Name: ....
Roll Number:...............................
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End Semester Examination
CSL7360 - Computer Vision

NOTE:

1. **Maximum Points:** 80, **Total Questions:** 18, **Total Page:** 8,**Total Time:** 2 Hours.
2. Q1–10 are 2 points each, Q11–14 are 5 points each and Q15–18 are 10 points each.
3. Use the rough sheet for calculations and only write the precise answer within the box in this sheet.
4. If there is anything not clear in problems, go ahead with your own assumption but state it clearly. No doubts will be entertained during the exam.
5. Be precise. Verbosity will be penalized.
6. It is a closed-book/closed-web exam.
7. For in-person students, It is Question-cum-Answer sheet. Online students may answer in plain sheets but make sure solutions are attached in sequence.

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1. (True/False) Edge detection filter is a low pass filter. **(2 Points)**
2. On an image of size $32 \times 32 \times 3$ if we apply a 1×1 convolution using 5 filters what will be the resultant activation map.**(2 Points)**

3. Average Precision is the area under ...... curve.**(2 Points)**

4. F1-score is ...... of precision and recall.**(2 Points)**

5. Which of these has an image as output (one or more correct answer): (a) Image captioning, (b) Image segmentation, (c) Scene Text Recognition, (d) Image Inpainting**(2 Points)**

6. Which of these have higher training data preparation costs: (a) Object Detection or (b) Semantic Segmentation?**(2 Points)**

7. (True/False) Gradient descent is a way to compute the gradient of large complex functions like Neural Networks.**(2 Points)**

8. While training your image classifier model, you realize that you do not have enough labeled images. List out two data augmentation techniques that can be used to overcome the shortage of data.**(2 Points)**

9. Which among these are valid non-linear activation functions in Neural Networks: (a) f(x) = - min (x,1) (b) f(x) = 0.2x+2 (c) Both of these (d) None of these.**(2 Points)**

10. (True/False) In Backprop during training a neural network for classification tasks, we compute the derivative of the loss function with respect to pixel values in the image. **(2 Points)**

11. Using appropriate mathematical expressions, define the following operations commonly used in computer vision: (a) Convolution (b) Correlation **(5**

Points)

12. Consider the following situation: The Jodhpur Traffic Police Commissioner approached you to address the traffic rule violations issues, using Computer Vision techniques.
(i) Name a related sub-problem you wish to give some solution to in say two months. **(1 Points)**

(ii) What will be your approach? **(2 Points)**

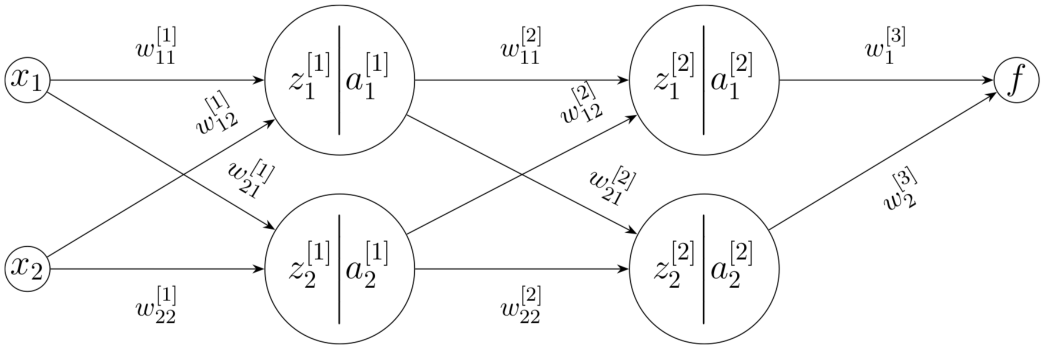
(iii) What are the challenges you expect while solving this problem?**(2 Points)**

13. **(Separable Filter)** Suppose Matrix A is a discrete 2D filter of size 5×5. After applying filter A on image I, we get a resulting image I_A as follows:
$I_A = \sum_{i=1}^{5} \sum_{i=1}^{5} A(i,j) I(x-i+3, y-j+3)$
Further, A is a separable filter, i.e., $A = bc$ where $b \in R^{5\times1}$ and $c \in R^{1\times5}$. and $I_A = I_{bc}$. Suppose the size of the image is 224×224, estimate the number of operations (an operation is an addition or multiplication of two numbers) saved if we apply the 1D filters b and c sequentially instead of applying the 2D filter A. **(5 Points)**

14. **(Geometry)**(a) What is camera calibration?**(2.5 Points)**

(b) Describe Epiopolar constraints in the context of multi-view geometry.**(2.5 Points)**

15. **Backprop** Consider a 3-layer network shown in Figure 1:



$$Z^{[1]} = \begin{bmatrix} z_1^{[1]} \\ z_2^{[1]} \end{bmatrix} = \begin{bmatrix} w_{11}^{[1]} & w_{12}^{[1]} \\ w_{21}^{[1]} & w_{22}^{[1]} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad , \quad A^{[1]} = \begin{bmatrix} a_1^{[1]} \\ a_2^{[1]} \end{bmatrix} = \begin{bmatrix} \sigma(z_1^{[1]}) \\ \sigma(z_2^{[1]}) \end{bmatrix}$$

$$Z^{[2]} = \begin{bmatrix} z_1^{[2]} \\ z_2^{[2]} \end{bmatrix} = \begin{bmatrix} w_{11}^{[2]} & w_{12}^{[2]} \\ w_{21}^{[2]} & w_{22}^{[2]} \end{bmatrix} \begin{bmatrix} a_1^{[1]} \\ a_2^{[1]} \end{bmatrix} \quad , \quad A^{[2]} = \begin{bmatrix} a_1^{[2]} \\ a_2^{[2]} \end{bmatrix} = \begin{bmatrix} \sigma(z_1^{[2]}) \\ \sigma(z_2^{[2]}) \end{bmatrix}$$

Figure 1: Three Layer Network.

Given that $f = w_1^{[3]} a_1^{[2]} + w_2^{[3]} a_2^{[2]}$. Compute the following derivatives: $\frac{\delta f}{\delta z_1^{[2]}}$, $\frac{\delta f}{\delta z_2^{[2]}}$, $\frac{\delta f}{\delta w_{11}^{[1]}}$, $\frac{\delta f}{\delta w_{22}^{[1]}}$ and $\frac{\delta f}{\delta w_{12}^{[1]}}$. Do the rough work separately and write down the final answer here. *(10 points)*

16. **(CNN)** Consider the following CNN architecture (shown in the first column of Table 1). Notations are defined as follows:

Layer	Activation map size	Number of weights	Number of biases
Input	$128 \times 128 \times 3$	0	0
CONV(9,32)			
POOL(2)			
CONV(5,64)			
POOL(2)			
CONV(5,64)			
POOL(2)			
FC(3)			

Table 1: Table for Question Number 16

(a) CONV(K,N) denotes a convolutional layer with N filters of size $K \times K$ each. Assume Padding=0, stride=1.

(b) POOL(K) indicates a $K \times K$ pooling layer. Assume Padding=0, stride=1.

(c) FC(N) indicates a fully-connected layer with N neurons.

Complete the table.

17. **(Deer Detector Evaluation)** Consider the images shown in the figure below. The dotted bounding box shows the ground truth. There are four such ground truth boxes around four deer images.

The detections by modern object detectors– A to E along with their confidence score and IoU are shown in Table 2. Complete this table.

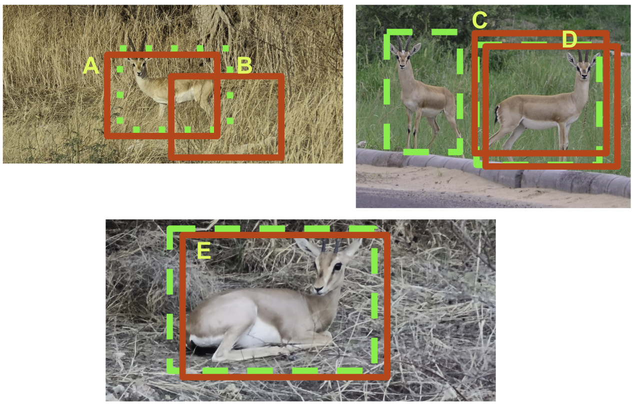


Figure 2: Figure for Object Detection Evaluation

Detection	IoU	Confidence	True Positive	False Positive	Precision	Recall
E	0.95	0.8				
A	0.7	0.7				
C	0.8	0.67				
D	0.78	0.5				
B	0.2	0.48				

Table 2: Table for Question Number 17.

18. Consider the following discrete optimization problem:
minimize $3a_1 + 4a_2 + 5a_3 + 4\bar{a}_1 + 5\bar{a}_3 + 3\bar{a}_2 + 2\bar{a}_1 a_2 + 3\bar{a}_1 a_3$

where $a_i \in \{0, 1\}$ is Boolean variable.

(i) Construct the flow graph corresponding to the above objective function. **(2 points)**

(ii) find out the min-cut of the graph in a rough sheet and show the min-cut in the graph here. **(5 points)**

(iii) Write down the assignments to the variables. **(3 points)**

End of Paper