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**ECE-GY 7123 Introduction to Deep Learning**

**Problem 1):**

**Solution a):**

**Solution b):**

**Solution c):**

**Solution d):**

**Solution e):**

One example of an image operation that cannot be implemented using a 3x3 convolutional filter is a non-linear edge detector. A non-linear edge detector aims to highlight the edges in an image using non-linear operations. This can be achieved using techniques such as morphological operations or non-linear filtering, which involve operations such as dilation, erosion, and median filtering. These non-linear operations cannot be implemented using a 3x3 convolutional filter because a convolutional filter is a linear operator that operates on a local neighborhood of pixels in a fixed way. It applies the same linear transformation to each pixel in the neighborhood, regardless of its value or position. Therefore, a 3x3 convolutional filter cannot capture the complex non-linear relationships between pixels that are necessary for non-linear edge detection.

**Problem 2):**

**Solution a):**

The formula for loss is given by

So the new loss with parameter for regularization is

**Solution b):**

If the learning rate , then the general gradient update rule is,

**Solution c):**

From the equation mentioned in Solution B, we can see that the updated consists of shrinking/decaying gradient by a factor of and then updating in the direction of the gradient

**Solution d):**

Increasing penalizes the norm of the weight vector, thus enforcing smaller weights on average. In order for the gradient to be stable, the constraining factor should be smaller than 1, i.e.

**Problem 3):**

**Solution a):**

The definition of IOU for any two bounding boxes A and B is given by:

Since the RHS is non-negative, the number has to be bigger than or equal to 0. Moreover, and hence the numerator has to be no bigger than the denominator. Therefore IOU is bounded between 0 and 1 (inclusive).

**Solution b):**

Consider two identical size square boxes A and B, both aligned at the same horizontal level. Fix B and then imagine sliding A from left to right. As A moves, the IOU will start from 0, increase until perfect overlap and then decrease until no overlap. The graph we will get is a step funtion i.e., it jumps from 0 to 1 when the boxes overlap and stays at 0 otherwise, the change in I)U will be discontinuous and will not have a well-defined derivative.