Motion Based Approaches For Object Detection

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Introduction

- ❏ Motion based approaches for object detection involve various techniques to detect any object under motion.
- ❏ These are used in computer vision with the help of image processing.
- ❏ Multiple consecutive frames from a video are compared by various methods to determine if any object is moving.

Introduction

- Motion of images is actually a sequence of static frames that is induced by the brain as actual motion and the techniques to compute this motion can be classified as-
    - Feature-based Methods
    - Direct, Dense Methods

Introduction

- **Feature-based Methods-**
  - Extract visual features (corners, textured areas) and track them over multiple frames.
  - Sparse motion fields, but more robust tracking.
  - Suitable for larger pixel size and dynamic changes in frames.

Introduction

- **Direct, Dense Methods-**
    - Directly recover image motion at each pixel from spatio-temporal image brightness variations.
    - Dense motion fields, but sensitive to appearance variations.

Techniques For Moving Object Detection :-

- Background Subtraction
  - Frame Differencing
  - Mean Filtering
  - Median Filtering
- Optical Flow

Background Subtraction :-

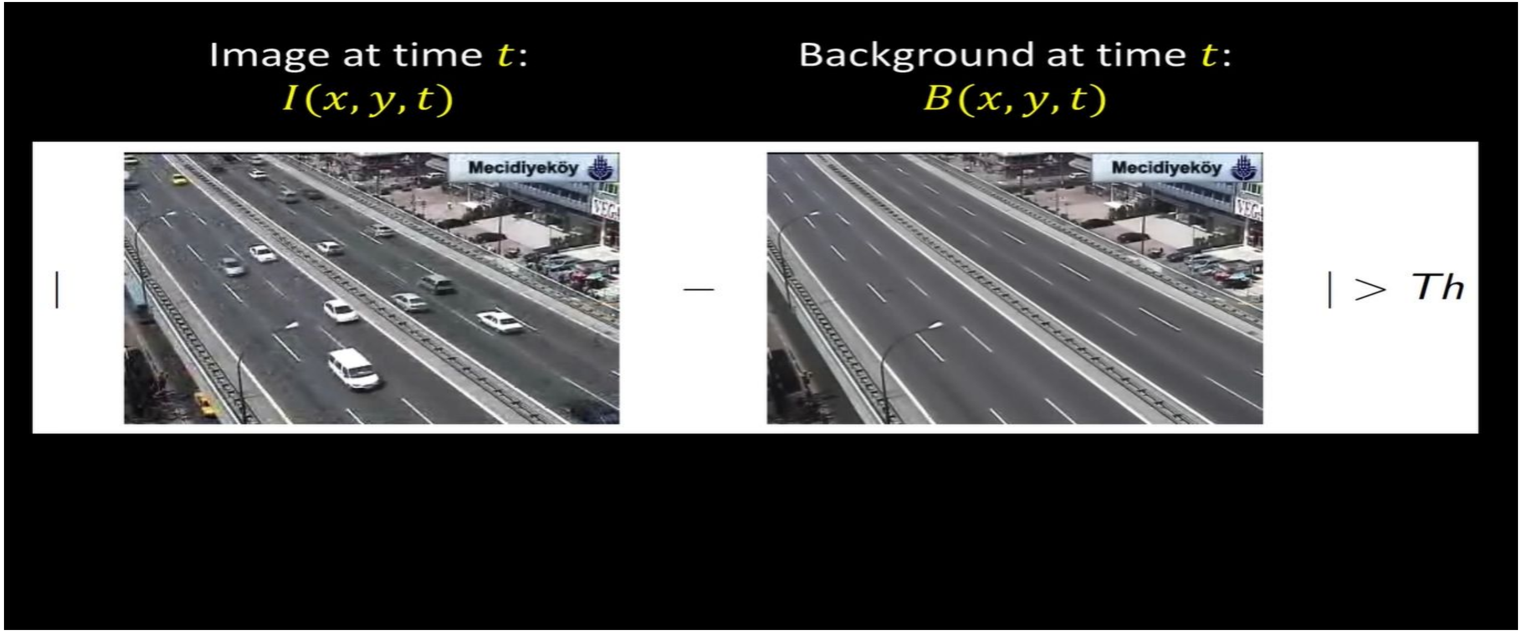
- Background subtraction is any technique which allows an image's foreground to be extracted for further processing (object recognition etc.).
- The rationale in the approach is that of detecting the moving objects from the difference between the current frame and a reference frame, often called "background image", or "background model".

Background Subtraction :-

Steps to do background subtraction:-

A. Estimate background for time ***t***.
B. Subtract estimated background from current input frame.
C. Apply a threshold to the absolute difference to get the foreground mask.

Background Subtraction[1] :-



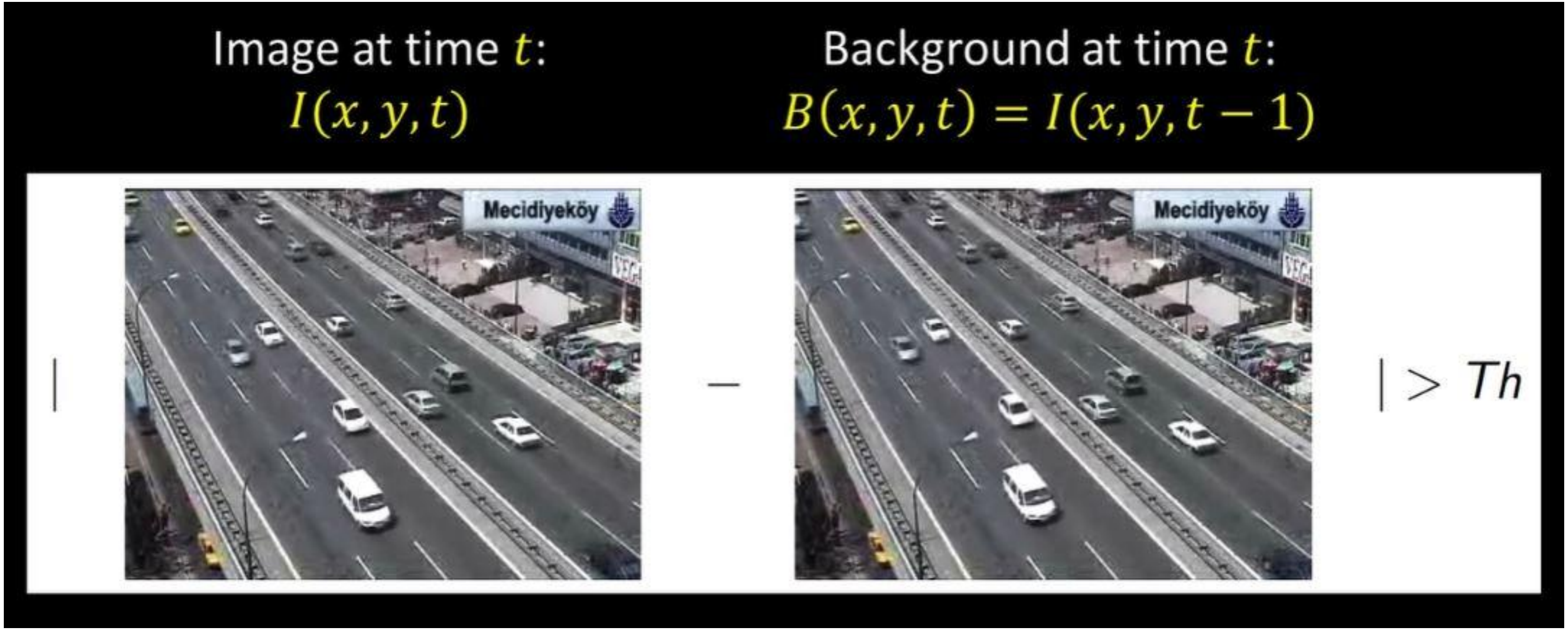
Background Subtraction :-

- Now a question will arise i.e, What is a good estimate for the background?
- So,let us see some of the approaches.

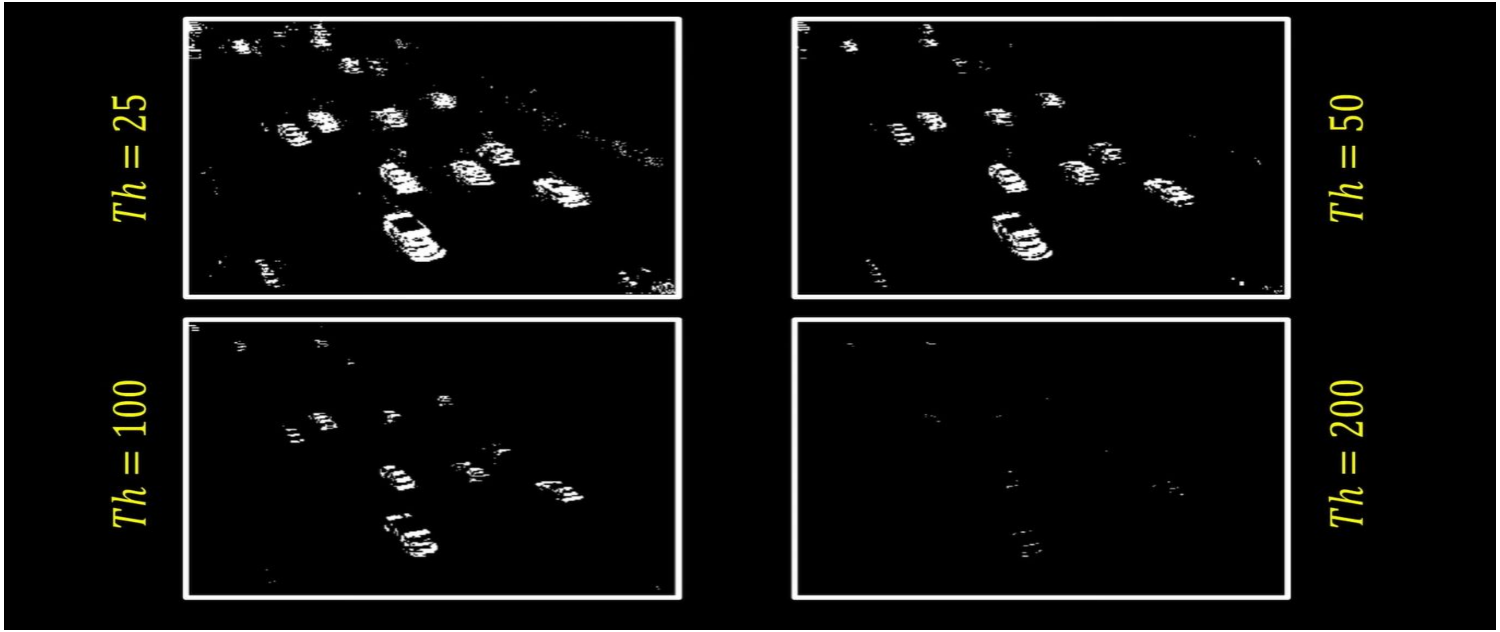
➢ Frame Differencing : -

- Background is estimated to be the previous frame:
  - $B(x,y,t) = I(x,y,t-1)$
- Background subtraction then becomes:
  - $| I(x,y,t)-I(x,y,t-1) | > Th$

➢ Frame Differencing[1] : -



➢ Frame Differencing[1] : -



➢ Frame Differencing : -

Limitations in this approach -

- ❑ Speed of the object
- ❑ Global Threshold
- ❑ Object Structure
- ❑ Frame Rate

➢ Mean Filtering[2] :-

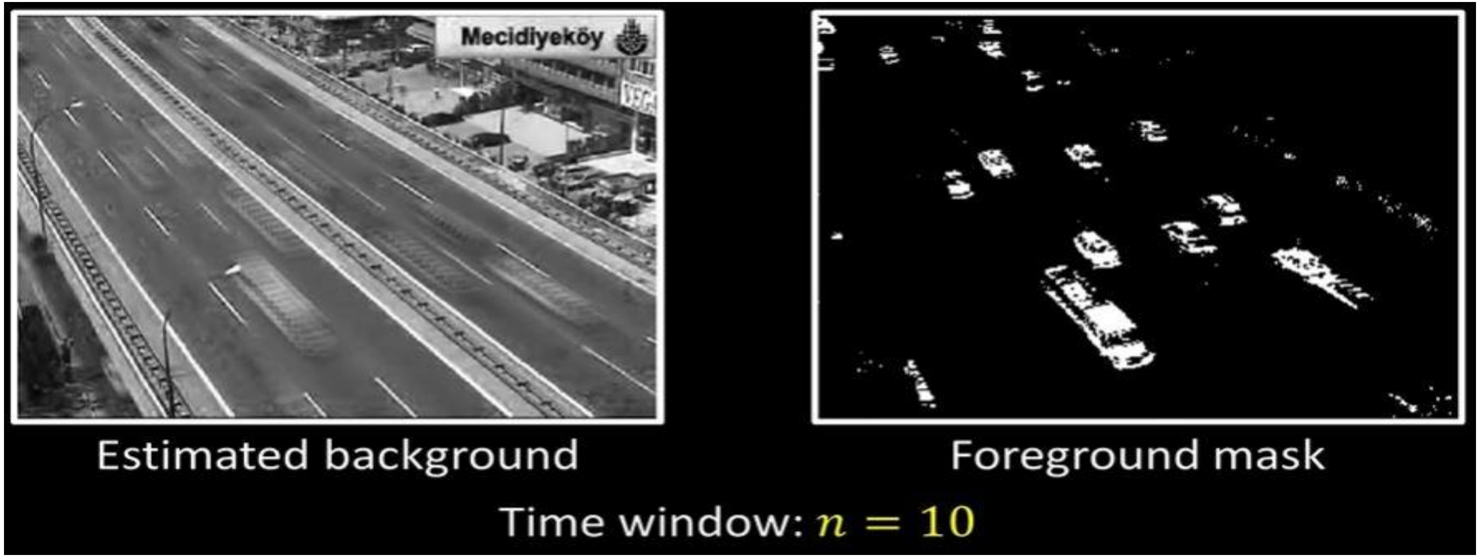
- In this case, background is the mean of the previous **n** frames:

$$B(x,y,t) = \frac{1}{n}\sum_{i=1}^{n} I(x,y,t-i)$$

- Therefore, foreground mask is computed as:

$$\left| I(x,y,t) - \frac{1}{n}\sum_{i=1}^{n} I(x,y,t-i) \right| > Th$$

➢ Mean Filtering[2] :-



➔ n is sensitive to random noise

➢ Median Filtering[3] :-

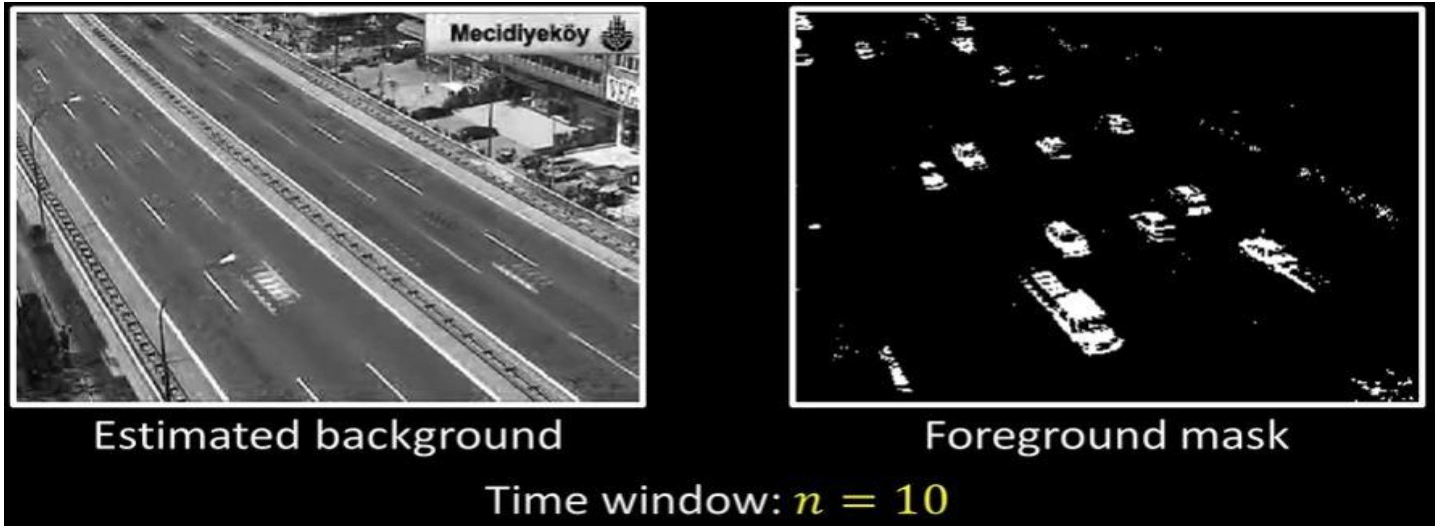
- Assuming that the background is more likely to appear in a scene, we can use the median of previous **n** frames as the background model:

$$B(x,y,t) = median\{I(x,y,t-i)\}$$

- Therefore the foreground mask is computed as:

$$|I(x,y,t) - median\{I(x,y,t-i)\}| > Th$$
$$\text{where } i \in \{1, \ldots, n\}$$

➢ Median Filtering[3] :-

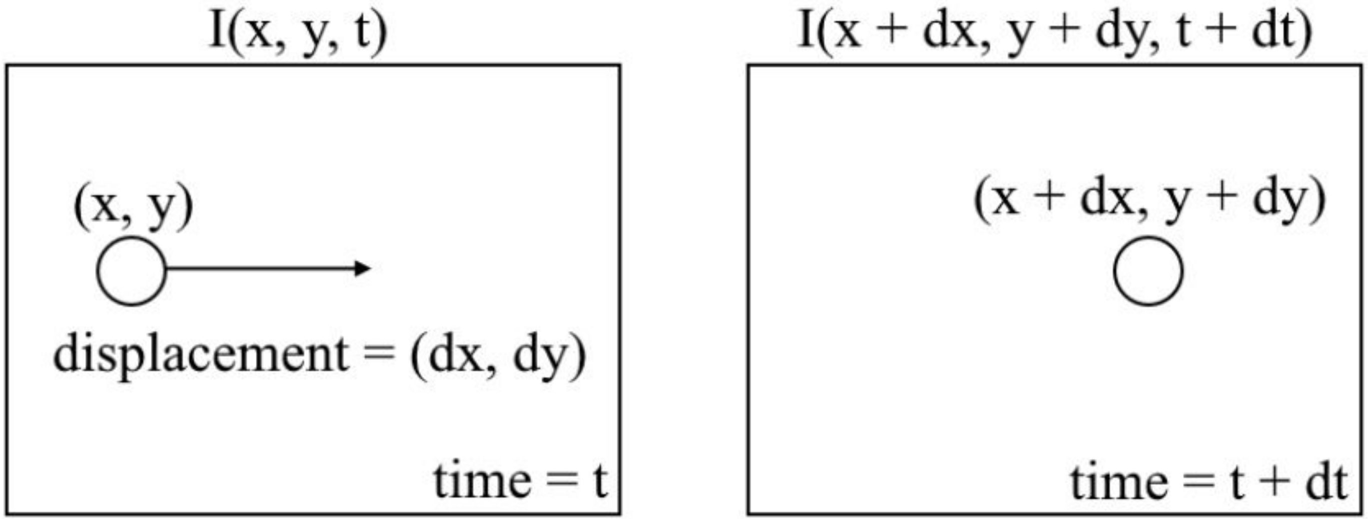


- ➔ **n** is less sensitive to noise as compared to mean filter.
- ➔ Small value of **n** causes problem

Optical Flow

- **Optical flow** is the motion of objects between consecutive frames of sequence, caused by the relative movement between the object and camera.
- The cardinal surroundings are in a three-dimensional coordinate system with time as an extra variable. As in image it is converted into a two-dimensional coordinate system with time as the third variable.
- Optical flow is expressed by the figure in next slide.

Optical Flow[5]



Optical Flow[5]

- Between consecutive frames, we can express the image intensity *(I)* as function of space *(x,y) and time (t).* In other words if we take the first image *I(x,y,t)* and move its pixel by *(dx,dy)* over time *t* we obtain the new image *I(x+dx,y+dy,t+dt).*
- First we assume that the pixel intensities of the object are constant between the consecutive frames.

$$I(x, y, t) = I(x + \delta x, y + \delta y, t + \delta t)$$

Optical Flow[5]

- By Taylor Series Approximation and removing common terms we get,

$$I(x+\delta x, y+\delta y, t+\delta t) = I(x,y,t) + \frac{\partial I}{\partial x}\delta x + \frac{\partial I}{\partial y}\delta y + \frac{\partial I}{\partial t}\delta t + \ldots$$

$$\Rightarrow \frac{\partial I}{\partial x}\delta x + \frac{\partial I}{\partial y}\delta y + \frac{\partial I}{\partial t}\delta t = 0$$

Optical Flow[5]

- Third we divide by *dt* to derive the optical flow equation,

$$\frac{\partial I}{\partial x}u + \frac{\partial I}{\partial y}v + \frac{\partial I}{\partial t} = 0$$

where *u = dx/dt and* v = *dy/dt*

Optical Flow

- This is the equation with two variables and cannot be solved. This is called *aperture problem.*
- To find optical flow another set of equations are needed given by additional constraints.
- One of the method to determine optical flow is Lucas Kanade method.

Lucas Kanade Method for Optical Flow

- Additional constraints are considered to get required linear equations to get value *u* and *v.*
- Smooth flow of pixels is considered as one of the constraint i.e neighbourhood pixels also has same value of u and v.

$$\begin{bmatrix} I_x(\mathbf{p}_1) & I_y(\mathbf{p}_1) \\ I_x(\mathbf{p}_2) & I_y(\mathbf{p}_2) \\ \vdots & \vdots \\ I_x(\mathbf{p}_{25}) & I_y(\mathbf{p}_{25}) \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} = - \begin{bmatrix} I_t(\mathbf{p}_1) \\ I_t(\mathbf{p}_2) \\ \vdots \\ I_t(\mathbf{p}_{25}) \end{bmatrix}$$

Lucas Kanade Method for Optical Flow

- ❑ All the linear equations are now solved to get the values of *u* and *v.*
- ❑ On the basis of this value of *u* and *v* flow is determined.

Challenges :-

- **Illumination Variations-** Illumination variations result in major recognition errors, especially for appearance based techniques.

- **Camouflage-** The mixing of foreground (Object) and the background due to similarity of the texture.

Challenges :-

- **Dynamic Scene Variations**- Object Detection techniques need to be incredibly fast at prediction time to meet the real-time demands of video process.

- **Aspect Ratio and Spatial Scale**- An object may appear in a wide range of sizes and aspect ratios in different scenes making the detection difficult.

Applications[4] :-

- ❑ Video Surveillance.
- ❑ Human Activity Analysis.
- ❑ Road Condition Monitoring.
- ❑ Airport Safety.
- ❑ Monitoring Of Protection Along Marine Border.

References :-

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THANK YOU