CSE 591
Intro to Image Processing and Analysis

Riley Tallman
Pengfei Zhang
Shivam Bajpai
Sandipan Choudhuri

Snakes: Active Contours

Snakes - **Active** Contours

- Active contours are lines evolving over time to fit on specific image features.
- Snakes algorithm is one of the most popular active contour model first proposed in [1].
- Snakes are initialized at first with several points, known as snake nodes, on an image.
- These nodes are updated over time based different energy functions.

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- In general, snake nodes are influenced by two types of energies, know as:
  - internal energy
  - Image forces
  - External constraint forces.

- The initial snake is represented using a parametric equation:

$$v(s) = (x(s), y(s))$$

- The final contour is found by minimizing the following energy function.

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

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

- Here, E_{int}, E_{image}, and E_{con} denotes internal, external energy, and energy function related to interaction, respectively.

- The internal energy function, E_{int}, is define as:

$$E_{int} = (\alpha|v(s)'|^2 + \beta|v(s)''|^2)/2$$

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$$E_{int} = (\alpha|v(s)'|^2 + \beta|v(s)''|^2)/2$$

- *v(s)'* and *v(s)''* are first and second order derivative of the contour.
- Minimizing the first order derivative makes the contour smaller.
- Minimizing the second order derivative makes the contour circular.

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- To move the snake contour based on image intensity values, image functional is used.
- The image force E_{image} is a combination of the Edge functional E_{edge}, Line functional E_{line} and the term functional E_{term}.
- E_{edge} is utilized to find edges in the image.
- E_{line} controls whether the snake will be attracted either to light lines or dark lines.
- E_{term} finds terminations of line segments and is calculated on slightly smoothed version of the original image.

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- Aside from these forces based on image properties, there are two types of user provided constraints:
    - soft constraints and
    - hard constraints.

- Soft constraints, also known as spring forces, is applied to help the snake to converge into a different local minima.

- Hard constraint forces a snake to pass through the point where it is applied on

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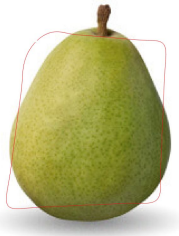
(a) $\alpha = \beta = 1$

(b) $\alpha = \beta = 1$
$W_{edge} = 1$

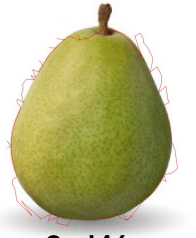
(c) $\alpha = \beta = 1$
$W_{line} = 1$

(d) $\alpha = \beta = 1$
$W_{term} = 1$



(e) $\alpha = 0, \beta = 1$

(f) $\alpha = 1, \beta = 0$



(g) $\alpha = \beta = 0$, $W_{edge} = W_{line} = W_{term} = 1$

Influence of internal and external energy functions on the closed active contour

Snakes - **Active** Contours

(a) Contour Initialization

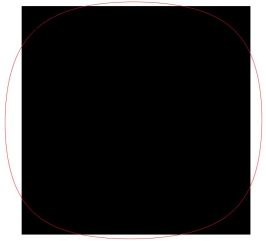
(b) Before convergence

(c) Spring force applied

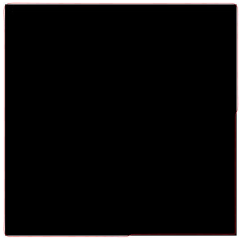
(d) Contour taking back the shape of the pear

Influence of spring force on the closed active contour

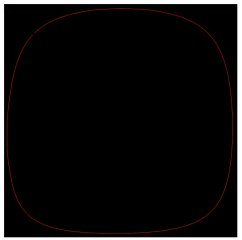
Snakes - **Active** Contours



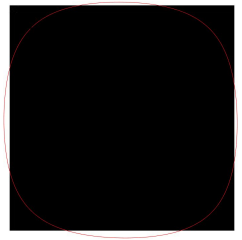
(a) α = β = 1



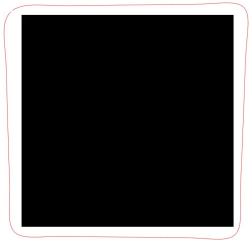
(b) α = β = 1
W_{edge} = 1



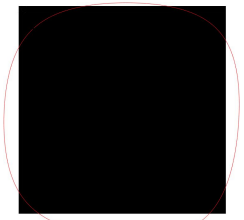
(c) α = β = 1
W_{line} = 1



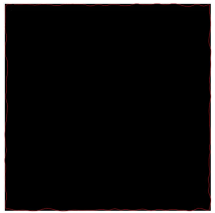
(d) α = β = 1
W_{term} = 1



(e) α = 0, β = 1



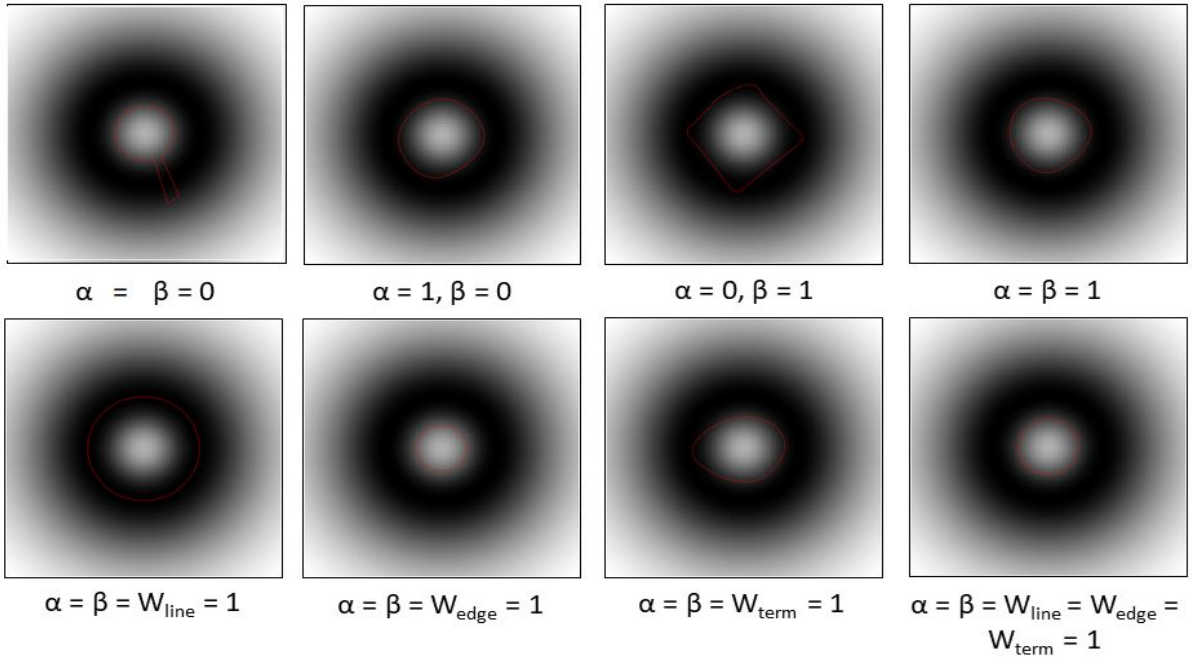
(f) α = 1, β = 0



(g) α = β = 1, W_{edge} = W_{line} = W_{term} = 1

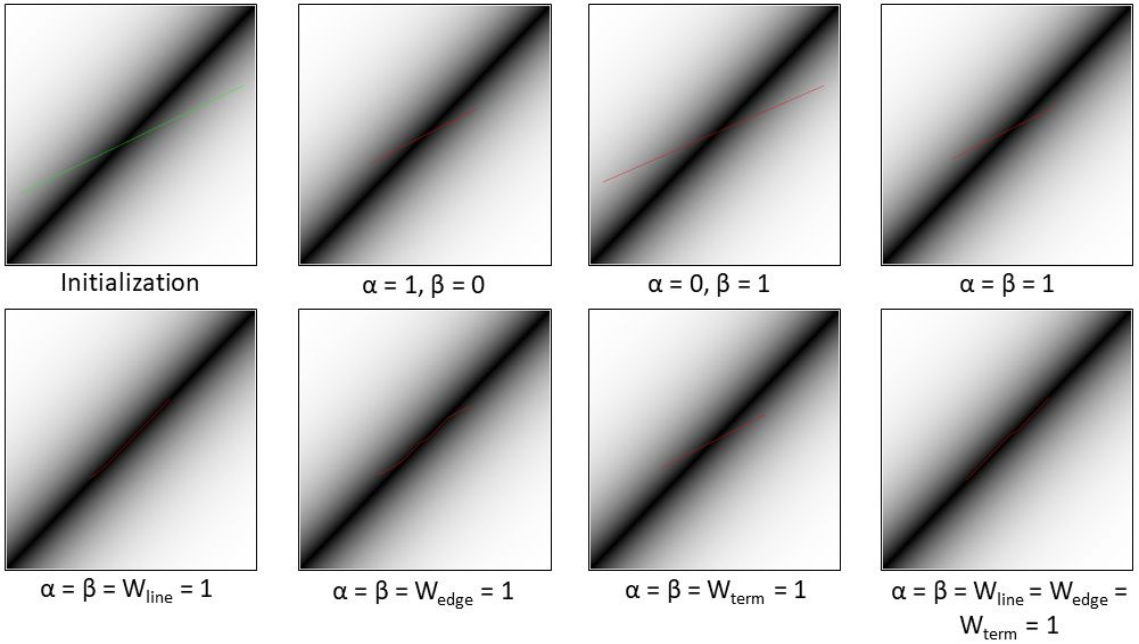
Influence of internal and external energy functions on scenarios with sharp corner for closed snakes

Snakes - **Active** Contours



Influence of internal and external energy functions on scenarios with blurry edges for closed snakes

Snakes - **Active** Contours

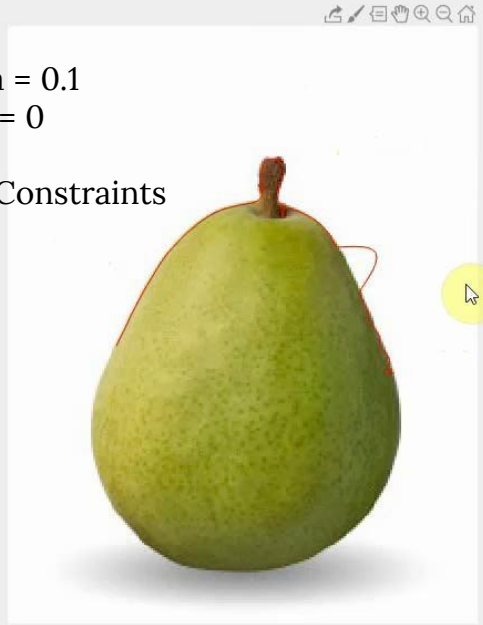


Influence of internal and external energy functions on scenarios with blurry edges for open snakes

Open Snakes and Springs

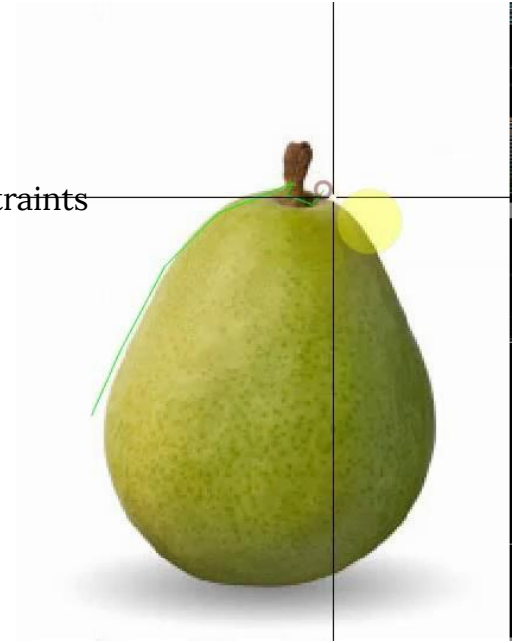
alpha = 0.1
beta = 0

Soft Constraints



alpha = 1
beta = 0

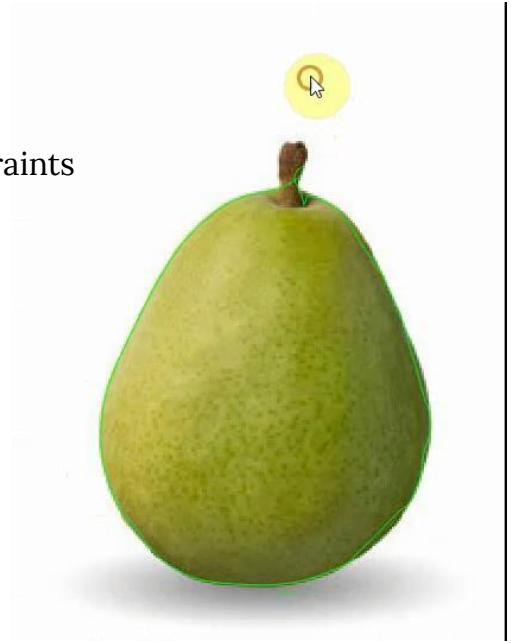
Soft Constraints



Closed Snakes and Springs

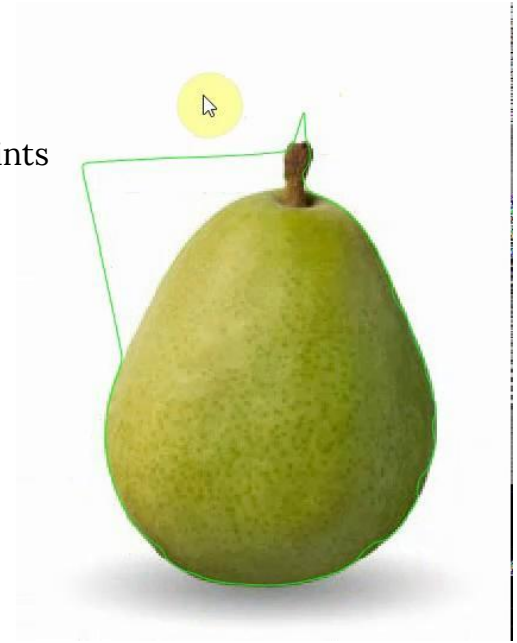
alpha = 1
beta = 1

Soft constraints



alpha = 1
beta = 1

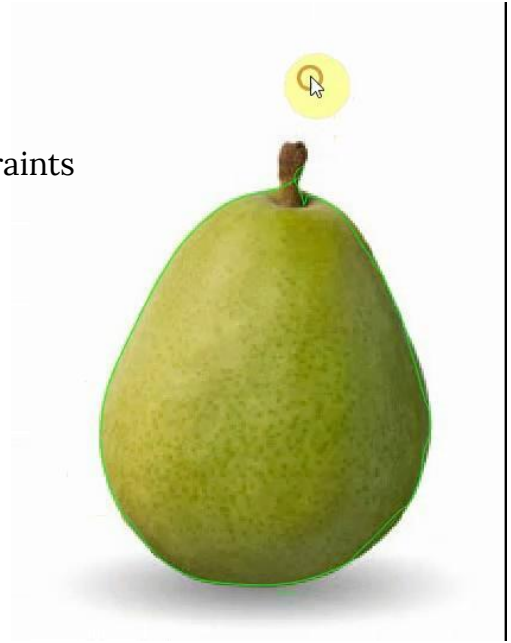
Hard constraints



Closed Snakes and Springs

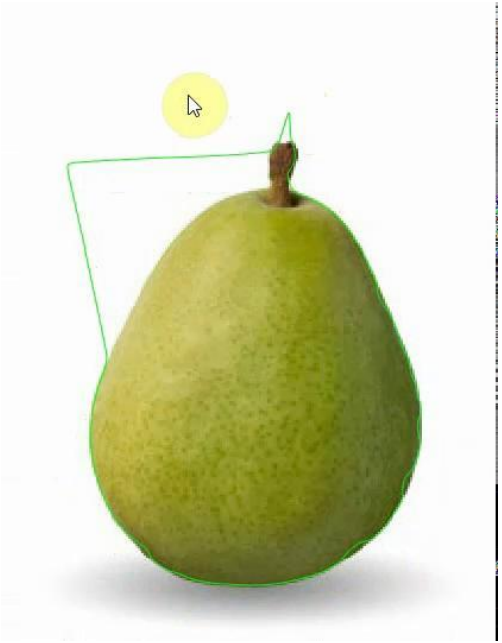
alpha = 1
beta = 1

Soft constraints



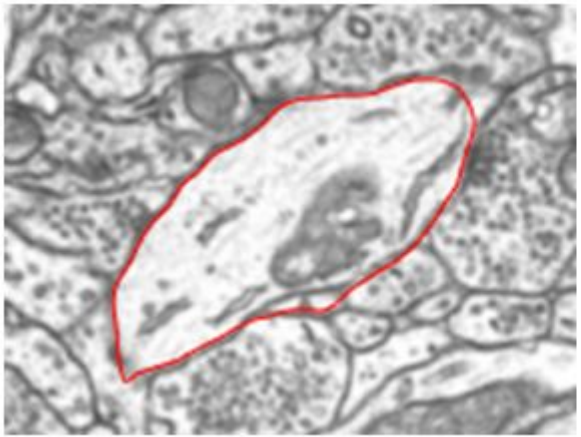
alpha = 1
beta = 1

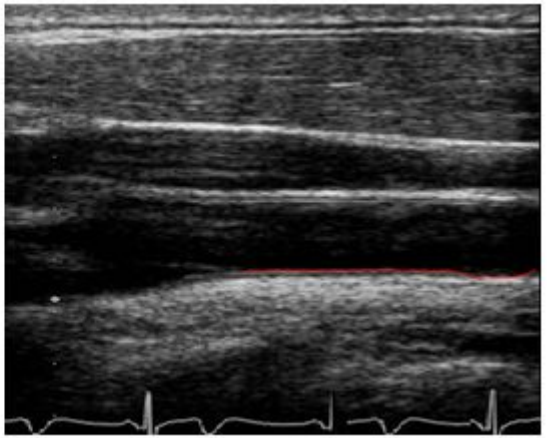
Hard constraints



Closed Snakes and Springs

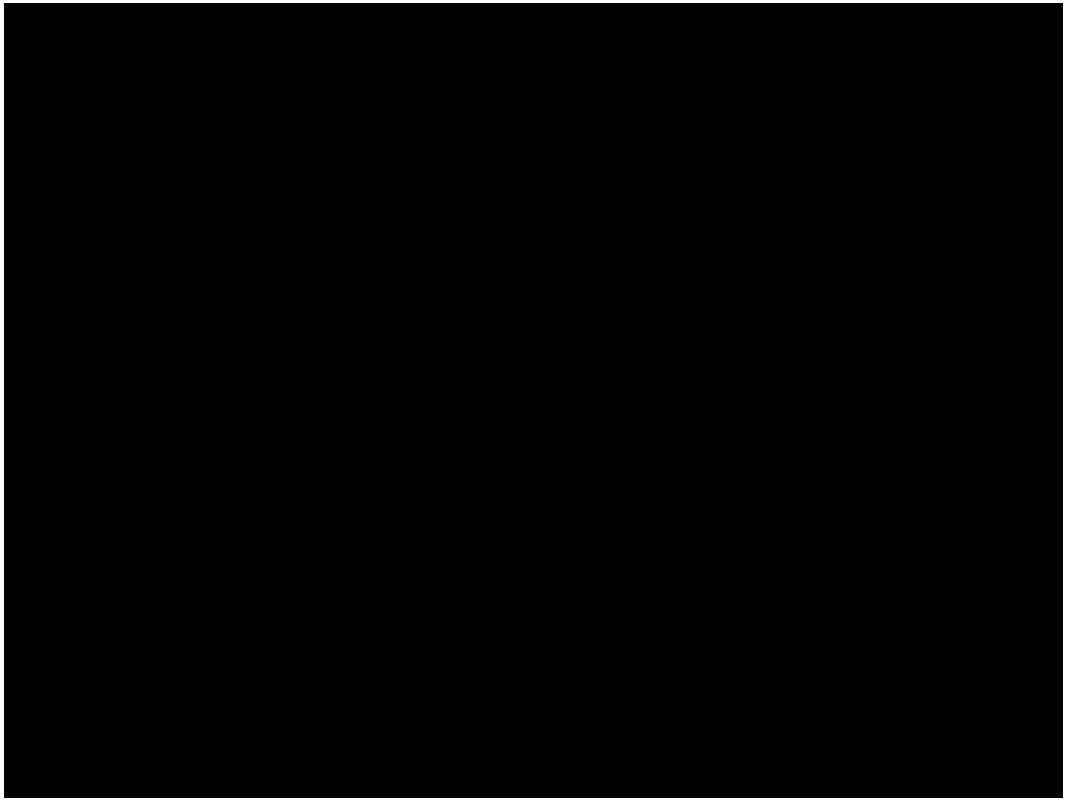
- Directional Sobel filtering on ROI image.
- Apply hough transform and then initialize the snakes on the transformed image.
- Run snake algorithm.





Snakes on real-world images (cell segmentation and Ultrasound images)

GUI Demo



References

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