TDT4195 - Assignment 5

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Task 1: Theory

a)

Since the $H_1 = H_2$ and $W_1 = W_2$ we can define

$$H_1 = H_2 = H$$
$$W_1 = W_2 = W$$

The values given by the task:

$$S_H = S_W = S = 1$$
$$F_H = F_W = F = 5$$

Then we can use the equations to calculate

$$H_2 = \frac{H_1 - F_H + 2P_H}{S_H} + 1$$
$$H = \frac{H - F + 2P_H}{S} + 1$$
$$H = \frac{H - 5 + 2P_H}{1} + 1$$
$$P_H = 2$$

And for the width

$$W_2 = \frac{W_1 - F_W + 2P_W}{S_W} + 1$$
$$W = \frac{W - F + 2P_W}{S} + 1$$
$$W = \frac{W - 5 + 2P_W}{1} + 1$$
$$P_W = 2$$

Which leads to

$$P_W = P_H = 2$$

b)

We know this:

$$\begin{aligned}
\text{Original image} &= H_1 \times W_1 = 512 \times 512 \\
\text{Spatial dimensions of feature map in the first layer} &= H_2 \times W_2 = 504 \times 504 \\
\text{Stride} &= S_W \times S_H = 1 \times 1 \\
\text{Padding} &= P_W \times P_H = 0 \times 0
\end{aligned}$$

Which gives us the following using the equations from the assignment:

$$\begin{aligned}
W_2 &= \frac{W_1 - F_W + 2P_W}{S_W} + 1 \\
W_2 &= W_1 - F_W + 2 \times 0 + 1 \\
F_W &= W_1 - W_2 + 1 \\
&= 512 - 504 + 1 \\
&= 9
\end{aligned}$$

And

$$\begin{aligned}
F_H &= H_1 - H_2 + 1 \\
&= 512 - 504 + 1 \\
&= 9
\end{aligned}$$

The kernel size in layer 1 is therefore: $F_H \times F_W = 9 \times 9$

c)

Given the values

$$\begin{aligned}
H_1 &= 504 \\
W_1 &= 504 \\
P_H &= P_W = 0 \\
F_H &= F_W = 2 \\
S_H &= S_W = 2
\end{aligned}$$

Computing the height:

$$\begin{aligned}
H_2 &= \frac{H_1 - F_H + 2P_H}{S_H} + 1 \\
H_2 &= \frac{504 - 2 + 2 \times 0}{2} + 1 \\
H_2 &= 252
\end{aligned}$$

Computing the width:

$$\begin{aligned}
W_2 &= \frac{W_1 - F_W + 2P_W}{S_W} + 1 \\
W_2 &= \frac{504 - 2 + 2 \times 0}{2} + 1 \\
W_2 &= 252
\end{aligned}$$

The dimensions will be 252×252

d)

Given:

$$
\begin{aligned}
H_1 \times W_1 &= 252 \times 252 \\
F_W \times F_H &= 3 \times 3 \\
S_W \times S_H &= 1 \times 1 \\
P_W \times P_H &= 0 \times 0
\end{aligned}
$$

Then:

$$
\begin{aligned}
W_2 &= \frac{W_1 - F_W + 2P_W}{S_W} + 1 \\
&= \frac{252 - 3 + 2 * 0}{1} + 1 \\
&= 249 + 1 \\
&= 250
\end{aligned}
$$

And:

$$
\begin{aligned}
H_2 &= \frac{H_1 - F_H + 2P_H}{S_H} + 1 \\
&= \frac{252 - 3 + 2 * 0}{1} + 1 \\
&= 249 + 1 \\
&= 250
\end{aligned}
$$

Which means that the sizes of the feature maps in the second layer is 250×250

e)

	$W_2 = H_2$	Pooling	Weight	Biases	Parameters	Total
n	$\frac{W_2 - F + 2P}{S} + 1$	$\frac{W_1 - F}{S} + 1$	$F_H \times F_W \times C_n \times C_{n+1}$	C_{n+1}	weight + biases	$\sum$
1	32	16	2400	32	2432	2432
2	16	8	18432	64	18496	20928
3	8	4	73728	128	73856	94784
4	-	-	$4 \cdot 4 \cdot 64 \times 128 = 131070$	64	131136	225920
5	-	-	$64 \cdot 10 = 640$	10	650	226570

Task 2

a)

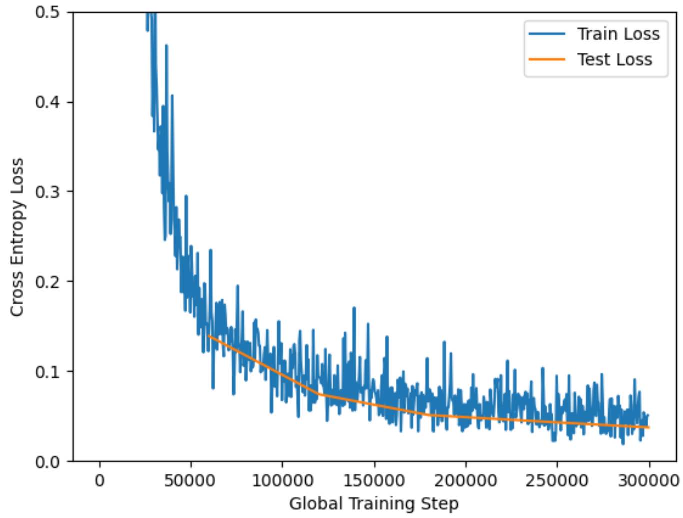


Figure 1: Training and loss for network in table 1

We're not able to see any evidence of overfitting with this model. Overfitting happens when a model gets too customized for the training data and therefore don't use general features when classifying. If there is too many parameters or a too small training set, this can happen.

One can spot overfitting in graphs where the training and test loss diverges. The training loss will continue to decrease loss while the test loss starts to increase. This does not happen in our model/graph.

b)

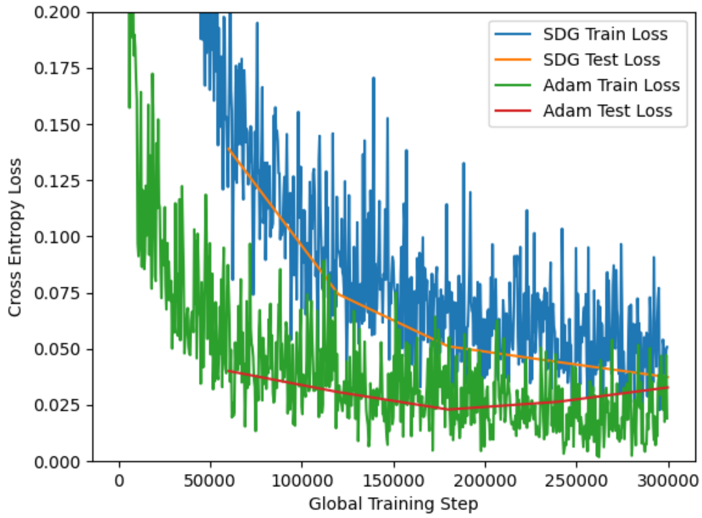


Figure 2: Training and loss with optimzers Adam and SDG compared

c)

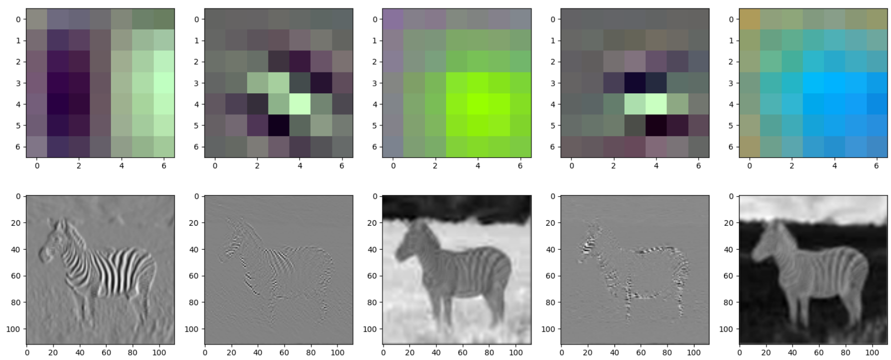


Figure 3: Visualization of filter and activation at indices [5, 8, 19, 22, 34]

d)

Filter at index	Feature	Explanation
5	Vertical lines	The filter is split vertically in the middle and the vertical lines at the zebra is visible while the horizontal lines is not.
8	Diagonal lines	The filter contains three diagonal lines (-45 degrees) and the zebra's neck and the diagonal part of its stripes is most visible.
19	Green color	The filter is mostly green and will therefore highlight pixels with a lot of green. This is why the grass is the most highlighted.
22	Horizontal lines	The filter is divided into three horizontal parts and the visible stripes at the zebra is the horizontal ones.
34	Blue color	The filter is mostly blue and will therefore highlight pixels with a lit of blue. This explains why the sky is the most highlighted.

Task 3

a)

The direction of the dots indicates the direction of the waves. Horizontal dots means waves that move in horizontal direction, giving a pattern with vertical stripes.

This means that we can group the pictures like this:

$$[1a, 1b, 1c] \to [2c, 2e, 2f]$$
$$[1d, 1e, 1f] \to [2a, 2b, 2d]$$

The dots represent the frequency of the waves in the spatial domain. The closer the dots are to the middle and each other, the lower frequency (bigger waves).

Based on this, we can pair the images from the spatial and frequency domain like this:

$$1a \to 2e$$
$$1b \to 2c$$
$$1c \to 2f$$
$$1d \to 2b$$
$$1e \to 2d$$
$$1f \to 2a$$

b)

High-pass filters only allows content above a certain frequency to pass through the filter. A high pass filter is needed for most sharpening methods. It works by reducing the low frequency information.

Low-pass filters only allow content below a certain frequency to pass through the filter. A low pass filter is often used for blurring or smoothing methods. It works by reducing the high frequency information, which removes rapid changes in intensity.

c)

As discussed in task a, the center of the image contains the lowest frequencies. Therefore picture a is a high pass kernel, with no pigments in the middle since only high frequencies are allowed to pass. Picture b is a low pass kernel only containing pigments in the middle since only low frequencies are allowed to pass.

Task 4

a)

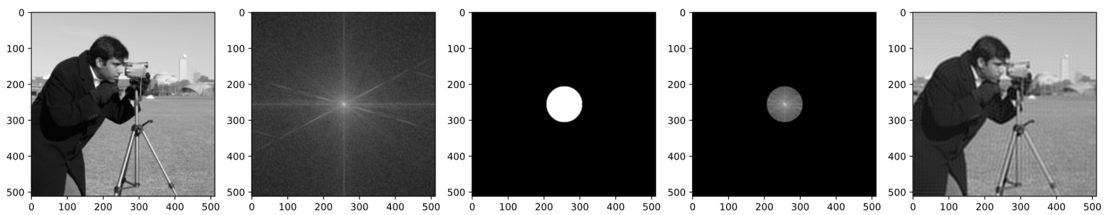


Figure 4: Low pass

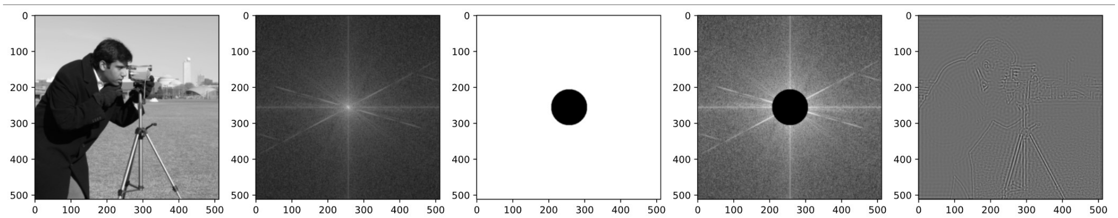
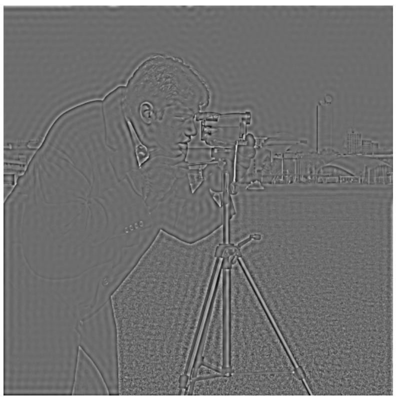


Figure 5: High pass

(a) Low pass higher resolution



(b) High pass higher resolution

The ringing effect in the filtered image happens because the filters are ideal. This means that they are 1 in areas where the frequencies pass through and 0 where they don't.

b)

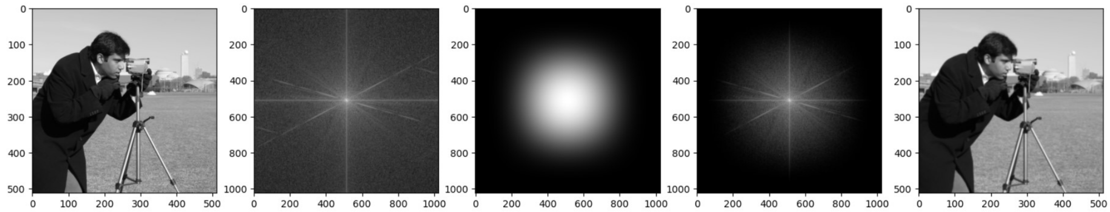


Figure 7: Gaussian filter

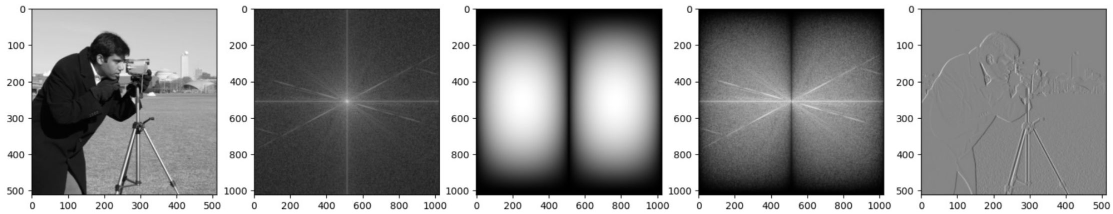
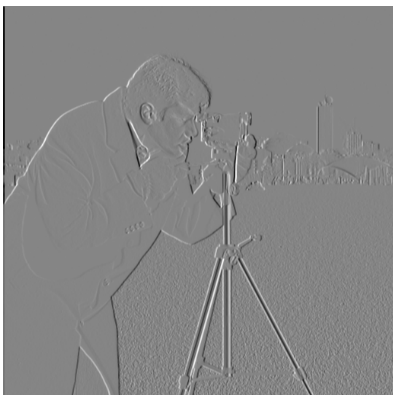


Figure 8: Sobel filter

(a) Gaussian filter higher resolution



(b) Sobel filter higher resolution

c)

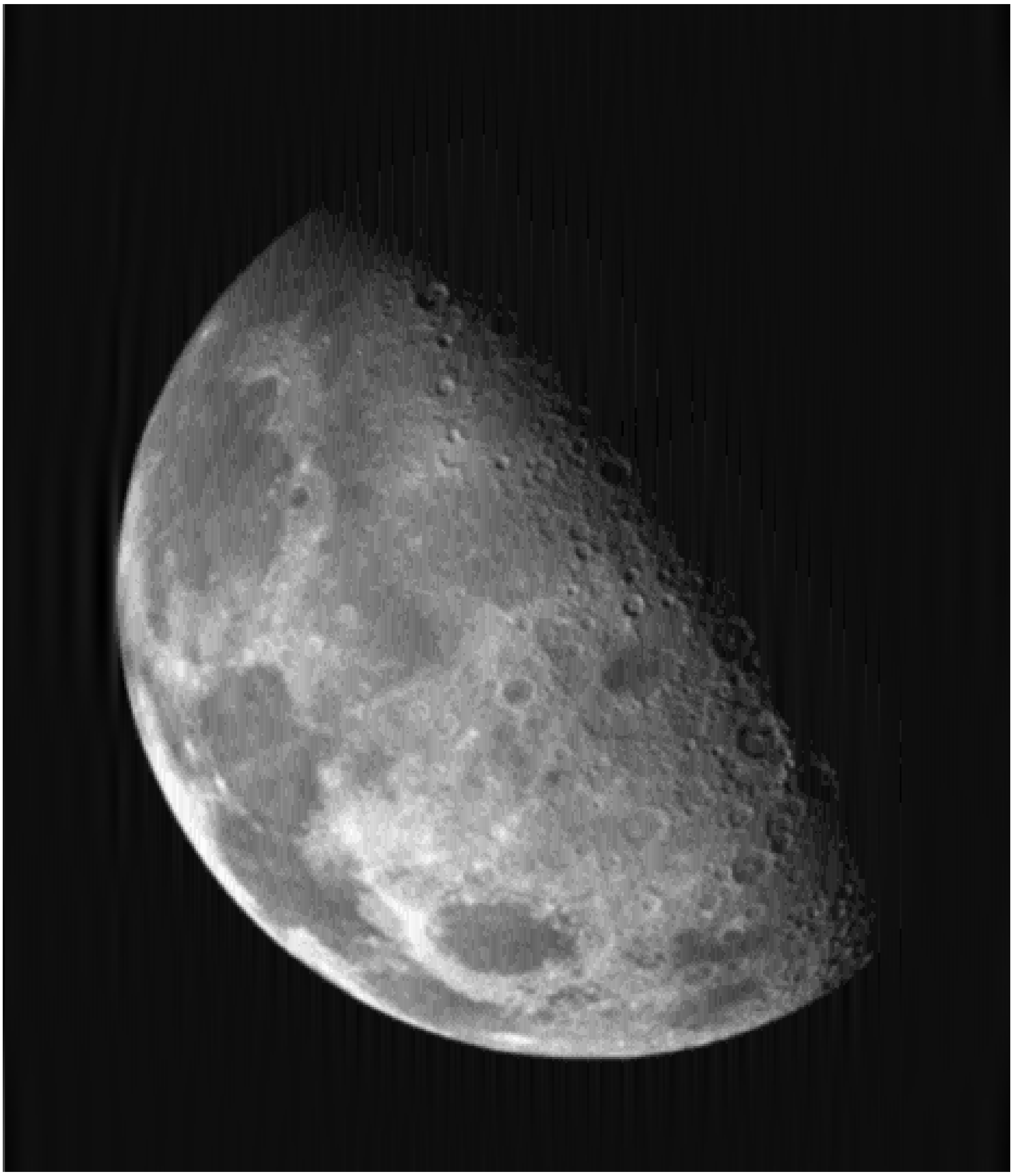


Figure 10: The moon

d)

Page	Angle
1	-21.81
2	90.00
4	26.82
6	-25.32
7	-67.44
8	90.00

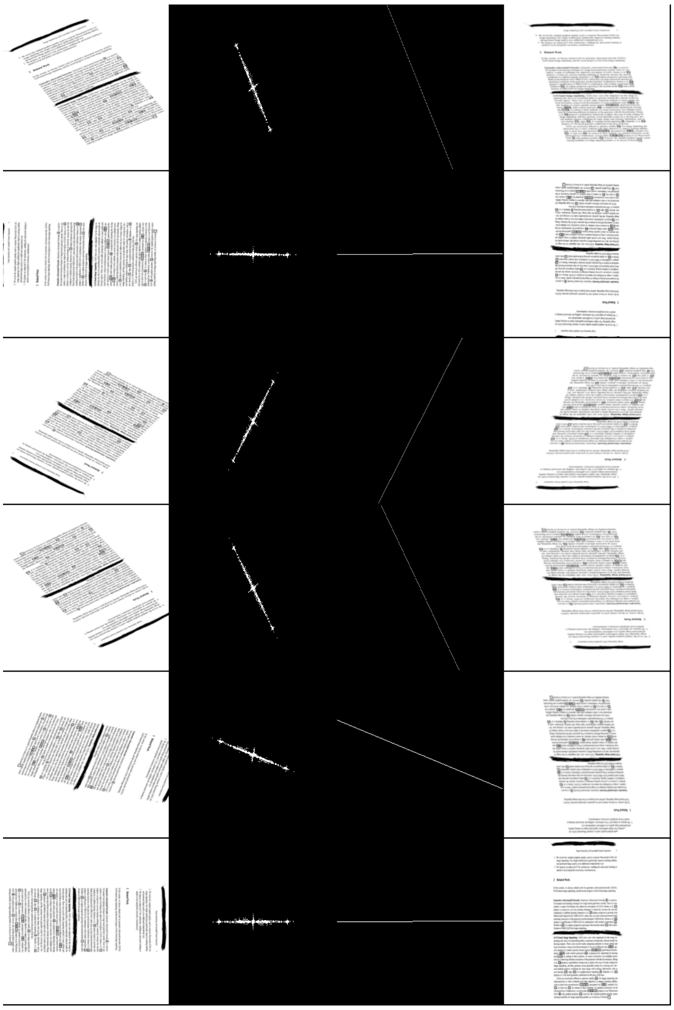


Figure 11: Generated image