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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

$\Delta b=\frac{\mathrm{d}f(\sigma)}{\mathrm{d}\sigma}\cdot\Delta\sigma$， Δσ 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 $\{p$ $(p_1,p_2)\,|\,\|p\|_\infty\le\alpha_1\}$ $Q=\left\{q=\begin{pmatrix}q_{11},q_{12}\\q_{21},q_{22}\end{pmatrix}\middle|\|q\|_\infty\le\alpha_0\right\}$；

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

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

g

[0001]

[0002] (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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[0005]

[0006]

Tikhonov

[0007]

Ag b A b g

[0008] $F(g) = = \frac{\lambda}{2} \| Ag - b \|_2^2 + \alpha_1 \|\nabla g - v\|_1 + \alpha_0 \|\varepsilon(v)\|_1$

[0009] λ ( ) $\|Ag - b\|_2^2$ (

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

[0010]

[0011] $\overline{g} = \arg\min_{g} F(g)$

[0012]

[0013]

[0014] 1. b A

b b_1 b_2

[0015] 2. , Ag b

[0016] 3.

[0017] 4. $\overline{g} = \arg\min_{g} F(g)$

[0018] 5. $\overline{g} = \arg\min_{g} F(g)$,

[0019] 6.

[0020]

Tikhonov

Tikhonov

[0021] 1

[0022] 2

[0023] 3 Tikhonov

[0024] 4 (Relative Error RE)
(Correlation Coefficient CC)

[0025] 5(a) RE CC (b)
RE CC

[0026] 1 2 3 4 5

[0027]

[0028]

[0029] 1

[0030] 2
16 5 2 1
3 4

[0031] 3
Tikhonov
((a) (c))
((d) (f)) Tikhonov
Tikhonov
Tikhonov

[0032]

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

F(g)

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

[0033] Tikhonov Tikhonov

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

L_2

[0034]

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

[0035]

[0036]

16

208 b b_1

b_2 b b_1 b_2

[0037] 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

[0038]

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

[0039] $F(g)==\frac{\lambda}{2}\|Ag-b\|_2^2+\alpha_1\|\nabla g-v\|_1+\alpha_0\|\varepsilon(v)\|_1$ $\alpha_1\|\nabla g-v\|_1$

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

λ $\frac{1}{2}\|Ag-b\|_2^2$

$\bar{g} = \arg\min_{g} F(g)$ 。

[0040] $\bar{g} = \arg\min_{g} F(g)$: $\min_{g,v} \max_{p \in P, q \in Q} \langle \nabla g - v, p \rangle + \langle \varepsilon(v), q \rangle + \frac{\lambda}{2} \| Ag - b \|_2^2$

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

[0041] $\bar{g} = \arg\min_{g} F(g)$

[0042] 1) w 0 ,v 0 , $\bar{v} = 0, p = 0, \bar{p} = 0$, q 0 , g_0 0 , τ 1/L , σ 1/L

[0043] 2) $p^{k+1} = \text{proj}_P(p^k + \sigma(\nabla \bar{g}^k - \bar{v}^k))$

[0044] 3) $q^{k+1} = \text{proj}_Q(q^k + \sigma(\varepsilon(\bar{v}^k)))$;

[0045] 4) $w^{k+1} = \text{prox}^{\sigma}(w^k + \sigma(A\bar{g}^k - b))$;

[0046] 5) $g^{k+1} = g^k + \tau(\text{div}\nabla p^{k+1} - A^T w^{k+1})$;

[0047] 6) v^{k+1} $v^k + \tau(p^{k+1} + \text{div}\,\varepsilon q^{k+1})$

[0048] 7) $\bar{g}^{k+1} = 2g^{k+1} - g^k$

[0049] 8) $\bar{v}^{k+1} = 2v^{k+1} - v^k$;

[0050] 9) g^{k+1} v^{k+1}

[0051]

[0052] 3 Tikhonov

Tikhonov

Tikhonov

RE CC

(1) (2) RE CC

RE CC 5

[0053] $$\text{RE} = \frac{\|\sigma - \sigma^*\|_2^2}{\|\sigma^*\|_2^2} \quad (1)$$

[0054] $$\text{CC} = \frac{\sum_{i=1}^{t} (\sigma_i - \bar{\sigma})(\sigma_i^* - \bar{\sigma}^*)}{\sqrt{\sum_{i=1}^{t} (\sigma_i - \bar{\sigma})^2 \sum_{i=1}^{t} (\sigma_i^* - \bar{\sigma}^*)^2}} \quad (2)$$

[0055] σ σ^* t $\bar{\sigma}$ $\bar{\sigma}^*$ σ

σ^* σ_i σ_i^* σ σ^* i

[0056] 4 RE CC Tikhonov

((a) (c))

RE CC

((d) (f)) RE CC

((a) (c)) (

(d) (f))

[0057] 0 2.5 5 7.5 10

(a) (e) 5

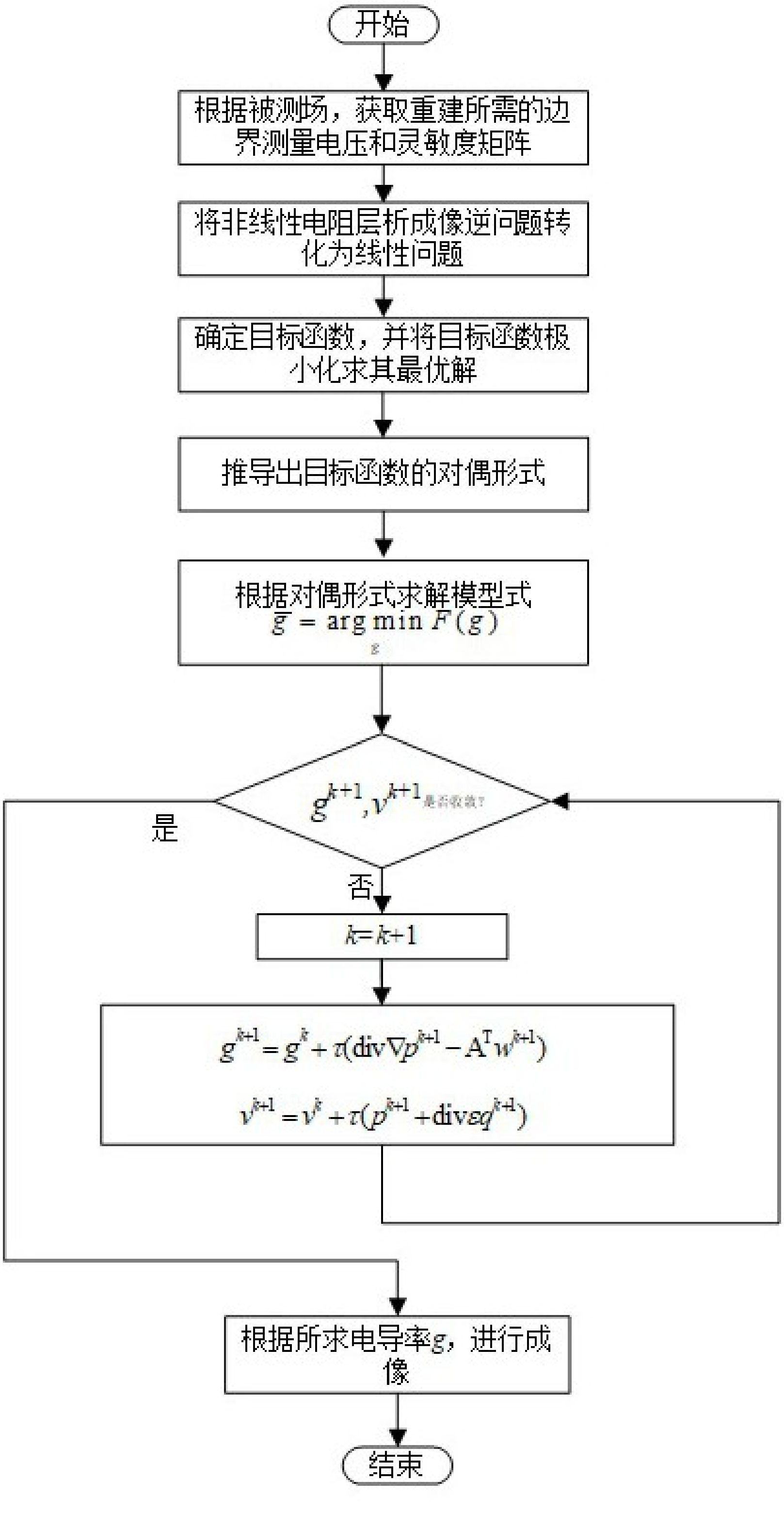
RE CC RE CC Tikhonov

(a) 5(a) RE

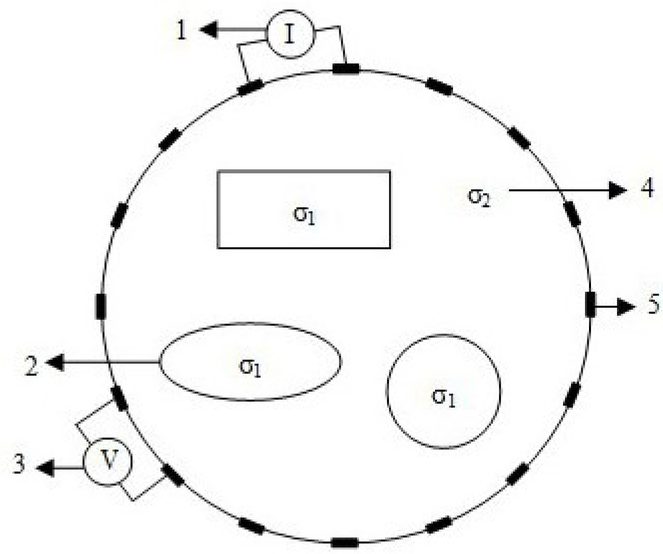
CC

(e) RE CC 5(b)

[0058]


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
是
否
k=k+1
根据所求电导率g，进行成像
结束

1



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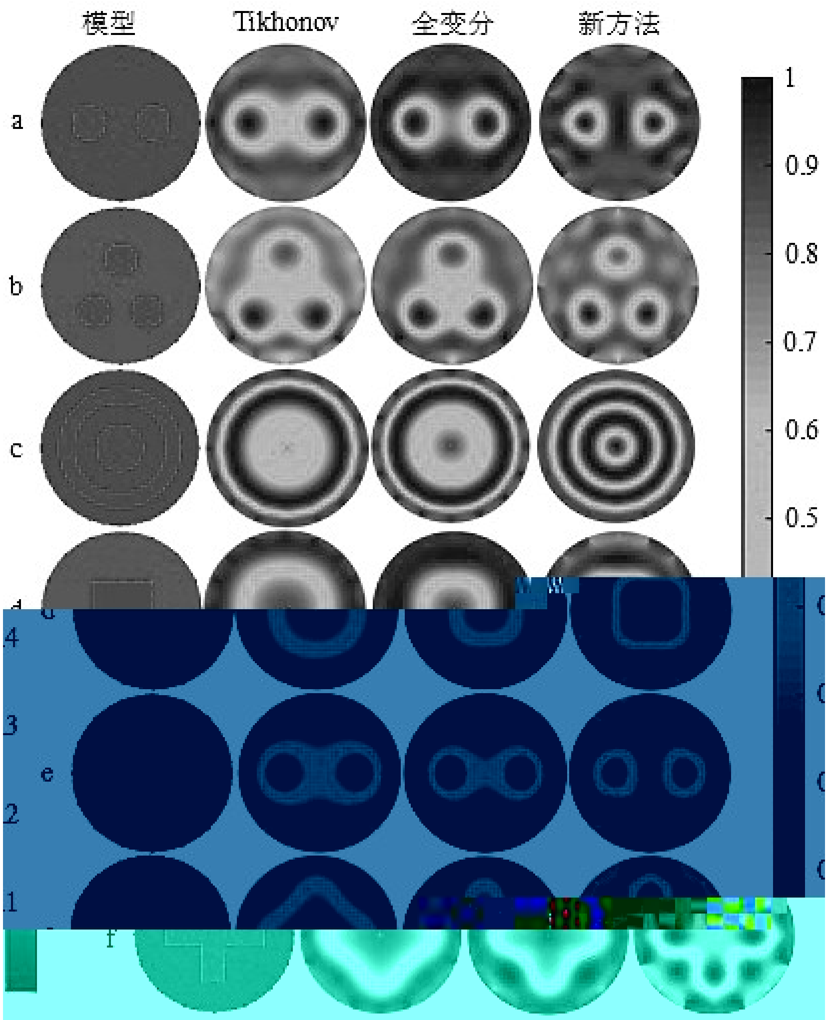
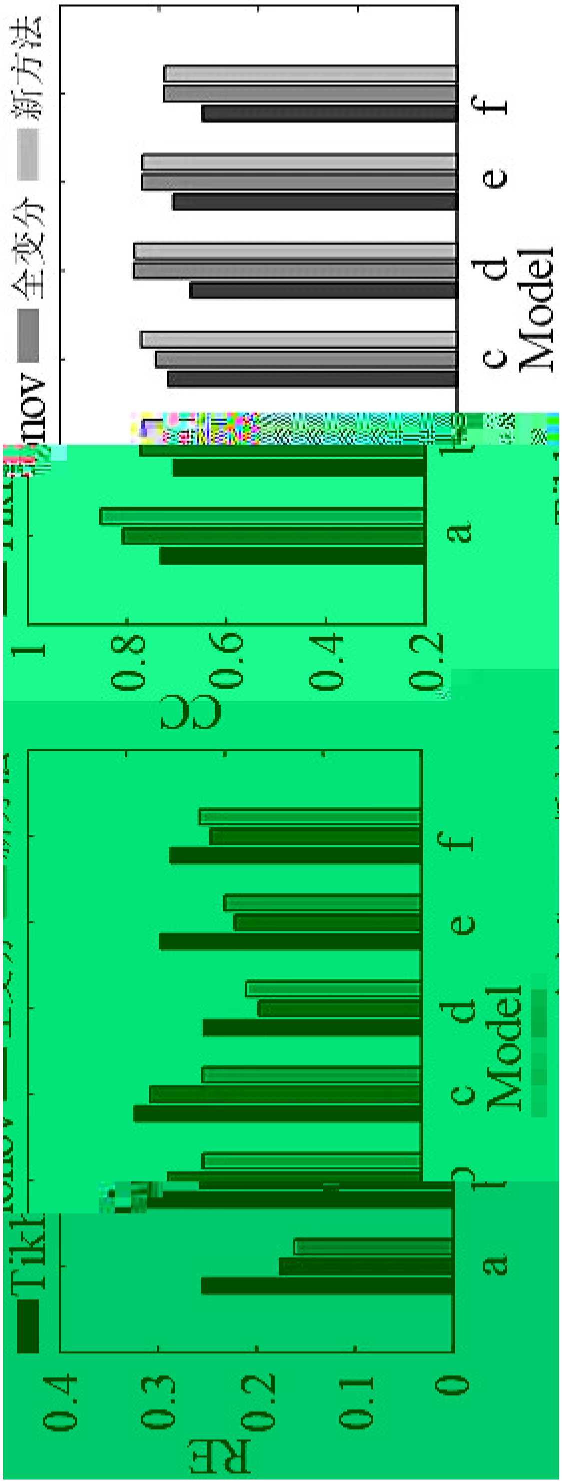
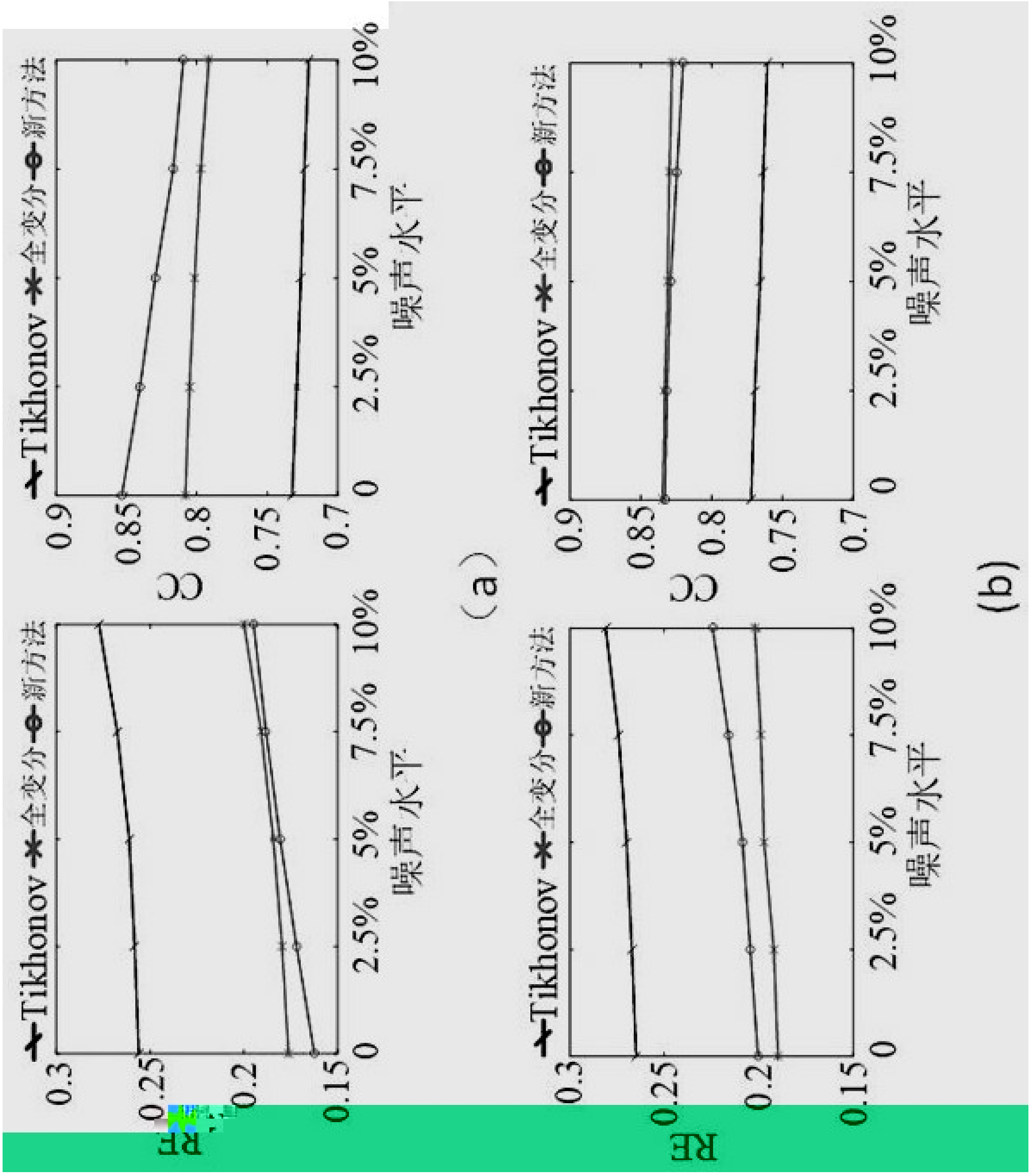


3



4


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

5