

### Bailstone method

Sum of all  
submatrices  
of a

given  
matrix

$$\begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \rightarrow 4 \text{ submatrices} - (1 \times 1) \rightarrow 4 \times 1$$

$$\begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \rightarrow 2 \text{ submatrices} \rightarrow (1 \times 2)$$

$$(2 \times 2) = 2 \times 2 = 4$$

$$\begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \rightarrow 2 \text{ submatrices} - (2 \times 1)$$

$$= 2 \times 2 = 4$$

contributing

$$\begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \rightarrow 1 \text{ submatrix} - (2 \times 2)$$

→ 1 × 4 = 4

→ 1 × 4 = 4

(16)

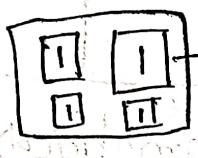
16 is the sum of all  
possible submatrices of a  
given matrix.

## Brute-force method

Sum of all  
Submatrices

of a  
given  
matrix

(1)	1
1	1



→ 4 Submatrices -  $(1 \times 1) \rightarrow 4 \times 1$

→ 2 Submatrices  $\rightarrow (1 \times 2)$

~~$(2 \times 2)$~~  =  $2 \times 2 = 4$

→ 2 Submatrices  $(2 \times 1)$

$= 2 \times 2 = 4$

contributing

1	1
1	1

→ 1 submatrix  $(2 \times 2)$

$\rightarrow 1 \times 4 = 4$

16 is the sum of all  
possible Submatrices of a  
given matrix.

16

1	2	3	4
1	2	3	4
2	3	4	5
3	4	5	6

(a) Extracting all possible submatrices

Submatrices

Submatrix can be

considered  
a rectangle  
this information will help in  
co-ordinate system.

(a)

No need of all the submatrices

subset

subset

→ Uniquely identifying a rectangle.

- ↳ Top — left corner
- ↳ Bottom — right corner

Top

0	(0,0)		
1			
2			
3			(2,3)

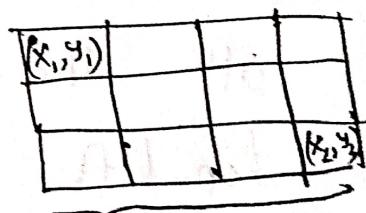
Easily extract the length and breadth of the rectangle.

Suppose, Top-left Co-ordinate  $(x_1, y_1)$

Bottom-right Co-ordinate  $(x_2, y_2)$

length is  $(y_2 - y_1 + 1)$

breadth is  $(x_2 - x_1 + 1)$



we get area

we can draw the rectangle.

To find a rectangle we just need top left bottom right.

### All possible

pair



( $x, y$ )

( $x, y$ )

{ L<sub>T</sub>, B<sub>R</sub>, y }

if we define all those

pairs

extract

submatrices

coordinates

$(x, y)$  to define

all the possible

$(x, y)$  coordinates to

top-left

possible

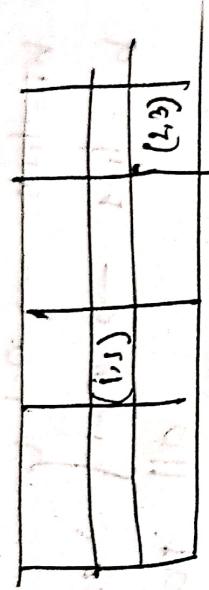
bottom right

all the define

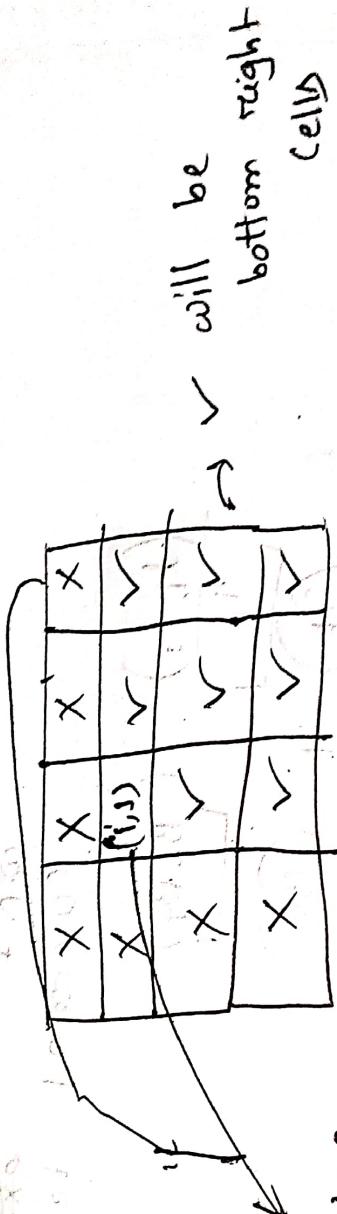
bottom

right

\* Top-left for coordinates will be  
earlier than  $\rightarrow$  Bottom-right  
of Co-ordinates



Initial position  $(i,j) < (2,3)$



$\rightarrow$  will be bottom-right cells

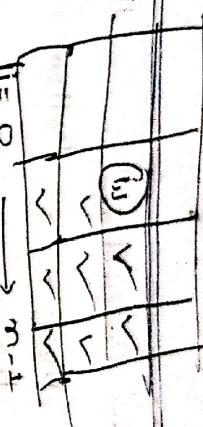
Bottom-right moves later than  
because all other

top-left index

$(i,j) \rightarrow T.L \rightarrow 0 \rightarrow end$

$B \pi \rightarrow i \rightarrow end$

$j \rightarrow end$



for

$i = 0$

$\rightarrow m-1$

extract all possible top left

for

$b_i = l_{i+1}$

$\rightarrow m-1$

extract all possible

for

$b_j = l_{j+1}$

$\rightarrow m-1$

extract all possible

for

$b_k = l_{k+1}$

$\rightarrow m-1$

extract all possible

for

$b_l = l_{l+1}$

$\rightarrow m-1$

extract all possible

for

$b_m = l_{m+1}$

$\rightarrow m-1$

extract all possible

for

$b_n = l_{n+1}$

$\rightarrow m-1$

extract all possible

for

$b_o = l_{o+1}$

$\rightarrow m-1$

extract all possible

for

$b_p = l_{p+1}$

$\rightarrow m-1$

extract all possible

for

$b_q = l_{q+1}$

$\rightarrow m-1$

extract all possible

for

$b_r = l_{r+1}$

$\rightarrow m-1$

extract all possible

for

$b_s = l_{s+1}$

$\rightarrow m-1$

extract all possible

for

$b_t = l_{t+1}$

$\rightarrow m-1$

extract all possible

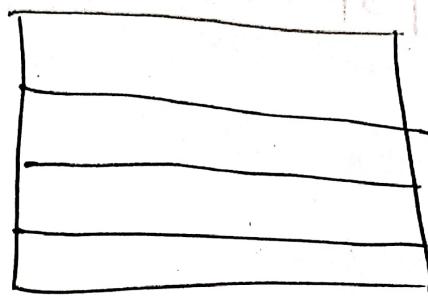
Y

Sum = arr[i][j]

such matrix

→ 2nd  
method

sum



	0	1	2
0	a	b	c
1	d	e	f
2	g	h	i

for  $i \rightarrow 0 \rightarrow n-1$

1	2	3	4	5
---	---	---	---	---

sum of a given sub-array

prefix				
sum				
1	2	3	4	5
1	3	6	10	15

$$15 - 3 + 2$$

$$= 15 - 1$$

$$= 14$$

$$\begin{array}{|c|c|c|} \hline & 15 & 6 & 3 \\ \hline & 15 & 12 & 9 \\ \hline \end{array}$$

Prefix  $\Rightarrow$  sum matrix

$$15 - 3 + 2 = 14$$

Prefix  $\Rightarrow$  sum matrix

Prefix  $\Rightarrow$  sum matrix

Prefix

a	b	c
d	e	f
g	h	i
j	k	l

a	a+b	a+b+c
d	d+e	d+e+f
g	g+h	g+h+i

a	a+b	a+b+c
a+d	a+b+d+e	a+b+c+d+e+f
a+d+g	a+b+d+e+g	a+b+c+d+e+f+g+h+i
		B.P

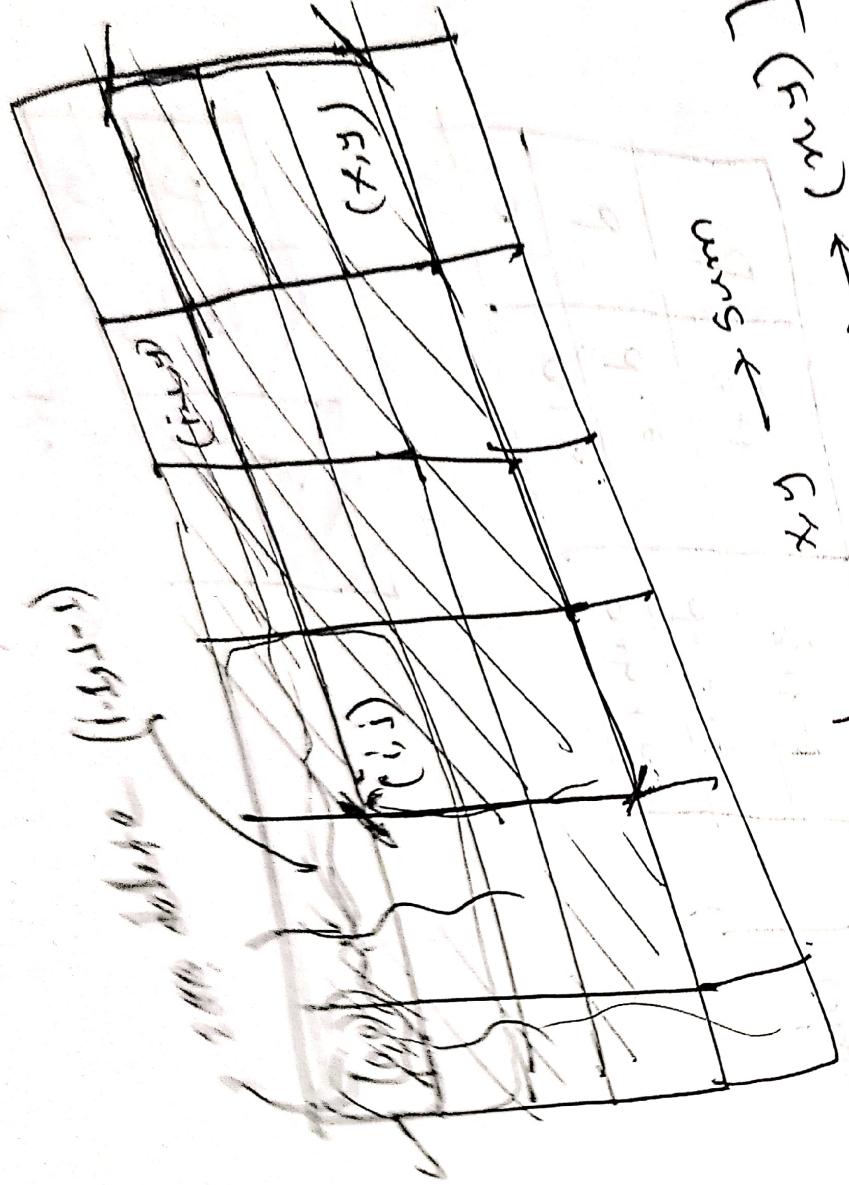
row wise  
column wise

row wise

row wise  
column wise

$$TC = d + e + d + f + g + h + i$$

$$BP = d + b + c + d + b + c + d + e + f + g + h + i$$
$$BP - TL = (c + g + h + i)$$



cell  
Duplicat  
divide.  
we  
old  
old  
new

$x, y \rightarrow \text{sum}[0, 0]$   
 at  $(x, y) \rightarrow (0, 0)$   
 value  $\downarrow$   
 $(i-1, j) \rightarrow \text{sum}[0, 0]$   
 at  $(x, y) \rightarrow (i-1, j)$   
 value  $\downarrow$   
 $(x, y-1) \rightarrow \text{sum}[0, 0]$   
 at  $(x, y-1) \rightarrow (x, y-1)$   
 value  $\downarrow$   
 $(i-1, j-1) \rightarrow \text{sum}[0, 0]$   
 at  $(i-1, j-1) \rightarrow (i-1, j-1)$   
 value  $\downarrow$   
 $\boxed{y - p \rightarrow Q + P}$   
 $\downarrow$   
 $\boxed{\text{sum}[0, 0]}$   
 all  $\downarrow$   
 $\text{sum}[0, 0] \rightarrow \text{def } L$   
 $L \rightarrow \text{def } R$   
 $R \rightarrow \text{def } Q$

for  $i = 0 \rightarrow n-1$  Prefix sum matrix

{ for  $j = 0 \rightarrow n-1$   $\alpha$

{ for  $B_i = q_i \rightarrow n-1$

$\beta$

for  $B_j = j - n-1$

$\gamma$

$\text{pre}[B_i][B_j] = \text{pre}[B_{i-1}][B_j]$

$\rightarrow \text{sum } \beta^+ =$

$\text{pre}[B_i][L_{j-1}] + \text{pre}[L_i][B_j]$

Extract  $\beta^+$

$\delta$

$\epsilon$

$\zeta$

$\Theta(n^4)$

$\alpha$   
 $\beta$   
 $\gamma$   
 $\delta$   
 $\epsilon$   
 $\zeta$

$\eta$

$\vartheta$

$\varphi$

$\psi$

$\chi$

$\psi$

$\omega$

$\nu$

$\mu$

$\lambda$

$\rho$

$\sigma$

$\tau$

$\pi$

$\omega$

$\nu$

$\mu$

$\lambda$

$\rho$

$\sigma$

$\tau$

$\pi$

$\omega$

$\nu$

$\mu$

$\lambda$

$\rho$

$\sigma$

$\tau$

$\pi$

$\omega$

10 2 0  
5 2  
10 4  
6

10 30  
5 2  
10 5  
60  
35  
12

10 30  
5 2  
60  
95  
45  
15  
51  
17

1	6	9	9	16	21	28	30
1	5	3	0	7	5	7	2

(5,0)

X	5	6	5
9	3	4	X
X	8	=	
2	5	8	0
-	6	3	6

٣

٦٣

A simple line drawing of a house with a gabled roof and a chimney on the left side. A horizontal line extends from the left side of the house. In front of the house is a circular area with a cross inside, representing a garden. The entire drawing is done in black ink on white paper.

→

Optimistic

0	a	b	c	
1	d	e	f	
2	g	h	i	

⇒

a	b	c	
d	e	f	
g	h	i	

$$\begin{aligned} & (e+f+h+i) \\ & + (d+e+f) \\ & + (b+c+h) \\ & + (- - -) \end{aligned}$$

② Every Element will be a part of  
more than 1 submatrix  
#

In each submatrix, the

element will be contributing  
for the sub

$\Rightarrow$  we just find the Conculation calculate at the Concilation.

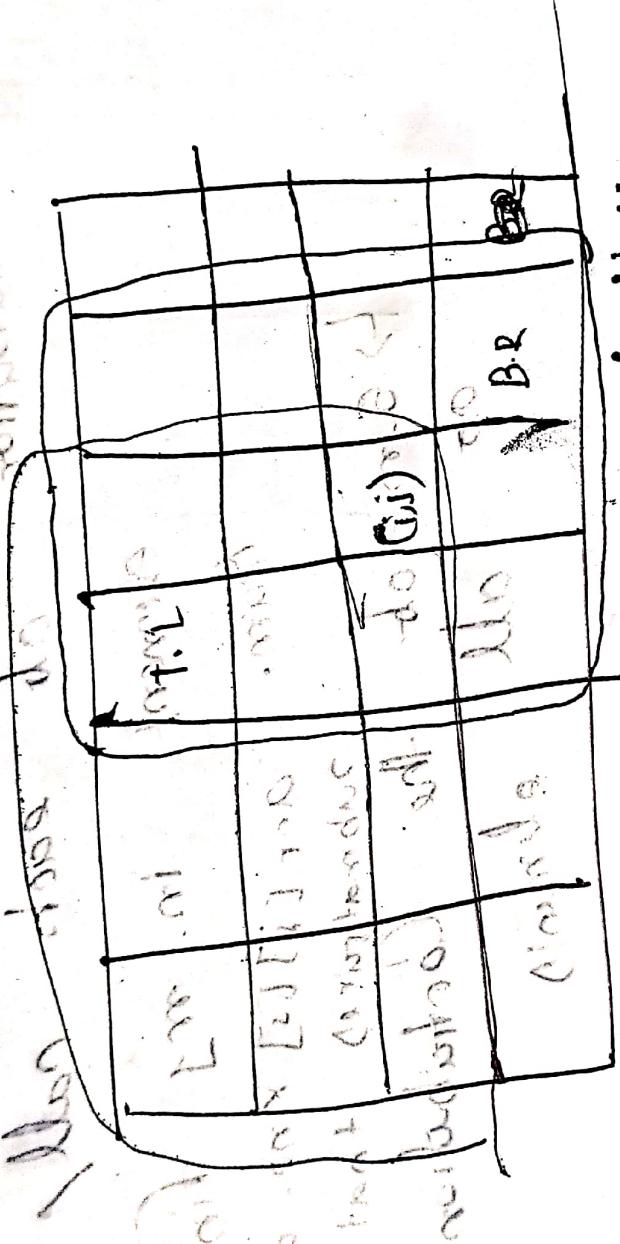
Contribution of each element to sum = sum of all ob.

ob each call/  
element in my final  
sum = array [ ] x no. ob  
submitted that will be part  
of the contribution  
all elements

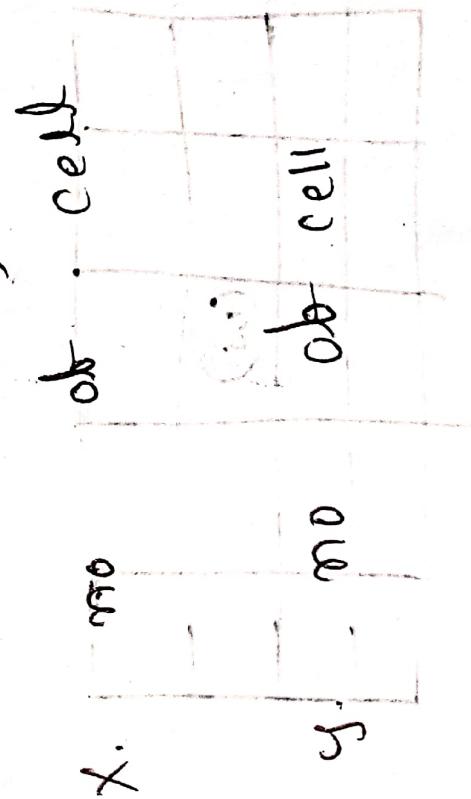
A hand-drawn grid consisting of four horizontal rows and three vertical columns, creating twelve rectangular cells. The word "ذري" (zahrī) is written vertically in the middle column, with the first letter "ذ" at the top and the last letter "ي" at the bottom. The entire grid is drawn with black ink on white paper.

If all the cell, when made  
red  
will have (i,j)  
T.L

A white  
cell



in the  
white  
area.



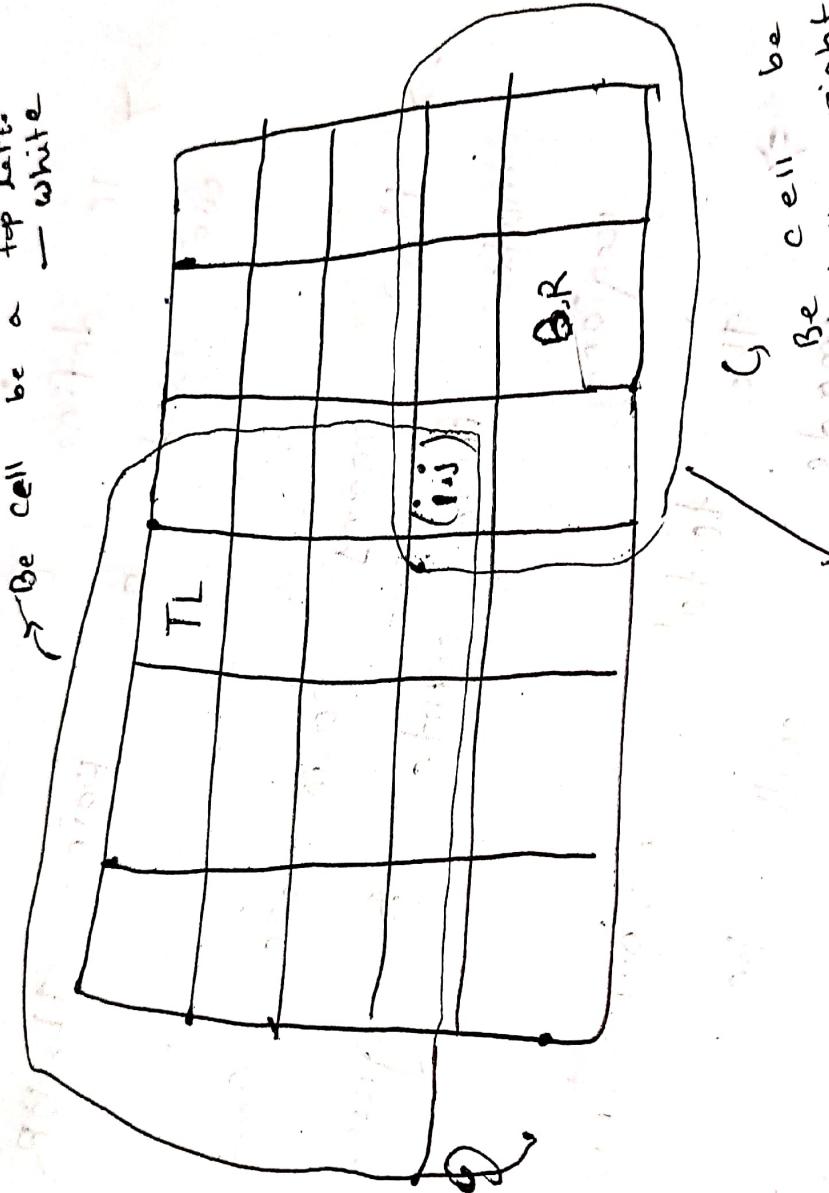
in the  
green  
area

To define a submatrix we  
need a  
pair

(TL, BR)

qq, a number.  
00-000 Drawn.  
200  
800  
→ 90°  
qq a bottom.

Be cell be a top left white



all the cell, when made a  
BR, when have a (i,j)  
↳ green

$\times$  mo cell in the white area  
y mo cell in the green area

⇒ To define a sub matrix;  
we need a pair, TL, BR

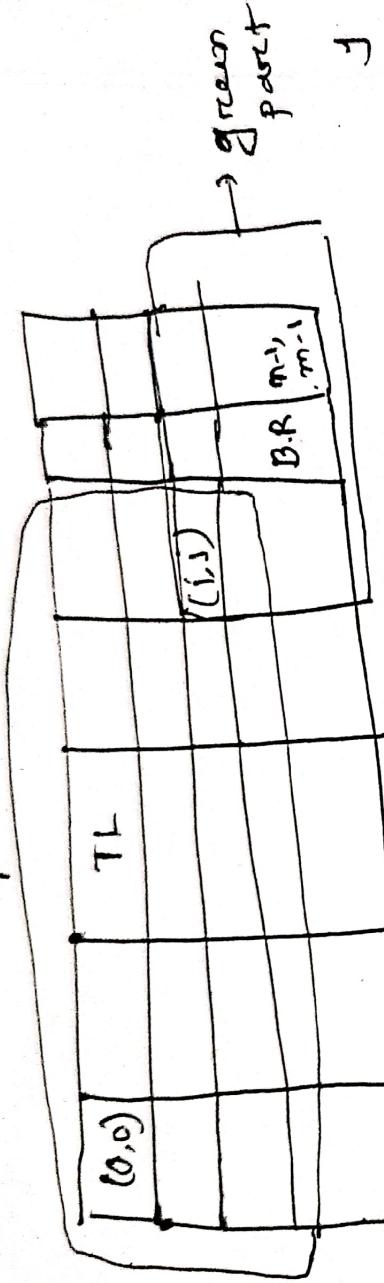
⇒ How many pairs we can make from white & green region.

⇒ The total submatrix made will be  $(x * y)$   
 $\rightarrow (i, j)$  is present.

-> starting indexing from (0,0)

$\delta =$

white part  $\times$



$n = (i+1) * (j+1)$   
row  
columns

$y = (m-i) * (n-j)$   $O(m^2)$

for  $i = 0$   $\rightarrow$   $m-1$   $\rightarrow$  Contribution  
for  $j = 0$   $\rightarrow$   $n-1$   $\rightarrow$   $(i,j)$  in my sum  
Sum += arr[i][j] \* [ (i+1) \* (j+1) ]  
 $\times (m-i) (n-j)$   
value of cell  $y_{m \times n}$  ob

will be  
part of  
sub matrices  
 $\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$  = 4  
 $\frac{1}{2} \cdot 2 \cdot 2 = 4$

$$= 4 + 4 + 4 + 4$$