**Cairo University**

**Faculty of Engineering**

**Systems & Biomedical Engineering**

**Computer Vision**

**(SBE 3230)**

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6. **Active Contour**
   1. **Introduction:**

Active Contour, commonly known as snakes, is a computer vision algorithm for outlining an object within an image. It works by evolving a curve with respect to the image's content, optimizing an energy function that reflects the contour's conformity to the object's boundaries. This report outlines the detailed steps involved in implementing Active Contour, focusing on the core algorithmic components.

* 1. **Step (1): Image Processing:**
* **Grayscale Conversion:** Convert the input image to grayscale to simplify the analysis. This is because the active contour algorithm primarily relies on intensity variations to detect edges.

**gray = cv2.cvtColor(image, cv2.COLOR\_BGR2GRAY)**

* **Smoothing:** Apply a Gaussian blur to the grayscale image to reduce noise and smooth out the edges, which helps in more accurate edge detection.

**smooth = cv2.GaussianBlur(gray, (5, 5), 0)**

* 1. **Step (2): Initial Contour:**
* **Define Initial Contour (Snake):** The initial placement of the snake is crucial for the success of the algorithm. This can be a simple circle, rectangle, or a user-defined shape positioned close to the object of interest.
* **Contour Representation:** Typically, the contour is represented as a set of points or a parametric curve in the image space.
  1. **Energy Functions Definition:**
* **Internal Energy:** Computes the snake's continuity and smoothness, discouraging sharp bends and stretching. It is a function of the first and second derivatives of the contour points.
  + **Let’s say the internal energy will take the symbol (E\_int):**
    - Comprises two terms, elasticity (Eelastic) and rigidity (Ebend).
  + **Let’s say the internal energy will take the symbol (E\_ext):**
* **External Energy:** Derived from the image data, encouraging the snake to conform to object boundaries. This often involves gradient vectors of the image intensity to attract the contour towards edges.
* **Total Energy:** The sum of internal and external energies, which the algorithm aims to minimize.
  1. **Iterative Refinement:**
* **Energy Minimization:** At each iteration, adjust the position of each contour point to minimize the total energy. This involves solving the energy minimization equation, typically using methods like gradient descent.
* **Update Rule:** Apply the update rule to each contour point, moving it in the direction that reduces the total energy. This process is repeated iteratively.

**contour points = contour points - gradient \* step size**

* **Convergence Check:** The iteration continues until a convergence criterion is met, such as a small change in the total energy or a maximum number of iterations.
  1. **Post Processing:**
* **Smoothing the Contour:** After convergence, the final contour may be smoothed to eliminate any remaining irregularities.
* **Result Analysis:** Evaluate the quality of the object delineation by comparing the final contour with the actual object boundaries in the image.
  1. **Conclusion:**

The Active Contour algorithm is a powerful tool for object delineation in images, capable of accurately capturing complex object shapes. The success of the algorithm heavily depends on the initialization of the contour and the careful tuning of the energy functions. By following the outlined steps and adjusting parameters according to specific application needs, one can implement an effective Active Contour model for various computer vision tasks.