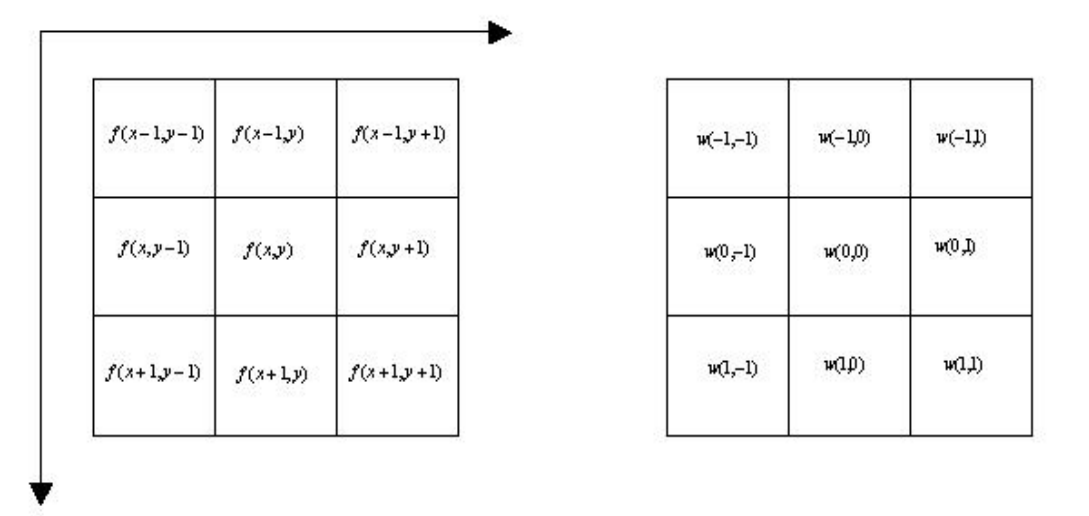
计算机图像处理

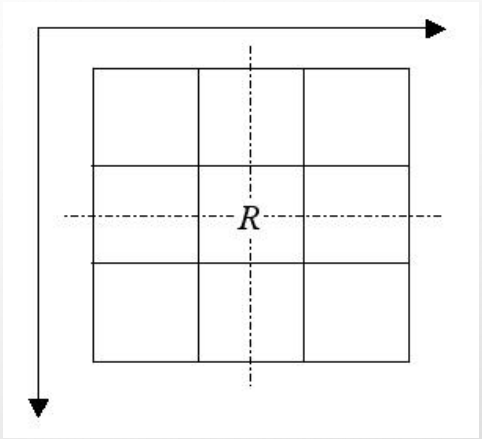
COMPUTER IMAGE PROCESSING

空域滤波增强

空域滤波

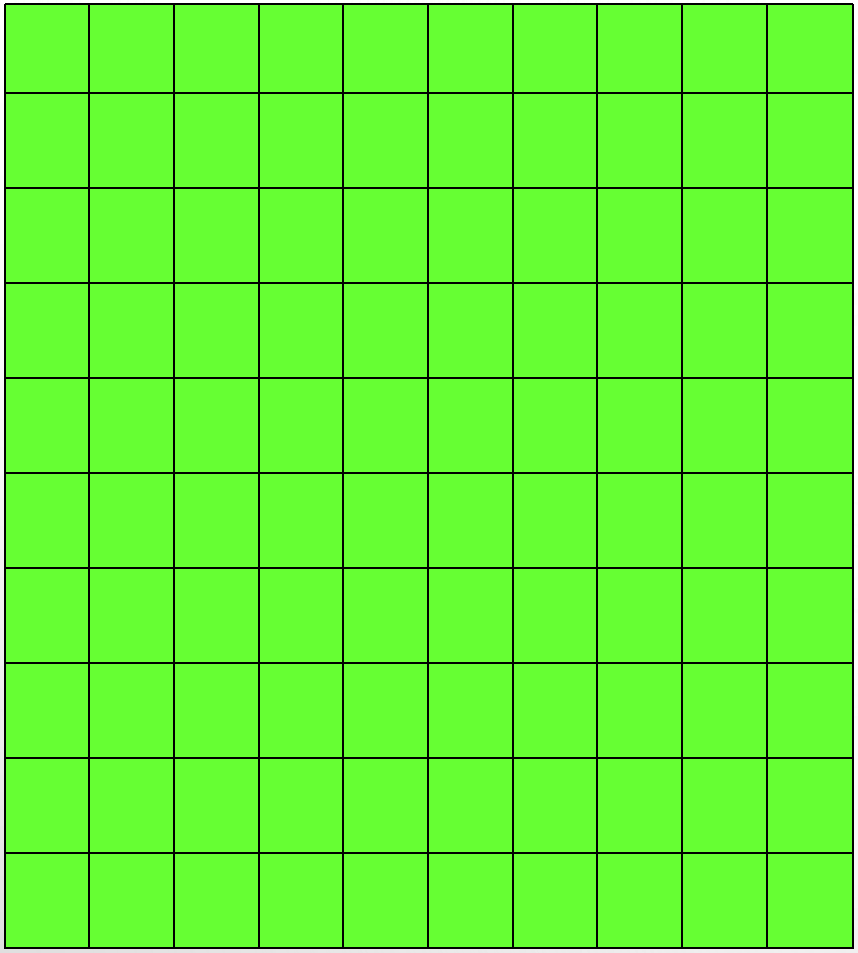
- 空域滤波就是在图像中逐点地移动模板，对每个点都进行模版操作。





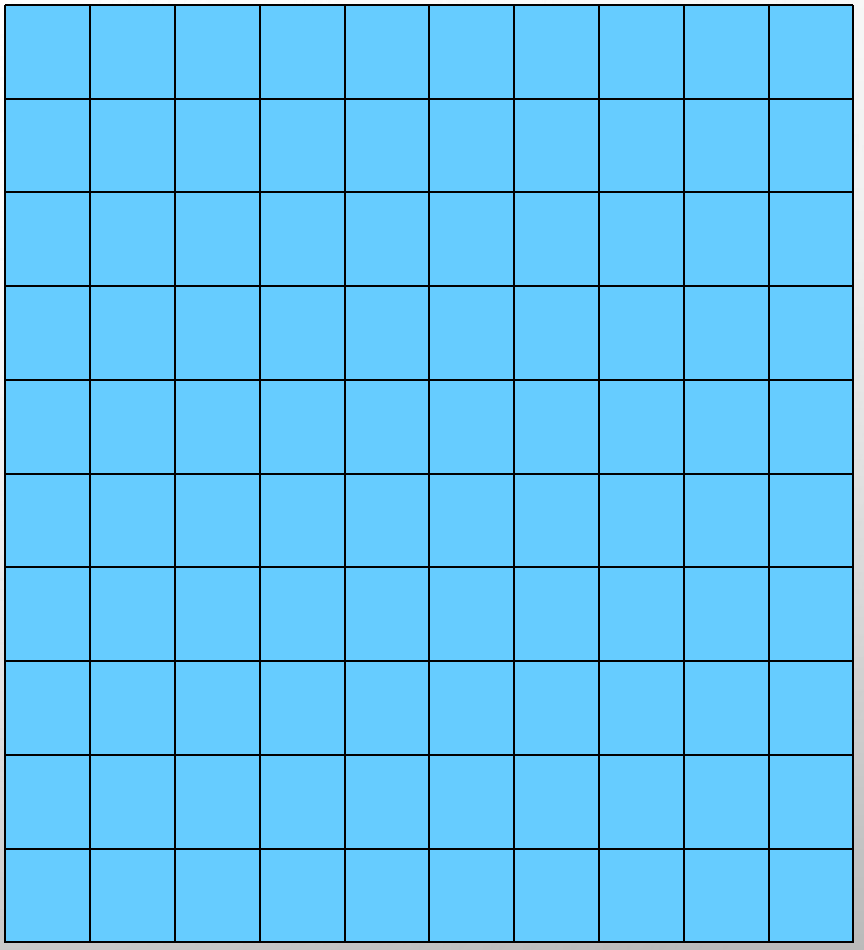
线性滤波，滤波器模板$m \times n$，令$a=(m-1)/2$，$b=(n-1)/2$，则

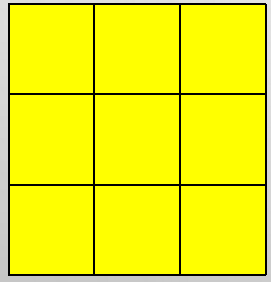
$$R=\sum_{s=-a}^{a}\sum_{t=-b}^{b}w(s,t)f(x+s,y+t)$$



f(x, y)

R(x, y)

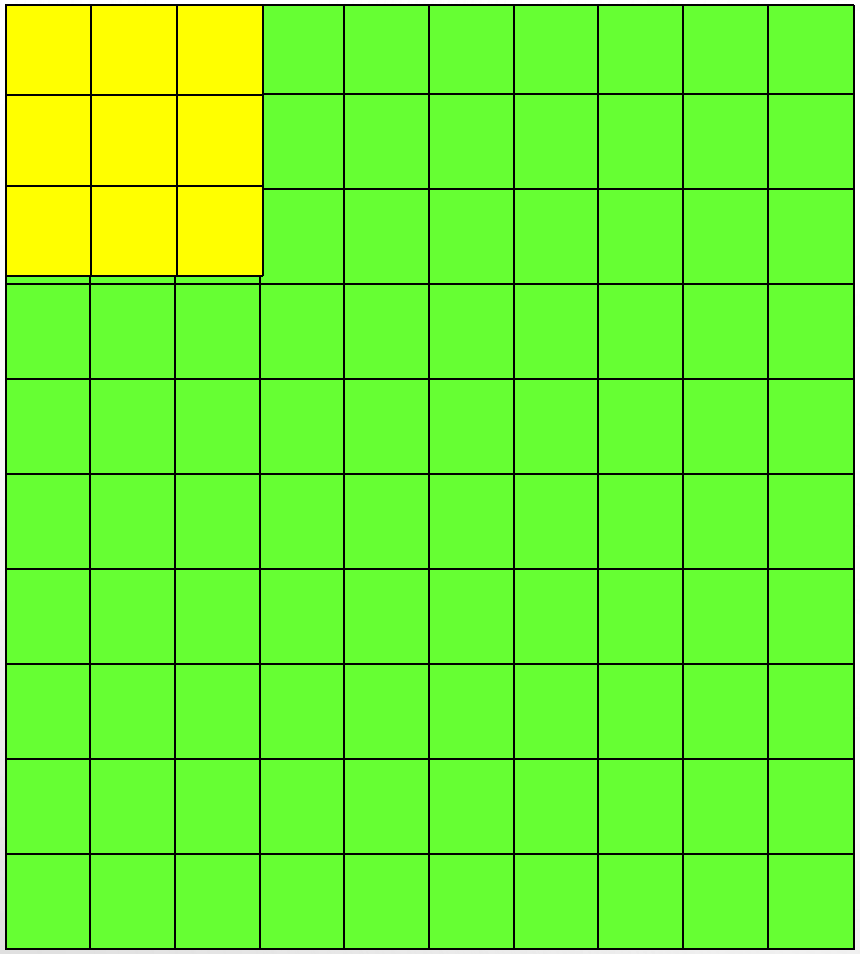




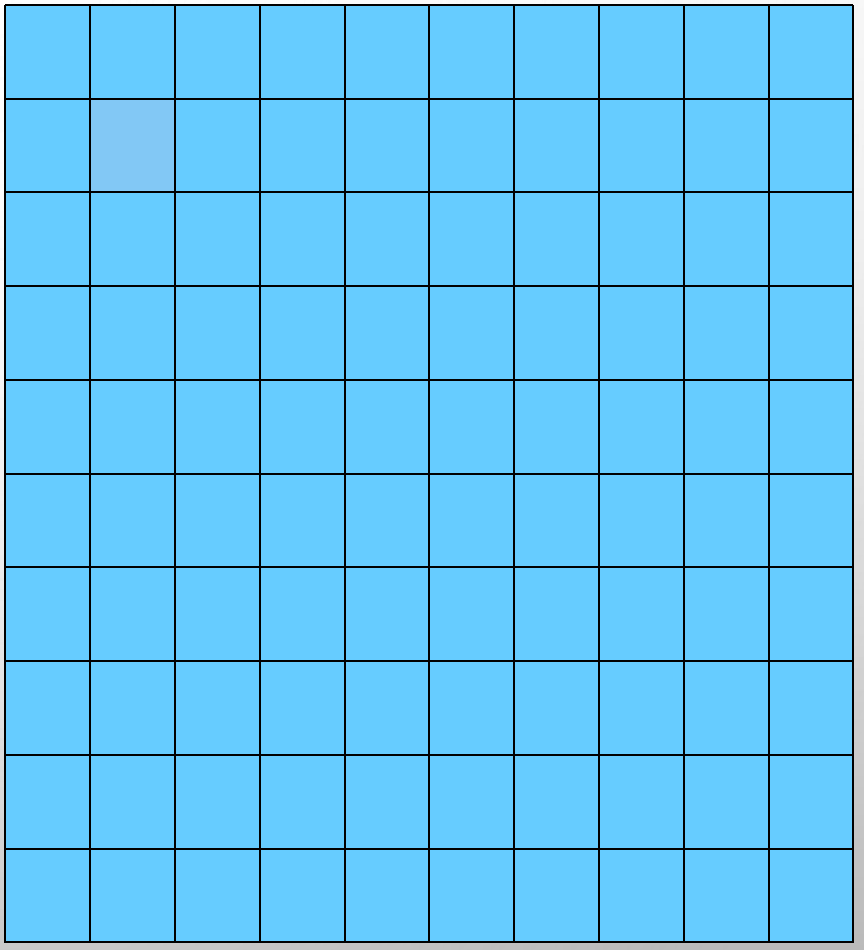
w(x, y)

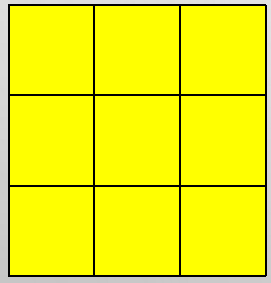
$$R = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)$$

f(x, y)



R(x, y)





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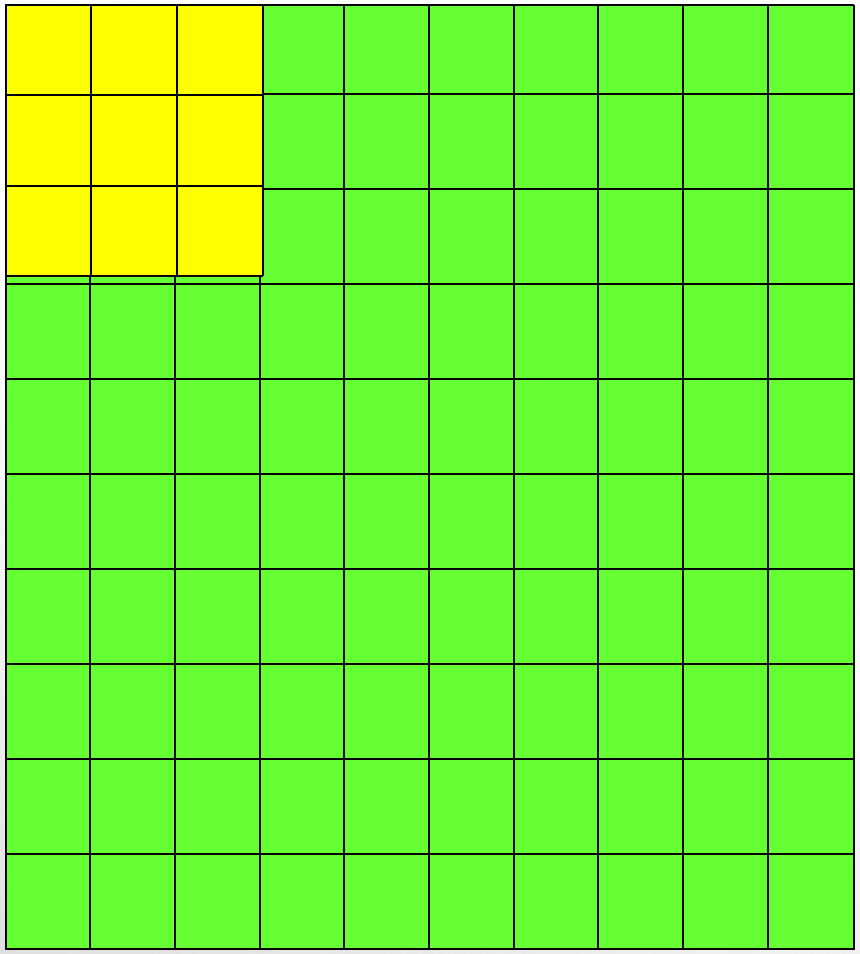
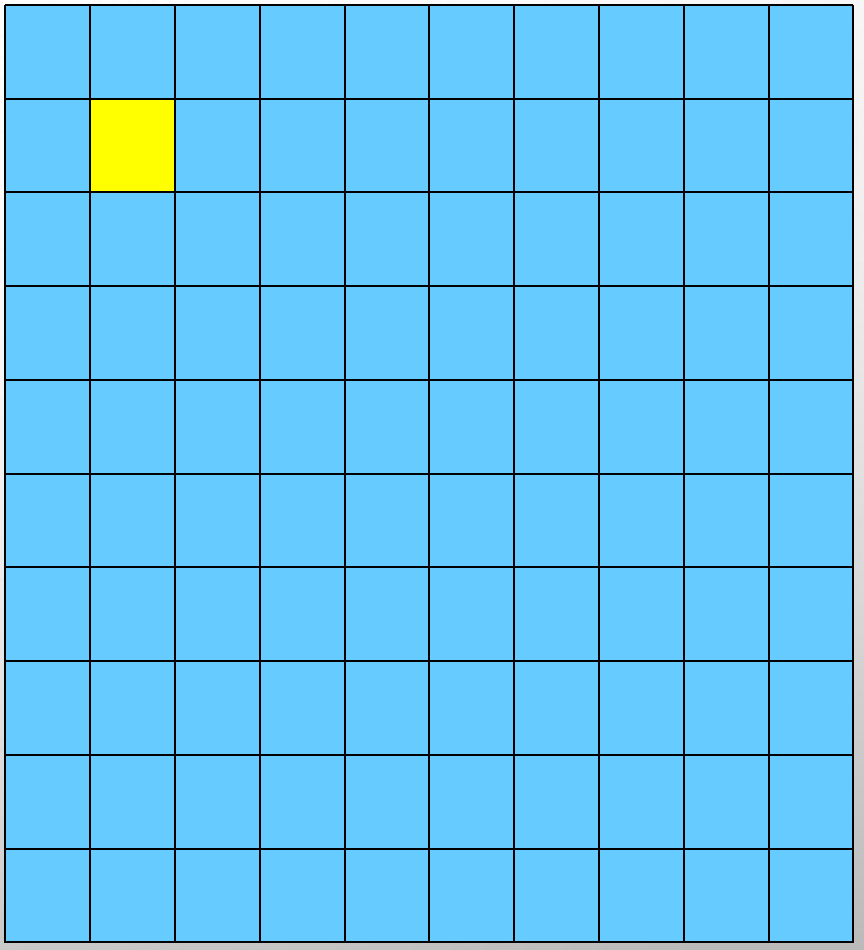
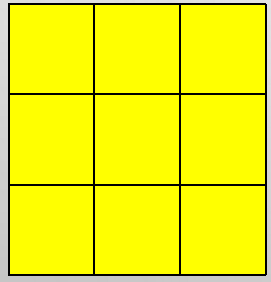
f(x, y)



R(x, y)





w(x, y)

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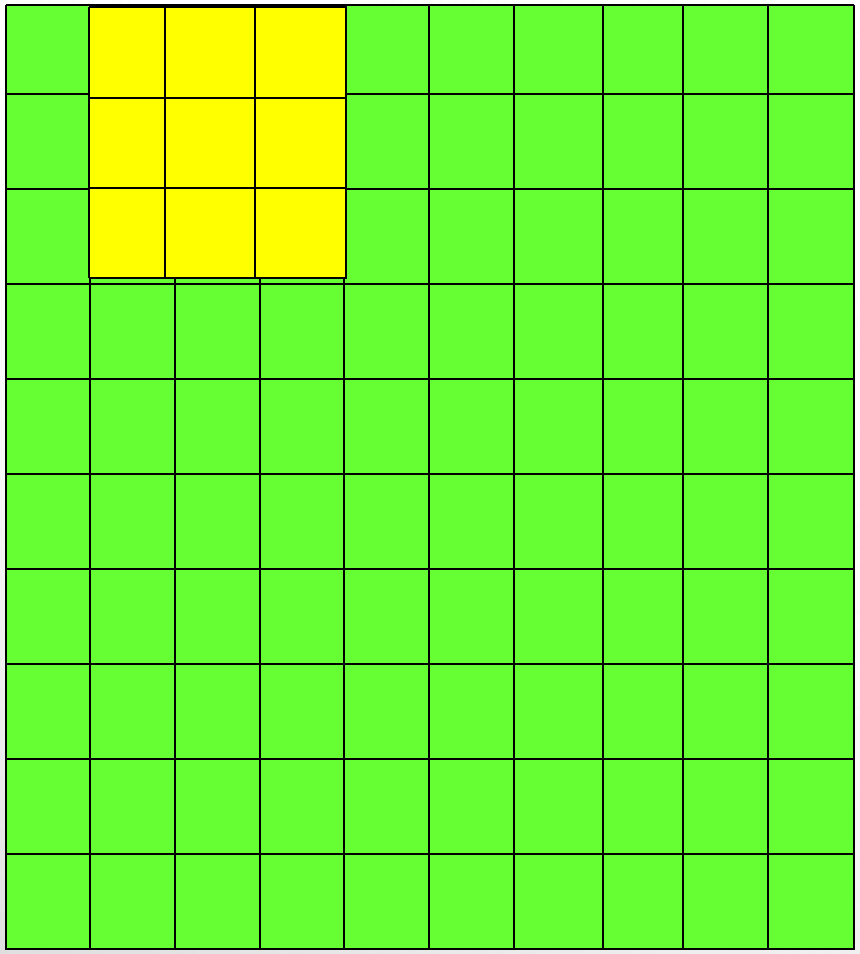
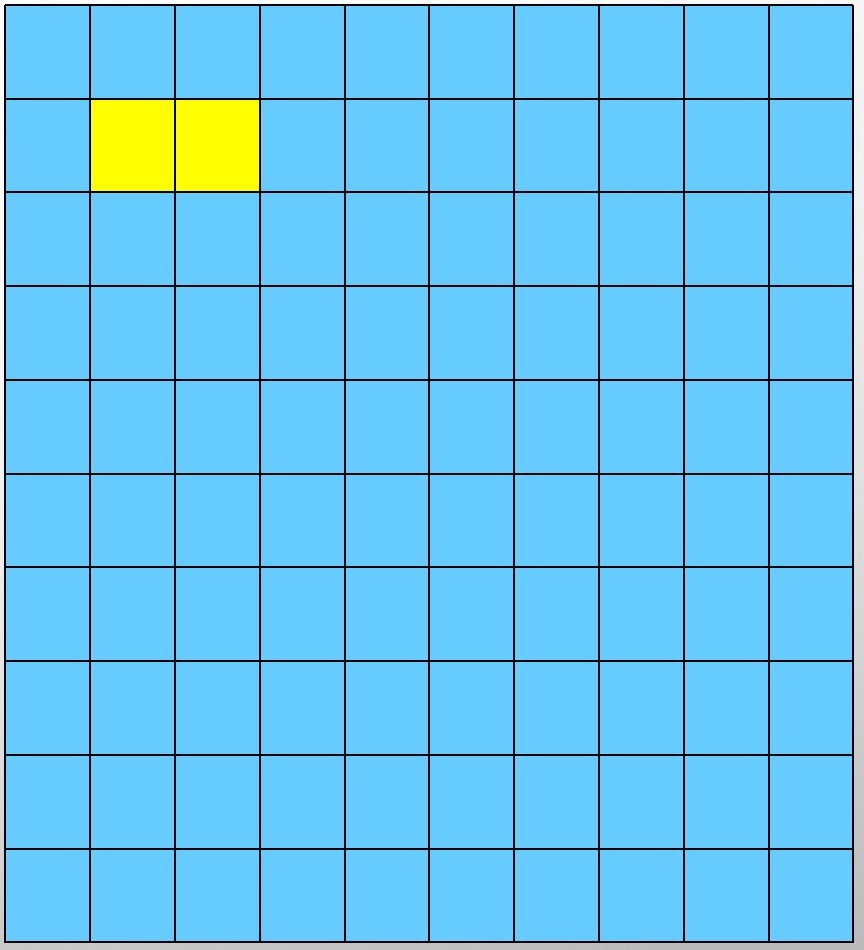
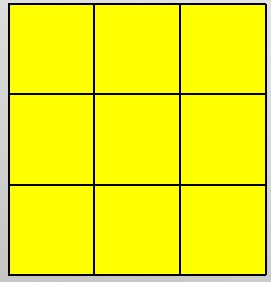
f(x, y)



R(x, y)





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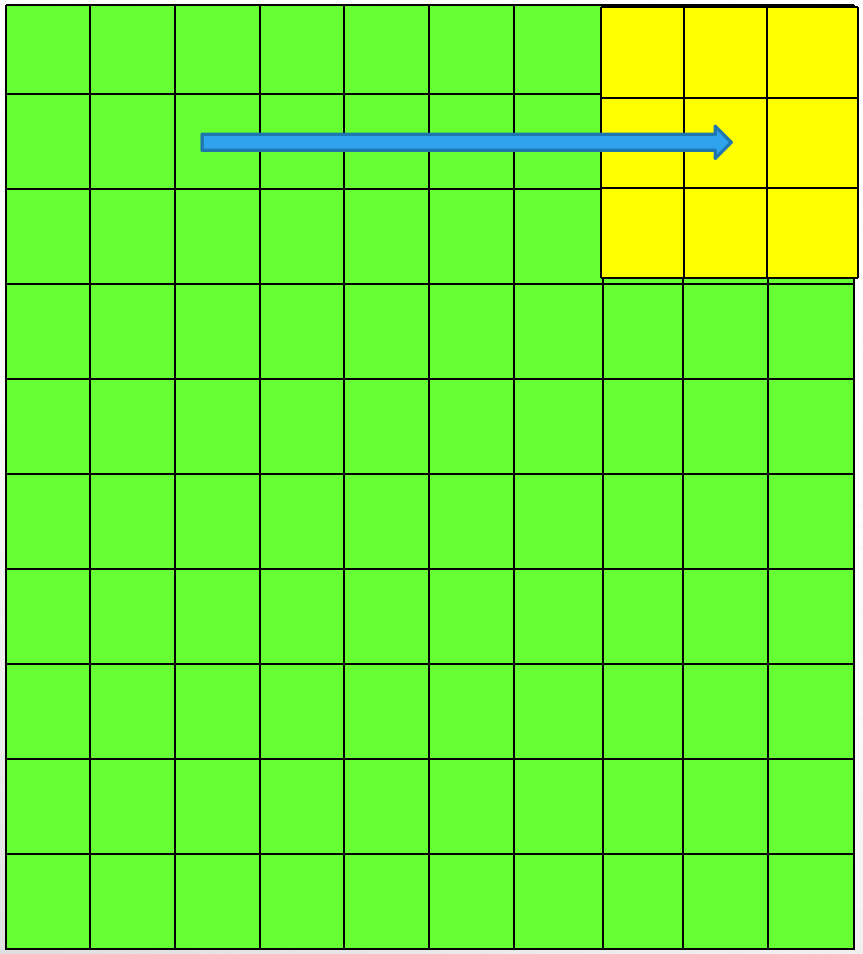
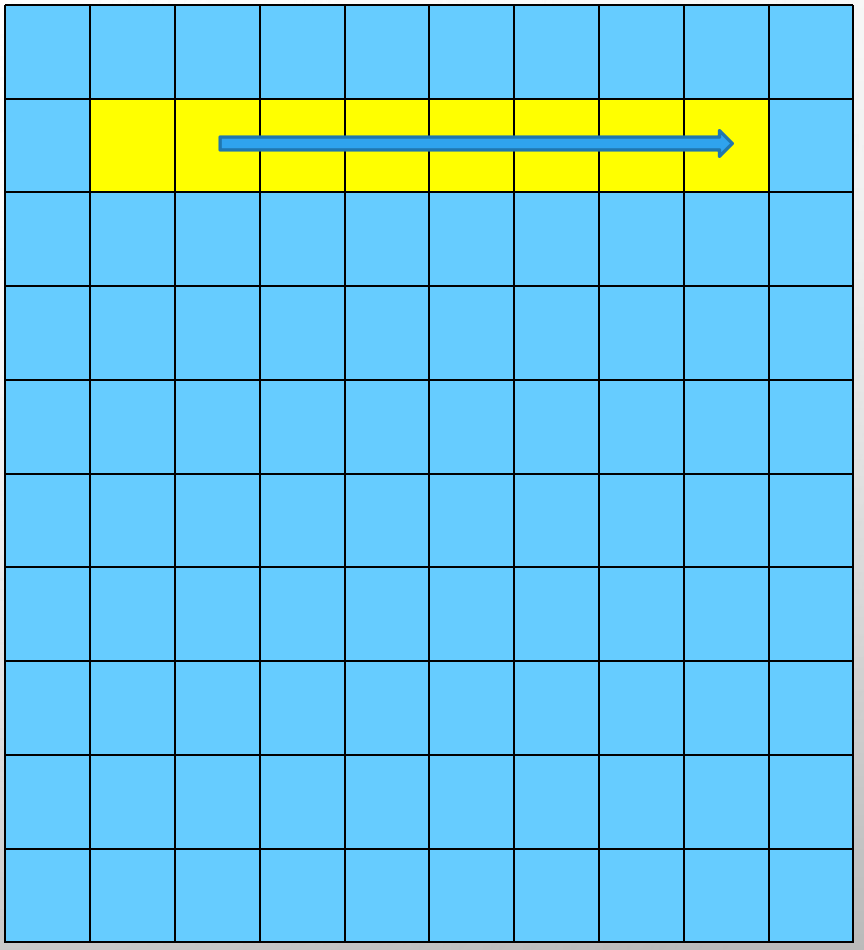
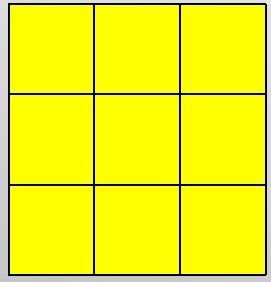
$$R = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)$$

f(x, y)



R(x, y)

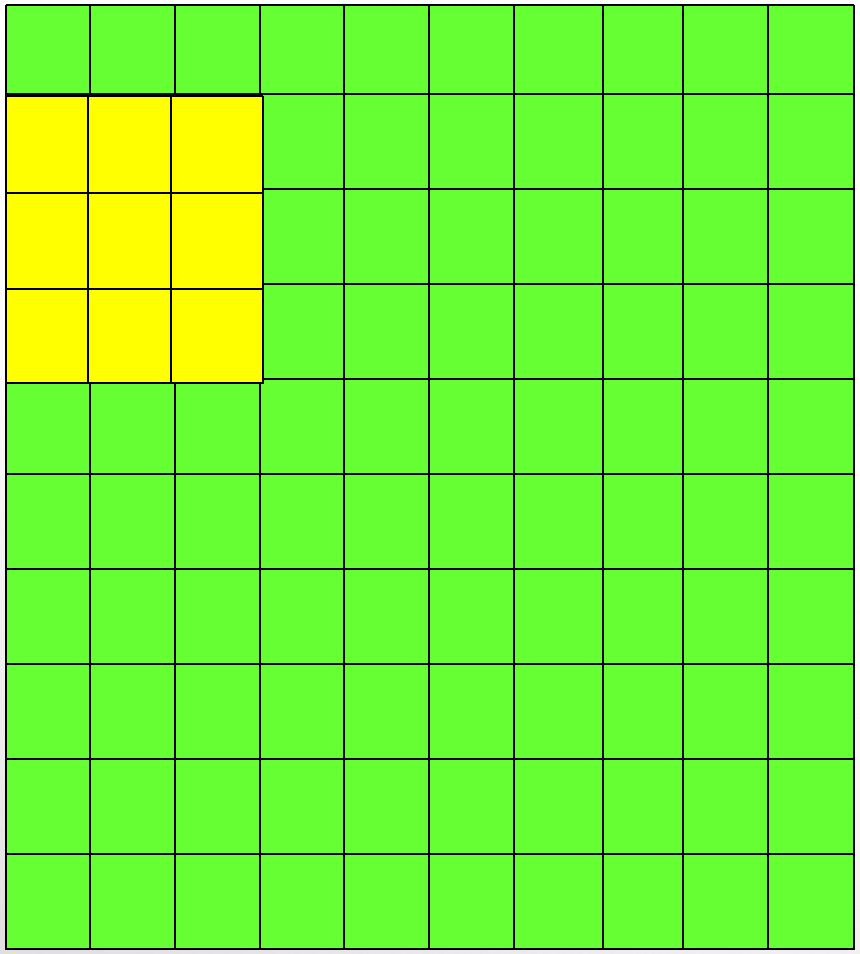




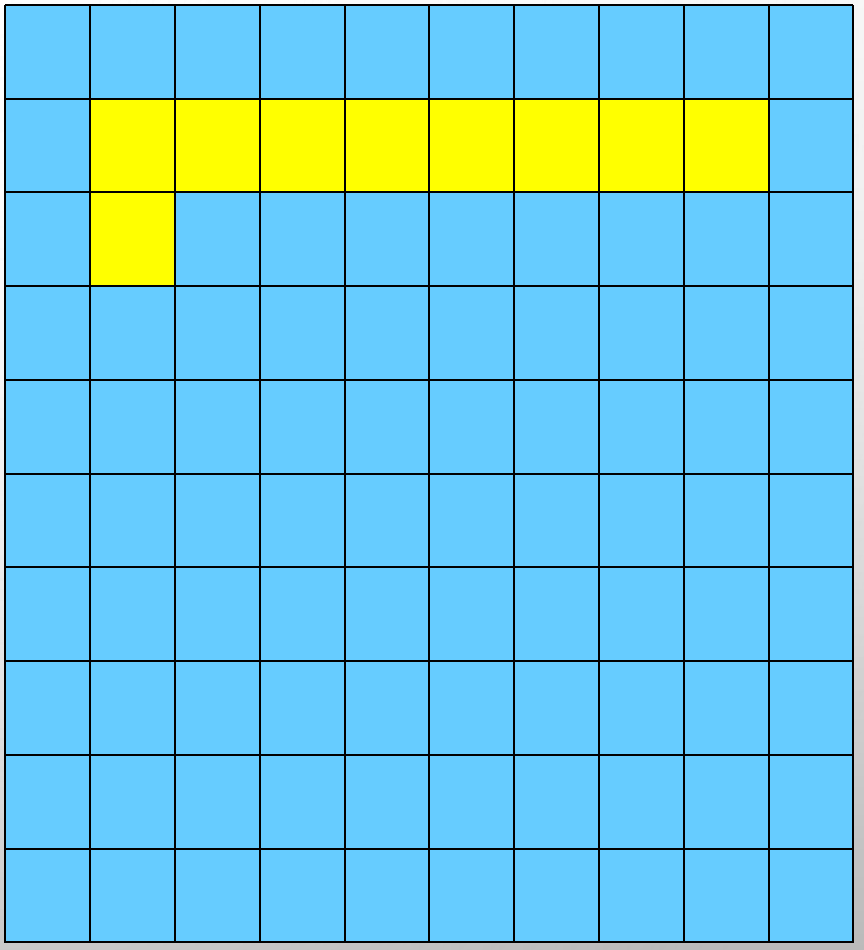
w(x, y)

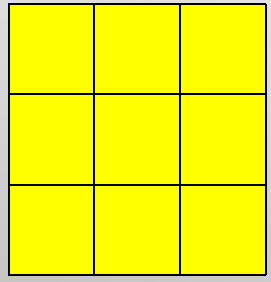
$$R = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)$$

f(x, y)



R(x, y)

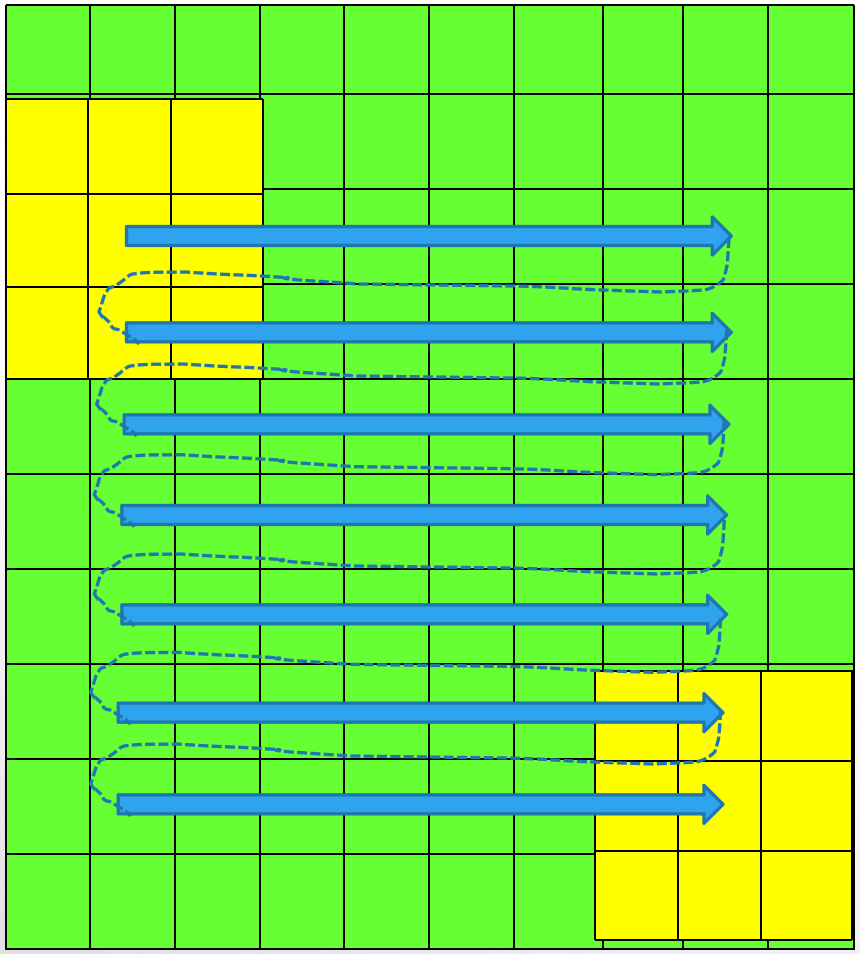




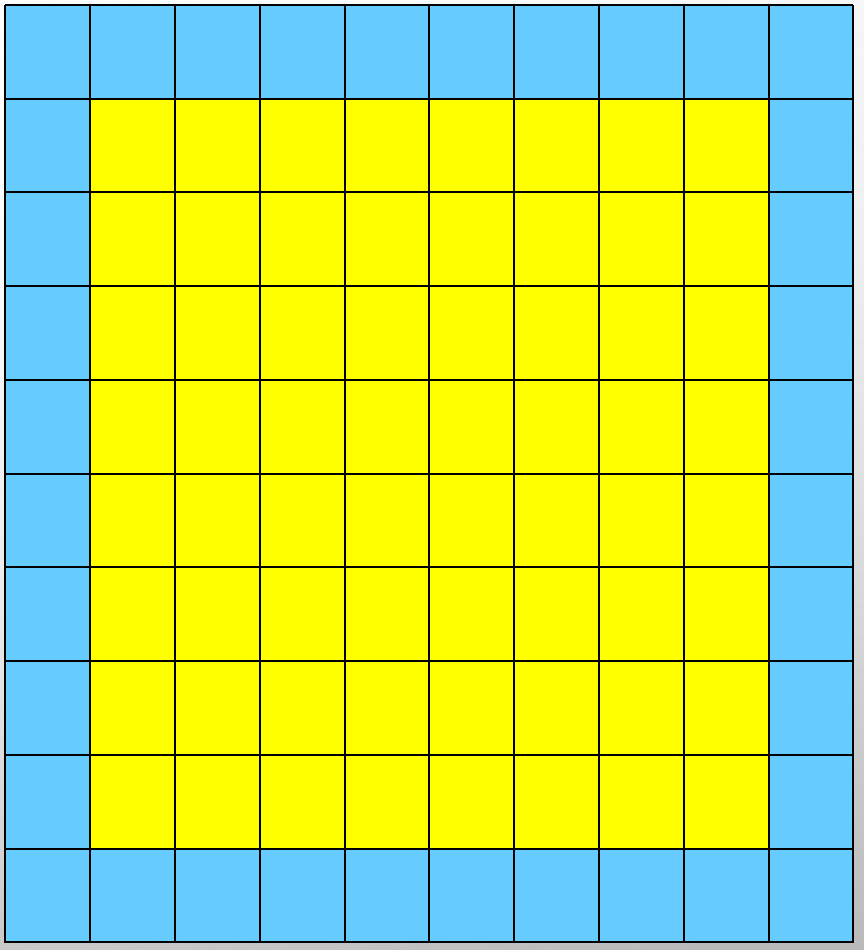
w(x, y)

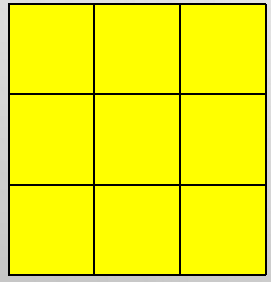
$$R = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)$$

f(x, y)

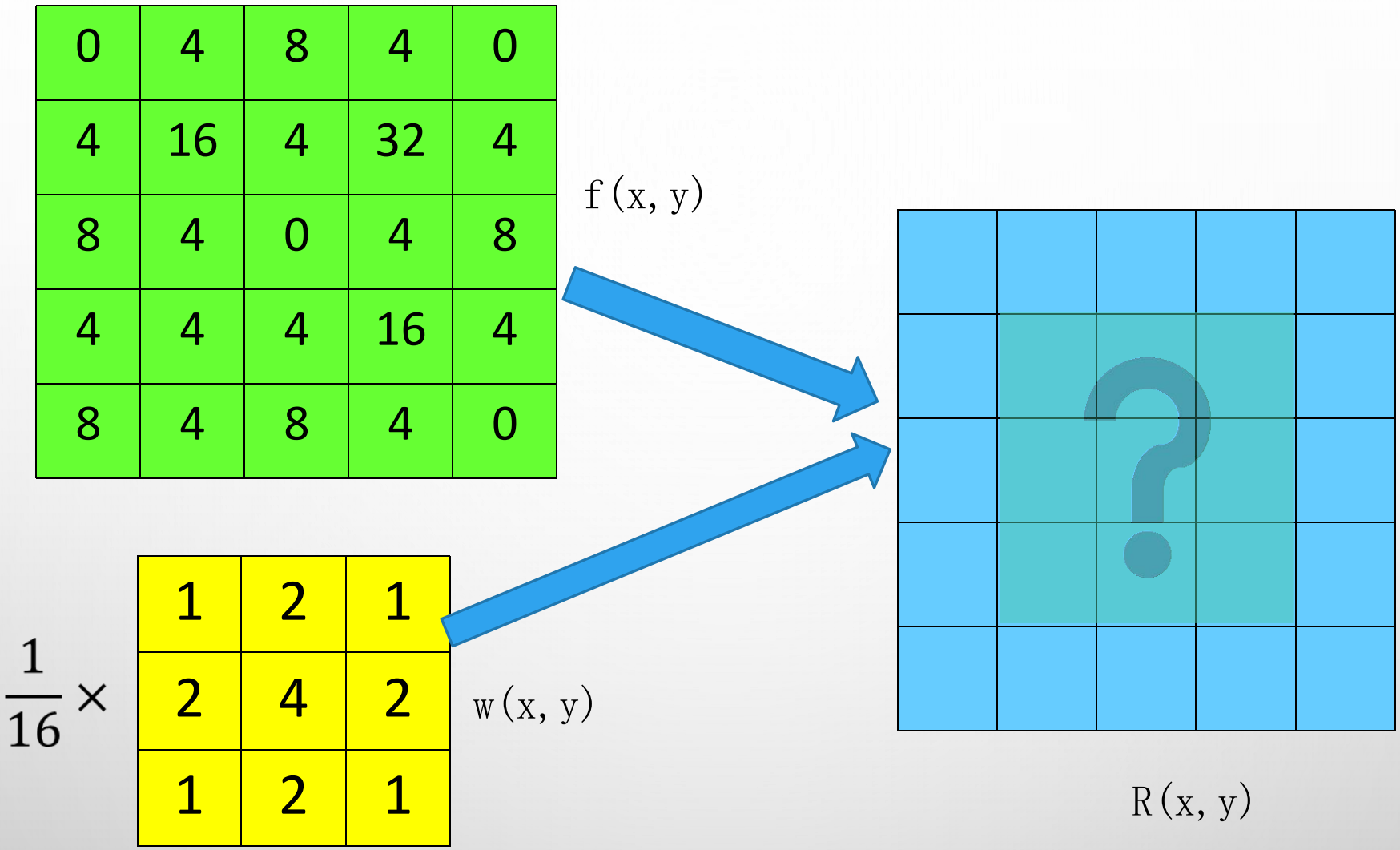


R(x, y)





w(x, y)


0 4 8 4 0
4 16 4 32 4
8 4 0 4 8
4 4 4 16 4
8 4 8 4 0
f(x, y)
1/16 ×
1 2 1
2 4 2
1 2 1
w(x, y)
?
R(x, y)

程序

（改正大小写）

```
void Spatialfilter(HXLBMPFILE *F, HXLBMPFILE *R, float *W, Int M, Int N)
{  int i,j,s,t;
   float r;
   int  A = (M-1)/2, B = (N-1)/2;

  for (j = A; j < F->imageh - A; j++)
  for (i = B; i < F->imagew - B; i++)
  {
    r = 0;
    for (s = -A; s < A; s++) for (t = -B; t < B; t++)
    r += (float)F->pDataAt(j+s)[i+t] * W[ (s + A) * M + (t + B)];
    R->pDataAt(j)[i] = (BYTE)r;
  }
  return;
}
```

线性平滑滤波器-平滑算子

$\frac{1}{9}\times$

1	1	1
1	1	1
1	1	1

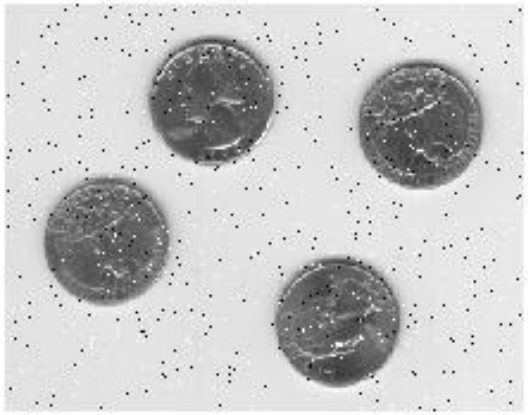
平滑滤波器模板

效果

原图像

(a)

添加椒盐噪声图像

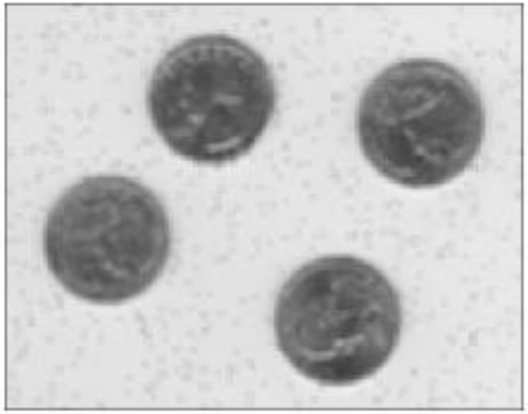


(b)

3×3模板平滑滤波

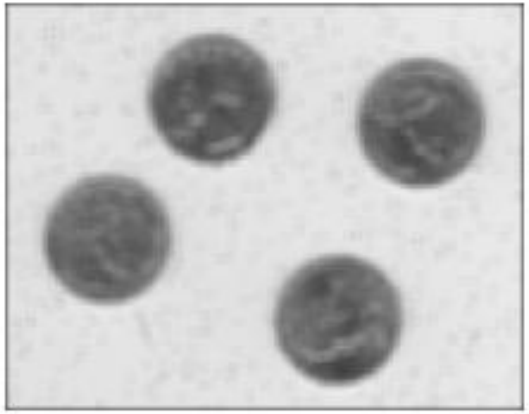
(c)

5×5模板平滑滤波



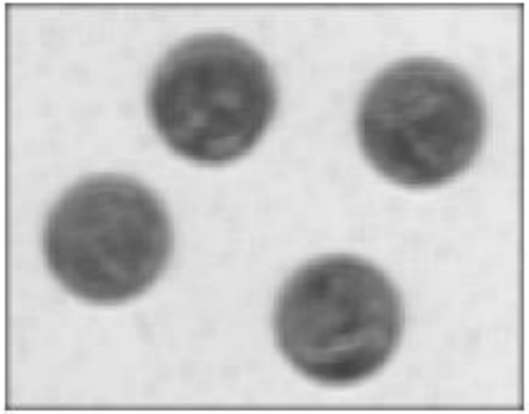
(d)

7×7模板平滑滤波



(e)

9×9模板平滑滤波



(f)

锐化滤波器-锐化算子

$f(x,y)$在(x,y)的梯度

$$G[f(x,y)]=\begin{bmatrix}G_x\\G_y\end{bmatrix}=\begin{bmatrix}\dfrac{\partial f}{\partial x}\\\dfrac{\partial f}{\partial y}\end{bmatrix}$$

其模值

$$G_M[f(x,y)]=\sqrt{G_x^2+G_y^2}=\sqrt{\left(\frac{\partial f}{\partial x}\right)^2+\left(\frac{\partial f}{\partial y}\right)^2}$$

近似梯度模值

$$G_M[f(x,y)]=|G_x|+|G_y|$$

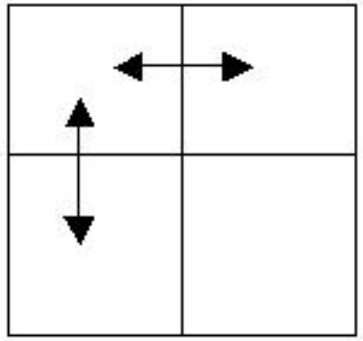
直接差分算子

G_x和G_y用近似值：

$$G_x = f(x,y) - f(x+1,y)$$

$$G_y = f(x,y) - f(x,y+1)$$

得到直接差分算子



1	0
-1	0

1	-1
0	0

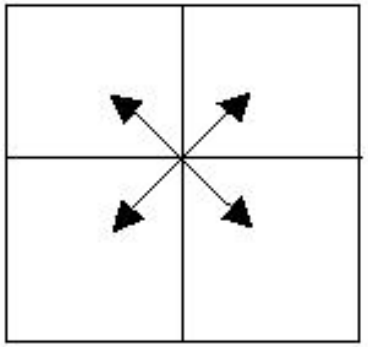
ROBERTS算子

G_x和G_y用近似值：

$$G_x = f(x,y) - f(x+1,y+1)$$

$$G_y = f(x+1,y) - f(x,y+1)$$

得到Roberts算子



1	0
0	-1

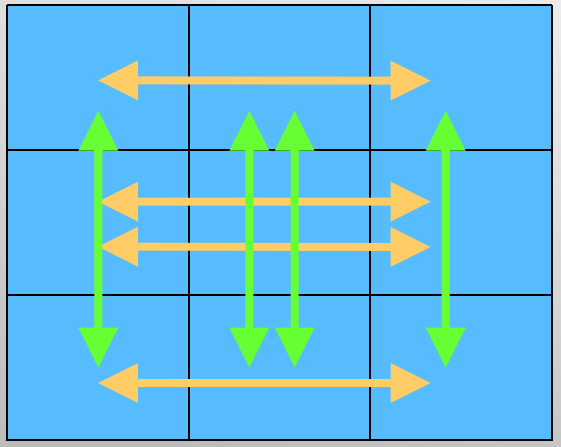
0	1
-1	0

SOBEL算子

G_x和G_y用近似值：

$$G_x = ((f(x-1,y-1)+2f(x-1,y)+f(x-1,y+1)) - (f(x+1,y-1)+2f(x+1,y)+f(x+1,y+1))$$

$$G_y = ((f(x-1,y-1)+2f(x,y-1)+f(x+1,y-1)) - (f(x-1,y+1)+2f(x,y+1)+f(x+1,y+1))$$



得到Sobel算子

1	2	1
0	0	0
-1	-2	-1

1	0	-1
2	0	-2
1	0	-1

拉普拉斯算子

$f(x,y)$在(x,y)的拉普拉斯算子为

$$\nabla^2 f = \frac{\partial^2 f}{\partial^2 x} + \frac{\partial^2 f}{\partial^2 y}$$

对数字图像

$$\nabla^2 f(x,y) = \nabla_x^2 f(x,y) + \nabla_y^2 f(x,y)$$

拉普拉斯算子

因$f(x,y)$离散，所以

$$\begin{aligned}&\nabla^2 f(x,y)\\&=[f(x+1,y)+f(x-1,y)\\&+f(x,y+1)+f(x,y-1)]\\&-4f(x,y)\end{aligned}$$

如果加上对角线元素，则

$$\begin{aligned}\nabla^2 f(x,y)=&[f(x+1,y-1)+f(x+1,y+1)\\&+f(x-1,y+1)+f(x-1,y-1)\\&+f(x+1,y)+f(x-1,y)\\&+f(x,y+1)+f(x,y-1)]-8f(x,y)\end{aligned}$$

0	1	0
1	-4	1
0	1	0

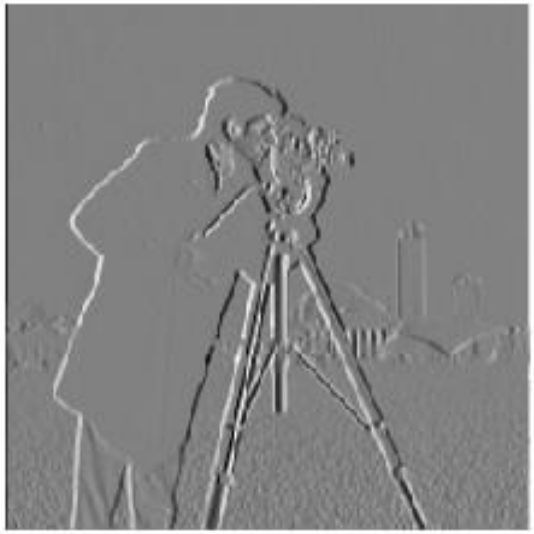
1	1	1
1	-8	1
1	1	1

拉普拉斯算子模板

梯度锐化实例

效果

a



b

c

- 图a:Cameraman原始图像，包含有各种朝向的边缘
- 图b:用Sobel水平模板，它对垂直边缘有较强的响应
- 图c:用Sobel垂直模板，它对水平边缘有较强的响应

中值滤波器

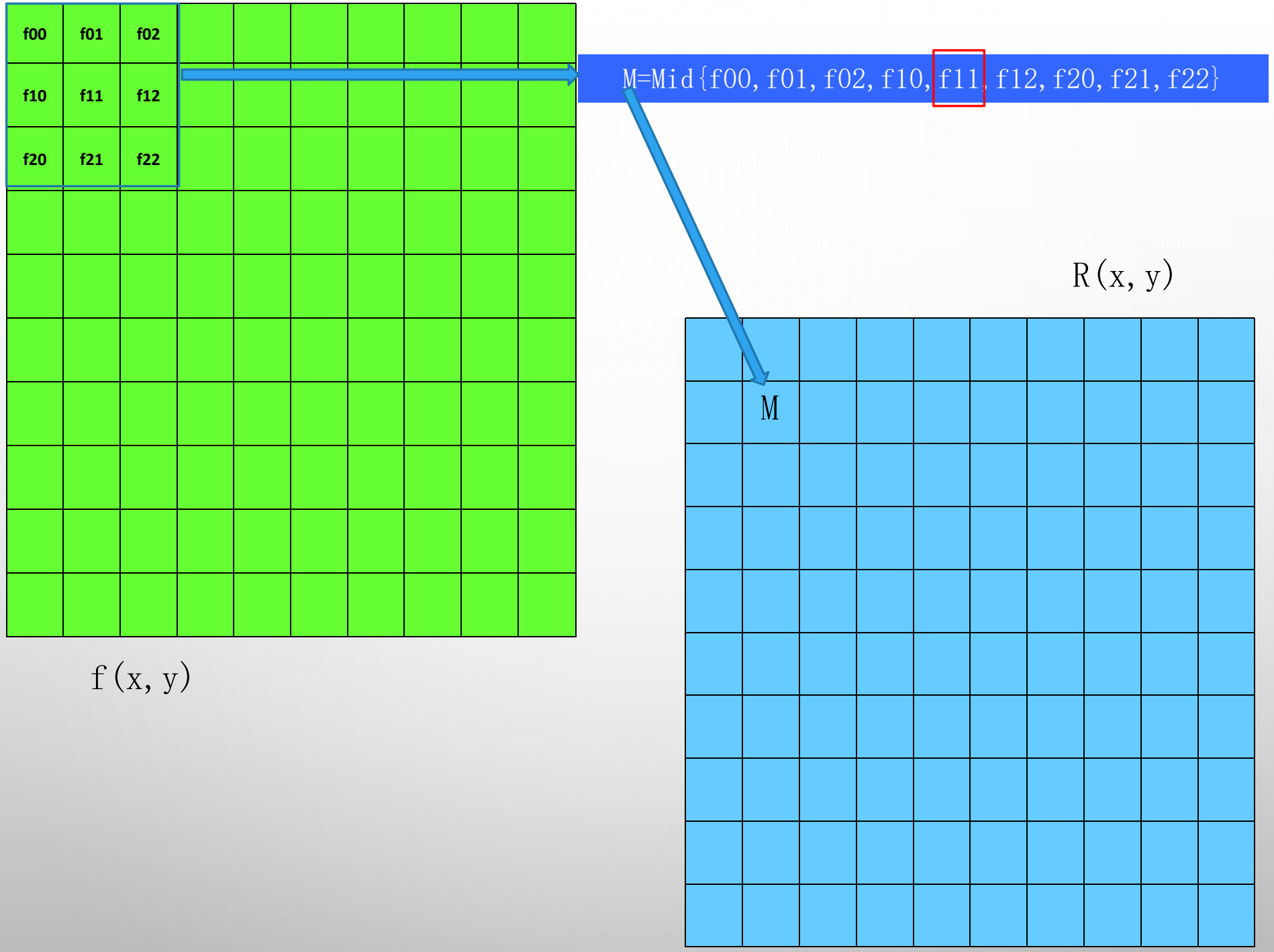
中值滤波是用一个有奇数点的滑动窗口，将窗口中心点的值用窗口各点的中值代替。具体操作步骤如下：

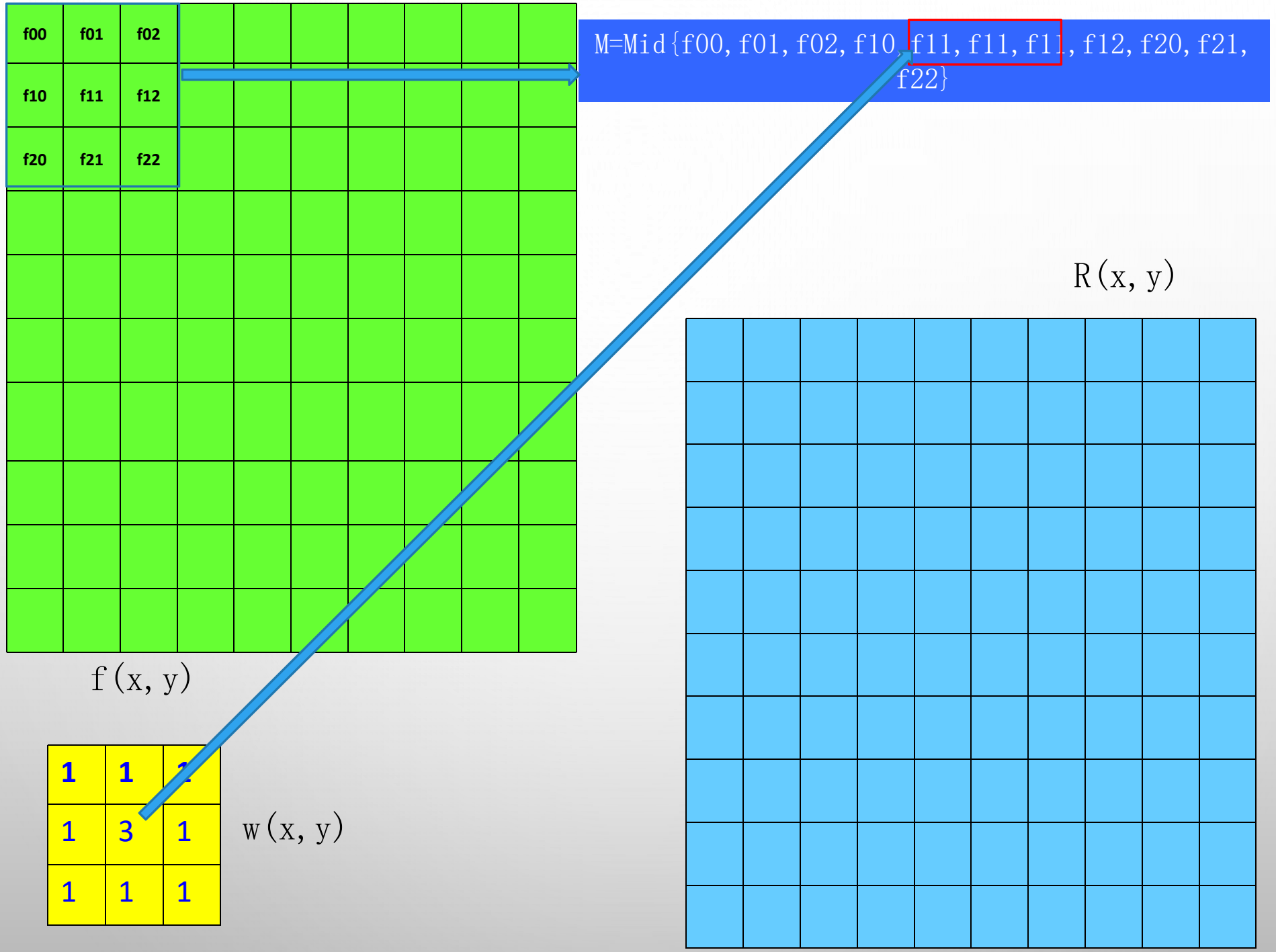
（1）将模板在图中移动，与图中某个象素位置重合。

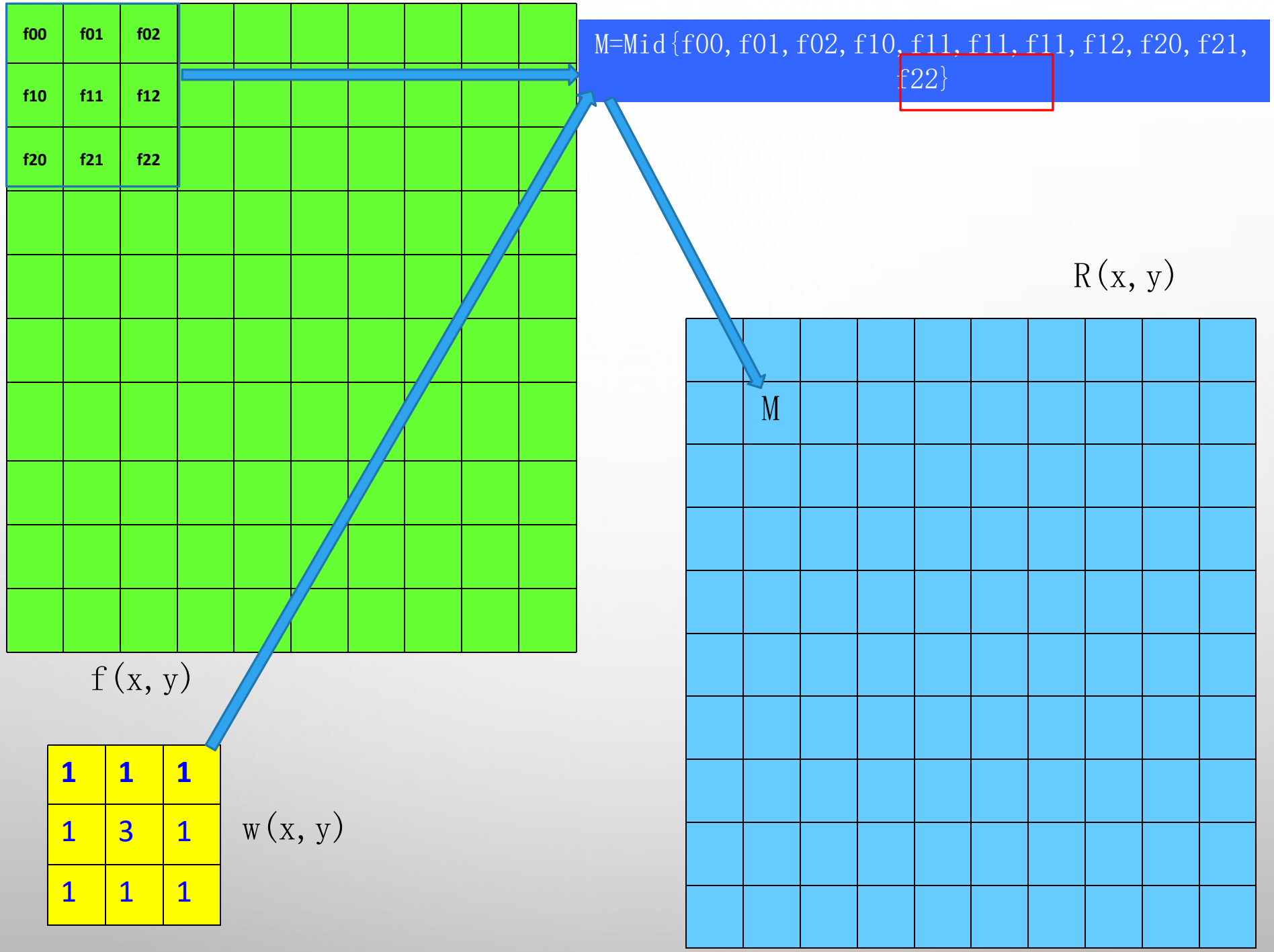
（2）读取模板下各对应象素的灰度值，并排序。

（3）将排序的中间值输出到目标图像中。

加权中值滤波：中值滤波模板中的值表示重复次数。


f00
f01
f02
f10
f11
f12
f20
f21
f22
M=Mid{f00, f01, f02, f10, f11, f12, f20, f21, f22}
R(x, y)
M
f(x, y)


f00
f01
f02
f10
f11
f12
f20
f21
f22
M=Mid{f00, f01, f02, f10, f11, f11, f11, f12, f20, f21, f22}
R(x, y)
f(x, y)
1
1
1
1
3
1
1
1
1
w(x, y)

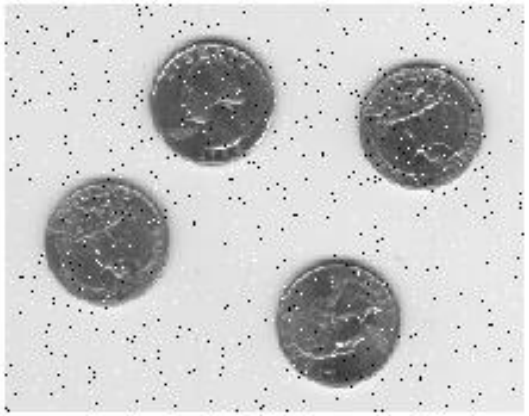

f00 f01 f02
f10 f11 f12
f20 f21 f22
M=Mid{f00, f01, f02, f10, f11, f11, f11, f12, f20, f21, f22}
R(x, y)
M
f(x, y)
1 1 1
1 3 1
1 1 1
w(x, y)

效果

原图像

(a)

添加椒盐噪声图像



(b)

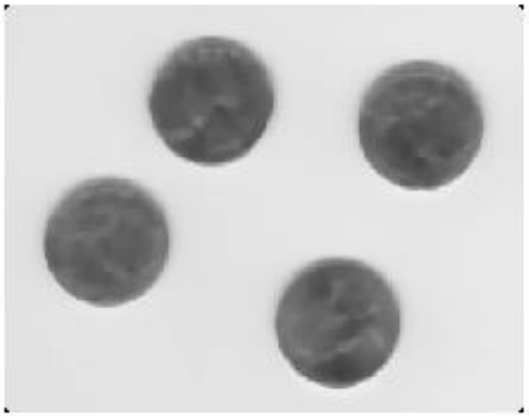
3×3模板中值滤波

(c)

5×5模板中值滤波

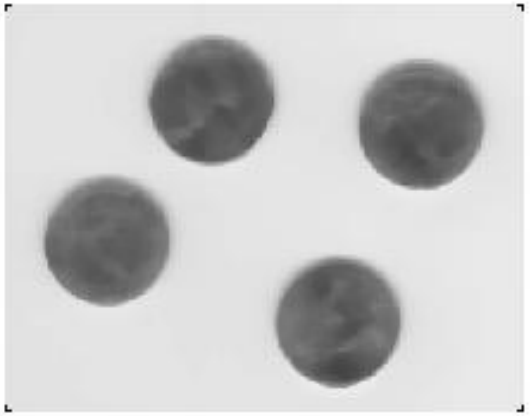
(d)

7×7模板中值滤波



(e)

9×9模板中值滤波



(f)

程序？