Part 2 – Video Manipulation Basics:

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. If we define A as the source image, and G_x and G_y are two images which at each point contain the vertical and horizontal derivative approximations respectively

$$G_x = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} * A \quad ; \quad G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A$$

The resulting gradients can be combined to give the gradient magnitude, using: $G = \sqrt{G_x^2 + G_y^2}$

and we can also calculate the gradient's direction: $\Theta = \arctan\left(\frac{G_y}{G_x}\right)$

The Sobel operator is used in image processing and computer vision, particularly within edge detection algorithms where it creates an image emphasizing edges. It works by calculating the gradient of image intensity at each pixel within the image. It finds the direction of the largest increase from light to dark and the rate of change in that direction. The result shows how abruptly or smoothly the image changes at each pixel, and therefore how likely it is that that pixel represents an edge.

Part 3 – Harris corner detection:

The Harris corner detector is invariant to translation and rotation since the derivates will be the same.

In case of illumination change ($I_{out} = a * I_{in} + b$) the M matrix will change, and the corners might change as well. For example, for a=5 and b=0, pixel grayscale value change of “1” to “10” will become a change of “5” to “50”. We can see that the derivative has changed, so M will change and R will change as well, resulting in different corner detection.