ECPE 293 Canny Edge Detection

Vivek Maheshwari

Abstract— This script implements the Canny Edge Detector algorithm to identify edges in an image. It calculates horizontal and vertical gradients to determine magnitude and orientation, followed by non-maximal suppression. Finally, hysteresis and edge linking are performed to produce the final edge output.

I. Classification Algorithm

A. Handling Input

The process begins with a user selecting an image from their local device. The image used during development, Fig 1., is saved as the “Input Image”.

B. Convolution

The convolution operation begins by flipping the kernel \(f \) and centering it on each pixel of the input image to compute the sum of products (SOP) for the output image, calculating the horizontal and vertical intensity gradients. For the horizontal component, the image is convolved with a vertical 1-D Gaussian to create a 'temporary_horizontal' image, which is then convolved with the horizontal Gaussian derivative. The vertical component is obtained similarly by convolving with a horizontal 1-D Gaussian and then the vertical derivative. The functions Gaussian() and Gaussian_Deriv() generate the necessary kernels. The final images are shown in Fig. 1 and Fig. 2.

C. Magnitude and Direction

To compute the angle of the gradient using the 'Horizontal' and 'Vertical' components in image processing, first calculate the horizontal and vertical changes, referred to as \(H \) and \(V \). The gradient's magnitude is obtained by taking the square root of the sum of the squares of these components. For each pixel, the orientation is derived using the arctangent of the vertical change over the horizontal change, with the atan2 function ensuring the angle is correctly oriented. This results in an angle image that indicates edge directions, providing valuable insights for edge detection and analysis. The magnitude can be seen in Fig. 3.

D. Non-Maximal Suppression

Non-maximal suppression is a technique used in edge detection to refine edges by retaining only the strongest responses. After computing the gradient magnitude and orientation for each pixel, the algorithm examines neighboring pixels along the edge direction. If a pixel's magnitude is not greater than its two neighbors, it is suppressed (set to zero). This process thins the edges, resulting in a clearer representation of edges in the image. The refined edge map aids in subsequent steps like hysteresis thresholding, improving edge linking and boundary accuracy. Suppression can be seen in Fig. 4.

E. Edge-Linking with Hysteresis

Edge-linking with hysteresis is the final step in the edge detection process, applied to the non-maximal suppression output to produce the final edges. This technique involves using two threshold values: a high threshold and a low threshold. Initially, pixels with gradient magnitudes above the high threshold are considered strong edges and are retained. Next, the algorithm examines neighboring pixels of these strong edges. Any pixels with magnitudes above the low threshold that are connected to the strong edges are also included as part of the edge. This approach effectively links edges that might be broken or thin, ensuring continuity and robustness in the edge map. As a result, the final output highlights significant edges while suppressing noise, providing a clean representation of the object's boundaries in the image. Look at Fig. 5 and Fig. 6.

F. Chamfer Distance

To calculate Chamfer distance on an edge image, use a binary image with edge pixels as 1 and non-edge pixels as 0. Initialize a distance map with high values for non-edge pixels and 0 for edges. Compute the Manhattan distance from each non-edge pixel to the nearest edge. For a reference shape, sum the distances to obtain the total Chamfer distance, indicating how far each pixel is from the nearest edge and aiding in shape matching. Look at Fig. 7

II. Results

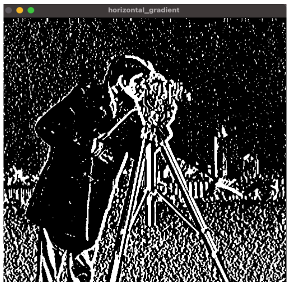

Fig 1. Horizontal Gradient (Cameraman)

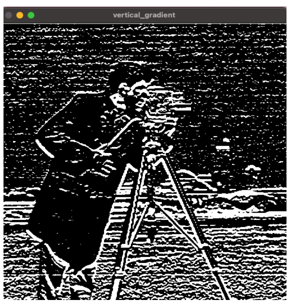

Fig 2. Vertical Gradient (Cameraman)

Fig 3. Magnitude (Camerman)

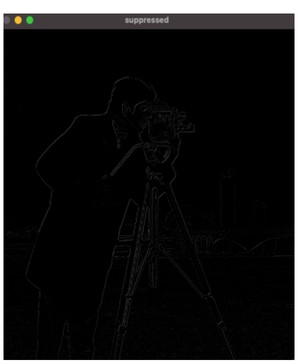

Fig 4. Suppressed (cameraman)

Fig 5. Hysteresis (cameraman)

Fig 6. Final Edges(cameraman)

Fig 7. Chamfer (Cameraman)