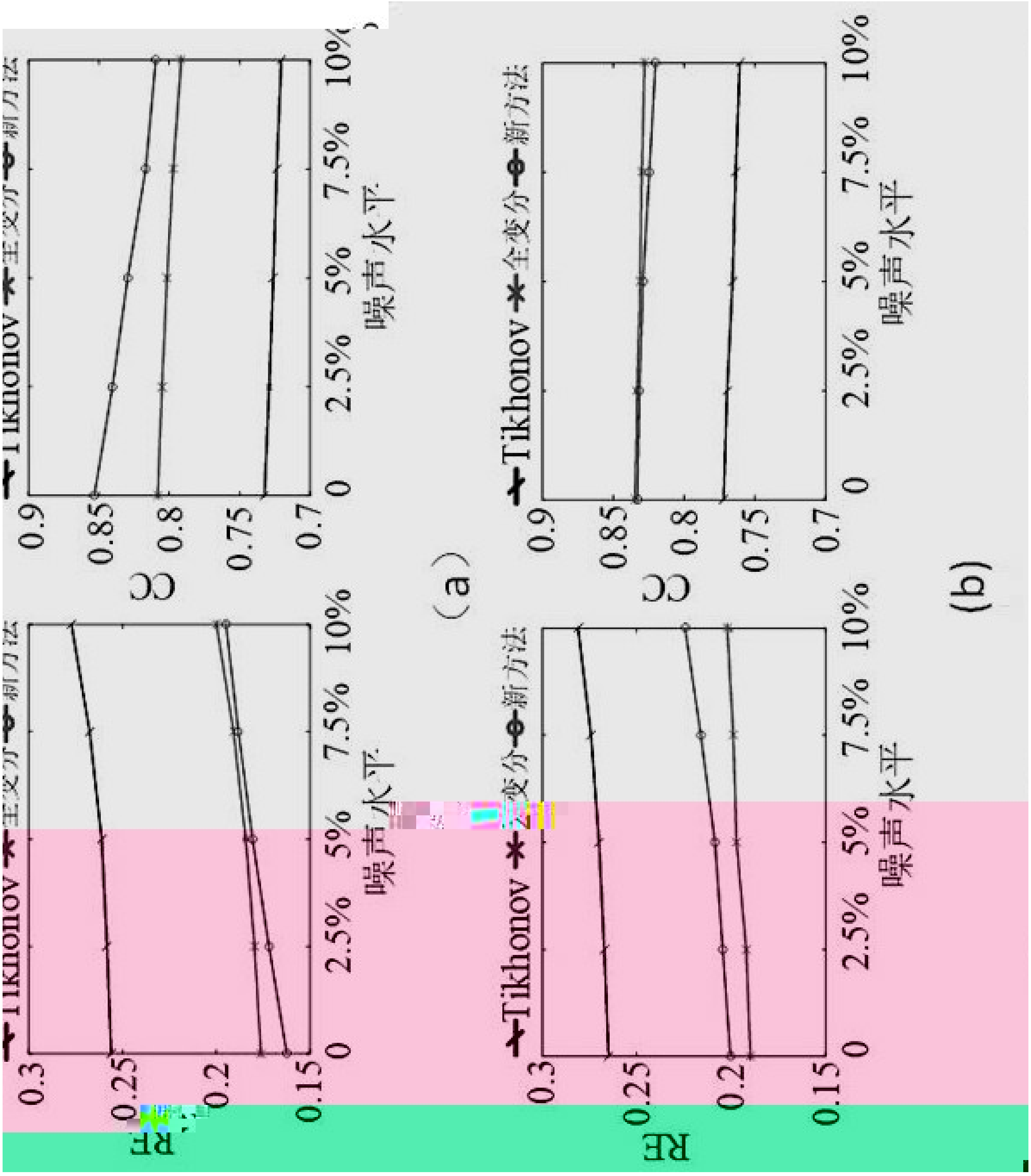
Tikhonov
全变分
新方法
噪声水平
RE
CC
0.3
0.25
0.2
0.15
0.9
0.85
0.8
0.75
0.7
0
2.5%
5%
7.5%
10%
(a)
(b)

5