Tutorial 05 - 07.12./10.12.2020

Group 02/11 - Moritz Makowski - moritz.makowski@tum.de

Multidimensional Arrays, Type Casting, Structs and Enums

Today's Agenda

- Revision: Arrays and Functions
- **Exercise 5.1: Arrays and Functions**
- Multidimensional Arrays
- **Exercise 5.2: Matrix Properties**
- Type Casting
- Struct's
- Union's
- Enum's
- **Exercise 5.3: Using Struct's, Union's and Enum's**

A short revision of **arrays**.

A short revision of **functions**.

Exercises 5.1: Arrays and Functions

(a) Return the largest element in a list.

(b) Check whether an element occurs in a list.

(c) Compute the running total of a list.

(d) Test whether a string is a palindrome.

(e) Reverse a list. Assume a fixed length of 10 elements!

You can put all your code inside `main` *(in the beginning, while testing your logic) and later divide it into functions. You can also start with separate functions right away.*

Multidimensional Arrays

The arrays we know ... `int my_array[10] = ...;` ... are *one-dimensional*. With regular arrays you **"iterate along one dimension"**.

However sometimes you want to have more dimensions than one.
Examples: Matrices/Tensors, Tables.

You cannot only have two-dimensional arrays but as many dimensions as you need. So you will have **one index for each dimension**.

Example Case: Two-Dimensional Arrays

We refer to the row index as i and to the column index as j.

With two dimensions we need to define two sizes: How many rows? How many columns?

The initialization looks a lot like for regular arrays.

```c
int my_matrix[3][4] = {
  {1, 2, 3, 4},
  {5, 6, 7, 8},
  {9, 10, 11, 12}
};
```

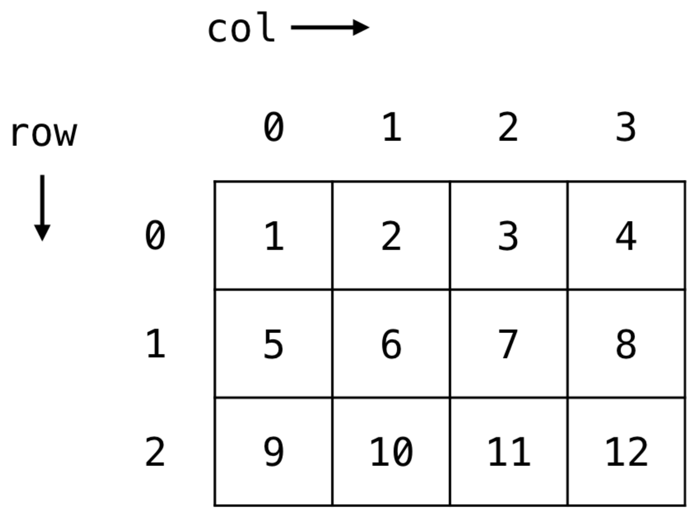


Image Source: https://www.dyclassroom.com/

See `example_5_1_matrix_initialisation.c` on GitHub.

col →

row ↓	0	1	2	3
0	1	2	3	4
1	5	6	7	8
2	9	10	11	12

Indexing an array is also very similar to regular arrays:

```
int value_at_bottom_left = my_matrix[2][0];  // Will return 9
```

Example Usecase: Matrix properties

See: `example_5_2_diagonal_matrix.c`

Exercise 5.2: Matrix Properties

I have prepared a `main`-file for you called `exercise_5_2_matrix_main.c`.

You are expected to implement two functions (either inside that file or in a separate file).

(a) The function `is_symmetric(char rows, char columns, matrix[row][columns])` returns `1` if the given matrix is symmetric and `0` otherwise.

(b) The function `is_skew_symmetric(char rows, char columns, matrix[row][columns])` returns `1` if the given matrix is skew-symmetric and `0` otherwise.

Revisiting Integer Division

When dividing two integers the result will always be an integer even when stored in a float.

```
int main() {
  int a = 11;
  int b = 5;

  float result = a/b;  // Will store 2.0000...

  return 0;
}
```

Enter "Type Casting"

Inside an equation you can convert variables to other data types so that the will be treated as a variable of their newly assigned type (only inside that equation).

```
int main() {
  int a = 11;
  int b = 5;

  float result_1 = (float)(a)/b;  // Will store 2.2000...
  float result_2 = a/(float)(b);  // Will store 2.2000...
  float result_3 = (float)(a/b);  // WRONG! Will store 2.0000...

  // The variables a and b themselves did
  // not change -> Both still of type 'int'

  return 0;
}
```

What if we want to **bundle related information of different data types** together?

Answer: We can use a `struct`!

Example Usecase: Points with 3D Coordinates - Bad

```c
int main() {

  float point_1_x = 12;
  float point_1_y = 8.5;
  float point_1_z = 0.2;

  float point_2_x = 12.1;
  float point_2_y = 7.5;
  float point_2_z = 0.4;

  ...

  return 0;
}
```

Example Usecase: Points with 3D Coordinates - Good

```c
struct point {
  float x;
  float y;
  float z;
}

int main() {

  struct point point_1;
  point_1.x = 12;
  point_1.y = 8.5;
  point_1.z = 0.2;

  struct point point_2;
  point_2.x = 12.1;
  point_2.y = 7.5;
  point_2.z = 0.4;

  return 0;
}
```

Example Usecase: Points with 3D Coordinates - Even Better

```c
struct point {
  float x;
  float y;
  float z;
}

int main() {
  struct point point_1 = {
    .x = 12,
    .y = 8.5,
    .z = 0.2
  };

  struct point point_2 = {
    .x = 12.1,
    .y = 7.5,
    .z = 0.4
  };

  return 0;
}
```

Example Usecase: Points with 3D Coordinates - Perfect

```c
struct point {
  float x;
  float y;
  float z;
}

int main() {
  struct point point_1 = {12, 8.5, 0.2};
  struct point point_2 = {12.1, 7.5, 0.4};

  return 0;
}
```

Why should you use `struct`'s? - #1

1. Cleaner code
2. Less variable names
3. Consistency accross same "object types" is required

Why should you use `struct`'s? - #2

Example usecase: You can loop over an array of structs.

See `example_5_3_struct_array.c` on GitHub.

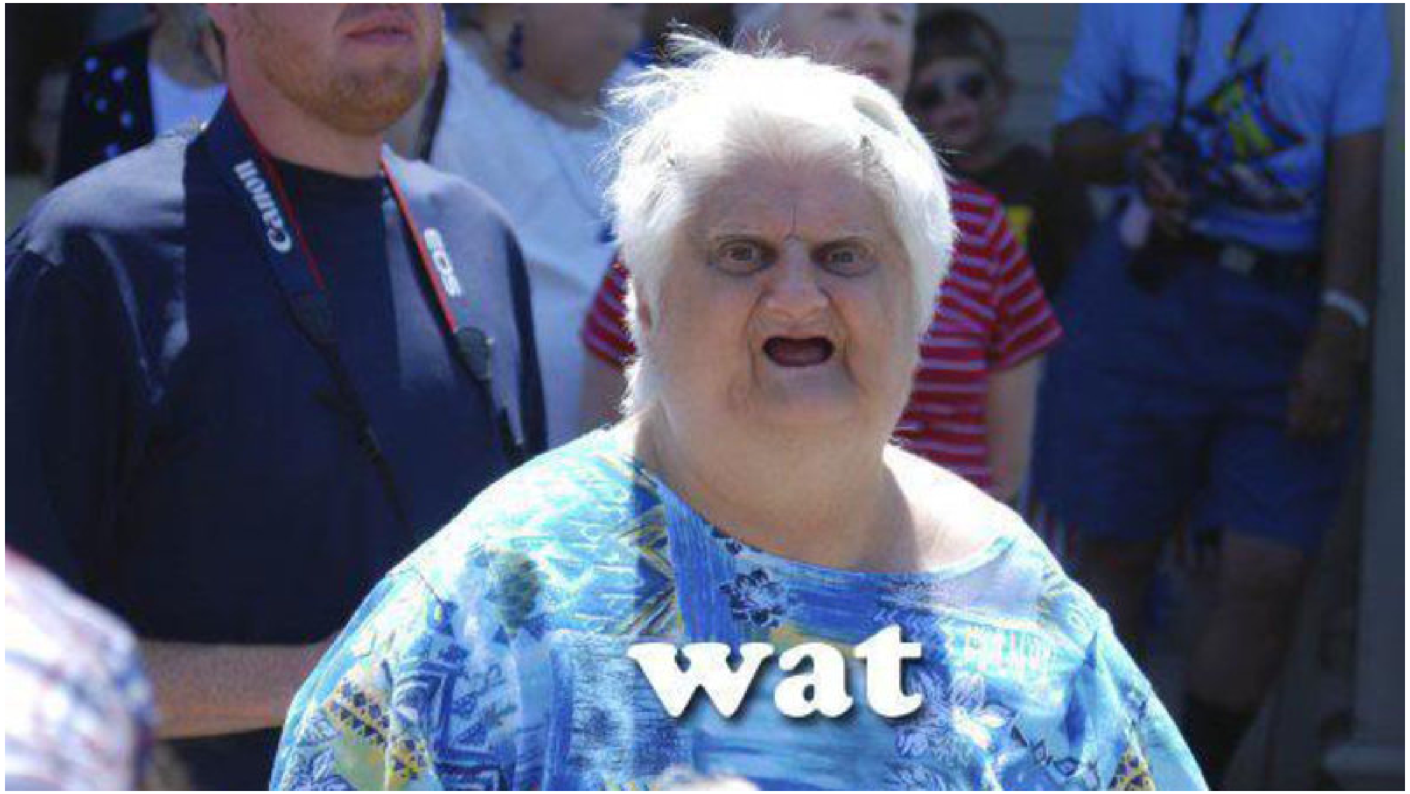
Union's

A `union` can store different data types as well.

BUT: All of them get stored in the same spot of memory.

The size of the `union` is determined by its largest component.

```
union my_union {
  int number;        // Takes up 4 bytes
  char letters[2];   // Takes up 2 bytes
}
```


Canon
EOS
wat

Shared Memory Space?

```
union mix {
  int number;                       // 4 bytes
  struct {short lo, hi;} s;         // 4 bytes
  char letters[4];                  // 4 bytes
} m;

// define as integer 'number'
m.number = 0xFF00F00F;  // 1111 1111   0000 0000   11110000   0000 1111

// interpret as struct 's'
m.s.lo;                 // 1111 1111   0000 0000
m.s.hi;                 //                         11110000   0000 1111

// interpret as char array 'letters'
m.letters[0];           // 1111 1111
m.letters[1];           //             0000 0000
m.letters[2];           //                         11110000
m.letters[3];           //                                    0000 1111
```

Enum's

Example usecase: Using variables that are supposed to store/represent a state, which is encoded in the form of an integer. E.g. the state of a traffic light.

You can now declare the state variable without remembering the encoding for each state:

```c
enum color_1 c = BLUE;

if (c == BLUE) {
  // do something
}
```

Defining Enum's

```
enum color_1 {
  RED = 1                  //  1
  YELLOW,                  //  2
  GREEN,                   //  3
}

enum color_2 {
  RED,                       //  0
  YELLOW,                    //  1
  GREEN = YELLOW + 2,        //  3
  BLUE,                      //  4
  GRAY = 17,                 // 17
  BROWN                      // 18
};
```

See `example_5_4_enums.c` on GitHub.

Exercise 5.3: Using Struct's, Union's and Enum's - #1

(a) Create a **`struct rectangle`** for a rectangle containing its length and width as `double` values.

(b) Create a **`struct triangle`** for a right triangle containing the length of its hypotenuse and its height as `double` values.

(c) Create a **`struct circle`** for a circle containing its radius as `double` value.

(d) For each shape, write a function that receives an appropriate `struct` as a parameter and returns its area as a `double`. You can find a constant named `M_PI` in `math.h`.

Exercise 5.3: Using Struct's, Union's and Enum's - #2

(e) Create an `enum shape_type` with a value for each of the shapes created above.

(f) Create a `struct shape` that uses a `union` to hold any of the shapes created above and in addition an `enum` indicating which type of shape is currently in use.

(g) Create a function `shape_area` that gets a shape as parameter. The function should then print the type and the area of the contained shape. Finally the function should return the area of the shape as a `double`.

(h) Declare a some shapes and check / use your function.

See You Next Week!

All **code examples** and **exercise solutions** on **GitLab** (solutions right after my tutorial):

https://gitlab.lrz.de/dostuffthatmatters/IN8011-WS20


It doesn't work...... why?
It works.......
why?
MemeBlender.com