$$P(\mathbf{x})$$

X

P_i

$g(\mathbf{x})$

$\mathbf{x}_i$

w

$$P(\mathbf{x}) \equiv \sum_i P_i \; w^{-1} \; g[(\mathbf{x} - \mathbf{x}_i)/w],$$

where

$$\int g(\mathbf{x})d\mathbf{x} = 1, \text{ and } \int g(\mathbf{x}) \|\mathbf{x}\|^2 \, d\mathbf{x} \approx 1.$$

b

N_b

t_{bh}

h

a

$$T_{bh} = \int_0^{a_{bh}} P[\mathbf{x}_{bh}(a)]da.$$

$$\mathbf{x}_{bh}(a)$$

$$a = 0$$

a_{bh}

T_{bh}

θ_{bh}

$$e_{bh} = (t_{bh} - T_{bh}) / \cos(\theta_{bh}/2).$$

$$\min_{P_i} = \sum_b \sum_h (e_{bh} - \frac{1}{N_b} \sum_{h'} e_{bh'})^2.$$

$$u(t, \mathbf{x}_s, \mathbf{x}_r)$$

t

S

r

(x, y, z)

Z

$$\mathbf{x}_s$$

$\mathbf{x}_r$

$$T(\mathbf{x}, \mathbf{x}_s)$$

$$1/v(\mathbf{x}) \equiv \left\| \boldsymbol{\nabla}_{\mathbf{x}} T[\mathbf{x}, \mathbf{x}'] \right\|$$

$R(\mathbf{x}, \mathbf{x}_s)$

T

R

$\mathbf{x}'$

$$u(t, \mathbf{x}_s, \mathbf{x}_r) = \int d\mathbf{x}\ m(\mathbf{x})\ \delta[t - T(\mathbf{x}, \mathbf{x}_s) - T(\mathbf{x}, \mathbf{x}_r)]\ R(\mathbf{x}, \mathbf{x}_s)\ R(\mathbf{x}, \mathbf{x}_r)\ \mathrm{gain}(t).$$

$$\text{gain}(t) = t^2$$

$$\hat{m}(\mathbf{x}_b) = \sum_{s,r} \int dt \;\; \dot{u}(t, \mathbf{x}_s, \mathbf{x}_r) \;\; \delta[t - T(\mathbf{x}_b, \mathbf{x}_s) - T(\mathbf{x}_b, \mathbf{x}_r)] \;\; R(\mathbf{x}_b, \mathbf{x}_s) \;\; R(\mathbf{x}_b, \mathbf{x}_r) \;\; \mathrm{gain}(t).$$

$$\mathbf{x}_c \equiv (\mathbf{x}_r + \mathbf{x}_s)/2$$

$$\mathbf{x}_h \equiv (\mathbf{x}_r - \mathbf{x}_s)/2$$

$$\hat{m}_h(\mathbf{x}_b) =$$

$$\sum_c \int dt \ \dot{u}(t, \mathbf{x}_c - \mathbf{x}_h, \mathbf{x}_c + \mathbf{x}_h) \ \delta[t - T(\mathbf{x}_b, \mathbf{x}_c - \mathbf{x}_h) - T(\mathbf{x}_b, \mathbf{x}_c + \mathbf{x}_h)] \ \cdot$$

$$\cdot\ R(\mathbf{x}_b, \mathbf{x}_c - \mathbf{x}_h)\ R(\mathbf{x}_b, \mathbf{x}_c + \mathbf{x}_h)\ \mathrm{gain}(t).$$

$$\hat{u}(t, \mathbf{x}_c - \mathbf{x}_h, \mathbf{x}_c + \mathbf{x}_h) =$$

$$\sum_b \hat{m}_h(\mathbf{x}_b)\ \delta[t - T(\mathbf{x}_b, \mathbf{x}_c - \mathbf{x}_h) - T(\mathbf{x}_b, \mathbf{x}_c + \mathbf{x}_h)]\ \cdot$$

$$\hat{m}_h(\mathbf{x}_b)$$

$\mathbf{x}_h$

p

$$\mathbf{p}[\mathbf{x}, \mathbf{x}'] \equiv \boldsymbol{\nabla}_{\mathbf{x}} T[\mathbf{x}, \mathbf{x}']$$

$$T[\mathbf{x}, \mathbf{x}'] = \int_{\mathbf{x}'}^{\mathbf{x}} \mathbf{p}[\mathbf{x}'', \mathbf{x}'] \cdot d\mathbf{x}'',$$

$$\boldsymbol{\nabla} \times \mathbf{p} = \mathbf{0}$$

P

$$P(\mathbf{x}) \equiv \left\| \mathbf{p}[\mathbf{x}, \mathbf{x}'] \right\|$$

$$\nabla^2 T = 0$$

$$\mathbf{x}(a)$$

$$\|d\mathbf{x}(a)/da\| \equiv 1$$

$$\frac{d}{da}\mathbf{x}(a) \equiv \mathbf{p}[\mathbf{x}(a), \mathbf{x}(a_0)]/P[\mathbf{x}(a)].$$

$$T[\mathbf{x}(a), \mathbf{x}(a_0)]$$

$$= \int_{a_0}^{a} da' \ \frac{d}{da'} T[\mathbf{x}(a'), \mathbf{x}(a_0)]$$

$$= \int_{a_0}^{a} da' \; \boldsymbol{\nabla} T[\mathbf{x}(a'), \mathbf{x}(a_0)] \cdot \frac{d}{da'}\mathbf{x}(a')$$

$$= \int_{a_0}^{a} da' \; \left\| \mathbf{p}[\mathbf{x}(a'), \mathbf{x}(a_0)] \right\| \; \left\| \frac{d}{da'} \mathbf{x}(a') \right\|$$

$$= \int_{a_0}^{a} da' \ P[\mathbf{x}(a')]$$

$$\mathbf{x}(a_0)$$

$$\mathbf{p}(a_0)$$

$$\frac{d}{da}\mathbf{p}[\mathbf{x}(a), \mathbf{x}(a_0)] = \boldsymbol{\nabla}_{\mathbf{x}} P[\mathbf{x}(a)].$$

$$\mathbf{x}_{bh} = [x_b, y_b, z_{bh}]$$

(x_b, y_b)

z_{bh}

$\mathbf{q}_{bh}$

$$\|\mathbf{q}_{bh}\| \equiv 1$$

$$\hat{m}_h(\mathbf{x}_b) \approx f\big[(\mathbf{x}_b - \mathbf{x}_{bh}) \cdot \mathbf{q}_{bh}\big]$$

$f(\cdot)$

$\{\mathbf{x}_{bh}$

$\mathbf{q}_{bh}\}$

$\mathbf{x}_b$

$\mathbf{x}_{bh}$

$$\mathbf{x}_h = (\mathbf{x}_r - \mathbf{x}_s)/2$$

$$\mathbf{x}_c = (\mathbf{x}_r + \mathbf{x}_s)/2$$

$$\mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c + \mathbf{x}_h)$$

$$\mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c - \mathbf{x}_h)$$

$$\max_{\mathbf{x}_c} \left\| \left[\mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c - \mathbf{x}_h) + \mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c + \mathbf{x}_h) \right] \cdot \mathbf{q}_{bh} \right\|$$

$$\mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c - \mathbf{x}_h) + \mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c + \mathbf{x}_h) = 2\ P(\mathbf{x}_{bh})\ \cos(\theta_{cbh}/2)\ \mathbf{q}_{bh},$$

where $\cos(\theta_{cbh}) \equiv [\mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c - \mathbf{x}_h) \cdot \mathbf{p}(\mathbf{x}_{bh}, \mathbf{x}_c + \mathbf{x}_h)]/P(\mathbf{x}_{bh})^2$.

$$\theta_{cbh}$$

$$t_{ch}(\mathbf{x}_{bh}) = T(\mathbf{x}_{bh}, \mathbf{x}_c - \mathbf{x}_h) + T(\mathbf{x}_{bh}, \mathbf{x}_c + \mathbf{x}_h).$$

$\mathbf{x}_C$

t_{ch}

$$\mathbf{p}_{ch} = \boldsymbol{\nabla}_{\mathbf{x}_c} t_{ch}$$

$$\boldsymbol{\nabla}_{\mathbf{x}_c} \equiv (\boldsymbol{\nabla}_{\mathbf{x}_s} + \boldsymbol{\nabla}_{\mathbf{x}_r})/2$$

$$\max_{\mathbf{x}_{bh}} \left\| \left[\mathbf{p}(\mathbf{x}_c - \mathbf{x}_h, \mathbf{x}_{bh}) + \mathbf{p}(\mathbf{x}_c + \mathbf{x}_h, \mathbf{x}_{bh}) \right] \cdot \mathbf{p}_{ch} \right\|$$

$$\{t_{ch}, \mathbf{p}_{ch}\}$$

$$\{\mathbf{x}_{bh}, \mathbf{q}_{bh}\}$$

$$t_{ch}(\mathbf{x}_{bh})$$

$$\Delta t_{ch}(\mathbf{x}_{bh}) \equiv t_{ch}(\mathbf{x}_{bh} + \Delta\mathbf{x}_{bh}) - t_{ch}(\mathbf{x}_{bh}) = 2P(\mathbf{x}_{bh})\cos(\theta_{cbh}/2)\mathbf{q}_{bh} \cdot \Delta\mathbf{x}_{bh}.$$

$$\Delta\hat{\mathbf{x}}_{cbh} = \frac{\Delta t_{ch}(\mathbf{x}_{bh})}{2P(\mathbf{x}_{bh})\cos(\theta_{cbh}/2)}\ \mathbf{q}_{bh}.$$

$$e_{cbh} \equiv \frac{\Delta t_{ch}(\mathbf{x}_{bh})}{\cos(\theta_{cbh}/2)}.$$