Segmentation
- Active contours

Objectives

- What is Segmentation?
- What are the effect of Segmentation in image processing and computer vision?
- What is the active contour technique?
- The techniques of active contours
- Specific applications of active contours

What is Segmentation?

- It is the process of dividing an image into different regions based on the characteristics of pixels to identify objects or boundaries to simplify an image and more efficiently analyze it
- The goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze.
- Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

What is Image Segmentation?

- The result of image segmentation is a set of segments that collectively cover the entire image or a set of contours extracted from the image

Why Image Segmentation?

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- Detecting cancerous cell(s) as quickly as possible can potentially save millions of lives.
- The shape of the cancerous cells plays a vital role in determining the severity of the cancer. Object detection will not be very useful here. We will only generate bounding boxes which will not help us in identifying the shape of the cells.

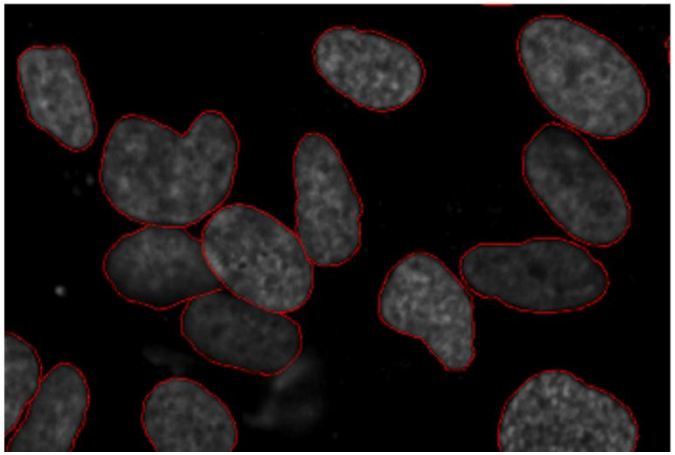
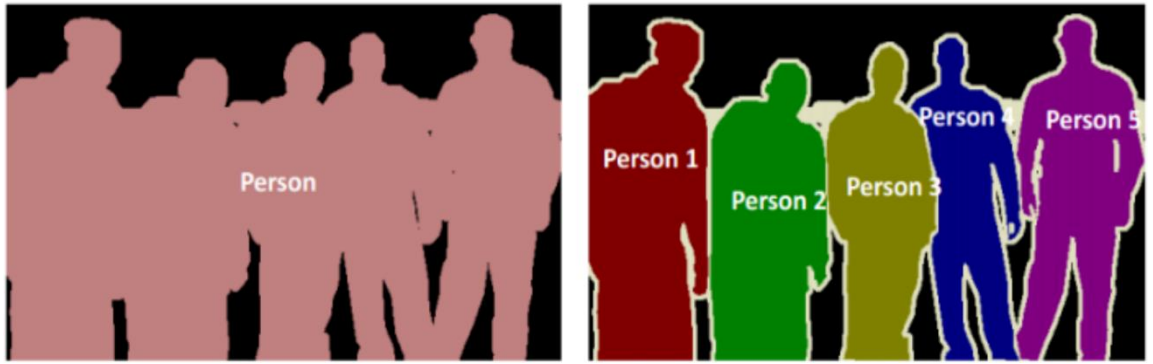


Image Segmentation Types

- Semantic segmentation is an approach detecting, for every pixel, belonging class of the object.
- Instance segmentation is an approach that identifies, for every pixel, a belonging instance of the object. It detects each distinct object of interest in the image.



Application Image Segmentation?

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- Content-based image retrieval
- Medical imaging: Locate tumors and other pathologies, Measure tissue volumes
- Object detection: Pedestrian detection, Face detection
- Recognition Tasks: Face recognition, Fingerprint recognition
- Traffic control systems
- Video surveillance
- …

Image Segmentation - Active Contours

- Contours are boundaries designed for the area of interest required in an image. Contour is a collection of points that undergoes interpolation process.
- Active contour is a type of segmentation technique which can be defined as use of energy forces and constraints for segregation of the pixels of interest from the image.
- Active contour defines a separate boundary or curvature for the regions of target object for segmentation.

Image Segmentation - Active Contours

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- Active contour is described as an active model for the process of segmentation.
- Types:
  - Snakes model
  - Dynamic snakes and CONDENSATION model
  - Scissors model Level
  - Sets model

Snakes model

- Snakes algorithm we try to move snake in a direction where energy is minimum.
- Snake model is designed to vary its shape and position while tending to search through the minimal energy state.
- Snake propagates through the domain of the image to reduce the energy function, and intends to dynamically move to the local minimum.

Snakes model

- The energy function of the snake is the sum of its external energy and internal energy:
  - Internal energy :

$$E^*_{\text{snake}} = \int_0^1 E_{\text{snake}}(\mathbf{v}(s))\,ds = \int_0^1 (E_{\text{internal}}(\mathbf{v}(s)) + E_{\text{image}}(\mathbf{v}(s)) + E_{\text{con}}(\mathbf{v}(s)))\,ds$$

$$E_{\text{internal}} = E_{\text{cont}} + E_{\text{curv}}$$

  - Image energy

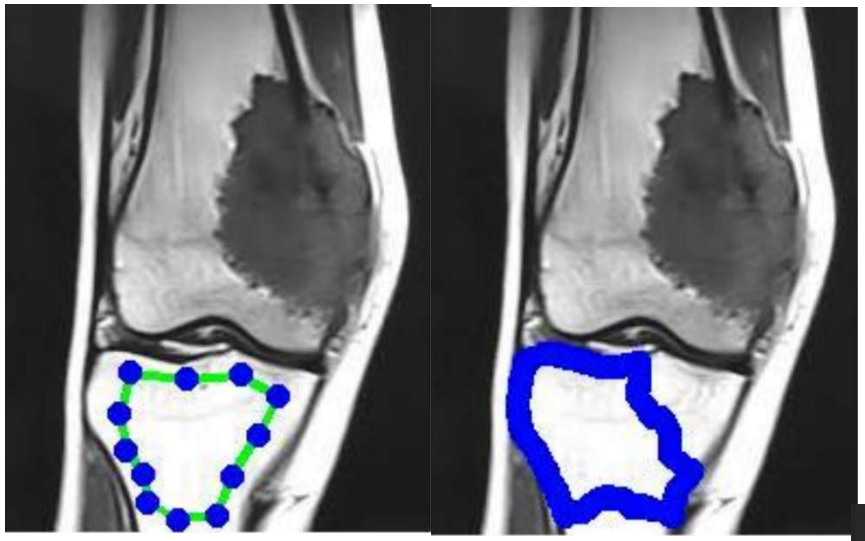
$$E_{\text{internal}} = \frac{1}{2}(\alpha(s)|\mathbf{v}_s(s)|^2) + \frac{1}{2}(\beta(s)|\mathbf{v}_{ss}(s)|^2) = \frac{1}{2}\left(\alpha(s)\left\|\frac{d\bar{v}}{ds}(s)\right\|^2 + \beta(s)\left\|\frac{d^2\bar{v}}{ds^2}(s)\right\|^2\right)$$

$$E_{\text{image}} = w_{\text{line}}E_{\text{line}} + w_{\text{edge}}E_{\text{edge}} + w_{\text{term}}E_{\text{term}}$$

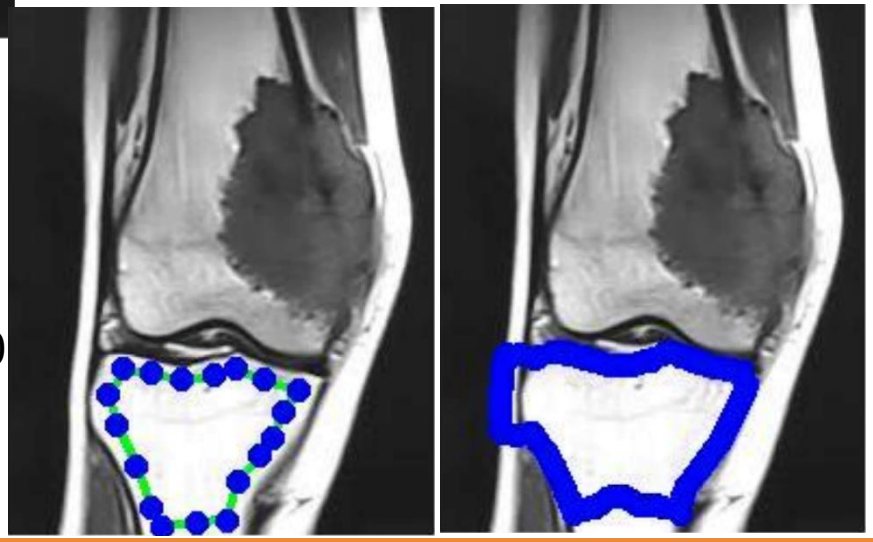
Snakes model

- Snakes model steps:
  - Initialize the boundary curve (the active contour)➔ important
  - The contour moves: “Active” contour, looks like a wiggling “snake”
  - The contour stops moving: when many/most points on the contour line up with edge pixels
- Advantage:
  - Autonomously and adaptively search for the minimum state.
  - Track dynamic objects.
- Disadvantages:
  - Sensitive to local minima states
  - Dependent: contour initialization points(Number and Location)
  - Not works perfectly even for binary images

Snakes model



Initial snake
and Iteration number= 1000



Initial snake
and Iteration number= 1000

Dynamic snakes and CONDENSATION

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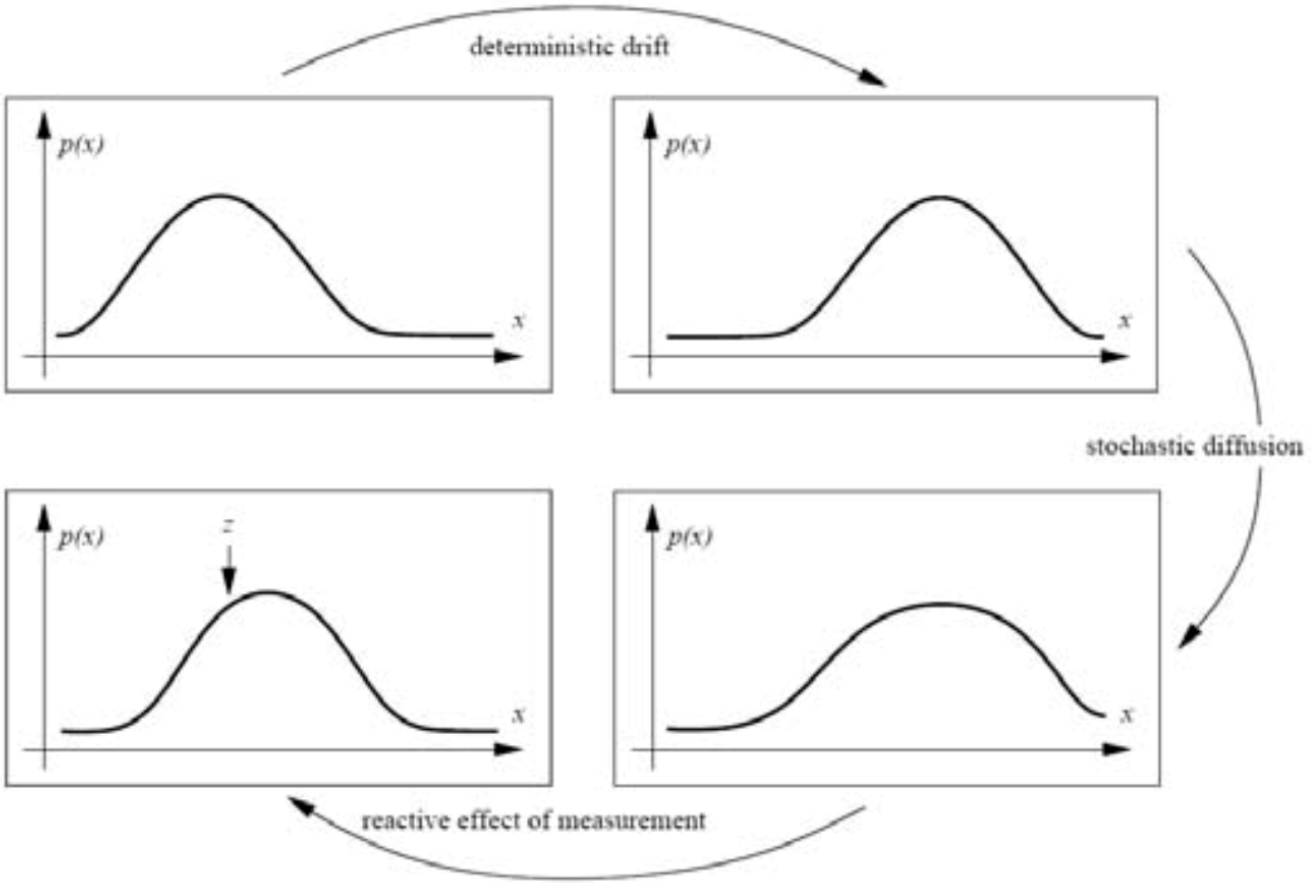
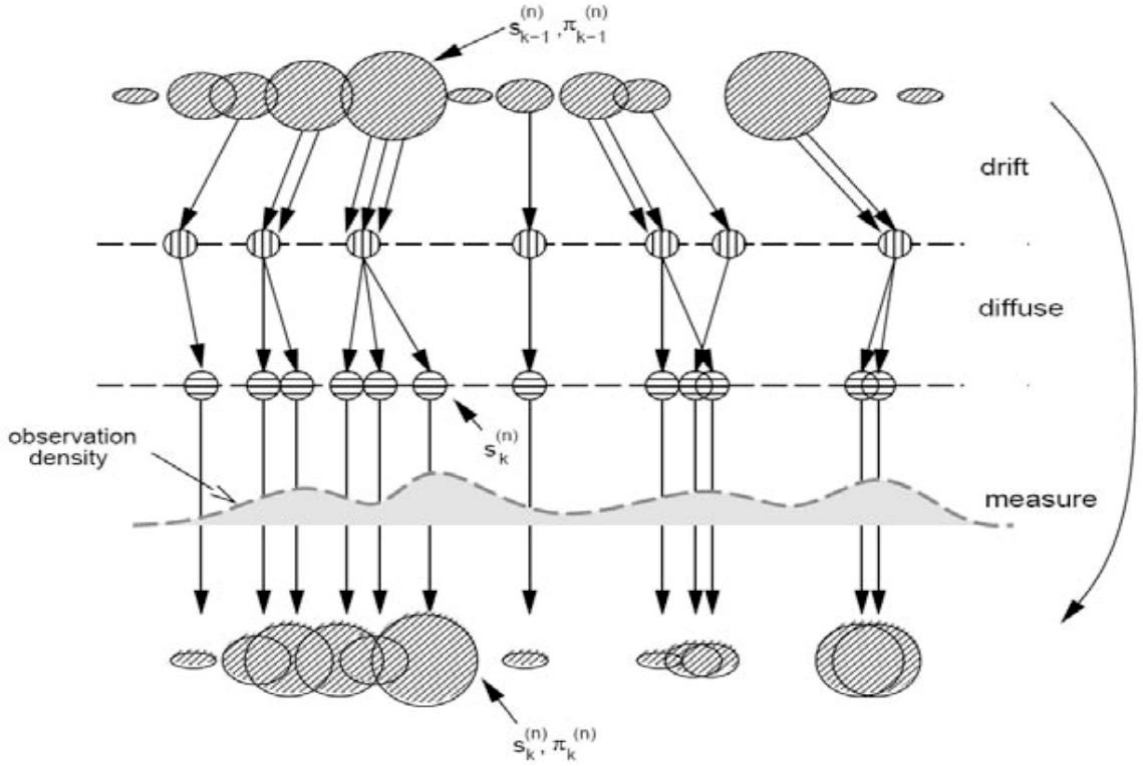
- Kalman Filter



Dynamic snakes and CONDENSATION

- The Condensation algorithm is based on factored sampling but extended to apply iteratively to successive images in a sequence

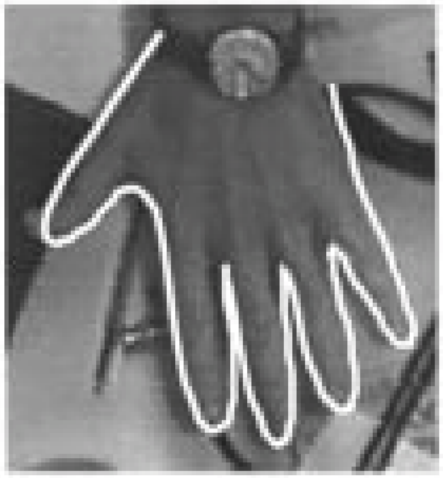


Dynamic snakes and CONDENSATION

Edge detector

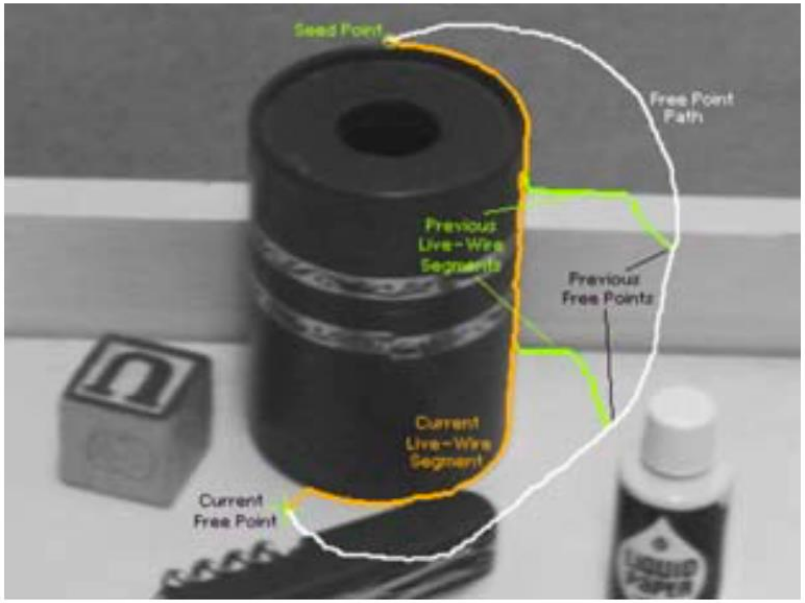
Original

CONDENSATION



Scissors

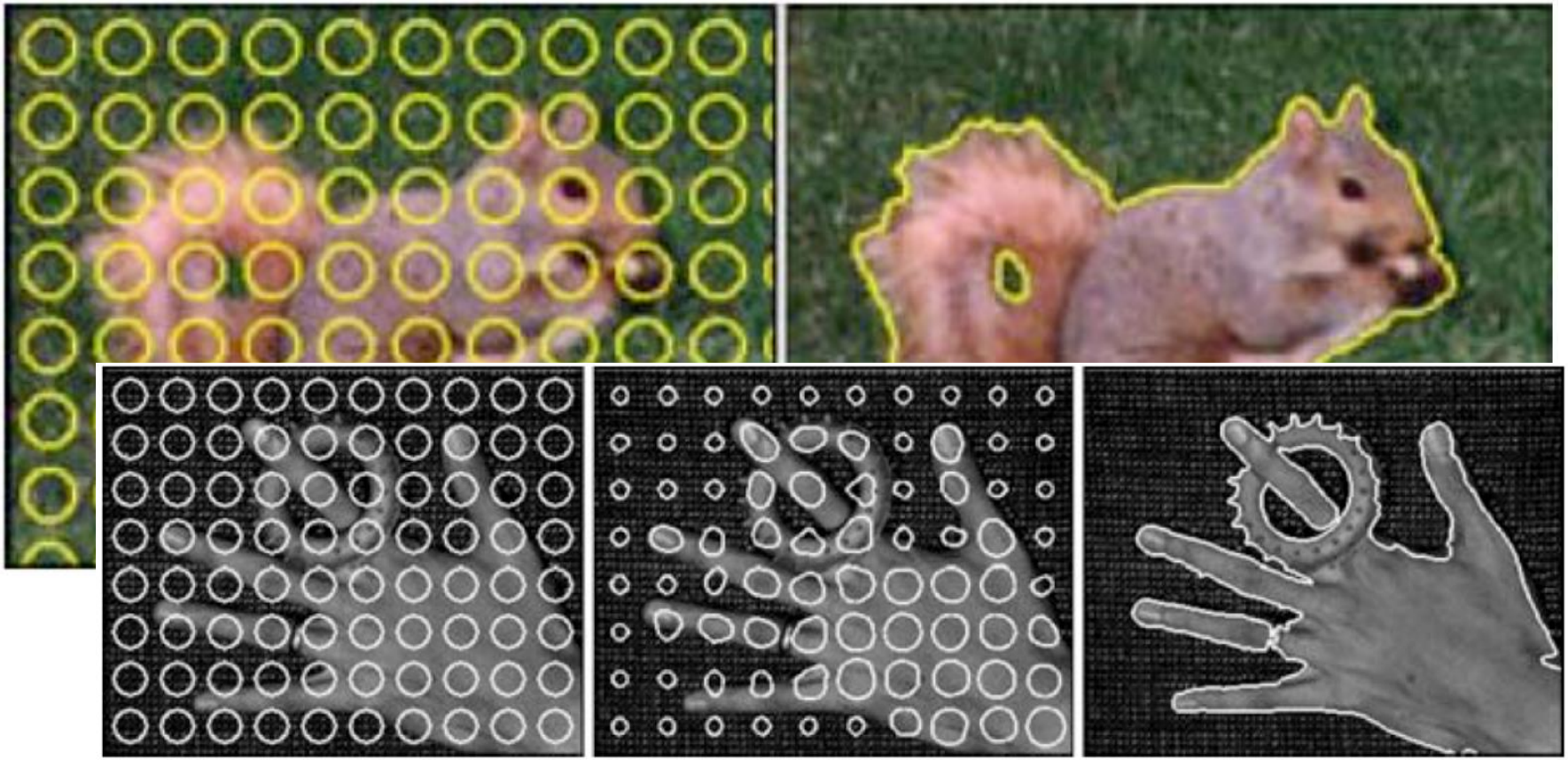
- The intelligent scissors system optimizes the contour in real-time as the user is drawing
- As the user draws a rough outline (the white curve), the system computes and draws a better curve that clings to high-contrast edges (the orange curve).



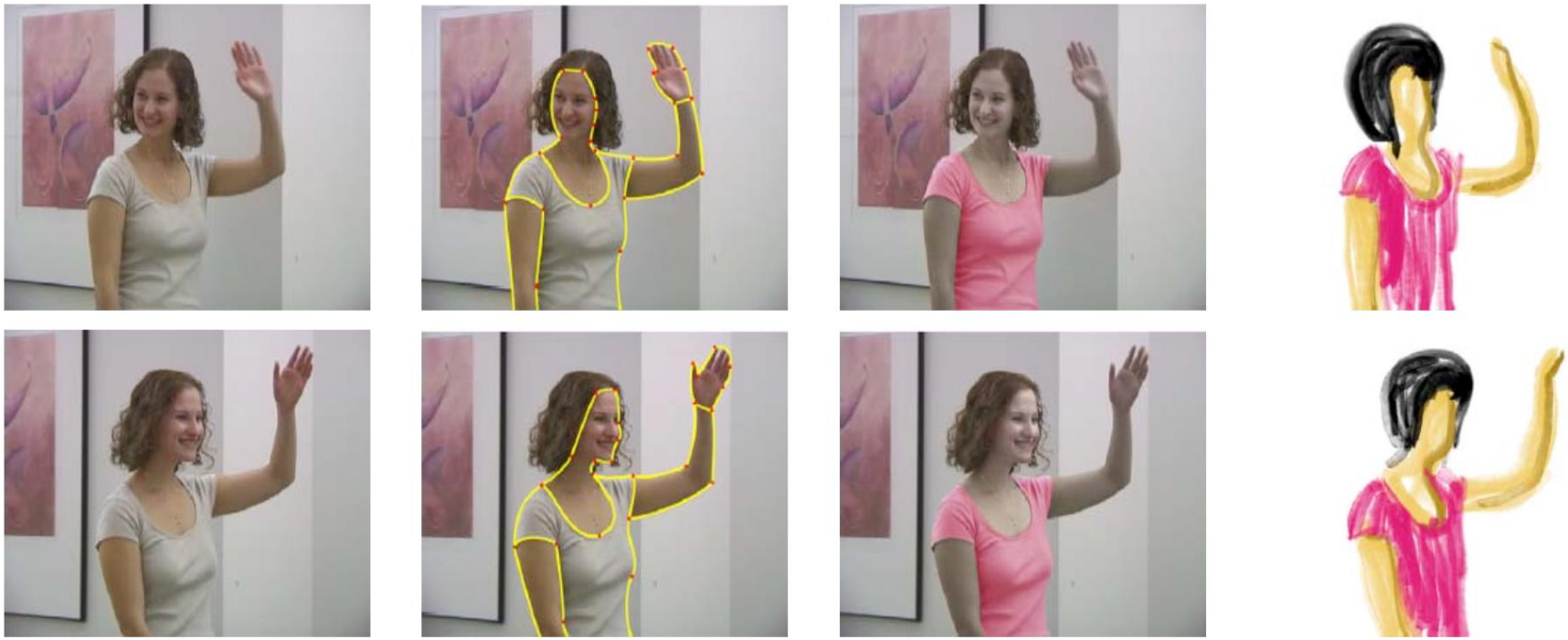
Level Sets

- Level set is one of active contour models, which is good at handling complex topologies and capturing boundary.
- The basic idea is to represent the curves or surfaces as the zero level set of a higher dimensional hyper-surface.
- The level set methods are specially used in image with intensity inhomogeneity, such as medical image, SAR image, etc.

Level Sets



Application: Contour tracking and rotoscoping



(a) (b) (c) (d)

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