SNAKE
(Active Contour Models)

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Outline

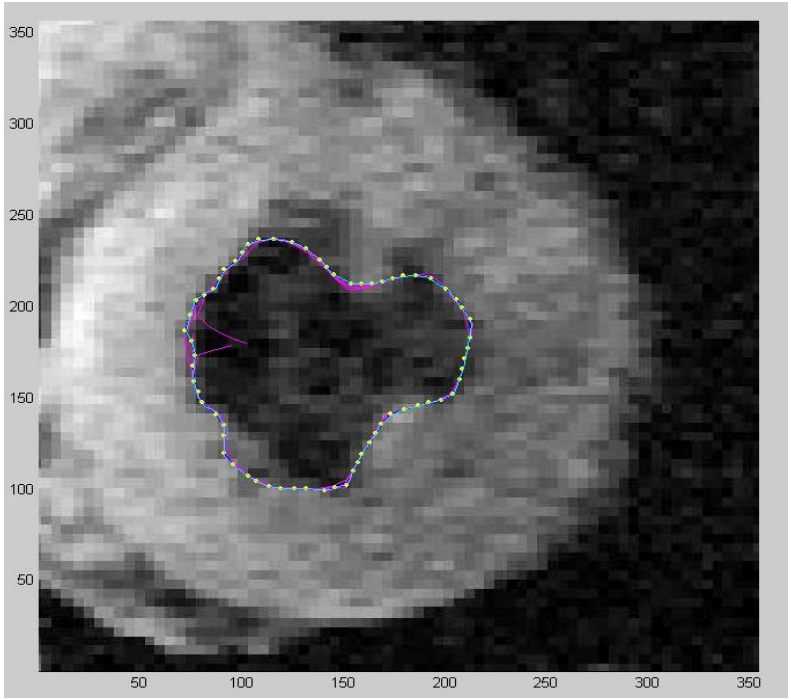
- An introduction to Contour Detection
- Framework of SNAKE
- Modeling SNAKE
- Other Examples

Contour Detection

- Classical methods fail ...

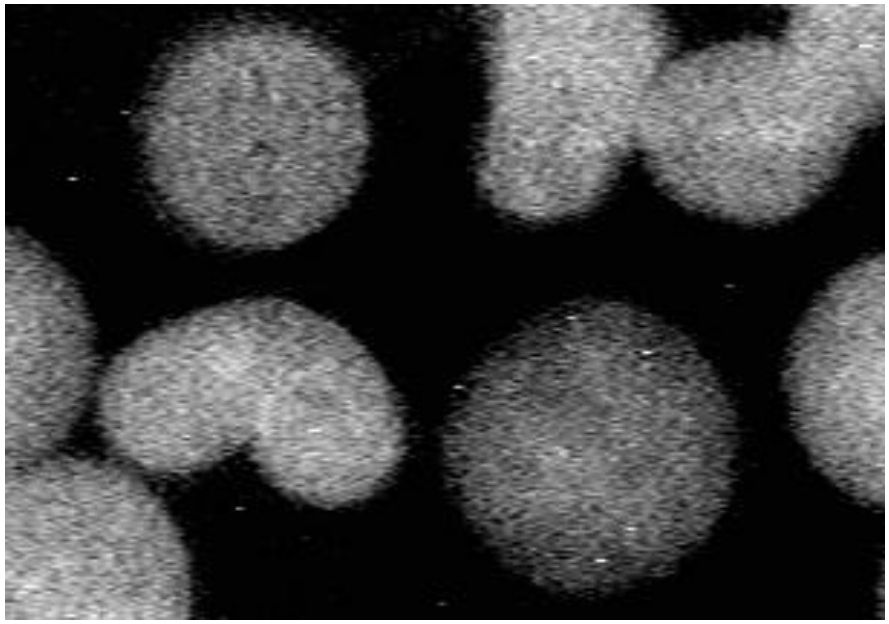
Contour Detection

- Snake (Active Contour Model)



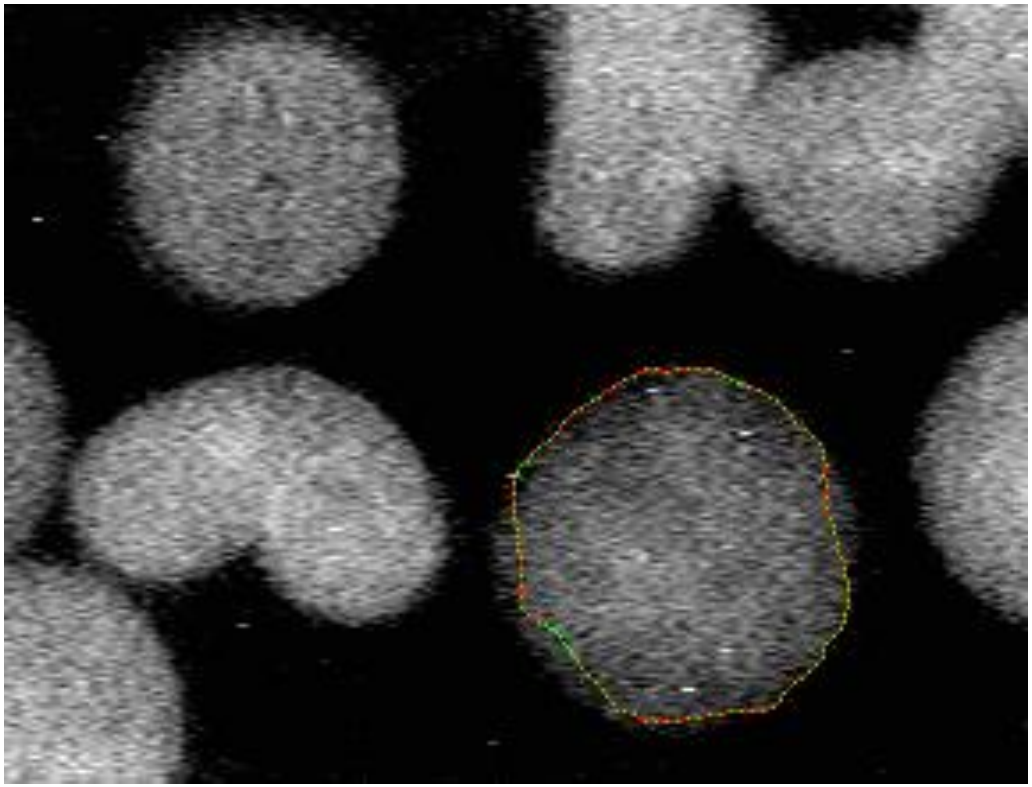
Contour Detection

- Classical Methods fail ....



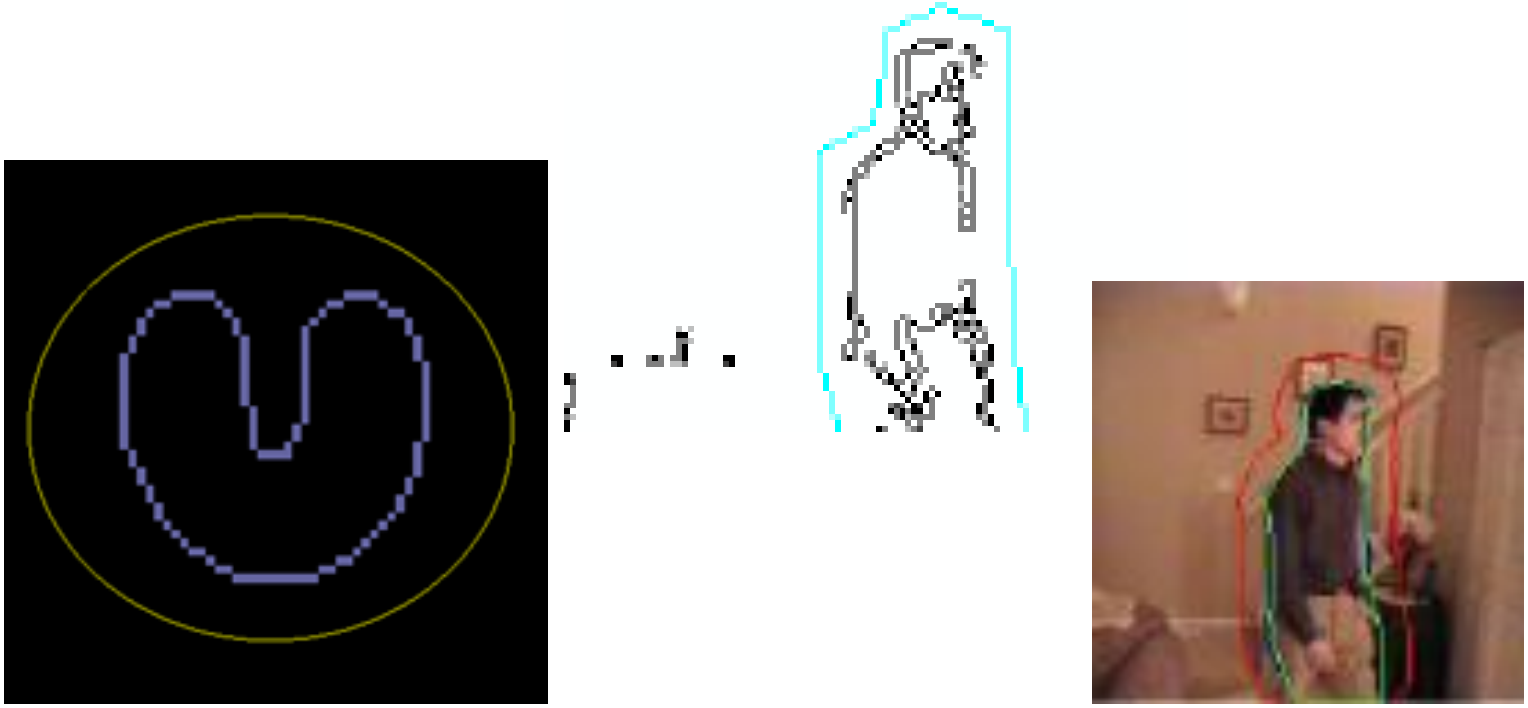
Contour Detection

- Snake (Active Contour Model)



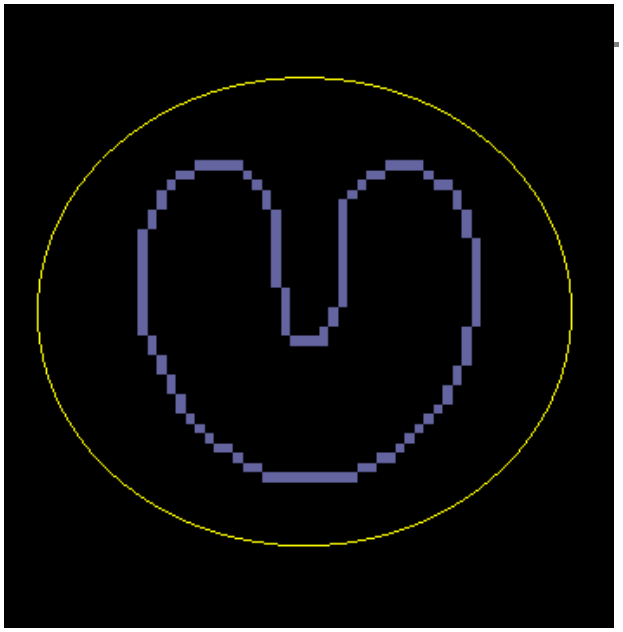
Framework of Snakes

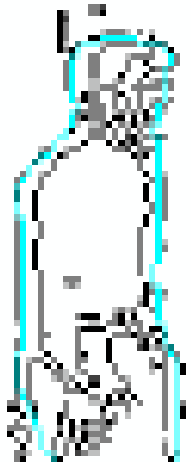
- Initial : Any curve close to the object



Framework of Snakes

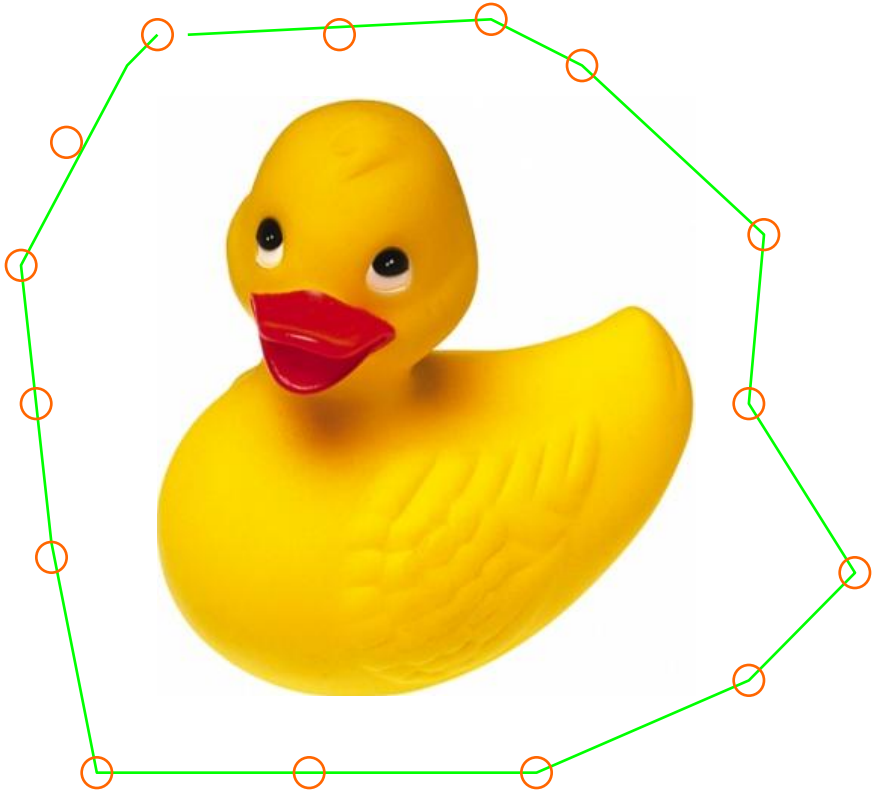
- Evolution:

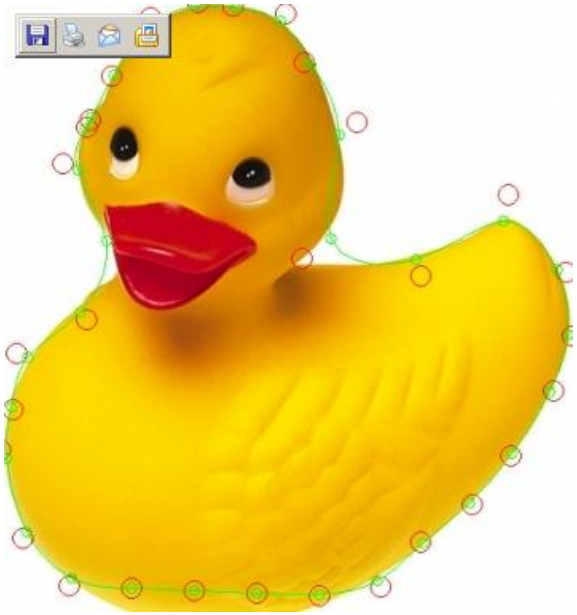




Framework of Snakes

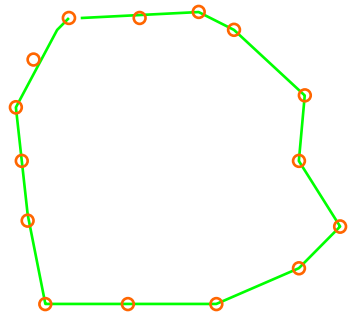
- Another Initial & Evolution:





Modeling

- Definition : Energy
  - $E_{snake} = E_{internal} + E_{external}$
- The final position of the snake will have a minimum energy.

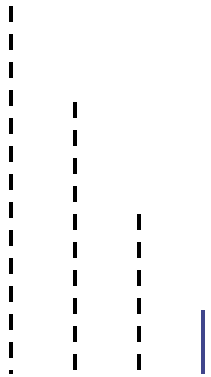


Internal Energy

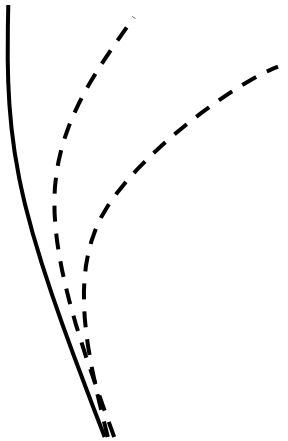
- Intrinsic properties of the Snake (Curve)

$$E_{internal} = E_{elastic} + E_{bending}$$

- Elastic

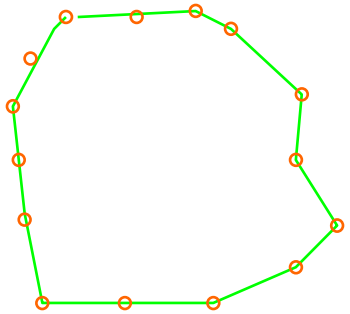


- Bending



Elastic Energy

- The Contour
  - $\mathbf{v}(s)=(x(s), y(s))$



- Elastic energy

$$E_{elastic} = \frac{1}{2}\int_{s} \alpha(s) \mid v_s \mid^2 \, ds \qquad v_s = \frac{dv(s)}{ds}$$

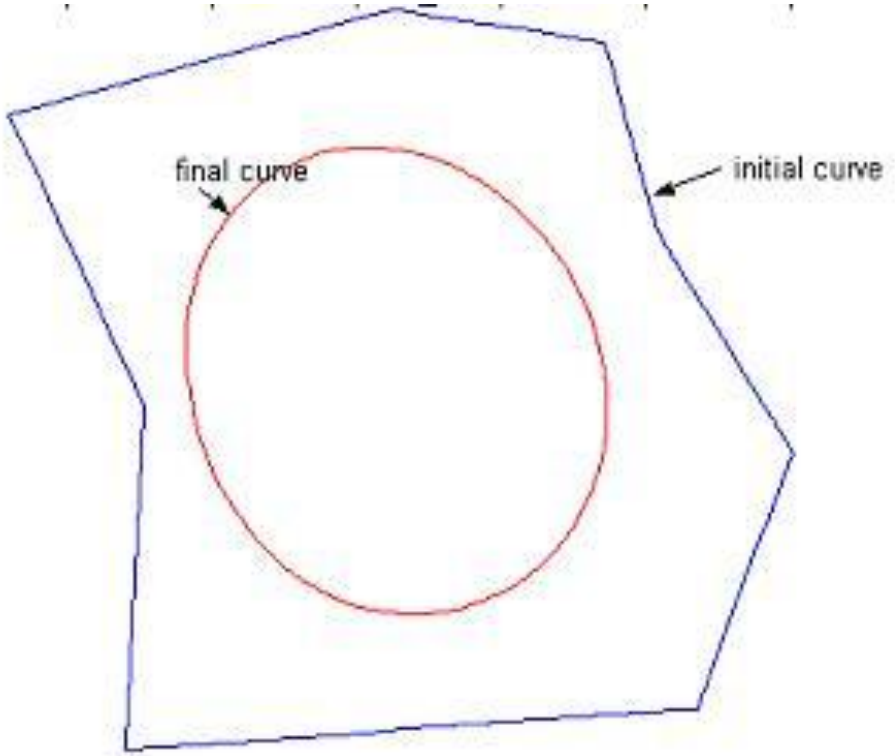
  - Discrete form

$$E_{elastic} = \sum \left\| v_{i+1} - v_i \right\|$$

  - Responsible for shrinking

Elastic Force

- Characteristics



Bending Energy

- Bending energy

$$E_{bending} = \frac{1}{2}\int_s \beta(s) \mid v_{ss} \mid^2 ds$$

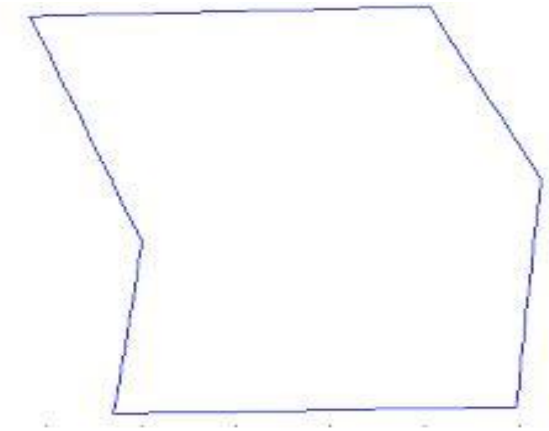
  - Discrete form

$$E_{bending} = \sum \left\| v_{i+1} - 2v_i + v_{i-1} \right\|$$

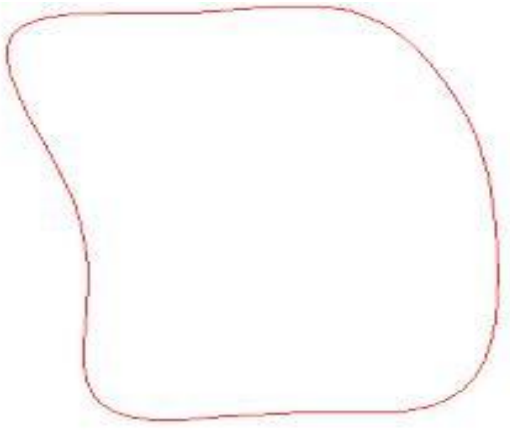
  - Responsible for a circle

Bending Force

- Characteristics: smooth out the curve



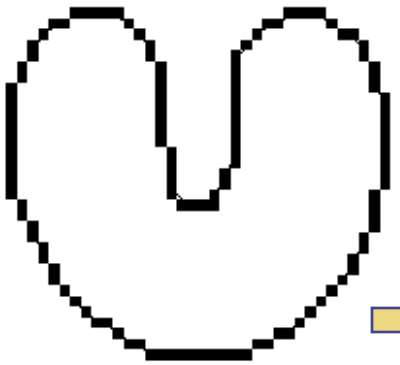
Initial curve (High bending energy)



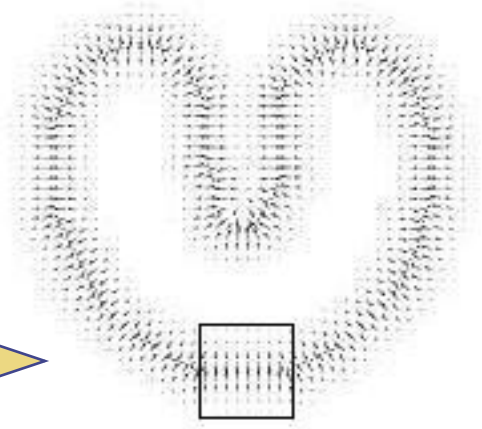
Final curve deformed by bending force. (low bending energy)

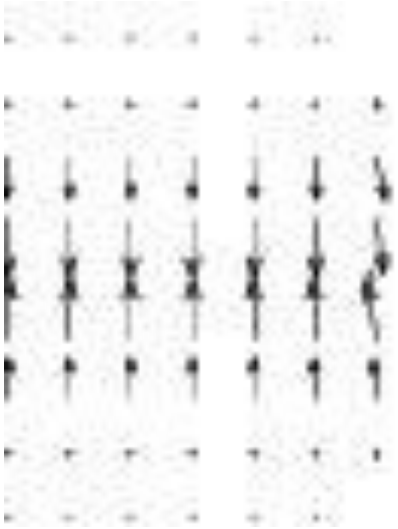
External Energy

- Derived from the Image



Blur





Image

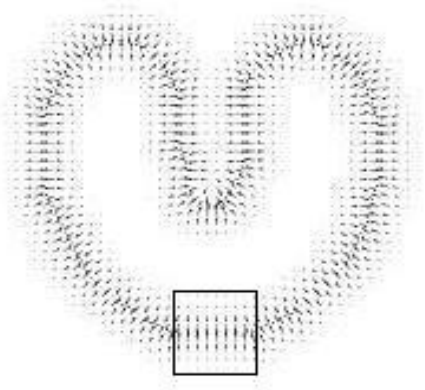
External force

Zoomed in

External Energy (cont.)

- $E_{external}$

$$E_{ext} = \int_s E_{image}(v(s))ds$$



- Example E_{image}

$$E_{image}(x,y) = -|\nabla \mathrm{I}(x,y)|^2$$

$$E_{image}(x,y) = -|\nabla(G_\sigma(x,y) * I(x,y))|^2$$

E_{snake}

- Total Energy

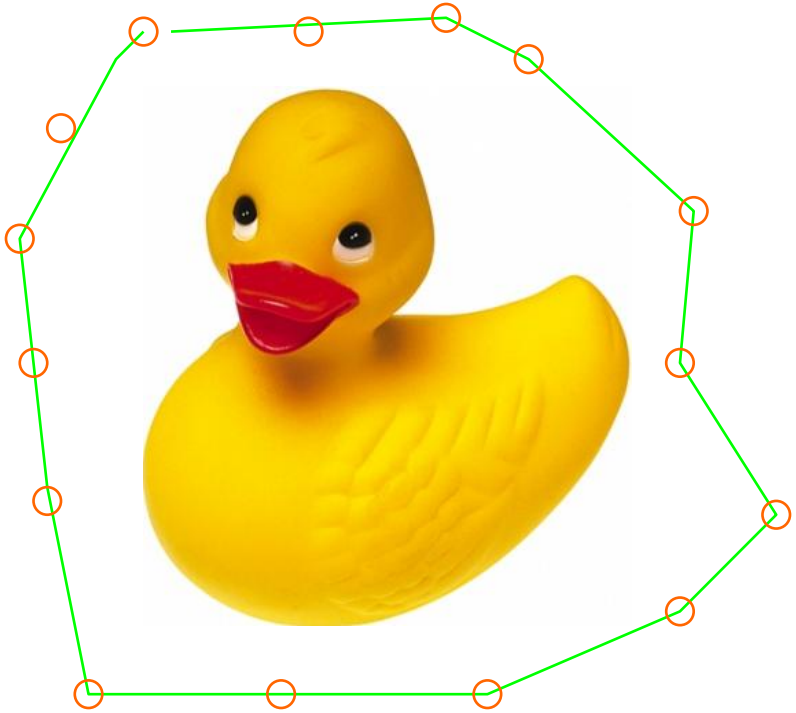
$$E_{snake} = \int_s \frac{1}{2}(\alpha(s)\,|\,v_s\,|^2 + \beta(s)\,|\,v_{ss}\,|^2) + E_{image}(v(s))\,ds$$

- Euler-Lagrange differential equation

$$\alpha v_{ss} - \beta v_{ssss} - \nabla E_{image} = 0$$

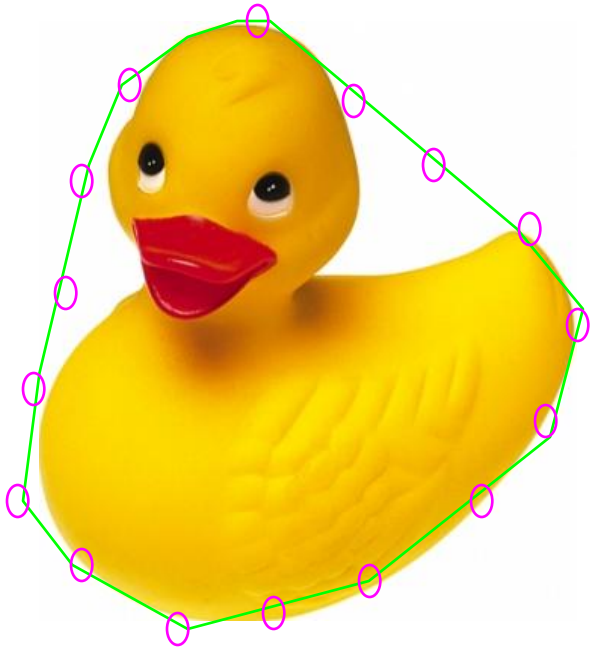
Greedy Algorithm

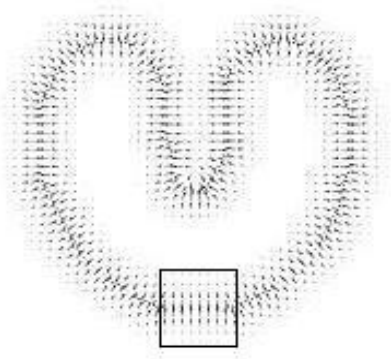
- For each contour points, search for a new position in its neighborhood

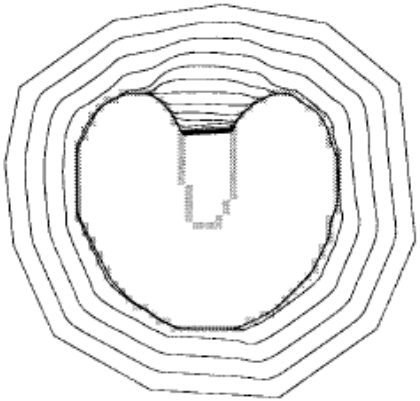


Problem

- The Snake cannot adhere to the contour of the image tightly.

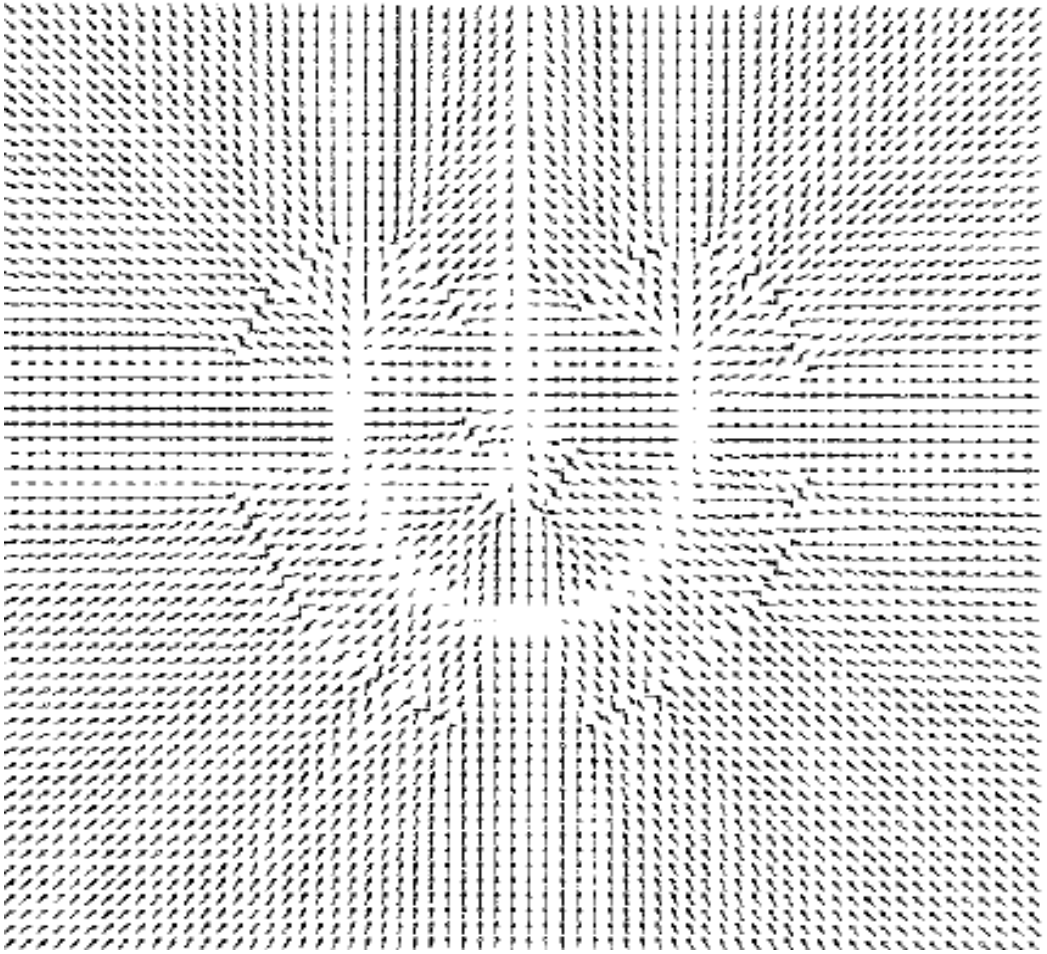




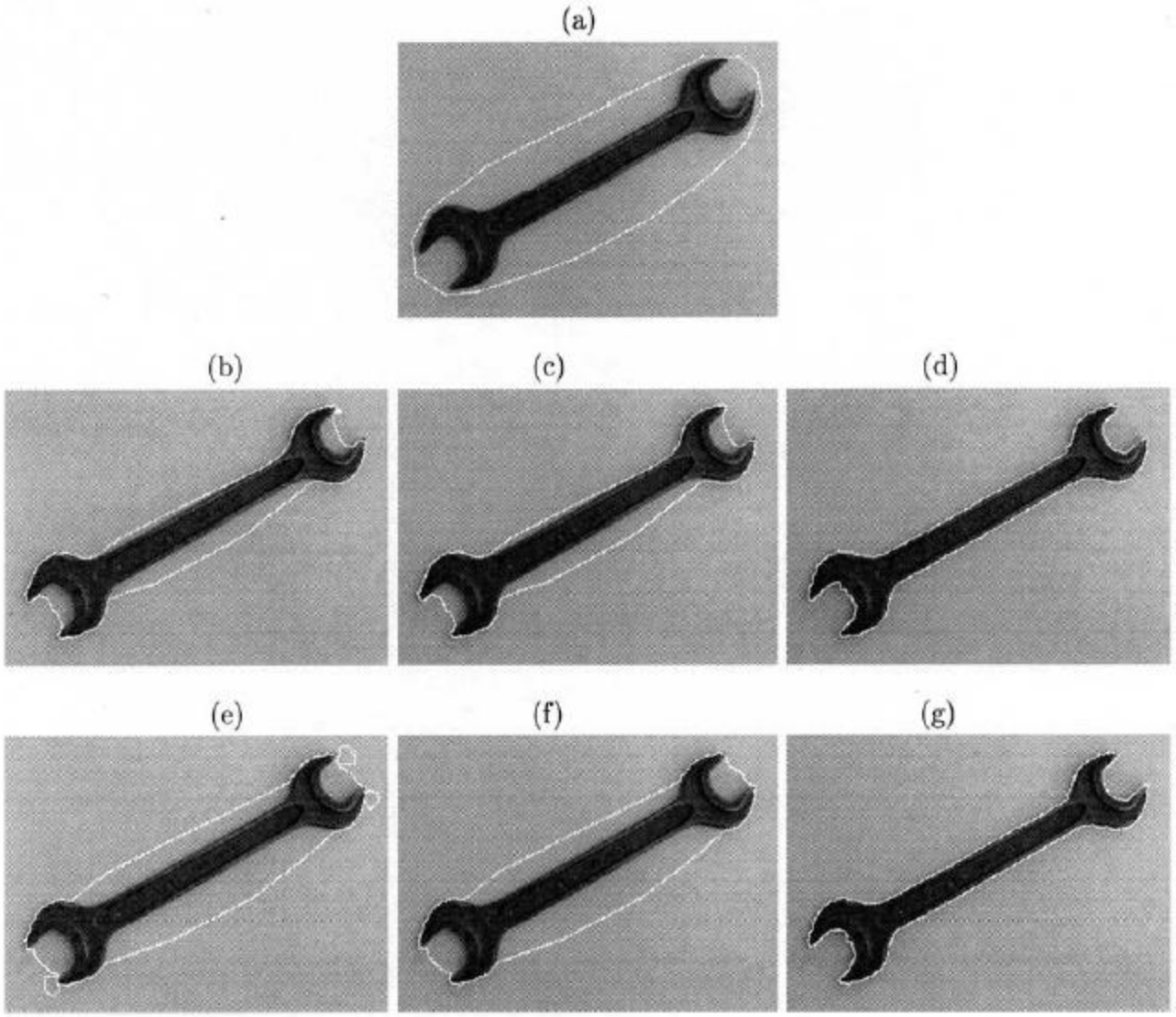


Solution

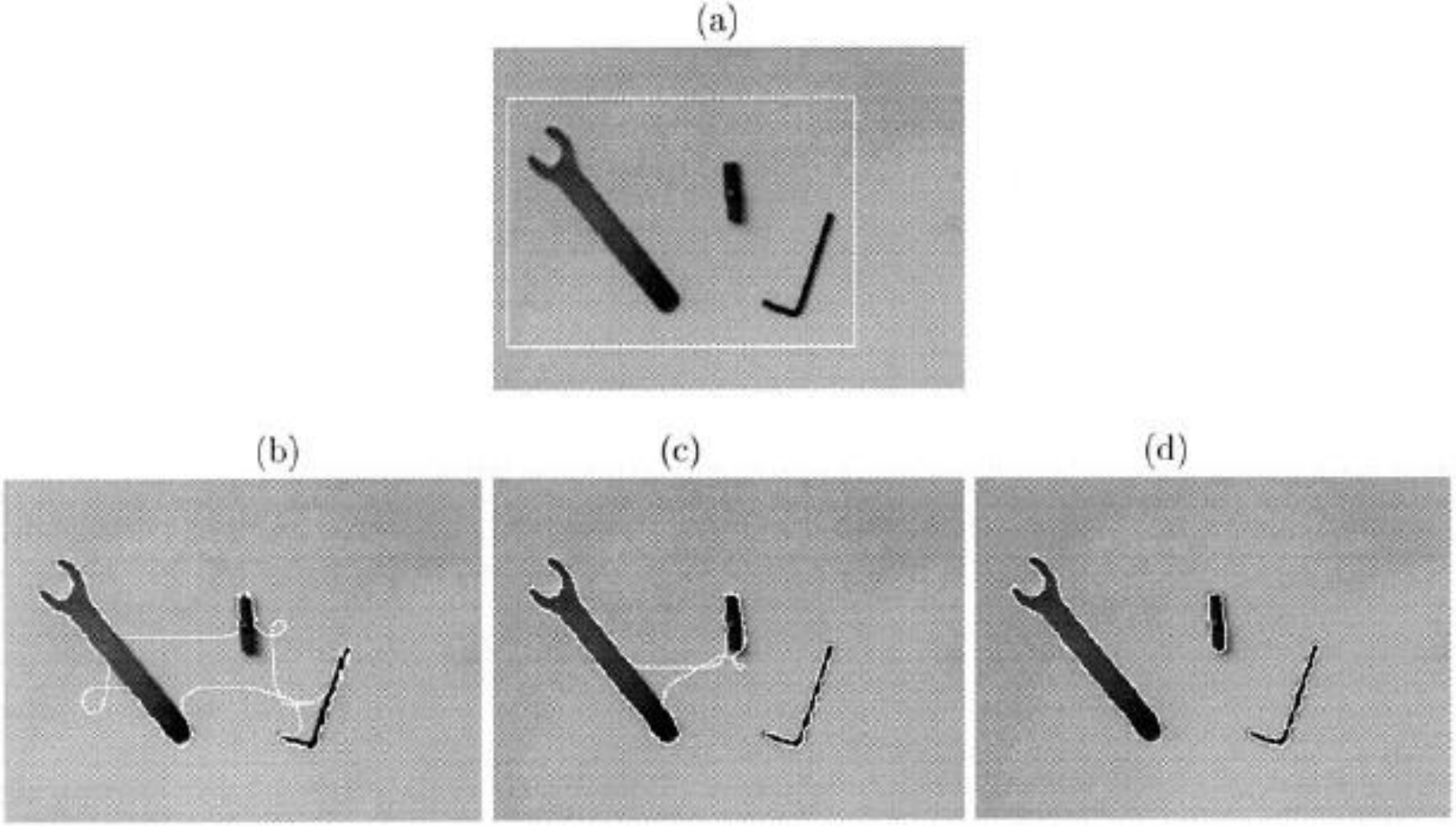
- Global forces



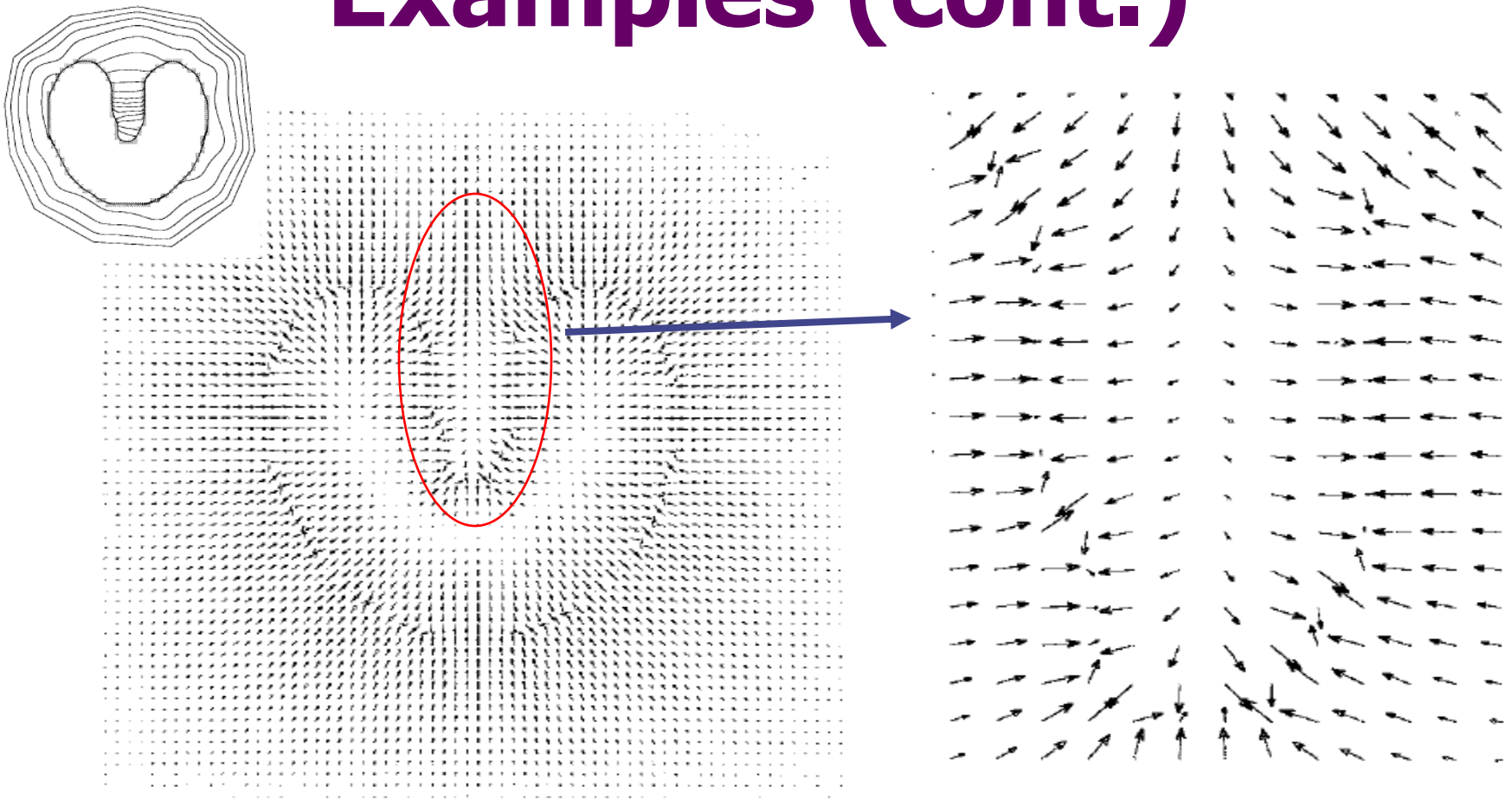
Examples



Examples (cont.)

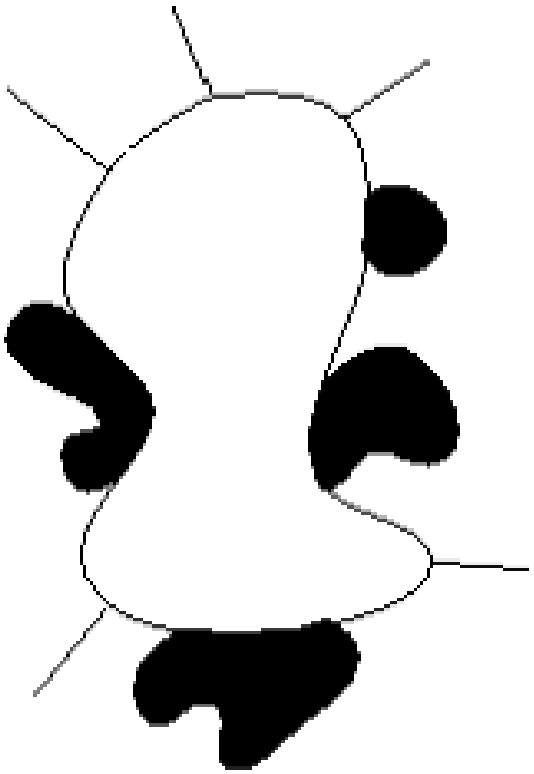


Examples (cont.)



Gradient Vector Flow : 101

Examples (cont.)

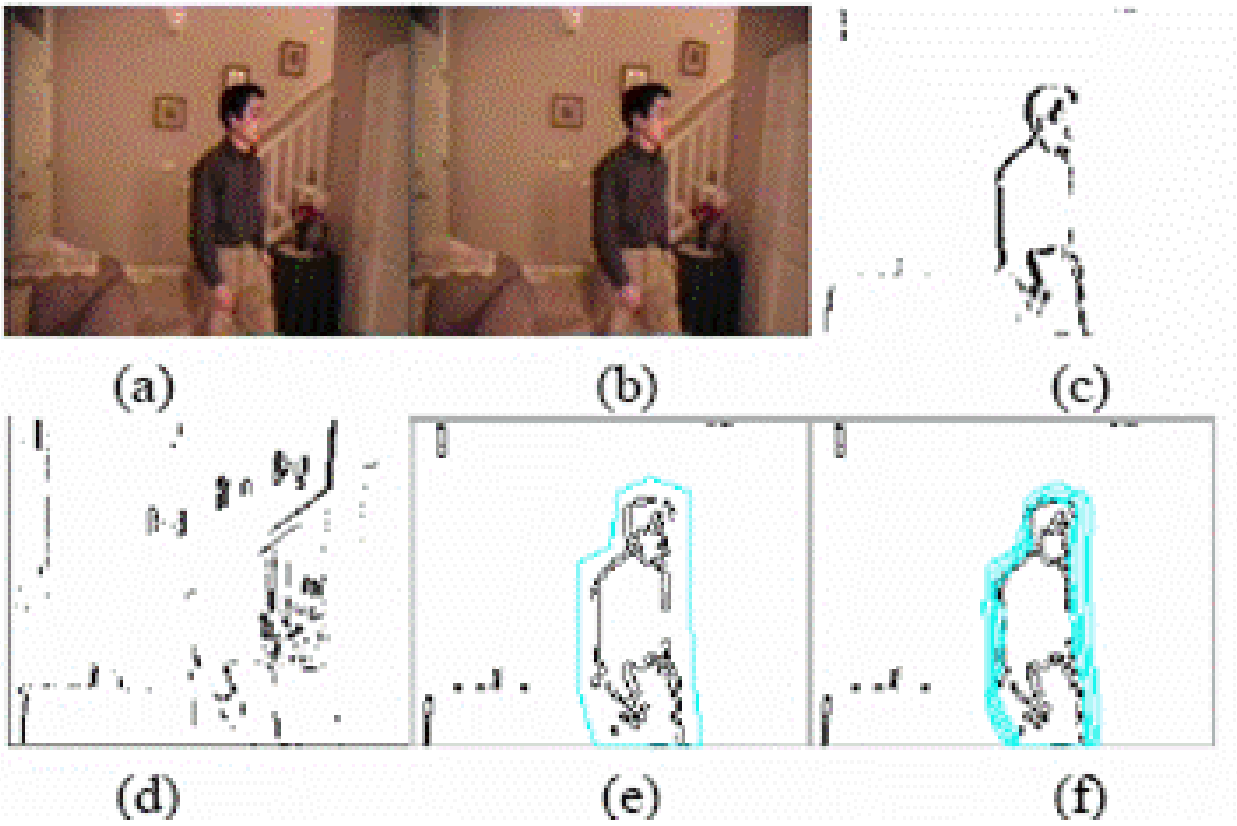


Examples (cont.)

- Object Tracking
  - using motion detecting & snake



Examples (cont.)



Thanks