Background Subtraction using Adaptive Gaussian Mixture Model[1]

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[1] Stauffer, Chris, and W. Eric L. Grimson. "Adaptive background mixture models for real-time tracking." Computer Vision and Pattern Recognition, 1999. IEEE Computer Society Conference on.. Vol. 2. IEEE, 1999.

Layout

- Object detection
  - Challenges
  - GMM based method
- Tracking
  - Challenges
  - Particle filter based tracking

Object Detection

- Goal: To detect the regions of the image that are semantically important to us:
  - People
  - Vehicle
  - Buildings
- Application
  - Crowd management
  - Traffic management
  - Video compression, video surveillance, vision-based control, human-computer interfaces, medical imaging, augmented reality, and robotics…

Object Detection in Images

- Subjectively defined
- Generally template based
- Mainly done by image segmentation

Object Detection in Videos

- Relatively Moving – Object
- Relatively Static - Background

The goal here is to differentiate the moving object from background!

Surveillance Video

- Static camera
- Background relatively static
- Subtract the background image from current image
- Ideally this will leave the moving objects
- This is not an ideal world…

Feature Based

- Objects are modeled in terms of features
- Features are chosen to handle changes in illumination, size and orientation
  - Shape based – Very hard
  - Color based – Low cost but not accurate

Template Based

- Example template are given
- Object detection becomes matching features
- Image subtraction, correlation

Motion Based

- Model background
- Subtract from the current image
- Left are moving objects ☺
- Remember! This is not a real world…

Problems in Modeling Background

- Acquisition noise
- Illumination variation
- Clutter
- New object introduced into background
- Object may not move continuously

Outline of Object Detection

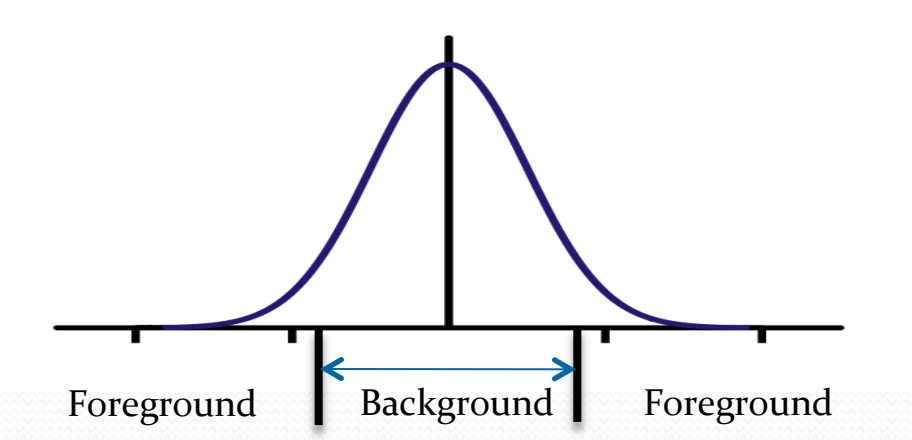
- Determine the background and foreground pixels
- Draw contours around foreground pixels
- Use heuristics to merge these contours

Ideal World

- Single value modeling of background
- Anything different is foreground

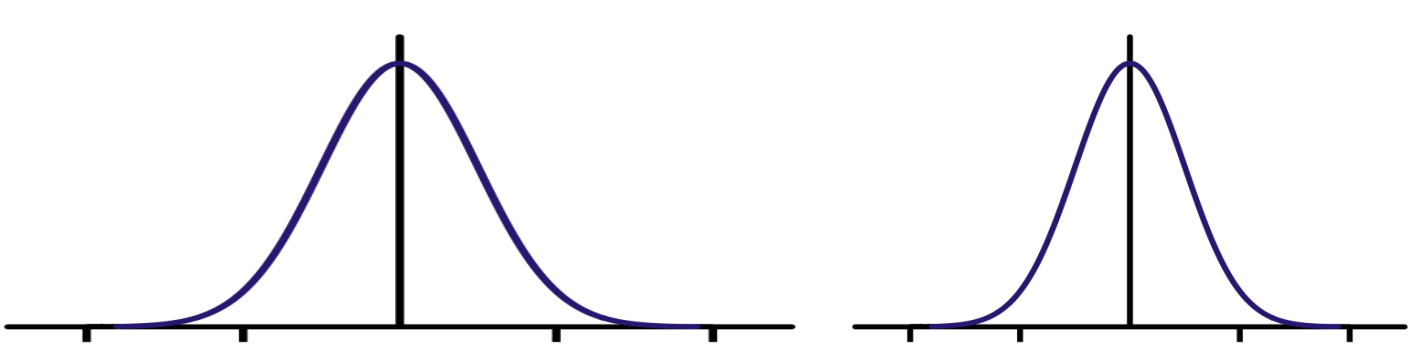
Static Background

- Each pixel resulted from a particular surface under particular lightening
  - Single Gaussian is enough (μ, σ)
- If $|P_t - \mu| < 2.5 * \sigma$
  - Pixel belongs to background, else foreground



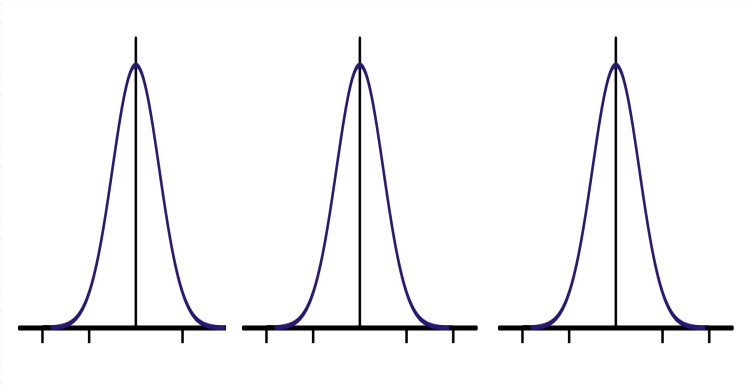
Illumination Variation

- Whenever a pixel matches the background Gaussian, update the background model i.e.
  - If $\left|P_t - \mu_t\right| < 2.5 * \sigma t$
  - Then $\mu_{t+1} = (1-\alpha)\mu_t + \alpha\mu_t$
  - Standard deviation updated accordingly



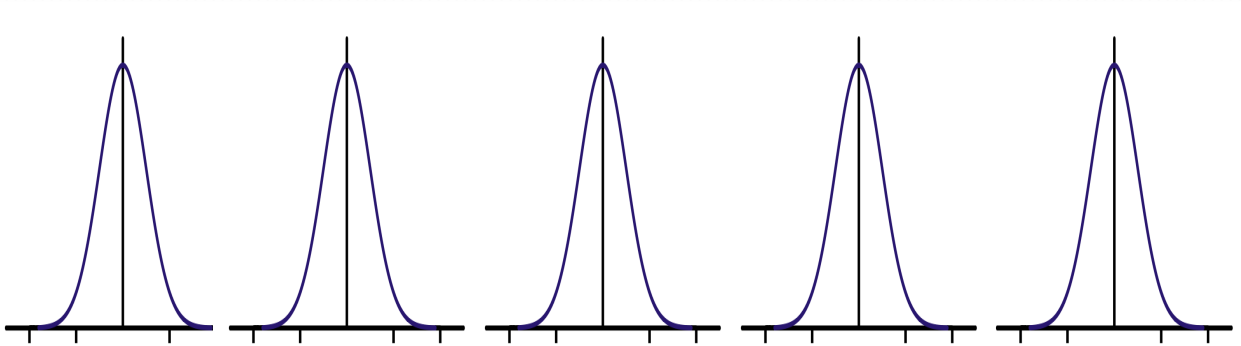
Clutter

- Think of tree leaves…
- Multiple surfaces, still part of background
- Gaussian Mixture Model
- Update each Gaussian after matching



Static Object Introduced

- Think of flower pot…
- Background model should adapt to this change
- Use Gaussian for new surface as well
  - Few extra Gaussians for the foreground



Measuring Persistence

- Modeled as prior weight *w*
- More persistent Gaussians belong to background
- If a new pixel does not match to any exiting Gaussians, least persistent Gaussian is replaced with a new Gaussian with:

$\mu_t = P_t$

And standard variation

σ_t = a large value

Background Selection

- A background Gaussian will have
  - More persistence – high *w*
  - Less variation – low σ_t
  - Sort Gaussians wrt w / σ_t
- Pick top k Gaussians as background such that

$$\arg\min_k \left(\sum_{i=1}^{k} w_i > T \right)$$

If pixel belongs to one of these, it's a background pixel

Adaptive Background Model

- Every pixel is modeled as mixture of Gaussians
- More persistent Gaussians belong to background and others to foreground
- The Gaussians are updated after each frame

Connecting the Dots

- The output of background modeling is a binary image
- Dilation/Erosion can further reduce noise
- Contour drawing
- Bounding boxes

Revisit the problems

- Problems
  - Slow moving background – clutter
  - New object introduced into background
  - Illumination variation
  - Object may not move continuously

Thank You

- Q & A