Canny Edge Detection: An Implementation and Analysis

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1 Introduction

The Canny edge detection algorithm is a multi-step process used to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed. This document provides a comprehensive explanation of our Canny edge detection implementation and presents the effects of varying the Gaussian filter's standard deviation, σ.

2 Implementation Details

2.1 Gaussian Function

Our implementation begins with the generation of a Gaussian filter:

$$G(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}$$

This function returns the Gaussian distribution values, which are essential for blurring the image to reduce noise and unwanted details.

2.2 Gaussian Derivative

To detect the intensity gradients of the image, we compute the first derivative of the Gaussian:

$$G'(x) = -\frac{x}{\sigma^3\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}$$

This function aids in highlighting areas with rapid intensity changes, which typically indicate edges.

2.3 Non-Maximum Suppression

To ensure that the edges are thin, we implement non-maximum suppression. This process involves thinning the edges by preserving only the local maxima in the gradient magnitude of the image.

2.4 Double Thresholding

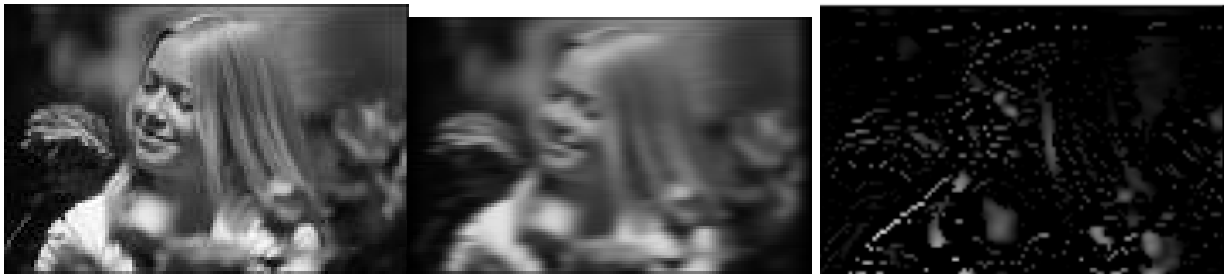
Hysteresis is used to distinguish between true and false edges. By setting a high and a low threshold, pixels with gradient magnitude more than the higher threshold are marked as strong edge pixels, while those below the lower threshold are suppressed.

3 Results

3.1 Intermediate Results

3.2 Effect of σ

The standard deviation, σ, of the Gaussian function plays a pivotal role in the Canny edge detection algorithm. A smaller σ will produce a narrow Gaussian curve, leading to the detection of finer edges. In contrast, a larger σ will yield a wider curve, detecting only significant edges.



(a) Original Image (b) Blurred Image (c) Edge Detection

Figure 1: Intermediate steps in Canny Edge Detection

(a) $\sigma = 0.5$ (b) $\sigma = 1$ (c) $\sigma = 2$

Figure 2: Effect of varying σ on edge detection

4 Conclusion

Through our implementation of the Canny edge detection algorithm, we demonstrated its robustness in identifying edges within images. By examining the effects of the Gaussian function's standard deviation, we noted how σ influences the detection of finer versus significant edges.