Lecture : 39

Object Detection in Video using Background Modeling

November 11, 2016

Abstract

This was a guest lecture given by Dr. Mukesh Saini on object detection in video using background modeling. Detecting moving objects has application in diverse areas of surveillance, video conferencing, augmented reality, etc. In this talk, he focused on the methods to detect moving objects in a surveillance video.

1 Introduction

IN surveillance we have objective to detect the object from a video that is captured using static camera. So first we will discuss what is an object. An object can be considered an important subjective part of the video that you are interested in. In the same given picture different people can be interested in different objects. Lets take an example, in Figure 1., some people can be interested in the number of kids, some can be interested in the greenery of the park, and some people can be interested in the rides available in the park. Thus we can see a same image can be used to detect different objects of your interest.

Similarly, if we capture the video of a road, we can be interested to detect the vehicles and humans walking around the road and ignore the static part of the road like, road boundary, greenery, posters or statues etc. In a video of an airport or platform, we will be interested in capturing the people.

2 Goal of the Lecture

Our main aim is to detect the moving object from the video that are also called foreground objects. We also need to detect the background of the video that is static. While discussing the work, we will assume that we are only focusing on one pixel only. If we consider more ares, we will explain it there only. So we need to design methods to differentiate moving objects from the static background.

3 Classical Approach

Surveillance cameras are statically placed so it looks a trivial task to find the moving objects from the given video. A classical method to detect the objects in an ideal world will be like: take the two continuous images from the video like one at time t and another at time t+1, and then take the difference of the images to find the moving objects. This phenomenon is shown in Figure 2.

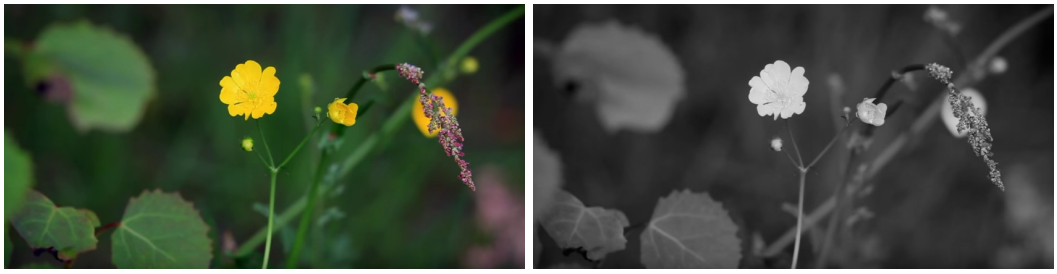
But this method do not work in the real world due to some problems that we will discuss next.

4 Challenges in the Object Modeling

There are various challenges faced in the object modeling. These are explained below:

1. Acquisition Noise: The static cameras are failed to detect the actual position of a point. For example if there is a point at pixel (10,11) then the camera will not tell the same position at every time. It can vary for example it can tell the position like (10,10) or (11,11) etc. This kind of error is called acquisition noise.

2. Illumination variation: This error is created as the effect of light changes with the time. For example, It can detect same object as two different objects at different times.



So, the proposed algorithm should be able to detect that whether it is illumination or a new object.

3. Clutter: In a static background there can be some objects that can oscillate around there position. Like in a road side view there is a tree that is a static object. But tree leaves can move around and it can be detected as a foreground image instead of a background image. The proposed method should be able to handle this situation.

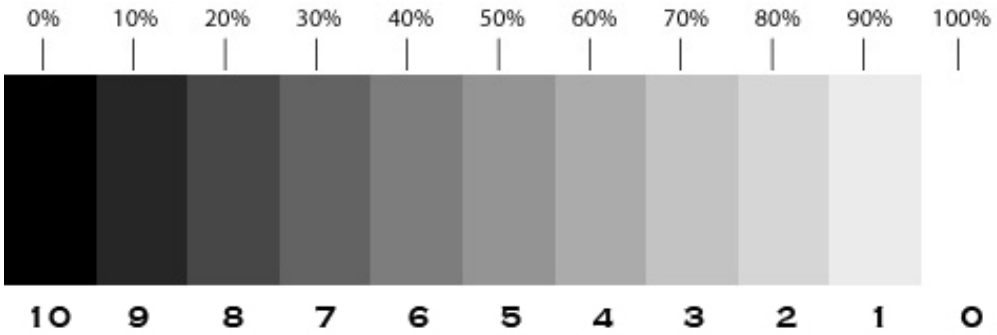
4. New Objects Introduced in the background: A new static object can be placed in the surveillance area, so the method should be able to detect it that it is a new static object not a new object that should be considered as a foreground object.

5. Foreground object should not go under the background object even if they are static. For example, if a vehicle has stopped on the road then it should not be considered as the background image. The proposed method should be able to handle all such kind of situations that can come in live object detection applications.

Here the last two points are very challenging. In the next section we will discuss the solution of all these points one by one. First we will state the refined problem statement so that you can follow the proposed solutions for all these challenges.

5 Refined Problem

A video consists many continuous images, and am image is the collection of pixels. A pixel can be represented using various methods like RGB method where we store the information of red, green and blue color for each pixel, or gray scale method where a single byte store the information of the colors. The gray scale method stores a value for each pixel that ranges from 0 to 255. In the next figure, we show gray scale values:



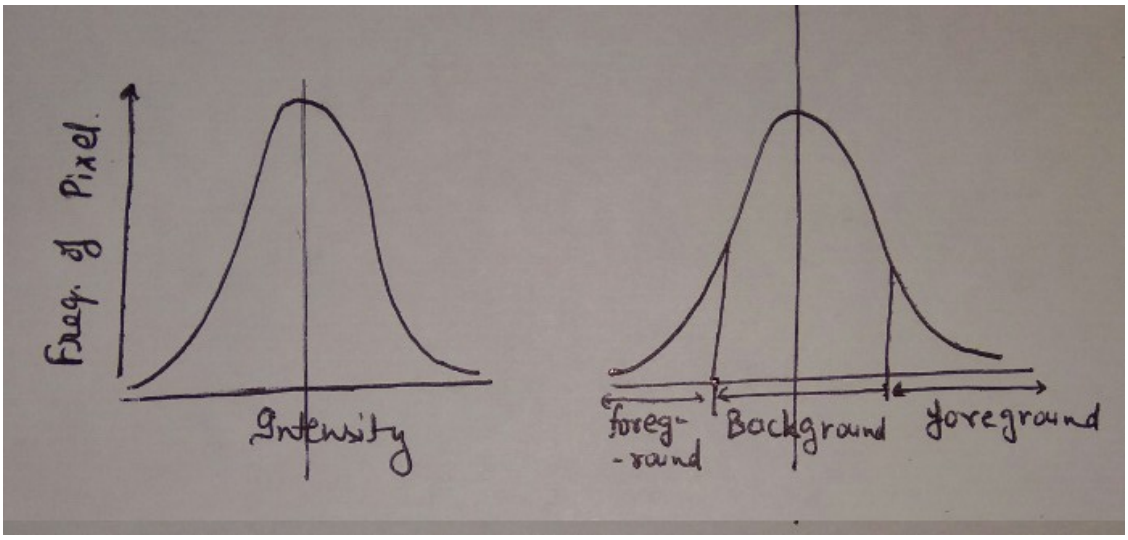
So our main aim is to detect that whether a pixel belongs to foreground or background. The proposed method takes the value of a pixel at time t and t+1 and declares that whether it belongs to foreground or background. The proposed method should also be able to train itself with the changes in the background of the area. In an ideal world, we can simply store the background image by capturing it once and then can use this image to compare the current scenario and detect the foreground objects. But this is not feasible in the real world so we need self trainable systems to detect the moving objects.

6 The Proposed Solution

In this section, we will consider the proposed solution for all the discussed problems one by one.

1. Acquisition Noise: In acquisition noise, each pixel is resulted from a particular surface under particular lightening, So single Gaussian (μ, σ) is enough to capture this.

   First take the video of the given camera for few seconds in the starting, and train the Gaussian model to handle the acquisition noise. So plot the Gaussian distribution using the starting video, for frequency of pixels versus its intensity. If $|p_t - \mu| < 2.5 * \sigma$, then pixel belongs to the background otherwise it belongs to the foreground.



2. Illumination Variation: To detect illumination variation, we can use adaptive Gaussian model. In this whenever a pixel matches with background Gaussian, update the background model. So, if $|p_t - \mu_t| < 2.5 * \sigma_t$, then update μ_{t+1} and standard deviation accordingly. So the curve of Gaussian distribution will change as the illumination changes.

3. Clutter: Clutter contains the background images that move slowly like tree leaves. Here for each pixel we have two values (μ_1, σ_1) and (μ_2, σ_2). Now as each pixel has two values that are changing alternatively, so we can detect that it belongs to background and not to foreground. It can also be used to handle multiple surfaces, that belongs to still part of the background. This method is called Adaptive Gaussian Mixture Model.

4. Static object Introduced: Here we will discuss how we can handle the situation when static objects are introduced in the background. For example: a flower pot or a dustbin is placed under the surveillance area. To handle this situation we use a little tricky method that uses foreground information of nearby pixels. Take more number of pixels and for each pixel we have Gaussian distribution (μ, σ). Now assign the weight w to current pixel based on its matching with the nearby pixels. For example, if we put a flower pot in the captured area, then the weights of the pixel corresponding to this new object will increase drastically. Decide a threshold value on the weight to differentiate new static introduced object.

5. Background Selection: In the captured video some objects may note move continuously but they might belong to the foreground not the background. for example, if there is a car that has stopped on the road, it should be detected as a foreground object not a background object. we will use background Gaussian for the same. The main point to detect it is: Gaussian of foreground will have more variance than the background even if both have the same color. We can use following properties to detect the same:

   - More Persistence: High Weight w
   - Less Variation: Low σ_t
   - Sort Gaussian with respect to w/σ_t
   - Decide the threshold weight to detect the foreground pixels.

   The adaptive background model is used for the background selection.

7 Outline of the Object Detection

The main point of object detection method can be considered as follows:

1. Determine the background and foreground pixels
2. Draw Contours around foreground pixels
3. Use heuristics to merge these contours

8 Topics for Further Study

The interested readers can look following topics in detail:

1. Gaussian Distribution
2. Adaptive Gaussian Model
3. Adaptive Gaussian Mixture Model
4. Adaptive Background Model
5. Erosion and Dilation
6. Various extensions of the proposed method to detect static objects.

9 Open Research Problems

This area contain various open research problems that one can look further. The one challenging problem is to detect the objects using moving camera. How we can use a background image of panorama to detect moving objects under the captured area.

10 Final Words

The lecture was concluded with the role of probability in the proposed problem. Interested readers can further explore the use of probabilities in real life applications.

11 Bibliography

[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.