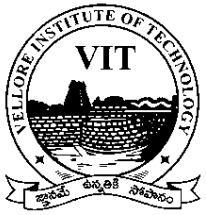

VIT-AP UNIVERSITY

Computer Vision

(Course Code: 4047)

Module-3:Lecture-1: Background Subtraction and Modeling

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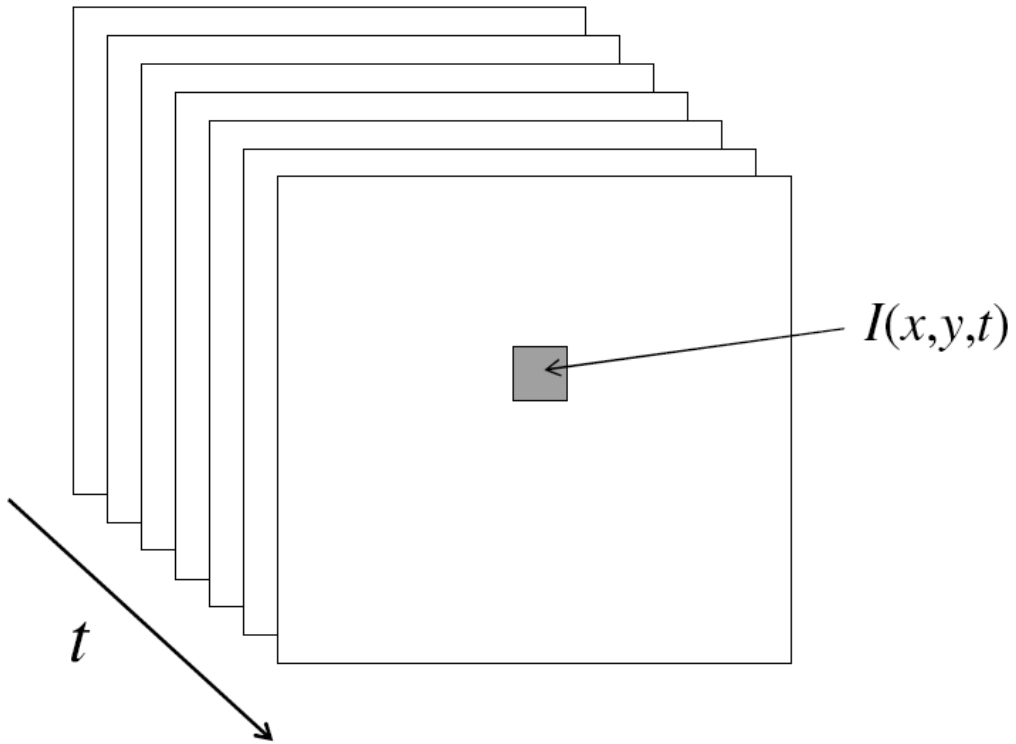
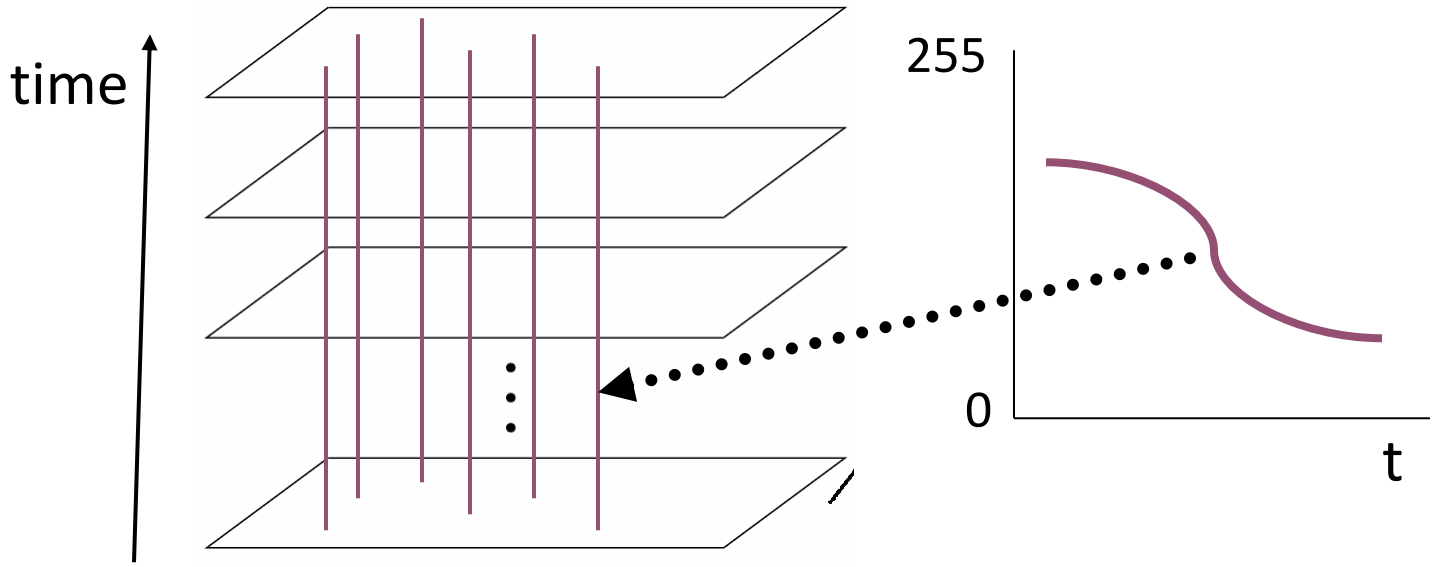
Video

- A video is a sequence of frames captured over time
- Now our image data is a function of space (x, y) and time (t)



Video as an “Image Stack”

- Can look at video data as a spatio-temporal volume
  - If camera is stationary, each line through time corresponds to a single ray in space



Background Subtraction

- Problem: separate the (static) background from the (dynamic) foreground.
- Applications:
  - surveillance
  - tracking of moving objects
  - classification
- General Approach:
  - For each frame ***i*** let

$x[n_1, n_2, i]$ intensity

$b[n_1, n_2, i]$ background

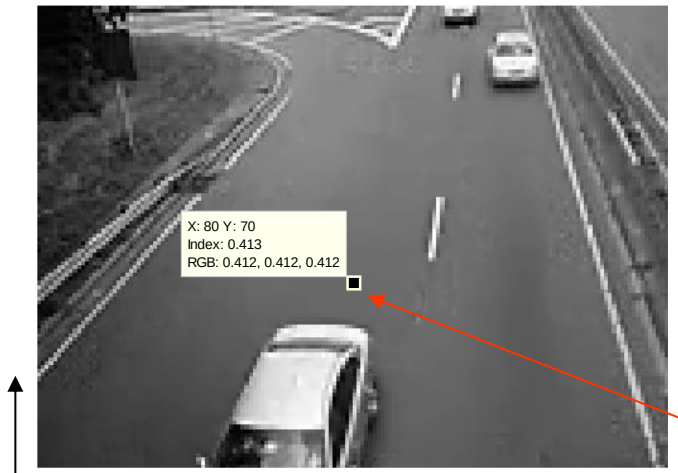
  - Then $\left|x[n_1, n_2, i] - b[n_1, n_2, i]\right| > threshold \quad \Rightarrow (n_1, n_2) \in object$

Issues with the Background

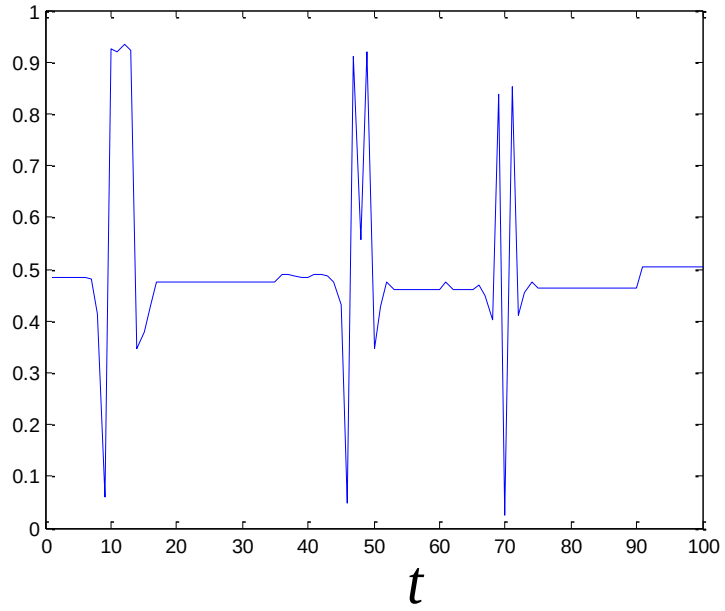
- Illumination Changes
  - Gradual Daily Changes (day/night)
  - sudden (clouds)
- Motion
  - Camera oscillations;
  - small motions of trees, leaves, …
- Changes in Background
  - Parked Cars and others

Approach

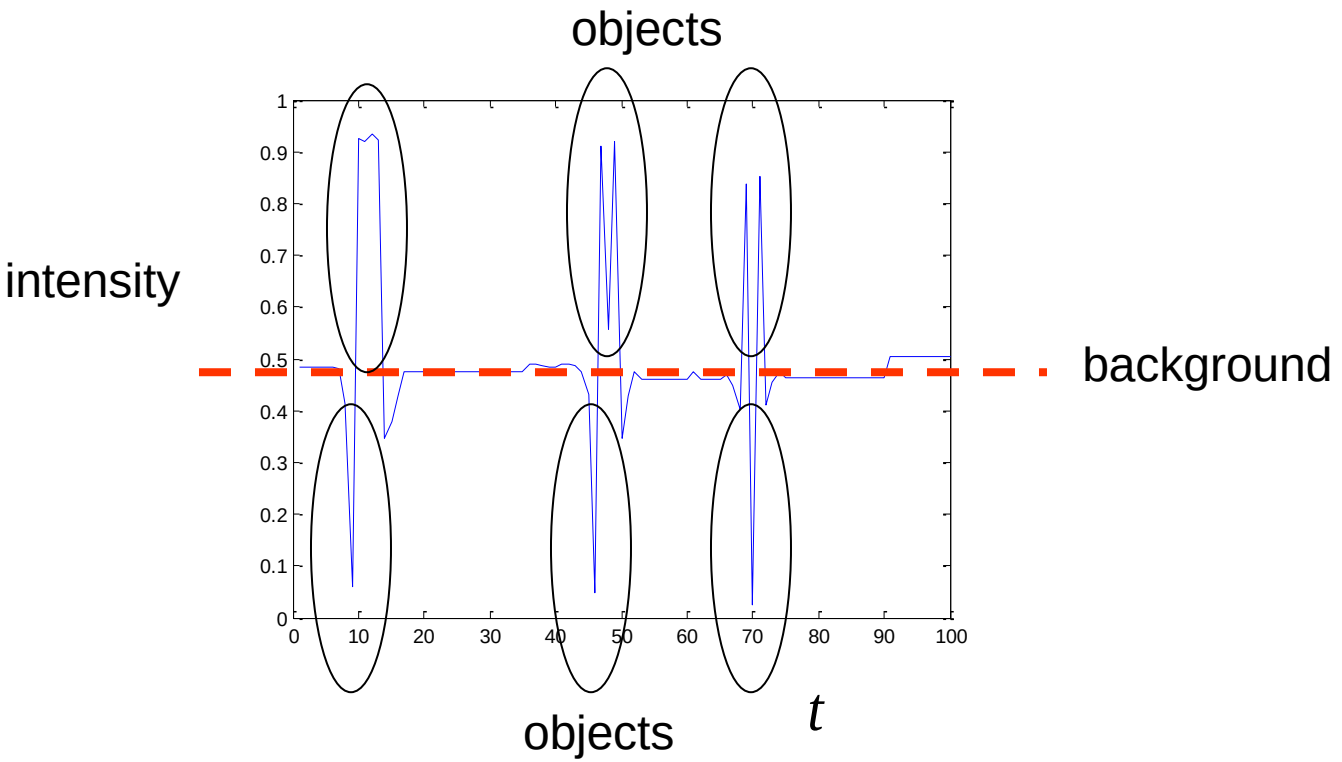
- Most approaches based on the time domain.
- Take one point and see how it changes in time:



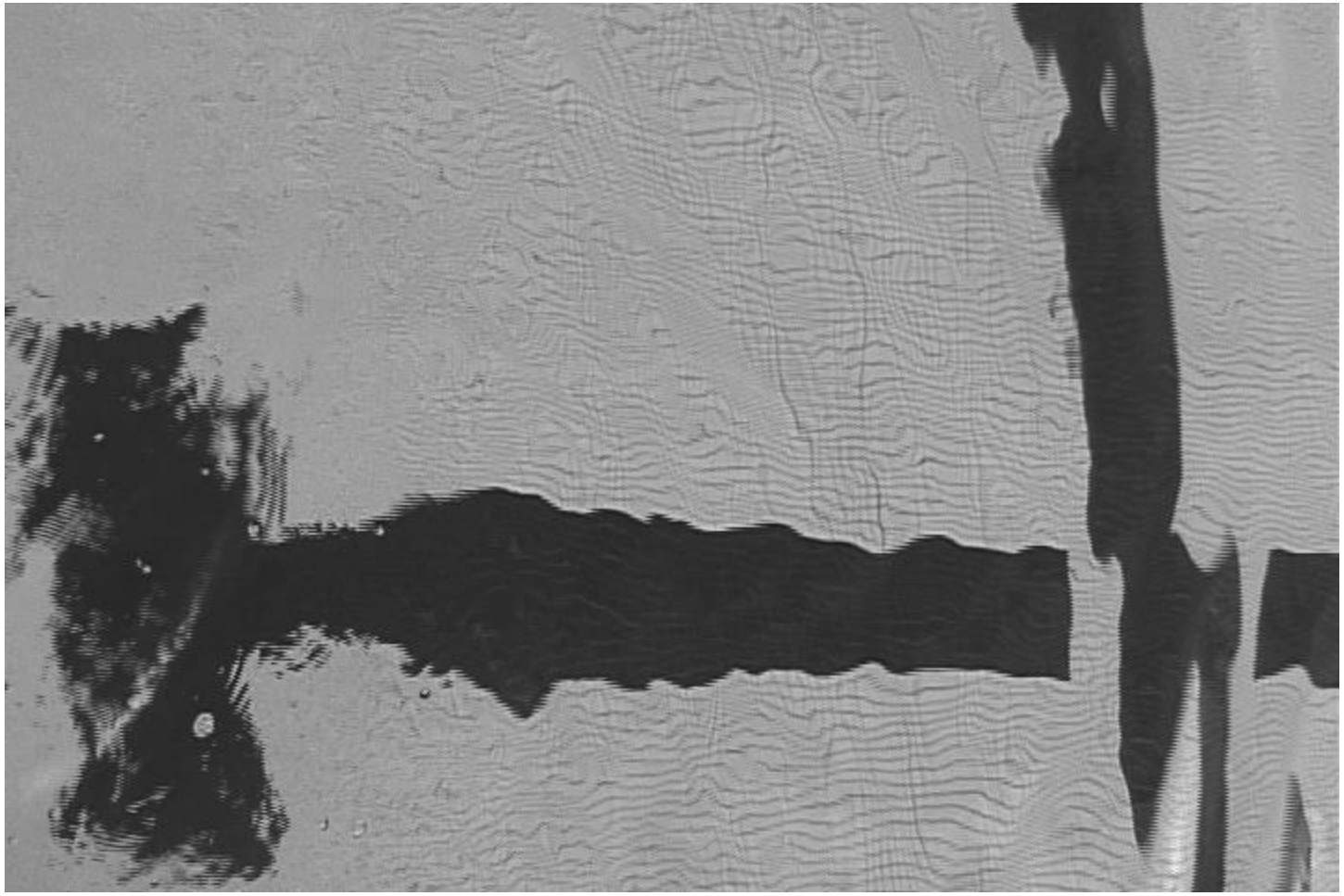
intensity



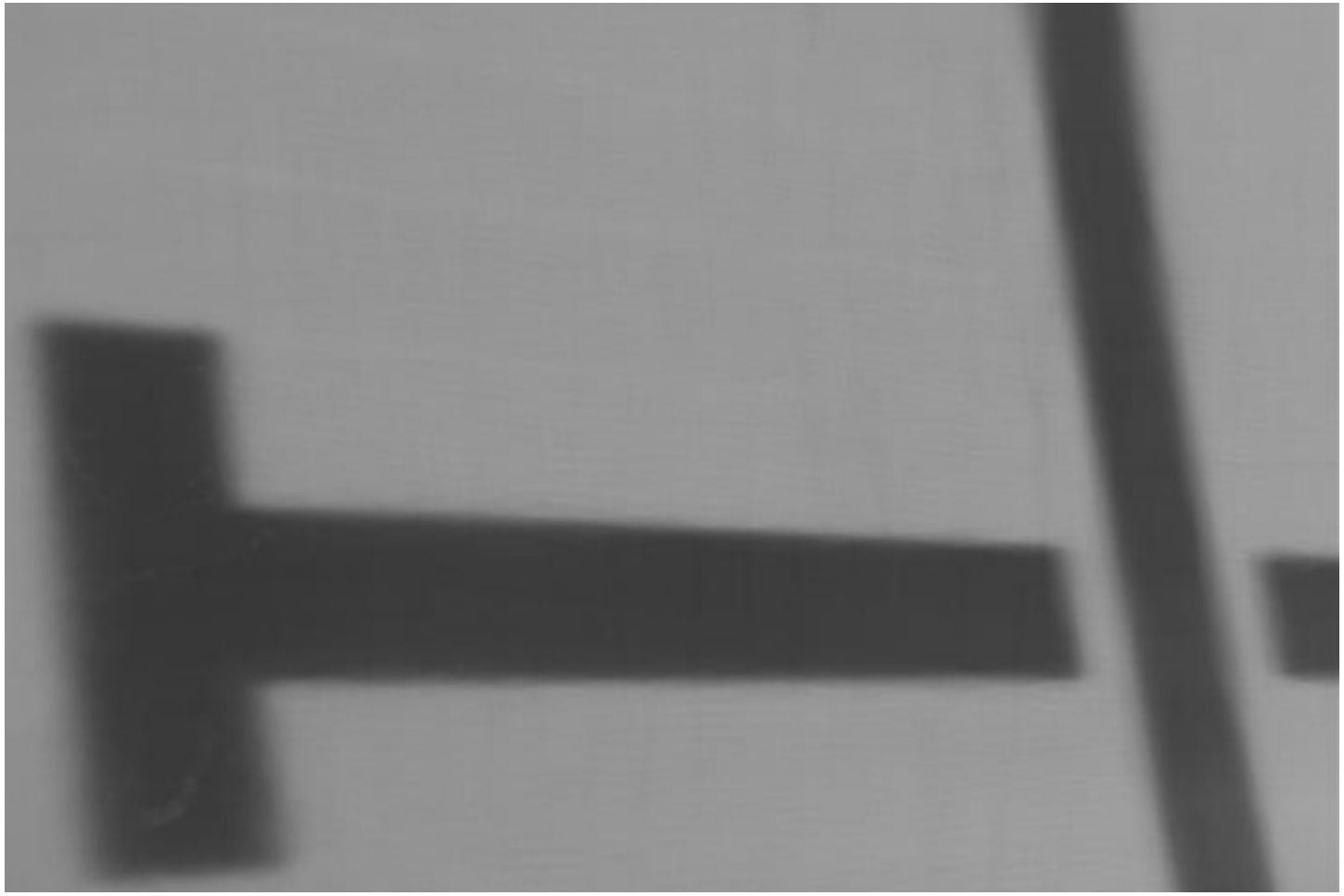
Here it is easy to separate the background from the objects:



Input Video



Average Image



Background subtraction

- Given an image (mostly likely to be a video frame), we want to identify the **foreground objects** in that image!

$\Rightarrow$

Motivation

- In most cases, objects are of interest, not the scene.
- Makes our life easier: less processing costs, and less room for error.

Background subtraction

- Simple techniques can do ok with static camera
- …But hard to do perfectly

- Widely used:
  - Traffic monitoring (counting vehicles, detecting & tracking vehicles, pedestrians),
  - Human action recognition (run, walk, jump, squat),
  - Human-computer interaction
  - Object tracking

Simple Approach

Image at time t:
$I(x, y, t)$

Background at time t:
$B(x, y, t)$

$$| \quad \text{  } \quad - \quad \text{  } \quad | > Th$$

1. Estimate the background for time t.
2. Subtract the estimated background from the input frame.
3. Apply a threshold, Th, to the absolute difference to get the **foreground mask**.

But, how can we estimate the background?

Frame Differencing

- Background is estimated to be the previous frame. Background subtraction equation then becomes:

$$B(x, y, t) = I(x, y, t-1)$$
$$\Downarrow$$
$$|I(x, y, t) - I(x, y, t-1)| > Th$$

- Depending on the object structure, speed, frame rate and global threshold, this approach may or may **not** be useful (usually **not**).

$|$  $-$  $| > Th$

Frame Differencing

$Th = 25$

$Th = 50$

$Th = 100$

$Th = 200$

Mean Filter

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

$$B(x, y, t) = \frac{1}{n} \sum_{i=0}^{n-1} I(x, y, t - i)$$

$$\Downarrow$$

$$|I(x, y, t) - \frac{1}{n} \sum_{i=0}^{n-1} I(x, y, t - i)| > Th$$

- For $n = 10$:

Estimated Background

Foreground Mask

Median Filter

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

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

$$\Downarrow$$

$$|I(x, y, t) - median\{I(x, y, t - i)\}| > Th \text{ where } i \in \{0, \ldots, n - 1\}.$$

- For $n = 10$:

Estimated Background

Foreground Mask

Average/Median Image

Previous N frame image

Average/median of these images
(Background of the image)

Background Subtraction

-

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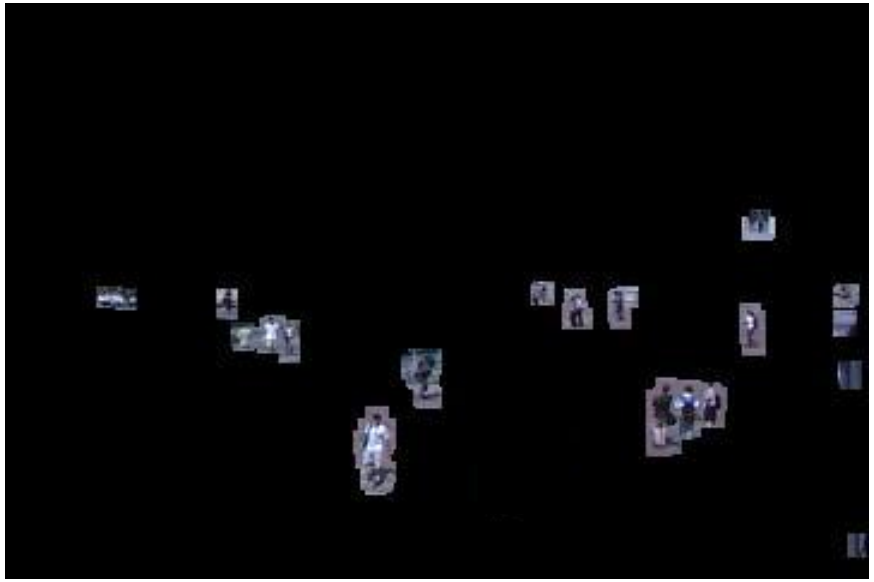

Pros and cons

Advantages:

- Extremely easy to implement and use!
- All pretty fast.
- Corresponding background models need not be constant, they change over time.

Disadvantages:

- Accuracy of frame differencing depends on object speed and frame rate
- Median background model: relatively high memory requirements.
- Setting global threshold Th…

When will this basic approach fail?

References

- Background Subtraction
- https://www.cs.utexas.edu/~grauman/courses/fall2009/slides/lecture9_background.pdf