**Sobel Edge Detection**

The purpose of edge detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing. Several algorithms exist, and my project is using Sobel operator.

The Sobel operator, sometimes called the Sobel–Feldman operator or Sobel filter, is used in image processing and computer vision, particularly within edge detection algorithms where it creates an image emphasizing edges. It is named after Irwin Sobel and Gary Feldman, colleagues at the Stanford Artificial Intelligence Laboratory (SAIL). It was co-developed with Gary Feldman at SAIL. Sobel and Feldman presented the idea of an "Isotropic 3x3 Image Gradient Operator" at a talk at SAIL in 1968. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel–Feldman operator is either the corresponding gradient vector or the norm of this vector. The Sobel–Feldman operator is based on convolving the image with a small, separable, and integer-valued filter in the horizontal and vertical directions and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation that it produces is relatively crude, in particular for high-frequency variations in the image.

**Sobel Edge Detection Algorithm**

The algorithm runs in 3 separate steps:

1. Smoothing: Blurring of the image to remove noise.

Implemented through Gaussian Filtering with Specific Kernel Size (N) and Gaussian Envelope Parameter Sigma.

2. Finding gradients: The edges should be marked where the gradients of the image have large magnitudes.

The operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives – one for horizontal changes, and one for vertical. The x-coordinate is defined here as increasing in the "right"-direction, and the y-coordinate is defined as increasing in the "down"-direction.

Sobel X and Y Masks are used to generate X & Y Gradients of Image; next function implements differentiation using Sobel Filter Mask

3. Applying Pythagorean formula to eliminate negative values and generate the medium value by combining the X and Y gradients.

At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

G =

Since the intensity function of a digital image is only known at discrete points, derivatives of this function cannot be defined unless we assume that there is an underlying continuous intensity function which has been sampled at the image points. With some additional assumptions, the derivative of the continuous intensity function can be computed as a function on the sampled intensity function, i.e. the digital image. It turns out that the derivatives at any particular point are functions of the intensity values at virtually all image points. However, approximations of these derivative functions can be defined at lesser or larger degrees of accuracy.

The Sobel-Feldman operator represents a rather inaccurate approximation of the image gradient, but is still of sufficient quality to be of practical use in many applications. More precisely, it uses intensity values only in a 3×3 region around each image point to approximate the corresponding image gradient, and it uses only integer values for the coefficients which weight the image intensities to produce the gradient approximation.

Picture 1: 128x128 px

Cuda: 0.094592 ms

Processor: 5 ms

Picture 2: 650x650 px

Cuda: 2.502880 ms

Processor: 92 ms

Picture 3: 3200x2400 px

Cuda: 11.0342 ms

Processor: 1187 ms