

# Arrays and Structures: Multidimensional Arrays

Joseph Chuang-Chieh Lin (林莊傑)

Department of Computer Science & Engineering,  
National Taiwan Ocean University

Fall 2024



# Outline

- 1 Two-Dimensional Arrays
- 2 Three and More Dimensional Arrays



# Representation of Multidimensional Arrays

- Implemented by a one-dimensional array.
- Two common ways of representation.
  - Row major or column major.
- Consider array  $A[3][2]$  as an example.



# Representation of Multidimensional Arrays

- Implemented by a one-dimensional array.
- Two common ways of representation.
  - Row major or column major.
- Consider array  $A[3][2]$  as an example.



# Representation of Multidimensional Arrays

- Implemented by a one-dimensional array.
- Two common ways of representation.
  - **Row major** or column major.
- Consider array  $A[3][2]$  as an example.

$\alpha$	$\alpha + 1$	$\alpha + 2$	$\alpha + 3$	$\alpha + 4$	$\alpha + 5$
$A[0][0]$	$A[0][1]$	$A[1][0]$	$A[1][1]$	$A[2][0]$	$A[2][1]$



# Outline

## 1 Two-Dimensional Arrays

## 2 Three and More Dimensional Arrays



# Two-Dimensional Arrays

- $A[u_0][u_1]$  is interpreted as  $u_0$  rows:  $\text{row}_0, \text{row}_1, \dots, \text{row}_{u_0-1}$ .
  - Each row contains  $u_1$  elements.
- The address of  $A[i][j]$  is  $\alpha + i \cdot u_1 + j$ , where  $\alpha$  is the address of  $A[0][0]$ .



# Two-Dimensional Arrays

- $A[u_0][u_1]$  is interpreted as  $u_0$  rows:  $\text{row}_0, \text{row}_1, \dots, \text{row}_{u_0-1}$ .
  - Each row contains  $u_1$  elements.
- The address of  $A[i][j]$  is  $\alpha + i \cdot u_1 + j$ , where  $\alpha$  is the address of  $A[0][0]$ .

	$\text{col}_0$	$\text{col}_1$	$\dots$	$\text{col}_{u_1-1}$
$\text{row}_0$	$A[0][0]$	$A[0][1]$	$\dots$	$A[0][u_1 - 1]$
$\text{row}_1$	$A[1][0]$	$A[1][1]$	$\dots$	$A[1][u_1 - 1]$
$\vdots$	$\dots$	$\dots$	$\dots$	$\dots$
$\text{row}_{u_0-1}$	$A[u_0 - 1][0]$	$A[u_0 - 1][1]$	$\dots$	$A[u_0 - 1][u_1 - 1]$





# Outline

- 1 Two-Dimensional Arrays
- 2 Three and More Dimensional Arrays



# Three-Dimensional Arrays

- $A[u_0][u_1][u_2]$  is interpreted as  $u_0$  two-dimensional arrays of dimension  $u_1 \times u_2$ .
- The address of  $A[i][0][0]$  is  $\alpha + i \cdot u_1 \cdot u_2 + j$ , where  $\alpha$  is the address of  $A[0][0][0]$ .



# Three-Dimensional Arrays

- $A[u_0][u_1][u_2]$  is interpreted as  $u_0$  two-dimensional arrays of dimension  $u_1 \times u_2$ .
- The address of  $A[i][0][0]$  is  $\alpha + i \cdot u_1 \cdot u_2 + j$ , where  $\alpha$  is the address of  $A[0][0][0]$ .
- The address of  $A[i][j][k]$  is  $\alpha + i \cdot u_1 \cdot u_2 + j \cdot u_2 + k$ .



# Multidimensional Arrays

- The address of  $A[i_0][i_1][i_2] \dots [i_{n-1}]$  is:

$$\begin{aligned}
 & \alpha + i_0 u_1 u_2 \dots u_{n-1} \\
 & + i_1 u_2 \dots u_{n-1} \\
 & + i_2 u_3 \dots u_{n-1} \\
 & \vdots \\
 & + i_{n-2} u_{n-1} \\
 & + i_{n-1} \\
 & = \alpha + \sum_{j=0}^{n-1} i_j a_j,
 \end{aligned}$$

where  $a_j = \prod_{k=j+1}^{n-1} u_k$  for  $0 \leq j \leq n-1$  and  $a_{n-1} = 1$ .



# Discussions

