TDT4195: Visual Computing Fundamentals

Image Processing – Assignment 1

Deadline: 25.10.2019

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Task 1

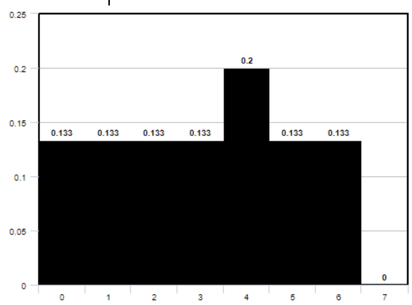
(a) Sampling is a process by which one or more samples are extracted from a continuous, analog signal to be represented digitally as a discrete function.

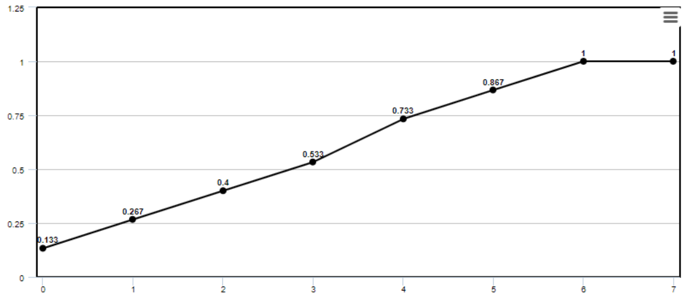
(b) Quantization is a process that exists because of the infinite precision of analog, continuous signals, and assigns a range of analog values to a single digital value.

(c) When looking at a normalized image histogram, a wide range of intensity values with reasonably high low-end and high-end values equates to an image with high contrast.

(d) $\boldsymbol{F_n = F_{n-1} + f_n}$

$\boldsymbol{n}$	0	1	2	3	4	5	6	7
$\boldsymbol{f_n}$	$^2/_{15}$	$^2/_{15}$	$^2/_{15}$	$^2/_{15}$	$^3/_{15}$	$^2/_{15}$	$^2/_{15}$	$^0/_{15}$
$\boldsymbol{F_n}$	$^2/_{15}$	$^4/_{15}$	$^6/_{15}$	$^8/_{15}$	$^{11}/_{15}$	$^{13}/_{15}$	$^{15}/_{15}$	$^{15}/_{15}$





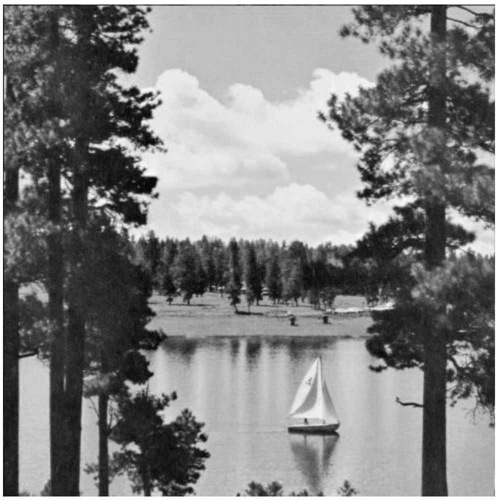
(e) Applying a log transform to an image with a large variance in pixel intensities will expand the range of low-intensity values, while compressing the range of high-intensity values.

(f) Boundary conditions: cells “outside” of the input image is considered to take the value 0.

$-20 + 3$	$2 + 2 + 5$	$-8 + 3$	$-12 + 4 + 5 + 2$	$-16 + 6 + 3$
$-12 + 5 + 2 + 4$	$-8 + 6 + 3$	$2 + 5 + 1 + 2$	$-20 + 3 + 6 + 1$	$-24 + 4 + 4 + 5$
$-16 + 3 + 6$	$-24 + 2 + 1 + 4$	$-4 + 1 + 6$	$-4 + 5 + 4 + 1$	$-16 + 6 + 1$

-17	9	-5	-1	-7
-1	1	10	-10	-11
-7	-17	3	6	-7

Task 2



(a) lake_greyscale.jpg

(b) lake_inverse.jpg

The transformation applied to image lake_inverse.jpg is called a negative transformation.

(c) convolved_im_h_a.jpg

(c) convolved_im_h_b.jpg

Task 3

(a)

(b) Hyperparameters is settings used to control the behavior of the learning algorithm and is thus not adapted by the algorithm itself. Batch size and learning rate are examples of hyperparameters.

(c) The purpose of using the softmax activation function in the last layer of a neural network is to turn the score produced by said neural network into a set of values that may be interpreted by humans (hence it must be used at the last layer).

(d)

$$\frac{\partial C}{\partial w_1} = \frac{\partial a_1}{\partial w_1}\frac{\partial c_1}{\partial a_1}\frac{\partial y}{\partial c_1}\frac{\partial C}{\partial y} = (x_1)(1)(1)(2) = 2(-1) = -2$$

$$\frac{\partial C}{\partial w_2} = \frac{\partial a_2}{\partial w_2}\frac{\partial c_1}{\partial a_2}\frac{\partial y}{\partial c_1}\frac{\partial C}{\partial y} = (x_2)(1)(1)(2) = 2(0) = 0$$

$$\frac{\partial C}{\partial w_3} = \frac{\partial a_3}{\partial w_3}\frac{\partial c_2}{\partial a_3}\frac{\partial y}{\partial c_2}\frac{\partial C}{\partial y} = (x_3)(1)(1)(2) = 2(-1) = -2$$

$$\frac{\partial C}{\partial w_4} = \frac{\partial a_4}{\partial w_4}\frac{\partial c_2}{\partial a_4}\frac{\partial y}{\partial c_2}\frac{\partial C}{\partial y} = (x_4)(1)(1)(2) = 2(2) = 4$$

$$\frac{\partial c_1}{\partial b_1}\frac{\partial y}{\partial c_1}\frac{\partial C}{\partial y} = (1)(1)(2) = 2$$

$$\frac{\partial c_2}{\partial b_2}\frac{\partial y}{\partial c_2}\frac{\partial C}{\partial y} = (1)(1)(2) = 2$$

(e)

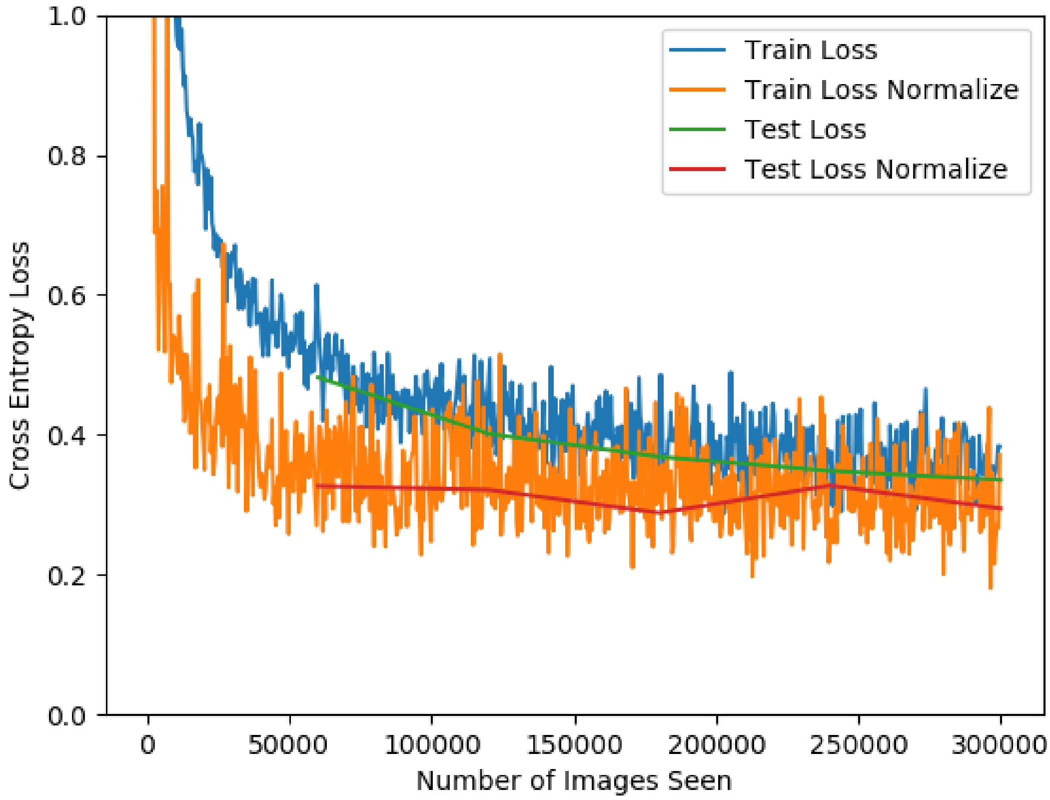
$$w_{1_{updated}} = w_1 - \alpha\frac{\partial C}{\partial w_1} = -1 - (0.1)(-2) = -0.8$$

$$w_{3_{updated}} = w_3 - \alpha\frac{\partial C}{\partial w_3} = -1 - (0.1)(-2) = -0.8$$

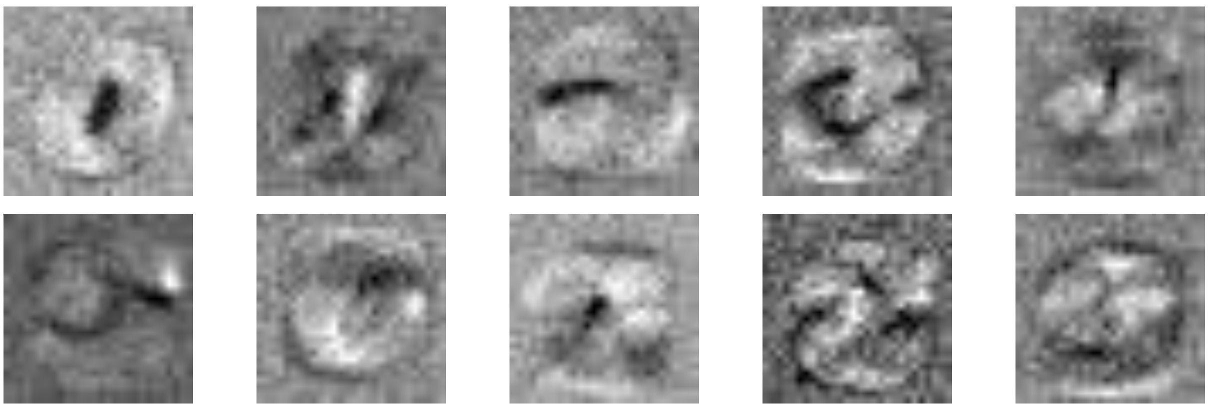
$$b_{1_{updated}} = b_1 - \alpha\frac{\partial C}{\partial b_1} = 1 - (0.1)(2) = 0.8$$

Task 4

(a)



(b)



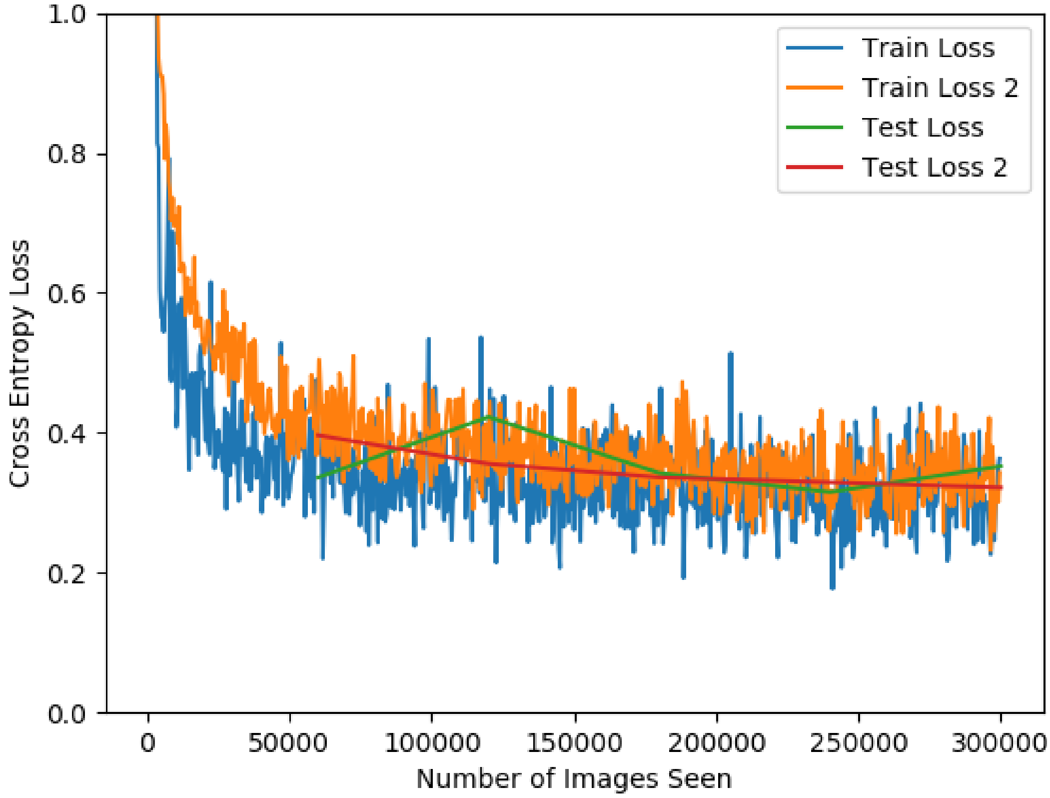
The learned weights, plotted in 28x28 images, resembles the numbers. Not all resembles their number well, but by looking at 0 and 3, it is very obvious this is what we're looking at.

(c)

Final Test Cross Entropy Loss: 49.43833339290254. Final Test accuracy: 0.6738

The learning rate determines how quickly we'll reach the minimum point. This means a high learning rate should be good, but in this case, a learning rate of 1.0 means we overshoot on the minimum point, meaning it isn't approaching the minimum, but rather moving towards it and passes it, making the results very unstable, an fairly unusable.

(d)



It seems adding a hidden layer makes the loss go down smoother and more stable.