UNIVERSITY OF WATERLOO

Midterm

Student name: *Zahin Mohammad*
z5mohamm
20669584

Course: *ECE 495* – Professor: *Krzysztof Czarnecki*
Due date: *March 3rd, 2021*

Q1. ADS Fundamentals [1 mark]

1a. A vehicle is equipped with a stop-and-go pilot, which can fully operate a vehicle on a highway in traffic jams, but with a fallback-ready user. Which level(s) of driving automation is this driving automation system operating at? [1 mark]

Answer. TODO

Q2. Computer Vision Fundamentals [11 marks]

2a. Compute 1-D cross-correlation by applying the following filter [0 2 1] to the following signal [0 1 3 0] (assume enough zero padding to show all non-zero output). [2 marks]

Answer. TODO

2b. Assume that the output of cross-correlating the 1-D filter [2 3 2] with some input signal resulted in the following output signal [7 10 7]. What would be the output signal have we used convolution instead of cross-correlation and why? [1 mark]

Answer. TODO

2c. What would be the result of applying this filter to an image (Hint: add the Gaussian kernel to this filter from question 2e to recognize it)? [1 mark]Explain.

$$\frac{1}{16}\begin{bmatrix} -1 & -2 & -1 \\ -2 & 28 & -2 \\ -1 & -2 & -1 \end{bmatrix}$$

Answer. TODO

2d. What is the name of the following filter and what is it computing? [1 mark]

$$\frac{1}{16}\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 2 & 1 & 0 \\ 0 & 2 & 4 & 2 & 0 \\ 0 & 1 & 2 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} - \frac{1}{273}\begin{bmatrix} 1 & 4 & 7 & 4 & 1 \\ 4 & 16 & 26 & 16 & 4 \\ 7 & 26 & 41 & 26 & 7 \\ 4 & 16 & 26 & 16 & 4 \\ 1 & 4 & 7 & 4 & 1 \end{bmatrix}$$

Answer. TODO

2e. Complete the Gaussian filter shown below by specifying the cells marked by "?". How did you determine the missing values? [2 marks]

$$\frac{1}{16}\begin{bmatrix} 1 & 2 & ? \\ ? & ? & ? \\ ? & ? & ? \end{bmatrix}$$

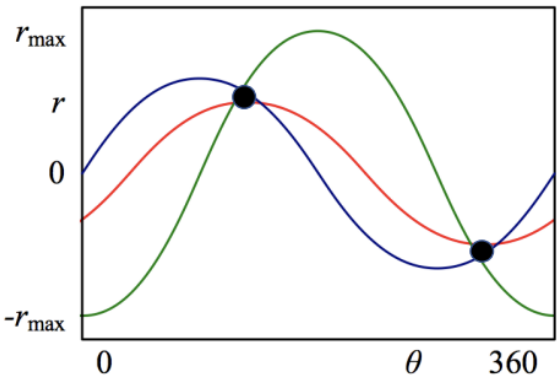
Answer. TODO

2f. Why is the Canny filter using double thresholding? [1 mark]

Answer. TODO

Zahin Mohammad
z5mohamm
20669584

2g. Consider the following representation in Hough space (polar coordinates).



2g.1 What is each of the individual sinusoids corresponding to in the input image? [1 mark]

Answer. TODO

2g.2 What is each of the black dots (sinusoid intersections) corresponding to in the input image (note that the horizontal axis sweeps 360 degrees)? [1 mark]

Answer. TODO

2h. Which of the following value profiles represent black in HSV? (select all that apply) [1 mark]

1. 0,high,high
2. any,low,low
3. any,low,high
4. 60,high,high
5. any,high,low
6. any,any,low

Answer. TODO

Q3. Machine Learning Fundamentals [21 marks]

3a. Starting with the probabilistic model for linear regression (assume single input x and single out y), show that maximizing the likelihood for a dataset (x, y) (with i.i.d. datapoints) is equivalent to minimizing the sum of squared errors. Hint: go via negative log likelihood [5 marks]

Answer. TODO

3b. What is the regression loss (as used in class) for a data point with label 0.4 and predicted output 0.7? [1 mark]

Answer. TODO

3c. (Apply what you've learned in lecture and Assignment 2) Given the following set of input vector X, ground truth vector Y, and weight matrices W_1, W_2, B_1, and B_2 of a 2 layer fully connected neural network, what is the inference probability of the correct class? What is the cross-entropy loss value? Assume ReLU activation on the first hidden layer and softmax activation on the output layer. Show each step of the computation. Hint: Use numerically stable softmax and assume $e^{-1}) \approx 0.37$ and $e^{-7} \approx 0.00$ [5 marks]

X	W1		B1	W2			B2	Y
2	10	8	-25	3	1	1	-3	0 (Man)
0	-5	3	11	1	2	3	3	1 (Moose)
	4	2	-10	5	4	2	0	0 (Deer)

Answer. TODO

3d. Consider the computational graph below for the following function

$$f(x_1, x_2) = ln(3x_1 + e^{2x_2}) \tag{1}$$

Draw the computational graph and annotate it with the forward pass (above the arrows) and backward pass (below the arrows) for $x_1 = 1$ and $x_2 = 0$ (propagate the gradient back to each function input). Recall

$$\frac{de^x}{dx} = e^x \tag{2}$$

$$\frac{dln(x)}{dx} = \frac{1}{x} \tag{3}$$

Assume $ln(4) \approx 1.39$ [5 marks]

Answer. TODO

3e. What is the difference between Stochastic Gradient Descent and ordinary (Batch) Gradient Descent? [1 mark]

Answer. TODO

3f. How is the condition of overfitting defined? [1 mark]

Answer. TODO

3g. Consider a convolutional layer with an input volume of depth 4 and output volume of depth 128. How many convolutional filters does the layer contain? What is the depth of each filter? [2 marks]

Answer. TODO

Q4. Semantic Segmentation [2 marks]

4a. (Apply what you've learned in lecture and Assignment 3) Semantic segmentation architectures sometimes use skip connections from early feature maps of the feature extractor to the corresponding-size upsampled maps in the decoder. What is the role of these connections? [1 mark]

Answer. TODO

4b. (Assignment 3) You were recommended to use batch norm as part of your network. Given a layer with the linear transformation and an activation function, where is the batch norm operation normally applied? [1 mark]

Answer. TODO

Q5. Object Detection [9 marks]

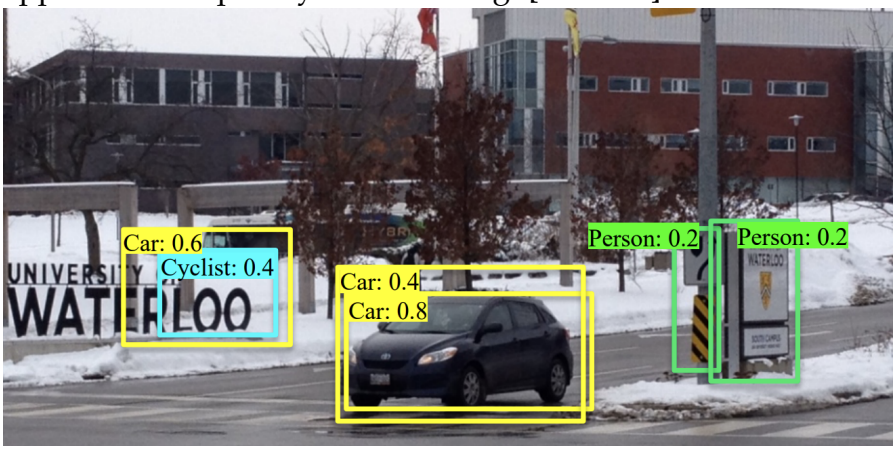
5a. Assume that an object detector uses a 5-by-5 grid and 3 anchor boxes at each cell. What is the maximum number of objects that the detector can detect? [1 mark]

Answer. TODO

5b. On a test set with a total of 4 of cars in the ground truth, a detector produced 3 bounding boxes with the following (score, IoU): (0.5,0.7), (0.7,0.8), (0.9, 0.2) (assume that each returned bounding box overlaps with a different ground truth). Assuming a score threshold of 0.6 and IoU threshold of 0.6, specify the number of TP, FP, and FN. [3 marks]

Answer. TODO

5c. (Assignment 4) Consider the figure below, which shows the bounding boxes predicted by a network (before non-maximum suppression). With an IoU threshold of 0.5 and detection threshold of 0.2, how many bounding boxes are left after non-maximal suppression? Explain your reasoning. [3 marks]



Answer. TODO

5d. How is it possible for two different bounding boxes to be generated for the same object (before non-maximum suppression)? [1mark]

Answer. TODO

5e. Which of the statements is correct? [1mark]

a) An output neuron in an object detector is influenced only by input pixels within the anchor box assigned to it.

b) An output neuron in an object detector is influenced only by input pixels within its positive anchor box.

c) An output neuron in an object detector is influenced only by input pixels within its empirical receptive field.

Answer. TODO