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The Sobel-Feldman operator (or simply Sobel filter) is a computer vision algorithm which can be used for edge detection. The filter takes a grayscale image as it's input and create another image emphasising the edges. This project uses the sobel filter as described in (7). The operator is named after Irwin Sobel and Gary M. Feldman, who introduced the idea in 1968 at Stanford Artificial Intelligence Laboratory (SAIL). This filter uses the convolution operator to extract the edges from image by the change in magnitude.

Convolution is an operation which takes two matrices (an input and a kernel) and outputs another matrix which is of same size as the input matrix. It is the process of adding each element of the input to its local neighbors, weighted by the kernel. The convolution operation is denoted by *. The operation usually uses a 3 * 3 sized kernel, but it is not necessary. Convolution is a simple to implement and fast operation to implement. But it is also very useful allowing for multiple useful filters. Some of the most simple and useful ones are Gaussian Blur, Sharpening and Sobel Filter (which we are using).

This project only uses the 3 * 3 sized kernels, this is done to make implementation simpler. This means in our case if the kernel is K and the input is I. Then the output O is given as
So we can have our Matrix class as
But this function will not work for the pixels at the border of the input matrix. Since if we try to get the the value for border pixel [0, 0] we will need to get $I[-1, -1]$, $I[-1, 0]$, etc. pixels which do not exist since there are no pixels to the left. There are three common ways to solve this problem
+ Filling with zeros, so that pixels outside the input are zero
+ Wrapping, the image is wrapped on all eight corners of the image
+ Mirroring, we mirror the image along the perimeter of the image

This project will fill with zeros if we need a pixel outside the boundry of the image.

Now that we know the definition of convolution and how to handle the edge cases, we can implement the this operation in code.

The sobel operator needs two convolution operations to detect the edges. The sobel operator works by calculating the change in image intensity, that is it works by calculating the difference in value of the value compared to its neighbors. The two convolution operations are to get the vertical changes and horizontal changes
1. Horizontal changes: This is represented as G_x and is calculated

2. Vertical changes: This is represented as G_y and is calculated as

We don't need the direction of the edge, we only need the magnitude. To calculate the magnitude, we will combine both the above results \[G = \sqrt{G_x^2 + G_y^2} \]

Using the Matrix class we implemented in previous section, we can implement this algorithm as

The code to calculate magnitude is as follows

Finally, we will output the image by converting the magnitude to an integer value between 0 and 255 by using the maximum magnitude.

The result of the sobel filter on one of the image from our dataset is shown in Figure 3. Here, we have shown the output in form of a image by converting magnitude to an integer between 0 and 255. In the project, we work using magnitudes directly.

A neural network is a type of machine learning model. It is inspired by the human brain, which is composed of neurons that form different pathways to process data and learn patterns. To mimic this behaviour, neural networks in coumputers are made of artificial neurons. An artificial neuron is a function which is conceived as a model of biological neuron in a neural network. An artificial neuron is the smallest unit of the Artificial Neural Network (ANN). The artificial neuron is based on how biological neurons work in human brain.

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Convolution is a mathematical operation that takes two matrices and merges them into a third matrix. In convolutional neural networks, the first matrix is called the input matrix, the second is a kernel/filter, and the output matrix is called the feature map.

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Some of the most simple and useful ones are described below. Remove the background of a local image. To do this, open a terminal and run: rembg i

https://itsfoss.com/remove-image-background-gimp