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Object Tracking

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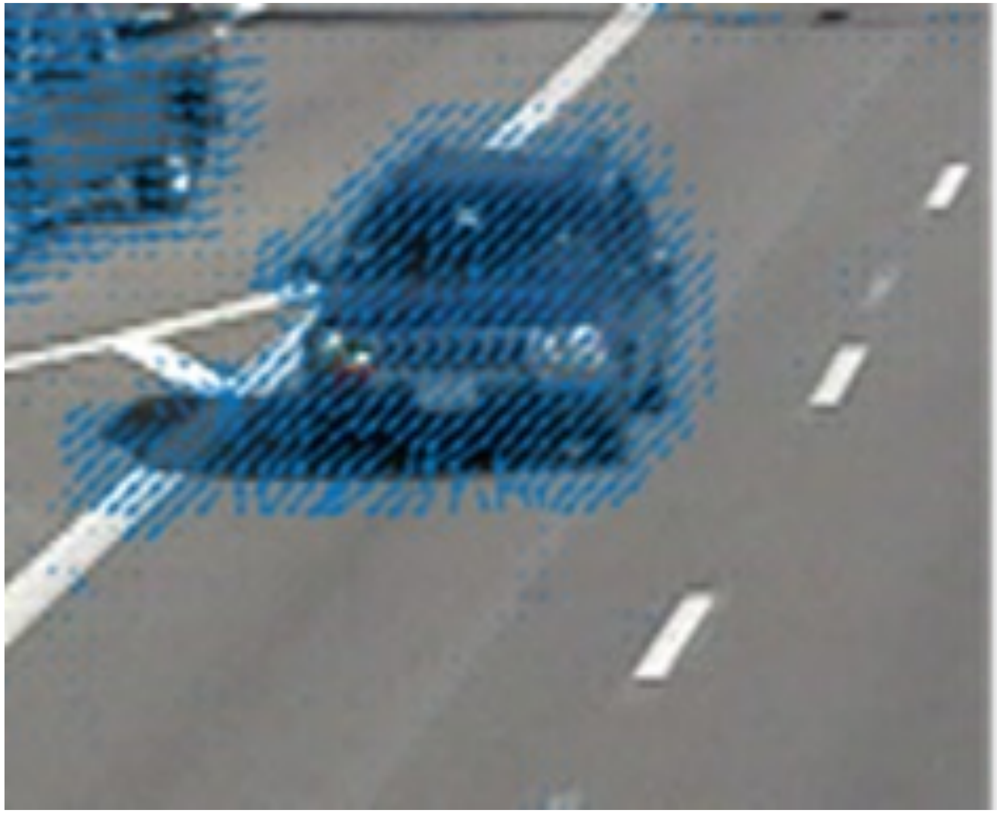
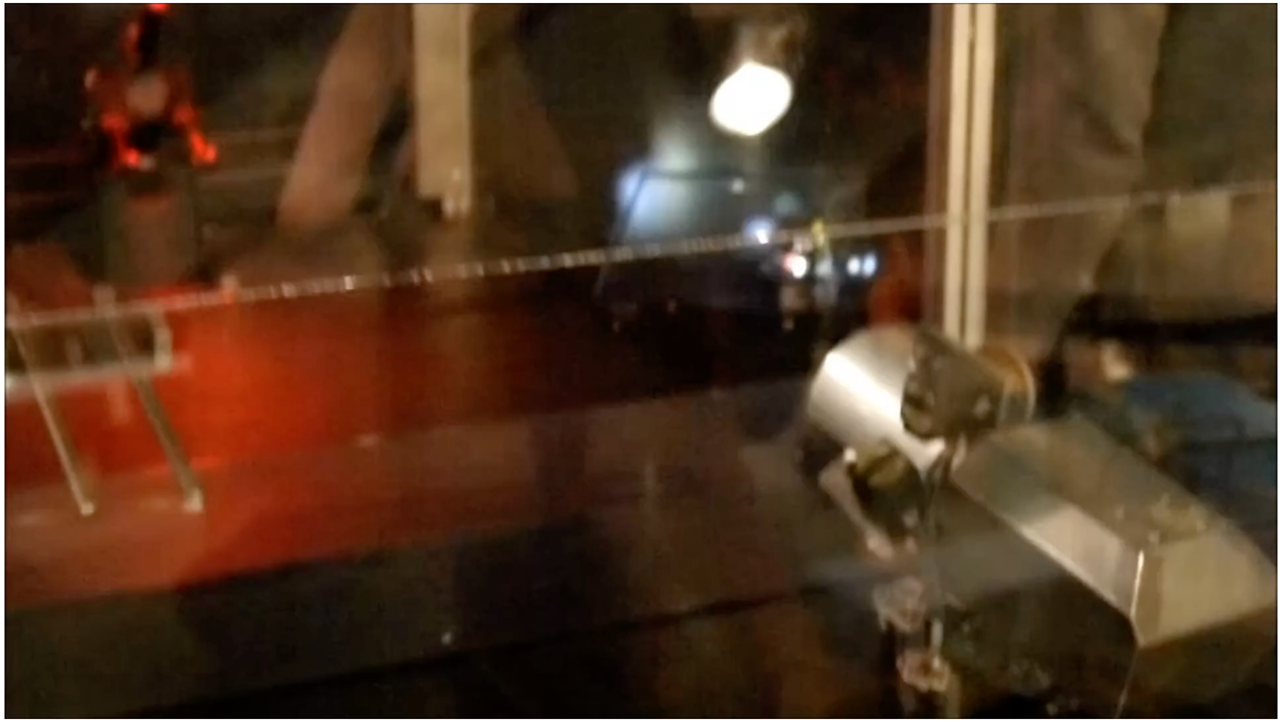
Object Tracking

- Process of locating and tracking a (moving) object (or multiple objects)
- Fundamental pre-processing step in Computer Vision
- Requires a video



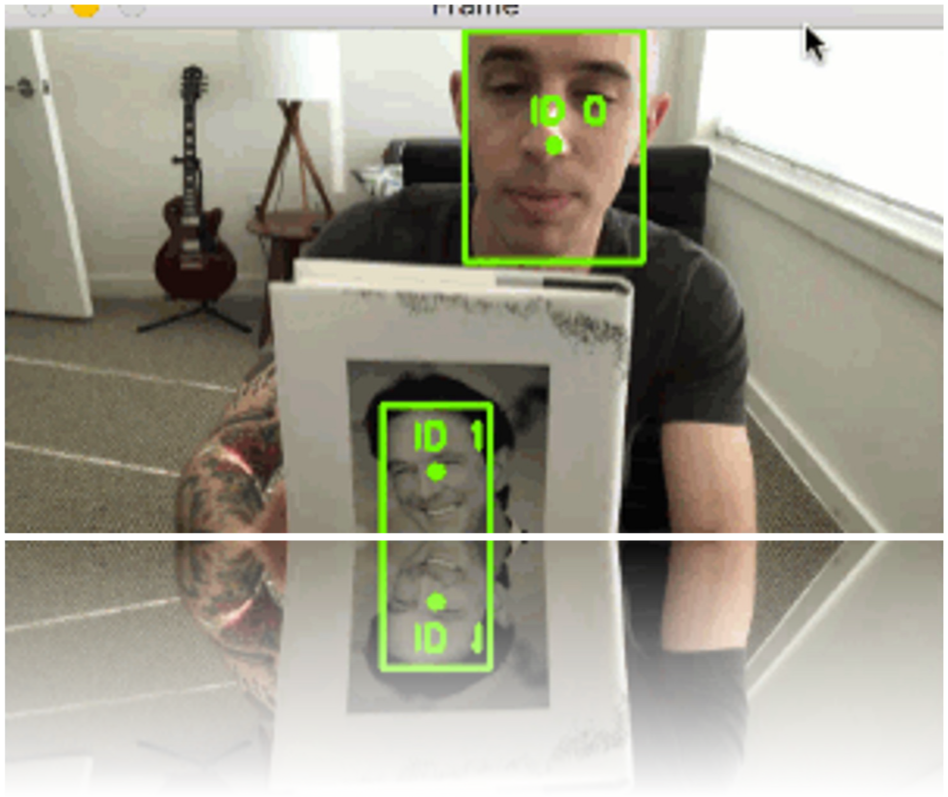
Applications



- Commonly added to e.g.:
  - Object detection
  - Process of modelling changes in object’s look

Applications

- Human-computer interaction
  - Gesture recognition
  - Eye gaze tracking
- Traffic monitoring
  - Surveillance systems
  - Person counter
- Medical imaging



GIF taken from this article at pyimagesearch.com

Theoretical Fundamentals

- Given an initial position, track object position in subsequent frames
  - In a non-ideal case, object detection needed from time to time
- Unique IDs for each tracked object needed
- Time consuming process
- One can track anything
  - If there is no dependency on an object detector

Centroid Tracking

1. Use initial bounding boxes of objects and compute centroids
    a. Assign unique IDs to centroids
2. Calculate the Euclidean distance between the centroids
3. Update centroids
    a. the lowest distance method
4. Register new objects
5. Deregister old objects
6. Go back to step 2.

Dependent on object detector

Steps taken from this article at pyimagesearch.com

Problem Complexity

- Still being improved
- Source of difficulties
  - Information loss, caused by transferring from a 3D world into its 2D representation
  - Capturing distortions
  - Changes in lighting
  - Computational complexity of convolutional neural networks (if an object detector used)
  - Frame rate of object detectors limited even on modern graphics processing unit

Problem Complexity

- Extra complexity when
  - Objects moving fast relative to the frame rate
  - Tracked objects changing orientation over time

- Complex training for deep learning
- Motion model helps with the changing orientation
  - how would an image look like for different object motions

Elon Musk’s Doubtful Sense of Humour

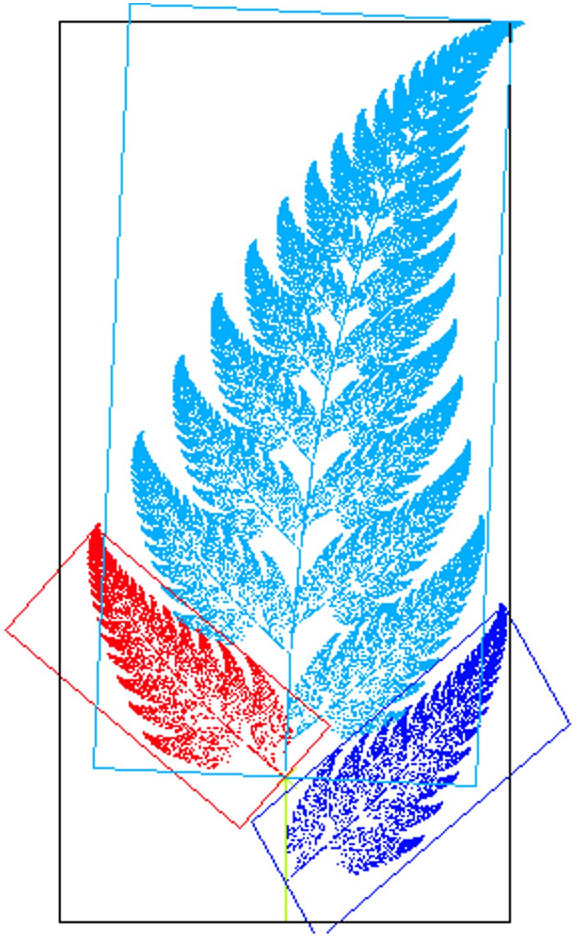
- Elon Musk stated in 2017 that robots will move so fast that you will not be able to see them without a strobe light
- That would be a nightmare for object tracking as well…

Motion Model Examples

- **2D object**: 2D transformation of object image (e.g. initial frame):
    - Affine transformation
    - Homography
    - Applies to planar objects
- **3D object**: aspect depending on its 3D position and orientation

Affine transformation

- » Preserves
  - – Points
  - – Lines
  - – Planes
- » Examples
  - – Translation
  - – Scaling
  - – Reflection
  - – Rotation



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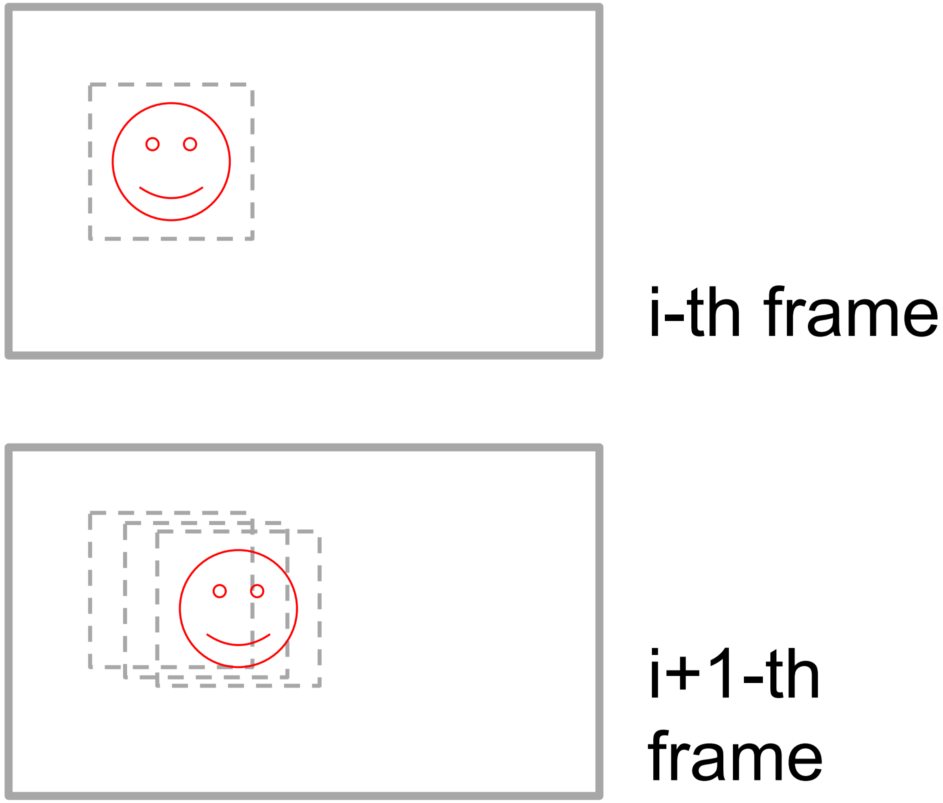
Motion
Model Examples

- **Deformable objects:**
  - Covered with mesh
  - Object motion defined by a position of mesh nodes
- **Video compression**:
  - Key frames divided into macroblocks
  - One tracks a motion of macroblocks
  - This motion is needed to recreate the video

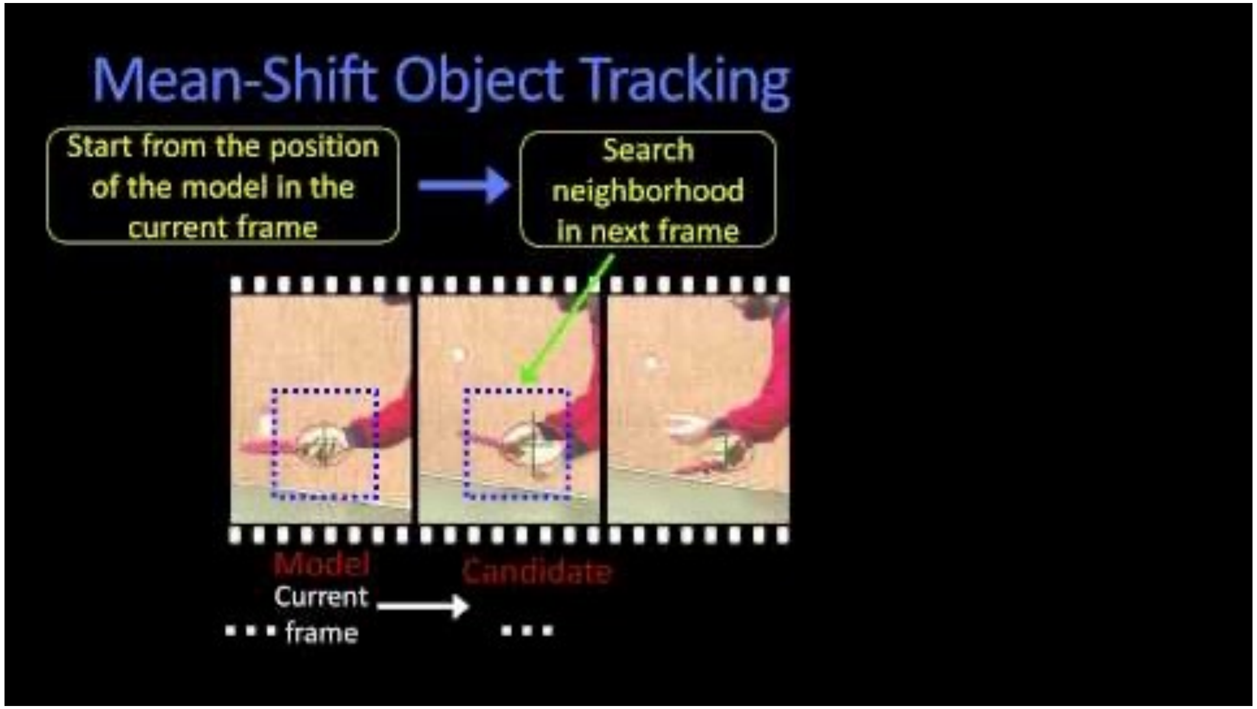
The Most Popular Approaches

Mean Shift Tracking

- » Given a region from the previous frame, find the most similar region in the current frame
- » Proposed in 1975



This Video Nicely Explains the Topic of Mean Shift Object Tracking



Mean-Shift Object Tracking

Start from the position of the model in the current frame

Search neighborhood in next frame

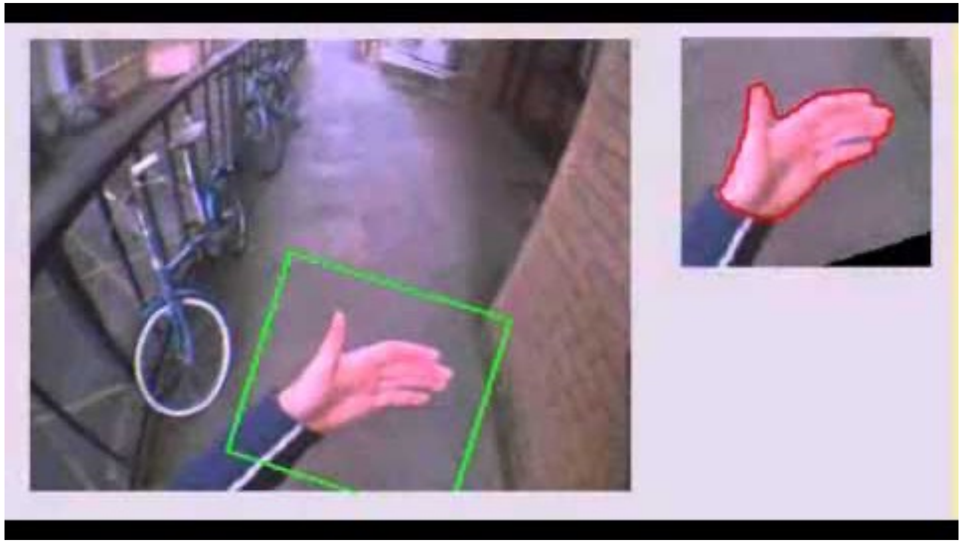
The Most Popular Approaches

Contour Tracking

Minimizing object energy

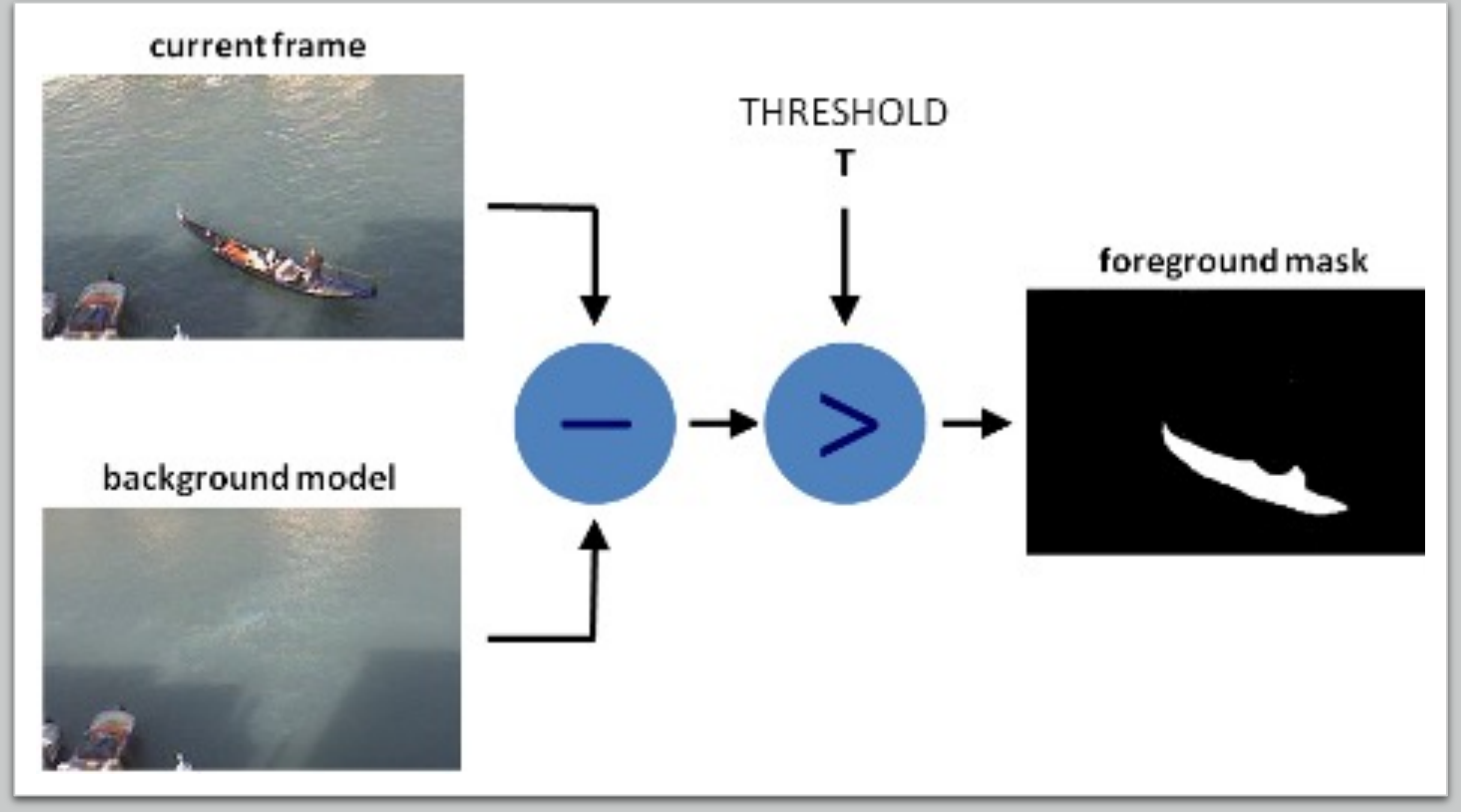
Using gradient descent, & by doing so iteratively evolving initial contour initialized from previous frame to its new position in the current frame

Best Understood in Action



Frame Differencing

- Comparing 2 subsequent images
- Computing differences between them
- Using threshold to distinguish noises from a real movement
- Method especially useful in situations when:
  - Background staying still
  - Tracking path of all moving objects



Frame Differencing

- A.k.a. foreground detection
- Extracting image foreground for further processing
  - in this case, for tracking
- Applicable when background is static

Live Demo

You can run this demo on your computer using this tutorial from pyimagesearch.com.