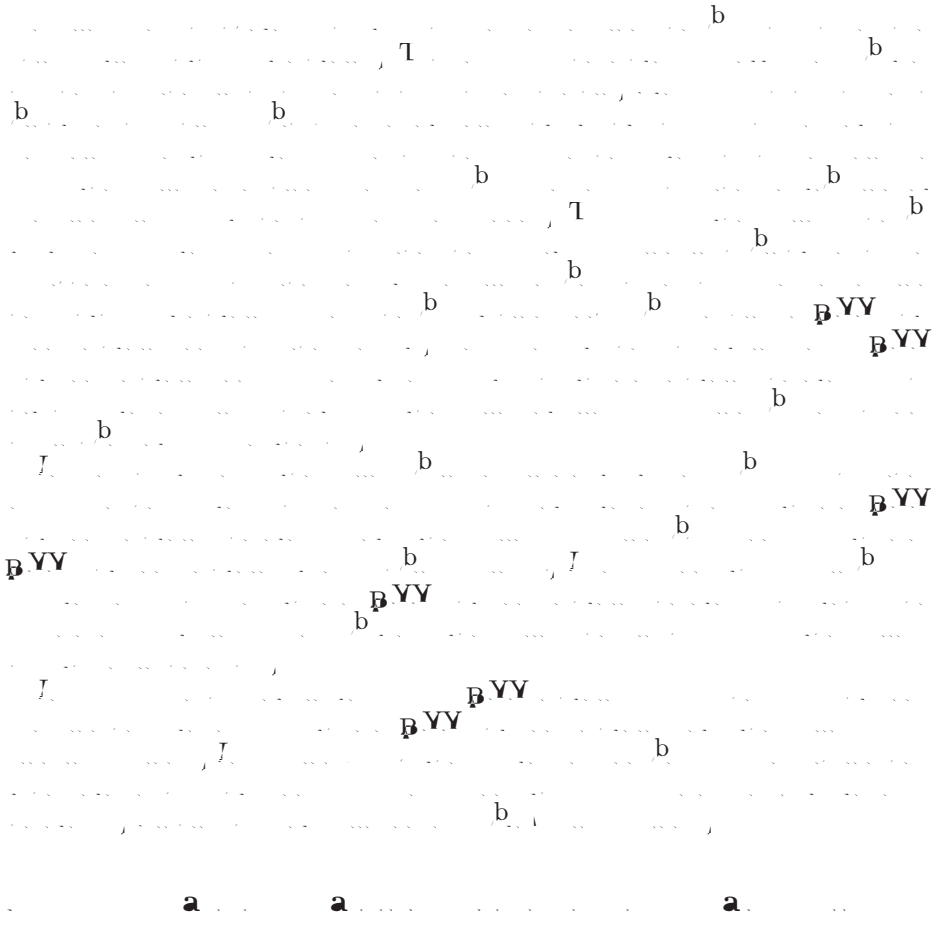


2.1 BYY Learning System and the Harmony Function

$$H\ p||q \quad \int p\ y|x\ p\ x\ ln\ q\ x|y\ q\ y\ \ dxdy,$$

$$KL\ p||q \quad \int p\ y|x\ p\ x\ ln\frac{p\ y|x\ p\ x}{q\ x|y\ q\ y}dxdy \quad -H\ p||q\ -H\ p\ ,$$

$H\ p$ $p\ x,y$ $q\ x,y$ b b $p\ y|x$ $q\ x|y$ θ D_x $\{x_t\}_{t=1}^N$ y $\{\ ,\ ,\cdots,k\}$ m b x $q\ y\ \ j\ \ \alpha_j \geq$ $\sum_{j=1}^k \alpha_j$ $p\ x$ b b D_x b $q\ x|y\ \ j\ \ q\ x|\theta_j$ b b b

$$q\ x|\theta_j \quad q\ x|m_j,\Sigma_j \quad \frac{}{\pi\ ^{\frac{}{2}}|\Sigma_j|^{\frac{1}{2}}}e^{-\frac{1}{2}(x-m\ )^T\Sigma\ ^{1}(x-m\ )},$$

m_j Σ_j b

$$p\ y\ \ j|x \quad \frac{\alpha_j q\ x|\theta_j}{q\ x|\Theta_k}, \qquad q\ x|\Theta_k \quad \sum_{j=1}^k \alpha_j q\ x|\theta_j\ ,$$

Θ_k $\{\alpha_j,\theta_j\}_{j=1}^k$ $q\ x|\Theta_k$ $p\ x$ D_x

$$H\ p||q \quad E_{p(x)}\sum_{j=1}^k \frac{\alpha_j q\ X|\theta_j}{\sum_{i=1}^k \alpha_i q\ X|\theta_i} ln\ \alpha_j q\ X|\theta_j\ ,$$

b b $\sum_{j=1}^k \frac{\alpha\ q(X|\theta\ )}{\sum\ _{=1}\alpha\ q(X|\theta\ )}$ $ln\ \alpha_j q\ X|\theta_j$ X b b $p\ x$ D_x $H\ p||q$ Θ_k

$$J\ \Theta_k \quad \frac{}{N}\sum_{t=1}^N\sum_{j=1}^k \frac{\alpha_j q\ x_t|\theta_j}{\sum_{i=1}^k \alpha_i q\ x_t|\theta_i} ln\ \alpha_j q\ x_t|\theta_j\ .$$

2.2 The Gradient Learning Rule for Straight Line Detection

$J\ \Theta_k$ b b

b

$$\alpha_j \quad e^{\beta} \Big/ \sum_{i=1}^{k} e^{\beta},$$

b b
$J\ \Theta_k$

$$q\ u|l \quad q\ x,y|l \quad \{-\frac{w_l^T\ x,y\ ^T - b_l\ ^2}{\tau_l^2 w_l^T w_l}\},$$

$u \quad x,y$ b

$\{u_t \quad x_t,y_t\ \}_{t=1}^{N}$ b

b w_l^T

b_l

$w_l^T x \quad b_l$ k k

$q\ u|l$ b

$$\Delta w_l \quad \eta\frac{\alpha_l}{N}\sum_{t=1}^{N} h\ l|u_t\ U\ l|u_t\ \frac{-\ w_l^T u_t - b_l\ ^2 w_l - \ w_l^T u_t - b_l\ w_l^T w_l u_t}{e^{r_l}\ w_l^T w_l\ ^2},$$

$$\Delta b_l \quad \eta\frac{\alpha_l}{N}\sum_{t=1}^{N} h\ l|u_t\ U\ l|u_t\ \frac{w_l^T u_t - b_l}{e^{2r_l}\ w_l^T w_l},$$

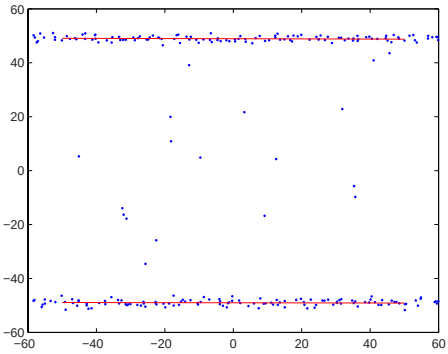
$$\Delta r_l \quad \eta\frac{\alpha_l}{N}\sum_{t=1}^{N} h\ l|u_t\ U\ l|u_t\ \frac{-\ w_l^T u_t - b_l\ ^2}{e^{2r_l}\ w_l^T w_l},$$

$$\Delta\beta_l \quad \eta\frac{\alpha_l}{N}\sum_{t=1}^{N}\sum_{j=1}^{k} h\ j|u_t\ U\ j|u_t\ \ \delta_{jl} - \alpha_j\ ,$$

$$U\ l|u_t \quad \sum_{r=1}^{k}\ \delta_{rl} - P\ r|u_t \quad \alpha_r q\ u_t|r\ \ ,$$

$$h\ l|u_t \quad q\ u_t|l\ /\sum_{r=1}^{k}\alpha_r q\ u_t|r\ , P\ r|u_t \quad \alpha_r h\ r|x_t\ .$$

$\eta >$ b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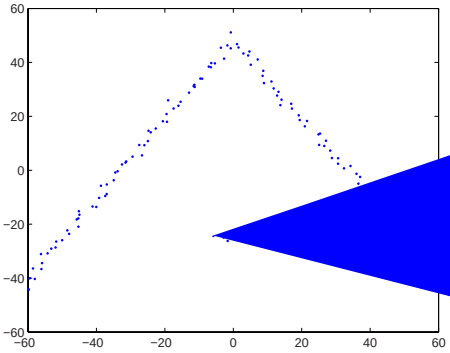
( ) r S4 k = 2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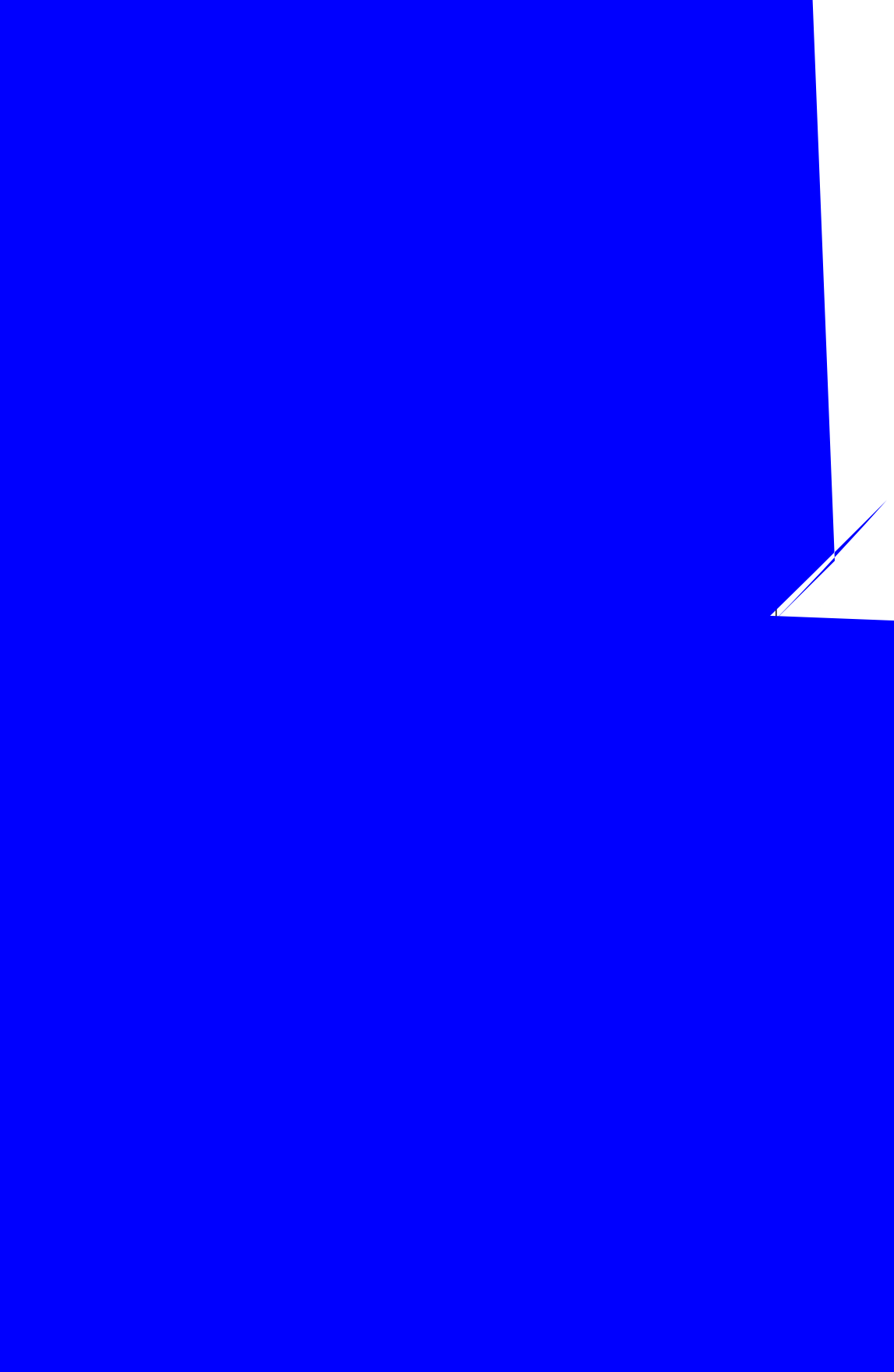

b

Þ ÝÝ

k^* b b

Þ ÝÝ b

$k > k^*$ η . ε .

$$|J\ \Theta_k^{new} - J\ \Theta_k^{old}| <$$

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b b

b

S_3 b k

b b b

b

b

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b S_2 k , k^*

Acknowledgments. T b N

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