FOOD IMAGE SEGMENTATION WITH ACTIVE CONTOURS

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ECE6310 - Introduction to Computer Vision

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TASKS

Goal: Implement an active contouring algorithm that allows user to semi-automatically segment food items in a photograph of multiple foods on a dinner plate.

Five Images:

1. Bacon-Eggs-Toast
2. Eggs-Pancakes-Milk
3. Hushpuppies-Biscuits
4. Fish-Lemon-Rice-Greens
5. Macaroni-Kale

Functions:

1. Load a color PNM image, but display greyscale image (average of the three color bands)
2. Options:
    a. *Left-click* – Draw around a food item that subsequently automatically shrinks to wrap to the food boundary.
    b. *Right-click* – Within a food item that grows a contour to its outer boundary.
    c. *Shift-click* (either button) – Manually drag a contour point to a new location.

Introduction

Segmentation is the process of identifying individual objects and creating a boundary around them. Active contouring is one of many segmentation methods. It uses internal and external energies to segment objects with a expanding (balloon) or shrinking (rubber band) force. In this project, a user is able to use a GUI to segment foods in food images in either mode.

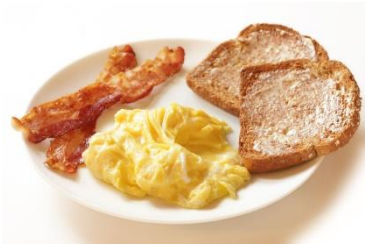
Input Images

The images are listed below with their respective dimensions.

#	IMAGE	Rows	Cols
1	Bacon-eggs-toast	565	849
2	Eggs-Pancakes-Milk	1140	1600
3	Hushpuppies-Biscuits	1000	1500
4	Fish-Lemon-Rice-Greens	600	720
5	Macaroni-Kale	360	480

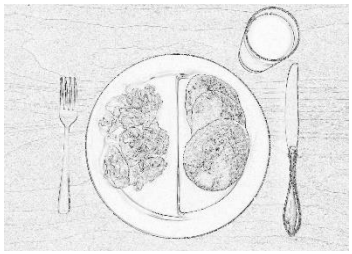
Below are original images, and their corresponding greyscale and sobel images.

Bacon-eggs-toast *Greyscale* *Sobel (inverted)*



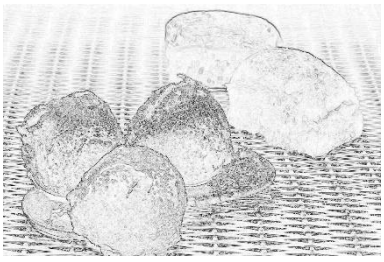
Eggs-pancakes-milk





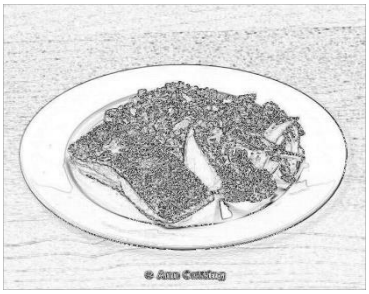
Hushpuppies-Biscuits





Fish-lemon-rice-greens





Macaroni-Kale



Discussion of Contouring Algorithms

There are two algorithms implemented in this project- **rubber band** and **balloon**. While the rubber band contour model uses shrinking forces to hug the edges of an object, the balloon model expands to find the same edges. Both models use three energies- distance energy, deviation energy and external (sobel) energy. The distance energy is used to bring together or drive away points, and the deviation energy is used to keep the points evenly spaced out. The external energy is used to find edges by driving the points to the minimum values in the sobel image.

The following table summarizes the optimal values for various parameters used in both models:

Parameter	**Rubber-band**	**Balloon**
Window size	7x7	11x11
Deviation energy	Weight = 1	Weight = 0.5
Distance energy	Weight = 1	Weight = 1.3
External energy	Weight = 1.4	Weight = 0.4
Iterations	100	100

After calculating the centroid of the pixels from the drawing, both models calculate the distance energy. The only and major difference between the two algorithms is how the distance energy is calculated. While the rubber-band model calculates this energy by subtracting the minimum distance from the centroid distance of the current value, the balloon model calculates the same but subtracts the maximum distance instead. By doing so, the former energy is pushing points towards each other while the latter is pushing them away from each other.

Weights were decided through trial and error. Larger window sizes worked better for the balloon model and smaller window sizes worked better for rubber-band models.

Model Analysis – Obstacles and Rectifications

Initially, the distance energy was calculated using two adjacent points in the array of points from the user's drawing. This did not work well and shifted the points in random directions. The aforementioned centroid calculation replaced the distance energy and proved to be much more successful.

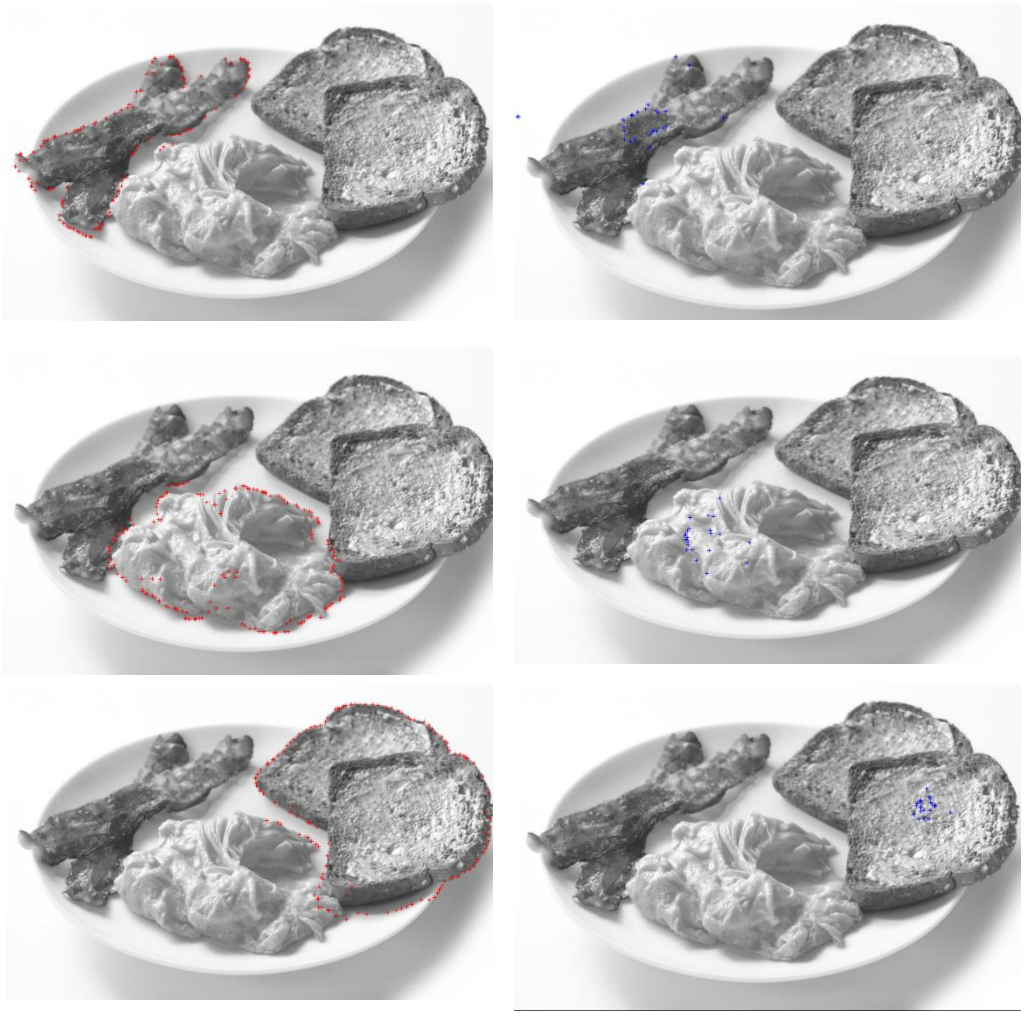
Although both models had difficulty segmenting foods with heavy texture, the rubber-band model performed better. Foods with texture produced false edges in the sobel image, preventing the balloon model to expand the points beyond those false edges.

Both models performed very well in images where there was a great contrast in pixel intensity at the edges. For instance, the milk in eggs-pancakes-milk image was perfectly segmented by both models.

This is clearly illustrated by the following output images.

Bacon-eggs-toast

Rubber-band Balloon



Eggs-Pancakes-Milk

Rubber-band

Balloon

Fish-Lemon-Rice-Greens

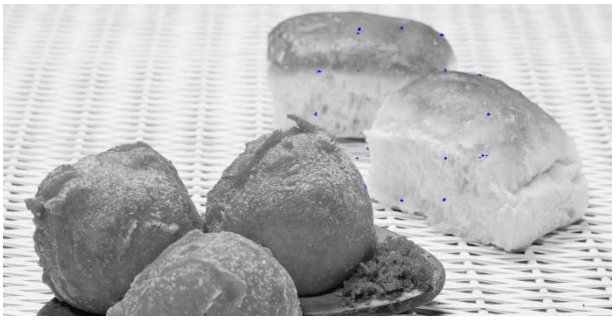
Rubber-band

Balloon

Hushpuppies-Biscuits

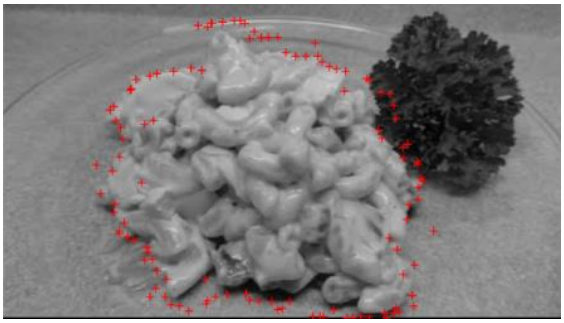
Rubber-band

Balloon

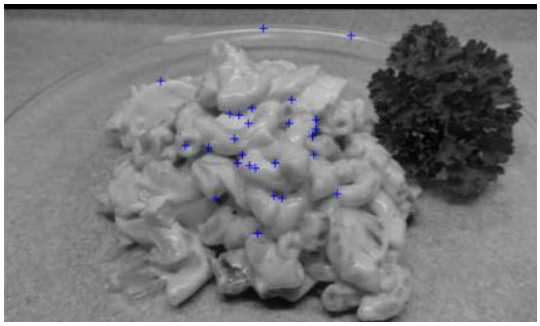


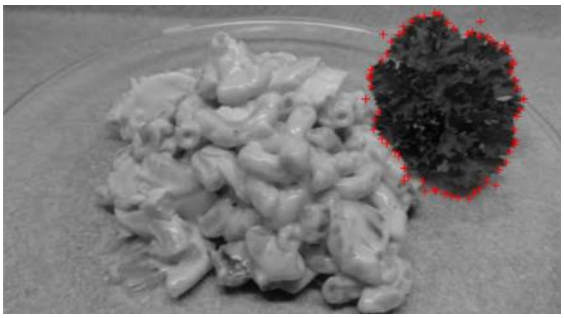
Macaroni-Kale

Rubber-band



Balloon





Conclusion

Some foods in the input images were perfectly segmented, indicating that the algorithm works well. However, the foods that were not segmented well indicate that there is much room for improvement. In future learning efforts, texture analysis could perform better in segmenting foods like kale from macaroni and kale image, and eggs from eggs-pancakes-milk image. Overall, in this study, the rubber-band model performed better than the balloon model.