1. CONVOLUTION

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1) 5x5 Zero padding

0 0 0 0 0
0 1 1 2 0
0 1 2 1 0 ANSWER
0 2 1 1 0
0 0 0 0 0

2) OUTPUT

0 0 0 0 0
0 1 1 2 0
0 1 2 1 0
0 2 1 1 0
0 0 0 0 0
Input

3 0 0
0 0 0
0 0 2
kernel

= ANSWER $\begin{pmatrix} 4 & 2 & 0 \\ 2 & 5 & 3 \\ 0 & 3 & 6 \end{pmatrix}$ output

2. FILTER DESIGN

ANSWER
0 0 0 0 0
0 0 0 0 0
0 0 0 0 0
0 0 0 0 0
0 0 0 1 0

5x5 filter
up by 2 pixels
left by 1 pixel

SOL) 3X3 Shift filter

1 2 3
4 5 6
7 8 9

0 0 0
0 0 1
0 0 0
Shifted left by 1 pixel

2 3 0
5 6 0
8 9 0

a b c d e 0 0 0 0 0
f g h i j 0 0 0 0 0
k l m n z 0 0 0 0 0
p q r s t 0 0 0 0 0
v v w x y 0 0 0 1 0

l m n z 0
q r s t 0
v w x y 0
0 0 0 0 0
0 0 0 0 0

3. GAUSSIAN FILTER SEPARABILTY

1) $\frac{1}{289}\begin{bmatrix}1&4&7&4&1\\4&16&28&16&4\\7&28&49&28&7\\4&16&28&16&4\\1&4&7&4&1\end{bmatrix} = \frac{1}{17}[1\,4\,7\,4\,1] * \frac{1}{17}\begin{bmatrix}1\\4\\7\\4\\1\end{bmatrix}$

$\frac{1}{17}[1\,4\,7\,4\,1]$ → g, $\frac{1}{17}\begin{bmatrix}1\\4\\7\\4\\1\end{bmatrix}$ → f

1D Gaussian filter

ANSWER: $\frac{1}{17}[1\,4\,7\,4\,1], \frac{1}{17}\begin{bmatrix}1\\4\\7\\4\\1\end{bmatrix}$

2) Giving Example

$f*(g*h)=(f*g)*h$

$$h=\begin{pmatrix}2&2&2&2&2\\2&1&0&1&2\\1&1&0&1&1\\2&1&0&1&2\\2&2&2&2&2\end{pmatrix}$$

$$f*g=\begin{matrix}1&4&7&4&1\\4&16&28&16&4\\7&28&49&28&7\\4&16&28&16&4\\1&4&7&4&1\end{matrix}$$

$g*h=$

34				
12				
10				
12				
34				

$(f*g)*h=$

$= 2+8+14+8+2=34$

$= 8+16+0+16+8=48$

$= 7+28+0+28+7=70$

$= 8+16+0+16+8=48$

$= 2+8+14+8+2=34$

$f*(g*h)=$

		234		

$= 234$

(only compute integar)

4 FEATURE MATCHING

1) value range for SSD

$SSD \geq 0$

The function of SSD(I,J) is $\sum_{i=1}^{N} (I(i) - J(i))^2$. Because the function is sum of SQUARED distances, the values would be inevitably higher than zero.

2) value range for CC

$-1 \leq CC \leq 1$

correlation coefficient

CC means the correlation between two vectors. In the definition of correlation, the values must range from -1 to 1. So cross-correlation's range is formed between -1 and 1