

# NTUST OOP Midterm Problem Design

**Subject: Convolution**

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**Main testing concept:**

**Basics**

- C++ BASICS
- FLOW OF CONTROL
- FUNCTION BASICS
- PARAMETERS AND OVERLOADING
- ARRAYS
- STRUCTURES AND CLASSES
- CONSTRUCTORS AND OTHER TOOLS
- OPERATOR OVERLOADING, FRIENDS, AND REFERENCES
- STRINGS
- POINTERS AND DYNAMIC ARRAYS

**Functions**

- SEPARATE COMPILATION AND NAMESPACES
- STREAMS AND FILE I/O
- RECURSION
- INHERITANCE
- POLYMORPHISM AND VIRTUAL FUNCTIONS
- TEMPLATES
- LINKED DATA STRUCTURES
- EXCEPTION HANDLING
- STANDARD TEMPLATE LIBRARY
- PATTERNS AND UML

**Description:**

Recently ChatGPT is very popular, especially the new generation version 4.0, which is different from the previous generation in that it can read picture information. In artificial intelligence, there are many ways to give neural network pictures information, and well-known methods such as CNN obtain picture features through a series of convolutions. The following formula is convolution:

$$O[m, n] = I[m, n] \otimes K[m, n] = \sum_{j=-\infty}^{\infty} \sum_{i=-\infty}^{\infty} I[i, j] \times K[m - i, n - j]$$

I is the input, K is the kernel, O is the output, If the kernel setting size is 3, the value will be a, b, ..., i. Note that when doing 2-dimensional convolution, the kernel needs to be flipped and then multiplied by the overlapping part of the input. Suppose you want to calculate  $O[1, 1]$ , then the answer will be  $I[0, 0] \times i + I[1, 0] \times h + \dots + I[2, 2] \times a$ .

a	b	c
d	e	f
g	h	i

Figure 1. A  $3 \times 3$  kernel

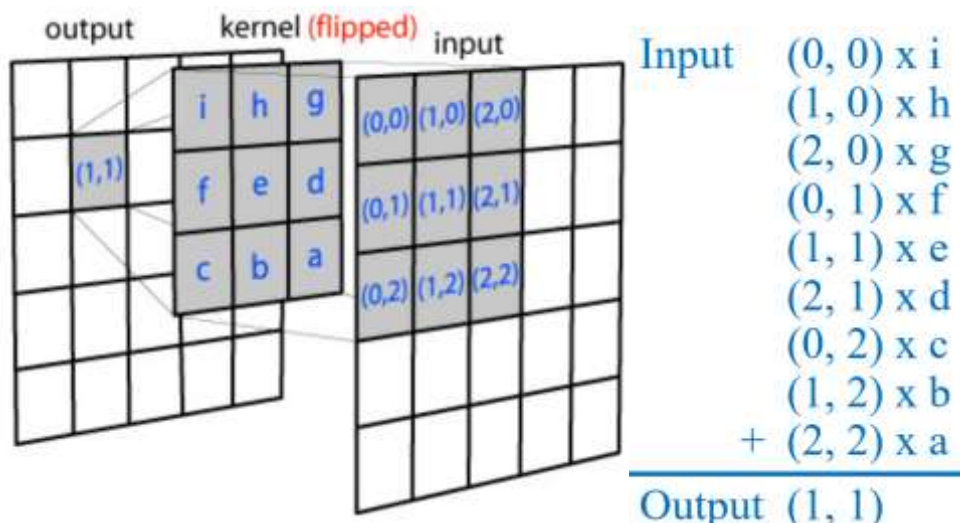


Figure 2. Calculating the value of output (1, 1)

If it accesses out of range of the input during the calculation process, it will be filled with 0 as padding. **In this problem, we will give you  $M \times N$  input and  $K \times K$  kernel. You have to calculate  $M \times N$  output.**

### Input:

You can use standard input to test your code. First, we input  $M$ ,  $N$ , and  $K$ . The  $M$  and  $N$  value range is 3 to 100, and  $K$  is an odd number from 3 to 9. Next, the  $K \times K$  integer  $K_{ij}$  is the kernel for convolution, separated by spaces. Afterward, we will input  $M \times N$  integers  $I_{ij}$  in the range  $0 \leq I_{ij} \leq 255$ , separated by spaces.

```
M N K
K11 K12 ... K1K
K21 K22 ... K2K
...
KK1 KK2 ... KKK
I11 I12 ... I1N
I21 I22 ... I2N
...
IM1 IM2 ... IMN
```

### Output:

Please print  $M \times N$  result as output and note the space after the last number.

```
O11 O12 ... O1N
O21 O22 ... O2N
...
OM1 OM2 ... OMN
```

### Sample Input / Output:

Sample Input	Sample Output
7 7 3	0 0 0 0 0 0 0
-1 -2 -1	0 -1 -4 -8 -8 -3 0
0 0 0	0 -4 -13 -20 -17 -6 0
1 2 1	0 -6 -18 -24 -18 -6 0
0 0 0 0 0 0 0	0 4 13 20 17 6 0
0 0 0 0 0 0 0	0 7 22 32 26 9 0
0 0 1 2 3 0 0	0 0 0 0 0 0 0
0 0 4 5 6 0 0	
0 0 7 8 9 0 0	
0 0 0 0 0 0 0	
0 0 0 0 0 0 0	

- ☐ **Eazy**, Only basic programming syntax and structure are required.
- ☒ **Medium**, Multiple programming grammars and structures are required.
- ☐ **Hard**, Need to use multiple program structures or more complex data types.

### Expected solving time:

20 minutes

### Other notes: