Segmentation α

$$E(\boldsymbol{\alpha}) = \sum_i \dot{\omega}_i E_1(\alpha_i) + \lambda \sum_{(i,j)\in\mathcal{E}} E_2(\alpha_i, \alpha_j)$$

$$\lambda \sum_{(i,j)\in\mathcal{E}} E_2(\alpha_i, \alpha_j)$$

two adjacent pixels (r, s)

$$E_2(x_r, x_s) = |x_r - x_s| \cdot \exp(-\beta \cdot d_{rs}).$$

$$\beta = \left(2\langle \|I_r - I_s\|^2 \rangle\right)^{-1}$$

$$d_{rs} = \|I_r - I_s\|^2$$

$$I_r = \begin{cases} B & p_B(I_r) > t_b \\ F & p_B(I_r) < t_f \\ U & otherwise \end{cases}$$

$$p_B(I_r) = N(I_r|\mu_r^B, \Sigma_r^B),$$

$$\mu_r^B = I_r^B$$

I_r^B and I_r are color values of pixel r in I^B

I^B be the known background image

$$\Sigma_r^B = \sigma_r^2 I.$$

I be the image at the current timestep

per-pixel variance σ_r^2

learned from a back-ground initialization phase.

$$\sum_i \dot{\omega}_i E_1(\alpha_i)$$

$$E_1(\alpha_i) = \begin{cases} -\log p(z_i|F) & \text{if} \quad \alpha_i = 1 \\ -\log p(z_i|B) & \text{if} \quad \alpha_i = 0 \end{cases}$$

$$p_*(z_i|F) = \sum_{k=1}^{K^F} \pi_k^F N(z_i|\mu_k^F, \Sigma_k^F)$$

Gaussian distribution $N(z_i|\mu_i, \Sigma_i)$.

The global background color model $p_*(z_i|B)$ is defined similarly

$$p(z_i) = \ddot{\omega}_i p_*(z_i) + (1 - \ddot{\omega}_i) p_i(z_i)$$

$p_*(z_i)$ is the normalized global color model,

$$p(z_i) = \frac{p(z_i|F)}{p(z_i|F) + p(z_i|B)}$$

$$\dot{\omega}_i = \frac{1}{2}(\mathcal{C}(p_*(z_i)) + \mathcal{C}(p_i(z_i)))$$

$$\ddot{\omega}_i = \frac{\mathcal{C}(p_*(z_i))}{\mathcal{C}(p_*(z_i)) + \mathcal{C}(p_i(z_i))}$$

$$\mathcal{C}(p_i(z_i)) = \sqrt{e^{-\beta \text{tr}(\Sigma_i)} * |2p_i(z_i) - 1|}$$

$$p_i(z_i) = \begin{cases} 0 & \text{if } \| z_i - \mu_i \| < T_i^B \\ 1 & \text{if } \| z_i - \mu_i \| > T_i^F \\ \frac{\|z_i - \mu_i\| - T_i^B}{T_i^F - T_i^B} & \text{otherwise} \end{cases}$$

$$T_i^B = \min(d_i/2, T_i) \quad T_i^F = \max(d_i, T_i)$$

$$d_i = \min\{\| \mu_i - \mu_k^F \| \, | k = 1, \cdots, K^F\}$$

where β is chosen to be $(2 < \text{tr}(\Sigma_i) >)^{-1}$

$\text{tr}(\Sigma_i)$ is the trace of the covariance matrix Σ_i.

$\dot{\omega}_i$ can be regarded as the confidence of the combined color model $p(z_i)$.

$$\mathcal{C}(p_*(z_i)) = 1 - \frac{p_*(z_i|U)}{p_*(z_i|F) + p_*(z_i|B) + p_*(z_i|U)}$$

$$p_*(z_i|F) = \sum_{k=1}^{K^F} \pi_k^F N(z_i|\mu_k^F, \Sigma_k^F)$$