Foreground Estimation

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Outline

Introduction
Frame Differencing
Averaging Filter
Mixture of Gaussians
Conclusion
Separating Background/Foreground
Motivation

Effective Background Estimation algorithms are needed for:

- Video Surveillance
- Traffic Analysis
- Gesture Recognition
Possible Methods

- Frame Differencing
- Median Filter
- Averaging Filter
- Linear Predictive Filter
- Non-Parametric Model
- Approximated median filter
- Kalman filter
- Single Gaussian
- Mixture of Gaussians (MoG)
- Eigenbackground Approximation
- Minimization of Gaussian Differences
Possible Methods

- Frame Differencing
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Frame Differencing

- Provides the outline of moving objects in simple scenes.

$$|frame_i - frame_{i+1}| > T$$
Subtraction from a Background Model

Subtract each frame from a Background Model and use a threshold to segment the background and foreground
Subtraction from a Background Model

Nonadaptive Fixed Background

- A fixed background is sometimes not available
- Errors accumulate over time
- This will only work in highly supervised short term applications
Subtraction from a Background Model

Averaging Background Model
Take the average of set frames.
Subtraction from a Background Model

Averaging Background Model
Take the average of set frames.

Problems:
- Requires continuous movement.
- Struggles with complex scenes
- Objects leave Ghosts
- Background Noise
- Recovers Slowly
Median Background Model
Take the median of a set of frames.
Median Background Model
Take the median of a set of frames.

Problems:
- Computationally Expensive
- Background Noise
Mixture of Gaussians

**Motivation:** Handle Multimodal background distributions.

**Example:** Leaf and the Sky
Mixture of Gaussians

Each pixel is modeled as a mixture of 3-5 Gaussians with a corresponding weight

\[ f(I_t = u) = \sum_{i=1}^{K} \omega_{i,t} \cdot \eta(u; \mu_{i,t}, \sigma_{i,t}) \]

[1] Robust techniques for background subtraction in urban traffic video. Sen-Ching S. Cheung and Chandrika Kamath
Mixture of Gaussians

For each new pixel value $I_t$ a matching gaussian is found. $|I_t - \mu_{i,t-1}| \leq D \cdot \sigma_{i,t-1}$.

This Gaussian's values are updated

$$\omega_{i,t} = (1 - \alpha)\omega_{i,t-1} + \alpha$$
$$\mu_{i,t} = (1 - \rho)\mu_{i,t-1} + \rho I_t$$
$$\sigma^2_{i,t} = (1 - \rho)\sigma^2_{i,t-1} + \rho (I_t - \mu_{i,t})^2,$$

$\rho \approx \frac{\alpha}{\omega_{i,t}}$

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Mixture of Gaussians

The non matched gaussians' weights are updated. \( \omega_{i,t} = (1 - \alpha)\omega_{i,t-1} \) All the weights for each pixel are then normalized to 1.

If no gaussian was matched the lowest weighted one is replaced with a new gaussian centered at that pixel. \( I_t \)

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Mixture of Gaussians

A rank of $\omega_{i,t}/\sigma_{i,t}$ is calculated for each Gaussian.

The Gaussians are sorted by their rank.

A higher rank corresponds to higher likelihood that the Gaussian is part of the background.

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Mixture of Gaussians

In order by rank, The first $M$ components with a weight of threshold $\Gamma$ are considered Background.

\[ \sum_{k=i_1}^{i_M} \omega_{k,t} \geq \Gamma, \]

Foreground pixels are those not within $D$ standard deviations of any background gaussian.

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Mixture of Gaussians

Better at removing Background Noise, but struggles with illumination changes.

Complex Parameter optimization problem

Computationally Expensive.
Current Matlab code, 30sec clip takes 10 Hours to process
What's Could be Next?

Better optimize Mixture of Gaussians

Extend Mixture of Gaussians to Color videos.

Implement and test other algorithms.
Questions?