

Lecture Notes on 2D Convolution (1)

IP/10 Deep Learning
Sept 23rd, 2017: HL. 1/

Today's Topics:

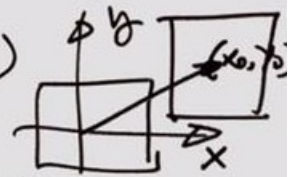
F.F.T. (Fast Fourier Transform)

-1		+1
-2	X	+2
-1		+1

Kernel $g(x, y)$

$g(x, y)$

$g(x_0 - x, y_0 - y)$



$a(x, y)$ $b(x_0 - x, y_0 - y)$

4

Size of the convolution result

1° Deep Learning Based ON Tensorflow.

2° Convolution & Kernel Design.

Homework: OpenCV, GPU Tensorflow.

X86 platform w/ GPU → Deployment: Embedded platform Tx1 & 2 or

Deep Learning Techniques: Neural Networks

2D Convolution:

1° Assumption: Linear System.

Input $x(t)$, Output $y(t)$

Hence $a_1 x_1(t) + a_2 x_2(t) \rightarrow a_1 y_1(t) + a_2 y_2(t)$

Convolution: (1) Shift (2) multiplication (3) Summation

2

Background 2D convolution

Kernel Design.

Image plane

$f(x, y)$

$K \times K$

$g(x, y)$

center

$N \times M$

3

Kernel size

$3 \times 3, 5 \times 5, 7 \times 7$

L-2-R

T-2-B

Lecture Notes on 2D Convolution (2)

Example: Calculation of 2D convolution

Example: Given Image $f(x, y)$, a kernel $k(x, y)$. Perform 2D Convolution

$f(x, y)$

100	100	100	0	0
100	100	100	0	0
100	100	100	0	0
100	100	0	0	0
100	100	0	0	0

$k(x, y)$

-1	1
-2	2
-1	1

$f(x, y) * k(x, y)$

0	-300	300	0
0	-300	300	0
0	-300	300	0
0	-300	300	0
0	-300	300	0

Sol: Duplicate Boundary Pixels

① $-1 \times 100 + 0 \times 100 + 1 \times 100$
 $-1 \times 100 + 0 \times 100 + 1 \times 100$
 $-1 \times 100 + 0 \times 100 + 1 \times 100 = 0$

Next, ② $-1 \times 100 + 0 \times 100 + 1 \times 0$
 $-1 \times 100 + 0 \times 100 + 1 \times 0$
 $-1 \times 100 + 0 \times 100 + 1 \times 0 = -300$

Next, ③ $-1 \times 100 + 0 \times 0 + 1 \times 0$
 $-1 \times 100 + 0 \times 0 + 1 \times 0$
 $-1 \times 100 + 0 \times 0 + 1 \times 0 = -300$

④ $-1 \times 0 + 0 \times 0 + 1 \times 0$
 $-1 \times 0 + 0 \times 0 + 1 \times 0$
 $-1 \times 0 + 0 \times 0 + 1 \times 0 = 0$

Derivation of Kernel

Derivation of Kernel

$\nabla^2 G(x, y)$ $\left\{ \begin{array}{l} \nabla^2 \\ \nabla \cdot \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y} \right) \\ \nabla^2 \left(\frac{\partial^2}{\partial x^2}, \frac{\partial^2}{\partial y^2} \right) \end{array} \right\}$

$G(x, y)$
DoG, G, Blur

White
Black
 $I(x, y)$

$\frac{\partial}{\partial y} I(x, y) \rightarrow \frac{d}{dy} I(y)$

$\frac{d}{dy} I(y) = \lim_{\Delta y \rightarrow 0} \frac{\Delta I(y)}{\Delta y} = \lim_{\Delta y \rightarrow 0} \frac{I(y + \Delta y) - I(y)}{\Delta y}$

$\approx \frac{I(y+1) - I(y)}{1} = I(y+1) - I(y)$

$= 1 * I(y+1) + (-1) * I(y)$

$I(y)$
 $I(y+1)$

The diagram shows a 2D grid with a white region and a black region. The x and y axes are indicated. The white region is labeled 'White' and the black region is labeled 'Black'. The image is labeled $I(x, y)$. Below this, a 1D grid is shown with a vertical arrow pointing to it, labeled y . The grid has cells containing $I(y)$ and $I(y+1)$. The derivation shows that the derivative of the image with respect to y is the difference between the image at $y+1$ and y , which can be written as $1 * I(y+1) + (-1) * I(y)$.