6.819 PSET 4
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Collaborators:

1 Convolution

a.*Forward Propagation*
$x_{out} = f_n(x_{in})$

$$x_{out} = \sum_{j=0}^{k-1} x_{in}[i-j]W[j]$$

Where i is specific index of x_{in} where convolution is being done and j ranges from 0 to $k-1$

b. *Gradients of Input and Update Rules*
$W^{(i+1)=W^i-\eta\frac{\partial C}{\partial W}}$
$\frac{\partial C}{\partial X_{in1}} = \frac{\partial C}{\partial X_{out1}}\frac{\partial X_{out1}}{\partial X_{in1}} + ... + \frac{\partial C}{\partial X_{outN}}\frac{\partial X_{outN}}{\partial X_{in1}}$
$\frac{\partial X_{outi}}{\partial X_{inj}} = \frac{\partial}{\partial x_{in}[i]}(x_{in}[i-1]W[1] + x_{in}[i-2]W[2] + ... + x_{in}[i-k]w[g]), g = [0,k]$
$= \frac{\partial}{\partial x_{in}[i]}(x_{in}[i-h]W[h]), h = i-j$
$= \frac{\partial}{\partial x_{in}[i]}(x_{in}[i-(i-j)]W[i-j])$
$= \frac{\partial}{\partial x_{in}[i]}(x_{in}[j]W[i-j]) = W[i-j]$

$$\frac{\partial C}{\partial x_{in}[j]} = \sum_{i=0}^{N-1}\frac{\partial C}{\partial x_{out}[i]}\frac{\partial x_{out}[i]}{\partial x_{in}[j]} = \sum_{i=0}^{N-1}\frac{\partial C}{\partial x_{out}[i]}W[i-j]$$

$$\frac{\partial C}{\partial W[j]} = \sum_{i=0}^{k-1}\frac{\partial C}{\partial x_{out}[i]}\frac{\partial X_{out}[i]}{\partial W[j]}, j$$

specific point where we compute gradient
$= \frac{\partial}{\partial W[j]}(x_{in}[i-1]W[1] + x_{in}[i-2]W[2] + ... + x_{in}[i-k]w[g], g = [0,k])$

$$= \sum_{i=0}^{k-1}\frac{\partial}{\partial w[j]}(x_{in}[i-j]W[j]) = x_{in}[i-j]$$

$$\frac{\partial C}{\partial W[j]} = \sum_{i=0}^{k-1}\frac{\partial C}{\partial x_{out}[i]}x_{in}[i-j]$$

c. *Handling Boundaries*
In boundaries , zero pad the kernel when to take care of out of bounds error for $k < 0$ or $k > n$