Multi-object Detection and Tracking Using Kalman Filter

Ajay Meena

OBJECTIVE

The objective of my work was to detect track multi objects in a video using Kalman filter.

APPLICATIONS

- Military Guidance
- Security Surveillance
- Intelligent Traffic

TWO PROBLEMS

First: Detect Objects from video

- Image Processing Techniques

Second: Track Detected Objects

- Kalman Filter
- Assignment Problem

OBJECT DETECTION: BACKGROUND SUBTRACTION

How to do Background subtraction

- Estimate background at time t
- Subtract estimated background from current input frame
- Apply a threshold to the difference to get the foreground mask.

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

$-$

Background estimation at t : B(x,y,t)

$= |\ > Th$

OBJECT DETECTION: BACKGROUND SUBTRACTION

If background estimated to be previous frame:

$$B(x,y,t) = I(x,y,t-1)$$

Background subtraction:

$$|I(x,y,t) - I(x,y,t-1)| > Th$$

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

Background estimation at *t* : B(x,y,t)

$$- \quad = \quad | > Th$$

OBJECT DETECTION: BACKGROUND SUBTRACTION

Use mean filtering for background estimation:

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

Background subtraction:

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

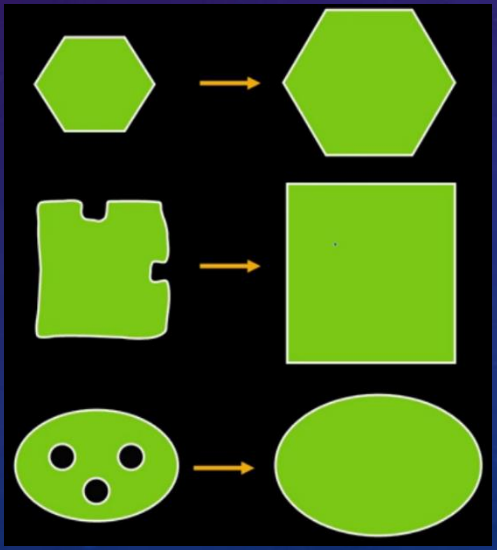
Time window
n = 10

Foreground mask after thresholding to *t :* I(x,y,t)

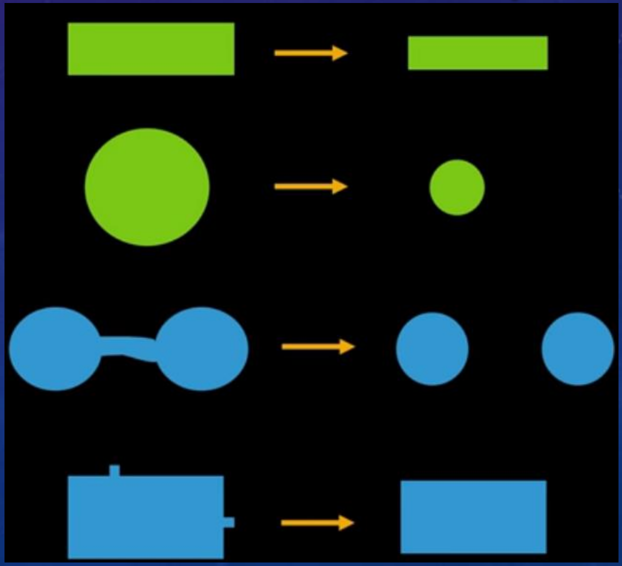
OBJECT DETECTION: MORPHOLOGICAL OPERATIONS

- Non-ideal Background estimation-> Noise in foreground mask, Objects are not enhanced
- Use Dilation and Erosion

Dilation technique

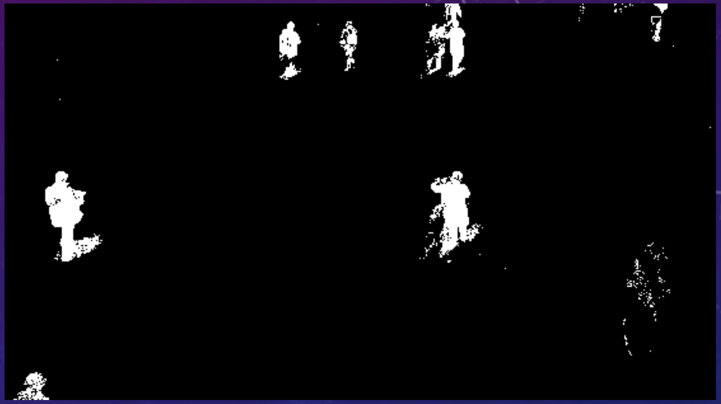


Erosion technique

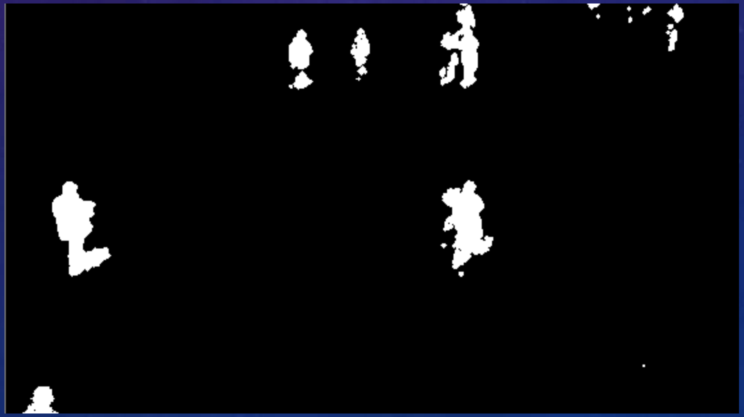


SUMMARY OF OBJECT DETECTION

Original frame at time *t*



Foreground Mask at time *t*

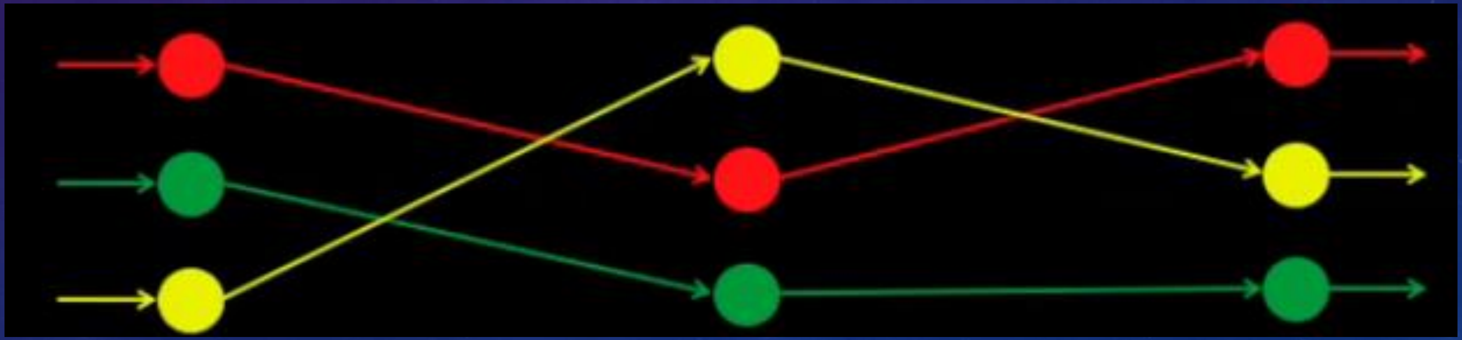


Using erosion followed by dilation at time *t*

OBJECT TRACKING: KALMAN FILTER

Why do we even need prediction algorithm like Kalman filter?

Objects detected in consecutive frames



Assigning node

OBJECT TRACKING: KALMAN FILTER

What is Kalman Filter?

-Combination of two Ideas

- Linear system
- Linear recursive estimation

The kalman filter is an efficient algorithm for estimating the state of a system from noisy measurement.

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OBJECT TRACKING: KALMAN FILTER

A discrete time linear time-invariant dynamical system is a set of matrix of the formula

$$x_i = Ax_{i-1} + w_i \qquad w_i : \text{ represents process noise} \sim N(0, Q)$$
$$z_i = Hx_i + v_i \qquad v_i : \text{ represents measurement noise} \sim N(0, R)$$

- x_i is a state variable at *ith* instance: coordinates of centroid of detected object
- A is the transition matrix
- H is the measurement matrix
- $E[w_i v_j^T] = 0$

OBJECT TRACKING: KALMAN FILTER

Kalman filter estimates states in two steps:

Time Update Equation

$$\hat{x}_i^- = A\hat{x}_{i-1} + w_i$$
$$P_i^- = AP_{i-1}A^T + Q$$

Prediction of state

- Estimate future state variable
- Estimate for error covariance

Kalman Gain

Measure update equation

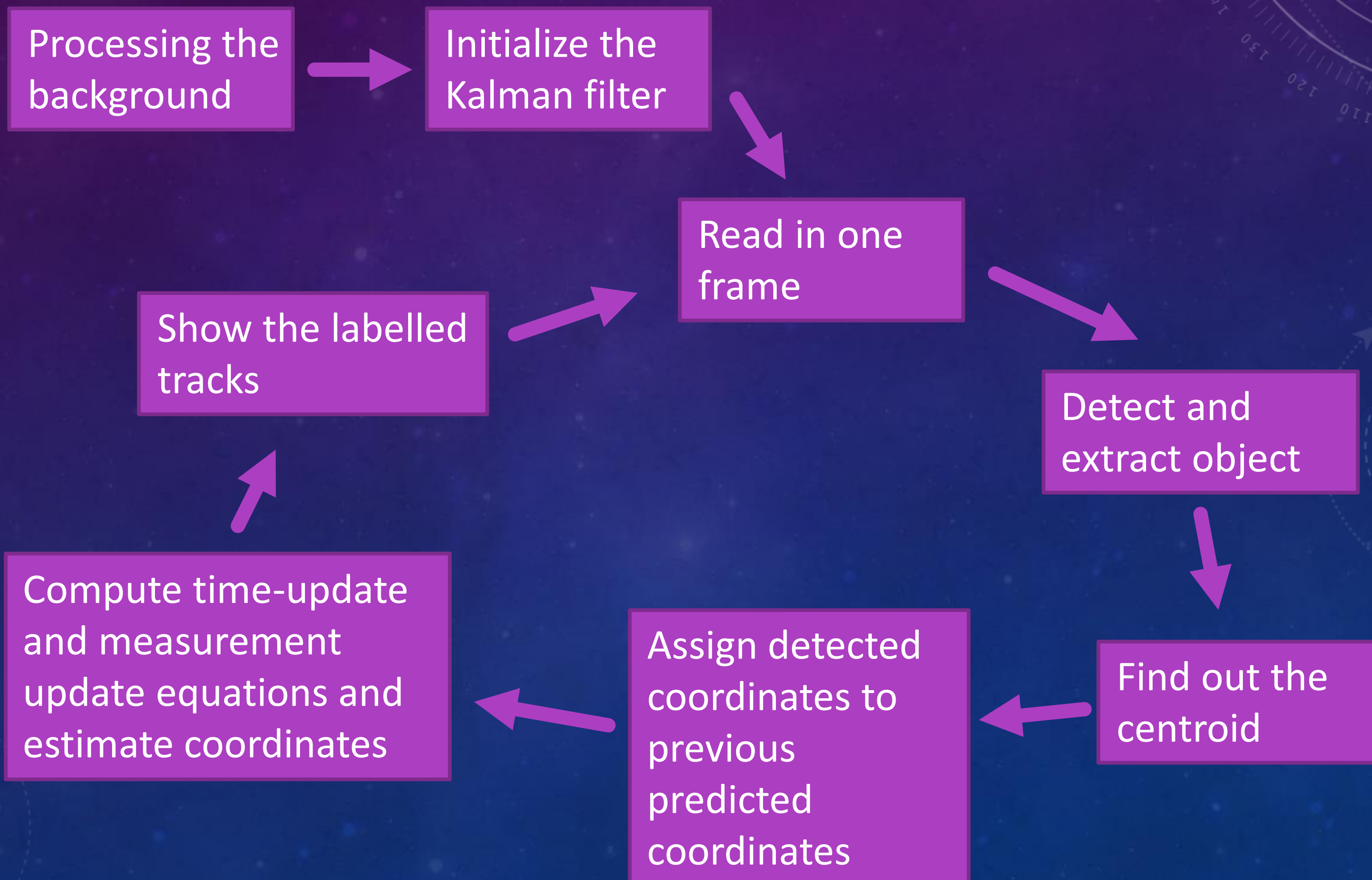
$$K_i = P_i^- H^T (HP_i^- H^T + R)^{-1}$$

$$\hat{x}_i = \hat{x}_i^- + K_i(z_i - H\hat{x}_i^-)$$
$$P_i = (1 - K_i H)P_i^-$$

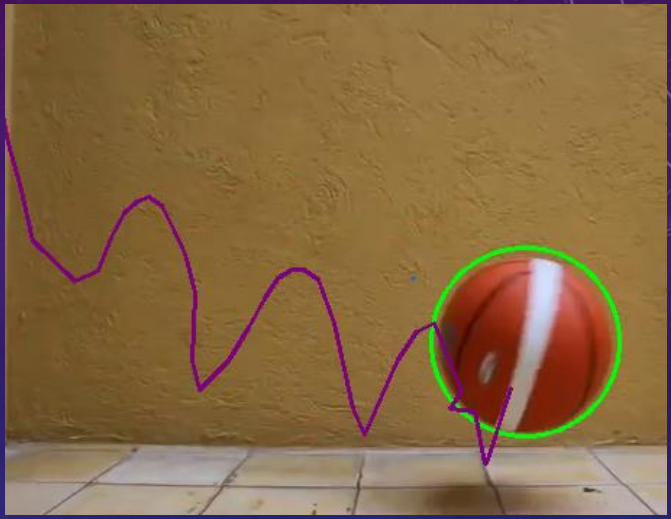
- Compute Kalman Gain
- Update state variable *x* based on measurement *z*.
- Update error covariance

OBJECT TRACKING: KALMAN FILTER

The basic programme process is as follows:



RESULTS



RESULTS

REFERENCES

1. Xin Li Kejun Wang,Wei Wang and Yang Li. A Multiple Object Tracking Method Using Kalman Filter.
2. Sumit Kumar Pal, Sohan Ghorai. Moving Object Tracking System In Video With Kalman Filter.
3. Jonathan Owensa, Andrew Hunter. A Fast Model-Free Morphology Based Object Tracking Algorithm.

THANK YOU