CSC 211: Object Oriented Programming
Multidimensional Arrays

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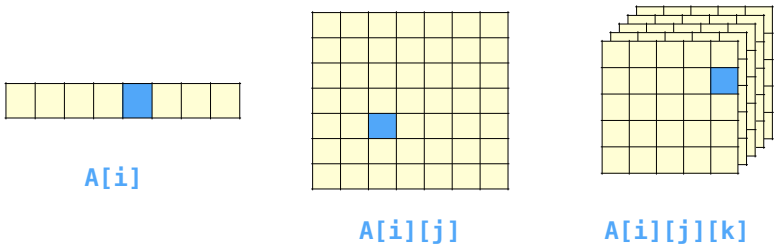
THINK BIG WE DO℠

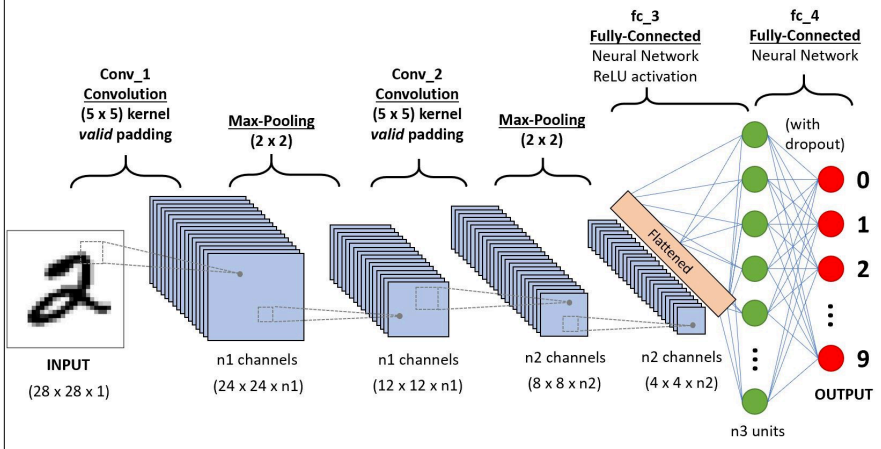
Arrays, of any dimension, are statically allocated in memory with a size calculated at compile time. That is, their size is **fixed** and **cannot** be changed later.

Multidimensional Arrays

- Generalization of **arrays** to multiple dimensions
  - e.g. matrices, tensors
- Each element can be accessed using its corresponding **indices**



Modern machine learning

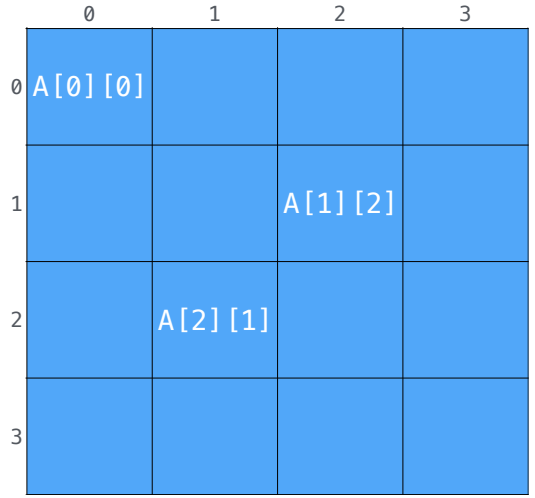


https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53

Declaration of 2D arrays

```
// array declaration by specifying size
int matrix1[10][10];

// can also declare an array of
// user specified size
int n = 8;
int matrix2[n][n];

// can declare and initialize elements
double matrix3[2]
[2] = { {10.0, 20.0}, {30.0, 40.0} };
```


Indexing 2D arrays



Indexing 2D arrays

- Individual elements can be accessed by using the **subscription operator [ ]**

1	2	3
4	5	6
7	8	9

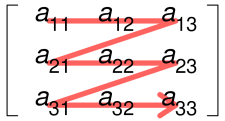
```
int matrix2[3][3];

for (int i = 0 ; i < 3 ; i ++) {
    for (int j = 0 ; j < 3 ; j ++) {
        matrix[i][j] = (j + 1) + i * 3;
    }
}
```


How are these arrays stored in memory?

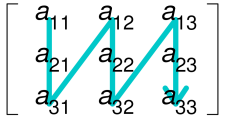
- In computing, **row-major** order and **column-major** order are two methods for storing multidimensional arrays as contiguous blocks of memory
  - row-major order is used in C, C++, Objective-C (for C-style arrays), PL/I, Pascal, Speakeasy, SAS, …
  - column-major order is used in Fortran, MATLAB, GNU Octave, S-Plus, R, Julia, …
- Alternatively, neither row-major or column-major approaches are also used (non-contiguous blocks)
  - Java, C#, CLI, .Net, Scala, Swift, Python, Lua, …

Row-major and column-major order

Row-major order



Column-major order



	0	1	2	3
0	1	2	3	4
1	8	6	4	2
2	10	20	30	40
3	5	7	9	11

Question

- How many bytes are these arrays using in memory?

```
int array[100000];

int matrix[1000][1000];

double tensor[1000][1000][1000];
```


Question

- Write a program that reads in the value of n, and prints the identity matrix of size n x n?

Multidimensional arrays and functions

- The first array size need not be specified
- The second (and any subsequent) must be given
- Example:

```
int foo(int list[][100], int rows, int cols);
```

size is required so the compiler can calculate the memory addresses of individual elements

Question

- Write a function that adds two 2D matrices?

Question

- Write a function that multiplies two 2D matrices?