Improved Canny Edge Detection Algorithm

BTP Phase I | Arpan Indora | Supervisor: Prof. Pradip K. Das

Introduction

- Edge detection is usually the first step in recovering information from an image.
- Its main purpose is to reduce image size and filter out features which may be regarded as irrelevant, while preserving image's structural properties for further processing.

Among the existing edge detection methods, John F. Canny's edge detection algorithm is the most widely used and optimized approach to problem. His approach was to develop an algorithm whose performance relies on following criteria:

1. Good Detection
2. Good Localization
3. Minimal Response

Canny edge detection

1. Apply Gaussian filter to smooth out the image, removing noise and other unwanted features.
2. Find the gradient of the image using 2x2 vertical and horizontal gradient operators, and then obtain gradient magnitude M and direction θ.
3. To obtain a single response for each edge, apply Non Maximum Suppression. Mark a point only if the gradient magnitude $M(x, y)$ of that point is greater than the neighbours in the gradient direction $\theta(x, y)$.
4. Using Double Threshold T_h and T_l, where $T_h > T_l$, reject the points whose gradient value is less than T_l, and if the gradient magnitude is greater than T_h mark those points as strong edges and output them. For points with gradient value between T_h and T_l, mark them as weak edges.
5. Perform Edge tracking using Hystersis. Add weaker edges to the output, if they are connected to the strong edges, directly or indirectly.

Otsu's Segmentation

- It divides the greyscale values in image into two classes, background and foreground, by separating them at a threshold.
- Threshold is such that it keeps the two resulting clusters tightly packed while maximizing the separation between them.
- This objective corresponds to maximizing between class variance of 2 clusters in image.

$$\sigma_b^2 = p_A(t)[\mu - \mu_A]^2 + p_B(t)[\mu - \mu_B]^2$$

where μ_A, μ_B are mean of the two classes, and p_A, p_B are the probabilities that the two classes are divided by threshold t and μ is the global mean.

Issues

There are few aspects of the algorithm which can be improved and made more adaptive to different images with varying properties like noise and edge information.

1. The Gaussian filter applied to remove noise in the image, also smooths out the real edges, which increases the probability of missing out a real weak edge.
2. Double threshold T_h and T_l are found by trail method, as there is no standard method to choose these values because of the varying properties of different images. In this project we provided a method to estimate these thresholds.

Future Works

- In images which edges are dense in some regions whereas sparse in others.Then the performance of canny edge detection algorithm will go down.
- Selecting a fixed threshold will result in loss of edge information in some regions, solution for this problem still needs to be found.
- Proper evaluation of the proposed method on a dataset still needs to be done.

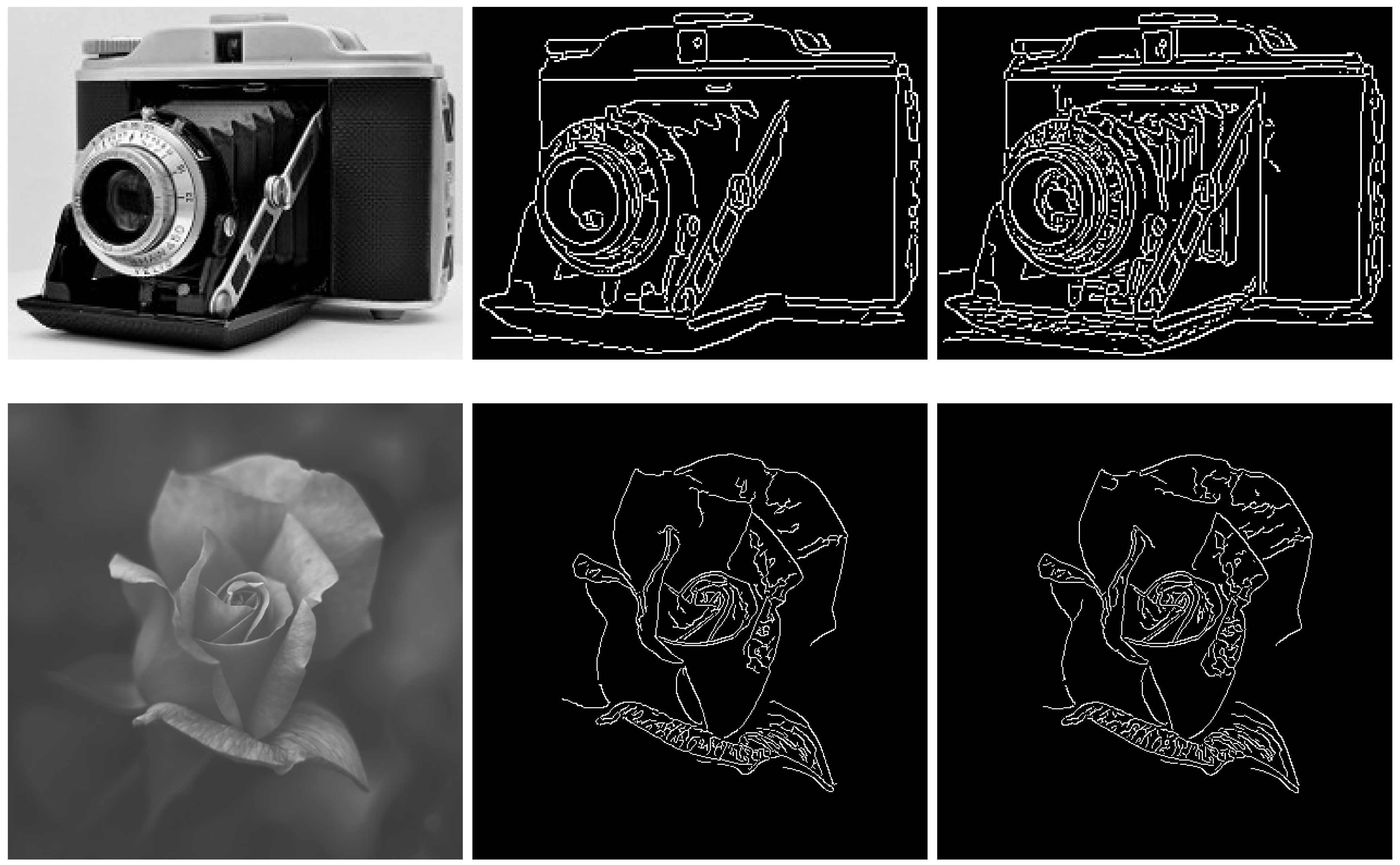
Improvements

Issue 1: To apply the image filtering without loosing any edge information, we need to reduce its effect on weak edges present in the image. So, we used an adaptive filter that will evaluate the discontinuity in pixel intensity at each point. Higher the discontinuity, lower will be the smoothing at that point and vice versa.

Issue 2: Using Ostu's segmentation method we find a threshold using gradient magnitude histogram of the image that separates the low and high gradients, then use this threshold to find the low and high threshold for the step of double thresholding.

- Find the threshold t that minimizes intraclass variance or maximizes interclass variance of gradient value classes formed by threshold t. Then two clusters formed by threshold t are, A and B, where A has edge points that have higher gradient values and B has non edge points with lower gradient values.
- We can assume that the non edge pixels lie in the range $\mu_B \pm \sigma_B$. So the high threshold T_h must not lie in this range, because if T_h lies in that range then non edge points will result as false edges. This implies that T_h should be greater than $\mu_B + \sigma_B$.
- Cluster B can be further divided for low threshold T_l into weak edge and non edge points by again using Otsu's Segmentation. The other choice is to simply choose $T_l = \mu_B$.

Conclusion and Results



Original Image | Previous Method | Presented Method

Performance of the presented method is better than previous method in cases when the edge information present in the image is high or moderate as can be seen in Camera Image. Whereas when presence of edge information in the image is on lower side like in the flower image, both the methods exhibit similar performance.