Bayesian Modeling of Dynamic Scenes for Object Detection

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Background \( \phi_b = \{y_1, y_2, \ldots, y_n\}, y = (r, g, b, x, y) \in \mathbb{R}^5 \)

Foreground \( \phi_f = \{z_1, z_2, \ldots, z_n\} \)

\[
P(x | \psi_b) = \frac{1}{n} \sum_{i=1}^{n} \phi_b(x - y_i)
\]

\[
P(x | \psi_f) = \alpha y + (1 - \alpha) m^{-1} \sum_{i=1}^{m} \phi_f(x - z_i)
\]

d--variate Gaussian density

\[
\phi_{H^1}(x) = \left[ H \right]^{-1/2} \left( 2\pi \right)^{-d/2} \exp \left( -\frac{1}{2} x^T H^{-1} x \right)
\]

Likelihood ratio classifier

\[
\tau = -\ln \frac{P(x | \psi_f)}{P(x | \psi_b)}
\]

**Algorithm**

Initialize \( \psi_b \) using 1st frame, \( \psi_f = \emptyset \). At frame \( t \), for each pixel,

**Detection Step**

1. Find \( P(x_t | \psi_f) \) (Eq. 7) and \( P(x_t | \psi_b) \) (Eq. 1) and compute the Likelihood Ratio \( \tau \) (Eq. 8).
2. Construct the graph to minimize Equation 13.

**Model Update Step**

1. Append all pixels detected as foreground to the foreground model \( \psi_f \).
2. Remove all pixels in \( \psi_f \) from \( \rho_f \) frames ago.
3. Append all pixels of the image to the background model \( \psi_b \).
4. Remove all pixels in \( \psi_b \) from \( \rho_b \) frames ago.