601.220 Intermediate Programming

Dynamic 2D arrays & const w/ pointers

Outline

- Dynamic allocation of 2D arrays
- Pointer types & `const`

Two dimensional arrays - static allocation review

- `int a[5][3];` creates array with 5 rows, 3 columns each
- `a[2][1] = 17;` stores value in 3rd row, 2nd column
- array is stored sequentially in memory, in row order
  - `*(a + 10)` is the same as `a[3][1]`

Dynamically-allocated two dimensional arrays - use a 1D array of items and "fake" two dimensions

- `int *a = malloc(sizeof(int) * num_rows * num_cols);`
- Use a single array with one dimension
  - Convert `[row][col]` indexing to `[row * num_cols + col]`, and back
  - `a[7] = 17;`
    // `a[7]` means `a[2][1]` for `num_cols`==3,
    // since 7 == 2*3 + 1
- `free(a);`

Dynamically-allocated two dimensional arrays - double (**) memory allocation

- Use a 1D array of pointers to item arrays

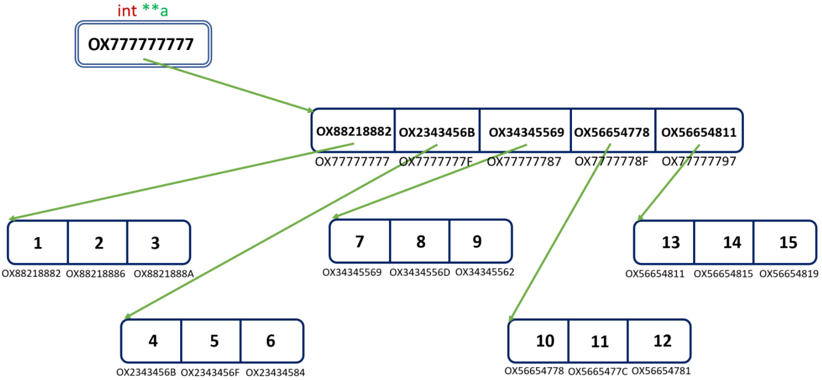
```
int **a = malloc(sizeof(int*) * num_rows);

for (int i = 0; i < num_rows; i++) {
    a[i] = malloc(sizeof(int) * num_cols);
}

a[2][1] = 17;  // this works!

for (int i = 0; i < num_rows; i++) {
    free(a[i]);
}
free(a);  // note this one last free!
```

5 by 3 2D Array using 1D array of pointers



int **a

OX777777777

OX88218882	OX2343456B	OX34345569	OX56654778	OX56654811
OX77777777	OX7777777F	OX77777787	OX7777778F	OX77777797

1	2	3
OX88218882	OX88218886	OX8821888A

4	5	6
OX2343456B	OX2343456F	OX23434584

7	8	9
OX34345569	OX3434556D	OX34345562

10	11	12
OX56654778	OX5665477C	OX56654781

13	14	15
OX56654811	OX56654815	OX56654819

Decomposing a dynamically-allocated 2D array

- given `int **a` has been fully allocated as in prior slides
    - `a[i]` is of type `int *`, for valid values of `i`
    - represents one row in the 2D array
    - can be used in the same ways a 1D array variable can be used

Rows of a 2D array as 1D arrays

```c
// rowProcessing.c:
#include <stdio.h>

void printFloats(float fray[], int count) {
  for (int i = 0; i < count; i++)
    printf("%.1f ", fray[i]);
}

int main(void) {
  float fra[5][3] = {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}, {10, 11, 12}, {13, 14, 15}};
  for (int r = 0; r < 5; r++) {
    printFloats(fra[r], 3);
    printf("\n");
  }
  return 0;
}
```

```
$ gcc -std=c99 -Wall -Wextra -pedantic rowProcessing.c
$ ./a.out
1.0 2.0 3.0
4.0 5.0 6.0
7.0 8.0 9.0
10.0 11.0 12.0
13.0 14.0 15.0
```

Non-uniform (jagged) 2D arrays - how to

It is possible for rows in a dynamically allocated 2D array to be different sizes

```
// create 10 pointers to rows
int **ra2d = malloc(sizeof(int*) * 10);

// create rows with sizes 1 to 10
for (int i = 0; i < 10; i++) {
    ra2d[i] = malloc(sizeof(int) * (i + 1));
}
```

Non-uniform (jagged) 2D arrays - pitfalls

- must remember to free the memory for each row, and then the ra2d itself
- need to be careful when using since rows are different sizes!
- might want a parallel array to hold the length of each row

Using `const`

- `const` means “constant” and prevents modification of the element to which it is applied
- Recall: to make a variable non-modifiable: `const int num`
  - if local variable, it must be initialized when declared
    `const int num = 10;`
  - if parameter variable, it cannot be changed within the function
  - can pass a non-const variable to a const parameter (more restrictive)
  - cannot pass a const variable to a non-const parameter
- `const` can be used at different points in pointer type declarations, each with different meanings

Pointers, arrays and const - protect the data pointed to

- To make a (mutable) pointer to const (non-modifiable) data:
  ```
  const int * iptr
  ```
- prevents changing contents of the pointed to memory
  ```
  *iptr = 10;   // not allowed
  iptr = &num;  // allowed for int variable num
  ```
- similar to const int iray[] as a function parameter
  ```
  iray[0] = 10; // not allowed
  iray = malloc(sizeof(int));  // allowed
  ```
  - only copy of the calling variable is affected, not the original

Pointers, arrays and const - protect the pointer

- To make a const (non-modifiable) pointer:
  `int * const iptr`
- similar to `int iray[10];` as a local variable
- if not a parameter, must set when declaring:
  `int * const iptr = &num;`
- prevents assignments to change (the address stored in) `iptr` or `iray`

```
iptr = &other;    // not allowed
iray = b;         // not allowed
```

Pointers, arrays and const - double const

- To make a const ptr to const data:

  ```
  const int * const iptr
  ```

- doesn't allow changes to pointer variable itself, or the memory it points to

  ```
  *iptr = 10;     // not allowed
  iptr = &num;    // not allowed
  ```

- similar to `const int iray[] = { 1, 2, 3 };` as local variable

  ```
  iray[0] = 10;   // not allowed
  iray = malloc(sizeof(int));  // not allowed
  ```

Read declarations from right to left to get them correct!