ES 331 - Probability And Random Processes

Assignment 03

Real-Time Object Tracking Using Background subtraction using Mixture of Gaussians

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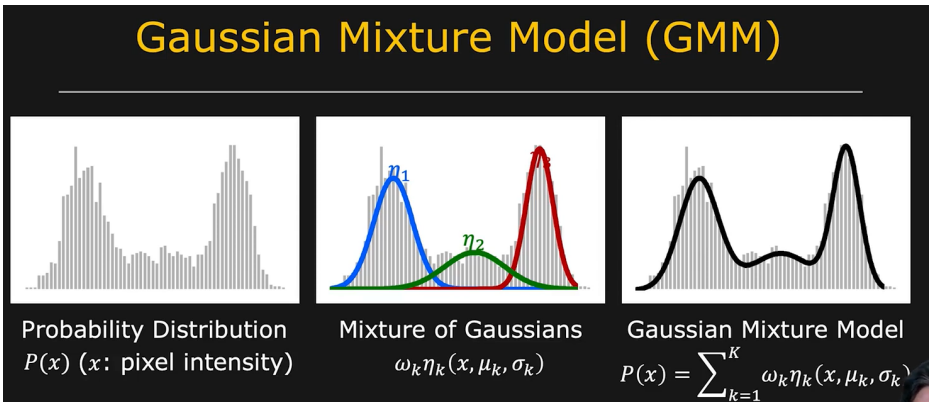
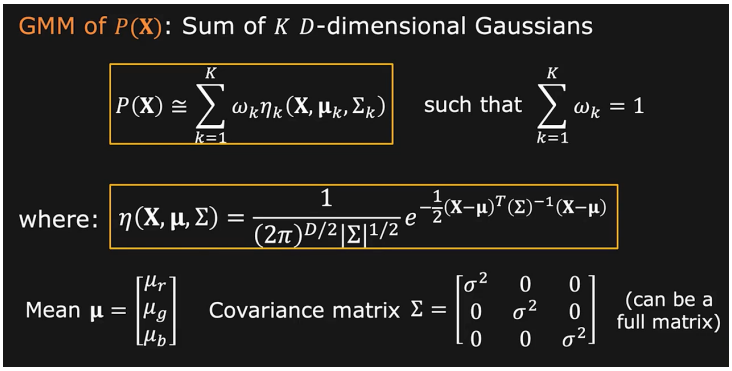
Introduction

Background modeling is frequently used in various applications, such as video surveillance, optical motion capture, and multimedia, to model the background and detect moving objects in the image. The simplest technique to simulate the background is to obtain an image that contains no moving objects. In some contexts, the background is unavailable or gets altered under important conditions, such as lighting changes or the addition or removal of objects from the picture. Many background modeling methods have been developed to address the issues of robustness and adaptation.

Mixture of Gaussians is a widely used approach for background modeling to detect moving objects from videos with a static background.





Algorithm:

Below is the algorithm for detecting changes using Gaussian Mixture Model.

For each pixel in the frame:

1. Represent the pixels as a mixture of K-Gaussians. For better performance and output, we need to set K from 3 to 5. In the code, I have used K = 3.
2. The video is reduced to grayscale to use 1D Gaussian distribution.
3. For subsequent frame:
    a. The pixel value X belongs to that Gaussian in GMM, for which $|X - \mu_k| < 2.5\sigma_k$.
    b. If the ratio ω_k/σ_k is large, then classify the pixel as background or else classify it as background.
    c. Repeat the steps frame by frame to detect new changes

After the object gets detected, apply the object_tracker, which tracks the object and gives an ID to the object.

Object detection using MOG is done in two ways:

1. Using inbuilt **cv.createBackgroundSubtractorMOG2()**
2. Using the MOG function implemented from scratch

Output:

Using Inbuilt MOG Background Subtractor

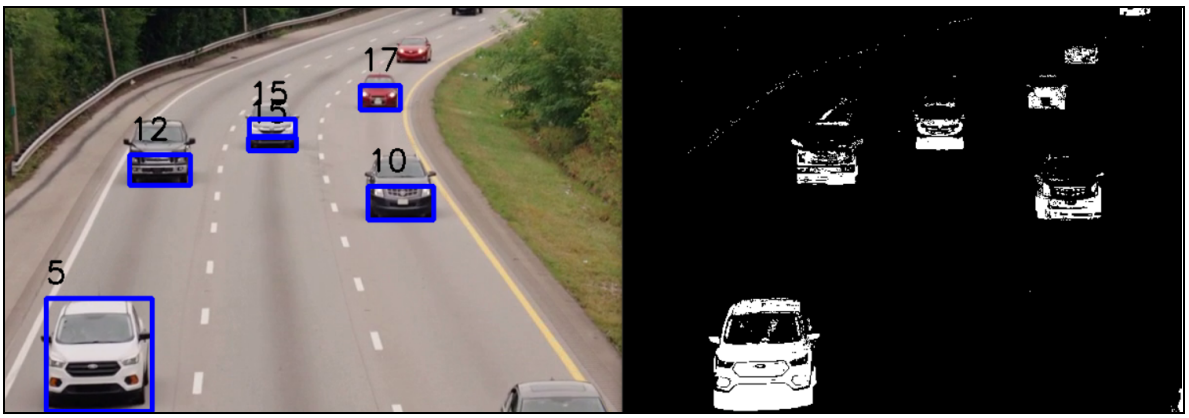


Fig. *showing the car being tracked with IDs on the surrounding box on left and background subtraction on right*

Using User-defined MOG Background Subtractor

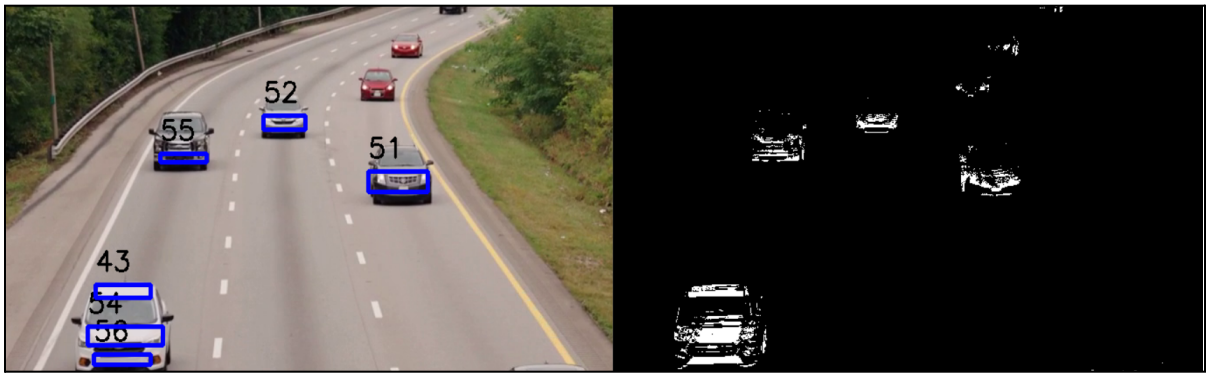


Fig. *showing the car being tracked with IDs on the surrounding box on left and background subtraction on right*

Challenges:

The following changes in the environment play a challenge in background subtraction:

1. Background fluctuations
2. Image noise
3. Rain, snow, turbulence
4. Illumination changes & shadows
5. Camera shake

Advantages:

1. The algorithm can be easily implemented.
2. The tracking is fast and accurate using MOG.
3. No need for machine learning is required.

Disadvantages:

1. The changes in the background affect object detection.
2. It cannot detect objects over a wide range of distances.
3. When the background and foreground have similar intensity, detection is not possible.
4. Also, if the region of interest is large, the algorithm processing takes a long time.

Conclusion:

The real-time object tracker using inbuilt MOG tracks all of the objects within the region of interest efficiently and accurately, even when the object is away from the camera. When using the user-defined background subtractor, objects that are near the camera are clearly tracked, but the ones that are away and look small are not detected.

When the background and moving object are similar in color, background subtraction does not happen properly, and the object does not get tracked sometimes. As a result of this, the ID assigned to the object in the region of interest gets changed frequently.

Overall the algorithm works well, and the accuracy of the user-defined function comes out to be around 80%.

Reference:

1. https://hal.archives-ouvertes.fr/hal-00338206/en/
2. https://www.youtube.com/watch?v=0nz8JMyFF14&t=6s